Motoring Insurance Travel Finance

RACQ EcoDrive Research Study

Final Report

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Executive summary

The RACQ EcoDrive Research Study investigated the effectiveness of eco-driving training for private motorists in the Australian context. It is the most comprehensive study of its type that RACQ has been able to identify in the English language literature.

Study findings

The RACQ EcoDrive Research Study not only confirmed that changing driver behaviour can lead to lower-cost motoring and better results for the environment, but also identified how best to achieve those outcomes.

Testing a range of education interventions in a real world situation with private motorists, the study quantified the respective fuel use and emission reductions that might reasonably be expected from them. While an intensive half-day workshop combined with an on-line learning program delivered the best results overall among study participants, the on-line learning program alone provided the most cost-effective method of showing motorists how to reduce their vehicles' fuel consumption.

The combined effect of all the eco-driving training trialled during the study was a statistically significant 4.6% reduction in fuel use. This equated to an average reduction of 0.51 litres per 100 kilometres (l/100km).

The participants in the top 15.9% (the mean fuel use plus one standard deviation) achieved a reduction of at least 15.1% or 1.7l/100km. Table ES1 provides the mean absolute and percentage reduction in fuel use achieved by participants in five different interventions, along with extrapolated, annual average financial savings and reduction in CO_2 emissions on a per vehicle basis.

Table ES1: Average absolute and percentage reduction in fuel use resulting from the eco-driving training

	Average absolute change in fuel use (l/100km)	Average percentage change in fuel use (%)	Annual average savings^ ($)	Annual average reduction in CO_2 (Kg)^
Intervention 1: On-line learning	0.47	4.5	98.14	155.7
Intervention 2: Classroom	0.52	4.7	108.78	172.2
Intervention 3: Driving lesson	0.54	4.3	112.75	178.8
Intervention 4: Classroom and driving lesson	0.41	4.0	85.61	135.8
Intervention 5: Half-day workshop	0.80	7.4	167.04	265.0
All interventions – the combined effect*	0.51	4.6	106.49	169.0

* Note: the combined effect is the average change of all the participants who completed training, not the average of the five interventions.

^ Annual savings and emissions are based on an assumed average travel distance of 14,400km per year and an average price of unleaded petrol of $1.45 per litre (Brisbane average price in 2011/12), or 2.3kg of CO_2 per litre of fuel.

As can be seen in table ES1, substantial reductions were achieved across the whole sample when participants were trained in eco-driving. While there appear to be some differences between the outcomes of the interventions, particularly intervention 5, these are not statistically significant. It is possible that the sample size of intervention 5 was too small to ascertain whether the difference in fuel use was significant.

The lowest intensity training (the on-line version) resulted in a 4.5% reduction in fuel use, which equated to a reduction of 0.47l/100km. The most intensive training (the half-day workshop) resulted in a 7.4% reduction in fuel use, equating to an average reduction of 0.80l/100km.

Therefore, the study concludes that eco-driving training, even at the lowest intensity, will reduce fuel consumption. It proves that motorists can directly and individually reduce their own motoring costs and their impact on the environment. In turn, eco-driving training could result in substantial cost savings to commercial and government fleets, as well as contributing to national energy security and efforts to reduce greenhouse gas emissions in the road transport sector.

Study details

Eco-driving is a group of behaviours related to the way drivers use their cars to minimise fuel consumption. These behaviours include: a person's driving style, the way the vehicle is used, how often the vehicle is used, its configuration and accessories (e.g., roof racks), and day-to-day and longer-term vehicle maintenance. These behaviours contribute to lower fuel consumption and longer life of vehicle components.

This study was jointly funded by the RACQ and the Queensland Government through the Department of Transport and Main Roads. The Centre for Accident Research and Road Safety - Queensland (CARRS-Q) at Queensland University of Technology (QUT) provided the method support and peer review of the research.

The review of the recent literature identified a lack of published, independent scientific studies on behaviour change resulting from eco-driving training. There are a number of eco-driving training programs and demonstrations of eco-driving within the heavy vehicle fleet context in Australia. These have identified some positive results. Similarly, a number of reports have identified positive benefits internationally. However, these have limited credibility for Australian driving conditions and in the private motoring context.

This study sought to address these limitations in the current body of knowledge by assessing which, if any, education interventions helped private motor vehicle drivers to implement strategies that reduced fuel consumption.

The study also attempted to understand what level of training intensity was required to influence drivers to adopt fuel-efficient driving – a driving style that minimises the amount of fuel used. The study incorporated low intensity tools such as on-line learning through to high intensity options, such as a half-day workshop with in-vehicle demonstrations.

Study methods

The eco-driving training in this study was completed by private motorists, with participants being responsible for all their vehicle running costs. The training was provided to a group of drivers demographically matched to the Queensland licence-holding population. The vehicles driven were predominantly light passenger vehicles, along with some four-wheel-drive and light commercial vehicles. The participants were drawn from Brisbane, Logan City and Moreton Bay Region in southeast Queensland, Toowoomba in southern Queensland, and Townsville in north Queensland.

There were 1,056 participants who completed all aspects of the study and whose results are included in the final analysis.

The eco-driving training was delivered using four methods, bundled into five training interventions:

- **On-line learning tool**– Included a brochure and on-line learning module of up to one hour. This was offered to all participants except the control group.
- **Classroom** – Two-hour classroom session in groups of up to 15. The classroom was conducted by one or two of the EcoDrive project team.
- **Driving lesson in eco-driving strategies** – A 50-minute lesson with an accredited and trained private driving instructor.
- **Half-day workshop** – Half-day eco-driving course, including an in-car drive using advanced telemetry, to provide evidence of the fuel reduction benefits and improved comfort from eco-driving.

The five interventions were:

Intervention 1: On-line tool;

Intervention 2: On-line tool plus classroom;

Intervention 3: On-line tool plus driving lesson;

Intervention 4: On-line tool plus classroom and driving lesson; and

Intervention 5: On-line tool plus half-day workshop.

Policy implications

The research demonstrated that individual motorists will change their behaviour when provided with eco-driving training. It addresses the limitations in the body of knowledge, in providing a randomised, controlled study in eco-driving behaviour change.

The study showed a 4.6% reduction in fuel use and emissions is achievable across the whole passenger vehicle fleet. This is a meaningful saving for an individual driver. Savings would be even higher in households where there are a number of vehicles and trained drivers, or where distances travelled are higher than average.

The reduction in fuel use is a conservative estimate of the savings. The study was a blind experiment and hence the participating cohort included people who were interested in fuel efficiency and those who were not at all interested. There is potential for greater savings with drivers who self-select for eco-driving training because they want to experience the benefits of the training. It is notable that the participants in the top 15.9% (the mean fuel use plus one standard deviation) achieved a reduction of at least 15.1% or 1.7l/100km. The measurement also takes no account of transport mode shift and the resulting reduction in vehicle kilometres travelled as a result of training.

A 4.5% or 0.5l/100km fuel consumption reduction was achieved by using the on-line learning tool. This would account for an average yearly fuel saving of $98 (using the average fuel cost of $1.45 per litre in Brisbane in 2011/2012 and an annual average distance travelled of 14,400km per year) for each individual, with greater savings achievable for drivers of larger vehicles and those travelling longer distances than average. In CO_2 reduction terms, this is a saving of 156kg per vehicle per year. Based on the results for the best performing participants in the study, it is possible for this to increase to a saving of $355 and a CO_2 reduction of 523kg per year.

The on-line tool is the cheapest and easiest option to implement on a mass scale. This training has the highest benefit-cost ratio. It could also be incorporated into learner driver training.

Similar savings can be achieved by attending the classroom and driving lessons. While this delivery mode is more expensive, it would be useful for those motorists who are unable or unwilling to access the on-line learning.

A 7.4% or 0.8 l/100km fuel use reduction can be achieved through completion of the half-day workshop. This would provide average yearly savings of $167 in fuel costs and 265kg in CO_2 per driver. This option is most appropriate for high-mileage drivers as the benefits are more substantial and the fuel cost savings are greater than the training cost. This option is also relevant for fleet drivers as the business costs can be reduced through taxation accounting.

Any reduction in fuel consumed benefits the community by reducing our reliance on liquid fuels. An overall 4.6% reduction in fuel consumption would improve Australia's energy security, as it would reduce our dependence on fuel imports and our exposure to supply disruptions. In addition, a mass campaign in fuel-efficient driving would provide drivers with information that would allow them to reduce their fuel consumption immediately if a supply disruption were to occur.

The literature review presented in this study identified limitations in the understanding of the relationship between eco-driving and safety. This is important as safety is of interest to almost all drivers and could be an additional motivator to drive efficiently. Further research is required to investigate possible relationships between eco-driving and safe driving.

Feedback from participants also suggests there may be benefits in research on driving stresses and encouraging courteous behaviour. Stress reduction is a potential motivator to engage in eco-driving, although a lack of courtesy from other drivers (e.g., to someone slowing in advance of a red light ahead) is a potential barrier.

Overall, this research study points to opportunities for the Queensland Government, CARRS-Q and/or RACQ to further develop and implement eco-driving training in future.

1 Introduction

The RACQ EcoDrive research study investigated the effectiveness of eco-driving training in the Australian context.

This chapter comprises four sections. Section 1.1 provides the background to this study. An explanation of eco-driving is provided in section 1.2. Section 1.3 presents the specific research questions addressed in this study, and section 1.4 describes the structure of this report.

1.1 Background

This study on eco-driving was jointly funded by the RACQ and the Queensland Government through the Department of Transport and Main Roads. It was conducted to identify which, if any, education interventions help private motor vehicle drivers to implement strategies that reduce fuel consumption.

RACQ gratefully acknowledges the funding support of the Queensland Government and Professor Narelle Haworth and Professor Andry Rakotonirainy, of QUT’s Centre for Accident Research and Road Safety – Queensland (CARRS-Q), who provided ongoing method support and peer review of the research.

RACQ’s interest in eco-driving stems from the range of possible benefits it offers to club members: reduced motoring costs through improved fuel economy, reduced vehicle emissions, increased safety, and less stress while driving.

There has been a lack of information available on the benefits of eco-driving in the Australian context. In 2008, the Clean Run trial (Department of Environment and Conservation, WA, 2008) identified benefits for cement trucks and other heavy vehicles through the implementation of eco-driving. Since then considerable research and effort has been undertaken in the heavy vehicle community, including companies, such as Linfox, that train their drivers in fuel-efficient driving.

A number of Australian motoring clubs also conducted a small trial of eco-driving with their road service fleets. The trial resulted in an overall 8.7% fuel consumption reduction, with Queensland participants achieving a 15.5% reduction (NTSU 2010:8).

These trials are relevant in the commercial context, where organisational motivations of safety and economy can drive behaviour change. However, they fail to provide information pertinent to private motorists, who have no organisational imperative to change driving behaviour. This trial sought to understand the applicability of eco-driving training for privately owned motor vehicles.

The RACQ and the Queensland Government funded this initiative jointly. The study project was conducted by RACQ, with method support and peer review from QUT’s CARRS-Q. The study started in July 2011, with 1,547 participants, and concluded in July 2012.

1.2 Defining eco-driving

Eco-driving is a way of driving designed to reduce fuel consumption, greenhouse gas emissions and crash rates. It is based on a group of behaviours related to how we use our cars. These behaviours include a person’s driving style, the way the vehicle is used, how often it is used, the configuration of the car and accessories such as trailers and roof racks, how and when luggage is carried, and day-to-day and longer-term vehicle maintenance. Positive application of these behaviours can contribute to lower fuel consumption and longer life of vehicle components.

Eco-driving as a concept and program is well developed in Europe as part of efforts to tackle climate change. The European programs include media campaigns, short and long-term post-licence training modules, learner driver training, and bus and fleet programs. The RACQ study focused on post-licence training programs for private passenger vehicle drivers.

1.3 Objectives and research questions

The study objectives were:

- Testing the effectiveness of long-term behaviour change strategies;
- Testing the efficacy of different behaviour change strategies, comparing the cost and benefits of varying levels of intensity; and
- Developing some prototype tools for full roll-out of an eco-driving program.

The research sought to meet the three study objectives by answering seven questions about the participants and the training interventions. These questions were:

1. Which training intervention is the most effective at reducing fuel use across the whole sample?
2. Which training intervention is the most effective at reducing fuel use, differentiated by age of participants?
3. Which training intervention is the most cost-effective (intervention delivery costs divided by fuel use costs/carbon costs) across the whole sample?
4. Which training intervention is the most cost-effective, differentiated by age of participants?
5. Which training intervention is the most effective at changing attitudes across the whole sample?
6. Which training intervention is the most effective at changing attitudes, differentiated by age of participants?
7. Which participant attributes (location, age, gender, vehicle attributes) impact on the overall and relative effectiveness of the training interventions?

1.4 Structure of the report

A literature review is provided in chapter 2. This examines the definitions of eco-driving and discusses its benefits. It also considers the issue of safety and the relationship between safety and eco-driving. It examines the literature on eco-driving studies and notes the lack of available, well-documented studies on eco-driving written in English. It also considers the literature related to behaviour change, particularly individual motivators, and how it might influence a program focused on sustainability. Chapter 2 concludes by identifying some successful Queensland travel behaviour change programs that have relevance to eco-driving programs.

Chapter 3 presents the research design and methods applied in the EcoDrive study. It describes the process of the randomised controlled study, the detail of the training interventions and the recruitment methods. It also describes the data collection methods, statistical analyses and the cost-effectiveness analysis.

The descriptive statistics of the research sample for the study are provided in chapter 4. It starts with a discussion of the participants, including their demographic profiles. The chapter provides a discussion of the statistically significant differences in the sample between the different cohorts. It also discusses participation rates. The profile of vehicles in the sample is also discussed in this chapter, including how the fuel use of the sample compares to the benchmarks provided in the Australian Government's Green Vehicle Guide. Pre-training fuel use data is provided in this chapter, along with a discussion of how the pre-training fuel dates were allocated for the active sample and the control group, which had no actual training dates.

Chapter 5 describes the findings of the study. The chapter reports on the changes in attitudes, fuel use and CO_2 emissions resulting from the eco-driving training. A cost-effectiveness analysis is presented in this chapter.

Chapter 6 discusses the conclusions, limitations and policy implications of the study. It also highlights the need for further research in some areas.

2 Literature review

This chapter identifies the key debates in the literature on the development, implementation and evaluation of eco-driving programs internationally and in Australia. It also includes a short discussion on the literature related to the development of community-wide education programs, particularly those focused on behaviour change and carbon emissions in the transport sector.

In section 2.1 eco-driving is defined. Section 2.2 discusses the measurement of benefits, while the broader context of eco-driving is incorporated in section 2.3. Sections 2.4 and 2.5 discuss international and Australian eco-driving programs and experiences. Section 2.6 discusses the relationship between technology, safety and eco-driving. Section 2.7 discusses behaviour change theory and Section 2.8 identifies key issues addressed in the study.

2.1 What is eco-driving?

Eco-driving encompasses driver behaviours, vehicle maintenance and non-driving actions to reduce fuel consumption. Eco-driving is defined as a way of driving designed to reduce fuel consumption, greenhouse gas emissions and crash rates. In the words of one report: “Eco-driving is about driving in a style suited to modern engine technology: smart, smooth and safe driving techniques that lead to average fuel savings of 5-10%.” (Ecowill, www.ecodrive.org retrieved on 17 July 2012).

Driver behaviour includes focusing on driving smoothly and anticipating traffic changes. Other driving strategies include shifting gears as early as possible to maximise fuel economy and avoiding hard braking and acceleration (Treatise, 2005). An additional strategy, focused on gear changing in automatic vehicles and using the accelerator to influence when the engine management system changes gear, is also added to driving strategies in Australia (where there is a higher proportion of automatic transmission vehicles) (Rakotonirainy, Haworth, Saint-Pierre, and Delhomme, 2011).

Vehicle maintenance incorporates checking tyre pressures and regular car servicing (Symmons, Rose, Rorke and Watkins, 2011).

Non-driving actions encompass reducing unnecessary idling and the use of peripherals such as air-conditioning, removing excess weight and optimising the aerodynamic profile of the vehicle (Symmons et al., 2011).

Timing of travel and mode shift to reduce vehicle kilometres travelled and the frequency of driving in congested traffic are also considered relevant eco-driving strategies (James, 2009).

Symmons, Rose and Van Doorn (2009) have compiled a comprehensive list of the strategies, namely:

- Shifting through the gears as soon as possible;
- Skipping gears when appropriate;
- Using the highest gear possible;
- Maintaining a steady speed in the optimal engine rpm range;
- Avoiding heavy and/or sudden acceleration or braking;
- Looking ahead as far as possible in order to anticipate the actions of other drivers and predict likely changes and interruption to traffic flow;
- Minimising idling time;
- Coasting to traffic lights or intersections so there is no unnecessary braking;

- Monitoring and maintaining appropriate tyre pressures;
- Ensuring that the recommended servicing intervals are met and maintenance is carried out;
- Maximising vehicle aerodynamics and minimising unnecessary weight;
- Not warming up the vehicle when it is first started; and
- Making smart use of in-car devices such as air-conditioning.

Barkenbus (2010) identifies the need to distinguish eco-driving from 'hypermiling'. Hypermiling is regarded as an extreme form of fuel-efficient driving, trading off safety for fuel economy. Strategies in hypermiling that are not incorporated in eco-driving include, but are not limited to, turning the ignition off when going down hills and slipstreaming close to the vehicle in front. Eco-driving seeks to minimise fuel efficiency without making any safety compromises. Many of the strategies overlap with safe driving techniques.

2.2 Benefits of eco-driving and their measurement

The benefits of eco-driving for individuals result from saving fuel and reducing car maintenance expenses. Benefits to the community come from reducing greenhouse and other emissions.

Symmons, Rose and Van Doorn (2009:3) describe these benefits as having a triple bottom line effect: "Financial from reduced fuel and maintenance costs, environmental from slowed depletion of resources and reduced emissions and savings to society from fewer crashes, less road trauma and reduced detrimental health impacts from vehicle related pollution".

Some authors have considered how to measure the benefits of eco-driving. Measuring the direct emissions of the vehicle fleet can be difficult given the variations in size, engine displacement and age of the fleet. Smit, Rose and Symmons (2010:11) examined the potential of using emissions modelling with simulators and direct measurement to understand the impact of eco-driving in the Australian context, using Australian drive cycles and replicating the types of vehicles in the Australian fleet. This area requires further research.

