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Factors Affecting the Risk of Crash Involvement Amongst New Zealand Truck Drivers

**A thesis presented in partial fulfilment of the requirements for
the degree of Doctor of Philosophy in Human Resource
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Abstract

Compared to countries such as Australia, England, Sweden and Finland, New Zealand has a relatively high rate of fatal road crashes. This high rate is not evenly distributed amongst the different groups of road users, with trucks being one group who are involved in a disproportionately high number of fatal crashes. Although truck drivers are an important group to study, if New Zealand is to reduce its relatively high road toll, very little research has investigated the role of human factors in the crash involvement of truck drivers.

Drawing upon research amongst private vehicle drivers and safety climate research from other industries, the current study investigated the relationship crash involvement has with two personality traits (driver selfishness and mild social deviance), four different types of aberrant driving behaviour (violations, errors, lapses and aggressive violations) and safety climate.

The violations factor was the only factor that directly predicted crash involvement amongst truck drivers. The relationship between violations and crash involvement was such that a one unit increase in the violations factor score increased the odds of being crash involved by 49%.

Tests for mediation effects revealed that a number of other variables indirectly increased the risk of crash involvement. One of the four different types of driver selfishness, mild social deviance and safety climate all indirectly affected crash involvement through their relationships with other variables.

The findings of this research highlight the important role human factors have in the risk of crash involvement amongst New Zealand truck drivers. Possible avenues for future research are discussed, along with the implications of the findings for decreasing truck drivers' crash involvement.

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Articles

The following articles based on this thesis were published or are currently in press (see Appendices 1-4).

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Chapter 1

Overview

The prevention of traffic crashes is one of the top priorities for injury prevention researchers and practitioners in New Zealand (Accident Compensation Corporation, 2002). Although the rate of traffic fatalities has been greatly reduced over the last decade, New Zealand still has a relatively high rate when compared to Australia, Great Britain, Sweden and most other European countries. Involvement in fatal traffic crashes is not evenly distributed amongst the different driver groups, with truck drivers being one group who are involved in a disproportionately high number of fatal crashes. Despite their importance to the New Zealand road toll, very little research has investigated the human factors affecting the likelihood of crash involvement amongst New Zealand truck drivers. This is of especial concern, as research has shown that the vast majority of traffic accidents can be attributed partially or completely to human factors (McKenna, 1983; Rothengatter, 1997; Sabey & Taylor, 1980). One important factor affecting the likelihood of being crash involved is the manner in which an individual behaves on the road.

An extensive body of research on overseas car drivers has shown that the manner in which an individual drives greatly influences their chances of being crash involved (e.g. French, West, Elander & Wilding, 1993; Hartley & El Hassani, 1994; Kontogiannis, Kossiavelou & Marmaras, 2002; Rimmö & Åberg, 1999; West, Elander & French, 1993a; Wouters & Bos, 2000; Xie & Parker, In Press). One of the most commonly used frameworks for investigating driving behaviours, and their relationship with crash involvement, is the Driver Behaviour Questionnaire (DBQ) (Reason, Manstead, Stradling, Baxter & Campbell, 1990). In the decade since the development of this framework, an

impressive body of literature on private motorists has built up showing that crash involvement can be predicted using subscales of the measure (e.g. Meadows, Stradling & Lawson, 1998; Parker, Manstead & Stradling, 1995a; Parker, McDonald, Rabbitt & Sutcliffe, 2000; Rimmö & Åberg, 1999; Xie & Parker, In Press). However, the generalisability of this research to a specialised population, such as truck drivers, has not yet been established.

While the relationships between the three main DBQ factors and crash involvement are clear, relatively little research has investigated the antecedent factors which affect whether a driver engages in the different types of aberrant driving behaviours. Amongst the factors that may influence the manner in which a truck driver behaves on the road are their individual personality traits and the safety ethic of their employing organisation. However, to date there appears to be no published research investigating the links between these factors in relation to driving behaviour and crash involvement.

The fact that an individual's personality characteristics influence the manner in which they drive, and thereby their risk of crash involvement, has been demonstrated by an extensive body of literature (e.g. Beirness, 1993; Burgess, 1999; Iversen & Rundmo, 2002; Lawton, 1998; Montag & Comrey, 1987; Ulleberg, 2002; West & Hall, 1997). Burgess (1999) argues that certain elements of personality make rule breaking more likely, simply because the acts committed in order to satisfy their personal needs come into conflict with the rule system. Therefore, certain personality traits increase the likelihood that an individual will engage in aberrant driving behaviour, thereby affecting the likelihood that they will be crash involved (Lawton, 1998; Lawton, Parker, Stradling & Manstead, 1997b; West et al., 1993a).

Another factor that would affect the way a truck driver behaves on the road, which is unique to those who drive professionally, is the safety climate of the employing company. The safety climate of the employing organisation has been shown to influence the way in which an employee thinks about safety and their engagement in safety behaviours (Clarke, 1998a; Cohen, 1977; Hofmann &

Stetzer, 1996; Lawton, 1998; Lawton & Parker, 1998; Mearns, Flin, Gordon & Fleming, 2001a). Therefore, in the case of truck drivers, the employing organisation's safety climate may be expected to be a significant factor affecting their risk of crash involvement. However, to date no published research has investigated the influence of safety climate on the driving behaviour and crash involvement of professional truck drivers.

Given the lack of research on New Zealand truck drivers, the overriding purpose of the current study is to investigate factors potentially related to crash involvement. More specifically, the research investigates the relationship truck driver crash involvement has with driver selfishness, mild social deviance, aberrant driving behaviour and safety climate.

Chapter 2 commences with a brief overview of traffic safety, comparing the size of the problem in New Zealand with the situation in other countries. Chapter 2 then considers a number of the demographic and descriptive variables affecting the risk of crash involvement amongst both private vehicle drivers and professional truck drivers.

Chapter 3 begins by outlining the development of the DBQ, describing the scale's characteristics and its psychometric properties. The chapter then reviews the research findings from studies using the scale on the general driving population, before shifting the focus towards those driving in a work-related context. The chapter concludes by noting the absence of research investigating aberrant driving behaviour amongst truck drivers and outlines the research aims in relation to this aspect of the present study.

The fourth chapter commences with a general discussion of research investigating the affect of personality traits on traffic behaviour. Amongst the personality traits that have been found to alter the way an individual drives are social deviance and egoism (or selfishness). Mild social deviance and selfishness have both been found to be predictive of driving behaviours that have been shown to be predictive of crash involvement. Chapter 4 explores the

literature linking both of these personality traits with driving behaviour and crash involvement. The Chapter closes by presenting the research aims in relation to mild social deviance and driver selfishness.

In Chapter 5, the notion of safety climate is discussed, along with the many dimensions that have been examined in safety climate research. The chapter then investigates the importance of safety climate in relation to accident involvement in general. Although no published research was found directly investigating safety climate amongst professional truck drivers, the few transport related research findings are presented. The chapter concludes by outlining the research aims relating to the safety climate part of this research.

Chapter 6 describes the methodology adopted for the present study. The development of the survey instrument is reviewed in detail, along with the sampling procedures and analytic strategies utilised in the research.

The results from the study are presented in Chapter 7. Descriptive statistics for all of the variables are presented, along with the correlations between them. The variables that were significantly correlated with number of crashes are tested for their ability to predict crash involvement using logistic regression. The chapter closes by presenting the results of tests for mediation effects amongst the main variables under investigation.

Chapter 8 presents a detailed discussion of the results and places them in the context of previous research findings. The utility of the results are discussed, along with the limitations and suggestions for future research. A brief summary of the main findings draws the thesis to a close.

Chapter 2

Introduction

2.1. – Chapter overview

Chapter 2 presents a brief overview of the topic of road safety, comparing the size of the problem in New Zealand with the situation in other countries. Although New Zealand's road toll has been greatly reduced over the last decade, it still remains considerably higher than other comparable countries. In order to improve the road toll, more knowledge is needed about the different groups of road users, how they behave and factors affecting their crash liability. The most basic of the variables affecting the risk of crash involvement are the demographic and descriptive characteristics of the drivers. A number of the demographic and descriptive variables affecting the risk of crash involvement amongst private vehicle drivers are introduced. Finally, the relationship between demographic and descriptive variables and crash involvement amongst truck drivers are discussed before the chapter closes.

2.2. – Size of the problem

Driving a vehicle is a relatively complex task conducted in a very hazardous environment where one lapse in concentration, poor decision or an erroneous action can result in a crash. It is little wonder then that traffic crashes are a leading cause of death in Western societies (Cunill, Vieta, Gras, Planes & Oliveras, 2001; Moyano-Díaz, 1997). For example, traffic crashes are the leading cause of death in Sweden (Murray, 1998) and, in the USA, almost as many young men (17-25 years old) die as a result of traffic crashes as die from

all other causes combined (Evans, 1991). The road toll has also been unfavourably compared to the casualties from wars. For example, Meadows (1994) states that traffic deaths on U.S. roads from 1977 to 1988 exceeded all deaths in all U.S. battles from the start of the revolutionary war in 1775 to the end of the Vietnam war 200 years later.

As could be expected, traffic safety is also a large problem in New Zealand. In New Zealand motor vehicle crashes are the leading cause of death by injury and the third largest cause of hospitalisation for injury (Feyer & Langley, 2000). In 2000, the most recent year for which complete data exists there were 462 fatalities and 12,368 reported injuries on New Zealand's roads. To put this into perspective, this means 1.8 road deaths per 10,000 registered vehicles and 12.1 road deaths per 100,000 people (Land Transport Safety Authority, 2002a). For the injury data, in 2000 there were 42.1 reported road injuries per 10,000 vehicles and 286 reported road injuries per 100,000 people (Land Transport Safety Authority, 2002a). The financial cost of these road crashes is very high. The Land Transport Safety Authority (2000) estimates that the average cost of a road fatality is NZ\$2.485 million. As there were 462 road fatalities in 2000, this equates to a total cost of \$1.1 billion. This figure is slightly lower than the total export earnings of the New Zealand forest industry (\$1.4 billion) and fish (\$1.2 billion), but is higher than the total value of New Zealand's export earnings from wool (\$797 million) (Statistics New Zealand, 2002). The social cost of road deaths in New Zealand is also extremely high, with traffic crashes accounting for more years of healthy life lost than any other cause (Accident Compensation Corporation, 2002).

The injury and death rates on New Zealand roads have declined dramatically in the last decade. For example, the total number of deaths per 100,000 people declined from 21.4 in 1990 to 12.1 in 2000. In terms of deaths per 10,000 vehicles, New Zealand's rate declined from 3.3 in 1990 to 1.8 in 2000. There have been a number of reasons proposed for the decline in road deaths, including a reduction in mean and higher percentile speeds, increased ticketing, the introduction of speed cameras, improvements in road design, improvements

in car design, increased enforcement of speeding and drink driving, increased penalties, random alcohol breath testing, improvements in medical treatment, and the implementation of various road safety campaigns (Keall, Povey & Frith, 2002; Scuffham & Langley, 2002). Whatever factors have caused this dramatic decrease in the number and proportion of road deaths, by international standards New Zealand still has a relatively high rate of road deaths.

- New Zealand's rate of road deaths, of 1.8 per 10,000 registered vehicles and 12.1 road deaths per 100,000 people, is considerably higher than most comparable countries, such as Australia (1.5 per 10,000 registered vehicles and 9.4 per 100,000 people), the United Kingdom (1.2 per 10,000 registered vehicles and 6.0 per 100,000 people), Sweden (1.2 per 10,000 registered vehicles and 6.7 per 100,000 people), Finland (1.6 per 10,000 registered vehicles and 7.7 per 100,000 people), and Germany (1.5 and 9.1 respectively). While, New Zealand's road fatality rates are almost the same as those found in Austria (1.9 and 12.0, respectively) and the United States (1.9 and 15.2 respectively), they are considerably lower than third world countries, such as South Korea (7.8 and 21.8 respectively) and China (no figures available per registered vehicle, 22.5 per 100,000 people¹) (Land Transport Safety Authority, 2001; Land Transport Safety Authority, 2002a).

2.3. – Demographic and descriptive variables related to crash involvement

A number of demographic and descriptive variables, such as age, gender, driving experience, preferred driving speed and annual mileage have been shown to be strongly related to crash involvement. Research has consistently found that male drivers are more likely to be crash involved than female drivers (Elander, West & French, 1993; Evans, 1991; Kontogiannis, et al., 2002; Lawton, Parker, Manstead & Stradling, 1997a; Parker, Manstead & Stradling, 1995a; Valent, Schiava, Savonitto, Gallo, Brusaferrero & Barbone, 2002). For example, Elander et al. (1993) reported that in the USA and UK, fatal crash

¹ 1999 figures.

rates for males were twice that of females. Evans (1991) also found that the rate of mens' involvement in fatal road accidents was twice as high as womens', and the chance of a woman getting hurt in a traffic accident was 25% lower than for a man.

However, if exposure to risk (in terms of annual mileage), type of accident, and time of day driving are taken into account, the difference between males and females becomes less clear. For example, after partialling out annual mileage (the only exposure variable they used), Kontogiannis et al. (2002) still found gender made a modest, but significant contribution to the prediction of crash involvement, with males being more often crash involved. Massie, Campbell and Williams (1995) found females were involved in a higher number of minor crashes per kilometre, but that males were involved in more fatal crashes per kilometre. One reason for this finding is that, on average, males drive faster than females (Wilson & Greensmith, 1983), and speed is related to the seriousness of the consequences when a crash happens (Rothengatter, 1997). Other researchers have found no significant differences in crash involvement rate by gender (Cartwright, Cooper & Barron, 1993; Lourens, Vissers & Jessurun, 1999), while some research has even found higher rates for female drivers (Assum, 1997). Despite the complexity of the relationship between gender and crash involvement, one consistent finding has been that young males have more crashes than females of all ages (Lawton et al., 1997a; Parker, Manstead, Stradling & Reason, 1992), meaning that age is also an important demographic factor.

Previous research has consistently found age to be strongly associated with crash risk, with younger drivers being involved in more crashes than older drivers (Evans & Wasielewski, 1983; Lawton et al., 1997a; Parker et al., 1995a; Reason et al., 1990; West et al., 1993a). There are a number of reasons why young drivers have more crashes than older drivers. For example, research has shown that young drivers engage in more risk taking behaviours whilst driving (Evans & Wasielewski, 1983; Jonah, 1986), spend a higher proportion of their time driving in more risky areas, and tend to drive at more risky times (Rolls,

Hall, Ingham, & McDonald, 1991). In addition, as most drivers (especially in New Zealand) obtain their licenses in their teenage years², younger drivers also tend to have less driving experience. This makes it relatively difficult to separate the role of age from the role of experience in the causation of crashes. However, there is evidence to suggest that both age and experience contribute separately to the increased risk of crash involvement of young drivers. For example, Laberge-Nadeau, Maag & Bourbeau (1992) found crash rates decreased with age, regardless of driving experience. This was corroborated by Laapotti, Keskinen, Hatakka and Katila (2001), who compared the crash rates of young novice drivers and middle aged novice drivers. They found that young novice drivers had more crashes than middle aged novice drivers, thus supporting the hypothesis that age contributes to higher crash rates, irrespective of driving experience.

Research has shown that inexperienced drivers have skill deficiencies (Matthews & Moran, 1986; Laapotti et al., 2001). This would account for some of the increased risk of crash involvement inexperienced drivers have. For example, Kaneko and Jovanis (1992) found that the risk of crash involvement was highest amongst those with less than five years experience. Furthermore, Kontogiannis et al. (2002) found that driving experience accounted for 45.4% of the variance in crash involvement, once annual mileage had been partialled out. However, despite the importance of age as a predictor of crash involvement, age was omitted from Kontogiannis et al.'s analysis. Given the fact that age has been found to be a significant predictor of crash involvement, irrespective of experience (Laberge-Nadeau et al., 1992; Laapotti et al., 2001), and the fact that age and experience are interrelated (Westerman & Haigney, 2000), we would expect some of this 45.4% to be due to age, rather than experience.

Another descriptive variable associated with increased accident risk is annual mileage (Lawton, Parker, Stradling & Manstead, 1997c; Stradling Parker, Lajunen, Meadows & Xie, 1998; West & Hall, 1997; West et al., 1993a). Annual mileage is an exposure factor, as clearly an individual must first travel by road

² The legal age for obtaining a license in New Zealand is 15 years old.

to be involved in a road crash. However, exposure to risk on the road is more complex than simply how many kilometres an individual drives each year, as risk is also affected by factors such as time of day/night, where they drive, and hours spent driving. Nevertheless, annual mileage has often been used as a relatively crude measure of exposure, possibly due to the ease with which it is measured and analysed (e.g. Kontogiannis et al., 2002; Lawton et al., 1997c; West et al., 1993a). As would be expected, most research has shown that the more kilometres an individual drives on the road the higher the risk of crash involvement (Lawton et al., 1997c; Maycock, 1997a; Stradling et al., 1998; West et al., 1993a). However, there have also been some studies that have reported conflicting findings. For example, in a study of Greek private vehicle drivers, Kontogiannis et al. (2002) found that annual mileage did not make a significant contribution to the prediction of crash involvement.

Driving speed is also correlated with crash involvement. The speed at which drivers' travel can be thought of as a type of driving behaviour, or an attitude (in the case of preferred speed). However, as driving speed has been found to be an important variable to control when studying other risk factors (e.g. Kontogiannis et al., 2002; Meadows et al., 1998), speed is considered in this section on demographic and descriptive variables. Driving speed has been found to be one of the most important individual risk factors for crash involvement (e.g. French et al., 1993; West et al., 1993a; Wasielewski, 1984). Choice of driving speed not only determines the amount of time available for corrective manoeuvres, but also the probability of crash involvement and the severity of the consequences (Rothengatter, 1997). For example, in an observational study, Wasielewski (1984) found that faster drivers were characterised by having a higher involvement in crashes. Likewise, Maycock (1997c) clearly showed that slower drivers were significantly less likely to be crash involved. Research has also confirmed the strong association with crash involvement using in-vehicle measurement (Wilson & Greensmith, 1983) and also with self-reported measures of speed (West et al., 1993a). Moreover, the relationship between self-reported speed and crash involvement has been found regardless of whether drivers were asked to report their actual speed

(e.g. Dobson, Brown, Ball, Powers & McFadden, 1999; West and Hall, 1997) or their preferred speed (Meadows, 1994; Meadows et al., 1998).

The relationship between speed and crash involvement has also been replicated at a population level. Baum, Lund and Wells (1989) found that when the legal speed limit was raised by 10 mph, although the average speed only increased by 2-3 mph, the number of fatal crashes increased by 15%. Quimby, Maycock, Palmer & Buttress (1997) found that a 1% change in speed was associated with a nearly 8% change in crash liability. Furthermore, Maycock (1997c) reported research from the UK, Finland, Denmark, Sweden, Germany, Switzerland and the USA which showed that, on average, a 1 mph change in the speed limit resulted in a change in injury accidents of between 5-8%.

Despite the strong link between speeding and crash involvement, speeding has been reported to be the most prevalent type of driving violation (Åberg & Rimmö, 1998; Blockey & Hartley, 1995; Dimmer & Parker, 1999; Kontogiannis et al., 2002; Lawton et al., 1997c). In fact, a number of researchers have found evidence to suggest that exceeding the speed limit is the rule, rather than the exception (Haglund & Åberg, 2002; Rothengatter, 1988; Rothengatter, 1991; Lawton et al., 1997c). There is also evidence to suggest that many drivers regard speeding with a degree of tolerance. For example, Parker et al. (1992) showed that speeding was the most tolerated of the four types of driving violations they investigated. This was also reported by Brown and Copeman (1975) who found that exceeding the speed limit by 10-20 mph was seen as the least serious of the 31 traffic violations they measured. In addition, the participants in Parker et al.'s (1992) research reported the lowest intention to avoid speeding. Moreover, Parker et al. (1992) and Lawton et al. (1997c) found that those with relatively high intentions to engage in speeding also showed less appreciation of the potential negative consequences. To illustrate the strength of this relationship, Lawton et al. (1997c) found that across five different types of road, the driver's perceptions of the negative consequences accounted for between 11% and 23% of the variance in intention to speed, over and above that afforded by age, gender and frequency of driving.

Speed choice has been shown to be consistent over time (Haglund & Åberg, 2002; Hauer, Ahlin, & Bowser, 1982; Rajalin, 1994), and has also been found to be associated with particular demographic and descriptive variables. For example, researchers have reported gender differences, with men generally driving faster than women. This assertion holds for both directly observed speed (Wilson & Greensmith, 1983) and self-reported speed (French et al., 1993; West & Hall, 1997). Age differences have also been reported, with older drivers generally driving at a slower speed than younger drivers (Maycock, 1997c; Quimby et al., 1997; West & Hall, 1997).

2.4. - Demographic & descriptive variables amongst heavy vehicle drivers

Extensive research has been published investigating driving hours and the effects of fatigue on heavy vehicle drivers (e.g. Baas, Charlton & Bastin, 2000a; Charlton & Baas, 2001; Feyer, Williamson & Friswell, 1997; Hartley, Arnold, Smythe & Hansen, 1994; Kaneko & Jovanis, 1992; Williamson, Feyer, & Friswell, 1996). However, relatively little published research has specifically investigated the relationship between demographic or descriptive variables (other than fatigue and driving hours) and crash involvement amongst truck drivers.

As research has shown that truck drivers differ from other road users in a number of ways, such as demographics, skill base and possibly also different attitudes to car drivers (Walton, 1999a), it is difficult to generalise the results of research on car drivers to the drivers of heavy vehicles. For example, it is known that professional truck drivers have a higher average age than the general driving population, engage in driving for a different purpose than the public, and spend more time on the road than the general public (Walton, 1999a; Walton, 1999b). In addition, although truck drivers travel more kilometres per year (so are exposed to the risk factor more often), they have a lower crash rate than car drivers (Walton, 1999b).

Unfortunately, despite being involved in fewer crashes per million kilometres, trucks are involved in a disproportionately large percentage of fatal crashes. While trucks account for around 6% of the total distance travelled on New Zealand's roads, they are involved in 22% of all fatal crashes (Baas, Mueller, & Sullman, 2000b). Although truck drivers are not responsible for the majority of these crashes (Baas et al., 2000b; Summala & Mikkola, 1994), they are an important group to study if New Zealand's relatively high road toll is to be addressed.

Although truck drivers differ from the general population of road users, researchers have found similar associations between demographic/descriptive variables and crash involvement. As with the drivers of private motor vehicles, the age of truck and bus drivers has been found to affect the risk of crash involvement, and also the likelihood that the driver was responsible for the crash. For example, Häkkänen and Summala (2001) investigated the causes and responsibility of drivers in fatal crashes and found that the odds of being responsible for a fatal crash were significantly higher for drivers younger than 30 years old. This is also substantiated by Hamelin (1987), who found that the risk of crash involvement was higher for younger drivers (18-29 years old) than for older drivers (30+ years old). In addition, Summala and Mikkola (1994) investigated the affects of fatigue and alcohol consumption on fatal crash involvement. They found that truck drivers who were very tired or fell asleep before becoming involved in a fatal crash tended to be younger. West (1997) also found that age was a significant predictor of crash involvement amongst Czechoslovakian bus drivers, while Campbell (1991) found that truck drivers under the age of 27 years old were over represented in the crash statistics. In fact Campbell (1991) found truck drivers under the age of 21 were six times more likely to be involved in a crash than truck drivers in general. This finding has also been replicated amongst New Zealand truck drivers, with younger drivers having a much higher crash rate than older truck drivers (Walton, 1999a).

Although most of the published research suggests younger truck drivers are involved in more crashes than older drivers, there is evidence that the higher rate can be attributed to greater exposure to risk factors rather than age. For example, Dionne, Desjardins, Laberge-Nadeau and Maag (1995) found that younger drivers had more crashes, but when exposure variables (annual mileage and hours spent driving) were taken into account, this effect disappeared. This suggests that the reason younger drivers are involved in more crashes may simply be that they spend more hours driving and drive more kilometres per year than older truck drivers.

Dionne et al. (1995) also found annual mileage was an important exposure factor. However, as with car drivers, annual mileage was not the only important exposure variable. They also found the working radius, type of road (e.g. highway, city streets, country road), number of hours the driver works and the time of day/night were important exposure factors. However, in contrast to Dionne et al.'s findings, Maycock (1997b) found mileage had no affect on the crash rates of truck drivers. Therefore, there is conflicting evidence on the importance of annual mileage as a risk factor for crash involvement amongst truck drivers.

There is also evidence to suggest that less experienced drivers of heavy vehicles are at a higher risk of crash involvement. For example, Hertz & Eastham (1987) found that driver experience, in terms of length of employment, was negatively related to fatal crash involvement amongst American truck drivers. Kaneko and Jovanis (1992) also found that years experience in the company had a significant affect on crash risk. They reported that drivers with less than one year's experience in the company had a lower risk of crash involvement than those who had been with the company 1-5 years. Truck drivers who had been with the company 1-5 years were at a significantly higher risk of crash involvement than those that had been with the company 5-10 years, and those who had been with the company more than 10 years had the lowest risk of crash involvement. However, as Kaneko and Jovanis (1992) correctly note, their measure of experience (i.e. years driving trucks for that

company) is only a rough measure of experience, as the company frequently hired drivers from other companies. Therefore, the new hires are not necessarily new to truck driving. In contrast, Häkkänen and Summala (2001) found that experience was not a significant predictor of whether a truck driver would be involved in an “at fault” fatal crash. In terms of non-fatal crashes, West (1997) found that years experience with the bus company was a significant predictor of crash involvement, with the more experienced bus drivers being less likely to be crash involved. Unfortunately, aside from West’s (1997) study, no research could be found investigating the role of experience in non-fatal crashes. Therefore, there are some gaps and some inconsistency in the literature on the affect of truck driver experience.

Speed has also been found to be an important variable for truck crashes. In New Zealand research has found speed to be a major contributing factor in 23% of all truck crashes investigated by the Commercial Vehicle Inspection Unit (CVIU) (Baas et al., 2000b). However, there appears to be little research to support this. Another area that does not appear to have been examined in the research literature is the issue of gender. As very few truck drivers are female, and most of the research studies only included male drivers (e.g. Dionne et al., 1995; Feyer et al., 1997; Williamson et al., 1996), there appears to be no evidence to indicate any gender differences in crash risk for truck drivers.

2.5. – Chapter summary

This chapter has outlined the scope of the road fatality and injury problem facing most westernised countries, and investigated a number of demographic and descriptive variables that affect the risk of crash involvement. The drivers’ age, experience, preferred speed, annual mileage and gender appeared to be related to the risk of crash involvement amongst car drivers. The research findings on the relationship crash involvement has with truck driver demographic and descriptive variables are relatively sparse, but are mostly consistent with the findings amongst car drivers. The present study will provide

further information on these relationships, and in particular the associations age, driving experience, annual mileage, and preferred speed have with crash involvement. The following chapter reviews the research studies that have used the DBQ to investigate aberrant driving behaviour.