An alternative to direct emissions modelling is to measure the savings in fuel used. There is a direct relationship between fuel consumption and carbon dioxide emissions. Eco-driving reduces carbon dioxide (CO_2) emissions by reducing the amount of fuel used for a given vehicle trip, thus reducing the emissions intensity of vehicle transport per kilometre (James, 2009).

The Australian Government provides a credible benchmark for CO_2 tailpipe emissions per litre of fuel consumed. This is provided in table 2.1.

Table 2.1: Benchmark emissions

Fuel type	CO_2 emissions
Petrol	2.3kg/l
LPG	1.6 kg/l
Diesel	2.7 kg/l

www.environment.gov.au/settlements/transport/fuelguide/environment.html (Retrieved 11 July 2012)

Measuring the benefits of individual driving strategies is useful as a learning tool. The Australian Automobile Association and de Haan (cited in James, 2009) identified some specific effects of individual strategies. Limiting air-conditioning can reduce fuel use by up to 17.5%; low tyre pressure can increase fuel use by 2% to 4%; gentle acceleration and engine braking can reduce fuel use by 11% and 2% respectively; and a 'sporty' driving style increases fuel use by 20%.

These individual strategies and their effects on fuel consumption were incorporated in the curriculum of the EcoDrive courses designed for this study.

2.3 The broader context of eco-driving

Eco-driving is part of a more comprehensive approach to reducing the transport sector's contribution to Greenhouse Gas (GHG) emissions. In 2009 road passenger transport in Australia was responsible for emissions equivalent to 41.5 million tonnes of CO_2, or 7.6% of total national emissions (Department of Climate Change and Energy Efficiency, 2011).

Individual drivers have a number of options available to them to reduce the GHG effect of their travel beyond eco-driving. These include purchasing more fuel-efficient vehicles or vehicles that use lower-carbon fuels, such as electricity, gas and ethanol blends. Reducing overall vehicle kilometres travelled (VKT) through using more sustainable modes such as public transport, walking, cycling and car-pooling is also important (Barkenbus, 2010). Additional measures identified by Smit et al (2010) include specific traffic management measures, such as reduced speed limits, optimised traffic signals and ramp metering. These are not considered in this study.

The International Energy Agency (IEA) is an autonomous body established in 2004, to promote energy security in the 16 European, UK, US and Asian member countries. It aims to facilitate a collective response to physical disruptions in oil supply and to advise countries on sound energy policy. In 2008, the IEA proposed a number of energy efficiency initiatives, with transport recommendations incorporating regulation on fuel efficiency standards and fuel economy labelling for both heavy and light vehicle segments, tyre energy efficiency standards and implementation of eco-driving initiatives. These initiatives have been only partially implemented in some jurisdictions, with very limited implementation in Australia and other countries outside the main vehicle-manufacturing regions (IEA, 2010:51). However, the inclusion of eco-driving provides an opportunity for Australia to implement some of the recommendations of the agency, even though it has a small vehicle-manufacturing sector.

2.4 Eco-driving experiences in other jurisdictions

Eco-driving as a concept and program is well developed in Europe as a strategy to reduce greenhouse gas emissions. The European programs comprise media campaigns, inclusion in basic driver licence training, short and long-term training modules and inclusion in bus and truck fleet management.

In the description of their Australian fleet trial, Symmons et al (2011) identified four key points from their review of the literature on eco-driving. There are only a small number of studies published in English and these generally have a European focus. Almost all of the studies report a positive result in terms of fuel reduction from using the strategies. Finally, they point out that the reviews, which are often conducted by organisations with vested interests, provide little detail of method or critical analysis. This highlights one of the benefits of conducting this study, which addresses shortcomings in the literature by providing a large, blind and controlled study of drivers using a number of education interventions across a representative sample of Queensland's driving population.

The IEA (2010) produced a table of implementation of programs and targeted improvements from eco-driving. This table (2.2) is reproduced below, though it is noted that this is based upon 2007 literature.

Table: 2.2: Eco-driving programs and targeted improvements in different countries or projects

	Method	Short-term	Mid-term
Netherlands	National Program	10-20%	5-10%
Austria	National Program	10-15%	5-10%
Japan	Smart driving contest	25%	
Japan	Idle stop driving	10%	
Japan	Eco-drive workshop	12%	
Japan	Average mileage workshop	26%	
Sweden	Driver training courses	5-15%	
Austria	ÖBB Post Bus Best Practice training courses, competition, monitoring, feedback rewards	10%	
Austria	Eco-driving competition for licensed drivers	30-50%	
Austria	Mobility management for company fleets	10-15%	
Deutsche Bahn	Training courses, monitoring, feedback, rewards	Not reported	3-5%
Shell		5-20%	
Ford	Training courses and trip/driving style analysis	25%	10%
FIA – ASAA (South Africa)		15%	
FIA- Plan Azul (Spain)		14%	
FIA – ADAC (Germany)		25%	
FIA – ÖAMTC (Austria)		6%	
FIA – JAF (Japan)		12-16%	
Nissan		18%	
UK – Lane Group		Not reported	4%
UK – Walkers		Not reported	9%

Source IEA 2010

The Netherlands has been conducting an eco-driving program since 1999 as part of implementation of the Dutch National Climate Change Action Plan to support achievement of the Kyoto protocol targets. The program sought a 6% reduction of CO_2 from implementation of eco-driving through five key areas: driving school curriculums, re-education of licensed drivers, fuel saving in-car devices, tyre pressure education and influencing vehicle purchase behaviour. The project used a partnership approach with a number of different providers and supporters, such as local municipal authorities and driving schools (EEA Technical Report No2/2008:20).

In its description of the results, the Executive Agency for Competitiveness and Innovation of the European Commission (EACI) (2009) claimed the project achieved the following outputs:

- At least 2.5 million drivers were encouraged to embrace eco-driving methods.
- The campaign will help to cut about 0.5 million tonnes of CO_2 and significant amounts of other emissions from road transport between 1999 and 2010.
- More than 130 national and local stakeholders from the public and private sectors have given their support to the campaign – including a number of non-government organisations (NGOs) .
- The project has managed to secure the involvement of a number of important umbrella organisations, such as Ford Europe, BP, the International Automobile Federation (FIA) the German Road Safety Council, the European Automobile Manufacturers' Association, GE Fleet Services and TNT.

2.5 Eco-driving programs in Australia

While there are a number of programs in the heavy vehicle segment, there is a lack of demonstrated effectiveness of eco-driving programs for the light vehicle fleet in Australia. This study seeks to address this gap.

The Cleanrun Behaviour Change Initiative (Department of Environment and Conservation, WA, 2008) attempted to demonstrate the impact of eco-driving training in three areas: measurable changes in idling behaviour, reduction in diesel emissions and development of a model for broader implementation. This initiative focused on light commercial vehicles and used a community-based social marketing approach. Seeking to work collaboratively with participants to identify the most effective strategy for implementation, it was considered successful in that participants reduced idling by 87% (the equivalent of three hours per week). There were some method issues in the Cleanrun Behaviour Change Initiative, including fleet fuel measurement inconsistencies, which meant some results relied on anecdotal information only.

The availability of fleet management data was also an issue considered in the trial conducted by Symmons et al (2011). While the results of that trial were not available at the time of writing this review, the authors have identified a data quality issue that is likely to be common to most fleets in Australia. In this case, the fleet data was inaccurate, often because of a lack of driver compliance in reporting accurate odometer readings to the fuel station attendant. This is despite fleet managers' belief that their fleet records are correct.

One major logistics company in Australia has implemented a substantial and ongoing eco-driving program into its vehicle fleet. Linfox is the largest, privately owned road-freight transport company in the Asia-Pacific region. It employs about 15,000 people, utilises 1.8 million square metres of warehousing and operates a fleet of nearly 5,000 vehicles across 11 countries. Linfox has implemented an international program to reduce CO_2 emissions across the organisation, of which 80% is transport-fuel related (Department of Resources, Energy and Tourism, 2012).

Linfox introduced an eco-driving program in 2007 as part of its overall strategy to reduce the GHG intensity of its business. The group piloted an education program that was developed with drivers, using on-line and face-to-face training. By June 2010, 826 drivers were trained in eco-driving and a further 1,000 were scheduled to complete the training by June 2011. The program included coaching and mentoring in eco-drive competencies that had been integrated into the company's performance management system. By June 2010, the company had reduced its CO_2 emissions by 14% (Linfox 2012).

2.6 Eco-driving, technology and safety

The use of technology is seen as beneficial to eco-driving because in-car feedback can provide motivation to reduce fuel consumption as well as reinforce and consolidate training (Symmons, Rose and Van Doorn 2009). RACQ has attempted to find and develop useful after-market devices to support feedback on instantaneous and trip-average fuel consumption. Monitoring consumption is also considered a key strategy in reducing fuel consumption, based on our understanding that "if you don't monitor it, you can't manage it". However, there are concerns about the safety issues associated with in-car feedback, particularly relating to driver distraction.

Many of the eco-driving strategies overlap with safe driving strategies. For example, looking ahead to drive smoothly, maintaining a consistent speed and driving at a slower pace are all eco-driving and safe driving strategies. While more work is required to research the direct link between eco-driving and safety, there are reasons to promote improved safety as a possible reason to eco-drive. Rakotonirainy et al (2011) identified a study that showed a positive correlation between crash rates and fuel consumption; but another study demonstrated that drivers who had the lowest fuel consumption were not necessarily the safest. They pointed out that reducing speed decreased the likelihood and severity of crashes and that speed reduction was a key strategy in most eco-driving training.

A number of studies have examined the benefits to, and preferences of, drivers in receiving in-car feedback. A French system developed in mid-2005, which provided driver information on smoothness, speed and gear management, produced a 15% reduction in fuel consumption (Barbe and Boy: 2006). Key recommendations for eco-driving initiatives in the IEA report included gear-shift indicators being compulsory in new vehicles and the inclusion of telematics for fuel economy.

Young, Birrell and Stanton (2009) undertook an experiment about interfaces in providing driver feedback for the UK 'Foot-LITE' program. This program encouraged drivers to adopt smart behaviours about safety and eco-driving. The experiment examined user reactions to different prototypes of in-car information about fuel economy, real-time traffic information, headway (distance to other vehicle), driver alertness and hazard warnings.

The research showed that drivers wanted information about fuel consumption, braking forces and emissions, though they were not interested in instantaneous information about cornering, as it presented a distraction and safety concern. Drivers preferred to receive simple information about gear-changing.

In examining the Foot-LITE website, it appeared that further work on such in-car information ceased following a cost analysis that identified drivers were unlikely to purchase the additional products for their vehicles.

Dogan, Steg, and Delhomme (2011) have also studied the link between safety, eco-driving and driver distraction. They examined the effect of the multiple goals of safety, time saving and fuel saving using a simulator with in-built fuel consumption feedback, and interviews with participants. They found that the actions of drivers in conflict situations seemed to be particularly directed by safety-oriented goals. This was reinforced in the verbal reports. For example, in the study drivers were more likely to focus on safety in built up areas, whereas attention to the fuel consumption monitor was stronger in less congested areas.

2.7 Behaviour change

Another key area of the literature relates to behaviour change, particularly the attitudinal preconditions motivating individuals to drive in certain ways and the importance of educational strategies that tap into those motivators. The psychology of behaviour change has played a significant role in the success of programs focusing on behaviour change. There is a plethora of literature about how to change attitudes, beliefs and behaviours and these have been used in the development of heath education, offender rehabilitation and sports programs for many years.

Two key behaviour change theories have been used in the development of the EcoDrive study training: the theory of planned behaviour and behavioural economics.

The theory of planned behaviour seeks to understand the link between behaviour and attitudes. According to the theory, attitudes to behaviour, subjective norms and perceived behavioural controls are all functions of behavioural beliefs. Originally proposed by Isek Azjen in 1985, it argues that an individual is more likely to adopt a new behaviour if they perceive it positively (they have a positive attitude to a behavioural belief); they think others around them want them to adopt the behaviour (normative → subjective norm); and provided they believe it is possible to overcome the barriers to success (perceived behavioural controls). When these conditions are present, there is greater intention to adopt a new behaviour and greater success in maintaining that behaviour. For example: “I believe it is good for me to stop smoking; my family, friends and doctor all want me to stop smoking; and there are programs which will help me get through the withdrawals and develop new habits when I feel like smoking. Consequently I will enrol in a quit program”. According to Azjen, this intention to act is critical to behaviour change (Hardeman et al: 2002).

In considering the theory of planned behaviour, the following descriptions are valuable:

- Normative beliefs are individuals’ perceptions about particular behaviours as influenced by those around them.
- Subjective norms are the individual’s perception of the normative beliefs of others.
- Perceived behavioural controls are the issues that an individual perceives will either support or impede the behaviour change and the perceived ease or difficulty in performing the behaviour.

The theory of planned behaviour links attitudes and behaviour. Figure 2.1 below shows the potential relationships of beliefs to behaviour change. It is adapted from Wallen Warner and Arberg (2008:377).

The theory of planned behave-our has been used widely in public relations and social change management. It has been used to measure and influence drivers’ normative beliefs about speeding to support the development of road safety initiatives. There are examples of this seen in some of the Victorian Traffic Accident Commission advertisements seeking to influence peers (Cameron, Haworth, Oxley, Newstead, and Tri, 1993). Consequently, the training modules in the EcoDrive study attempted to influence individual participants’ views on possible motivations for change (i.e., reduced costs, stress, improved safety and reduced GHG emissions). Other aspects were incorporated into the education tools to support behaviour change.

The theory of planned behaviour also provides some direction in targeting a broader campaign. For example, those people who have a desire to reduce their fuel costs or emissions (i.e., have a high control belief power) and are ready to change their behaviour to improve fuel efficiency may be the first targets of a program. These early adopters can then potentially be champions to influence driving culture to make a more relaxed driving style the new norm, thus influencing others’ subjective norms.

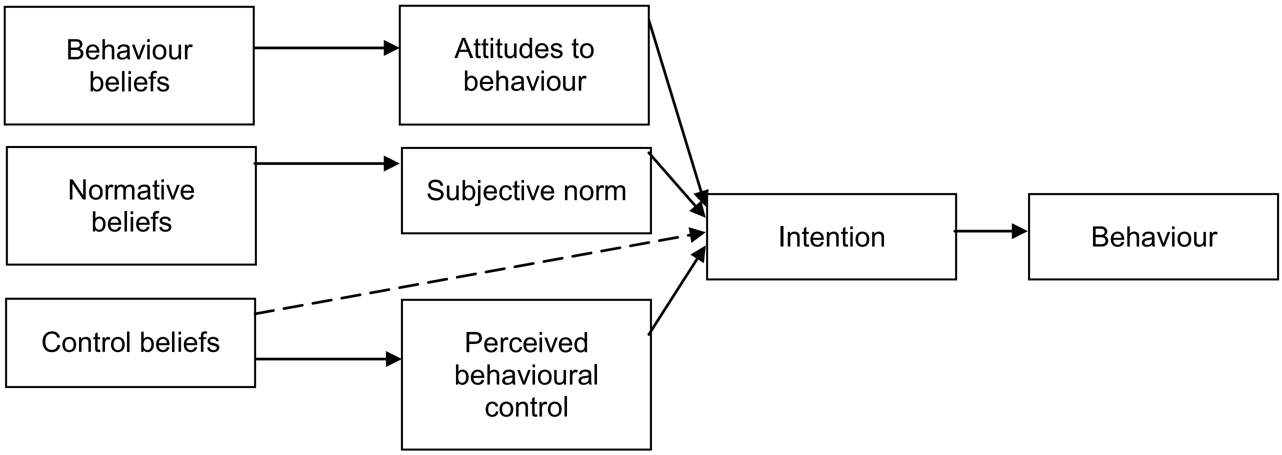

Figure 2.1: A schematic representation of the theory of planned behaviour

Behavioural economics also looks at motivators for behaviour change. Challenging the rational economic theory premise, it provides alternative motivators to those based on the notion that consumers are rational and driven by self-interest and profit maximisation. This is important when looking at behaviour such as driving in a social context.

The New Economics Foundation (2005) identifies seven key principles for behavioural economics. These are:

- Other people's behaviour matters (we like to do and be like others).
- Habits are important.
- People are motivated to do the right thing.
- People's self expectations influence how they behave.
- People are loss-averse.
- People are bad at computation.
- People need to feel involved and effective to make a change.

These principles are useful in considering a behaviour change strategy, as they give direction to the shape and form of an education curriculum.

Implementation of behavioural economics has relevance when considering behaviour related to climate change. In the Sustainable Development Research Network (SDRN) briefing, Jackson (2005) makes a number of key points about how the behavioural economics principles affect behaviour change when considering climate change initiatives. Firstly, he argues that for individuals, habits on consumption are often 'locked in' behaviours that are influenced by cultural norms and what others do. In this setting, to change behaviours there needs to be an understanding of the role of social and moral norms, through what Jackson describes as discursive consciousness or logical goal-oriented action. This incorporates awareness at one level (e.g., I will behave in pro-social ways when I understand the consequences of my actions) and a social motivation (I will do this because that is what my social group believes and does). For the development of an education program, Jackson argues that a concerted approach is required that engages with people, makes behaviour change easy and incorporates incentives and rules that enable access to good choices. Modelling good behaviour is also essential. The relationships affecting consumption are demonstrated in Figure 2.2 below, adapted from Jackson (2005:6).

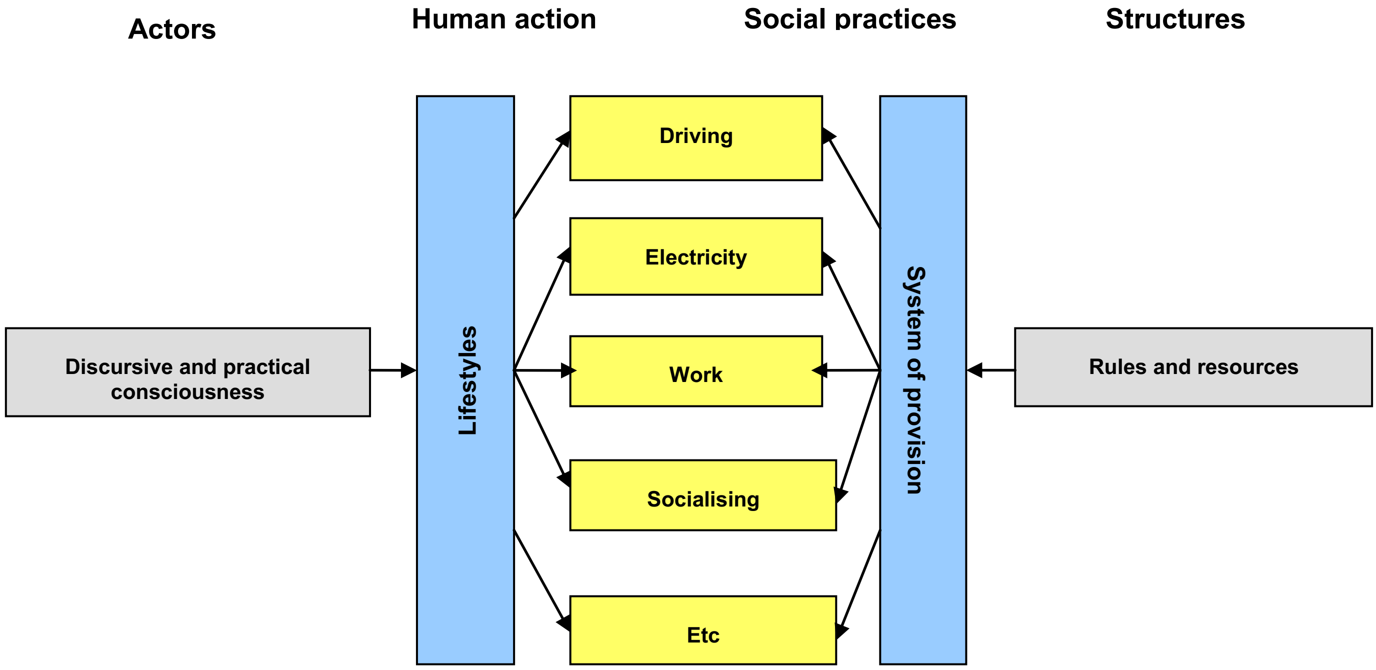

Figure 2.2: Consumption as a social practice

Another significant approach to behaviour change is the approach used in the TravelSmart and IndiMark programs in Australia and internationally. These programs are relevant to future work because they were applied in Queensland and relate to travel behaviour change.

TravelSmart and IndiMark focus on mode-shift from car to walking, cycling and public transport (Marinelli and Roth, 2002). They seek to shift people from 'expecting to change' to actually changing their behaviour through a dialogue with individuals in households. The programs promote the notion that small actions have a cumulative effect and can work to reduce the negative consequences of motoring.

The programs use varying levels of intensity based upon the needs of the household, with the most intensive intervention reserved for those who require the greatest support to achieve the behavioural changes. Varying the level of intensity according to need, helps ensure the program is cost-effective.

The outcomes of the TravelSmart and IndiMark programs are very positive. The pilot program in Queensland produced a 13% reduction in car driver trips and has been rolled out into a number of suburbs in Brisbane and the Sunshine Coast (Department of Environment and Heritage, 2006). Overall, the combined modal share of walking, cycling and public transport increased from 17 % to 24 %, and that of car and other motorised private modes decreased from 83% to 76 % (Socialdata, 2006:6). This is a successful travel behaviour change intervention in the same community in which the eco-driving study has been conducted.

2.8 Conclusions

The literature review suggests that eco-driving training is a potentially cost-effective intervention to reduce motorists' fuel costs and vehicle emissions while improving safety. There has been a lack of robust research applicable to the Australian context to establish the potential extent of those benefits. This study seeks to address the gaps in the current research, although the safety benefits are outside the scope of this study.

The RACQ study assessed eco-drive training in a randomised, controlled environment. This is important, as there is a need for an unambiguous study that provides evidence of the efficacy of eco-driving programs in Australia.

This study design incorporates an experimental model using a randomised sample to address the lack of data. This is particularly relevant in the Australian context, where most eco-driving programs have been conducted among heavy vehicle fleets. There are a number of models of education strategies available that have demonstrated effects in similar contexts. These have influenced the design of the RACQ study.

A set of questions arising from this literature review were developed for the study:

1. Which training intervention is the most effective at reducing fuel use across the whole sample?
2. Which training intervention is the most effective at reducing fuel use, differentiated by age?
3. Which training intervention is the most cost-effective (intervention delivery costs divided by fuel use costs/carbon costs) across the whole sample?
4. Which training intervention is the most cost-effective, differentiated by age?
5. Which training intervention is the most effective at changing attitudes across the whole sample?
6. Which training intervention is the most effective at changing attitudes, differentiated by age?
7. Which participant attributes (location, age, gender, vehicle attributes) impact on the overall and relative effectiveness of the training interventions?

2.9 Summary

Eco-driving encompasses driver behaviours, vehicle maintenance and non-driving actions to reduce fuel consumption. Eco-driving is defined as a way of driving that reduces fuel consumption, greenhouse gas emissions and crash rates. Eco-driving is distinct from hypermiling, as it does not trade off safety for efficiency.

The benefits of eco-driving accrue to individuals through fuel and car maintenance cost savings, and to the community through reduced greenhouse and other emissions. Cost savings and emission reductions are used in this study to measure the benefits of eco-driving to the individual and to the community.

Eco-driving as a concept and program is well developed in Europe as a strategy to reduce greenhouse gas emissions. The programs comprise media campaigns, inclusion in basic driver licence training, short and long-term training modules and inclusion in bus and truck fleet management. In Australia, eco-driving programs are limited to heavy vehicle and fleet settings. In these settings some significant benefits have been reported, though there is a lack of controlled research.

There is a place for the use of in-car technology to provide instantaneous feedback for drivers and much work has been done to understand the safety benefits and issues of in-car telemetry and driver distraction. Many of the eco-driving strategies overlap with safe driving strategies. While more work is required to research the direct link between eco-driving and safety, there are reasons to promote improved safety as a possible incentive to eco-drive.

This study has focused on encouraging participants to monitor fuel consumption and to use their own in-car telematics to provide consumption information. In discussing this issue with participants, educators emphasised the need to focus on safety first.

Another key area of the literature relates to behaviour change, particularly the attitudinal preconditions motivating individuals to drive in certain ways and the importance of educational strategies that tap into those motivators. Two key behaviour change theories have been used in the development of the EcoDrive study training: the theory of planned behaviour and behavioural economics.

Both of these theories seek to understand the link between behaviour and attitudes. This link is important when looking at behaviour such as driving in a social context. This has been shown to be useful in considering individuals’ attitudes to sustainability and consumption.

Finally, the TravelSmart and IndiMark programs have had considerable success in changing travel behaviour in the Queensland context and have been used in developing the educational programs for the study.

3 Research methods

This chapter presents the research design and methods applied in the EcoDrive study. The study sought to answer the following questions about the participants and the training interventions:

1. Which training intervention is the most effective at reducing fuel use across the whole sample?
2. Which training intervention is the most effective at reducing fuel use, differentiated by age?
3. Which training intervention is the most cost-effective (intervention delivery costs divided by fuel use costs/carbon costs) across the whole sample?
4. Which training intervention is the most cost-effective, differentiated by age?
5. Which training intervention is the most effective at changing attitudes across the whole sample?
6. Which training intervention is the most effective at changing attitudes differentiated by age?
7. Which participant attributes (location, age, gender, vehicle attributes) impact on the overall and relative effectiveness of the training interventions?

Section 3.1 presents the research methods applied to evaluate the effectiveness of the training interventions. The interventions are described in section 3.2. Section 3.3 describes the participant recruitment process and participant retention rates.

3.1 The research methods applied in the RACQ EcoDrive research study

In order to have a clear and unambiguous understanding of the role of each training intervention in the behaviour change, an experimental research design was used. The design entailed:

- Selecting or assigning participants to groups.
- Selecting or assigning groups for specific treatments or conditions of the experiment (experimental manipulation).
- Specifying the order or arrangement of the treatment or treatments.
- Selecting a parallel control group to isolate external impacts affecting fuel consumption.
- Specifying the measurements to be taken.

This project employed a simple experimental design to assess the effectiveness of the eco-driving training interventions. The amount of fuel used (in litres per 100 kilometres, l/100km) was measured for 1,300 volunteer drivers. The drivers were then trained in eco-driving techniques and the pre-training and post-training fuel use was then compared. To account for seasonal variations the fuel use of the trained drivers was compared with that of a group of non-trained drivers (the control group). Where drivers' fuel use dropped, it was assumed that the eco-driving was successful. When there was no change in fuel use, it was assumed the training was not successful.

3.2 Driver training interventions

An agreed curriculum was developed following a substantial review of eco-driving messages provided by Australian motoring clubs and local and international websites. This curriculum was then prioritised according to the most effective strategies in reducing fuel consumption. A copy of the curriculum is provided at appendix A.1.

The training in eco-driving was delivered using four methods, bundled into five training interventions. The delivery methods were as follows:

- **On-line learning** – Participants received a brochure on eco-driving and were invited to undertake an on-line learning module of up to one hour in duration. All non-control group participants received access to the online tool. A copy of the online tool frames is provided in appendix A.2.
- **Classroom** – Participants in interventions 2 and 4 were invited to attend a two-hour classroom session in groups of up to 15. The classroom was conducted by one or two of the EcoDrive project team. A summary of the classroom PowerPoint presentation is provided in appendix A.3.
- **Driving lesson** – Participants in interventions 3 and 4 undertook a 50-minute lesson with an accredited and trained private driving instructor. All lessons were conducted in the driver's own vehicle from an agreed meeting point (such as a Department of Transport and Main Roads testing centre) or from the participant's home. Driving instructors were trained in the eco-driving strategies and encouraged to assess the needs of individual drivers and ascertain which strategies were the most likely to benefit the individual. Common strategies included gear-changing, coasting in gear and showing participants how to inflate their tyres with air.
- **Half-day workshop** – Participants in intervention 5 attended a half-day eco-driving course, including an in-car drive using advanced telemetry, to provide evidence of the fuel reduction benefits and improved comfort from eco-driving. This course involved a pre- classroom drive on a set route in a vehicle fitted with advanced telemetry, classroom training and a post-classroom drive in the same vehicle and on the same route. The drive was conducted over 30 minutes with three drivers each following a set route. While it may have involved coaching in techniques where appropriate, it was not a driving lesson. The telemetry was used to measure fuel use (instantaneous, average and overall), duration of journey, average speed, maximum speed, vehicle movement (i.e., acceleration, steering, braking) and GPS location. It also provided a comprehensive report for comparison of driving technique and fuel consumption for each participant in their pre and post-classroom drives. An example report is presented in appendix A.4.

The five interventions were:

Intervention 1: On-line tool.

Intervention 2: On-line tool plus classroom.

Intervention 3: On-line tool plus driving lesson.

Intervention 4: On-line tool plus classroom plus driving lesson.

Intervention 5: On-line tool plus half-day workshop.

3.3 Data collection, and participant recruitment and retention

The methods used to collect fuel use data were linked to the recruitment of participants. The data collection methods were updated and refined to maximise participation.

3.3.1 Data collection

The study used three methods for collecting fuel use data. The largest group used a fuel card provided by RACQ. The second group of fuel card users formed the control group and consisted of Queensland drivers who salary-packaged their vehicle costs (i.e., privately funded their ongoing fuel and maintenance costs) through a large salary sacrifice provider. These drivers were not aware that they were in the study and were an ideal control group. The third group of drivers were actively recruited by RACQ and manually recorded their fuel use. These participants recorded their fuel purchases and odometer readings on paper forms and posted them to RACQ. This group included a control group of drivers that were untrained and were able to be compared separately with the fuel card users in the study.

In all groups, drivers were selected to match the profile of the Queensland licence-holding population to monitor broad environmental effects on fuel demand.

3.3.2 Participant incentive

Two incentives were offered to participants to support their involvement in the study. The first was three $1,000 prizes, drawn from participants who met all of the project requirements (i.e., fuel monitoring and training). Prize winners were drawn randomly from all the participants who fulfilled the criteria. This was designed to maximise the quality of data available for analysis without otherwise impacting driver behaviour.

While prizes were the main incentive to participate, a second incentive was a 4 cents per litre (4cpl) discount on all fuel purchased during the test period. The 4cpl discount was offered in lieu of the ‘shopper docket’ discount, which could not be used with the fuel cards to discourage participants from purchasing fuel without the fuel card. The 4cpl discount remained consistent despite fluctuations in the ‘shopper docket’ discounts.

3.3.3 Recruitment detail

Participants for this study were largely, although not exclusively, recruited from the RACQ membership. RACQ membership was not a requirement for participation.

The first recruitment task was an invitation email to complete the online survey sent to RACQ members with postcodes in the study areas. This was limited to members for whom RACQ held a valid email address, as the study required a high degree of on-going communication via electronic media (e.g., the on-line learning). These members were also asked to forward the invitation email to friends and family who they thought might be interested in participating.

The purpose of the research was masked in the survey and in other recruitment and participation activities prior to training so that individuals were blind to the study focus. The survey and study were referred to as the ‘Driving Costs, Attitudes and Behaviours Study’ and the questions in the survey were broad, including many questions about safety and fuel purchasing.

The on-line survey was used to assess participant suitability and to collect data on attitudes to various transport related questions. Suitability questions assessed whether the respondent was:

- The main driver of their vehicle, assessed by percentage of driving;
- At least 18 years old;
- Agreeable to using a fuel-card for all their fuel purchases;
- Agreeable to undertaking some driver training; and
- Not intending to sell or modify their vehicle.

In addition, there was a criterion ensuring that their vehicle was privately owned, and not owned by a business.

The survey was also used to collect attitude data on various transportation issues, as well as demographic data, data on the participants’ transport use patterns and their contact details.

There were 3,221 complete, qualifying responses to the on-line survey. Complete responses were those in which all questions had been completed and agreement with the terms and conditions signed.

As acceptance rates of the fuel card were lower than expected, a number of strategies were employed iteratively to improve take-up. These included:

- Softening the minimum requirement of 80% driving by the main driver to 60% .
- Changing fuel card conditions to add credit card to the initial direct debit payment arrangements, with RACQ paying the additional transaction fees.
- Invitation emails sent out to students at James Cook University in Townsville and University of Southern Queensland in Toowoomba to increase the number of young participants, especially in those areas.
- Phone calls to young people who did not respond to the initial survey, inviting them again to complete the survey.
- Introduction of a manual monitoring group, as a large number of survey respondents expressed an interest in being involved but were unwilling to use a fuel card.

3.3.4 Sampling methods

This section is focused on how the control group was used as a comparison for the active group. A control group was required in the study because fuel use is subject to variation through the year. The two main factors that influence seasonal changes in fuel use are air-conditioning use and school holidays. Anecdotally, air-conditioning use increases in the summer months. Increased air-conditioning use and increased loads on the air-conditioning unit due to higher temperatures cause an increase in fuel use. Conversely, school holidays are related to a drop in fuel use. This is believed to be due to reduced congestion, as fewer trips are made during the peak periods because children are not being driven to school.

To enable a comparison of the fuel use pre and post-training, both the active and the control groups required a period of time to be allocated as pre-training and a second to be allocated as post-training. For the active group there were clear dates when training started and ended. However, the control group received no training and subsequently there was no easily defined pre and post-training periods. Therefore, nominal pre and post-training dates were set for the control group.

The first task was to allocate participants to the various training interventions. This was completed so that the demographic profile of each intervention matched the profile of the Queensland licence-holding population. The required number of participants split by demographics was calculated first. The distribution of the available pool of participants was adjusted so that it best matched the Queensland licence-holding population. This resulted in a list of demographic groups, each with a quota of participants required to maintain the desired demographic profile. Participants were then randomly allocated to interventions.

3.3.5 Training dates and the pre and post-training fuel monitoring periods for the active participants

The training dates for the active group depended on the number of times participants refuelled their vehicles and the scheduling of the training. The first training offered to all participants was the on-line training package. An email requesting participants to access the on-line tool was sent to all of the active participants. These were predominantly sent in four main batches, with a small number of supplementary emails sent towards the end of the training period.

For those participants required to complete multiple training in interventions 2, 3, 4 and 5, email and phone invitations were sent prior to scheduling of the training. Contact was typically made two weeks prior to the training to allow scheduling and allocation of participants to the available training dates.

For each trained participant, the dates they were invited to training or actually received training were recorded. These dates were used to define the pre and post-training fuel-monitoring periods. For those participants in intervention 1 – on-line learning only – this was the date they completed the quiz section of the on-line learning. For the other interventions the last training date was the day they completed their last training.

The pre-training period was the six-week period immediately prior to the sending of the email invitation to complete the on-line training. The post-training fuel-monitoring period was the twelve-week period immediately after they completed their last training.

The training dates for participants in Toowoomba and Townsville were constrained by the need for Brisbane-based trainers to travel to these cities.

3.3.6 Training dates and the pre and post-training fuel-monitoring periods for the control group

To enable comparison of the fuel use of the active group with that of the control group, pre and post-training dates needed to be assigned to the control group. These dates were nominal, as the control group did not receive any training. These nominal training dates were chosen to match the dates of the active group.

For the control group the nominal first training date was matched to the four dates when emails were sent to the active group inviting them to complete the on-line tool. Control participants were allocated dates, maintaining a demographic profile consistent with the profile of the whole sample. Control group participants were allocated first training dates maintaining a similar proportion of participants (compared with the active group) to each date.

The last training date was similarly matched. As there was a high degree of variability in the last training dates, these were allocated weekly. The numbers of active participants finishing each week was calculated. A similar proportion of the control group was allocated to each week. The last training date, allocated to the control group, was assumed to be the Wednesday of each week.

3.3.7 Fuel use data quality measures

The fuel use records received from the different sources varied substantially in quality, with many proving unusable. To be suitable, each participant's fuel use record needed to contain at least three fuel purchases (refuelling) in the six weeks immediately prior to training and three fuel purchases in the twelve weeks immediately after the end of training. Fuel use data was required for both periods for a participant's data to be useful.

The following criteria were used to assess the quality of each record:

1. There must be at least three fills in both the pre-training and the post-training periods. At least three purchases were required for an accurate measure of fuel use.
2. Odometer readings needed to be consistently present and logically valid, i.e., the odometer reading increased with time and increased by an amount consistent with the average fuel use.
3. The first and last odometer reading must be present and logical for the pre- and post-training periods.

Missing odometer readings were common throughout the active and control fuel card group's data. Missing readings caused problems only if they fell on the first or last reading in the pre or post-training periods. When calculating the fuel use, only the first and last readings were required. These were used to calculate the total distance travelled in the period in question. Fuel consumption was then calculated using the sum of all fuel purchased and the total distance travelled.