Chapter 3

Driver Behaviour Questionnaire

3.1. – Chapter overview

This chapter begins by outlining the development of the DBQ and then discusses the scale's characteristics and psychometric properties. The DBQ has been used extensively on populations of private vehicle drivers. The results of these studies are reviewed before the focus shifts to those driving in a work-related context. The chapter concludes by identifying the gaps in the literature and presenting the research aims that will be investigated in this study.

3.2. - Errors, lapses and violations

Previous research has confirmed that certain driving behaviours increase the risk of crash involvement (e.g. Hartley & El Hassani, 1994; Meadows et al., 1998; Parker, Lajunen & Stradling, 1998; Sabey & Taylor, 1980; Wouters & Bos, 2000). There have been several self-report measures developed to measure these driving behaviours (Iversen & Rundmo, 2002). However, one of the most prominent attempts to place these behaviours into some kind of framework was proposed by the Manchester Driver Behaviour Research Group. Their research was based upon Reason's (1990) Generic Error Modelling System (GEMS), in which unsafe acts can be placed into two broad categories (i.e. errors and violations). Errors and violations are postulated to have different psychological origins and therefore necessitate different methods of remediation (Reason et al., 1990). Based upon this work the Manchester Driver Behaviour Research Group developed a survey instrument called the Driver Behaviour

Questionnaire (Reason et al., 1990). Using a 50-item version of the DBQ, Reason et al. (1990) identified three different types of aberrant driving behaviour; errors, lapses and violations.

Errors can be defined as a type of driving mistake involving failures of observation or misjudgement and include such behaviours as failing to notice a 'Stop' or 'Give Way' sign, or failing to check your mirrors before pulling out or changing lanes (Parker et al., 1998). In contrast, violations are deliberate deviations from those practices thought to be necessary to safely operate a vehicle, and include such behaviours as speeding and close following (Reason et al., 1990). Lapses involve problems with attention and memory and include such things as switching on one thing when meaning to switch on something else (Parker et al., 1998).

In addition to the errors, lapses and violations distinction, more recent research by Lawton et al. (1997a) extended the violations scale from eight to 12 items, including six items deemed to be aggressive violations and six items deemed to be ordinary violations. Aggressive violations are to do with expressing hostility towards another road user or driving in an aggressive manner. Factor analysis of the extended violations scale produced a three factor solution, with the three factors being interpreted as 'fast driving', 'maintaining progress' and expressing 'anger/hostility'. Unfortunately, Lawton et al. did not report the alpha coefficients of the three factors, meaning that it was not possible to judge the internal reliability of the three factors.

Parker et al. (1998) also used the extended version of the DBQ-violations scale on the general driving population. They produced a three factor solution which broadly agreed with Lawton et al.'s (1997a) findings. However, due to instability, Parker et al. (1998) combined the 'fast driving' (also called 'gaining advantage') and 'maintaining progress' factors together and reported two factors. The first factor (fast driving and maintaining progress) was labelled 'ordinary violations', while the second factor was labelled 'anger/hostility' and replicated Lawton et al.'s (1997a) factor three.

3.3. - Type and frequency of reported aberrant driving behaviour

In most research using the DBQ the most frequently reported type of aberrant driving behaviour has been speeding in various situations (e.g. Åberg & Rimmö, 1998; Dimmer & Parker, 1999; Meadows, 1994; Parker, Reason, Manstead & Stradling, 1995b; Reason et al., 1990). For example, using an extended 104-item version of the DBQ, Åberg and Rimmö (1998) found that the three most commonly reported aberrant driving behaviours were all to do with speeding in different situations. These studies also report drunken driving as the least often reported aberrant driving behaviour (Åberg & Rimmö, 1998; Dimmer & Parker, 1999; Meadows, 1994; Parker et al., 1995b; Reason et al., 1990).

Although there is substantial consistency in the frequency and type of violations found in the British studies, there are some differences among studies undertaken outside Britain. For example, in a cross-country comparison, Stradling et al. (1998) report that in Britain, the most commonly reported violation was speeding, while in Australia and China overtaking on the inside was the most common violation. Swedish drivers report lower levels of all violations, except speeding, which they report engaging in more than any of the other samples (Stradling et al., 1998).

3.4. – Reliability of the DBQ

Research has shown that all the subscales of the DBQ have satisfactory reliability. For example, Westerman & Haigney (2000) computed reliability coefficients for the 24-item version of the DBQ. They found Cronbach's alpha coefficients of 0.76 for the errors scale, 0.74 for the violations scale and 0.74 for the lapses scale, demonstrating that all of the subscales had satisfactory internal reliability. This finding has been confirmed elsewhere (Dobson et al., 1999; Parker et al., 1995b; Parker et al., 1998). For example, Dobson et al. reported alpha coefficients of 0.66 for the lapse scale and 0.74 for both

violations and errors, while Parker et al. (1995b) found 0.84 for errors, 0.80 for violations and 0.72 for the lapses scale.

Although the extended violations scale was developed by Lawton et al. (1997a), they did not report the alpha coefficients. However, Parker et al. (1998) reported a two factor solution with alpha coefficients of 0.75 for the 'ordinary violations' scale and 0.70 for an 'anger/hostility' factor. The extended violations scale was also used by Lajunen, Parker and Stradling (1998), who reported acceptable alpha coefficients for both ordinary violations (0.76) and aggressive violations (0.70). Thus there is also evidence that the six item violations and aggressive violations scales have acceptable internal reliability.

Scores on the DBQ have also been shown to be reliable over time (Parker et al., 1995a). Parker et al. examined the test-retest reliability of the DBQ by getting 80 respondents to complete the DBQ twice within a seven month period. They found relatively high test-retest correlations of 0.69 for the errors subscale, 0.81 for the violation subscale and 0.75 for the lapse subscale. Unfortunately, the test-retest reliability has not been examined for the 'anger/hostility' (or aggressive violations) subscale.

3.5. - Factor structure of the DBQ

Research using the DBQ on private motor vehicle drivers has produced a relatively stable factor structure. This stability has been found both within and across different countries and cultures. Three or four factor solutions (depending on the version of the DBQ used) have been found by researchers in Britain (Parker et al., 1995a; Reason et al., 1990), Australia (Blockey & Hartley, 1995), Sweden (Åberg & Rimmö, 1998), and in China (Stradling et al., 1998). These findings clearly demonstrate the validity of the conceptual distinction between these three types of aberrant driving behaviour, and that the three-fold typology is stable across samples and across cultures. However, there were

some minor differences in the findings between studies that have been attributed mainly to sampling differences.

In the original research using the 50-item version of the DBQ, Reason et al. (1990) produced a three-factor solution which accounted for 33% of the variance. The first factor accounted for 22.6% of the variance and consisted almost exclusively of violations, while the second factor accounted for 6.5% of the variance and contained mainly errors. The third factor accounted for the remaining 3.9% variance and consisted of mainly lapses.

Blockey and Hartley (1995) attempted to reproduce Reason et al.'s (1990) factor solution using the 50-item version of the DBQ and found a three-factor solution which accounted for 27.7% of the variance. Although Blockey and Hartley produced a three-factor solution, there were some significant differences from the original research. For example, violations came out as the strongest factor in Reason et al.'s research, while violations were the third strongest factor in the Australian study (i.e. Blockey & Hartley, 1995). The differences in factor structure could be attributed to a number of factors, such as age and gender differences between the samples, different sample sizes, socio-economic differences, and differences in the traffic cultures. In the British research (Reason et al., 1990), 58% of the sample were male, while in the Australian research only 45% were male. Younger drivers also dominated the Australian sample, while the British sample had a wider age spread. The sample sizes may also have affected the results, as Blockey and Hartley (1995) surveyed a relatively small number of drivers (135). Blockey and Hartley's sample size of 135 drivers is low, compared to the 520 drivers in Reason et al.'s (1990) sample, and is in fact 115 cases short of what Tabachnick and Fidell (1989) suggest is an acceptable item to subject ratio for factor analysis.

More recent research by Rimmö (2002) found further evidence to suggest that differences in Blockey and Hartley's (1995) factor structure were due to the small sample size, rather than age and gender differences. Using the extended Swedish version of the DBQ, Rimmö (2002) tested whether a four-factor model

would be appropriate for samples of drivers of both genders and across different age ranges. Rimmö found the four-factor model of aberrant driving behaviour was appropriate in all cases. This suggested the differences in factor structure found by Blockey and Hartley (1995) were most likely due to socio-economic factors, differences in the traffic culture, or their small sample size. Rimmö (2002) contends that "it is reasonable to suspect that Blockey and Hartley's results were due to a comparatively small sample size ($n = 135$), not to differences in age and gender" (p. 578).

Following on from Reason et al.'s (1990) research, Parker et al. (1995a) reduced the DBQ to a 24-item questionnaire containing eight error items, eight violation items and eight lapses. This research again confirmed the three-fold typology of aberrant driving behaviour. Using the 24-item DBQ amongst Swedish drivers, Åberg and Rimmö (1998) again confirmed the generalisability of the three factor model of aberrant driving behaviour to a population outside of Great Britain.

More recent research has investigated aberrant driving behaviour amongst the general driving population using a 28-item version of the DBQ, which consisted of eight errors, eight lapses, six violations and six aggressive violations (Mesken, Lajunen & Summala, 2002). Using more than 1,100 Finnish drivers, Mesken et al. found a four factor solution consisting of errors, lapses, interpersonal violations and speeding violations best described their data. The errors and lapse factors consisted almost exclusively of errors and lapses, respectively. However, the speeding violations factor consisted of mainly ordinary violations, with one aggressive violation. The interpersonal violations factor consisted of the three items Lawton et al. (1997a) described as 'anger/hostility', along with an aggressive driving item and one ordinary violation. Unfortunately this was the only published research to use the 28-item version of the DBQ on a sample of ordinary drivers, raising the issue of the generalisability of these findings. Although the four factors had acceptable internal reliability and the factor solution was found on one half of the sample and replicated on the other, this is still only one study. Consequently, further

research using the 28-item version of the DBQ is needed to test the generalisability of this finding.

In summary, although there is now evidence to suggest that the 28-item version of the DBQ produces a four factor solution, most other research using the DBQ on private vehicle drivers has produced a relatively stable three factor solution consisting of errors, lapses and violations. Furthermore, where there have been differences in the factor structure, these can be attributed to sampling differences or the version of the DBQ used.

3.6. – Correlations between the DBQ and driver characteristics

Research has shown that the DBQ factors have different patterns of correlations with driver demographic and descriptive variables. Males of all ages report engaging in violations more often than females (Kontogiannis et al., 2002; Parker et al., 1995a; Parker et al., 1998; Rimmö & Hakamies-Blomqvist, 2002; Westerman & Haigney, 2000). However, although males are considerably more likely to be high violators, high violating male and female drivers have the same elevated risk of crash involvement (Stradling et al., 1998). Violations are also generally reported with higher frequency by younger drivers (Parker et al., 1995a; Rimmö & Hakamies-Blomqvist, 2002). In fact, Rimmö and Hakamies-Blomqvist (2002) demonstrated that even after the age of 55 years old the reported frequency of violations continues to decrease. However, there is some evidence to suggest that part of the strong relationship between age and the violations factor is due to experience. For example, Westerman and Haigney (2000) showed that when experience was controlled (through the calculation of partial correlations), the significant relationship between age and violations was greatly reduced (the correlation was reduced from $-.23^{***}$ to $-.08^{***}$), but still remained significant.

The pattern of correlations for the aggressive violations factor has been shown to be similar to the pattern for the violations factor. Those drivers who report

engaging in aggressive violations more frequently tend to be younger and male, rather than female (Kontogiannis et al., 2002; Lawton et al., 1997a; Mesken et al., 2002).

Although errors are not normally associated with any particular demographic group (Parker et al., 1998), there has been some research evidence to suggest that males are more likely to report them. For example, Parker et al. (1995b) found that males reported significantly more errors than females. Westerman and Haigney (2000) also found that males reported a higher level of errors than females, but this difference was not significant.

Lapses have also been found to be associated with age, with older drivers reporting more lapses than younger drivers (Parker et al., 1998; Rimmö, 2002; Westerman & Haigney, 2000). However, as Westerman and Haigney (2000) also showed, part of this correlation with age is due to experience. In addition to the relationship with age, lapses are reported more often by female drivers (Mesken et al., 2002; Parker et al., 1995b; Parker et al., 1998; Rimmö, 2002; Westerman & Haigney, 2000).

In addition, there is evidence to suggest that higher reported engagement in aberrant driving behaviour is also related to speeding and other types of driving convictions. For example, Kontogiannis et al. (2002) found that violations and aggressive violations were significant predictors of convictions for speeding, independent of age, gender and driving experience. Furthermore, Kontogiannis et al. found that the aggressive violations factor was predictive of convictions for driving offences other than speeding and drink driving.

3.7. - Correlations between the DBQ and crash involvement

There has been substantial consistency in terms of which of the four types of aberrant driving behaviour is predictive of crash involvement for the drivers of private motor vehicles. Research has consistently demonstrated that it is those

drivers who score highly on the violations subscale who are more likely to have been accident involved in the past (e.g. Kontogiannis et al., 2002; Parker et al., 1995a) and to be accident involved again in the future (Parker, West, Stradling & Manstead, 1995c). Although there has been some recent evidence to suggest that errors and lapses may also be associated with crash involvement (Mesken et al., 2002), the majority of the research on the general driving population has found only the violations scale to be predictive of crash involvement (e.g. Kontogiannis et al., 2002; Parker et al., 1995a; Parker et al., 1995c).

While the violations factor has been reliably found to be a significant predictor of crash involvement, it accounts for a relatively modest proportion of the variance in crash involvement. For example, Kontogiannis et al. (2002) found that once the contributions of gender, annual mileage and experience had been partialled out, highway code violations accounted for a rather modest, but significant 1.2% of the variance in crash involvement. Their finding was similar to the 1% found by Parker et al. (1995a), and appears to show an extremely weak relationship. However, the use of ordinary statistics in the case of crash involvement can be misleading (e.g. Hansen, 1989; West, 1995a). As crashes are rare events, and there is some element of chance involved, it is difficult to obtain good relationships between the precursors and crash involvement. For example, West (1995a) reports research where the variance accounted for was between 1 and 16%. On the surface, such low variance accounted for seems to mean a very weak relationship. However, West states that this is misleading, as smoking accounts for only 1% of the variance in lung cancer, yet smokers have a relative risk of developing lung cancer 20 times higher than that of non-smokers. Therefore, it is argued that epidemiological techniques such as rate ratios, odds ratios, relative risk calculations or Poisson regressions provide a more useful indication of the strength of the relationship between independent variables and crash involvement (Elander et al., 1993; West, 1995a).

Despite the fact that traditional statistical techniques may underestimate the size of the relationship between the DBQ factors and crash involvement, surprisingly few researchers have used alternative epidemiological techniques

when studying the relationship between crash involvement and aberrant driving behaviour. In one of the studies which did use such statistical techniques, Lawton et al. (1997b) showed that high violators had a crash rate which was 2.8 times higher than that of low violators. Therefore, although the DBQ factors explain a relatively low proportion of the variance in crash involvement, the crash rate of high violators has been shown to be considerably higher than that of low violators.

3.8. – The DBQ and special driver populations

Although there have been substantial consistencies in the findings with the DBQ amongst the general driving population, the picture is not as clear in the case of special driving populations, or for those driving in a work-related context. Research on special driver populations, such as elderly people, has produced both a different factor structure and occasionally a different pattern of correlations with crash involvement. For example, Parker et al. (2000), using the 24-item version of the DBQ on elderly drivers (aged 50 or over), found that a five factor solution best fit the data. Although the factor analysis produced a five factor solution, they retained the original three way distinction for further analysis. There were also differences in the type of aberrant driving behaviour reported most often. Their sample of older drivers reported two lapses (misreading signs & getting into the wrong lane approaching a roundabout) as the most frequently reported forms of aberrant driving behaviour. This is in contrast to most previous research, which has found speeding (in various situations) to be the most common aberrant driving behaviour. Parker et al. (2000) also found that relatively high scores on the error and lapse factors were predictive of crash involvement, not the violations score.

Differences have also been found with samples of younger drivers (Dobson et al., 1999; Rimmö & Åberg, 1999) and for samples consisting solely of female drivers (Dobson et al., 1999). For example, using the 24-item version of the DBQ, Dobson et al. (1999) investigated accident rates in both young women

(18-23 year olds) and middle age women (45-50 years old). They found that the most commonly reported aberrant driving behaviours for young women were both violations (disregarding the speed limit at night and overtaking on the inside), while for the middle aged women they were lapses (forget where they parked their car and get into the wrong lane approaching an intersection or junction). Dobson et al. (1999) also found that mean scores for lapses were similar for the two age groups and similar to those found in other studies (Blockey & Hartley, 1995; Parker et al., 1995b; Reason et al., 1990). However, in contrast to previous findings, the mean score for errors amongst the younger women was higher than for the middle aged group, and was also higher than those found in previous research (Blockey & Hartley, 1995; Parker et al., 1995b; Reason et al., 1990).

In contrast to most other studies using the DBQ, Dobson et al. (1999) found the lapse score to be the strongest predictor of crash involvement for both groups of women. In addition, the error score was also a strong predictor of crash involvement in both groups. Furthermore, although the violations score was not predictive of crash involvement amongst the younger women, it was a significant predictor of crash involvement amongst the middle aged women. However, some caution is required when interpreting these results, as Dobson et al. did not submit their data to a factor analysis. Therefore, it is possible that this arrangement of errors, lapses and violations may not have best described their data. Moreover, had they submitted their data to factor analysis this would have provided the opportunity to eliminate differences in the Australian traffic culture as a potential explanation for the differences in factor structure found by Blockey and Hartley (1995).

The above findings show that the driver behaviours of special groups differ from those of the general driving population and that these may be related to crash involvement in different ways. This highlights the importance of measuring the different types of road users, rather than assuming that all drivers are the same as the general population of road users. One important group of road users are those driving in a work-related context.

3.9. - Driving in a work-related context

There has been relatively little research looking at those who drive in a work-related context. The few researchers that have investigated the crash risk of company car drivers have concluded that company car drivers are at a higher risk of crash involvement, when compared to the general driving population (e.g. Chapman, Roberts & Underwood, 2001; Dimmer & Parker, 1999; Lynn & Lockwood, 1998). For example, Lynn and Lockwood (1998) found that company car drivers were 49% more likely to be crash involved than the general public, even after taking into consideration their relatively high exposure and demographic risk factors. Dimmer and Parker (1999) also found that 27% of company car drivers reported involvement in at least one crash over the previous three year period, which is considerably higher than the 18% reported by the drivers of private motor cars in Britain.

Although Chapman et al. (2001) found company vehicle drivers had an increased risk of crash involvement of around 50%, they also found that this figure was not uniformly spread amongst the different types of company vehicle drivers. They divided company car drivers into five groups: those who drove for business using their own car; those who received a car as a part of their remuneration package (a 'perk' car); first or second line managers who received a car because of their requirement to drive for work; those who received a car as their job relied on it (e.g. sales representatives); and those who drove liveried vehicles. Those who received their car as a part of their remuneration package (perk car) and those who received a car as a requirement of their job (e.g. sales representatives) were particularly at risk of crash involvement. Conversely, those who drove their own car, first or second line managers who drove a company car and the drivers of liveried vehicles had a level of risk much closer to that of the general driving population (taking into account mileage).

The DBQ factor structure has also been found to be different amongst those who drive in a work-related context. Using the 28-item version of the DBQ (six violations, six aggressive violations, eight errors, and eight lapses), Dimmer and

Parker (1999) surveyed over 400 people, who drove company cars. Factor analysis of the data produced a six factor solution, rather than the four factor solution found by Mesken et al. (2002) amongst the general driving public. Dimmer and Parker's first factor consisted of all the error items with two of the ordinary violations. The second factor consisted solely of aggressive violations, while the third factor consisted of ordinary violations. The fourth and fifth factors consisted of lapses, while the sixth factor consisted of one lapse (hitting something while reversing) and two aggressive violations (dive in at the last minute and forcing your way out of a junction). It has been suggested that the sixth factor might reflect the fact that the drivers of company cars do not care about their vehicles to the same extent as those with more of a vested interest in the vehicle (A. R. Dimmer, personal communication, August 9, 2000).

Also using the 28-item version of the DBQ, Chapman et al. (2001) measured the aberrant driving behaviour of more than 500 employees from a large firm in England. They almost exactly replicated Dimmer and Parker's (1999) six factor solution for the DBQ items. Therefore, although the three or four factor solution has been found consistently with drivers of private motor vehicles across countries and cultures, there is evidence that the DBQ factor structure may be different for those driving in a work-related context.

In addition to the differences in the factor structure, there have also been differences in the relationship between DBQ scores and crash involvement. Dimmer and Parker (1999) found that those who had been involved in an accident had higher mean scores on all six factors. However, only in the sixth factor (one lapse and two aggressive violations) was the mean significantly higher in those who had been involved in a crash than those who had not been crash involved. In contrast, Chapman et al. (2001) found that those who had been crash involved did not score significantly higher on any of the six factors.

Therefore, although there is substantial consistency in the factor structure and the relationship between DBQ scores and crash involvement for the drivers of private motor vehicles, this does not appear to be the case for specific

populations within the general driving population. This lack of consistency also extends to those driving in a work-related context.

3.9.1. - Truck drivers

Another important group of road users who drive for a living are truck drivers. Unfortunately no published research has used the DBQ to investigate aberrant driving behaviours amongst the drivers of heavy vehicles, or trucks. As truck drivers have a different set of demographics, skill base and possibly also different attitudes than car drivers, it is hard to generalise the results of previous research to the drivers of heavy vehicles. For example, it is known that professional truck drivers have a higher average age than the general driving population, engage in driving for a different purpose than the public, spend more time on the road than the general public, and are involved in fewer crashes per million kilometres (Baas et al., 2000b; Walton, 1999a; Walton, 1999b). Considering these differences, and the differences found amongst those who drive in a work-related context, it would seem realistic to expect some differences in the factor structure of the DBQ, the pattern of correlations, and the prediction of crash involvement.

3.10. – Research aims

No known research has investigated aberrant driving behaviour amongst professional truck drivers using the DBQ. Although the research using the 28-item version of the DBQ on private vehicle drivers produced a four factor solution, the two studies using this version of the DBQ amongst company car drivers found a six factor solution to be more appropriate. Moreover, these three studies also found different relationships between the resultant factors and crash involvement. Given these divergent findings, it seems inappropriate to speculate on the likely factor structure or how the resultant factor may relate to crash involvement.

Therefore, the research aims that have emerged from this chapter are to investigate:

- The level of aberrant driving behaviour amongst New Zealand truck drivers, and the relative ordering of the DBQ items.
- The factor structure of the DBQ amongst New Zealand truck drivers.
- Whether any of the resultant factors are correlated with, and/or predictive of, truck driver crash involvement.

3.11. – Chapter summary

The findings using the DBQ amongst the general population have been relatively consistent. This consistency has been found not only in terms of the relative ordering of the aberrant driving behaviours and the factor structure, but also in the relationship of the resultant factors with crash involvement. However, the findings amongst special populations of drivers (e.g. older drivers and company car drivers) have been less consistent. These inconsistent findings make it difficult to generalise previous findings to truck drivers, who have not yet been studied. The following chapter investigates personality factors that have been found to be correlated with crashes, or have been shown to be potentially useful in the prediction of crash involvement.

Chapter 4

Traffic Accidents and Personality Traits

4.1. - Chapter overview

Chapter 4 commences by investigating the research findings pertaining to personality traits and driving behaviour. The literature linking social deviance and driving behaviour is reviewed, with particular attention to the relationship with crash involvement. A second personality trait, which appears closely aligned with mild social deviance, is egoism or selfishness. The research evidence linking selfishness with various forms of deviant behaviour is explored, with particular emphasis on deviant driving behaviours. In addition, the literature investigating the impact of personality traits on driving behaviour amongst professional drivers is reviewed, before the gaps in the literature are identified and the research aims presented.

4.2. - Personality traits and driving behaviour

Almost 80 years of empirical research has shown that certain individuals have more accidents than would be expected by chance alone. In addition, it has been clearly demonstrated that the high accident rate for many of these individuals is relatively stable over time (Elander et al., 1993; Sorensen, 1994; West, 1997; West et al., 1993a). This suggests that there is something about these crash involved individuals that places them at increased risk compared to other people. This led early researchers to propose the existence of a group of 'accident prone' individuals (Greenwood & Woods, 1919). The concept of 'accident prone' individuals was discredited by later researchers (e.g. McKenna,

1983) for a number of reasons, such as the lack of an adequate definition. However, the most fundamental flaw was the inability to develop tests of accident proneness that were capable of predicting accident involvement (Meadows, 1994). Therefore, subsequent research has eschewed the global concept of accident proneness and instead has focused attention on identifying more specific individual differences that increase, or decrease, the risk of accident involvement.

Personality traits are one category of individual differences that have been implicated in accident or crash liability. Personality is thought to influence an individual's driving style, which in turn is acknowledged as significantly affecting their chances of becoming crash involved (Burgess, 1999; Iversen & Rundmo, 2002; Parker et al., 1995a; Parker et al., 1995b; West et al., 1993a). Certain elements of personality can not only compel individuals to engage in particular driving behaviours, but can also mediate the effects of social influences designed to constrain these behaviours (Burgess, 1999). With this in mind, it should not be surprising that there has been a large amount of research investigating the impact of a plethora of different personality variables on driving style and crash involvement. For example, driving behaviour has been linked to: antisocial tendencies, general psychopathology, negativism and external locus of control (Mayer & Treat, 1977); neuroticism and extroversion (Pestonjee & Singh, 1980; Shaw & Sichel, 1971); sensation seeking (Jonah, 1997); social deviance (Barmack & Payne, 1961; West et al., 1993a); selfishness (Burgess, 1999); conscientiousness (Arthur & Graziano, 1996); self-esteem (Smith & Heckert, 1998); and Type A behaviour (Magnavita, Nada, Sani, Carbone, De Lorenzo & Sacco, 1997).

However, research using personality traits as an independent variable has been criticised for producing inconsistent findings. For example, researchers investigating the effect of extroversion on crash involvement have found crash involved drivers to be more extroverted than non-crash involved drivers (Fernandez Seara, 1978; Lajunen, 2001; Smith & Kirkham, 1981; Shaw & Sichel, 1971), while other researchers have found no differences (Wilson &

Greensmith, 1983), or have even found the opposite (Roy & Choudhary, 1987; Pestonjee & Singh, 1981). There are a number of possible explanations for these inconsistent findings, such as different traffic cultures, type of instrument(s) used to measure the personality trait, and methodological flaws – such as failure to control for exposure (Elander et al., 1993; Lajunen, 2001; Lajunen, Corry, Summala & Hartley, 1997; Lajunen & Summala, 1997). However, there are also personality traits that demonstrate robust relationships across traffic cultures and regardless of the type of instrument used to measure the trait. One example of such a personality trait is social deviance.