3.3.8 Evaluation data sources

The following data was collected and used to assess the effectiveness of the training interventions. Table 3.1 displays a summary of the evaluation data and the source of this data.

Table 3.1: Evaluation data and data sources

Data	Source
Pre and post-training fuel use data	RACQ-issued fuel cards Manual monitoring forms Queensland salary sacrifice control group fuel cards
Standard fuel use	Australian Government's Green Vehicle Guide website
Participant demographics	Recruitment survey
Participants' vehicle attributes	Recruitment survey
Participant attitudes	Recruitment and exit surveys

3.3.9 Study areas

The study areas were chosen to represent drivers from the inner and outer metropolitan areas in southeast Queensland as well as from Queensland's regional cities, as follows:

- Brisbane (inner metropolitan): Postcodes 4000 to 4018, 4030 to 4034, 4037 to 4113, 4115, 4116, 4120 to 4122, 4151 to 4157, 4169 to 4179.
- Moreton Bay Region (outer metropolitan): Postcodes 4019 to 4025, 4035 and 4036, 4500 to 4514, 4516, 4520 and 4521.
- Logan City (outer metropolitan): Postcodes 4114, 4117 to 4119, 4123 to 4133.
- Townsville (regional): Postcodes 4810 to 4819.
- Toowoomba (regional): Postcode 4350.

In 2008, Toowoomba City Council was combined with other councils in the eastern Darling Downs to form Toowoomba Regional Council. The 2008 pre-amalgamation boundaries were used in this study.

In a few cases, individual postcodes straddled the boundary of two local government areas. In these cases, the whole postcode was assigned to the local government area that accounted for the largest proportion of its geographic area. These assessments were only required on the boundaries of Brisbane City and Moreton Bay Region, and Brisbane City and Logan City.

Participants were recruited primarily through the RACQ membership base, with their residential postcodes, collected with other demographic data, used to assign them to the study areas.

For the purposes of the study, participants from Brisbane represented inner metropolitan drivers, with Logan City and Moreton Bay Region participants representing outer metropolitan drivers. Townsville and Toowoomba participants represented regional drivers.

3.3.10 Statistical analyses

Statistical analyses were used to complete two tasks in this study. Firstly, descriptive statistics were used to describe the composition of the study sample. They were also used to assess whether any apparent change in fuel use could be attributed to the training interventions.

Two statistical tests were used to identify differences in the sample as these measured the two different types of data. Firstly, categorical data was used to split the sample into categories, such as gender, and present a count of the number of participants in each category. Numeric data was used for standard fuel use for each type of vehicle.

In using statistics to describe the sample, inherent differences in the sample were identified. These differences were analysed to ascertain whether they would impact negatively on the study and to identify differences between the participants assigned to each training intervention. For example, males tend to drive larger engine vehicles than females. While engine size could possibly have an effect on the ability to reduce fuel use, this would have a negative impact on the study only if one intervention had more large-engine vehicles than the others did. In the sample method, each intervention was assigned a similar proportion of males and females (as well as older and young participants and automatic and manual transmission vehicles). It was assumed that random chance would provide an appropriate distribution of large and small engine vehicles, and similar appropriate distributions for other vehicle attributes. These assumptions are tested by statistical analyses in chapter 4.

For categorical data, differences were identified using cross-tabulations and Chi-square tests. The cross-tabulations calculated the expected number of participants and compared this to the actual count of participants. The Chi-square tests assessed whether differences in the number of participants between categories were significantly different. The result of the test is a p-value between 0 and 1. A p-value of 0.05 or less indicates statistical significance in the difference in number of participants between the two groups being compared. In reporting the results of the chi-square tests, the standard format is used. For example, there were no significant differences in the demographic profile defined by age and gender between the three data study areas, X^2 (2, N = 1,056) = 0.410, p = 0.815. In this example the Chi-square (X^2) value = 0.410, the degrees of freedom = 2, the number of cases = 1,056, and the p-value = 0.815.

For numerical data, differences were identified using analysis of variance (ANOVA). ANOVA is a collection of tests that identify differences between two or more groups or between cohorts within the sample of participants. Differences found in the ANOVA are subsequently tested using the *post hoc* comparisons of means to identify differences between specific cohorts. For each comparison, a value of 0 to 1 is returned, with a value of 0.05 or less indicating that there are statistically significant differences between the two samples. For example, the ANOVA of GVG fuel use between participants differentiated by intervention, suggests no statistically significant difference, F (5, 1,050) = 1.211, p = 0.302. In this example the degrees of freedom within groups is 5 and between groups is 1,050. The ANOVA F-value test result is 1.211 and the p-value is 0.302. The p-value is greater than 0.05 suggesting that there is no statistically significant difference between the groups.

In a similar fashion, ANOVA was used to assess change in fuel use. The change in fuel use between the pre and post-training period was calculated for each participant. This change was calculated as the absolute reduction measured in litres per 100km (l/100km) and the percentage reduction – the absolute change as a percentage of the pre-training fuel use.

The two measures of fuel use change were used as the key measures for the effectiveness of the training packages. Initially ANOVA was used to assess the statistical significance of the change in fuel use between the group that received the eco-drive training (the active group) and those who did not (the control group). The analysis resulted in a mean change in fuel use for each group and a measure of statistical significance of this change. The significance test returns a value between zero and one, with a value of less than 0.05 indicating that there are statistically significant differences between the two groups. Statistical significance indicates that the apparent differences not are caused by random variations in the sample, but are caused by some other influence. In the case of the study, that difference is the result of the training.

A large number of ANOVA are reported in the study. Firstly, differences in the fuel use between the training interventions were analysed. Further tests investigated the potential for differences to be due to participants' demographic attributes (age, gender or residential location) or the type of vehicle they drove (transmission, engine size/ displacement, engine size/number of cylinders or fuel-type).

3.3.11 Cost-effectiveness analysis

The final analysis tool was the cost-effectiveness analysis. This assessed the effectiveness of the intervention relative to its costs. The effectiveness was measured by the reduction in volume of fuel used post-training compared with pre-training. It used the average change in fuel use in the post-training period compared with the pre-training period. An estimate of annual cost savings was calculated using the average reduction in fuel use, and assuming 14,400 km which was the average motor vehicle kilometres travelled in Queensland in 2010 (ABS, 2011a) and the average cost of fuel. The average cost of unleaded petrol, in metropolitan Brisbane for the 2011/2012 financial year ($1.45 per litre) was used.

This was a financial analysis, using the implementation costs and fuel savings only. It was not an economic analysis, so did not consider issues such as transfer payments or externalities such as GHG permit savings.

The analysis is repeated, assessing the cumulative costs and benefits for up to three years post-training.

3.4 Summary

This study tested eco-driving training interventions in a real world situation with private motorists. All participants were responsible for all vehicle ownership and running costs. The whole sample was substantial in size and demographically representative of the Queensland driving population.

The study was an experimental design blind study, controlled for environmental factors and it used a statistically robust analysis.

The study was designed to assess which training was the most effective training intervention to reduce fuel use and CO_2 emissions. The study also assessed which intervention was the most cost-effective for reducing fuel use. The relative effectiveness of the interventions between different cohorts in the sample was also assessed.

4 Statistical description of the research sample

This chapter describes the attributes of the research sample – the drivers who volunteered to monitor their fuel use and undertake the driver training, as well as the customers of the salary sacrificing company who provided the main control group. The chapter discusses the number of participants and their retention rates through the recruitment, monitoring and training phases of the study. The descriptive statistics of the demographic profile of the participants and the attributes of the vehicles they drive are also provided. The chapter concludes with a discussion of the significant differences in the sample and the implications of these for the analysis of the eco-driving training interventions.

This chapter comprises five sections. Section 4.1 presents the participation and retention rates, section 4.2 describes the statistical tests applied to identify the differences within the sample, and section 4.3 presents the detailed descriptive statistics of the sample. Section 4.4 presents a discussion of the significant differences in the sample. A summary of the chapter is provided in section 4.5.

4.1 Participant numbers and participation rates

Table 4.1 presents the number of emails sent to RACQ members, inviting them to participate in the EcoDrive study. These represented all the RACQ members who resided in the study areas and for whom RACQ held an active email address on its member database.

Table 4.1: Numbers of RACQ members invited to participate in the EcoDrive study

Region	Number of Invitations
Brisbane	122,873
Moreton and Logan	47,536
Toowoomba and Townsville	24,253
Total	194,662

Table 4.2 presents the retention numbers throughout the recruitment, fuel monitoring and analysis phases of the study.

Table 4.2: Numbers of participants at each stage of the research process

Recruitment phase	Date	Recruitment task	Number of participants or potential participants
Initial invitation to participate	**12 April 2011**	Initial invitation email set to all RACQ members in the study area	194,662
Recruitment survey	**6 May 2011**	Potential participants access the initial survey	6,705
	6 May 2011	Potential participants complete the survey and agree to the terms and conditions of the study	3,221
Fuel card applications and Processing	**6 May 2011**	Potential participants invited to apply for the fuel card	3,221
	1 July 2011	Total number of active participants at the start of the study	1,247
	1 July 2011	Number of control group participants	300

	1 July 2011	Total Number of participants at the start of the study	1,547
Fuel use monitoring	**1 July 2011**	Total number of active participants at the start of the study who agreed to participate and continued to provide fuel use data.	1,126
	1 July 2011	Number of control group participants	300
	1 July 2011	Total number of participants at the end of the study. Those who provided fuel use data.	1,426
Post monitoring	**29 February 2012**	Number of active participants completing all the requirements of the study	895
	29 February 2012	Number of control group participants completing the requirements of the study	281
	29 February 2012	Total number of participants completing the requirements of the study	1,176
Data analysis	**29 February 2012**	Number of active participants with useful fuel use records	853
	29 February 2012	Number of control group participants with useful fuel use records	203
	29 February 2012	Total number of participants with useful fuel use records	1,056

As can be seen in table 4.2, 1,126 participants agreed to undertake fuel monitoring and training. With the additional 300 control group participants, this took the number of active participants to 1,426.

Table 4.3 profiles the participant retention by fuel monitoring type. The first column of data displays the total number of participants at the start of the study. The next column displays the number of participants who provided some fuel use data. Then the retention rate between these first two steps is presented. In the last two columns on the right, the number of participants completing all the requirements of the study, including the exit survey, and the percentage with useful fuel use records rate is presented.

Table 4.3: Numbers of participants and retention rates during the training and fuel monitoring stage of the study

	Participant numbers at the start of the study	Participant numbers completing all study requirements (training and fuel monitoring)	Retention rate	Participant numbers providing useful fuel logs	Percentage with useful fuel use records
Fuel card holders	930	805	86.6%	794	98.6%
Manual monitors	196	90	45.9%	59	65.5%
Active Total	1,126	895	79.5%	853	95.3%
Control group	300	281	93.6%	203	72.2%
Grand total	1,426	1,176	82.5%	1,056	82.7%

The retention rate for the fuel card holders at 86.6% was the highest. This was expected as this group had already undertaken an extensive recruitment process, including applying for the fuel card.

The retention rate of the manual monitors was low at 45.9%. This could be due to the low level of commitment required to join this group.

The retention rate in the control group was less than 100.0% because some of the participants would have ended their salary sacrifice arrangements. There was no data available to investigate why these participants ended their salary sacrifice arrangements. The reasons are not critical to this study as the drivers were unaware that their fuel use data was included in this study.

4.1.1 Percentage of useful records

Useful records were determined using the data quality measures described in section 3.3.6.

At 98.6% the percentage of useful records in the fuel card group was high. This is likely to reflect the high level of commitment among this group, as discussed above.

The percentage of useful records in the manual monitoring group was low, reflecting the low level of commitment in this group.

The percentage of useful records in the fuel card control group was low. This was due to data quality issues. Many participants in this group appeared to fabricate their odometer readings, or provide a very rough estimate of the odometer reading. This group had an elevated number of low-mileage drivers, with the number of fills in the pre and post-training periods often less than three.

In all groups, many participants only partially filled their fuel tanks. It was not possible to calculate fuel use on partial fills. Many of these records were disregarded. It was possible to use records with some partial fills if they were interspersed with complete fills and these complete fills were close to the start and finish dates of the pre and post-training periods.

Many participants had an accurate measure of fuel use for the post-training period only. Only participants with fuel use for both periods were included in the study.

At the end of the study, there were 1,056 participants who had completed all the training requirements of the study and provided enough fuel use and distance travelled data to calculate sufficiently accurate fuel use data.

4.2 Descriptive statistics of the active and control samples

This section presents the descriptive statistics. These statistics describe the attributes of the participants and the vehicles they drive and identify any differences in the sample when differentiated by participant and vehicle demographics.

4.2.1 Participant demographics

This section presents a description of the demographic profile of the participants differentiated by various attributes. Cross-tabulations and Chi-square tests were used to identify statistically significant differences between specific cohorts within the research sample. These tests are summarised and discussed in this section with further detailed statistics presented in appendix B.1.

Table 4.4 presents the demographic profile of all the people who agreed to participate in the study (the people represented in the active and the control groups) and compares these to the Queensland licence-holding population.

Table 4.4: Demographic profile of Queensland licence-holding population and the research sample differentiated by fuel use monitoring methods

	Qld licence-holding population	Fuel card holders	Manual monitors	Salary sacrifice control group	Participant total
Male	51.9%	52.7% (424)	51.1% (46)	56.2% (158)	53.4% (628)
Young (18-26)	7.0%	6.2% (50)	7.8% (7)	8.9% (25)	7.0% (82)
Mid (27-59)	32.8%	28.1% (226)	37.8% (34)	34.9% (98)	30.4% (358)
Older (60+)	12.1%	18.4% (148)	5.6% (5)	12.5% (35)	16.0% (188)
Female	48.0%	47.3% (381)	48.9% (44)	43.8% (123)	46.6% (548)
Young (18-26)	6.5%	7.5% (60)	4.4% (4)	7.5% (21)	7.2% (85)
Mid (27-59)	31.5%	33.2% (267)	34.4% (31)	26.7% (75)	31.7% (373)
Older (60+)	10.0%	6.7% (54)	10.0% (9)	9.6% (27)	7.7% (90)
Total	100.0%	100.0% (805)	100.0% (90)	100.0% (281)	100.0% (1,176)

The Chi-square tests show there were no significant differences in the demographic profile defined by gender between the three data collection methods, X^2 (2, N = 1,176) = 1.797, p = 0.407. There were also no significant differences in the demographic profile defined by age group between the three data collection methods, X^2 (4, N = 1,176) = 6.436, p = 0.169.

Table 4.5 presents the demographic profile of the participants who completed all the requirements of the study in terms of fuel use recording and training, and had reliable fuel use records for the pre and post-training periods. This is the active sample reported throughout the study. This group excludes participants who did not have reliable fuel use records. These excluded persons would have completed the training and provided some fuel use records. However, if they did not drive often or only partially refilled their vehicle, it was not possible to calculate a reliable fuel use value.

Table 4.5: Demographic profile of Queensland licence-holding population and the final research sample differentiated by fuel use monitoring methods

	Qld licence-holding population	Fuel card holders	Manual monitors	Salary sacrifice control group	Participant total
Male	51.9%	52.5% (417)	54.2% (32)	56.2% (114)	53.3% (563)
Young (18-26)	7.0%	5.7% (45)	1.7% (1)	7.9% (16)	5.9% (62)
Mid (27-59)	32.8%	28.6% (227)	33.9% (20)	34.0% (69)	29.9% (316)
Older (60+)	12.1%	18.3% (145)	18.6% (11)	14.3% (29)	17.5% (185)
Female	48.0%	47.5% (377)	45.8% (27)	43.8% (89)	46.7% (493)
Young (18-26)	6.5%	8.2% (65)	5.1% (3)	6.4% (13)	7.7% (81)
Mid (27-59)	31.5%	33.0% (262)	33.9% (20)	29.6% (60)	32.4% (342)
Older (60+)	10.0%	6.3% (50)	6.8% (4)	7.9% (16)	6.6% (70)
Total	100.0%	100.0% (794)	100.0% (59)	100.0% (203)	100.0% (1,056)

The Chi-square tests show there were no significant differences in the demographic profile of the final sample of participants, defined by gender between the three data collection methods, X^2 (2, N = 1,056) = 0.881, p = 0.644. There were, also, no significant differences in the demographic profile defined by age group between the three data collection methods, X^2 (4, N = 1,056) = 2.959, p = 0.565.

The licence-holding population does not necessarily reflect the population of active drivers in Queensland, as persons may hold a licence but rarely drive. This became evident in the sampling task as some cohorts were under-represented in the recruited sample. For example, there is an under-representation of older females, as this group tends to drive less, even if they retain their driver's licences.

The general inclination to participate in research projects affected the age and gender profile of the sample. This was evidenced by an under-representation of young males. This cohort is difficult to recruit and retain in research projects.

Table 4.6 presents the demographic profile of the participant numbers by location.

Table 4.6: Participant numbers differentiated by location

	Brisbane	Townsville & Toowoomba	Moreton & Logan	Total
Male	53.3% (353)	51.1% (70)	54.5% (140)	53.3% (563)
Young (18-26)	5.7% (38)	5.8% (8)	6.2% (16)	5.9% (62)
Mid (27-59)	31.4% (208)	28.5% (39)	26.8% (69)	29.9% (316)
Older (60+)	16.2% (107)	16.8% (23)	21.4% (55)	17.5% (185)
Female	46.7% (309)	48.9% (67)	45.5% (117)	46.7% (493)
Young (18-26)	8.0% (53)	5.8% (8)	7.8% (20)	7.7% (81)
Mid (27-59)	32.6% (216)	33.6% (46)	31.1% (80)	32.4% (342)
Older (60+)	6% (40)	9.5% (13)	6.6% (17)	6.6% (70)
Total	100.0% (662)	100.0% (137)	100.0% (257)	100.0% (1,056)

The Chi-square tests showed there were no significant differences in the demographic profile defined by gender between the three study areas, X^2 (2, N = 1,056) = 0.410, p = 0.815, or by age group, X^2 (4, N = 1,056) = 4.394, p = 0.355.

Table 4.7 presents the profile of the participant numbers by training intervention.

Table 4.7: Participant numbers differentiated by training intervention

	Intervention 1: On-line learning	Intervention 2: Classroom	Intervention 3: Driving lesson	Intervention 4: Classroom and driving lesson	Intervention 5: Half-day workshop	Control	Total
Male	51.1% (94)	51.3% (101)	55.9% (114)	53.7% (108)	47.8% (32)	56.2% (114)	53.3% (563)
Young (18-26)	3.8% (7)	5.6% (11)	5.4% (11)	6.0% (12)	7.5% (5)	7.9% (16)	5.9% (62)
Mid (27-59)	29.3% (54)	29.4% (58)	29.4% (60)	27.9% (56)	28.4% (19)	34% (69)	29.9% (316)
Older (60+)	17.9% (33)	16.2% (32)	21.1% (43)	19.9% (40)	11.9% (8)	14.3% (29)	17.5% (185)

Female	48.9% (90)	48.7% (96)	44.1% (90)	46.3% (93)	52.2% (35)	43.8% (89)	46.7% (493)
Young (18-26)	8.7% (16)	9.1% (18)	6.9% (14)	6.5% (13)	10.4% (7)	6.4% (13)	7.7% (81)
Mid (27-59)	35.3% (65)	33% (65)	30.4% (62)	33.3% (67)	34.3% (23)	29.6% (60)	32.4% (342)
Older (60+)	4.9% (9)	6.6% (13)	6.9% (14)	6.5% (13)	7.5% (5)	7.9% (16)	6.6% (70)
Total	100.0% (184)	100.0% (197)	100.0% (204)	100.0% (201)	100.0% (67)	100.0% (203)	100.0% (1,056)

There were no statistically significant differences between the interventions based on gender, X^2 (5, N = 1,056) = 2.742, p = 0.740, or age group, X^2 (10, N = 1,056) = 5.122, p = 0.883.

Table 4.8 presents the participant numbers differentiated by intervention and study area.

Table 4.8: Participant numbers differentiated by location and training intervention

	Brisbane	Townsville & Toowoomba	Moreton & Logan	Total
Intervention 1: On-line learning	16.8% (111)	17.5% (24)	19.1% (49)	17.4% (184)
Intervention 2: Classroom	18.9% (125)	16.8% (23)	19.1% (49)	18.7% (197)
Intervention 3: Driving lesson	18.7% (124)	21.9% (30)	19.5% (50)	19.3% (204)
Intervention 4: Classroom and driving lesson	18.1% (120)	25.5% (35)	17.9% (46)	19.0% (201)
Intervention 5: Half-day workshop	8.8% (58)		3.5% (9)	6.3% (67)
Control group	18.7% (124)	18.2% (25)	21% (54)	19.2% (203)
	100.0% (662)	100.0% (137)	100.0% (257)	100.0% (1,056)

There were statistically significant differences between the interventions based on study area, X^2 (10, N = 1,056) = 23.60, p = 0.009. This is further investigated below.

The expected number of intervention 5 participants in Townsville/Toowoomba and Logan/Moreton was higher than the actual number of participants. This contributed to significant differences between the study areas. This was due to Intervention 5 being offered only to participants in the south of Brisbane and Logan. Intervention 5 was delivered at the RACQ driver training facility at Eight Mile Plains in southern Brisbane. This package required specialist equipment to be installed into the training vehicles and could not be offered at any other locations. This is considered unlikely to have affected the study outcomes, as there were no other significant differences between the study areas.

4.2.2 Vehicle demographics

This section describes the vehicles that the participants drove. Cross-tabulations and Chi-square tests were used to identify statistically significant differences between specific cohorts within the research sample. These tests are summarised and discussed in this section with further detailed statistics presented in appendix B.2.

Table 4.9 presents vehicle numbers differentiated by transmission type.

Table 4.9: Vehicle numbers differentiated by training intervention and transmission type

	Automatic	Manual	Not known	Total
Intervention 1: On-line learning	59.2% (109)	40.8% (75)		100.0% (184)
Intervention 2: Classroom	56.9% (112)	43.1% (85)		100.0% (197)
Intervention 3: Driving lesson	62.3% (127)	37.7% (77)		100.0% (204)
Intervention 4: Classroom and driving lesson	59.2% (119)	40.8% (82)		100.0% (201)
Intervention 5: Half-day workshop	59.7% (40)	40.3% (27)		100.0% (67)
Total: Active only	59.4% (507)	40.6% (346)		100.0% (853)
Control group			100.0% (203)	100.0% (203)
Total	48.0% (507)	32.8% (346)	19.2% (203)	100.0% (1,056)

There were no statistically significant differences between the interventions based on vehicle transmission, X^2 (4, N = 1,056) = 1.227, p = 0.874.

Table 4.10 presents the participant numbers differentiated by transmission and study area.

Table 4.10: Vehicle numbers differentiated by study area and transmission type

	Automatic	Manual	Not known	Total
Brisbane	48.3% (320)	32.9% (218)	18.7% (124)	100.0% (662)
Townsville & Toowoomba	46.0% (63)	35.8% (49)	18.2% (25)	100.0% (137)
Logan & Moreton	48.2% (124)	30.7% (79)	21.0% (54)	100.0% (257)
Total	48.0% (507)	32.8% (346)	19.2% (203)	100.0% (1,056)

There were no statistically significant differences between the study areas based on vehicle transmission, X^2 (2, N = 853) = 0.701, p = 0.704.

Table 4.11 presents the participant numbers differentiated by gender and transmission type.

Table 4.11: Vehicle numbers differentiated by gender and transmission type

	Automatic	Manual	Not known	Total
Male	51.5% (290)	28.2% (159)	20.2% (114)	100.0% (563)
Female	44.0% (217)	37.9% (187)	18.1% (89)	100.0% (493)
Total	48.0% (507)	32.8% (346)	19.2% (203)	100.0% (1,056)

There were significant differences in the transmission type driven by males and females, X^2 (1, N = 853) = 10.432, p = 0.001. Males were more likely to drive automatic transmission vehicles and females more likely to drive manual transmission vehicles. These differences will be discussed in section 4.2.5.

Table 4.12 presents the participant numbers differentiated by transmission and age group.

Table 4.12: Vehicle numbers differentiated by age group and transmission type

	Automatic	Manual	Not known	Total
Young (18-26)	33.6% (48)	46.2% (66)	20.3% (29)	100.0% (143)
Mid (27-59)	45.1% (297)	35.3% (232)	19.6% (129)	100.0% (658)
Older (60+)	63.5% (162)	18.8% (48)	17.6% (45)	100.0% (255)
Total	48.0% (507)	32.8% (346)	19.2% (203)	100.0% (1,056)

There were significant differences in the transmission type driven by age group, X^2 (2, N = 853) = 43.890, $p < 0.001$. Investigation of the expected numbers showed that older drivers were more likely to drive automatic transmission vehicles and younger ones more likely to drive manual transmission vehicles. These differences will be discussed in section 4.2.5.

Table 4.13 presents the participant numbers differentiated by intervention and engine size (cylinders).

Table 4.13: Vehicle numbers differentiated by training intervention and engine size (cylinders)

	2-4 Cylinders	5-8 Cylinders	Not known	Total
Intervention 1: On-line Learning	71.7% (132)	28.3% (50)		100.0% (184)
Intervention 2: Classroom	75.6% (149)	24.4% (47)		100.0% (197)
Intervention 3: Driving lesson	77.0% (157)	23.0% (36)		100.0% (204)
Intervention 4: Classroom and driving lesson	72.6% (146)	27.4% (50)		100.0% (201)
Intervention 5: Half-day workshop	86.6% (58)	13.4% (9)		100.0% (67)
Total: Active only	75.3% (642)	24.7% (211)		100.0% (853)
Control group			100.0% (203)	100.0% (203)
Total	60.8% (642)	20.0% (211)	19.2% (203)	100.0% (1,056)

There were no significant differences between the interventions by engines size measured in number of cylinders, X^2 (4, N = 853) = 6.901, p = 0.141.

Table 4.14 presents the vehicle numbers differentiated by study area and engine size (cylinders).

Table 4.14: Vehicle numbers differentiated by study area and engine size (cylinders)

	2-4 Cylinders	5-8 Cylinders	Not known	Total
Brisbane	61.9% (410)	19.3% (117)	18.7% (124)	100.0% (662)
Townsville & Toowoomba	59.1% (81)	22.6% (26)	18.2% (25)	100.0% (137)
Logan & Moreton	58.8% (151)	20.2% (49)	21.0% (54)	100.0% (257)
Total	60.8% (642)	20.0% (192)	19.2% (203)	100.0% (1,056)

There were no significant differences between the study areas by engine size measured in number of cylinders, X^2 (2, N = 853) = 0.863, p = 0.650.

Table 4.15 presents the vehicle numbers differentiated by gender and engine size (cylinders).

Table 4.15: Vehicle numbers differentiated by gender and engine size (cylinders)

	2-4 Cylinders	5-8 Cylinders	Not known	Total
Male	52.9% (298)	26.8% (136)	20.2% (114)	100.0% (563)
Female	69.8% (344)	12.2% (56)	18.1% (89)	100.0% (493)
Total	60.8% (642)	20.0% (192)	19.2% (203)	100.0% (1,056)

There were significant differences in the engine size (cylinders) of vehicles driven by males and females, X^2 (1, N = 853) = 40.281, $p < 0.001$. Males were more likely to drive larger vehicles and females more likely to drive smaller vehicles. These differences will be discussed in section 4.2.5.

Table 4.16 presents the participant numbers differentiated by age group and engine size (cylinders).

Table 4.16: Vehicle numbers differentiated by age group and engine size (cylinders)

	2-4 cylinders	5-8 cylinders	Not known	Total
Young (18-26)	66.4% (95)	13.3% (19)	20.3% (29)	100.0% (143)
Mid (27-59)	62.3% (410)	18.1% (108)	19.6% (129)	100.0% (658)
Older (60+)	53.7% (137)	28.6% (65)	17.6% (45)	100.0% (255)
Total	60.8% (642)	20.0% (192)	19.2% (203)	100.0% (1,056)

There were significant differences in the engine size (cylinders) and age group, X^2 (2, N = 853) = 16.752, $p < 0.001$. Investigation of the expected numbers showed the older drivers were more likely to drive larger-engine vehicles. These differences will be discussed in section 4.2.5.

Table 4.17 presents the participant numbers differentiated by training intervention and engine size (displacement).

Table 4.17: Vehicle numbers differentiated by training intervention and engine size (displacement)

	Less than 1.9 litres	2.0 to 2.9 litres	3.0 litres or greater	Unsure / don't know	Not known	Total
Intervention 1: On-line Learning	21.2% (39)	25.5% (47)	20.7% (38)	32.6% (60)		100.0% (184)
Intervention 2: Classroom	26.4% (52)	32.5% (64)	18.8% (37)	22.3% (44)		100.0% (197)
Intervention 3: Driving lesson	27% (55)	33.8% (69)	24.0% (49)	15.2% (31)		100.0% (204)
Intervention 4: Classroom and driving lesson	22.4% (45)	27.9% (56)	26.4% (53)	23.4% (47)		100.0% (201)
Intervention 5: Half-day workshop	22.4% (15)	35.8% (24)	14.9% (10)	26.9% (18)		100.0% (67)
Total: Active only	24.2% (206)	30.5% (134)	21.9% (187)	23.4% (200)		100.0% (853)
Control group					100.0% (203)	100.0% (203)
Total	19.5% (206)	24.6% (134)	17.7% (187)	18.9% (200)	19.2% (203)	100.0% (1,056)

There were significant differences between the training interventions in engine size (displacement), X^2 (12, N = 853) = 23.335, p = 0.025. Further investigation of expected numbers showed that participants in training intervention 4 tended to drive more large-engine vehicles than the other interventions. These differences will be discussed in section 4.2.5.

Table 4.18 presents the participant numbers differentiated by study area and engine size (displacement).

Table 4.18: Vehicle numbers differentiated by study area and engine size (displacement)

	Less than 1.9 litres	2.0 to 2.9 litres	3.0 litres or greater	Unsure / don't know	Not known	Total
Brisbane	20.2% (134)	25.7% (170)	16.6% (110)	18.7% (124)	18.7% (124)	100.0% (662)
Townsville & Toowoomba	16.8% (23)	19.7% (27)	23.4% (32)	21.9% (30)	18.2% (25)	100.0% (137)
Logan & Moreton	19.1% (49)	24.5% (63)	17.5% (45)	17.9% (46)	21.0% (54)	100.0% (257)
Total	19.5% (206)	24.6% (260)	17.7% (187)	18.9% (200)	19.2% (203)	100.0% (1,056)

There were no significant differences between the study areas in engine size (displacement), X^2 (8, N = 853) = 5.668, p = 0.684.

Table 4.19 presents the participant numbers differentiated by gender and engine size (displacement).

Table 4.19: Vehicle numbers differentiated by gender and engine size (displacement)

	Less than 1.9 litres	2.0 to 2.9 litres	3.0 litres or greater	Unsure / don't know	Not known	Total
Male	16.5% (93)	28.1% (158)	27.7% (156)	7.5% (42)	20.2% (114)	100.0% (563)
Female	22.9% (113)	20.7% (102)	6.3% (31)	32.0% (158)	18.1% (89)	100.0% (493)
Total	19.5% (206)	24.6% (260)	17.7% (187)	18.9% (200)	19.2% (203)	100.0% (1,056)

There were significant differences in the engine size (displacement) of vehicles driven by males and females, X^2 (4, N = 935) = 185.246, p < 0.001. Investigation of the expected numbers showed that males were more likely to drive larger vehicles and females more likely to drive smaller vehicles. These differences will be discussed in section 4.2.5.

Table 4.20 presents the participant numbers differentiated by age group and engine size (displacement).

Table 4.20: Vehicle numbers differentiated by age group and engine size (displacement)

	Less than 1.9 litres	2.0 to 2.9 litres	3.0 litres or greater	Unsure / don't know	Not known	Total
Young (18-26)	29.4% (42)	20.3% (29)	9.1% (13)	21% (30)	20.3% (29)	100.0% (143)

Mid (27-59)	18.5% (122)	25.7% (169)	15.0% (99)	21.1% (139)	19.6% (129)	100.0% (658)
Older (60+)	16.5% (42)	24.3% (62)	29.4% (75)	12.2% (31)	17.6% (45)	100.0% (255)
Total	19.5% (206)	24.6% (260)	17.7% (187)	18.9% (200)	19.2% (203)	100.0% (1,056)

There were significant differences in the engine size (displacement) and age group, X^2 (6, N = 853) = 46.168, $p < 0.001$. Investigation of the expected numbers showed that older and mid age groups of drivers were more likely to drive larger engine vehicles. These differences will be discussed in section 4.2.5.

Table 4.21 presents the participant numbers differentiated by training intervention and fuel type.

There was insufficient data from the control group to complete the cross tabulation and Chi-square analysis on fuel type. The control group data did not differentiate between the petrol grades: regular unleaded petrol, premium unleaded petrol and ethanol-blended unleaded petrol (E10). In the active group, fuel-type data was available from the survey and from the fuel purchase records. In order to complete the cross tabulations and Chi-square analyses, categories were collapsed into a single ULP category used across the whole sample.

Table 4.21: Vehicle numbers differentiated by intervention and fuel type

	Unleaded (Grade not known)	E10 unleaded	Regular unleaded	Premium unleaded	Diesel	LPG	Grand total
Intervention 1: On-line learning		15.2% (28)	47.8% (88)	21.7% (40)	15.2% (28)		100.0% (184)
Intervention 2: Classroom		18.3% (36)	45.2% (89)	21.8% (43)	12.7% (25)	2.0% (4)	100.0% (197)
Intervention 3: Driving lesson		15.7% (32)	38.2% (78)	25.5% (52)	19.1% (39)	1.5% (3)	100.0% (204)
Intervention 4: Classroom and driving lesson		21.4% (43)	38.3% (77)	23.9% (48)	14.9% (30)	1.5% (3)	100.0% (201)
Intervention 5: Half-day workshop		20.9% (14)	46.3% (31)	20.9% (14)	10.4% (7)	1.5% (1)	100.0% (67)
Total: Active only		17.9% (153)	42.6% (363)	23.1% (197)	15.1% (129)	1.3% (11)	100.0% (853)
Control group	83.3% (169)				16.7% (34)		100.0% (203)
Total	16.0% (169)	14.4% (152)	34.4% (363)	18.7% (197)	15.4% (163)	1.0% (11)	100.0% (1,056)

There were no significant differences between interventions differentiated by fuel type, X^2 (10, N = 1,056) = 11.551, $p = 0.316$.

Table 4.22 presents the participant numbers differentiated by study area and fuel type.

Table 4.22: Vehicle numbers differentiated by study area and fuel type

	Unleaded (Grade not known)	E10 unleaded	Regular unleaded	Premium unleaded	Diesel	LPG	Grand total
Brisbane	15.6% (103)	14.7% (97)	35.5% (235)	19.5% (129)	14.2% (94)	0.6% (4)	100.0% (662)
Townsville & Toowoomba	15.3% (21)	9.5% (13)	35% (48)	20.4% (28)	19.0% (26)	0.7% (1)	100.0% (137)
Logan & Moreton	17.5% (45)	16.7% (43)	31.1% (80)	15.6% (40)	16.7% (43)	2.3% (6)	100.0% (257)
Total	16.0% (169)	14.4% (152)	34.4% (363)	18.7% (197)	15.4% (163)	1.0% (11)	100.0% (1,056)

There were no significant differences between study areas differentiated by fuel type, X^2 (4, N = 1,056) = 8.117, p = 0.087.

Table 4.23 presents the participant numbers differentiated by gender and fuel type.

Table 4.23: Vehicle numbers differentiated by gender and fuel type

	Unleaded (Grade not known)	E10 unleaded	Regular unleaded	Premium unleaded	Diesel	LPG	Grand Total
Male	16.0% (90)	11.9% (67)	29.7% (167)	19.5% (110)	21.3% (120)	1.6% (9)	100.0% (563)
Female	16.0% (79)	17.4% (86)	39.8% (196)	17.6% (87)	8.7% (43)	0.4% (2)	100.0% (493)
Total	16.0% (169)	14.4% (152)	34.4% (363)	18.7% (197)	15.4% (163)	1.0% (11)	100.0% (1,056)

There were significant differences in the fuel type used between genders, X^2 (2, N = 1,056) = 36.572, p < 0.001. Investigation of the expected numbers showed that male drivers were more likely to drive diesel vehicles. These differences will be discussed in section 4.2.5.

Table 4.24 presents the participant numbers differentiated by age group and fuel type.