4.3. - Social deviance and driving behaviour

Social deviance is characterised by behaviour that goes against the norms of a society, and according to West and Hall (1997) social deviance forms one of the five main personality dimensions encompassed by current personality theories. The research findings have generally found a strong positive association between social deviance and crash involvement (Barmack & Payne, 1961; Conger, Gaskill, Glad, Hassel, Rainey & Sawrey, 1957; Mayer & Treat, 1977; Schuman, Pelz & Ehrlich, 1967; Suchman, 1970; Tilman & Hobbs, 1949) and also between crash involvement and crime (Sivac, 1983; West, 1997). Unfortunately, in the majority of the earlier studies, inadequate account was taken of exposure and risk factors, such as annual mileage, age and gender. However, more recent studies have addressed these methodological shortcomings and have also found strong positive relationships between social deviance and crash involvement (e.g. Lawton et al., 1997b; Meadows et al., 1998; West et al., 1993a; West et al., 1993b; West & Hall, 1997; West, 1997).

One potential problem with the research reporting the link between social deviance and crash involvement is that the results would appear to apply to a very small portion of the population, as only a very small segment of the drivers would be classified as socially deviant. West et al. (1993a) argued that the issue of relevance was only a problem if social deviance was treated as a

dichotomous variable, and was therefore not normally distributed amongst the general population. They hypothesised that social deviance was normally distributed amongst the general population and set out to investigate whether social deviance, within the normal range, was related to crash involvement. In order to measure more mild forms of social deviance, West et al. (1993a) developed a 10-item measure of mild social deviance (MSD), the Social Motivation Questionnaire (SMQ). The scale asked respondents to rate the likelihood of engaging in certain antisocial acts, if they were completely certain of getting away with it. All the behaviours described in the scale carried the risk of causing harm to others, either directly or indirectly, and included such things as calling in sick when they were not sick, or earning money without paying tax on it.

West et al. (1993a) hypothesised that MSD would be associated with an increased risk of crash involvement “independent of any of the other personality measures, age, sex and annual mileage” (p. 210). They also hypothesised that at least part of this association would be mediated by speed and/or driving violations. West et al. (1993a) interviewed 108 subjects and asked them to complete the SMQ, along with a number of other factors underlying accident risk, such as age, gender and annual mileage. As expected, they found MSD was a significant predictor of crash rates, independent of age, sex and annual mileage. In fact, they found that the 25% who reported the highest levels of MSD, also reported four times as many crashes as those in the lowest quartile. Also as hypothesised, the relationship between MSD and crash involvement was partially mediated by faster driving speed. These findings have since been replicated by West (1995b) using a sample of almost 700 UK drivers, and again by West and Hall (1997) using a sample of 406 UK drivers.

Lawton et al., (1997b) further explored the relationship between MSD and crash involvement. Lawton et al. argued that West et al.’s (1993a) finding of partial mediation was due to the fact that their measure of speed consisted of only three items, and hypothesised that a broader measure of driving violations would fully mediate the relationship between MSD and crash involvement. In

order to investigate their hypothesis Lawton et al. used the DBQ violations scale to measure driving violations more broadly. Their data confirmed that MSD was significantly correlated ($r = .12$) with crash involvement. However, using Baron and Kenny's (1986) test for mediation effects, Lawton et al. (1997b) found that, contrary to their hypothesis, the violations score only partially mediated the relationship between MSD and crash involvement. Therefore, MSD mostly has its effect on crash involvement via its relationship with driving violations, but also has a small, but significant direct effect on crash involvement. Lawton et al. (1997b) also found MSD was a strong significant predictor of violations, such that those with higher social deviance scores also reported high scores on the violations factor. Commenting on the significant relationship between MSD and violations, Lawton et al. (1997b) stated that violating behaviour on the roads may be one way in which social deviance manifests itself. This would appear to be common sense, as we would certainly expect more socially deviant individuals to violate rules (including road rules) more often, as this is one of the factors that defines them as being socially deviant.

In a follow up study, Meadows et al. (1998) extended the SMQ by developing five extra items designed to measure extreme social deviance (ESD). The five ESD items included behaviours that only extremely deviant individuals would engage in, such as stealing a car or burgling a house. The more extreme measure of social deviance was needed for this study due to the higher level of deviance expected amongst the participants, who were 100 young male offenders attending a criminal reform centre. Less than 40% of the subjects were at the reform centre because of driving-related offences. As expected, the offenders reported significantly higher levels of mild social deviance and driving violations than subjects in comparable UK research (e.g. Lawton et al., 1997b). As expected, Meadows et al. (1998) found crash involvement was significantly correlated with MSD ($r = .20$) and was very strongly correlated with ESD ($r = .46$). However, using forced entry logistic regression (with mileage entered first), it was scores on the ESD scale, not the MSD scale, that significantly and independently predicted crash involvement. So, although social deviance was still predictive of crash involvement, it was extreme social deviance that was

predictive. Meadows et al. (1998) also tested for mediation effects between ESD, violations and crash involvement. They replicated Lawton et al.'s finding that the violations factor score partially mediated the relationship between social deviance and crash involvement.

While Meadows et al.'s findings provide further support for the link with crash involvement, and for West et al.'s (1993a) supposition that social deviance is a continuum, because of the characteristics of the respondents it was the more extreme measure of social deviance that was related to crash involvement, rather than MSD. One of the reasons MSD was not a significant predictor of crash involvement was due to moderate range restriction effects. As the participants had been found guilty of a variety of criminal offences, we would expect these individuals to be more socially deviant than the general population, which was confirmed by Meadows et al. Thus the MSD scale was not able to discriminate between the most deviant and least deviant individuals as well as the ESD scale, and was therefore unable to predict crash involvement.

Further evidence attesting to the influence of social deviance on crash involvement comes from studies using alternative measures of social deviance, such as criminal convictions (Elander et al., 1993; Haviland & Wiseman, 1974, Cited in West et al., 1993a; West, 1997), and other social deviance scales (Suchman, 1970; West, 1997). Therefore, there is relatively strong evidence that traffic crashes seem to be related in some way to social deviance, particularly mild social deviance.

In addition to crash involvement, MSD has also been shown to be related to certain demographic variables. Research has shown that MSD is significantly correlated with age (younger drivers report higher levels of MSD), gender (males report higher levels of MSD), and experience (less experienced drivers report higher levels of MSD) (Lawton et al., 1997b; West, 1995b; West & Hall, 1997; West et al., 1993a). Furthermore, MSD has also been found to be strongly related to driving behaviour. For example, West et al. (1993a) found that drivers reporting higher levels of MSD, also reported speeding, running red

lights and overtaking on the inside more often. This finding was extended by West (1995b), who found that MSD had a strong positive correlation ($r_s = .23$) with an 11-item measure of driving violations drawn from the original version of the DBQ (Reason et al., 1990).

4.4. - Selfishness and driver behaviour

Another personality trait that appears similar to social deviance is selfishness. Selfishness or egoism³ may be defined as a personality construct involving “the excessive concern with one’s own pleasure or advantage at the expense of the community well-being” (Weigel, Hessing & Elffers, 1999, p. 350). The opposite of selfishness is not the absence of concern with one’s own self interests, but rather a strong belief that individual fulfilment and community well-being are not able to be separated. According to Adams and Webley (1996), the more self-serving an individuals is, the less likely they are to adhere to rules and regulations, when these rules and regulations are at odds with their own interests. In an attempt to explain tax evasion behaviour, Weigel, Hessing and Elffers’s (1987) developed a generic measure of selfishness or egoism. The scale frames tax evasion as a social dilemma, in which the individual is faced with the conflict between the pursuit of their own personal outcomes (avoiding some, or all of their taxes) and the pursuit of collective outcomes (paying their taxes in full).

This social dilemma can also be extended to road user behaviour, since traffic flow is only possible with the collective compliance of all road users with the rules and regulations. Although the violation of road traffic regulations is not normally an offence against a visible individual or group, it is ‘society’ as a whole, or the community that is the ‘victim’ of such an offence. The social dilemma here is the choice between cooperating (obeying the road rules) or defecting (breaking some, or all of the road rules). An individual motorist would

³ Although Weigel et al. (1999) attempt to separate selfishness, egoism and self-serving orientation, the distinction between the three is beyond the scope of this research, and the terms selfishness and egoism are used interchangeably here.

be better off (particularly in terms of getting to their destination faster) if they drove at a speed beyond the posted speed limit, did not give way to other drivers and were able to park anywhere they wanted. Therefore, as the cooperation of all drivers is very important to ensure the safe and efficient flow of traffic, the degree to which an individual values actions that benefit themselves, as opposed to others (i.e. is selfish), is extremely important.

According to Burgess (1999), individuals high in egoism would be likely to 'bully' other road users, seeing them as an annoyance or an obstacle that needs to be overcome. They would also consider their own judgement and driving skills to be superior to those who designed the roads (Burgess, 1999). Therefore, it appears likely that these individuals would engage more often in aberrant driving behaviours than those low in selfishness. This contention has been supported by research evidence (Adams & Webley, 1996; Burgess, 1999; Weigel et al., 1999). For example, Adams and Webley (1996) found that individuals scoring highly on the egoism scale were significantly ($r = .40$) more likely to park in a restricted area. In addition, they also found that higher selfishness was not only a significant predictor of self-reported propensity to park illegally, but was also a significant predictor of actual parking behaviour. In another study relating selfishness to traffic behaviour, Weigel et al. (1999) found that individuals who were unobtrusively observed driving through red lights had significantly higher levels of egoism than individuals observed to obey the traffic lights. The finding of a link between high egoism scores and running red lights has also been reported by other researchers (e.g. van Giels, Hessing & Elffers, 1991; cited in Adams & Webley, 1996).

In research more focused on driver behaviour, Burgess (1996; cited in Burgess, 1999) found high egoism scores to be significantly associated with a higher self-reported likelihood of breaking a number of road rules (close following, overtaking on the inside, running red lights, speeding and queue jumping). In his later research, Burgess (1999) again found that drivers high in selfishness also reported engaging more often in the five different driving violations ($r = .26$). The relationship between selfishness and driving violations has also been

found with an adapted version of the DBQ violations scale. Using a sample of 117 drivers Klumb (1994) found selfishness to be positively ($r = .16$) related to the violations scale⁴. In the same study, Klumb also reported that selfishness was not significantly related to crash involvement. However, given the small sample size and the fact that traffic crashes are relatively rare events, this study may not have been an adequate test of the relationship between selfishness and crash involvement. Moreover, as research suggests personality affects crash involvement by influencing driving behaviours (Burgess, 1999; Iversen & Rundmo, 2002; Parker et al., 1995a; Parker et al., 1995b; West et al., 1993a), the relationship between selfishness and crash involvement may be mediated by another variable. Therefore, the area of driver selfishness appears to be a fruitful subject in which to extend and develop the knowledge on traffic safety.

The selfishness scales used by previous researchers (Adams & Webley, 1996; Burgess, 1999; Klumb, 1994; Weigel et al., 1999) were generic scales, in that they were measuring selfishness in general, not selfish driving behaviour. The association between selfishness and driving violations may be even stronger if a scale was tailored specifically to measure selfish driving behaviour. Lajunen and Summala (1997) have commented that one of the likely causes of inconsistent correlations between personality variables and risky driving is the fact that personality characteristics are normally measured using general inventories that do not specifically include traffic targeted measures. The problems associated with the utilisation of non-specific measures have been noted by other researchers working in the area (e.g. Arthur & Doverspike, 1992; Iversen & Rundmo, 2002). The same point was made by Montag and Comrey (1987), who noted that attempts to relate the personality construct of internality-externality to other criteria were more successful when the measures have been tailored specifically to the targeted behaviour, than when a general measure was used. Therefore, not only has the link between selfishness and crash involvement not been adequately investigated, research has yet to examine the

⁴ Klumb (1994) included two additional violation items (double parking and insisting on one's right-of-way, even after realising that another driver has been inattentive).

possible links between traffic targeted measures of selfishness, aberrant driving behaviour and crash involvement.

Another relationship that has not been investigated is that between selfishness and MSD. There seems to be considerable overlap and potential redundancy between the concepts, as the definitions appear to be very similar. West et al. (1993a) defines MSD as "self-serving behaviours which might directly or indirectly harm the interests of others" (p. 207), while Weigel et al. (1999) define egoism as "the excessive concern with one's own pleasure or advantage at the expense of the community well-being" (p. 350). Both definitions specify that those individuals high in the trait will engage in behaviours that benefit the individual, while being at the expense (directly or indirectly) of some other individual, or society in general.

Further evidence of the relationship between the selfishness and MSD is provided by Weigel et al. (1999), who state, in relation to the earlier development of their selfishness scale, that they attempted to "accommodate the spirit of a general theory of deviance to the particulars of the existing data on tax evasion" (p. 350). In addition, although no published research was found comparing West et al.'s (1993a) measure of MSD with selfishness, egoism scores have been found to be significantly associated with other measures of deviance. For example, Weigel et al. (1999) found that individuals with high egoism scores were observed to cheat more frequently in a business management task. Weigel et al. (1999) also found that individuals high in egoism were significantly more dismissive about the seriousness of sexual harassment, had stronger tendencies to blame the victims of sexual attacks and had higher estimated probabilities of personally engaging in date rape or sexual harassment. In addition, Weigel et al.'s selfishness scale has also been found to be related to other forms of deviant behaviour, such as tax evasion (Hessing, Elffers & Weigel, 1988) and social security fraud (Hessing, Elffers, Robben, & Webley, 1993). Therefore, it appears likely that selfishness may in actual fact be another aspect of social deviance, or at least behaviours that are a result of social deviance.

4.5. - Personality traits and professional drivers

Despite the strong positive correlations between various personality traits and crash involvement amongst private motorists, very little research has been conducted using professional drivers. Furthermore, the research that does exist has focused predominately on bus drivers, has mainly concentrated on a few personality traits, and has produced relatively inconsistent findings. For example, Shaw & Sichel (1971) found that 'bad' bus drivers were significantly more extroverted than 'good' drivers. These findings were subsequently replicated by Pestonjee and Singh (1980) who studied Indian bus drivers. Also using bus drivers, Evans, Palsane and Carrere (1987) investigated the impact of Type-A behaviour on the driving behaviour of professional drivers, and found that the Indian bus drivers with Type-A behavioural pattern braked, passed and honked their horns more often than those classified as Type-B's. This finding was not confirmed using US bus drivers, where no differences between Type-A and Type-B drivers were found (Evans et al., 1987).

Only two articles were found investigating the relationship between social deviance and crash involvement, and one of these was also conducted on bus drivers. West (1997) used psychological data from the pre-employment interviews of Czechoslovakian bus drivers as his measure of social deviance. The tool used to measure social deviance, the Problem Behaviour Inventory, presents 30 attitudinal statements and asks the respondent to answer yes, no, or don't know. The scale includes a number of obviously relevant items (e.g. laws are not made in the interests of ordinary people, and the courts are incapable of judging people fairly) and some less obviously relevant items (e.g. I would rather visit a circus than a boxing match, and I have had a lot of unusual experiences). Although the potential drivers knew the tests would affect their employment prospects, West (1997) still found a significant association (Partial $R^2 = .07$) between social deviance and subsequent crash involvement.

However, there are a number of issues which limit the generalisability of West's (1997) research. For example, the data were collected between 1981 and 1989,

during which time Czechoslovakia was still under communist rule. It seems likely that there would be differences between the traffic culture in communist Czechoslovakia and more democratic countries, such as New Zealand. In addition, the problem behaviour inventory measures attitudes, as opposed to self-reported behaviours used in the SMQ. West (1997) also states that the correlation between MSD and crash rates he found was not as large as those found in previous research using the SMQ.

The second research study investigating the relationship between social deviance and crash involvement used a population of American truck drivers (McFarland and Moseley, 1954; cited in Sorensen, 1994). They found that accident repeaters were more likely to have been involved with the criminal justice system, various social service agencies and have childhood histories of emotional disturbance. Unfortunately McFarland and Moseley did not directly measure social deviance, but inferred it from the truck drivers' involvement in the criminal justice system and various social service agencies. Therefore, given the indirect measure of social deviance and the age of the research (advances in technology and possibly also cultural norms may have changed in 50 years), some doubt must be cast on the ability to generalise these results to modern day New Zealand truck drivers.

Despite the limitations of the previous research on professional drivers, these findings, along with the findings amongst private vehicle driver, suggest two things. Firstly, the relationship between social deviance and crash involvement appears to be robust, irrespective of how social deviance is measured. Secondly, the association between social deviance and crash involvement transcends vehicle type. The latter point is also important, as earlier research has suggested differences in driving behaviour and risk of crash involvement, based on vehicle type (Evans & Wasielewski, 1983; Kim, Li, Richardson & Nitz, 1998).

4.6. - Research aims

No known research has directly investigated the association between social deviance and aberrant driving behaviours amongst professional truck drivers. In addition, no published research could be found investigating the link between social deviance and crash involvement amongst truck drivers. The research using private motor vehicle drivers has found MSD to be directly and indirectly linked with crash involvement, and directly linked with violations. Therefore, given these findings, and the two studies measuring social deviance in professional drivers, we would expect MSD to be linked directly with violations and to be directly, and indirectly, related to crash involvement.

Another interesting association, which has yet to be adequately investigated, is the role selfishness plays in vehicle crashes. As generic measures of selfishness have been shown to be associated with the propensity to violate, we would also expect selfishness to be either directly or indirectly associated with crash involvement. Although research has advocated the use of traffic targeted measures for investigating the link with crash involvement (Arthur & Doverspike, 1992; Lajunen & Summala, 1997; Montag & Comrey, 1987), no traffic targeted measure of selfishness (driver selfishness) was found in the literature. Furthermore, the links between driver selfishness, MSD and the DBQ subscales amongst truck drivers have not yet been investigated.

Therefore, the present research set out to:

- Develop a traffic targeted measure of driver selfishness, and to test that measure.
- Determine whether driver selfishness is correlated with, or predictive of crash involvement.
- Explore the relationship between driver selfishness and other variables, such as violations, MSD and driver demographics.

- To quantify the level of MSD reported by a sample of New Zealand truck drivers.
- To determine whether MSD is correlated with, or predictive of crash involvement amongst New Zealand truck drivers.
- To explore the relationship between MSD and other variables, such as violations and driver demographics.

4.7. - Chapter summary

It is clear that personality variables are related to both the way an individual drives and their risk of crash involvement. This chapter explored the literature investigating the effect of both MSD and selfishness on driver behaviour. There appears to be strong evidence to suggest that regardless of how it is measured, social deviance is related to the way an individual drives and their risk of crash involvement. This relationship holds irrespective of whether they were private vehicle drivers or professional drivers. The sparse research evidence for the role selfishness plays in the driving behaviour of private motorists was also presented, before the gaps in the literature were highlighted and the research aims outlined. The following chapter explores the concept of safety climate and discusses the impact an organisation's safety climate has on the safety behaviours and accident involvement of its employees.

Chapter 5

Safety Climate and Accidents

5.1. - Chapter overview

Chapter 5 discusses the concept of safety climate and describes some of the many dimensions researchers have included in safety climate research. Some of the reasons for the lack of agreement on the dimensions which comprise the safety climate construct are outlined, before the chapter moves on to consider the importance of safety climate in relation to accident involvement and engagement in unsafe behaviours. The very few articles relating organisational factors to driving are reviewed, prior to the presentation of the research aims.

5.2. - Safety climate

When studying the accident risk of people in their workplace, the characteristics of the employing organisation must also be taken into account. It seems axiomatic that the employing organisation would have some kind of influence on their employees' attitudes and perceptions of safety, and also their safety behaviours. For example, Varonen and Mattila (2000) suggest that employees observe the work environment, the actions of their fellow workers and supervisors to create cognitive models associated with safety. They argue that these models are used to regulate the actions of the individuals and groups in the workplace, thereby having an influence on safety.

One approach to the investigation of organisational factors that influence safety is through the measurement of safety climate⁵. Safety climate, as originally operationalised by Zohar (1980), was developed from Schneider's proposal (1975) that any given organisation creates a number of different climates, and the term organisational climate has to be supplemented by an appropriate adjective to indicate the type of climate that is being researched. Safety climate can be defined as a summary concept that describes the safety ethic in an organisation and is reflected in the employees beliefs about safety (Williamson, Feyer, Cairns & Biancotti, 1997).

Researchers have generally broken safety climate into a number of different dimensions. For example, the original research by Zohar (1980) on high and low accident rate companies in Israel produced a measure of safety climate with eight dimensions, including; importance of safety training programmes, management attitudes towards safety, effects of safe conduct on promotion, effects of required workplace on safety, level of risk at the workplace, status of the safety officer, effects of safe conduct on social status, and the status of the safety committee. Brown and Holmes (1986) attempted to replicate Zohar's findings using workers from the USA. Unfortunately, their results did not support Zohar's findings, as confirmatory factor analysis revealed a three factor solution was more appropriate. The three factors were; employee perceptions of management concern for their well-being, how active management was in responding to the workers concerns, and the workers' own perception of physical risk.

Using construction workers, Dedobbeleer and Beland (1991) attempted to replicate Brown and Holmes's (1986) three factor solution, but found a two factor solution was more appropriate. Their two factors were interpreted to be management commitment to safety and workers' involvement in safety. More recently Niskanen (1994) found the safety climate of Finnish roading workers

⁵ The concept of safety climate is interlinked and overlaps with the concept of safety culture. Much debate has been generated about when to use each term and the boundaries of each concept (for a full discussion see Cox & Flin, 1998 and Mearns & Flin, 1999). The current research does not intend to enter into this debate, but uses the term safety climate, given the questionnaire-based approach taken here.

consisted of four dimensions; attitudes towards safety in the organisation, changes in work demands, appreciation of the work, and safety as a productive part of work. However, in a study of airport personnel, Díaz and Cabrera (1996) found a six factor solution best described their data. They labelled the six factors; company policies towards safety, emphasis on productivity verses safety; group attitudes towards safety, specific strategies of prevention, safety level perceived at the airport, and safety level perceived on the job.

Clearly there has been little agreement on the dimensions that form an organisation's safety climate. This lack of agreement is due in part to the absence of a theoretical model of safety climate (Williamson et al., 1997). The absence of a theoretical model has lead to the proliferation of different assessment instruments, which have been developed in different languages and cultures, in different industries and tailored specifically for individual organisational requirements (Flin, Mearns, O'Connor & Bryden, 2000).

Recent efforts have attempted to address the lack of agreement on the number and type of dimensions, and to develop a better understanding of the dimensions encompassed within the safety climate construct (Flin et al., 2000; Williamson et al., 1997). For example, after reviewing the literature Williamson et al. reported the eight most frequently reported dimensions to be; safety awareness, safety responsibility, safety priority, management safety commitment, safety control, safety motivation, safety activity and safety evaluation. However, Flin et al. (2000) examined a larger sample of safety climate studies than Williamson et al. (1997) and found three main dimensions appeared in two thirds of the questionnaires. These were management's attitude and behaviours towards safety, satisfaction with safety systems and risk taking. Flin et al. also found factors relating to work pressure and the competence of the workforce to be commonly reported dimensions. Flin et al. likened these five dimensions to the 'Big Five' factors in personality measurement. However, it remains to be seen whether the following studies will support the concept of the 'Big Five' safety climate components.

5.3. - The utility of safety climate

Although there is still no agreement regarding the dimensions comprising safety climate, the construct appears to offer a useful and valid methodology for the evaluation of safety in organisations. Research has found that measures of safety climate produce very similar results to those of more objective methods, such as a physical auditing of workplace condition and safety measures (Mattila, Rantanen, & Hyttinen, 1994).

The measurement of safety climate provides information that can be used to prevent accidents occurring. Mearns et al. (2001a), for example, state that safety climate information is a 'leading indicator' of safety, as it indicates the workforces' perceptions and attitudes about safety in their workplace, prior to an accident or incident occurring. This is as opposed to accident information, which can be describe as a 'lagging indicator', as it indicates the presence of danger or a failure after it has already happened (Flin et al., 2000; Mearns, Whitaker & Flin, 2001b). Essentially, measures of safety climate can provide prewarning that a safety problem exists. This information can then be used to make necessary changes to forestall employees engaging in unsafe behaviours, thereby preventing accidents. The potential of safety climate has led to industries where significant hazards exist (such as nuclear power and offshore oil platforms), moving away from relying on retrospective measures of safety (e.g. lost time injuries) to leading measures of safety, such as the use of safety climate information (Flin et al., 2000).

Safety climate has been shown to be related to unsafe behaviours, such that in organisations with positive safety climates workers engage less frequently in unsafe behaviours (Clarke, 1998a; Cohen, 1977; Hofmann & Stetzer, 1996; Smith, Cohen, Cohen & Cleveland, 1978). For example, Hofmann and Stetzer (1996) measured organisational factors in a chemical processing plant and found that safety climate was significantly correlated with unsafe behaviours. They state that one explanation of this significant correlation with safety behaviour is that a strong safety climate results in the employees taking

personal control of safety activities and developing strong norms regarding the performance of tasks in a safe manner. This results in them engaging less frequently in unsafe behaviour (Hofmann & Stetzer, 1996).

The correlation of safety climate with unsafe behaviour is a particularly important one, as research has shown engagement in unsafe behaviour to be the best predictor of self-reported accidents and near misses (Lawton, 1998; Lawton & Parker, 1998; Mearns et al., 2001a). With this in mind, it is not particularly surprising that research has generally been supportive of the link between safety climate and accident rates (Díaz & Cabrera, 1996; Dwyer & Raftery, 1991; Hofmann & Stetzer, 1996; Rundmo, 1994; Tomás et al., 1999; Varonen & Mattila, 2000; Zohar, 1980). Varonen and Mattila (2000), for example, found that companies with better than average accident rates had more positive safety climates than those with worse than average accident records. In addition, Díaz and Cabrera (1996) found that low accident companies were eminently better than high accident companies in terms of the management commitment to safety, employee training, standard of selection procedures, absenteeism and turnover.

In an analysis of the safety climate on offshore oil rigs, Mearns, Flin, Gordon and Fleming (1998) found a number of differences between workers who had been accident involved in the previous two years and those who had not been. Statistically significant differences were found on: job communication (accident involved reported less job communication); safety behaviour (accident involved reported committing more unsafe acts); work task hazards (accident involved felt less safe); satisfaction with accident prevention (accident involved less satisfied); and satisfaction with emergency response procedures (accident involved less satisfied). Mearns et al. (1998) also measured safety attitudes. Significant differences between accident involved and non-accident involved individuals were found for seven of the 10 factors identified from the safety attitudes scale. For example, those who had been accident involved expressed more negative attitudes towards safety, felt under more pressure to violate rules and regulations to get the job done, held less positive attitudes to rules and

regulations, and reported lower personal responsibility for their own safety (locus of control). Unfortunately using a cross sectional survey, such as Mearns et al. (1998) used, it is not possible to say whether those who had an accident held those perceptions and attitudes all along, or whether their experience of an accident had formed them.

In an effort to address the issue of the association between safety climate and prospective accident involvement, Mearns et al. (2001b) assessed the safety climates of nine offshore oil and gas installations twice, at one year intervals. They found that safety climate scores at year one had a significant negative correlation with accident rates in year two, and were predictive of self-reported accidents. However, no significant correlations were found between the safety climate and accident rate of the corresponding year (Mearns et al., 2001b). Mearns et al. (2001b) also found that changes in perceived management commitment to safety (one aspect of safety climate) was closely associated with changes in safety behaviour.

Zohar (2000) hypothesised that perceptions of safety climate would also be related to minor injuries. These were defined as injuries that required first aid treatment, rather than resulting in lost time. In order to test this, Zohar assessed safety climate using an especially constructed scale and recorded incidents of minor injuries over the following five months. Factor analysis of Zohar's data revealed two dimensions. The first dimension was labelled 'supervisory action' and was to do with the degree of feedback from the workers' supervisors and the initiation of action concerning safety issues. The second factor had mainly to do with the workers' perception of the supervisors preference for production verses safety. Further analysis of the data found that both factors were significant predictors of minor injury rate, jointly accounting for 16% of the variance in minor injuries. Therefore, evidence is beginning to emerge that safety climate can be used to predict future accident, and minor accident involvement.

Safety climate information can also be used as a method for assessing the effectiveness of safety programmes. Measurements of safety attitudes, beliefs or behavioural tendencies can be measured both before and after the implementation of a safety intervention to determine whether it has resulted in the desired changes. Unfortunately little use has been made of this potential (Coyle, Sleeman & Adams, 1995), with most organisations and researchers instead focusing on measures of lost time and injury frequency rates.

Clearly the concept of safety climate has considerable potential for improving organisational safety. However, despite the potential utility of safety climate, there has been relatively little research in this area (Saari, 1990; Shannon, Mayr, & Haines, 1997; Zohar, 2000). Moreover, the research which has been conducted has largely been confined to a few 'high reliability' industries, such as nuclear power and oil drilling platforms (Zohar, 2000). This lack of research is particularly notable amongst those driving as a part of their work.

5.4. - Safety climate and driving

The risk of being killed while driving as a part of work is very high. Figures from Finland have shown that traffic crashes were the leading cause of death at work, accounting for 38-63% of all work-related fatalities between the years 1975 and 1994 (Salminen & Lähdeniemi, 2002). The proportion of work-related fatalities due to crash involvement has also been found to be similarly high in the United States (Miller, 1995) and Australia (Harrison, Mandryk & Frommer, 1993).

However, despite the size of the problem, and the apparent importance of safety climate, very few published articles investigating the impact of particular organisational factors on driving could be found. Of the research that had been published, only one focused upon those who drive on the road. In a study investigating the organisational factors affecting the incident reporting of train drivers, Clarke (1998a) found that one aspect of safety climate (negative perceptions of managements reaction to incident reports) suppressed the

reporting of incidents. This provides some evidence that a negative safety climate may also affect safety behaviours (in this case, reporting incidents) amongst professional drivers in the same way as employees in other industries.

There is also evidence to suggest that safety climate is related to incidents and accidents amongst train drivers. For example, Edkins and Pollock (1997) found that organisational factors (e.g. rules, policies, procedures, and communication) were represented in 15% of all incidents and accidents. In addition, a poor safety culture was implicated as a substantial contributor to the Clapham Junction rail disaster, in which 35 people lost their lives (Clarke, 1998b). Thus there is a limited amount of evidence to suggest that a negative safety climate affects train drivers' engagement in safety behaviours and their involvement in accidents and incidents.

Although research has postulated that an organisation's climate will have an affect on the performance of those who drive on the road for a living (e.g. Jacobs, Conte, Day, Silva & Harris, 1996), the actual research evidence is limited. Only one published study was found, which explored the impact of a single organisational factor, stress, upon the crash histories of company car drivers. Cartwright et al. (1993) investigated the crash histories and reported stress amongst company car drivers in four companies. They found that the employees in the company with the highest crash involvement also reported significantly higher levels of stress emanating from all aspects of their working environment, including organisational climate. This research provides very limited evidence that one specific organisational factor (stress – induced by the workplace) can affect crash risk amongst company car drivers. However, it is possible that this will also be the case for other types of professional drivers, who are also subjected to organisational stressors.

5.5. - Research aims

No known research has directly investigated the association between safety climate and unsafe driving behaviours amongst professional truck drivers. Furthermore, research could not be found investigating the link between perceptions of safety climate and crash involvement amongst truck drivers. The research evidence from other industries indicates that safety climate has an affect on employee engagement in safety behaviours, and thereby their involvement in accidents. Therefore, it would seem likely that the perceptions of safety climate would also influence the way truck drivers behave on the road, and their involvement in crashes.

Therefore, the research aims that emerge from the present chapter include:

- To explore the relationship between safety climate and crash involvement.
- To investigate the links between safety climate and other variables, such as MSD, driver selfishness and aberrant driving behaviour.

5.5. - Chapter summary

This chapter described the safety climate concept and the dimensions that make up a safety climate. Research evidence supporting the relationship between safety climate and important dependent variables, such as engagement in unsafe behaviours and accident involvement, were summarised. The literature has clearly shown that a negative safety climate is associated with higher levels of unsafe behaviour and accident involvement. Conversely, a positive safety climate has been found to be associated with lower levels of unsafe behaviour and lower accident involvement. Despite the obvious importance of safety climate to an organisations' safety, a dearth of research

investigating safety climate amongst professional drivers was found. The present study will investigate the relationships safety climate has with the other main variables, such as driver selfishness, aberrant driving behaviour, preferred speed and crash involvement. The following chapter describes the methodology that was used in the current research.

Chapter 6

Methodology

6.1. – Procedural overview

The first stage of the research required the development of a suitable measurement instrument. This involved the adaptation of a number of existing scales as well as the construction of a new scale. The scales of aberrant driving behaviour, mild social deviance and safety climate needed only relatively minor wording changes to reflect the different terminology used in New Zealand, and in particular by New Zealand truck drivers. However, the concept of driver selfishness had previously only been measured using a generic selfishness scale. Therefore, a scale of selfish driving behaviours, specific to driving trucks, was constructed after interviewing a number of truck drivers. The survey instrument was then posted to truck drivers working in the logging, petroleum and milk transport industries. Once the data had been collected, it was analysed using a number of different statistical techniques, including; simple correlations, factor analysis and logistic regression.

6.2. - The survey instrument

A survey instrument was developed, which incorporated six different categories of measures, including; demographic and descriptive variables, aberrant driving behaviours, selfish driving behaviours, mild social deviance, safety climate, and questions about the participant's crash history over the previous three years.

6.2.1. - Demographics and descriptive variables

The following demographic and descriptive variables were collected; age, gender, annual mileage, type of load (logs, petrol, milk), employment situation (employee, owner-driver, etc), years driving trucks, years driving trucks in their current industry (logging, petrol or dairy), and type of rig normally driven. Drivers were also asked their preferred driving speed, using an adapted version of the 4-item preferred speed scale used by Meadows (1994) and Meadows et al. (1998). The scale asked respondents to state their preferred driving speed on the four following road types; the open road, a winding country road, a busy main street, and a road through a residential area (see Appendix 5).

6.2.2. - Aberrant driving behaviours

The 28 item version of the DBQ, as used by Dimmer and Parker (1999), was adapted and used to measure self-reported aberrant driving behaviour. This version of the DBQ included eight error items, eight lapse items and the twelve violation items developed by Lawton et al. (1997b). The scale was adapted slightly to fit New Zealand terminology and the sample population (truck drivers). For example, the term “motorway” was changed to “open road” and “car park” was changed to “truck park”. Participants were asked to indicate, on a six-point frequency scale (0 = Never, 5 = All the time), how often they engaged in each of the 28 aberrant driving behaviours over the past year (see Appendix 5).

6.2.3. - Mild social deviance

The 10-item Social Motivation Questionnaire (SMQ), developed by West et al. (1993a) was used to measure mild social deviance. Participants were asked to indicate on a three point scale (1 = Not at all likely, 3 = Very likely) how likely it

was that they would engage in each of the 10 different types of mildly deviant behaviour, if they were certain of getting away with it (see Appendix 5).

6.2.4. - Driver selfishness

As no measure of driver selfishness could be found in the published literature, a driver selfishness scale was developed. Firstly, a set of questions was developed to form the basis of structured interviews (see Appendix 6). The questions were developed by the researcher and were designed to get the truck drivers to articulate exactly what types of driving behaviours they perceived to be selfish. The structured interview contained two very general questions about road safety, which were followed by six questions designed to glean information from the truck drivers about selfish driving behaviour. The questions asked the truck drivers what they perceived as selfish driving behaviour, the selfish driving behaviour they themselves had engaged in, the selfish driving behaviours they had seen other truck drivers engage in, and how they would train others to avoid engaging in selfish driving behaviours.

Thirty two truck drivers were interviewed using the structured interview, all of whom also had the opportunity to participate in the final survey. The drivers were selected according to their proximity to the researcher, in order to facilitate the interview process. Ten of the drivers interviewed drove logging trucks, 10 drove petrol tankers and 12 drove milk tankers. These interviews provided a large number of statements about the kinds of driving behaviours that truck drivers believed constituted driver selfishness. These statements were categorised according to their content and the most representative item was chosen from each category for inclusion in the scale. These statements were combined to form a 23-item driver selfishness scale. Participants were asked to indicate, using a six-point frequency scale (0 = Never, 5 = All the time), how often they engaged in each of the 23 selfish driving behaviours over the past year (see Appendix 5).

6.2.5. - Safety climate

Safety climate was measured using the 17-item unidimensional scale developed by Williamson et al. (1997). The scale had what Williamson et al. called an acceptable alpha coefficient of 0.61, and was able to distinguish between those who had experienced an accident from those who had not at the 0.06 level of significance. A number of the items were re-worded slightly in order to make them more relevant for the truck drivers. For example, "Everybody works safely in my workplace" was changed to "Everybody drives safely in my company". Participants were asked to indicate, on a five point scale (1 = Strongly agree, 5 = Strongly disagree), whether they personally agreed with 17 statements about the safety on their job (see Appendix 5).

6.2.6. - Crash involvement

Drivers were asked for details of all trucking accidents they had been involved in, while driving a truck, during the previous three years. They were also asked to indicate how many crashes they had been involved in over their entire career as a truck driver. The definition of accident, adapted from Parker et al.'s (1995a) definition, was "By accident we mean any incident which involved injury to another person or yourself, damage to property, damage to another vehicle or damage to the vehicle you were driving".

6.3. - Data collection procedure

The milk transport companies were identified by contacting all milk processing factories whose telephone numbers were published in the 1998 telephone directories for every region in New Zealand. At the time of the research the New Zealand dairy products market was dominated by three main companies, all of whom were contacted. Market share information could only be found for the two largest of these, which together claimed to have 89% of New Zealand's total

milk production (Kiwi Dairies Co-operative, 2000; New Zealand Dairy Co-operative, 2000). All companies were contacted by phone, informed about the research and asked to participate.

The log transport companies were identified by contacting Carter Holt Harvey Forests, Fletcher Challenge Forests, Weyerhaeuser New Zealand, Rayonier New Zealand, Wenita New Zealand, City Forests, and Juken Nissho New Zealand. These companies were the main forest harvesting companies working in New Zealand and together owned over 51% of the production forests in New Zealand (New Zealand Forest Owners Association, 2000). The percentage of forest ownership is an under-estimate of the total proportion of New Zealand's logging trucks used by these seven companies, as six of the seven also purchase, harvest and transport wood grown in forests other than their own. The forest companies were contacted, informed about the research and asked for the names and contact details of the transport companies who transported logs for them.

The companies who transported petrol were identified by contacting BP, Caltex, Challenge, Mobil and Shell. They were informed about the proposed research and asked for the name(s) and contact details for the transport companies who transported petrol for them. At the time of the survey, these were the only oil companies selling petrol in New Zealand.

In total fifty five transport companies working in the New Zealand dairy, petroleum and logging industries were contacted by telephone, informed about the research and asked if they would be interested in participating. Forty eight transport companies agreed to participate and the appropriate number of questionnaires and reply-paid envelopes were posted, along with a covering letter explaining the research (Appendix 7). The transport companies then distributed the materials to all the drivers they employed. The drivers were given full information about the nature and purpose of the research. They were also assured their responses would remain completely confidential and that the researcher would be the only person to see their individual questionnaire. The

participants were assured of anonymity and asked to fill out the questionnaire and return it using the reply-paid envelope.

In an attempt to increase the response rate, the transport companies were all contacted by phone and asked to remind their drivers to fill out and return the questionnaires. Each transport company was given three reminders, at fortnightly intervals. In order to further ensure an adequate response rate, an inducement was included. Participants were asked to include their name on the back page of the questionnaire to go into the draw to win three possible prizes. First prize was a \$120 Mitre 10 gift voucher (a New Zealand wide chain of hardware stores), second prize was a \$50 Repco gift voucher (a New Zealand wide chain of stores selling vehicle accessories, tools and supplies), and third prize was a \$30 Whitcoulls gift voucher (a New Zealand wide chain of book stores). The back page of the questionnaire containing the name of the driver was detached from the rest of the questionnaire so that the individual participants could not be identified. The research complied with the Massey University Human Ethics Committee guidelines for research involving human participants.

6.4. – Participants

In total, 1065 questionnaires were sent out to truck drivers working for companies transporting logs, milk and petrol in New Zealand. A total of 382 questionnaires were received back, giving a response rate of 36%. Four of the 382 returned questionnaires had not provided answers to the majority of the questions and were thus excluded. The remaining 378 truck drivers were mainly male (99.2%), with a very small number of females (0.8%). The average age of the participants was 40.38 years (*SD* 9.64) with a minimum age of 20 (a person must be at least 18 years old to obtain a license to drive a truck) and a maximum of 62 years old.

6.5. – Data analysis

6.5.1. - Data screening

Prior to data cleaning, the raw data were entered into the statistical package SPSS (V.9.0), which was used for all data analysis. The data were then examined for accuracy of input and consistency (i.e. if a driver answered yes to having been crash involved during the last three years, they also must have reported being crash involved during their career). Univariate descriptive statistics were studied for out of range values, plausible means and standard deviations. Out of range data were identified and removed. Once it had been established that the data were accurately entered, coefficients of variation were calculated for continuous variables.

When the item means are very large and the standard deviations very small, the values in the correlation matrices are also sometimes too small (Tabachnick & Fidell, 1989). Statistical programmes such as SPSS encode the first digit of a very large number and then round off the rest. If the variability is contained solely in the digits that are rounded off, then the correlations between the variable and other variables are inaccurate. One indicator of this problem is the coefficient of variation, which is calculated by dividing the standard deviation by the mean. When the coefficient of variation is very small (≤ 0.0001) computational inaccuracies may occur (Tabachnick & Fidell, 1989). In all cases the coefficients of variation found amongst this data set were above the 0.0001 criteria specified by Tabachnick and Fidell (1989).

The next stage in the data screening was to examine the amount and distribution of missing data. Although relatively little of the data appeared to be missing, it is the pattern of the missing data that is vital. Tabachnick and Fidell (1989) state that non-random missing values are important because they affect the generalisability of the results. Refusal to answer questions may be related to important variables. For example, drivers who fail to report their age may be

older rather than younger drivers. However, examination of the missing data revealed no discernible pattern.

Univariate normality of relevant variables was assessed by computing skew and kurtosis values for each item. Analysis of the individual items for both the DBQ and Driver Selfishness scales revealed that the majority of the variables had skew and/or kurtosis problems. Items with skew or kurtosis values above ± 1.00 were transformed using progressively severe transformations until the skew and kurtosis values were below, or as close as possible to ± 1.00 .

For the DBQ scale, six of the items had acceptable levels of skewness and kurtosis, while the remaining 22 items ranged from having moderate to severe skewness. The skew and kurtosis problems were eliminated for six of the variables using square root transformations, and a further six using log transformations. The remaining 10 DBQ items had severe positive skewness, which was by and large resolved using reflect and inverse transformations.

Skew and kurtosis were much less severe for the Driver Selfishness scale, with almost half (10) of the items having acceptable levels of skewness and kurtosis. For the remaining items, the skew and kurtosis problems were eliminated for six of the variables using square root transformations, and a further six using log transformations. Only one of the items had severe positive skewness, which was reduced to within acceptable limits using a reflect and inverse transformation.

Once the transformations had been completed the data were screened for univariate outliers through the calculation of z scores. Individual responses which resulted in the production of z scores over ± 3.00 were removed as univariate outliers. This process was undertaken for all the main scales. For the DBQ scale 23 univariate outliers were removed, while for the selfishness scale 37 univariate outliers had z scores higher than ± 3.00 and had to be removed. For the two univariate scales (safety climate and mild social deviance) the items were combined to produce means. These means were then screened for

normality and univariate outliers. Only one outlier was removed from the safety climate scale, while no z scores were greater than ± 3.00 for the mean MSD scale.

Multivariate normality was also examined for the DBQ and selfishness scales through the calculation of Mahalanobis distances. The Mahalanobis distances were calculated by using all the items in each scale as independent variables in a regression, with the case number as the dependent variable. Cases where the Mahalanobis distances were above the critical chi-square value were removed. As it is possible for multivariate outliers to be partially obscured by other outliers, this process was repeated several times, until no further outliers were identified.

For the DBQ scale, with 27 degrees of freedom (it was not 28 as one item had been removed prior to this analysis) the critical value was 55.476 ($p < 0.001$). Three runs were needed, resulting in the removal of three multivariate outliers. For the selfishness scale, with 23 degrees of freedom, the chi-square critical value was 49.728. This required two runs and resulted in the removal of five multivariate outliers in the first run. No further outliers were identified in the second run.

6.5.2. – Combining scale items

As the four preferred speed items were essentially different scales, they were standardised using a z score transformation before being combined to form the preferred speed scale, which was used in all further analyses. Both the MSD and safety climate measures were univariate scales and therefore were not factor analysed. Instead the individual items were each combined to form a mean MSD score and a mean safety climate score. These were then used in all subsequent analyses.

Previous research has shown the DBQ scale consists of several different components. Therefore, Principal Components Analysis (PCA) was used to investigate the scales factor structure. As the component structure of the DBQ scale had not previously been investigated amongst truck drivers, no preconceptions were held about the factor structure of the scale, meaning exploratory PCA was appropriate. Exploratory PCA was also undertaken for the driver selfishness scale, as there were again no preconceived ideas about the scale's factor structure.

6.5.3. – Factor analysis strategy

Prior to analysing data using factor analysis, there are a number of conditions that must be satisfied. According to Tabachnick and Fidell (1989) the general rule of thumb is to have at least five cases to each variable. As there were more than 10 cases per variable in the largest scale (DBQ with 28 items), the sample sizes for both scales were considered adequate for factor analysis. The Kaiser-Meyer-Olkin measure of sampling adequacy was used to determine factorability for the DBQ and Driver Selfishness scales. In both cases the data sets produced KMO's above the .6 criteria, specified by Tabachnick and Fidell (1989), suggesting that the data for the DBQ and Driver Selfishness scales were suitable for PCA.

One of the difficulties in determining the number of factors to retain is the fact that there is no objective criterion by which to judge how many factors to keep (Hakstian, Rogers & Cattell, 1982). In order to decide upon the number of factors to retain for each PCA the Kaiser 1 rule (Kaiser, 1970), the scree test (Cattell, 1966) and the residual correlation matrix were used.

The Kaiser 1 rule recommends the retention of components with eigenvalues greater than 1.00. Researchers (e.g. Gorsuch, 1983) have stated that the Kaiser 1 rule is intended to identify the maximum number of components that should be retained. Therefore, to assess whether the Kaiser 1 rule had over-

estimated the number of components the scree test was performed (Cattell, 1966). The scree test involves a visual assessment of the eigenvalues, plotted against the number of factors, to identify graphically the separation of non-trivial and trivial components. The assumption behind this method is that factor variance will decrease as components measure random error. The test involves looking for the point of inflection, which is where a line drawn through the data points changes direction.

The residual correlations matrix indicates the difference between the actual correlations and the model's correlations. In a good factor analysis the proportion of non-trivial residuals will be low (Everitt, 1996). However, if there are a large number of non-redundant residuals, this may indicate the presence of another factor. The percentage of non-redundant residuals in the residuals correlation matrix was used as a final check on the most appropriate number of factors.

Once the number of components has been selected, the next problem is which method of rotations to use. Rotating the items is used to assist in the interpretation of the final component matrix (Tabachnick & Fidell, 1989). The method of rotation can be orthogonal or oblique, depending on the degree of correlation between the components. The strategy for selecting the appropriate method of rotation was that outlined by West (1991) and described below. The data were subjected to PCA the first time using oblimin rotations to assess the size of inter-correlations. If any of the components were correlated at 0.3, or above, oblique rotations were appropriate. However, if there were no inter-correlations at, or above, 0.3 then varimax was the technique selected. Varimax and oblimin rotations are the most commonly used orthogonal and oblique (respectively) rotation techniques (West, 1991).

6.5.4. - Testing for relationships between variables

Zero-order correlations (Pearson's r) were calculated to assess the relationships amongst the main variables. Those variables that were highly correlated with the variables of interest (e.g. number of crashes) were further analysed using regressions to test for prediction.

When the outcome variable was normally distributed, linear regressions were used. If, however, the dependent variable was non-normally distributed, then logistic regression was used. Logistic regression is a mathematical modelling approach that can be used to describe the relationship between several independent variables and a dichotomous dependent variable (Kleinbaum, 1996). Logistic regression is a popular procedure used to analyse epidemiological data when the outcome of interest is dichotomous and relatively rare (as is the case with crash involvement). Participants who reported no crashes during the previous three years received a score of 0, while those who reported involvement in one or more crashes received a score of 1. Drivers with less than three years experience driving trucks (eight drivers) were excluded from these analyses to ensure a uniform period for comparison.

Logistic regression produces a number of statistics analogous to those found in linear regression. For example, the Wald statistic is analogous to the t statistic and the Nagelkerke R^2 is analogous to the R^2 in linear regression. Logistic regression also produces an odds ratio (Exp (B) column), which tells us the relative amount by which the odds of an outcome increase (with odds ratios > 1) or decrease (with odds ratios < 1) when the value of the predictor variable is increased by one unit.

6.5.5 - Testing for mediation effects

Mediation effects amongst the important variables were tested for two main reasons. Firstly, previous research has found mediation effects to exist between

variables that were also measured in the current research. Secondly, the properties of the newly developed driver selfishness scale were unknown. Therefore, tests of mediation were undertaken to more fully understand its relationships with the other variables of interest.

Several recommendations exist for how to test for mediating relationships. The method proposed by Baron & Kenny (1986) was chosen, in order to be consistent with previous research investigating similar variables (Lawton et al., 1997b; Meadows et al., 1998). Baron and Kenny (1986) suggest mediating relationships can be tested using a combination of three regression equations. Firstly, the mediator is regressed on the independent variable. Secondly, the dependent variable is regressed on the independent variable, and thirdly, the dependent variable is regressed on the independent variable and the mediator. A mediation relationship is present if the independent variable affects the mediator in the first regression, the independent variable affects the dependent variable in the second equation, and the mediator affects the dependent variable in the third regression. Finally, the independent variable should have no effect or a reduced effect in the third regression when the mediator is controlled. If the independent variable is found to have no effect when the mediator is controlled, this demonstrates complete mediation. However, if the independent variable is found to have a lower effect when the mediator is controlled, this indicates partial mediation.

6.6. – Chapter summary

This chapter had three sections and summarised the methodology for the research project. The first section of the methodology chapter described the survey instrument, where the scales came from and/or how they were developed. The second part of this chapter outlined the process by which the data were collected and the final part of this chapter provided a description of the statistical procedures used to analyse the data. The following chapter presents the results from the research described in this chapter.

Chapter 7

Results

7.1. – Chapter overview

Chapter 7 presents the main findings of this research. The chapter commences by presenting the demographic and descriptive variables associated with the participants. The results from the factor analysis of the DBQ and Driver Selfishness scales are then presented, followed by the correlations between the main variables. The factors that were significantly correlated with crash involvement were then tested for the ability to predict crash involvement. Finally, the relationships between a number of the variables are tested for mediation using the approach developed by Baron and Kenny (1986).

7.2. – Demographic and descriptive variables

Table 1 presents the demographic and descriptive variables for the participants in the study. The majority of the participants were male (99.2%). Almost half (47.9%) of the sample hauled logs, less than a quarter (24.3%) hauled petrol and just over a fifth (22.0%) hauled milk. A truck and trailer was the most commonly driven truck (76.2%), followed by a tractor semi (11.1%) and a single truck (5.6%). The vast majority of the participants were either employees of a company (89.7%) or worked for an owner-driver (5.6%). Only 3.7% stated that they were owner-drivers.

The average age of the drivers was 40.4 years, with a minimum of 20 (a person must be at least 18 years old to obtain a license to drive heavy vehicles) and a

maximum of 62. The participants were very experienced at driving trucks in general (average of 18.4 years) and in their current industry (average of 9.7 years). They were also extremely experienced in terms of annual mileage, reporting an average annual mileage of 95,092 km/year (range 1,500 - 251,000 km/year)⁶.

The drivers reported preferring to travel at an average speed of 93.3 km/hr on the open road, and 66.1km/hr on a winding country road. The legal speed limit for trucks depends upon the truck configuration. For a single truck the open road (and country road) the speed limit is 90km/hr, while a truck and trailer combination must travel at, or below, 80km/hr. On a busy main street the drivers reported preferring to travel at an average speed of 43.1 km/hr, and 49.8km/hr on a residential road⁷. For subsequent analyses the four speed items were combined to form an index of preferred speed, in line with Meadows et al. (1998).

Most of the truck drivers (62.7%) reported that they had not been crash involved in the last three years. Of those who reported being crash involved, 22.5% reported being involved in one crash, 9.9% reported two crashes and 4.9% reported being involved in more than two crashes over the last three years. Almost a quarter (24.1%) of the drivers reported that they had not been involved in a crash over their career, 24.9% reported being involved in one crash, 21.3% reported two crashes, and 13.5% reported being involved in three crashes. The remaining 15.8% reported being involved in more than three crashes in their career, with a maximum of 7⁸.