Table 4.24: Vehicle numbers differentiated by age group and fuel type

	Unleaded (grade not known)	E10 unleaded	Regular unleaded	Premium unleaded	Diesel	LPG	Grand Total
Young (18-26)	18.9% (27)	16.8% (24)	37.8% (54)	17.5% (25)	8.4% (12)	0.7% (1)	100.0% (143)
Mid (27-59)	15.3% (101)	15.5% (102)	35.1% (231)	18.8% (124)	14.9% (98)	0.3% (2)	100.0% (658)
Older (60+)	16.1% (41)	10.6% (27)	30.6% (78)	18.8% (48)	20.8% (53)	3.1% (8)	100.0% (255)
Total	16.0% (169)	14.5% (153)	34.4% (363)	18.7% (197)	15.4% (163)	1.0% (11)	100.0% (1,056)

There were significant differences between the age groups in fuel type, X^2 (4, N = 1,056) = 26.552, p < 0.001. Investigation of the expected numbers showed that older age groups of drivers were more likely to drive diesel vehicles. There were too few cases of LPG vehicles to draw any conclusions, with the young and mid age groups having two or fewer participants.

These differences will be discussed in section 4.2.5 below. A further analysis into vehicle size and fuel type can be found in appendix B.2.

4.2.3 Green Vehicle Guide

This section presents the standard fuel use for the vehicles as stated in the Green Vehicle Guide (GVG). The GVG is a database of fuel use for all vehicles that have commonly been available in Australia since 2003. A second database exists for vehicles manufactured between 1986 and 2003. The 1986 to 2003 database covers a smaller proportion of the vehicles available in this period.

The fuel use figures are measured under laboratory conditions using a chassis dynamometer, in accordance with the Australian design rules. The vehicle is required to undertake a series of accelerations, gear changes and breaking patterns designed to emulate a typical urban and extra-urban drive. An exhaust gas sampling system is attached to the vehicle exhaust and is used to measure the CO_2 and other pollutants.

As the GVG data is continuous numerical data rather than categorical data, as displayed so far in this chapter, similarities and correlations in this type of data were identified using ANOVA rather than the cross-tabulations and Chi-square tests used for the categorical data.

The following tables display data descriptive statistics of the combined cycle GVG data differentiated by intervention. Further statistical analyses are presented in appendix B.3. All reported fuel use is provided in litres per 100km (l/100km) unless otherwise stated.

Table 4.25 presents the average combined cycle GVG fuel use value differentiated by training intervention.

Table 4.25: Combined cycle GVG fuel use split by intervention

	Number of cases	Mean fuel use l/100km	Standard deviation
Control	203	8.555	1.722
Intervention 1: On-Line learning	184	8.251	1.856
Intervention 2: Classroom	197	8.397	2.084
Intervention 3: Driving lesson	204	8.583	2.287
Intervention 4: Classroom and driving lesson	201	8.375	1.988
Intervention 5: Half-day workshop	67	8.060	1.482
Total	1,056	8.412	1.972

The ANOVA of GVG fuel use between participants, differentiated by intervention, suggests no statistically significant difference, $F(5, 1{,}050) = 1.211$, $p = 0.302$.

Table 4.26 presents the average combined cycle GVG fuel use value differentiated by gender.

Table 4.26: Combined cycle GVG fuel use split by gender

	Number	Mean	Standard deviation
Male	563	8.889	2.072
Female	493	7.868	1.696
Total	1,056	8.412	1.972

The ANOVA shows statistically significant differences in the GVG fuel use differentiated by gender, F (1, 1054) = 75.546, p < 0.001. These differences are discussed in section 4.2.5 below.

Table 4.27 presents the average combined cycle GVG fuel use value differentiated by age group.

Table 4.27: Combined cycle GVG fuel use split by age group

	Number	Mean	Standard deviation
Young (18-26)	143	7.727	1.694
Mid (27-59)	658	8.363	1.877
Older (60+)	255	8.921	2.215
Total	1,056	8.412	1.972

The ANOVA shows statistically significant differences in the GVG fuel use differentiated by age group, F (2, 1053) = 17.876, p < 0.001. The post hoc tests revealed statistically significant differences between all the age groups. These differences are discussed in section 4.2.5 below.

Table 4.28 presents the average combined cycle GVG fuel use value differentiated by study area.

Table 4.28: Combined cycle GVG fuel use split by study area

	Number	Mean	Standard Deviation
Brisbane	662	8.308	1.899
Logan & Moreton	257	8.498	2.131
Townsville & Toowoomba	137	8.755	1.976
Total	1,056	8.412	1.972

The ANOVA shows statistically significant differences in the GVG fuel use differentiated by study area, F (2, 1053) = 3.243, p = 0.039. The post hoc tests revealed that the differences are limited to Brisbane compared with the Toowoomba & Townsville areas. These differences are discussed in section 4.2.5 below.

4.2.4 Vehicle age

The next test compared the vehicle age, defined as the year of manufacture. Table 4.29 presents the average vehicle age differentiated by training intervention.

Table 4.29: Vehicle age split by intervention

	Number	Mean vehicle year	Standard deviation
Control	202	2009.20	1.382
Intervention 1: On-line learning	184	2003.97	4.953
Intervention 2: Classroom	197	2004.28	4.900
Intervention 3: Driving lesson	204	2004.77	4.725
Intervention 4: Classroom and driving lesson	201	2004.21	4.888
Intervention 5: Half-day workshop	67	2004.19	5.335
Total	1,055	2005.24	4.845

The ANOVA shows statistically significant differences in vehicle age differentiated by intervention, F (5, 1,049) = 794.911, p < 0.001. The post hoc tests revealed that there were significant differences between the control group and the active group, but no difference between the active groups. The vehicles in the control group were newer than the active group. These differences are discussed in section 4.2.5 below.

Table 4.30 presents the vehicle age differentiated by gender.

Table 4.30: Vehicle age split by gender

	Number	Mean vehicle year	Standard deviation
Male	562	2004.97	5.220
Female	493	2005.55	4.364
Total	1,055	2005.24	4.845

There is no significant difference in vehicle age between participants differentiated by gender, F (1, 1,053) = 87.864, p = 0.053. However, a significance value of 0.053 is close to the threshold of 0.05. This suggests that females may drive slightly newer cars than males. However, there is only a six-month difference in the mean vehicle age differentiated by gender.

Table 4.31 presents the vehicle age differentiated by age group.

Table 4.31: Vehicle age split by age group

	Number	Mean vehicle year	Standard deviation
Young (18-26)	142	2004.36	5.472
Mid (27-59)	658	2005.42	4.707
Older (60+)	255	2005.28	4.792
Total	1,055	2005.24	4.845

There is no significant difference in vehicle age between participants differentiated by age group, F (2, 1,052) = 2.817, p = 0.060.

Table 4.32 presents the vehicle age differentiated by study area.

Table 4.32: Vehicle age split by study area

	Number	Mean vehicle year	Standard deviation
Brisbane	661	2005.16	4.912
Logan & Moreton	257	2005.42	4.950
Townsville & Toowoomba	137	2005.32	4.318
Total	1,055	2005.24	4.845

There is no significant difference in vehicle age between participants differentiated by age group, F (2, 1,052) = 0.289, p = 0.749.

4.2.5 Significant differences in the participant sample

There were significant differences between the types of vehicles driven by males and females. Males were more likely than females to:

- Drive large engine vehicles, both in terms of displacement and number of cylinders;
- Drive cars with a higher GVG fuel use rating;

- Drive vehicles with automatic transmission;
- Drive diesel-powered cars; and
- Consume more fuel per distance travelled.

There were significant differences between the types of vehicles driven by the different age groups. The combined cycle GVG standard fuel use increases with age group. The oldest cohort drove vehicles with the highest GVG fuel use and the youngest drove vehicles with the lowest GVG fuel use.

The majority of diesel vehicles in the study were also large engine vehicles, typically four-wheel-drive vehicles. There were relatively few small-engine diesel vehicles in the study.

In analysing the vehicle attributes, some differences were identified. Older and mid-aged drivers were more likely than younger drivers to:

- Drive large engine vehicles, both in terms of displacement and number of cylinders;
- Drive cars with a higher GVG fuel use rating;
- Drive vehicles with automatic transmission;
- Drive diesel-powered cars; and
- Consume more fuel per distance travelled.

There are many possible explanations for these differences, which reflect the needs of the different groups to fulfil varying transport tasks. There may also be different cultural aspects that influence each cohort's vehicle choices. Vehicle age does not appear to be a factor in the different vehicle choices made by each cohort, as there is no significant difference in vehicle age between cohorts.

These differences in vehicle choice between cohorts defined by age and gender do not influence the outcomes of this study, because the training interventions were similar in composition. This is supported by the analysis of the demographic profile (age and gender) differentiated by training intervention. There were no significant differences in age and gender between training interventions.

The differences in the vehicles driven by the different cohorts are not reflected when the GVG fuel use measures are compared by study area or training intervention. There were no significant differences in GVG fuel use ratings between training interventions.

There was a tendency for drivers assigned to interventions 3 and 4 to have an over-representation of the larger vehicles – those with an engine displacement of greater than three litres. This was due to a sampling error. This sampling error arose from the random nature of the sampling process with regard to some vehicle demographics. When constructing the sample, participants were not assigned on engine size, only on gender, age, study area and transmission. It was assumed that participant numbers were sufficiently large that sampling on engine size was not required. This assumption has proved to be invalid.

However, there are relatively few of the very large engine vehicles (with a displacement of greater than four litres) in the whole study. These vehicles are too few in number to have a significant effect on the average GVG fuel use for each training intervention. As there was no difference in the GVG measures between training interventions, the tendency towards larger-engine vehicles in interventions 3 and 4 does not affect the results of the study.

There was no significant difference between Brisbane, and Logan/Moreton, or between Logan/Moreton and Townsville/Toowoomba. However, the GVG fuel use measure for vehicles in the Townsville/Toowoomba study area was significantly greater than for vehicles in the Brisbane study area at 8.73 l/100km and 8.29 l/100km respectively. This does not affect the study, as participants from Logan/Moreton were equally distributed between the training interventions.

There are significant differences between the control group and the active group, but no difference between the active groups. The control group drove newer vehicles than the trained group. This is likely to be because the control data was sourced from a salary sacrificing company. These salary-sacrificing arrangements include the novated lease of a new car.

These differences do not affect the outcomes of the study, as there was no difference in the GVG fuel use ratings between the active and the control groups.

4.2.6 Pre-Training fuel use

This section presents the pre-training fuel use. Differences in pre-training fuel use differentiated by intervention and participant demographics will be discussed.

Table 4.33 presents the average fuel use at the date of first training differentiated between the active and control groups.

Table 4.33: Pre-training fuel use split by active versus control groups

	Number	Pre-training Fuel use (l/100km)	Standard deviation
Control	203	9.622	2.138
Active	853	9.991	2.742
Total	1,056	9.920	2.640

There are no significant differences in the pre-training fuel use of the active and control groups, $F(4, 1{,}054) = 3.211$, $p = 0.073$.

Table 4.34 presents the pre-training fuel use differentiated between the interventions and control group.

Table 4.34: Pre-training fuel use split by intervention

	Number	Pre-training fuel use (l/100km)	Standard deviation
Control	203	9.622	2.138
Intervention 1: On-Line learning	184	9.848	2.517
Intervention 2: Classroom	197	10.018	2.648
Intervention 3: Driving lesson	204	10.093	3.145
Intervention 4: Classroom and driving lesson	201	10.034	2.735
Intervention 5: Half-day workshop	67	9.865	2.338
Total	1,056	9.920	2.640

There are no significant differences in the pre-training fuel use of the active and control groups differentiated by interventions $F(5, 1{,}050) = 0.855$, $p = 0.511$.

Table 4.35 presents pre-training fuel use differentiated by gender.

Table 4.35: Pre-training fuel use split by gender

	Number	Pre-training Fuel use (l/100km)	Standard deviation
Male	563	10.467	2.767
Female	493	9.295	2.336
Total	1,056	9.920	2.640

There are significant differences in pre-training fuel use differentiated by gender, F (1, 1,054) = 54.450, p < 0.001. Males used more fuel than females. This is discussed in Section 4.2.7.

Table 4.36 presents pre-training fuel use differentiated between age groups.

Table 4.36: Pre-training fuel use split by age group

	Number	Pre-training Fuel use (l/100km)	Standard deviation
Young (18-26)	143	9.108	2.232
Mid (27-59)	658	9.914	2.593
Older (60+)	255	10.391	2.858
Total	1,056	9.920	2.640

There were significant differences in pre-training fuel use differentiated by age group, F (2, 1,053) = 75.499, p < 0.001. Older drivers used more fuel than younger drivers. This is discussed in section 4.2.7 below.

Table 4.37 presents pre-training fuel use differentiated between study areas.

Table 4.37: Pre-training fuel use split by study area

	Number	Pre-training Fuel use (l/100km)	Standard deviation
Brisbane	662	9.966	2.596
Logan & Moreton	257	9.507	2.582
Townsville & Toowoomba	137	10.473	2.847
Total	1,056	9.920	2.640

There were significant differences in pre-training fuel use differentiated by study area, F (2, 1,053) = 45.532, p = 0.002. The *post hoc* test showed that drivers in Logan/Moreton tended to use less fuel than those in Toowoomba/Townsville. This is discussed in section 4.2.7 below.

4.2.7 Significant differences in the pre-training fuel use

The differences in average pre-training fuel use between the interventions are not significant because the standard deviation is large compared with the absolute differences. There is a maximum difference of 0.4l/100kms between the groups and the standard deviation within the groups is between 2.1 and 3.1l/100km.

There were significant differences in the pre-training fuel use differentiated by age group and gender, with males and drivers in the mid and older age groups tending to use more fuel. This is likely to be related to the larger vehicles that these cohorts tend to drive. This does not affect the study as these participants were equally distributed among the interventions.

There were significant differences in the pre-training fuel use between Logan/Moreton, and Townsville/Toowoomba. Drivers in Logan/Moreton tended to use less fuel than those in Toowoomba/Townsville.

This effect is similar to the differences in engine size differentiated by age and gender. While it is interesting, it does not affect the study as participants from Logan/Moreton were equally distributed between the training interventions.

The results of the ANOVA show that there were no statistically significant differences in pre-training fuel use between the active and control groups differentiated by intervention. Any apparent differences in fuel use between the interventions prior to training were due to random variation rather than inherent differences in the samples. The ANOVA test proves that there is a common baseline against which any change in fuel use due to the training or environmental factors can be assessed.

4.3 Allocation of training interventions and construction of the control group – training dates

This section focuses on how the control group was used as a comparison for the active group. To enable a comparison of the fuel use pre and post-training, both the active and the control groups required a period of time to be allocated as pre and post-training. For the active group there were clear dates when training started and ended. However, the control group received no training and subsequently there were no easily defined pre and post-training periods. A nominal pre and post-training date was developed for the control group.

The process of matching and allocating training dates to the control was outlined in section 3.3.5.

The following analysis compares the pre and post-training dates of the active participants differentiated by the training intervention to the nominal pre and post-training dates assigned to the control group.

Table 4.38 presents the average date of first training differentiated between the active and control groups.

Table 4.38: First training dates split by active versus control

	Number	First training date	Standard deviation (Days Hours:Minutes)
Control	203	15-SEP-11	23 07:37*
Active	853	12-SEP-11	22 10:34
Total	1,056	13-SEP-11	22 14:46

*The Standard Deviation is expressed in days, hours and minutes, e.g., the standard deviation for the date of first training for the control group is 23 07:37, this being 23 days, 7 hours and 37 minutes.

There were no statistically significant differences in the date of first training differentiated by active and control, $F (1, 1{,}054) = 0.201$, $p = 0.654$.

Table 4.39 presents the average date of last training differentiated between the active and control groups.

Table 4.39: Last training dates split by active versus control

	Number	Last training date	Standard deviation (Days Hours:Minutes)
Control	203	08-OCT-11	22 16:52
Active	853	12-OCT-11	26 19:00
Total	1,056	11-OCT-11	26 02:35

There were significant differences in the last training date, $F (1, 1{,}054) = 5.028$, $p = 0.025$. The active group was trained, on average, four days after the control group. These differences will be discussed in section 4.3.1 below.

Table 4.40 presents the average date of first training differentiated between the interventions and control group.

Table 4.40: First training dates split by intervention

	Number	First training date	Standard deviation (Days Hours:Minutes)
Control	203	15-SEP-11	23 07:37
Intervention 1: On-Line learning	184	11-SEP-11	18 20:13
Intervention 2: Classroom	197	15-SEP-11	23 23:25
Intervention 3: Driving lesson	204	16-SEP-11	24 18:07
Intervention 4: Classroom and driving lesson	201	12-SEP-11	21 20:46
Intervention 5: Half-day workshop	67	30-AUG-11	14 18:10
Total	1,056	13-SEP-11	22 14:46

There were significant differences in the first training date differentiated by intervention, $F(5, 1{,}050) = 7.133$, $p < 0.001$. The *post hoc* tests revealed that participants in intervention 5 were trained earlier than those in the other interventions and the control. These differences will be discussed in section 4.3.1 below.

Table 4.41 presents the average date of last training differentiated between the interventions and control groups.

Table 4.41: Last training dates split by intervention

	Number	Last training date	Standard deviation (Days Hours:Minutes)
Control	203	08-OCT-11	22 16:52
Intervention 1: On-line learning	184	17-SEP-11	18 22:24
Intervention 2: Classroom	197	10-OCT-11	25 10:41
Intervention 3: Driving lesson	204	30-OCT-11	17 13:49
Intervention 4: Classroom and driving lesson	201	28-OCT-11	16 13:07
Intervention 5: Half-day workshop	67	17-SEP-11	19 16:15
Total	1,056	11-OCT-11	26 02:35

There were significant differences in the last training date differentiated by intervention, $F(5, 1{,}050) = 133.483$, $p < 0.001$. Participants in interventions 1 and 5, finished training significantly earlier than those in the other interventions and the control group. These will be discussed in section 4.3.1 below.

Table 4.42 presents average date of first training differentiated by gender.

Table 4.42: First training dates split by gender

	Number	First training date	Standard deviation (Days Hours:Minutes)
Male	563	13-SEP-11	22 11:20
Female	493	14-SEP-11	22 19:07
Total	1,056	14-SEP-11	22 14:46

There were no statistically significant differences in the date of first training differentiated by gender, $F(1, 1{,}1161) = 0.115$, $p = 0.735$.