⁶ Two drivers reported annual mileages of over 400,000km/year. These values were removed as outliers, as it was not possible to legally drive this far in one year.

⁷ Three values that indicated the driver preferred to travel at 80-85km/hr on a busy main street were removed as outliers.

⁸ One driver reported 56 crashes. The figure was viewed as an outlier and removed.

Table 1
Descriptive and Demographic Variables

| | | | | |
|-----------------------------|------|-------------------|--------------------|-------------------|
| <i>Gender</i> | % | <i>Truck Type</i> | % | |
| Male | 99.2 | Truck & trailer | 76.2 | |
| Female | 0.8 | Tractor semi | 11.1 | |
| | | Single truck | 5.6 | |
| <i>Load Carried</i> | % | B-train | 3.7 | |
| Logs | 47.9 | A-train | 1.9 | |
| Petrol | 24.3 | Other | 1.5 | |
| Milk | 22.0 | | | |
| Other | 5.8 | | | |
| | | | | |
| <i>Employment Situation</i> | % | <i>Crashes</i> | <i>3 years (%)</i> | <i>Career (%)</i> |
| Employee driver | 89.7 | 0 | 62.7 | 24.1 |
| Work for owner-driver | 5.6 | 1 | 22.5 | 24.9 |
| Owner-driver | 3.7 | 2 | 9.9 | 21.3 |
| Other | 1.0 | > 2 | 4.9 | 29.3 |

| | | | | |
|-----------------------------|-------------|-----------|----------------|----------------|
| <i>Variable</i> | <i>Mean</i> | <i>SD</i> | <i>Minimum</i> | <i>Maximum</i> |
| Age (years) | 40.4 | 9.6 | 20.0 | 62.0 |
| Mileage (km) | 95,092.0 | 42,586.0 | 1500.0 | 251,000.0 |
| Years truck [*] | 18.4 | 9.7 | 0.2 | 44.0 |
| Years industry [#] | 9.7 | 7.9 | 0.0 | 34.0 |

| | | | | |
|------------------------|-------------|-----------|----------------|----------------|
| <i>Preferred Speed</i> | <i>Mean</i> | <i>SD</i> | <i>Minimum</i> | <i>Maximum</i> |
| Open road | 93.3 | 5.1 | 80 | 120 |
| Windy road | 66.1 | 12.7 | 30 | 100 |
| Busy street | 43.1 | 8.1 | 20 | 65 |
| Residential | 49.8 | 8.1 | 20 | 85 |

• The number of years the driver had been driving trucks

The number of years the driver had been driving trucks in that industry

7.3. - Driver Behaviour Questionnaire

Table 2 shows the mean responses for each DBQ item. When the DBQ items were ranked according to their rated mean frequencies, the three most commonly reported behaviours were: "Disregarding the speed limit on the open road"; "Sound your horn to indicate your annoyance with another road user"; and "Become angered by a particular type of driver and indicate your hostility by whatever means you can". The three least frequently reported behaviours were: "Forgetting where you left your truck parked"; "Stay in a motorway lane that you know will be closed ahead until the last minute before forcing yourself into another lane"; and "Miss 'Give Way' signs, and narrowly avoid colliding with the traffic having right of way".

7.3.1. - Factor analysis of the DBQ

The DBQ data were subjected to Principle Component Analysis (PCA) to determine the factor structure of the scale. Using the Kaiser 1 rule, PCA of the DBQ data produced an eight factor solution. However, the visual analysis of the scree plot indicated that a three or four factor solution was more appropriate. Therefore, the residuals correlation matrix was examined for two separate PCA's, one specifying three factors and one specifying four. The residual correlation matrix specifying three factors had a number of large residuals, which was decreased by re-running the PCA specifying four factors. Therefore, a four factor solution was selected as the most appropriate number of components. The factor analysis was rerun specifying four factors and using oblique rotations. Once low inter-correlations (no correlations higher than 0.3) between oblique factors were established, varimax rotations were performed. The four sets of items with factor loadings $>.40$ were then interpreted (see Table 3).

Table 2

Means and standard deviations of the DBQ items

| Item No. | DBQ Item | Mean (SD) |
|------------------------------|---|-------------|
| <i>Violations</i> | | |
| 28 | Speed on an open road | 1.45 (1.26) |
| 11 | Speed in a residential area | 0.80 (0.88) |
| 23 | Drive too close to car in front, hard to stop in emergency | 0.69 (0.77) |
| 24 | Cross a junction knowing the lights have already turned | 0.54 (0.69) |
| 3 | Drive when you suspect that you may be over the legal limit | 0.24 (0.54) |
| 20 | Overtake on the inside | 0.24 (0.59) |
| <i>Aggressive Violations</i> | | |
| 7 | Sound your horn to indicate your annoyance | 1.29 (1.02) |
| 25 | Angered by a particular type of driver, show your hostility | 1.07 (1.00) |
| 21 | Race away from the traffic lights to beat another driver | 0.50 (0.79) |
| 10 | Pull out of a junction so far you force your way into the traffic | 0.45 (0.68) |
| 17 | Angered with another driver, give chase | 0.28 (0.69) |
| 18 | Stay in a lane about to end until the last minute, then dive in | 0.14 (0.44) |
| <i>Lapses</i> | | |
| 4 | Get in the wrong lane approaching a roundabout or junction | 0.99 (0.81) |
| 26 | No clear recollection of the road you have just travelled on | 0.97 (0.86) |
| 12 | Switch on one thing when you meant something else | 0.94 (0.88) |
| 15 | Attempt to drive away from traffic lights in 3 rd gear | 0.73 (0.98) |
| 1 | Hit something when reversing that you hadn't seen | 0.59 (0.64) |
| 22 | Misread signs & exit roundabout on wrong road | 0.43 (0.67) |
| 2 | 'Wake up' to find yourself on wrong but more familiar route | 0.32 (0.56) |
| 19 | Forget where left truck in a truck park | 0.10 (0.33) |
| <i>Errors</i> | | |
| 27 | Underestimate the speed of an oncoming car when overtaking | 0.78 (0.67) |
| 5 | Queuing to turn left, you nearly hit car in front | 0.43 (0.62) |
| 8 | Fail to check rear-view mirror before a manoeuvre | 0.43 (0.67) |
| 9 | Brake too quickly, or steer wrong way into skid | 0.41 (0.60) |
| 13 | On turning left, nearly hit a cyclist coming up on the inside | 0.40 (0.65) |
| 6 | Fail to notice pedestrians crossing, turning into a side street | 0.36 (0.57) |
| 16 | Attempt to overtake someone signalling a right turn | 0.23 (0.47) |
| 14 | Miss Give Way sign, and narrowly avoid a collision | 0.19 (0.43) |

The resulting four factor solution accounted for 35.8% of the variance. The first factor contained 18.0% of the variance accounted for, and consisted of six errors, one aggressive violation, and one lapse. As this factor was predominately errors, this factor was called the 'Error Factor'. The second factor, 'Violations', accounted for 6.9% of the variance and contained four violations, and one aggressive violation. The 'Lapse' factor contained 5.6% of the variance accounted for, and consisted of four lapses and two errors. A fourth factor, labelled 'Aggressive violations', consisted solely of aggressive violations and accounted for 5.4% of the variance. None of the items had cross loadings greater than .33, with only one item having a cross loading above .30. This item was placed on the factor it loaded most highly on.

Reliability statistics were computed for the items comprising the errors, violations, lapses and aggressive violations factors. Cronbach's alphas were .71, .66, .62, and .57, respectively. The alpha coefficient for the aggressive violations scale was improved to .60 with the removal of item 17.

Table 3

Factor analysis of the DBQ items

| Item No. | Item | DBQ Category | Factor Loading |
|---|---|--------------|----------------|
| <i>Factor 1: Errors (E) – accounts for 18.0% of the variance</i> | | | |
| 5 | Queuing to turn left, nearly hit the car in front | E | .654 |
| 14 | Miss 'Give Way' sign, narrowly avoid a collision | E | -.617 |
| 10 | Pull out of a junction so far you force your way into the traffic | A | .572 |
| 6 | Fail to notice pedestrians when turning into a side street | E | -.540 |
| 16 | Attempt to overtake someone signalling a right turn | E | -.512 |
| 8 | Fail to check your rear-view mirror before a manoeuvre | E | .489 |
| 4 | Get into the wrong lane approaching a roundabout or junction | L | .410 |
| 13 | Turning left, nearly hit a cyclist who has come up on your inside | E | -.410 |
| <i>Factor 2: Violations (V) – accounts for 6.9% of the variance</i> | | | |
| 11 | Speed on a residential road | V | .770 |
| 28 | Speed on the open road | V | .710 |
| 23 | Drive so close to car in front, hard to stop in an emergency | V | .621 |
| 21 | Race away from traffic lights to beat another driver | A | .428 |
| 24 | Cross intersection knowing the lights already turned against you | V | .404 |
| <i>Factor 3: Lapses (L) – accounts for 5.6% of the variance</i> | | | |
| 2 | "Wake up" to find yourself on wrong, but more usual destination | L | -.616 |
| 27 | Underestimate the speed of an oncoming car when overtaking | E | .575 |
| 26 | No clear recollection of the road you have just travelled in | L | .567 |
| 9 | Brake too quickly on a slippery road | E | .560 |
| 12 | Switch on one thing meaning to switch on something else | L | .490 |
| 22 | Misread the signs & exit roundabout on wrong road | L | .490 |
| <i>Factor 4: Aggressive violations (A) – 5.4% of the variance</i> | | | |
| 25 | Angered by a particular type of driver, show your hostility | A | .704 |
| 7 | Sound your horn to indicate your annoyance | A | .676 |
| 17 | Angered with another driver, give chase | A | -.557 |

7.4. - Mild social deviance

The means and standard deviations of the MSD items are presented in Table 4. The items with the highest means were “Keep a \$20 note you have found in the street”, followed by “Earn cash payments without paying tax on them”. The lowest means were for the items “Leave a shop with goods that you have not paid for”, followed by “Make a fraudulent insurance claim”.

The 10 items were then added together to form a mean MSD score for comparison with the other main variables. The alpha coefficient for the scale was 0.65, which could not be greatly improved by deleting any items.

Table 4
Mean scores on the MSD items

| Item No. | Item | Mean (SD) |
|----------|--|-------------------|
| 7 | Keep a \$20 note you have found in the street | 2.32 (.63) |
| 3 | Earn cash payments without paying tax on them | 1.78 (.71) |
| 9 | Own and watch a TV without having a licence | 1.74 (.81) |
| 8 | Hit someone who has annoyed or upset you | 1.32 (.58) |
| 2 | Park on (dashed) yellow lines | 1.30 (.49) |
| 1 | Ride on public transport without paying a fare | 1.19 (.43) |
| 10 | Take time off work sick when there are more interesting things to do | 1.11 (.39) |
| 6 | Drive down the shoulder of a motorway when lanes jammed | 1.05 (.21) |
| 5 | Make a fraudulent insurance claim | 1.03 (.21) |
| 4 | Leave a shop with goods that you have not paid for | 1.01 (.10) |
| | <i>Overall</i> | <i>1.39 (.25)</i> |

7.5. - Driver selfishness

The ranked mean scores on each of the driver selfishness items are shown in Table 5. The most frequently reported selfish driving behaviour was “exceeding the speed limit”. This was followed closely by “driving an overloaded truck” and “taking the right hand lane at the traffic lights when a loaded truck is in the left lane”. The least frequently reported form of selfish driving behaviour was “increasing speed when another truck attempted to overtake”. This was followed by not letting “other vehicles into traffic when merging” and “ensuring others obey the speed limit by slowing down in front of them”.

7.5.1. - Factor analysis of the driver selfishness scale

The 23 driver selfishness items were subjected to PCA to determine the factor structure of the scale. PCA of the scale produced a six factor solution. However, the scree plot clearly indicated that a four factor solution was more appropriate. Therefore, the factor analysis was rerun specifying four factors and using oblique rotations. As a number of the factors were correlated at a level higher than .30, direct oblimin rotations were retained. The resulting four factor solution accounted for 45.2% of the variance. The four sets of items with factor loadings $> .35$ were then interpreted (see Table 6). The first factor accounted for 24.3% of the variance. As this factor was predominately driving behaviours that would inconvenience other drivers, this factor was labelled ‘Inconsiderate driving’. The second factor accounted for 8.8% of the variance and was called ‘Right lane’ driving, as it contained behaviours involving the use of the right lane. The third factor accounted for 6.6% of the variance and consisted of risky driving behaviours. This factor was labelled ‘Risky driving’. The fourth factor consisted of driving behaviours that involved holding up other drivers and accounted for 5.5% of the variance. Accordingly, this factor was called ‘Holding up’ other drivers. Three items (items 11, 17 & 23) loaded on more than one factor $> .30$. These items were placed on the factor they loaded most highly on.

Table 5

Means and standard deviations of the driver selfishness items

| Item No. | Item | Mean (SD) |
|----------|--|-------------|
| 3 | Exceeded the speed limit. | 2.12 (1.06) |
| 14 | Driven an overloaded truck | 1.67 (1.08) |
| 21 | Unloaded, taken the right lane at the lights to pass a loaded truck | 1.47 (1.34) |
| 1 | Followed too closely to a vehicle that has annoyed you | 1.40 (0.96) |
| 12 | Crossed the centre line while cornering | 1.34 (0.90) |
| 22 | Moved into right lane to avoid being cut off when lanes are merging | 1.28 (1.29) |
| 6 | Held up vehicles by using a passing opportunity to overtake | 1.26 (0.99) |
| 4 | Indicated too late | 1.18 (0.83) |
| 2 | Tailgated to alert them to the fact that they are holding you up | 1.08 (1.02) |
| 15 | Failed to completely stop at a stop sign | 0.98 (0.91) |
| 13 | Driven for longer than the driving hours permit | 0.94 (0.98) |
| 17 | Travelled too fast downhill | 0.89 (0.82) |
| 10 | Not waited for other vehicles to go past before pulling onto a road | 0.81 (0.77) |
| 9 | Not pulled off the road and stopped to let faster vehicles past when a large number are stuck behind you | 0.77 (1.13) |
| 5 | Failed to indicate at all | 0.76 (0.73) |
| 8 | Not pulled over to the side to let faster vehicles past when you could have safely done so | 0.72 (1.05) |
| 11 | Made an overtaking manoeuvre you were not 100% certain you could safely complete | 0.68 (0.74) |
| 7 | Failed to adequately clear debris from your truck or trailer | 0.68 (0.89) |
| 23 | Not pulled to the side until the very last moment when turning left | 0.67 (0.86) |
| 16 | Followed another truck close enough to make it difficult for other vehicles to over take either you or the other truck | 0.61 (0.68) |
| 20 | Ensured that other vehicles obeyed the speed limit by slowing down in front of them | 0.48 (0.90) |
| 19 | Have not let other vehicles into traffic when traffic was merging | 0.44 (0.66) |
| 18 | Increased your speed when another truck attempted to overtake | 0.15 (0.45) |

Table 6

Factor analysis of the driver selfishness items

| Item No. | Item | Factor Loading |
|---|--|----------------|
| <i>Factor 1: Inconsiderate Driving – accounts for 24.3% of the variance</i> | | |
| 4 | Indicated too late | .681 |
| 5 | Failed to indicate at all | .667 |
| 18 | Increased your speed when another truck attempted to overtake | -.660 |
| 16 | Followed another truck close enough to make it difficult for other vehicles to over take either you or the other truck | .482 |
| 19 | Have not let other vehicles into traffic when traffic was merging | .440 |
| 17 | Travelled too fast downhill | .412 |
| 20 | Ensured other vehicles obey the speed limit by slowing down in front of them | .392 |
| 23 | Not pulled to the side until the very last moment when turning left | .355 |
| <i>Factor 2: Use of Right Lane – accounts for 8.8% of the variance</i> | | |
| 21 | Unloaded, taken the right hand lane at the traffic lights to pass loaded truck | .758 |
| 22 | Moved into the right lane early to avoid being cut off when two lanes merge | .750 |
| 6 | Held up vehicles by using a passing opportunity to overtake a slower vehicle | .511 |
| 10 | Not waited for other vehicles to go past before pulling out onto a road | .346 |
| <i>Factor 3: Risky Driving – accounts for 6.6% of the variance</i> | | |
| 2 | Tailgated a vehicle in front to alert them to the fact they are holding you up. | .815 |
| 1 | Followed too closely to a vehicle that has annoyed you in some manner | .785 |
| 3 | Exceeded the speed limit. | .576 |
| 13 | Driven for longer than the driving hours permit | .553 |
| 14 | Driven an overloaded truck | .530 |
| 15 | Failed to completely stop at a stop sign | .458 |
| 11 | Been stuck behind a slow vehicle and made an overtaking manoeuvre that you were not 100% certain about | .436 |
| 12 | Crossed the centre line while cornering | .427 |
| <i>Factor 4: Holding Up – accounts for 5.5% of the variance</i> | | |
| 8 | Not pulled over to the side to let faster vehicles past when you could have safety done so | .856 |
| 9 | Not pulled off the road and stopped to let faster vehicles past when a large number are stuck behind you | .844 |
| 7 | Failed to adequately clear debris from your truck or trailer | .458 |

Reliability statistics were computed for the items comprising the inconsiderate driving, right hand lane, risky driving and holding up other drivers factors. Cronbach's alphas were .71, .62, .78, and .58, respectively. The alpha coefficient for the holding up other drivers scale was improved to .72 with the removal of item 7.

7.6. - Safety climate

The ranked mean scores on each of the safety climate items are shown in Table 7. A number of the items had to be reverse scored to ensure they were all worded in the same direction. The alpha coefficient for the scale was .59, which was improved to .64 with the deletion of items 2 and 6. With the removal of these two items, the scale was deemed to have an acceptable level of internal coherence. The remaining 15 items were then added together to form a mean safety climate score for comparison with other variables.

7.7. – Correlations amongst the main variables

The relationships between the main variables were examined through the calculation of Pearson's Product Moment Correlation Coefficients. The resulting correlations are presented in Table 8. The number of crashes reported in the previous 3 year period was significantly correlated with: years experience driving trucks (more experience less crashes); experience in their current industry (more experience fewer crashes); MSD (lower MSD, less crashes); risky driving (less risky driving, fewer crashes); violations (less violations, fewer crashes) and age (younger drivers have more crashes).

Table 7
Mean scores on the safety climate scale

| Item No. | Item | Mean (SD) |
|----------|---|--------------------|
| 3 | People not taking the necessary precautions are responsible for what happens to them ^ψ | 3.96 (0.83) |
| 15 | Driven unsafely because I didn't know what I was doing was wrong | 3.66 (0.85) |
| 17 | Driven unsafely because the right equipment was not provided or working | 3.60 (0.90) |
| 5 | If I worried about safety all the time I would not get my job done | 3.54 (1.05) |
| 4 | Safety works until we are busy then other things are done first | 3.24 (1.17) |
| 12 | All the safety rules and procedures in my workplace really work ^ψ | 3.14 (0.95) |
| 13 | It would help me to drive more safely if my supervisor praised me for it | 3.14 (1.03) |
| 14 | It would help me to drive more safely if safety procedures were more realistic | 3.14 (0.97) |
| 16 | Driven unsafely in order to complete the task quickly | 3.14 (1.02) |
| 7 | I cannot avoid taking risks in my job | 3.05 (1.19) |
| 10 | Not all accidents are preventable, some people are just unlucky | 2.93 (1.05) |
| 8 | Accidents will happen no matter what I do | 2.87 (1.06) |
| 11 | Everybody drives safely in my company ^ψ | 2.66 (0.99) |
| 6 | People who drive to safety procedures will always be safe ^ψ | 2.65 (0.98) |
| 1 | Everyone has an equal chance of having an accident. | 2.52 (1.31) |
| 9 | It is unlikely I will have an accident because I am a careful person ^ψ | 2.41 (0.83) |
| 2 | In the normal course of my job, I do not encounter any dangerous situations ^ψ | 1.93 (1.02) |
| | <i>Overall</i> | <i>3.23 (0.41)</i> |

^ψ Reverse scored items

The age of the driver was strongly correlated with the number of years experience a driver had in both their current industry, and in driving trucks in general, with the older drivers generally having more experience. Age was also negatively correlated with: preferred driving speed (the older the driver the lower the preferred speed); the level of mild social deviance (as drivers get older the reported level of social deviance declines); violations (older drivers report less violations); aggressive violations (older drivers report less involvement in aggressive violations) and risky driving (the older the driver, the lower the level of risky driving). Therefore, age is not only directly correlated with the number of crashes involved in the previous 3 years, it is also correlated with several other

variables (truck driving experience, MSD, risky driving and involvement in driving violations) which are also strongly correlated with being crash involved. Age was also positively correlated with holding up other drivers, indicating that it is the older drivers who report engaging in these behaviours more often than younger truck drivers.

Annual mileage was positively correlated with preferred speed, aggressive violations and using the right lane. This means that the more kilometres a truck driver has to drive, the faster they will go, the more likely they were to commit aggressive violations and use the right lane. Annual mileage was also negatively correlated with lapses (greater the annual mileage, the fewer the lapses).

Years experience driving trucks had significant negative correlations with violations, (meaning the more years experienced a driver is the less violations they engage in), MSD (more experienced drivers had lower MSD) and risky driving behaviour (more experienced drivers report less risky driving). The two experience variables were strongly correlated with each other. With this in mind, it is not surprising that years experience in their current industry had the same correlations as total truck driving experience. However, in addition, industry experience was also negatively correlated with lapses (more experienced, less lapses).

Preferred speed was positively correlated with violations and risky driving behaviour, such that a higher preferred speed was associated with more frequently reported risky driving behaviour and violations. This is not too surprising, as speeding is one component of both risky driving and the violations scale. Preferred speed was negatively correlated with safety climate, indicating that drivers with a preference for higher driving speeds were more likely to have negative perceptions of safety climate.

Table 8

Correlations amongst the main variables

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|-------------------|----------|---------|---------|---------|----------|---------|---------|---------|----------|---------|-------|----------|------|------|---------|
| 1. Age | | | | | | | | | | | | | | | |
| 2. Mileage | -.049 | | | | | | | | | | | | | | |
| 3. Crashes | -.209*** | .068 | | | | | | | | | | | | | |
| 4. Errors | .102 | .085 | -.015 | | | | | | | | | | | | |
| 5. Violations | -.160** | .002 | .190*** | .001 | | | | | | | | | | | |
| 6. Lapses | -.090 | -.127* | .083 | .001 | .006 | | | | | | | | | | |
| 7. Aggressive | -.147* | .250*** | .007 | -.004 | .008 | -.013 | | | | | | | | | |
| 8. Speed | -.120* | .111* | .045 | -.023 | .298*** | -.022 | .032 | | | | | | | | |
| 9. MSD | -.258*** | .062 | .126* | .077 | .276*** | .085 | .279*** | .046 | | | | | | | |
| 10. Inconsiderate | -.050 | .011 | .033 | .438*** | .263*** | .320*** | .065 | -.028 | .216*** | | | | | | |
| 11. Right lane | -.104 | .175** | .002 | .315*** | .015 | .080 | .236*** | -.046 | .148** | .195*** | | | | | |
| 12. Risky driving | -.274*** | .097 | .121* | .122 | .543*** | .258*** | .228*** | .224*** | .407*** | .345*** | .098 | | | | |
| 13. Holding up | .142* | -.074 | .066 | .210*** | .203*** | .170** | .066 | .033 | .063 | .271*** | .121* | .187*** | | | |
| 14. Climate | .055 | -.090 | -.071 | -.121* | -.198*** | -.104 | -.135* | -.116* | -.132** | -.143* | .028 | -.365*** | .000 | | |
| 15. Industry | .547*** | -.002 | -.131* | .057 | -.105 | -.127* | -.065 | -.104* | -.286*** | -.024 | .020 | -.213*** | .061 | .074 | |
| 16. Years | .806*** | -.009 | -.129* | .091 | -.170** | -.099 | -.057 | -.083 | -.227*** | -.033 | .021 | -.227*** | .055 | .061 | .595*** |

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; Years = years experience driving trucks; Industry = years driving trucks in current industry

Safety climate was negatively correlated with MSD, meaning that poor perceptions of safety climate were associated with higher scores for MSD. There were also significant negative correlations between safety climate and the level of errors, violations and aggressive violations, meaning those drivers with poor perceptions of safety climate were more likely to report engaging more often in violations, errors and aggressive violations. Safety climate also had strong, negative correlations with inconsiderate driving and risky driving.

There were significant correlations between MSD and three of the four selfish driving factors (right lane, risky driving and inconsiderate driving). These were all positive correlations, so higher MSD scores were associated with higher scores on these three driver selfishness factors. Of the DBQ factors, only aggressive violations and violations had significant positive correlations with MSD, meaning that higher levels of MSD were associated with higher engagement in both violations and aggressive violations. There were no significant correlations between MSD and “Holding up” other drivers, Errors or Lapses.

There were also a number of significant correlations between the driver selfishness variables and the DBQ factors. Inconsiderate driving and holding up both had significant positive correlations with errors, lapses and violations, meaning that higher levels of holding up and inconsiderate driving were associated with higher levels of errors, lapses and violations. Using the right lane was correlated with errors and aggressive violations, such that higher use of the right lane was associated with higher errors and aggressive violations. Risky driving had significant positive correlations with lapses, violations and aggressive violations, indicating that higher levels of these four variables are associated with higher levels of risky driving.

7.8. - Prediction of crash involvement

To investigate further the relationship between crash involvement and the variables that were strongly correlated with crash involvement, a number of forced entry logistic regressions were performed. Logistic regression uses sets of independent variables to estimate the coefficients of a probabilistic model that best predicts a dependent variable which has only two values (i.e. in this case crash/no crash), and has previously been used in this type of research (e.g. Al-Ghamdi, 2002; Meadows et al., 1998). In order to partial out the effects of the demographic and descriptive variables, the variables were entered in blocks. Firstly annual mileage was entered to partial out the contribution of what is normally considered to be the exposure factor. The second block consisted of the remaining demographic and descriptive variables of interest (although preferred driving speed could also be classified as an attitudinal variable). As the two experience variables were very strongly correlated, only the experience variable with the strongest correlation with crash involvement (years driving trucks in their current industry) was entered along with the other variables in block two. Once these variables had been entered into the regression, the variable(s) of interest were entered (i.e. DBQ factors, driver selfishness factors, MSD, safety climate). The general form of the models follow the same format as Meadows et al. (1998), as depicted below.

Block 1

Annual mileage

Block 2

Age

Years driving trucks in their current industry

Preferred speed

Block 3

Variable(s) of interest (e.g. DBQ factors, driver selfishness factors, MSD, safety climate)

Table 9 shows the results of the hierarchical logistic regression to predict crash involvement using the DBQ factors. Mileage was not a significant predictor, while the addition of age, experience and preferred speed resulted in a

significant improvement in the model. The introduction of the four DBQ factor scores resulted in a significant improvement in the model, with the violations factor being a significant predictor of crash involvement. The “Exp (*B*)” column presents the odds ratios. The majority of the odds ratios were low and their 95% confidence intervals included 1.00 (i.e. no difference in odds of being crash involved). However, both age and the violations factors had 95% confidence intervals that excluded 1.00. The odds ratio for the violations factor indicates that for each one unit increase in violations factor score, the odds of being crash involved increase by 49% (CI 1.14 – 1.95). In order to aid interpretation of the age odds ratio, the reciprocal was calculated ($1/0.959 = 1.04$). This shows that for every year increase in age, the odds of being crash involved are reduced by 4%.

Table 9

Prediction of crash involvement using the DBQ factors

| Block | | Model chi-square improvement | % Correctly classified | <i>B</i> | Wald | Exp (<i>B</i>) | <i>R</i> ² |
|-------|------------|------------------------------|------------------------|----------|--------|------------------|-----------------------|
| 1 | Mileage | 3.15 | 62.2 | 0.00 | 3.12 | 1.00 | .02 |
| 2 | Age | 10.23* | 64.0 | -0.04 | 6.59** | 0.96 | .06 |
| 2 | Experience | | | 0.00 | 0.00 | 1.00 | |
| 2 | Speed | | | 0.02 | 0.20 | 1.02 | |
| 3 | Errors | 10.53* | 64.3 | 0.01 | 0.00 | 1.01 | .11 |
| 3 | Violations | | | 0.40 | 8.66** | 1.49 | |
| 3 | Lapse | | | 0.17 | 1.65 | 1.18 | |
| 3 | Aggressive | | | -0.01 | 0.01 | 0.99 | |

Experience = years experience driving trucks in current industry, *R*² = Nagelkerke *R*²

* *p* < .05, ** *p* < .01, *** *p* < .001

Although MSD was strongly correlated with crash involvement, once the demographic and descriptive variables had been partialled out, MSD was not a significant predictor of crash involvement (see Table 10). All of the odds ratios (except age) included 1.00 in the 95% confidence intervals.

Table 10

Prediction of crash involvement using MSD

| Block | | Model chi-square improvement | % Correctly classified | <i>B</i> | Wald | Exp (<i>B</i>) | <i>R</i> ² |
|-------|------------|------------------------------|------------------------|----------|--------|------------------|-----------------------|
| 1 | Mileage | 3.85* | 62.5 | 0.00 | 3.81 | 1.00 | .02 |
| 2 | Age | 10.38* | 63.1 | -0.04 | 6.63** | 0.96 | .05 |
| 2 | Experience | | | -0.00 | 0.02 | 1.00 | |
| 2 | Speed | | | -0.01 | 0.01 | 1.00 | |
| 3 | MSD | 1.94 | 64.2 | 0.66 | 1.94 | 1.93 | .06 |

Experience = years experience driving trucks in current industry, R^2 = Nagelkerke R^2 * $p < .05$, ** $p < .01$, *** $p < .001$

Hierarchical logistic regression was also used to test whether any of the driver selfishness factors were predictive of crash involvement (see Table 11). The addition of the driver selfishness factors did not result in a significant improvement in the model above that afforded by the demographic and descriptive variables. Therefore, although risky driving behaviour was strongly correlated with crash involvement, once the demographic and descriptive variables had been taken into consideration it was not a significant predictor of crash involvement.

7.9. – Prediction of other variables

To investigate the relationships between MSD, violations, safety climate and the four driver selfishness variables further, a number of additional hierarchical linear regressions were performed. Firstly, as previous research has found MSD to be a significant predictor of violations, a hierarchical linear regression was run to test this relationship. Furthermore, as Driver Selfishness and MSD appeared to be closely related constructs, the ability of MSD to predict Driver Selfishness was tested using hierarchical linear regression. In addition, the relationship MSD had with safety climate was also investigated, due to the

significant correlation between the two variables. Finally, as the research on safety climate has clearly demonstrated a link with safety behaviours, two regressions were run testing whether safety climate could be used to predict violations and risky driving behaviour.

Table 11

Prediction of crash involvement using the driver selfishness factors

| Block | | Model chi-square improvement | % Correctly classified | <i>B</i> | Wald | Exp (<i>B</i>) | <i>R</i> ² |
|-------|---------------|------------------------------|------------------------|----------|-------|------------------|-----------------------|
| 1 | Mileage | 1.04 | 65.1 | 0.00 | 1.05 | 1.00 | .01 |
| 2 | Age | 6.41 | 65.5 | -0.04 | 4.94* | 0.96 | .04 |
| 2 | Experience | | | 0.01 | 0.10 | 1.01 | |
| 2 | Speed | | | 0.00 | 0.00 | 1.00 | |
| 3 | Inconsiderate | 1.94 | 64.2 | -0.08 | 0.36 | 0.92 | .07 |
| 3 | Right lane | | | -0.03 | 0.05 | 0.97 | |
| 3 | Risky driving | | | 0.28 | 3.43 | 1.32 | |
| 3 | Holding up | | | 0.22 | 2.64 | 1.25 | |

Experience = years experience driving trucks in current industry, *R*² = Nagelkerke *R*²

* *p* < .05, ** *p* < .01, *** *p* < .001

7.9.1. – Prediction using MSD

Table 12 shows that mileage was not a significant predictor of violations. The addition of the remaining demographic and descriptive variables resulted in a significant improvement in *R*², with age and preferred driving speed both being significant predictors of violations score. Once the demographic and descriptive variables had been partialled out, MSD was still a strong predictor of violations.

Table 12

Prediction of violation score using MSD

| Block | | F Change in R^2 | beta | <i>t</i> | Sig. | R^2 |
|-------|------------|-------------------|-------|----------|------|-------|
| 1 | Mileage | 0.00 | -0.00 | 0.19 | 0.85 | .00 |
| 2 | Age | 12.92*** | -0.16 | -2.43* | 0.02 | .11 |
| 2 | Experience | | -0.00 | 0.06 | 0.95 | |
| 2 | Speed | | 0.29 | 5.22*** | 0.00 | |
| 3 | MSD | 20.60*** | 0.26 | 4.54*** | 0.00 | .17 |

Experience = years experience driving trucks in current industry, R^2 = Adjusted R^2 * $p < .05$, ** $p < .01$, *** $p < .001$

Mileage was not a significant predictor of safety climate (Table 13). Furthermore, the addition of the block containing age, experience and preferred driving speed did not result in a significant improvement in R^2 . However, the addition of the MSD score resulted in a small, but significant improvement in the R^2 .

Table 13

Prediction of safety climate score using MSD

| Block | | F Change in R^2 | beta | <i>t</i> | Sig. | R^2 |
|-------|------------|-------------------|-------|----------|------|-------|
| 1 | Mileage | 2.70 | -0.09 | -1.64 | 0.10 | .01 |
| 2 | Age | 2.19 | 0.03 | 0.39 | 0.69 | .02 |
| 2 | Experience | | 0.05 | 0.84 | 0.41 | |
| 2 | Speed | | -0.11 | -2.03* | 0.04 | |
| 3 | MSD | 4.42* | -0.12 | -2.10* | 0.04 | .02 |

Experience = years experience driving trucks in current industry, R^2 = Adjusted R^2 * $p < .05$, ** $p < .01$, *** $p < .001$

Table 14 shows the results of the hierarchical linear regressions using MSD to predict the four driver selfishness factors. Mileage was a significant predictor of

right lane driving, but was not a significant predictor of the other three forms of driver selfishness. The addition of age, experience and preferred speed resulted in a significant improvement in R^2 for risky driving and right lane driving, but not for holding up or inconsiderate driving. However, the addition of the MSD variable resulted in a significant change in R^2 for three (inconsiderate driving, right lane, risky driving) of the four driver selfishness variables. Therefore, MSD was found to be a significant predictor of the violations factor and for three of the four driver selfishness factors, after the effects of the demographic and descriptive variables had been partialled out.

7.9.2. – Prediction of violations and risky driving using safety climate

As the safety climate score was significantly related to two (violation and risky driving) of the variables strongly related to crash involvement, hierarchical linear regression was used to test whether perceptions of safety climate were predictive of scores on these two variables.

After mileage was again found to be a non-significant predictor of violations, the addition of the second block resulted in a significant increase in R^2 (see Table 15). Both age and preferred speed were significant predictors. However, the addition of safety climate to the model did not result in a significant change in R^2 .

Table 16 shows that after mileage was partialled out, the addition of the other three demographic and descriptive variables resulted in a significant increase in R^2 . As with the violations score, age and preferred speed were both strongly predictive of engagement in risky driving behaviour. The addition of safety climate to the model also resulted in a significant change in R^2 , meaning that once the contributions of the demographic and descriptive variables had been partialled out, safety climate remained a very strong predictor of risky driving.

Table 14

Prediction of driver selfishness factors using MSD

| Block | | F Change in R^2 | beta | t | Sig. | R^2 |
|------------------------------|------------|-------------------|-------|---------|------|-------|
| <i>Inconsiderate driving</i> | | | | | | |
| 1 | Mileage | 0.01 | -0.00 | -0.01 | 0.92 | -.00 |
| 2 | Age | 0.35 | -0.06 | -0.82 | 0.41 | -.01 |
| 2 | Experience | | -0.01 | -0.12 | 0.90 | |
| 2 | Speed | | -0.04 | -0.58 | 0.56 | |
| 3 | MSD | 3.36** | 0.25 | 3.98*** | 0.00 | .04 |
| <i>Right lane</i> | | | | | | |
| 1 | Mileage | 7.17** | 0.16 | 2.68 | 0.01 | .03 |
| 2 | Age | 3.40** | -0.17 | -2.44* | 0.02 | .05 |
| 2 | Experience | | 0.10 | 1.43 | 0.15 | |
| 2 | Speed | | -0.05 | -0.81 | 0.42 | |
| 3 | MSD | 3.58** | 0.13 | 2.04* | 0.04 | .06 |
| <i>Risky driving</i> | | | | | | |
| 1 | Mileage | 2.24 | 0.09 | 1.50 | 0.14 | .01 |
| 2 | Age | 10.81*** | -0.20 | -2.98** | 0.00 | .13 |
| 2 | Experience | | -0.10 | -1.52 | 0.13 | |
| 2 | Speed | | 0.21 | 3.65*** | 0.00 | |
| 3 | MSD | 19.49*** | 0.38 | 6.86*** | 0.00 | .26 |
| <i>Holding up</i> | | | | | | |
| 1 | Mileage | 1.43 | -0.07 | -1.20 | 0.23 | .00 |
| 2 | Age | 1.72 | 0.15 | 2.06* | 0.04 | .01 |
| 2 | Experience | | -0.03 | -0.39 | 0.70 | |
| 2 | Speed | | 0.05 | 0.85 | 0.40 | |
| 3 | MSD | 2.19 | 0.12 | 1.99* | 0.05 | .02 |

Experience = years experience driving trucks in current industry, R^2 = Adjusted R^2 * $p < .05$, ** $p < .01$, *** $p < .001$

Table 15

Prediction of violations score using safety climate

| Block | | F Change in R^2 | beta | <i>t</i> | Sig. | R^2 |
|-------|----------------|-------------------|-------|----------|------|-------|
| 1 | Mileage | 0.00 | -0.00 | -0.02 | 0.98 | .00 |
| 2 | Age | 12.92*** | -0.16 | -2.43* | 0.04 | .11 |
| 2 | Experience | | -0.00 | -0.06 | 0.70 | |
| 2 | Speed | | 0.29 | 5.22*** | 0.00 | |
| 3 | Safety climate | 3.78 | -0.11 | -1.94 | 0.05 | .12 |

Experience = years experience driving trucks in current industry, R^2 = Adjusted R^2 * $p < .05$, ** $p < .01$, *** $p < .001$

Table 16

Prediction of risky driving using safety climate

| Block | | F Change in R^2 | beta | <i>t</i> | Sig. | R^2 |
|-------|----------------|-------------------|-------|----------|------|-------|
| 1 | Mileage | 2.24 | 0.09 | 1.50 | 0.14 | .00 |
| 2 | Age | 13.56*** | -0.20 | -2.98** | 0.00 | .12 |
| 2 | Experience | | -0.10 | -1.52 | 0.13 | |
| 2 | Speed | | 0.21 | 3.65*** | 0.00 | |
| 3 | Safety climate | 20.37*** | -0.25 | -4.51*** | 0.00 | .18 |

Experience = years experience driving trucks in current industry, R^2 = Adjusted R^2 * $p < .05$, ** $p < .01$, *** $p < .001$

7.10. – Testing for mediation effects

Regression analyses were used to further investigate the relationships amongst MSD, violations, risky driving behaviour and crash involvement. In order to test whether the relationships between the variables and crash involvement were

mediated by any of the other variables, the procedure used by Baron and Kenny (1986) was employed⁹.

To establish mediation the first two regressions must yield significant beta weights and the effect of the mediator on the dependent variable must be significant in the third regression. Finally the effect of the independent variable on the dependent variable must be less in the third equation than in the second. If the independent variable has no effect when the mediator is controlled, this demonstrates perfect mediation.

Figure 1 presents the results of the test for mediation effects of violations on the prediction of crash involvement using MSD. MSD was a significant predictor of violations score (beta = .28, $t = 4.98$, $p < .001$). MSD was also a significant predictor of crashes ($B = 1.03$, Wald = 5.68, $p < 0.05$). Thirdly, it was established that violations score was a significant predictor of crash involvement ($B = .42$, Wald = 11.58, $p < .001$), but that MSD was no longer a significant predictor ($B = .30$, Wald = .31, ns). These results indicate that the violations score fully mediated the relationship between MSD and crash involvement. In other words, MSD only has an impact upon crash involvement through its relationship with violations.

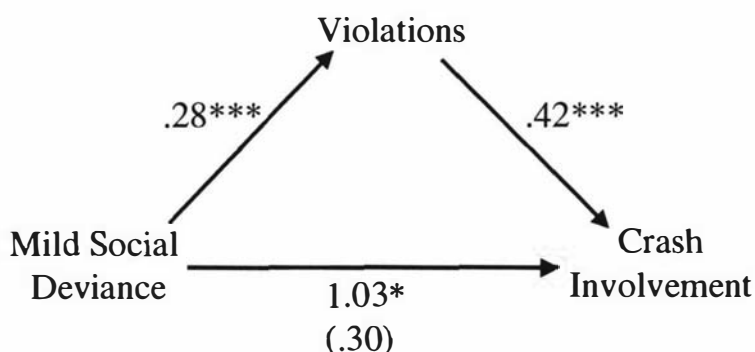


Figure 1. Multiple regression testing mediation of crash involvement on mild social deviance by violation score. [Coefficients outside the brackets are standardised regression weights (Beta or beta); the value within the brackets is the standardised regression weight when violations score was added to the third equation].

⁹ Prior to testing for mediation effects a logistic regression was run attempting to predict crash involvement using all the main variables (violations factor, risky driving, MSD, safety climate). As expected, after the control variables had been partialled out, only the violations factor was significant.

Figure 2 depicts the results of the test for mediation effects of risky driving on the prediction of crash involvement using MSD. MSD was a significant predictor of risky driving score ($\beta = .41$, $t = 7.68$, $p < .001$). Secondly, MSD was a significant predictor of crashes ($B = 1.03$, Wald = 5.68, $p < 0.05$). Thirdly, it was established that risky driving was a significant predictor of crash involvement ($B = .33$, Wald = 6.84, $p < .01$), but that MSD was no longer a significant predictor ($B = .26$, Wald = .23, ns). This indicates that the risky driving score fully mediated the relationship between MSD and crash involvement.

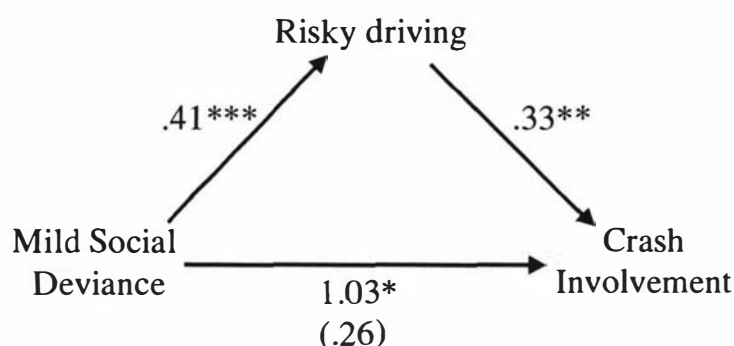


Figure 2. Multiple regression testing mediation of crash involvement on mild social deviance by risky driving score. [Coefficients outside the brackets are standardised regression weights (Beta or beta); the value within the brackets is the standardised regression weight when risky driving was added to the third equation].

Figure 3 presents the results of the test for mediation effects of violations on the prediction of crash involvement using risky driving. Risky driving was found to be highly predictive of violations ($\beta = .54$, $t = 10.31$, $p < .001$). Risky driving was also a significant predictor of crash involvement ($B = .33$, Wald = 6.84, $p < .05$). Thirdly, it was established that violations score was a significant predictor of crash involvement ($B = .42$, Wald = 11.58, $p < .001$), but that risky driving was no longer a significant predictor ($B = .14$, Wald, .720, ns). This indicates that the violations score fully mediated the relationship between risky driving and crash involvement.

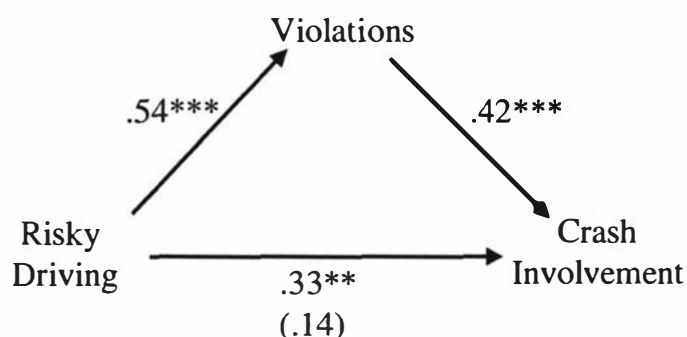


Figure 3. Multiple regression testing mediation of crash involvement on risky driving by violation score. [Coefficients outside the brackets are standardised regression weights (Beta or beta); the value within the brackets is the standardised regression weight when violation score was added to the third equation].

Figure 4 shows the results of the test for mediation effects of risky driving on the prediction of violations using MSD. MSD was a significant predictor of risky driving (beta = .41, $t = 7.68$, $p < .001$). MSD was also a significant predictor of violations (beta = .28, $t = 4.98$, $p < .001$). It was also established that risky driving was a significant predictor of violations (beta = .54, $t = 10.31$, $p < .001$), and that MSD remained a significant predictor (beta = .13, $t = 2.28$, $p < .05$), even when risky driving behaviours had been statistically controlled. As the beta weight is lower in the third regression than in the second, this indicates that the risky driving score partially mediated the relationship between MSD and violations score. In other words, MSD has a direct impact upon violations, but has a stronger indirect impact through its relationship with risky driving.

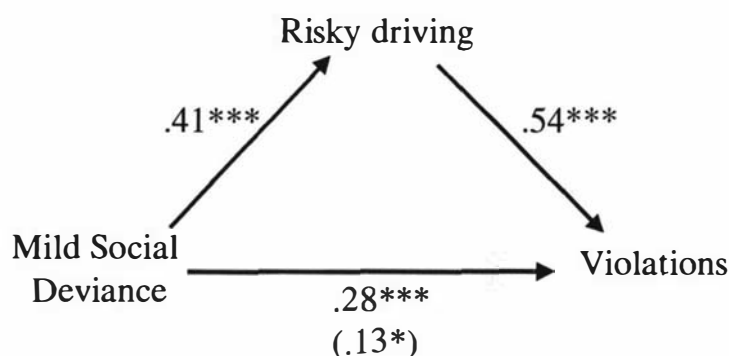


Figure 4. Multiple regression testing mediation of violations on MSD by risky driving score. [Coefficients outside the brackets are standardised regression weights (Beta or beta); the value within the brackets is the standardised regression weight when risky driving was added to the third equation].

Figure 5 shows the results of the test for mediation effects of risky driving on the prediction of violations using safety climate. Safety climate was a significant predictor of risky driving (beta = $-.37$, $t = -6.76$, $p < .001$). Safety climate was also a significant predictor of violations (beta = $-.20$, $t = -3.49$, $p < .001$). Thirdly, it was established that risky driving was a significant predictor of violations (beta = $.54$, $t = 10.31$, $p < .001$), but that safety climate was no longer a significant predictor (beta = $-.03$, $t = -.50$, ns). These results indicate that the risky driving factor fully mediates the relationship between safety climate and violations. In other words, safety climate only has an impact upon violations through its relationship with risky driving.

A pictorial representation of the mediation relationships is shown in Figure 6. This shows that MSD has strong direct relationships with both the risky driving and safety climate. MSD also has a weak, but significant relationship with the violations factor. Safety climate has its only impact on risky driving, while risky driving has a strong relationship with the violations factor, which is the only variable to have a direct relationship with crash involvement.

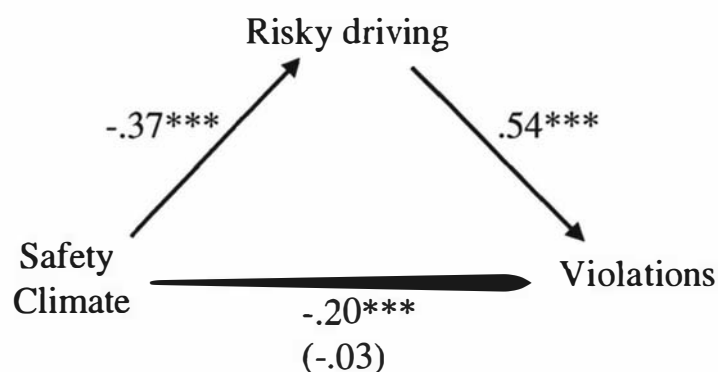


Figure 5. Multiple regression testing mediation of violations on safety climate by risky driving score. [Coefficients outside the brackets are standardised regression weights (Beta or beta); the value within the brackets is the standardised regression weight when risky driving was added to the third equation].

As a final test of the model a logistic regression was conducted using all four variables to predict crash involvement (see Table 17). As expected, only the violations score was a significant predictor of crash involvement.

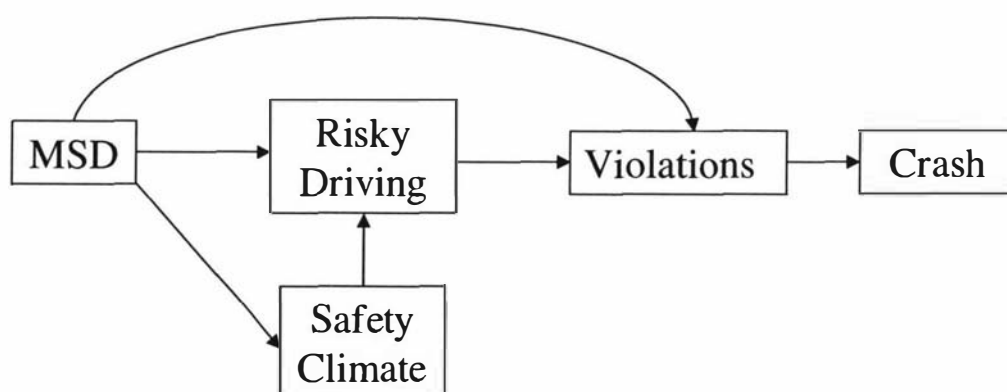


Figure 6. Pictorial representation of the mediation relationships

Table 17

Prediction of crash involvement using the four main variables

| | % Correctly classified | <i>B</i> | Wald | Exp (<i>B</i>) | <i>R</i> ² |
|----------------|---------------------------|----------|-------|------------------|-----------------------|
| Violations | 63.8 | 0.33 | 3.96* | 1.39 | .06 |
| MSD | | -0.05 | 0.01 | 0.95 | |
| Risky driving | | 0.10 | 0.33 | 1.11 | |
| Safety Climate | | -0.31 | 0.68 | 0.73 | |

Experience = years experience driving trucks in current industry, R^2 = Adjusted R^2 * $p < .05$, ** $p < .01$, *** $p < .001$

7.11. – Chapter summary

Chapter 7 presented the main findings from the present research. Analysis of the DBQ data found four orthogonal factors, with only the violations factor being a significant predictor of crash involvement. The Driver Selfishness scale also produced four factors, but they were correlated. Although one of the four factors (risky driving) was associated with the number of crashes reported, it was not a significant predictor of crash involvement. MSD was also correlated with number of crashes, but was not a significant predictor of crash involvement. However, MSD was a significant predictor of violations and three of the four driver selfishness factors. Safety climate was not correlated with the number of crashes reported, but safety climate was a significant predictor of risky driving behaviour. The following chapter discusses the results in the context of previous findings.

Chapter 8

Discussion

8.1. – Chapter overview

Chapter 8 discusses the results of the research in seven sections. The first section briefly presents the results of the study with reference to the research aims. Section two discusses the key relationships the demographic and descriptive variables had with the other variables of interest. Following on from that, the mediation effects between the main variables are discussed, before the utility of the findings and suggestions for future research are outlined. The sixth section identifies the main limitations of the study, while the final section presents the conclusions of the research.

8.2. – Research aims

8.2.1. - Level of aberrant driving behaviours

This sample of New Zealand truck drivers reported what appeared to be a much lower level of aberrant driving behaviour than private motorists (Lawton et al., 1997b), and a slightly lower level than company car drivers (Dimmer & Parker, 1999). The level of aberrant driving behaviours in the present study was compared with those found by Dimmer and Parker (1999) using t-tests (see Table 18). This showed that truck drivers were significantly less likely to engage in 16 of the 28 behaviours than the sample of company car drivers. There was no significant difference for seven of the items and truck drivers reported

significantly higher levels for five items. Therefore, in most cases New Zealand truck drivers reported lower levels of aberrant driving behaviour than British company car drivers. This finding was not completely surprising, as there are a number of reasons why truck drivers would engage in aberrant driving behaviours less often.

Firstly, there is the size of the trucks. The size and handling characteristics of trucks, which are currently limited to 44 tonnes on New Zealand's public roads, means there is less leeway for the truck drivers to use their vehicle in an aberrant manner without some kind of accident or incident resulting (e.g. being involved in a crash, being reported or fined). Moreover, the consequences of a crash are also normally more severe, due to the extra size and weight of trucks. The size of the trucks also makes them more visible on the roads, meaning that a truck being driven in an aberrant manner would be more likely to be noticed than a car. It is also more likely that the public would complain about a truck driver's behaviour on the road, than for a car driver. The chances of being reported are especially high for logging trucks, as most of them have a sign attached to the back of their truck (or trailer) which invites other road users to comment on their driving using a free-phone number. There is also the fact that there tends to be a lot of media interest when trucks crash, which truck drivers would be keenly aware of. Concern over the negative media publicity created by truck crashes has been recognised by the New Zealand Road Transport Forum (which is a lobby group representing road transport companies in New Zealand), who have been investigating methods for combating this negative publicity, which they believe is both unbalanced and unwarranted (P.H. Baas, personal communication, February 16, 2000).