Table 4.43 presents average date of last training differentiated by gender.

Table 4.43: Last training dates split by gender

	Number	Last training date	Standard deviation (Days Hours:Minutes)
Male	563	11-OCT-11	26 03:23
Female	493	12-OCT-11	26 02:17
Total	1,056	11-OCT-11	26 02:35

There were no statistically significant differences in the date of last training differentiated by gender, F (1, 1,161) = 0.089, p = 0.765.

Table 4.44 presents average date of first training differentiated by age groups

Table 4.44: First training dates split by age group

	Number	First training date	Standard deviation (Days Hours:Minutes)
Young	143	12-SEP-11	21 09:43
Mid	658	12-SEP-11	22 16:00
Older	255	14-SEP-11	23 03:30
Total	1,056	13-SEP-11	22 14:46

There were no statistically significant differences in the date of first training differentiated by age group, F (2, 1,053) = 0.875, p = 0.417.

Table 4.45 presents average date of last training differentiated by age groups.

Table 4.45: Last training dates split by age group

	Number	Last training date	Standard deviation (Days Hours:Minutes)
Young	143	10-OCT-11	24 21:51
Mid	658	11-OCT-11	26 08:25
Older	255	14-OCT-11	26 00:17
Total	1,056	11-OCT-11	26 02:35

There were no statistically significant differences in the date of last training differentiated by age group, F (1, 1,053) = 2.151, p = 0.117.

Table 4.46 presents average date of first training differentiated by study area.

Table 4.46: First training dates split by study area

	Number	First training date	Standard deviation (Days Hours:Minutes)
Brisbane	662	13-SEP-11	22 18:45
Logan & Moreton	257	11-SEP-11	21 06:56
Townsville & Toowoomba	137	17-SEP-11	23 19:31
Total	1,056	13-SEP-11	22 14:46

There were statistically significant differences in the date of first training differentiated by study area, F (2, 1,053) = 3.337, p = 0.036. The *post hoc* tests revealed that there were significant differences in the first training dates between Logan/Moreton and Townsville/Toowoomba. These differences are discussed in section 4.3.1 below.

Table 4.47 presents average date of last training differentiated by study area.

Table 4.47: Last training dates split by study area

	Number	Last training date	Standard deviation (Days Hours:Minutes)
Brisbane	662	09-OCT-11	26 13:02
Logan & Moreton	257	13-OCT-11	25 22:24
Townsville & Toowoomba	137	17-OCT-11	23 04:19
Total	1,056	11-OCT-11	26 02:35

There were statistically significant differences in the date of last training differentiated by study area, $F(2, 1{,}053) = 6.046$, $p = 0.002$. The *post hoc* tests revealed that there were significant differences in the last training dates between Brisbane and Townsville/Toowoomba. These differences are discussed in section 4.3.1.

4.3.1 Significant differences in the training dates

There were significant differences in the first and last training dates when comparing the intervention groups.

Participants in intervention 5 were trained significantly earlier than the other interventions. This was due to resource availability issues. Intervention 5, delivered by RACQ's Driver Education Department, was the highest-intensity training package. The courses were arranged for August and September 2011, and there was no scope for rescheduling when the recruitment took longer than expected. All participants allocated to this group were trained in August and September.

For the last training date, interventions 1 and 5 finished significantly earlier than the other interventions. For the reasons stated above, intervention 5 started earlier and subsequently finished earlier. Intervention 1 was the lowest-intensity intervention, requiring the participants to complete the on-line learning only. On average, participants completed the on-line training within six days of receiving the email request to complete the training.

Differences in the first training dates were assumed not to affect the analysis of the fuel use, because there were no significant differences in the measured fuel use in the pre-training period between the interventions and the control group. The differences in start date did not have a significant impact on the pre-training fuel use. As the pre-training fuel use was not significantly different between the interventions and control group, it was assumed that all groups shared a common pre-training fuel use.

The post-training analyses of fuel use and the last training dates both showed statistically significant differences between the trained group (the interventions) and the control group. However, they did not show statistically significant differences between the interventions (excluding the control group). These differences are presented in chapter 5.

This raises the question of whether the differences in fuel use are an effect of the training or the differences in the dates when the fuel use was measured. In the design of the study, the last training dates assigned to the control were matched to the distribution of the last training dates in the active sample (the process of matching was described in section 3.3.4). However, despite extensive efforts to train all the participants in the shortest possible time period, there were significant differences in the last training date between the interventions. There was one exception: there was no significant difference in the last training dates of the control and intervention 2(the classroom sessions).

Considering the change in fuel use as the study progressed, the control group showed a steady increase in fuel use. This is consistent with expectations. The study started in late winter (in July 2011), when air-conditioning use is low, leading to slightly lower fuel use. The study ended in the summer, (January 2012), when air-conditioning use and, subsequently, fuel use is higher. The fuel use data from the control group increased as the study progressed, supporting this hypothesis. However, the fuel use of the active group decreased over the same period. Therefore, it is assumed that the change in fuel use was a result of the training rather than differences in training dates. The monthly fuel use of the control group and the active group is presented in appendix B.4.

Similar to the differences in the training dates between interventions, there were differences in first and last training dates differentiated by the study area. Participants in Brisbane started and finished training significantly earlier than those in Townsville/Toowoomba. This is likely to be due to the early training of participants in intervention 5, which was offered in Brisbane and Logan only. Another factor was the scheduling of training for interventions 2 and 4. These were scheduled later for Townsville/Toowoomba than the Brisbane and Logan/Moreton training. As the trainers were required to travel from Brisbane, all the training in Townsville/Toowoomba was scheduled around two or three trips to each city.

The same assumptions can be applied to the study areas as were applied to the interventions as participants from the different study areas were, as far as logistically possible, distributed among all the interventions. Change in fuel use between study areas was assumed to be an effect of the training rather the study area.

To complete the analysis of change in fuel use it was assumed that the differences in pre and post-training fuel use were an effect of the training interventions, rather than an effect of other factors.

4.4 Summary

There were no significant differences in the attributes of the different samples that affected the outcomes of the study.

There were significant differences between demographic cohorts, especially in terms of age and gender. Male drivers and mid-aged and older drivers tended to drive larger vehicles, more automatic transmission vehicles and more diesel vehicles. Male drivers and mid-aged and older drivers also tended to use more fuel per distance travelled than the other cohorts. However, these participants were equally distributed throughout the sample and between the training interventions, so this did not affect the outcome of the study.

There were no significant differences in pre-training fuel use between the participants allocated to each training intervention. It can be assumed that the differences in the pre and post-training fuel use are an effect of the training interventions, rather than other factors. It can also be assumed that the pre-training fuel use values represent a common baseline against which any relative change in fuel use can be compared.

5 Findings

This chapter describes the findings of the analyses. The chapter discusses the change in fuel use as a result of the eco-drive training.

This chapter comprises six sections. Section 5.1 discusses attitude changes as a result of the training. Section 5.2 presents the findings of the pre-training fuel use analyses. Section 5.3 presents the statistical tests applied to identify the differences within the sample, and section 5.4 presents the analyses differentiated by participant and vehicle demographics. Section 5.5 presents a discussion of the real changes in fuel use. A summary of the chapter is presented in section 5.6.

5.1 Attitude change – normative beliefs

There are two ways of measuring attitude change – one from the normative beliefs elicited using the pre and post-survey and another from the implicit attitude change demonstrated by changes in driving behaviour and fuel reductions. This section is focused on normative beliefs.

All of the participants in the recruitment and the exit survey were asked a series of attitude questions. The majority of these questions were designed to mask the main focus of the study. One question was used to assess whether participants believed they could affect change in their vehicles' CO_2 emissions and fuel use by changing their driving behaviour.

Participants were asked the degree to which they agreed with the statement: *"I can reduce my vehicle's emissions if I change my driving style."*

Figure 5.1 shows the distribution of responses from the recruitment and exit surveys. The frequency of responses from the recruitment survey is indicated by the blue bars and the exit survey by the red bars.

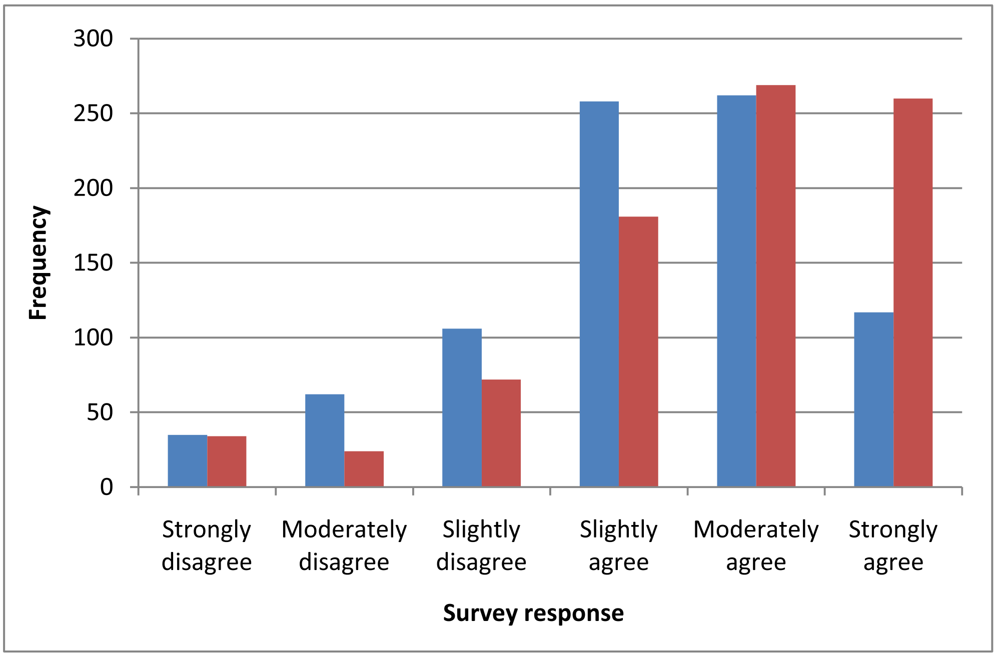

Figure 5.1: Distribution of responses to the *statement in the recruitment survey: I can reduce my vehicle's emissions if I change my driving style*

A paired t-test shows that there are significant differences between the responses in the recruitment survey and the exit survey, t (875) = 0.382, $p < 0.001$.

As can be observed in figure 5.1, there was a substantial increase in the number of participants who strongly agreed with the statement: *"I can reduce my vehicle's emissions if I change my driving style".* In addition, the overall number of "agree" responses increased from 75.8% in the recruitment survey to 84.5% in the exit survey. This increase was the result of a shift from the moderately and slightly disagree responses to the agree responses.

Considering all the agree responses, there was a strong shift from the slightly agree to the strongly agree response. The slightly agree response fell from 30.7% of all responses in the recruitment survey to 21.5% in the exit survey, while the strongly agree responses increased from 13.9% in the recruitment survey to 31% in the exit survey. The moderately agree response remained stable at 31% to 32%.

The frequency of the strongly disagree responses remained stable at 4%. This suggests that a small group of participants retained a firm belief they could not reduce their vehicle emissions.

The trend of increased participant belief in their ability to reduce vehicle emissions was common across all cohorts, with the exception of age group.

The belief that participants could reduce vehicle emissions by changing their driving style was common across all cohorts differentiated by:

- Participant Demographics
  - Gender
  - Study Area
- Vehicle Demographics
  - Transmission type
  - Engine size – numbers of cylinders
  - Engine size – engine displacement.

In terms of age group there was significant change in the responses of the mid and older age groups, those participants aged 27 and over. However, it was unclear whether the attitude of participants in the young age group changed. The potential change in the attitudes of the young age group failed the significance test, $t(108) = 0.186$, $p = 0.053$. The test result was close to the required significance level (of 0.05) and the number of responses in some categories was low. Therefore, it is possible that this result is spurious.

The change in participants' attitudes was common across all the interventions. An ANOVA shows there were no significant differences between the interventions in the recruitment survey. There were significant differences between the interventions in the exit survey. The analyses of the individuals are presented in appendix B.5.

5.2 Pre-training fuel use

While there were apparent differences in the average pre-training fuel use between the interventions, the standard deviation was large compared with the differences. There was a maximum difference of 0.4l/100kms between the groups and the standard deviation within the groups was between 2.1 and 3. l/100km. The results of the ANOVA showed that there were no statistically significant differences between the active and control groups and between the interventions.

The ANOVA tests show that any apparent differences in fuel use between the interventions prior to training are due to random variation rather than inherent differences in the samples. The ANOVA test proved that there was a common baseline against which to assess any change in fuel use due to training or environmental factors. It can be assumed that the differences in the pre and post-training fuel use were an effect of the training interventions, rather than environmental factors.

5.3 *Analysis of the change in fuel use*

This section presents the change in fuel use comparing the six weeks immediately before the first training and the twelve weeks immediately after completion of the last piece of training. The control group participants were assigned pre and post-training dates that matched the active group. The matching was completed using participant age, gender, study area and vehicle transmission type. The matching process was described in section 3.3.5. Consistency between interventions was established in the discussion of training dates presented in section 4.4.

Two measures were used for assessing the change in fuel use pre and post-training.

The first was the absolute reduction in fuel use. This was measured in litres per 100 km, and was the fuel use in the pre-training period less the fuel use in the post-training period. This measure was calculated for each participant. The change in fuel use for each group was measured as the average value of the change in fuel use for each participant.

The second measure used was the percentage change in fuel use.

Table 5.1 presents the mean absolute change in fuel use of the participants differentiated by active versus control groups. Table 5.2 presents the absolute reduction in fuel use differentiated by intervention.

Table 5.1: Absolute reduction in fuel use differentiated by active versus control

	Fuel use reduction (l/100km)	Number	Standard deviation
Control	-0.124	203	0.984
Active	0.386	853	1.311
Total	0.288	1,056	1.271

The ANOVA results show that the differences in change in fuel use between the active and control group are statistically significant, $F (1, 1{,}054) = 25.045$, $p < 0.001$.

Table 5.2: Absolute reduction in fuel use differentiated by intervention

	Fuel use reduction (l/100km)	Number	Standard deviation
Control	-0.124	203	0.984
Intervention 1	0.341	184	1.191
Intervention 2	0.340	197	1.240
Intervention 3	0.419	204	1.439
Intervention 4	0.285	201	1.288
Intervention 5	0.673	67	1.473
Total	0.288	1,056	1.271

The negative values in table 5.1 and 5.2 indicate the fuel use had increased in the control group.

The ANOVA results show that the differences in absolute change in fuel use between the interventions are statistically significant $F (5, 1{,}050) = 6.455$, $p < 0.001$. The *post hoc* test showed a significant difference between the control group and all the interventions, but no statistically significant differences between the individual interventions.

These analyses show that each intervention provided a reduction in fuel use not seen in the control. This reduction in fuel use was a result of the training interventions. Without the training, the data suggested that fuel use would have increased, as it did in the control group. Because the difference between the active group and control group was statistically significant, it suggested that the increase in fuel use in the control group was caused by environmental factors not random changes in the group.

Table 5.3 presents the mean change in fuel use (in percentage change before and after training) of the participants differentiated by active versus control groups. Table 5.4 presents mean change in fuel use (percentage change before and after training) differentiated by intervention. In tables 5.3 and 5.4, a negative number indicates an increase in fuel use.,

Table 5.3: Percentage change in fuel use differentiated by active versus control

	Percentage change in fuel use	Number of participants	Standard deviation
Control	-1.730	203	10.545
Active	2.899	853	12.165
Total	2.009	1,056	12.006

The ANOVA results show that the differences in change in fuel use between the active and control group are statistically significant, $F(1, 1{,}054) = 24.933.045$, $p < 0.001$.

Table 5.4: Percentage reduction in fuel use differentiated by intervention

	Percentage change in fuel use	Number of participants	Standard deviation
Control	-1.730	203	10.545
Intervention 1	2.788	184	11.155
Intervention 2	2.997	197	11.466
Intervention 3	2.598	204	12.985
Intervention 4	2.286	201	12.202
Intervention 5	5.675	67	13.996
Total	2.009	1,056	12.006

The ANOVA results show that the differences in change in fuel use between the interventions are statistically significant, $F(5, 1{,}050) = 5.861$, $p < 0.001$.

The *post hoc* tests of percentage change in fuel use differentiated by intervention, showed significant differences when comparing the active interventions with the control group. However, these tests showed no difference between the interventions. As with the *post hoc* tests of absolute change in fuel use differentiated by intervention, these analyses showed that each intervention provided a reduction in fuel use not seen in the control group. This reduction in fuel use was a result of the training interventions. Without the training, the data suggests that fuel use would have increased, as was seen in the control group.

The analysis of fuel use change showed that, as a result of the eco-driving training, the participants reduced their fuel use by an average of 2.9% (or 0.4 l/100km) with a standard deviation of 12.2% (or 1.3 l/100km). The mean plus or minus one standard deviation accounted for 68.2% of the sample. Of the remaining 31.8%, half (15.9%) achieved fuel use reductions of greater than 15.1% (or 1.7 l/100km).

The change in fuel use discussed in this section is the observed change in fuel use for each intervention and the control group. While the average fuel use for each intervention reduced, fuel use among the control increased. It is assumed that if the participants in the interventions had not received training, their fuel use would have also increased. This will be discussed in section 5.5. First the change in fuel use differentiated by participant and vehicle demographics will be discussed.

5.4 *Change in fuel use differentiated by participant and vehicle demographics*

To explore any differences based on the participant demographics or vehicle types, the change in fuel used was further differentiated by participant demographics (gender, age group and study area) and vehicle attributes (transmission type, engine size in cylinders and engine size in displacement).

An ANOVA was used to identify any possible relationships between these attributes and change in fuel use. It was also used to identify any cohorts that might be more likely to reduce their fuel use after the eco-driving training.

There were no significant differences in the change in fuel use seen in the trained group when differentiated by participant and vehicle demographics. This indicated that there were no groups that were more or less likely to reduce their fuel use. It can therefore be assumed that the positive response to the eco-driving training is independent of age, gender, location or vehicle type.

5.5 *Real change in fuel use due to the eco-driving training*

The analyses presented in this section look at the real change in fuel use. This is different from the previous two sections, where observed changes for each intervention and the control were presented separately.