Table 18
Comparison of the item means on the DBQ

| Item No. | DBQ Item | Trucks | Comp. |
|------------------------------|---|---------|---------|
| <i>Violations</i> | | | |
| 28 | Speed on a motorway | 1.45*** | 2.82 |
| 11 | Speed in a residential area | 0.80*** | 1.71 |
| 23 | Drive close to car in front making it hard to stop | 0.69** | 0.84 |
| 24 | Cross a junction knowing the lights have already changed | 0.54 | 0.60 |
| 3 | Drive when you suspect that you may be over the legal limit | 0.24 | 0.23 |
| 20 | Overtake on the inside | 0.24*** | 1.16 |
| <i>Aggressive Violations</i> | | | |
| 7 | Sound your horn to indicate your annoyance with another | 1.29 | 0.81*** |
| 25 | Angered by a particular type of driver, show your hostility | 1.07 | 0.93* |
| 21 | Race away from the traffic lights to beat another driver | 0.50*** | 0.97 |
| 10 | Pull out of a junction so far you force your way into the traffic | 0.45*** | 0.84 |
| 17 | Angered with another driver, give chase | 0.28 | 0.19* |
| 18 | Stay in a lane about to close until the last minute, then dive in | 0.14*** | 0.70 |
| <i>Lapses</i> | | | |
| 4 | Get in the wrong lane approaching a roundabout or junction | 0.99*** | 1.50 |
| 26 | No clear recollection of the road you have just travelled on | 0.97*** | 1.47 |
| 12 | Switch on one thing when you meant something else | 0.94 | 0.87 |
| 15 | Attempt to drive away from traffic lights in 3 rd gear | 0.73 | 0.61 |
| 1 | Hit something when reversing that you hadn't seen | 0.59 | 0.46** |
| 22 | Misread signs & exit roundabout on wrong road | 0.43*** | 1.09 |
| 2 | 'Wake up' to find yourself on wrong but more familiar route | 0.32*** | 0.89 |
| 19 | Forget where left truck/car in a car/truck park | 0.10*** | 1.01 |
| <i>Errors</i> | | | |
| 27 | Underestimate speed of oncoming vehicle when overtaking | 0.78 | 0.77 |
| 5 | Queuing to turn left, you nearly hit car in front | 0.43*** | 0.75 |
| 8 | Fail to check rear-view mirror before a manoeuvre | 0.43*** | 0.60 |
| 9 | Brake too quickly on a slippery road, skid | 0.41*** | 0.64 |
| 13 | On turning left, nearly hit a cyclist coming up on the inside | 0.40 | 0.31* |
| 6 | Fail to notice pedestrians crossing, turning into a side street | 0.36* | 0.45 |
| 16 | Attempt to overtake someone signalling a right turn | 0.23 | 0.29 |
| 14 | Miss Give Way sign, and narrowly avoid a collision | 0.19 | 0.23 |

Truck = Current research, Comp. = Company car drivers (Dimmer & Parker, 1999)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

It also seems likely that truck drivers would be better trained and more practiced at driving than most car drivers, which should also reduce their engagement in aberrant driving behaviours. There is also the fact that, for truck drivers, the loss of their driving licence would be more debilitating than for the majority of the company car drivers in Dimmer and Parker's (1999) sample. The truck drivers' livelihood requires them to retain an active license. While this may be the case for some of the drivers in Dimmer and Parker's study, given the reported business mileage (mean = 21,000 miles/year, range = 1,000 – 70,000 miles/year), it is unlikely to be the case for all.

Although we have speculated about the causes of the low level of aberrant driving behaviours reported here, future research needs to be conducted to provide a definitive answer. Knowledge of why truck drivers report lower levels of aberrant driving behaviours may provide information that could be used to reduce levels amongst car drivers. For example, it may be the free-phone numbers attached to the back of the logging trucks which reduces the drivers' engagement in aberrant driving behaviours. If this were the case, then attaching free-phone numbers to cars may be an effective means of improving the road behaviour of ordinary car drivers, or particular at risk groups (e.g. repeat offenders, young drivers). Similarly, an alternative approach might be using a publicity campaign to encourage the public to report the driving transgressions of other drivers using a free-phone number.

Of the five aberrant driving behaviours truck drivers' reported engaging in more often than company car drivers, three were aggressive violations, one was a lapse and one was an error. The greater frequency of the particular lapse and error is not surprising in the case of truck drivers. It is easy to imagine the lapse (Hit something when reversing that you had not previously seen) could be made more often by truck drivers, as there is a greater distance between where they are sitting and the back of the trailer. Also, truck drivers would have more limited rearward vision, given that most cars allow the driver to check both wing mirrors and the rear view mirror (which looks through the back window), while most truck drivers would have to rely solely on their wing mirrors. This would

mean that truck drivers have larger blindspots and would therefore be more likely to back into things. With this in mind, it is also easy to see how truck drivers could also report the error "On turning left, nearly hit a cyclist coming up on your inside" more often. The size and shape of the truck means that the truck drivers are sitting considerably higher than car drivers, and there is a larger distance between where the truck driver is sitting and the left hand window (and hence also the left hand wing mirror). Thus, truck drivers would have to rely solely on their left hand wing mirror to locate a cyclist. Car drivers on the other hand would be able to look at the wing mirror, rear view mirror and out the windows to check for a cyclist.

The three aggressive violations that were reported with greater frequency by truck drivers all had to do with expressing hostility towards another driver (rather than aggressive driving). There are a number of possible reasons for this. Firstly, truck drivers may be inconvenienced more by the inconsiderate behaviour of other drivers. For example, if a car pulls out in front of them on a highway, they may have to change down 8 gears. It would take them considerably longer to slow down and also to speed up once again. Furthermore, it would be much easier for a car driver to overtake a driver that was holding them up or had pulled out in front of them. Whereas, for a truck this option is available for a much lower proportion of the time, while beeping the horn, gesticulating, and chasing after a car might be used more often to vent their frustration. Although this study found aggressive violations were not related to crash involvement, it would be interesting to investigate the reasons why truck drivers report higher levels of aggressive violations. There is evidence from research on private vehicle drivers which indicates there is a strong positive relationship between the level of anger drivers report from different driving situations and the driver's engagement in aggressive violations (Lajunen, Parker & Stradling, 1998). Future research needs to determine whether the same relationship exists with truck drivers. If so, it would also be interesting to find out why truck drivers experience more anger than car drivers. For example, is it because truck drivers are exposed more frequently to potential anger evoking situations, that the pressures of work magnify the

degree of anger experienced, or is it simply to do with the characteristics of the truck drivers themselves. Furthermore, it would also be interesting to investigate whether there were any links with road rage, an increasingly prominent phenomena in the developed world.

Consistent with previous research (e.g. Åberg & Rimmö, 1998; Blockey & Hartley, 1995; Dimmer & Parker, 1999; Kontogiannis et al., 2002; Lawton et al., 1997a; Parker et al., 1995b; Reason et al., 1990), the aberrant driving behaviour most frequently reported by the truck drivers was speeding on the open road. However, one issue that might appear to be of concern is the fact that, unlike previous research (Åberg & Rimmö, 1998; Dimmer & Parker, 1999; Lawton et al., 1997a; Parker et al., 1995b), drink driving was not one of the three least frequently reported aberrant driving behaviours.

The fact that driving over the alcohol limit was not the least reported behaviour does not indicate that truck drivers have a relatively large problem with drink driving. In terms of absolute frequency, truck drivers reported a level of drink driving that was almost exactly the same as that reported by UK company car drivers (Dimmer & Parker, 1999), and was considerably lower than that found amongst earlier samples of UK private vehicle drivers (Lawton et al., 1997a) and Australian car drivers (Blockey & Hartley, 1995). The reason drink driving was not the least frequently reported form of aberrant driving behaviour has more to do with the fact that a number of the less frequently reported aberrant driving behaviours were very difficult, if not impossible for a truck driver to engage in (this issue is discussed further in the section on limitations).

8.2.2. - DBQ factor structure.

Factor analysis of the truck driver data produced a factor structure that broadly provided support for the distinction between the four hypothetical types of aberrant driving behaviour (violations, aggressive violations, lapses and errors). The factors were relatively clear, having few misplaced items and three of the

four factors having acceptable levels of internal validity. Although the aggressive violations factor had a low alpha coefficient, the grouping of these three aggressive violations has been reported in previous research (Dimmer & Parker, 1999; Chapman et al., 2001; Lawton et al., 1997b). All three items loading on this factor involved expressing hostility towards another driver, providing further evidence that such actions may be a subcategory of aggressive violations. Of the three remaining aggressive violations identified by Lawton et al. (1997a), one loaded on the errors factor, one on the violations factor and one did not load on any of the factors. These findings call into question the coherence of the aggressive violations form of aberrant driving behaviour, at least for the drivers of heavy vehicles.

The four factor solution found here appeared to have more in common with the four factor solution found by Mesken et al. (2002) amongst private vehicle drivers, than the six factor solutions found amongst company car drivers (Dimmer and Parker, 1999; Chapman et al., 2001). This finding suggests that truck drivers may be a special population of those driving in a work-related context, and should therefore be treated in a different way when interventions are planned. Further evidence of the differences between truck drivers and company car drivers includes the different demographics (e.g. age restriction and the fact that they were almost exclusively male) and the higher annual mileage reported by the truck drivers. There were also differences in the crash liability (company car drivers are more at risk of a crash than the general public, who in turn are more at risk of a crash than truck drivers, once annual mileage is taken into consideration). In addition, as mentioned earlier, there is also the fact that the vehicle dynamics of these trucks is greatly different from cars, potentially restricting the types of aberrant driving behaviours which they may be able to engage in. Furthermore, the roads New Zealand truck drivers travel on may also be very different from those driven by the UK company car drivers in Dimmer and Parker's (1999) sample.

8.2.3. – DBQ factors and crash involvement.

The finding that only the violations factor was significantly correlated with crash involvement is also consistent with previous research amongst private vehicle drivers (Reason et al., 1990; Parker et al., 1995a; Meadows et al., 1998). In fact, the odds ratio produced here showed that even after the control variables were partialled out, a one unit increase in the violations factor score increased the odds of crash involvement by 49%. As an illustration of the size of the relationship, if this figure were applied to the 696 reported crashes involving trucks in 2001 (Land Transport Safety Authority, 2002b), a one unit decrease in the violations factor score could mean 341 less crashes, which is a substantial number.

The odds ratio reported in the present research (1.49) is lower than the odds ratio of 3.37, found by Meadows et al. (1998). However, one possible explanation for this disparity is that unlike the current research, Meadows et al. did not partial out the effects of age, preferred speed or experience, all factors that may have contributed to the size of their odds ratio. Although Mesken et al. (2002) also reported an odds ratio, the independent and dependent variables were different to those used in the present study, and thus were not comparable.

The relationship between violations and crash involvement is also consistent with previous research on truck drivers. Using a different method of measuring violations, Hartley and El Hassani (1994) found that truck drivers who reported a higher level of violations were also more often crash involved. Moreover, they found that low violating truck drivers had virtually no crashes in the previous two years. The fact that Hartley and El Hassani (1994) did not use the DBQ, adds to the generalisability of the finding that high violators are more at risk of crash involvement. These results also suggest that one way to reduce truck crash involvement would be to reduce the truck drivers' commission of violations. Also in agreement with previous research (e.g. Kontogiannis et al., 2002; Meadows et al. 1998; Parker et al., 1995a; Stradling et al., 1998) were the

findings that truck drivers who violate more often tended to be younger, less experienced, preferred a faster driving speed and reported a higher level of MSD.

8.2.4. - Factor structure of the Driver Selfishness scale.

PCA of the 23-item driver selfishness scale produced a four factor solution which accounted for 45.2% of the variance. The four factors were; inconsiderate driving, right lane driving, risky driving and holding up. As this was the first use of this scale, it was only possible to look at the apparent logic of the groupings. All four factors proved to be highly interpretable and had acceptable internal validity. In addition, there were only three cross loadings above .30, and only one of these (item 17) appeared to be misplaced. Item 17 (travelling too fast downhill) loaded on the inconsiderate driving factor. However, for truck drivers, travelling too fast downhill would appear to be more correctly categorised as a risky driving behaviour, as this behaviour would increase the risk of being crash involved, just like the other behaviours in the risky driving factor.

8.2.5. – Driver selfishness factors and crash involvement

Of the four driver selfishness factors, only the risky driving factor had a significant correlation with crash involvement. The remaining three factors had very low, non-significant correlations with crash involvement. However, once the contributions of annual mileage, age, experience and preferred speed had been partialled out, the risky driving factor was not predictive of crash involvement. This finding supports earlier research which has not found a direct relationship between generic selfishness and crash involvement (Klumb, 1994).

8.2.6. – Variables correlating with the driver selfishness factors

There were a number of interesting correlations between the four driver selfishness factors and the other main variables assessed in the study. Risky driving behaviour was associated with younger, less experienced drivers who reported more violations, lapses and aggressive violations, had a higher level of MSD and preferred a higher driving speed. Although the risky driving factor and the violations factor were moderately correlated and had a similar pattern of correlations, a correlation of .54 suggests that they were not measuring exactly the same thing. Not only were most of the scale items different, but there were also differences in the pattern of correlations. For example, the risky driving factor also had significant positive correlations with lapses, and aggressive violations, unlike the violations factor. The risky driving factor also had significant correlations with both measures of driving experience, while the violations factor was only correlated with total years experience. In addition, although risky driving behaviour was strongly associated with crash involvement, it was not found to be a direct predictor of crash involvement. The pattern of relationships between the risky driving factor, violations and crash involvement raises the possibility that risky driving has its affect on crash involvement via its relationship with violations. This is discussed later in the chapter.

As this was the first piece of research investigating driver selfishness using a specifically constructed scale, it was only possible to compare these results with those found using generic selfishness scales. The current research extends and supports the findings of other researchers, who have found generic selfishness to be correlated with driving violations using the DBQ (Klumb, 1994) and other measures of driving violations (Adams & Webley, 1996; Burgess, 1999; Weigel et al., 1999). For example, Weigel et al. (1999) found individuals high in selfishness were observed to run more red lights, while Klumb (1994) found that such individuals reported higher mean scores on a 10-item version of the DBQ violations scale.

8.2.7. – Level of MSD.

In terms of absolute means, the truck drivers reported levels of MSD that appeared to be only slightly lower than UK motorists (Lawton et al., 1997b), and greatly lower than the sample of young offenders (Meadows et al., 1998). The fact that truck drivers reported a lower level of MSD than young offenders should have been expected, as by their very nature young offenders would normally be considered to be more socially deviant. The ordering of the ten MSD items was also similar to those found amongst UK car drivers and young offenders (Lawton et al., 1997b; Meadows et al., 1998).

Notwithstanding the similarities between the findings in this research and those found in the UK, a number of the MSD items were less relevant for New Zealand conditions. For example, the use of public transport in New Zealand is not as widely available, or as well utilised as it seems to be in the larger cities around England. In addition, the item which asked the likelihood of driving down the hard shoulder of the motorway may not have had the same relevance for most New Zealand drivers, as only about 5% of the roads in New Zealand are motorways (Baas et al., 2000b). Therefore, a higher level of MSD may have been reported if these items had held more relevance for the current participants. In addition, another item that may raise concern is the item about owning and watching of a TV without a license. Although the data were collected in early 1999, prior to the removal of the television license fee, this item is no longer relevant for assessing the level of MSD in New Zealand. Therefore, future research is needed to either develop a measure of MSD that translates more completely across national contexts, or a version specific to New Zealand conditions should be developed.

8.2.8. – MSD and crash involvement.

The MSD score had a significant positive correlation with the number of crashes reported, which is consistent with previous findings amongst UK car drivers

(Lawton et al., 1997b; Meadows et al., 1998; West et al., 1993a), and Czechoslovakian bus drivers (West, 1997). However, in contrast to previous research (Lawton et al., 1997b; West, 1997; West et al., 1993a), once the demographic and descriptive variables had been taken into account the current research did not find MSD to be a significant predictor of crash involvement. This in turn suggests that the correlation between MSD and crash involvement may be due to the relationship between MSD and age, or it may be due to the involvement of a third variable, such as the violations factor.

8.2.9. –Variables correlated with MSD.

The MSD score had significant negative correlations with age and both measures of driving experience, replicating previous research amongst both private vehicle drivers and professional drivers (Lawton et al., 1997b; West, 1997; West et al., 1993a). However, the lack of a significant correlation between MSD and preferred driving speed was an unexpected result, and is in contrast to previous findings by Meadows et al. (1998) and West et al. (1993a). The absence of a significant result also appears counter intuitive, as we would expect speeding to be another way in which MSD is expressed (in addition to other violations)¹⁰. The lack of a significant correlation between MSD and preferred speed could be due to a number of large differences between driving trucks and driving cars (as discussed earlier), which reduce the degree of discretion truck drivers have when choosing the speed they travel at. Therefore, the lack of a significant correlation between preferred speed and MSD again appears to highlight the differences between car and truck drivers.

Somewhat surprisingly, higher levels of MSD were also associated with drivers perceiving a less positive safety climate. There are a number of possible explanations for this correlation. For example, it could be that individuals who work in an organisation with a negative safety climate become more socially deviant. However, as MSD has been typically regarded as a personality trait

¹⁰ Lawton et al. (1997b) and West (1997) did not measure preferred driving speed.

(Ulleberg, 2002; West et al., 1993a), this seems an unlikely explanation. Another possible explanation could be that MSD amongst the truck drivers has a negative impact upon the safety climate. This would seem a plausible explanation, as the attitudes, ideas and beliefs of the individuals within an organisation would have an affect on the safety climate. Another explanation along similar lines is that organisations with a poor safety climate attract and retain individuals who are more socially deviant. In support of this explanation is the anecdotal evidence in the log transport sector that companies with particularly poor safety records (which may also indicate a poor safety climate) also attract and retain truck drivers with poor attitudes, poor traffic infringement records and crash histories. However, the most likely explanation of the relationship between MSD and safety climate is that the relationship is due to the manner in which safety climate was measured. As individual perceptions of safety climate were used in the present study, the relationship between MSD and safety climate could simply be due to the fact that poor perceptions of safety could also be categorised as being more socially deviant. In other words, poor attitudes, ideas and beliefs about safety may simply be another way in which MSD gets expressed.

The finding of a significant positive correlation between MSD and violations was consistent with previous research that has measured both variables (Lawton et al., 1997b; Meadows et al., 1998). This is not particularly surprising and provides further evidence that violations are simply forms of MSD that are expressed whilst driving. However, both Lawton et al. (1997b) and Meadows et al. (1998) also found MSD had a significant correlation with errors. The absence of such a correlation in the current research could again be due to the nature of the participants in this sample. Truck drivers generally reported significantly fewer errors than company car drivers. A number of factors could contribute to the lower engagement in errors. For example, truck drivers would be very highly practiced in the art of driving, given the high average annual mileage, and greater level of training. In addition, the consequences associated with the commission of errors (e.g. miss a give way sign) would be more serious for a truck, than for a car. Therefore, truck drivers may be more motivated, and better

equipped to avoid committing errors irrespective of the level of MSD. If this is the case, it suggests that training and external contingencies can assist to effectively overcome innate predispositions to engage in certain types of driving behaviours.

The finding that aggressive violations were correlated with MSD has not been reported elsewhere, as previous research measuring MSD did not use the 28-item version of the DBQ. However, this correlation should not be particularly surprising, as it seems obvious that more socially deviant individuals would engage more often in expressing anger and hostility towards other road users.

In addition to MSD's significant correlations with both forms of violations, MSD was also significantly correlated with three of the four driver selfishness factors. This raises the issue of whether driver selfishness is simply a traffic targeted measure of MSD. Although MSD and selfishness are related concepts, and have similar definitions, they are not measuring exactly the same thing. The definitions are similar, in that they both involve the engagement in behaviours that benefit the individual at the expense of another individual, or society in general. However, the correlations between MSD and the four driver selfishness factors was generally relatively low (.06 to .22), except for the risky driving factor, which had a moderate correlation (.41). Furthermore, although MSD was a significant predictor of three of the four factors, it accounted for relatively small proportions of the variance in those factors. After the demographic and descriptive variables had been partialled out, MSD explained 4% of the variance in the inconsiderate driving factor, 6% of the right lane factor and 26% of the risky driving factor. In addition, MSD and the four driver selfishness factors had a different pattern of correlations. Although MSD was not significantly correlated with either annual mileage or preferred speed, risky driving had a significant correlation with speed and the right lane factor had a significant relationship with mileage. The evidence from the present study suggests that MSD and selfishness are not identical concepts, but are strongly related and may in fact be separate parts of a broader personality trait (e.g. general social maladjustment).

8.2.10. – Safety climate and crash involvement.

The present research found no significant correlation between crash involvement and safety climate. On the face of it this finding appears to conflict with previous studies that have reported a strong link between safety climate and accident involvement (Díaz & Cabrera, 1996; Dwyer & Raftery, 1991; Hofmann & Stetzer, 1996; Rundmo, 1994; Tomás et al., 1999; Varonen & Mattila, 2000; Zohar, 1980). However, there is also research which has found current safety climate to be related to future accident history, rather than prior accident history (e.g. Mearns et al., 2001b). This makes intuitive sense, as for a safety climate to have an impact upon an individual's accident involvement, the individual must firstly be exposed to the safety climate. Secondly, the safety climate would then have to affect the individual's attitudes, values and beliefs about safety (which may take some time) before possibly also altering their behaviour and thereby their risk of accident involvement. With this in mind, we would expect the truck drivers' perceptions of safety climate to be associated with the truck drivers' future crash involvement. Further research needs to investigate this issue to confirm (or otherwise) the importance of safety climate in transport companies.

8.2.11. – Safety climate and other main variables.

Truck drivers with poor perceptions of safety climate reported engaging more often in both violations and risky driving behaviour, and preferred a higher speed. Although this research appears to be the first to have found a significant relationship between perceptions of safety climate and the way a truck driver behaves on the road, it substantiates previous research in other industries which has found a clear link between safety climate and safety behaviours (Clarke, 1998a; Cohen, 1977; Hofmann & Stetzer, 1996; Smith et al., 1978). The correlation of safety climate with the unsafe behaviours (faster driving, violations and risky driving) is a particularly important finding, as research has shown unsafe behaviour to be the best predictor of self-reported accidents and near misses (Lawton, 1998; Lawton & Parker, 1998; Mearns et al., 2001a).

Therefore, although there was no direct relationship between safety climate and crash involvement, safety climate may affect whether a driver is crash involved through its significant correlations with violations and risky driving behaviour.

8.2.12. – Mediation effects amongst the main variables

The relationship between safety climate, MSD, the risky driving factor, the violations factor and crash involvement was also tested using the path analysis model developed by Baron and Kenny (1986). Tests for mediation effects between MSD, the risky driving factor, the violations factor and crash involvement were conducted for a number of reasons. Firstly, the effect of MSD on crash involvement has previously been found to be mediated by violations score (Lawton et al., 1997b; Meadows et al., 1998). Secondly, research has also found selfishness to be correlated with engagement in socially deviant behaviours (Weigel et al., 1999). Furthermore, selfishness has also been hypothesised to lead to the production of driving violations (Burgess, 1999; Weigel et al., 1999).

The tests for mediation effects found that the impact of MSD on crash involvement was fully mediated by its relationship with violations. This is in contrast to previous research, which has found partial mediation (e.g. Lawton et al., 1997b; Meadows et al., 1998). Further, the relationship between MSD and violations was partially mediated by the risky driving factor. Therefore, MSD mainly has its affect on violations via its relationship with the risky driving factor, but also has a weak (but significant) direct effect. This suggests that MSD leads to the production of selfish driving behaviours in the form of risky driving behaviour, which in turn leads to the production of violations, thereby affecting crash involvement.

Safety climate was predictive of the risky driving factor, but the relationship with the violations factor score was fully mediated by safety climate's relationship with risky driving. Therefore, safety climate had an indirect effect on crash

involvement, through its relationships with the risky driving factor and subsequently, the relationship between the risky driving factor and violations.

The effect of the risky driving factor on crash involvement was also fully mediated by the violations factor. Therefore, the risky driving factor appears to have its affect on crash involvement via its relationship with the violations factor. This finding also lends further weight to the belief that individual selfishness leads to drivers engaging more often in violations.

The violations factor was the only variable with a direct link to crash involvement, while all the other variables only affected crash involvement through their relationship with violations. This finding provides further evidence that personality traits affect an individual's crash liability by increasing, or decreasing the likelihood that they will drive in a particular manner (Burgess, 1999; Iversen & Rundmo, 2002; West et al., 1993a). Also in agreement with previous research (Díaz & Cabrera, 1996) is the finding that safety climate has its effect on crash involvement indirectly by encouraging or discouraging unsafe behaviours.

8.3. – Demographic and descriptive variables

The descriptive and demographic characteristics of the truck drivers, with regards to age, annual mileage, preferred speed and experience, were related to the main variables under investigation.

One very consistent finding in the literature has been the strong negative relationship between age and crash involvement, which has been reported amongst private vehicle drivers (e.g. Parker et al., 1995a; Parker et al., 1995b) and truck drivers (e.g. Campbell, 1991; Häkkinen & Summala, 2001; Hamelin, 1987; Walton, 1999a). The present research replicates the majority of the findings, in that a strong negative correlation was found between age and the number of crashes reported. Furthermore, age was found to be a significant

predictor of crash involvement, which is again consistent with previous research on private motor vehicle drivers (Parker et al., 1995a; Parker et al., 1995b).

There could be a number of reasons why age is normally found to be related to crash involvement. For example, in the present research, age was found to be related to a number of other variables associated with crash involvement. Younger drivers were found to have a higher level of MSD, prefer a higher speed and to engage more frequently in both violations (DBQ factor) and risky driving behaviour (Driver Selfishness factor). Therefore, part of the reason younger truck drivers are involved in more crashes is due to their driving behaviour on the road.

Another important factor which may have contributed to the strong relationship between age and crash involvement is driver experience, as younger drivers also tended to be less experienced. Experience driving trucks and experience driving trucks in their current industry were both negatively related to the number of crashes reported. These findings provide support for previous research using on private motorists (Trimpop & Kirkcaldy, 1997) and professional drivers (Hertz & Eastham, 1987; Kaneko & Jovanis, 1992; West, 1997). For example, Hertz & Eastham (1987) found that driver experience was negatively related to fatal crash involvement amongst American truck drivers. Similarly, West (1997) found that the number of years bus drivers were with the company was a significant predictor of crash involvement. This was also confirmed by Kaneko and Jovanis (1992) who found that experience contributed directly to crash risk amongst those with less than five years experience.