The outcome of the training received by the participants was a drop in fuel use across the whole sample. Over the same time, the fuel used by the control group increased. Before the study, there were no statistically significant differences between the fuel use of the active and control samples. From this, it could be assumed that all participants have a common baseline of fuel use. It could also be assumed that, without the training, the fuel used by the active group would have increased by the same degree as the control group. Therefore, the real change in fuel use attributed to the training was the reduction seen in the active group plus the increase seen in the control group.

Table 5.5 presents the absolute reduction in fuel use in the active group plus the increase in fuel use of the control group.

Table 5.5: Average percentage and absolute reduction in fuel use as a result of the eco-driving training split by intervention

	Percentage reduction in fuel use (%)	Absolute reduction in fuel use (l/100km)
Intervention 1: On-line learning	4.52	0.47
Intervention 2: Classroom	4.73	0.46
Intervention 3: Driving lesson	4.33	0.54
Intervention 4: Classroom and driving lesson	4.02	0.41
Intervention 5: Half-day workshop	7.40	0.80
All interventions – the combined effect*	4.63	0.51

* Note: the combined effect is the average change of all the participants who completed training, not the average effect of the total change for each training intervention.

As can be seen in table 5.5, substantial reductions were achieved across the whole sample trained in eco-driving. The degree of fuel use reduction appeared to be similar for the first four training interventions, but there was a greater fuel use reduction for intervention 5 – the most intensive training intervention. However, the *post hoc* tests revealed no significant differences between the interventions; although it is possible that the sample size was too small to ascertain whether the difference in fuel use was significant.

In terms of the distribution of fuel use reduction, the participants in the top 15.9% (the mean fuel use reduction plus one standard deviation) achieved a fuel use reduction of more than 15.1% (or 1.7 l/100km).

5.6 Carbon dioxide reductions achieved by eco-driving training

This section discusses the reduction in CO_2 emissions achieved as a result of the ecodriving training. These calculations assume that each person drives 14,400 km per year (ABS 2011a), and a litre of fuel emits 2.3kg of CO_2 (http://www.environment.gov.au/settlements/transport /fuelguide/environment.html, retrieved 11 July 2012).

Table 5.6 presents the annual reduction in CO_2 emissions for each participant differentiated by intervention.

Table 5.6: Annual reduction in CO_2 per person split by intervention

	Annual reduction in CO_2 per capita (kg)
Intervention 1: On-line learning	155.6
Intervention 2: Classroom	152.4
Intervention 3: Driving lesson	178.8
Intervention 4: Classroom and driving lesson	135.8
Intervention 5: Half-day workshop	265.0
All Interventions – the combined effect*	169.0

As can be seen in table 5.6, substantial CO_2 reductions can be achieved across the whole sample after training in eco-driving. On average, individuals would reduce their CO_2 emissions by 169 kg per year. Some individuals could achieve substantially higher reductions.

In 2011 there were 3,100,000 passenger and light commercial vehicles registered in Queensland (ABS 2011b). Widespread eco-driving training could reduce Queensland's annual emissions of CO_2 by 523,627 tonnes. Queensland's total transport related CO_2 emissions, in 2009, were 20 million tonnes of CO_2 (Queensland Government, 2011). Widespread application of eco-driving training could reduce this by 2.6%.

5.7 Cost-effectiveness analysis

The final analysis undertaken in this study was the cost-effectiveness of each training intervention. This compared the cost of delivering the intervention with the savings from reduced fuel use over the first three years. This comparison was calculated as benefit/cost ratio, with the benefit in fuel savings divided by the delivery cost. This ratio was calculated separately over the first three years. Each year the cumulative benefit of fuel savings was compared with the on-going costs of training delivery, reminders and program updates. This calculation assumed that the reduction in fuel use would be maintained over the course of the study. Further investigations are required to test this assumption.

This was a financial analysis, using the implementation costs and fuel savings only. It was not an economic analysis, so did not consider issues such as transfer payments or externalities such as GHG permit savings.

The costs were based upon a commercial service delivery model that could be provided by the RACQ and/or local, appropriately qualified organisations, such as driving schools or training organisations.

A program management cost was included for each participant. It was assumed that program management would be centralised. The administration costs included a component for booking individuals into training.

It was assumed that promotion was a separate program cost, which would be based upon the objectives of a training program.

Delivery cost assumptions per participant per package (in dollars) are provided in table 5.7.

Table 5.7: Delivery cost per participant

	Intervention 1: On-line learning ($)	Intervention 2: Classroom ($)	Intervention 3: Driving lesson ($)	Intervention 4: Classroom and driving lesson ($)	Intervention 5: Half-day workshop ($)
Delivery	10	70	65	135	200
Admin – year 1	10	10	10	10	10
Year 1 Total	20	80	75	145	210
Admin – year 2	10	20	20	20	20
Year 1 and 2 Total	30	100	95	165	230
Admin – year 3	10	20	20	20	20
Year 1, 2 and 3 Total	40	120	105	185	250

Benefits from a successful eco-driving program accrue to the individual and to the environment. Benefits are measured in cost savings to the consumer on the basis of litres of fuel saved per year.

The fuel use reductions observed in the active sample were used to calculate the benefit-cost ratios. These are based on the active versus control differences and are statistically significant. However, between groups, no statistically significant differences were found. This means that any apparent differences in terms of cost savings may also not be statistically significant.

The financial benefit of litres saved was calculated for each participant, assuming an average fuel price of $1.45 per litre, this being the average retail price of unleaded petrol in Brisbane for the 2011-2012 financial year. It was also assumed that each person travelled 14,400 km per year (ABS 2011a).

Table 5.9 displays individual benefit-cost ratios for all participants differentiated by training intervention.

Table 5.9: Summary of individual benefit-cost ratios for all participants split by training intervention

		Number	Benefit-cost ratio	Standard deviation
Benefit-cost ratio – Year 1	Intervention 1: On-line learning	194	3.380	12.137
	Intervention 2: Classroom	207	0.993	3.166
	Intervention 3: Driving lesson	212	1.122	3.937
	Intervention 4: Classroom and driving lesson	208	0.397	1.825
	Intervention 5: Half-day workshop	76	0.590	1.391
	Total	897	1.367	6.309
Benefit-cost ratio – Years 1 and 2	Intervention 1: On-line learning	194	4.506	16.183
	Intervention 2: Classroom	207	1.589	5.065
	Intervention 3: Driving lesson	212	1.771	6.216
	Intervention 4: Classroom and driving lesson	208	0.697	3.207
	Intervention 5: Half-day workshop	76	1.077	2.540
	Total	897	2.013	8.730
Benefit-cost ratio – Years 1 to 3	Intervention 1: On-line learning	194	5.069	18.206
	Intervention 2: Classroom	207	1.986	6.332
	Intervention 3: Driving lesson	212	2.404	8.436
	Intervention 4: Classroom and driving lesson	208	0.932	4.290
	Intervention 5: Half-day workshop	76	1.486	3.505
	Total	897	2.465	10.237

The ANOVA results for year one show there are statistically significant differences, $F(4, 892) = 6.892$, $p < 0.001$. These differences are retained in years one to two, and years one to three, with the ANOVA result being, $F(4, 892) = 5.634$, $p < 0.001$, and $F(4, 892) = 4.669$, $p = 0.001$, respectively.

From the data presented in table 5.9, intervention 1 has a substantially higher benefit-cost ratio compared with other interventions in the first year. However, interventions 2, 3 and 5 become more cost-effective over time. This is due to the performance of these two interventions improving with time, as the costs are spread over more years.

In the first year intervention 1 is the most cost-effective. However, over three or more years duration, interventions 2, 3 and 5 are also worthy of consideration. With a longer time period over which to spread the relatively higher cost of these interventions, the benefit-cost ratios improve.

5.8 Summary

The eco-drive training in this study was completed by private individuals using their own vehicle. All participants were responsible for their vehicle running costs. The training was provided to a group of drivers demographically matched to the Queensland licence-holding population. The vehicles driven were predominantly light passenger vehicles, with some four wheel drive vehicles and light commercial vehicles included. The participants were drawn from Brisbane, Logan City and Moreton Bay Region in southeast Queensland, Toowoomba in southern Queensland, and Townsville in north Queensland.

In terms of attitude change, eco-driving training affected the attitude of most participants. Only the young participants showed no statistically significant differences in attitude after the training compared with before the training.

Considering all of the participants who received eco-drive training, the training resulted in a statistically significant 4.6% reduction in fuel use. This equated to an average reduction of 0.5 l/100km. The 15.9% of participants with the greatest fuel use reduction achieved a reduction of greater than 15.1% (or 1.7 l/100km).

The lower intensity training resulted in a 4.5 % reduction in fuel use, equating to a reduction of 0.47 l/100km. The most intensive training resulted in a 7.4% reduction in fuel use. This equated to an average reduction of 0.80l/100km. While this reduction was statistically significant compared with the control group, there was no statistically significant difference between the training interventions.

In the short-term, intervention 1 (the on-line training) was the most cost-effective. In the longer-term, interventions 2 (classroom), 3 (driving lesson) and 5 (half-day workshop) become increasingly attractive.

6 Conclusions, limitations and policy implications

In this chapter the specific research questions are answered and the policy implications are discussed.

6.1 Research questions

The research sought to meet the three pilot objectives by answering seven questions about the participants and the training interventions:

1. Which training intervention is the most effective at reducing fuel use across the whole sample?
2. Which training intervention is the most effective at reducing fuel use differentiated by age of participants?
3. Which training intervention is the most cost-effective (intervention delivery costs by fuel use costs/carbon costs) across the whole sample?
4. Which training intervention is the most cost-effective differentiated by age of participants?
5. Which training intervention is the most effective at changing attitudes across the whole sample?
6. Which training intervention is the most effective at changing attitudes differentiated by age of participants?
7. Which participant attributes (location, age, gender, vehicle attributes) impact on the overall and relative effectiveness of the training interventions?

Considering all of the participants who received eco-drive training, the training resulted in a statistically significant 4.6% reduction in fuel use. This equated to an average reduction of 0.5 l/100km. The 15.9% of participants with the greatest fuel use reduction achieved a reduction of more than 15.1 % (or 1.7 l/100km).

There was a shift in attitudes pre and post-training indicated by a statistically significant increase in the number of participants strongly agreeing they could affect change in their CO_2 emissions by changing their driving behaviour. In the recruitment survey 13.9% of participants strongly agreed with this statement, this increased to 31.0% in the exit survey. There was also a moderate, but statistically significant, increase in the number of participants agreeing (strongly, moderately or slightly agreeing) with the statement. A total of 75.8% agreed in the recruitment survey, compared with 84.5% in the exit survey.

Question 1: Which training intervention is the most effective at reducing fuel use across the whole sample?

Intervention 5 appeared to be the most effective achieving a mean fuel use reduction of 7.4% (or 0.8 l/100km). However, the effect of intervention 5 was not statistically different from the other packages.

Question 2: Which training intervention is the most effective at reducing fuel use differentiated by age?

There were no statistically significant differences between the training interventions when differentiated by age.

Question 3: Which training intervention is the most cost-effective (intervention delivery costs by fuel use costs/carbon costs) across the whole sample?

In the first year intervention 1 was the most cost-effective; however over three or more years duration, interventions 2, 3 and 5 are worthy of consideration. With a longer time period over which to spread the increased cost of these interventions, the benefit-cost ratios improve.

Question 4: Which training intervention is the most cost-effective differentiated by age?

There were no statistically significant differences in the cost-effectiveness of the training interventions, differentiated by age.

Question 5: Which training intervention is the most effective at changing attitudes across the whole sample?

While there were statistically significant changes in attitude between the control group and the active group (those who received training), there were no statistically significant differences between interventions. That is, all interventions were equally effective at changing attitudes.

Question 6: Which training intervention is the most effective at changing attitudes differentiated by age?

Eco-driving training most affected the attitudes of the mid and older age groups. The participants in the mid and older age groups were more likely after the training to agree that they could change their emissions if they changed the way they drove. There were no statistically significant differences between interventions, that is, all interventions were equally effective at changing attitudes.

Question 7: Which participant attributes (location, age, gender, vehicle attributes) impact on the overall and relative effectiveness of the training interventions?

There were no statistically significant differences in the effectiveness of the training interventions, differentiated by study area, age, gender or vehicle attributes.

6.2 Limitations

The fuel discount and participant incentive could have induced perverse outcomes, although this is considered unlikely. This incentive, based on the volume of fuel purchased, could have encouraged participants to purchase greater volumes of fuel, or to drive in a manner that consumed greater volumes of fuel, as the fuel was cheaper than it would have been otherwise.

The four cents per litre discount was offered in lieu of the ‘shopper docket’ discount. Due to the terms and conditions of the fuel cards, ‘shopper docket’ discounts could not be used. The discount incentive was offered to discourage participants from purchasing fuel without the fuel card. The four cents per litre discount remained consistent despite fluctuations in the discounts offered by the supermarkets. The two major supermarket chains in Australia typically offer a four cents per litre discount on fuel purchased from their own branded fuel retailers, when a person spends $30 or more in one of their supermarkets. As the major supermarket chains accounted for 45% of total fuel sales in Australia in 2010/11 (ACCC, 2011), it was assumed that a large proportion of the participants would normally use the supermarket ‘shopper docket’ discounts. Rather than encouraging increased fuel use, the four cents per litre discount offered in lieu of the ‘shopper docket’ discount ensured that participation in the study was cost- neutral to participants.

Fuel use reductions were potentially diluted by sharing vehicles with non-participants. In the exit survey 21.3% of participants reported that they drove their vehicle less than 90% of the total distance it travelled, and 8.2% less than 80% of the total distance travelled. It was not possible to repeat the whole analysis differentiated by percentage driving because there was no data from the control group. However, limited analyses from the active group showed that the fuel use change for the whole group was in-line with the fuel use change of the participants reporting 90% or greater of the distance travelled.

The choice of local government areas limited the participants largely to urban and suburban areas. While a selection approach that also targeted rural postcodes would have more accurately sampled the Queensland driving population, such an approach was likely to have proven impractical. Most of the participants were required to attend some training, so offering the training in areas of very low population density would have been expensive and time-consuming, for both the participants and the trainers.

This study was drawn predominately from RACQ members. Participants volunteered for a research study but were unaware that the study was about minimising fuel use through changes in driving style – eco-driving. Subsequently, the research sample included participants with no interest in reducing their fuel use. This disinterested group may have reduced the overall measured effect of the training by ignoring the training and not attempting to change their driving style. In a real world application of eco-driving training, participants either would self-select to attend such training or be required to attend training in the course of their employment (and, it would be assumed, required to reduce the fuel used in the course of their employment).

Drivers with a personal and business interest in reducing fuel use are more likely to adopt the eco-driving techniques, and are therefore more likely to reduce their fuel use. In this way, the potential benefits presented in this study are likely to be low, compared with the potential benefits achievable for a motivated individual driver, or a fleet driver. However, this study shows that there are real and significant benefits of eco-driving training for the whole population. The benefits reported in this study are the benefits that are likely to ensue from a mass deployment of eco-driving training.

6.3 Policy implications

The research demonstrated that individuals will change their behaviour when provided with eco-driving training. In providing a randomised, controlled study in eco-driving behaviour change, this study addresses the limitations in the body of knowledge on the subject.

A 4.6% reduction in fuel use and emissions is achievable across the whole passenger vehicle fleet. This is a meaningful saving for an individual driver. Savings would be higher in households where there are a number of vehicles and trained drivers, or where distances travelled are greater than average.

The reduction in fuel use is a conservative estimate of the savings. The study was a blind experiment and hence the participating cohort included people who were interested in fuel efficiency and those who were not at all interested. There is potential for greater savings with drivers who self-select for eco-driving training because they want to experience the benefits of the training. It is notable that the participants in the top 15.9% (the mean fuel use plus one standard deviation) achieved a reduction of at least 15.1% or 1.7l/100km. The measurement also takes no account of transport mode shift and the resulting reduction in vehicle kilometres travelled as a result of training.

A 4.5% or 0.47 l/100km fuel use reduction can be achieved through the use of the on-line learning tool. If sustained, this would account for an average yearly fuel saving of $98 (using the average fuel cost for Brisbane in 2011/2012 and average annual km of 14,400km) for each individual, with greater savings achievable for drivers of larger vehicles and those travelling longer distances than average. In CO_2 reduction terms, this equates to a saving of 156kg per vehicle per year. For the top 15.9% of drivers (the mean fuel use plus one standard deviation – the group of drivers with the highest fuel use reduction) it is possible to achieve cost savings of $355 per year, and CO_2 reductions of 523 kg per year.

The on-line tool is the cheapest and easiest option to implement on a mass scale. This training has the highest benefit-cost ratio. It could also be incorporated into learner driver training.

Similar savings are achieved by attending the classroom or driving lessons. While this delivery mode is more expensive, it is useful for those who are unable or unwilling to access the online learning.

A 7.4% or 0.8 l/100km fuel use reduction can be achieved through completion of the half-day workshop. This would account for an average fuel saving of $167 and 265 kg of CO_2 per driver per year. This option is most appropriate for high-mileage drivers as the benefits are more substantial and the fuel cost savings are greater than the training cost. This option is also relevant for fleet drivers as the business costs can be reduced through taxation accounting.

The reduction in fuel consumed has benefits to society in terms of our reliance on liquid fuels. An overall 4.6% reduction in fuel consumption would improve Australia's energy security, as it would reduce our dependence on fuel imports and our exposure to supply disruptions. In addition, a mass campaign in fuel-efficient driving would provide drivers with access to information about how to reduce their fuel consumption immediately if a supply disruption were to occur.

The literature review presented in this study identified limitations in the understanding of the relationship between eco-driving and safety. This is important, as safety is of interest to almost all drivers and could be an additional motivator to drive efficiently. Further research is required to investigate possible relationships between eco-driving and safe driving.

Feedback from participants also suggests there could be benefits in research into driving stresses and encouraging courteous behaviour. Reduction in stress is a potential motivator to engage in eco-driving; although a lack of courtesy from other drivers (e.g., to someone slowing in advance of a red light ahead) is a potential barrier to its adoption.

Opportunities exist for the Queensland Government, CARRS-Q and RACQ to enhance eco-driving training in future.

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8 List of Appendices

The appendices are presented separately in the document "***RACQ EcoDrive Research Study: Appendices"***.

The appendices include the following:

Appendix A EcoDrive training: additional material

- A.1 Eco-drive curriculum
- A.2 On-line tool frames
- A.3 Classroom power point
- A.4 An example report from intervention 5

Appendix B Supplementary statistical analyses