Although years driving trucks in the drivers' current industry was significantly correlated with crash involvement, it was not a significant predictor of crash involvement when entered into the regression equation with age and preferred speed. Thus, driving experience in their current industry does not significantly explain any of the variance in crash involvement over and above that explained by age. Therefore, the current research provides some support for previous research which showed that experience was related to crash involvement.

However, in this sample the correlation may simply be due to the fact that more experienced drivers tend to be older and less experienced drivers tend to be younger.

Contrary to most previous research using car drivers (Lawton et al., 1997c; Stradling et al., 1998; West et al., 1993a) and truck drivers (Dionne et al., 1995), annual mileage was not predictive of crash involvement. This finding is somewhat surprising, given the fact that annual mileage is generally regarded as one of the most important exposure factors. Most previous research has shown that the more time an individual spends on the road the higher the risk of crash involvement (Dionne et al., 1995; Lawton et al., 1997c; Stradling et al., 1998; West et al., 1993a).

Although the vast majority of research findings amongst private vehicle drivers have found annual mileage and crash involvement to be strongly related, the research on those who drive as a part of work has generally been less supportive of the relationship (Dimmer and Parker, 1999; Cartwright, Cooper and Barron, 1996). In particular, the research findings for truck drivers has been completely balanced. For example, Maycock (1997) found mileage had no effect on crash rates, Dionne et al. (1995) found annual mileage was significantly related to crash involvement. The present study provides further evidence that annual mileage is not a significant predictor of crash involvement amongst truck drivers.

There could be a number of reasons for the lack of a significant relationship between annual mileage and crash involvement. For example, professional truck drivers have a relatively homogeneous annual mileage, when compared to the general public. This restriction in the range of annual mileage would attenuate any relationship with crash involvement. Furthermore, the absence of a significant relationship with crash involvement could be due to the operation of some kind of ceiling effect. It is possible that there is a level of exposure to risk (annual mileage) at which no further exposure would increase that individual's chances of being crash involved. Some support for this contention comes from

the fact that the present study, and Dimmer and Parker's (1999) research, reported average annual mileages considerably higher than any of the other studies using the DBQ. These two studies were also the only two studies using the DBQ that did not find a significant relationship between annual mileage and crash involvement. Moreover, Maycock (1997c) found that crash involvement did not increase in proportion to exposure, but flattened off at higher levels of exposure (higher annual mileages).

Another possible explanation for the absence of the relationship between exposure (annual mileage) and crash involvement may be that mileage is one of the less important exposure factors for truck drivers. It could be that the types of roads they drive upon, the average hours spent driving and the time of day are far more important exposure variables for truck drivers than annual mileage. For example, milk tankers have to drive on farms, which can be extremely muddy and slippery, and contain hidden hazards, narrow spaces and tight turning angles. Milk tanker drivers also spend the vast majority of their time on rural roads, many of which have been poorly designed and constructed (Haight, 2000). In addition, milk tanker drivers have to drive at all times of the day and night. Driving at night and early in the morning has been found to lead to significantly higher levels of crash involvement amongst truck drivers (Kaneko and Jovanis, 1992). Therefore, the type of roads they drive on and the time of day/night they drive may be more important measures of exposure. Therefore, future research should take into account other exposure factors in addition to annual mileage.

The present study did not find a significant relationship between speed and crash involvement amongst truck drivers. This is at odds with previous research on private vehicle drivers (French et al., 1993; West et al., 1993a) and appears to be at odds with the results from the one published study on New Zealand truck drivers (Baas et al., 2000b), in which speed was found to be a major contributing factor in 23% of all truck crashes investigated by the CVIU (Commercial Vehicle Inspection Unit).

One potential reason why speed was not found to be related to crash involvement in the current research could be due to issues surrounding the measurement of speed. The scale used to measure speed asked the drivers to report the speed they preferred to drive at, rather than the speed that they actually drove at. However, this seems to be an unlikely explanation, as research on private vehicle drivers has also found a significant relationship between preferred speed and crash involvement (e.g. Meadows et al., 1998). The more likely explanations would appear to be either differences between fatal and non-fatal crashes, and/or differences between car and truck drivers, both of which are explored below.

The only published research linking speed and crash involvement in truck drivers (Baas et al., 2000b) found a relationship between speed and fatal crashes. The dissimilar finding here may be due to differences in the factors contributing to fatal and non-fatal truck crashes¹¹. Some evidence in support of this proposition is the fact that the CVIU found speed to be a contributory factor in 11% of all fatal crashes, 17% of all crashes involving serious injuries, and 28% of all crashes that resulted in minor injuries (Baas et al., 2000b). Therefore, the contribution of speed varies as a function of crash severity. There is also evidence from research on car drivers' that supports the fact that the contributions of the individual factors vary between fatal and non-fatal crashes (Zhang, Lindsay, Clarke, Robbins & Mao, 2000). Furthermore, research on fatal and non-fatal occupational accidents has found the contributory factors to be different (Jeong, 1998; Saloniemi & Oksanen, 1998).

Another possible explanation for the absence of a relationship between speed and crash involvement lies in the differences between car drivers and truck drivers. It seems likely that truck drivers would not have the ability to exceed the speed limit to the same extent that car drivers have. There are a number of obvious reasons for this, including the size and performance characteristics of the truck (as discussed earlier) and the fact that many of the trucks have speed

¹¹ This explanation could not be investigated using the current data, as there were very few fatal crashes.

limiters installed to prevent the driver grossly exceeding the speed limit (e.g. they are limited to speeds below 100km/hr, or 110km/hr).

The absence of a relationship between speed and crash involvement may have also been due to the fact that the majority of the crashes reported here were very minor and may not have had speed as a contributory factor (e.g. slowly backing onto the grass to turn around. Backed onto farm implement hidden in the long grass). This in contrast to the data reported by Baas et al. (2000), as the CVIU only investigates crashes which are relatively severe, or involve disruptions to the public roading network. Therefore, further research needs to investigate the relationship speed has with truck crashes of different severity.

In summary, although there has been very little research on the impact of demographic and descriptive variables on crash risk amongst truck drivers, most of the findings amongst overseas car drivers and professional drivers were also replicated here amongst a novel sample of New Zealand truck drivers.

8.4. - Utility of Findings

The findings from the present study demonstrate that certain driving behaviours are in fact directly predictive of crash involvement amongst truck drivers. Therefore, it would seem obvious that one method of reducing truck crashes would be to reduce the frequency at which the drivers engage in these behaviours.

As the different types of aberrant driving behaviours have different psychological origins, different remedial measures are also needed. For example, if errors or lapses had been found to be predictive of crash involvement, strategies for reducing crash involvement may have included; training to enhance driving skills, providing in-vehicle memory aids, or the ergonomic redesign of the vehicle interior. In this research it was violations that were found to be predictors of crash involvement. As violations are deliberate

actions which have an attitudinal basis (Lawton, 1998), a different approach must be taken. One of the methods Lawton (1998) suggests for reducing the frequency of violations is to change the individual's attitudes. A number of other possibilities exist for reducing the engagement in violations.

The ability to exceed the speed limit could be taken away from the truck drivers by ensuring that all trucks have speed limiters installed. Obviously this may have implications for safety when overtaking. A more technological approach would be to install all trucks with devices that record the driver's transgressions (such as speeding). Company managers, or enforcement agents could then check these devices, and issue tickets based on this information. An alternative method would be to increase the level of enforcement to ensure that truck drivers obey the speed limits and are driving in a safe manner. Furthermore, the use of roadside warnings and advertising could be used to reduce the truck drivers engagement in violations. This approach already seems to be popular in New Zealand, with many anti-speeding messages already displayed on roadside billboards. However, as Rothengatter (1996) reports, these types of interventions are most effective when paired with relatively high levels of enforcement. Therefore, a combination of these strategies would be warranted.

Examining relationships between personality, dangerous driving behaviour and crash involvement opens up the possibility of the early identification of the drivers most likely to be involved in a crash (Iversen & Rundmo, 2002). In particular, the use of general (non-traffic targeted) personality traits provides the opportunity of identifying at risk individuals before they even commence learning to drive. As the current research has identified one general personality trait that is behind a truck driver's engagement in aberrant driving behaviours, in principle, potentially at risk drivers could be identified before they even obtained a license to drive a truck. Once identified, these individuals could then be put through special training, or some other type of intervention designed to reduce the likelihood that they will engage in these undesirable types of driving behaviour. Alternatively, the information could be used to avoid selecting at risk drivers for driving trucks in industries particularly vulnerable to crash

involvement. For example, logging trucks have been found to be particularly prone to rolling over. Therefore, truck drivers who would be more likely to engage in risky driving and violations could be identified and employed in other less risky parts of the industry. Unfortunately, there is research evidence that suggests selecting on the basis of future accident liability is not a useful approach, due mainly to the fact that the causal relationships are extremely complex (Lawton & Parker, 1998).

However, another rationale for identifying individuals with a higher risk of crash involvement relates to the development of interventions tailored towards these groups. One of the reasons traffic interventions (such as television advertising) may have failed, is that they try to influence a group of drivers that are too large and too heterogeneous (Iversen & Rundmo, 2002). Evidence of this argument is provided by Ulleberg (2002) who found personality influenced how the individuals' evaluated and responded to a traffic safety campaign. Therefore, different intervention strategies may be needed for different subgroups of drivers. Information about the characteristics of particularly at risk drivers could be used not only for deciding which groups to target, but in developing intervention strategies and techniques more likely to be successful at improving the driving behaviour of at risk groups.

8.5. - Limitations

The use of self-report as a means of studying the relationship between independent variables and crash involvement has been criticised as being particularly vulnerable to distortion and social desirability bias (Adams & Webley, 1996; Hatakka, Keskinen, Katila & Laapotti, 1997; Lajunen et al., 1997). Although researchers have found social desirability bias to result in the underreporting of driving behaviours and crash involvement (Lajunen et al., 1997; Loftus, 1993), its impact may be overstated (Iversen & Rundmo, 2002; West, 1995a; West & Hall, 1997).

The use of self-report to study relationships between different driving behaviours would only appear to be a problem if there was a great deal of variance between self-reported driving behaviour and the actual behaviour. Research that has directly investigated the correspondence between self-reported and observed driving behaviour, has generally supported the accuracy of self-reported driving behaviours (Adams and Webley, 1996; Greening and Groeger, 1997; Parker, 1997; Rolls et al., 1991; Walton, 1999a; West et al., 1993b).

Rolls et al. (1991), for example, reported a high level of correspondence between self-reported driving behaviour (measured by the DBQ) and actual driving behaviour on a 40km test route. This was backed up by West et al. (1993b), who also examined the relationship between self-report and observations of driving behaviour. Despite the fact that the drivers were unaware that their driving behaviour was being monitored, West et al. (1993b) found good agreement between most of the self-reported and observed driving behaviours. In particular, they found a correlation of .65 between observed driving speed and responses on the driving speed subscale of their Driving Style Questionnaire. In line with West et al.'s (1993b) finding, Parker (1997) also reported a significant relationship between self-reported speed and unobtrusively observed speeding behaviour.

The accuracy of self-reported data has also been investigated amongst New Zealand truck drivers. Walton (1999a) compared the self-reported speeds of truck drivers with the mean speeds observed by the Land Transport Safety Authority and found the truck drivers accurately reported the speeds at which they travelled on the road. The above research suggests that self-report can be an acceptable substitute for objective measures of driving behaviour.

There is also evidence to suggest the use of self-reported crashes has advantages over the use of archival data. One of the drawbacks of the information gathered by insurance companies and traffic enforcement authorities is that not all crashes are at a level of severity that would entail an

insurance claim or a report to the traffic enforcement agency. Furthermore, even if they are reported, insurance companies and the police may only record the details of crashes above a certain level of severity or cost. This would result in these archives underreporting crashes. This was shown to be the case by Arthur, Tubre, Day, Sheehan, Sanchez-Ku, Paul, Paulus & Archuleta (2001) who found more crashes were reported through self-reports than were recorded in archival data. The underreporting of archival crash data has also been shown to be a problem in New Zealand. For example, Scuffham and Langley (2002) found that half of the crashes requiring hospitalisation were not reported, and suggest that the underreporting of less severe crashes would be even higher.

Part of the problem with relying on archival data is that not only may it underrepresent the true extent of crash involvement, but as a consequence it can also result in underestimating the relationship between crash involvement and the relevant predictors. This is because the underreporting of crashes by archival data results in range restriction effects. For example, in Arthur et al.'s (2001) research the mean, standard deviation and maximum number of crashes were all lower for the archival data, than for the self-reported data. This resulted in Arthur et al. finding stronger relationships between self-reported crashes and the predictors, as range restriction attenuated the relationship between archival crash data and the independent variables. Therefore, as Arthur et al. concluded, self-report data is not inherently inferior to archival data. In fact, self-reports could be considered more accurate, as they can cover all crashes, rather than just those that are either very severe or costly.

Another issue associated with self-report data is the potential for social desirability bias to influence the results. If self-reported driving behaviours were to be greatly influenced by social desirability bias then we would expect the reporting of both the independent variables (e.g. violations, preferred speed) and the dependent variable (crash involvement) would be depressed. This in turn would decrease the likelihood of finding a relationship, rather than inflating it, or creating a relationship where one did not exist. Furthermore, as Hatakka et al. (1997), Lawton et al. (1997a) and West (1995a) argue, if social desirability

was to result in a reduction of the reporting of some behaviours, any resulting associations found would be underestimates of real associations, rather than overestimates. Therefore, the above research provides some degree of confidence that the self-reported driving behaviours measured here were not overly influenced by social desirability bias. Furthermore, as the truck drivers were assured of anonymity and individual confidentiality, there were no external benefits to be gained by underreporting the independent variables or involvement in crashes.

A well known problem with research using postal questionnaires is the poor response rate (Iversen & Rundmo, 2002). It could be suggested that the 36% of the truck drivers who responded were not representative of the population of New Zealand truck drivers. However, the fact that the demographic and descriptive variables of the participants in the survey were similar to those reported in previous research on New Zealand truck drivers supports the representativeness of the sample. The average age, experience, gender and annual mileage were similar to those reported by Charlton and Baas (2001) and Walton (1999a).

There is also some general evidence to suggest that non-responders are not different to those who respond to surveys, in terms of crash history. For example, West and Hall (1997) received an unusually high response rate of 90%, and yet the accident rates and correlations found in their study were very similar to those found previously, where response rates had typically been around 70%. West and Hall took this to suggest that the failure to respond to surveys of this kind was not related to prior accident history. Moreover, Iversen and Rundmo (2002) tested whether the non-responders in their research were dissimilar from the responders. To achieve this they conducted individual interviews with a subsample of those who did not reply to the survey. Their results showed that the sub-sample did not differ significantly from the total sample on any of the background variables measured, nor on crash involvement. Therefore, given the similarities in the demographic and descriptive variables found here with those previously found amongst New

Zealand truck drivers, and the results from the two studies referred to above, we can have some degree of confidence in the representativeness of the current sample of truck drivers.

There were also questions surrounding the generalisability of the DBQ and Driver Selfishness scales. As the DBQ was designed for car drivers, there were a number of aberrant driving behaviours that were not entirely applicable to truck drivers (e.g. forgetting where they parked their truck). The vast majority of trucks do not use car parks (or truck parks) in the same way car drivers do. In addition, it seems likely that truck drivers may also engage in slightly different aberrant driving behaviours, which are not measured by the DBQ. However, in support of the generalisability of the scale to truck drivers are the facts that the hypothetical four factor solution was broadly supported, and the relationships between the DBQ factors and the other main variables generally replicated previous findings amongst private vehicle drivers. Nevertheless, it is recommended that a measure of aberrant driving behaviour for truck driving be developed for future research on truck drivers.

The issues surrounding the generalisability of the Driver Selfishness scale are slightly different and involve the ability to use the scale in other driver populations. The Driver Selfishness scale was developed specifically for the purposes of the present study, and was an initial foray into the measurement of driver selfishness. Despite the fact that the scale was developed specifically to measure selfishness amongst New Zealand truck drivers, only three of the items (driven an overloaded truck, driven for longer than driving hours permit, and failed to adequately clear debris from truck or trailer) have little or no relevance for car drivers. With the removal of these three items, only minor rewording would be required to make the scale applicable to car drivers. Nevertheless, as with the DBQ, efforts should be made to ensure that the scale is more fully tailored to the car driving situation. This would include interviewing both car and truck drivers about the driving behaviours which demonstrate driver selfishness. Another important question is whether this scale could also

be used to measure driver selfishness amongst overseas truck drivers. This question should be addressed in future research.

There is also the possibility that elements of bias were introduced during the development of the Driver Selfishness scale. The scale was developed by interviewing truck drivers from the three industries, and asking them to describe selfish driving behaviours that they had seen other truck drivers engaging in, or that they themselves had engaged in. Unfortunately, the data from these interviews may have been incomplete, due to the particular perspective that truck drivers may have. A more complete understanding of driver selfishness may have been obtained by also interviewing other road users, such as car drivers, who would have introduced a different point of view. Therefore, future research on driver selfishness should attempt to refine the scale by incorporating information from other road users.

There are also issues surrounding the measurement of safety climate. As the organisation is normally considered to have a safety climate, the standard approach is to measure an organisation's safety climate and compare this with the engagement in safety behaviours (or unsafe behaviours) and the organisation's accident rates. However, due to confidentiality issues, and the fact that the majority of the participating companies were small, it was not possible to identify which transport companies the responses came from. This situation prevented the comparison of each organisation's safety climate with reported unsafe behaviours and crash involvement. Therefore, each individual drivers' perception of their organisations safety climate was compared with their self-reported engagement in unsafe driving behaviours and crash involvement. Although this is not the standard approach, the findings were in agreement with previous research, in that perceptions of a poor safety climate were also related to higher engagement in unsafe driving behaviours (higher preferred speed, violations and risky driving). Further support for the validity of this approach can be drawn from Clarke's (1998b) statement that deficiencies in an organisations safety climate (or safety culture) would be evident at both the individual level (as done here) and the organisational level. This statement was backed up by

Mearns et al. (1998) who found significant differences on a number of safety climate and attitude dimensions between individuals' who had been accident involved and those that had not. Moreover, in addition to analysing safety climate at the organisational level, Mearns et al. (2001b) also used individual scores to predict individual accident involvement. Therefore, although the standard approach could not be used here, there is some evidence to suggest the validity of this approach.

Although the violations factor score was a significant predictor of crash involvement, it should be noted that the addition of the four DBQ factor scores only resulted in a 5% improvement in the prediction of crash involvement over and above that afforded by annual mileage, age, preferred speed, and experience. Although this may seem relatively insubstantial, it is higher than the 3.4% found by Xie, Parker and Stradling (In Press), and is considerably higher than the 1% reported by Parker et al. (1995a). However, using a more appropriate indicator of the relationship, the odds ratio found in the present study showed that a one unit increase in the violations factor score increased the odds of being crash involved by 49%. This provides further evidence that the use of ordinary statistics in the case of crash involvement can be misleading, and further illustrates the need to use epidemiological techniques when studying crash involvement.

8.6. - Future research

Although the Driver Selfishness scale, developed here, produced a number of findings similar to that of the generic selfishness scales, future research needs to be undertaken to test whether the driver selfishness scale is measuring the same thing as the generic scales measuring selfishness. Further research is also needed to clearly disentangle the concepts of MSD and selfishness.

Future research should also address whether New Zealand truck drivers report a lower level of aberrant driving behaviour than the New Zealand driving public,

as the comparisons that have been made were mainly with UK car drivers. As the overall crash rates in the UK are lower than in New Zealand (in terms of crashes per 100,000 people and per 10,000 registered vehicles), it would be more interesting and valid to compare the level of violations between New Zealand truck drivers and New Zealand car drivers. As the level of reported violations is strongly predictive of crash involvement, and truck drivers have a lower crash rate, we would expect car drivers to report a significantly higher level. In addition, it would be pertinent to investigate whether truck drivers drive their cars in a different manner from the way they drive their trucks, which would be expected, given the differences discussed earlier. If this proves to be the case, it would be interesting to delve into the reasons for the differences (other than vehicle dynamics). These may then be used to design interventions to decrease car drivers' engagement in aberrant driving behaviours. For example, it may be the free-phone numbers attached to the back of a large number of the trucks that deters the truck drivers from behaving in an aberrant manner.

Another area in which future research needs to be undertaken is in the development of a version of the DBQ for truck drivers. In the current study, only minor wording changes were made to the DBQ to encapsulate appropriate terminology, and make the scale relevant to New Zealand truck driving conditions. As the current DBQ was designed for car drivers, there were a number of aberrant driving behaviours that were not entirely applicable to truck drivers (e.g. forgetting where they parked their truck). Furthermore, there may have also been different aberrant driving behaviours, specific to truck drivers, which were not measured by the DBQ. Therefore, future research needs to more effectively tailor the DBQ to the measurement of aberrant driving behaviour amongst truck drivers, in order to provide a more complete understanding of the relationship between aberrant driving behaviour, the precursors of aberrant driving behaviour and crash involvement.

In line with the recommendations of Lawton and Parker (1998), the current research has demonstrated a significant relationship between unsafe behaviours (in this case violations and risky driving behaviours) and crash

involvement. The focus now needs to be shifted towards investigating the factors that cause truck drivers to engage in the unsafe driving behaviours and how to resolve these. For example, how to prevent truck drivers exceeding the speed limit or tailgating other traffic? The penalties associated with speeding or tailgating (e.g. fines and crashes) are sporadic, but the benefits (e.g. getting to the destination more quickly and venting frustration) are immediate and frequent. From a societal point of view the cost of crashes are large, but from an individual truck driver's perspective the costs are unlikely and very distant when compared to the immediate benefits (Lawton, 1998). Therefore, research is needed to investigate how to increase the benefits to truck drivers of engaging in safe driving behaviours, while also decreasing the benefits of driving in an unsafe manner.

Considerably more research needs to be undertaken with regards to the influence of safety climate amongst transportation companies and its impact upon the manner in which the truck drivers behave on the roads. Research needs to confirm the relationships found here at an organisational level, rather than solely at the individual level.

As the current research used a short unidimensional measure of safety climate it was not possible to investigate whether particular aspects of the safety climate were correlated with the different DBQ factors and the driver selfishness factors. It is possible that a more in depth scale with a greater number of dimensions would have found a direct relationship between safety climate and crash involvement. Using a more detailed survey, research should be carried out to investigate more thoroughly the safety climate of transport companies and its relationship with unsafe behaviours and crash involvement. As well as cross-sectional designs, future research should also utilise a longitudinal design to enable the investigation of the relationship between safety climate and future outcomes (e.g. safety behaviours and crashes).

8.7. - Conclusions

The present study is important because it adds to the body of knowledge in the following ways. Firstly, despite the obvious differences between driving trucks and driving cars, this study produced a remarkable number of similarities to previous research involving car drivers. This was clearly demonstrated in the factor analysis of the DBQ scale, which provided broad support for the four hypothetical factors. There was also the fact that, of the four DBQ factors, only the violations factor was significantly predictive of crash involvement. Therefore, truck drivers who are higher violators are at a greater risk of being crash involved.

In addition, the research has developed a traffic targeted measure of selfishness. One of the resultant factors, risky driving, was predictive of violations score. Furthermore, the relationship between risky driving and crash involvement was fully mediated by the relationship between risky driving behaviour and violations, meaning that risky driving behaviour affects crash involvement through its relationship with violations.

This research also found a significant correlation between perceptions of safety climate and safety behaviours, such that drivers who perceived a negative safety climate reported a higher preferred driving speed and also reported engaging more frequently in both violations and risky driving behaviour. However, although safety climate was not significantly correlated with crash involvement, it was significantly correlated with the safety behaviours (risky driving behaviour, violations and speed preference). Furthermore, safety climate was a significant predictor of the risky driving factor. As risky driving behaviour was found to be indirectly predictive of crash involvement (via violations), safety climate affects crash involvement indirectly.

MSD was a significant predictor of both violations and risky driving behaviour. However, tests for mediation revealed that although MSD was directly predictive of risky driving, the relationship with violations score was partially mediated by

the risky driving variable. Therefore, MSD had its affect on crash involvement indirectly through its relationships with the risky driving and violations factors. MSD was also strongly correlated with, and predictive of, three of the driver selfishness factors, demonstrating that the concepts of MSD and selfishness are closely related. Although they are closely related concepts, they are clearly not exactly the same thing.

In summary, the present study was the first to measure aberrant driving behaviour, MSD, safety climate, and driver selfishness amongst truck drivers, and to investigate how these variables contribute to crash involvement. A number of significant results were reported, particularly the finding that engagement in violations was predictive of crash involvement, and that the other main variables were all related to the commission of violations. This research can serve as an impetus for further research into the factors that lead a truck driver to violate, and to develop practical methods transport companies can use to reduce truck drivers' engagement in violations.

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Appendix 1

Sullman, M.J.M., Meadows, M.L., & Pajo, K. (2002). Aberrant driving behaviours amongst New Zealand truck drivers. *Transport Research – Part F*, 5(3), 217-232.

Appendix 2

Sullman, M.J.M., Pajo, K., & Meadows, M.L. (2002). The impact of transport company safety climate on truck crashes. In D. de Waard, K.A. Brookhuis, J. Moraal, and A. Toffetti (Eds.). *Human Factors in Transportation, Communication, Health and the Workplace* (121-129). Maastricht, The Netherlands: Shaker Publishing.

Appendix 3

Sullman, M., Meadows, M., & Pajo, K. (2001). *The role of attitudes and reported driving behaviour in truck crashes*. COHFE Report, 2 (6): Rotorua, New Zealand.

Appendix 4

Sullman, M.J.M., Meadows, M.L., & Pajo, K. (In Press). Errors, lapses and violation in the drivers of heavy vehicles. In the Proceedings of the *International Conference on Traffic and Transport Psychology*. Berne, Switzerland (4-7th September).

Appendix 5

Questionnaire

TRUCK DRIVER QUESTIONNAIRE

INFORMATION

Previous research on private vehicle drivers has clearly shown that a number of variables are associated with increased risk of involvement in specific types of accidents. The aim of this research is to discover whether these same factors are also related to heavy vehicle accidents. If this finding is confirmed, then the questionnaire could provide information that may be used by truck drivers to identify the type(s) of accidents they are most at risk of having, so that they can seek training or education to avoid having these accidents.

The research is being conducted in association with Transport Engineering Research New Zealand Limited (TERNZ) and Liro - Forestry Solutions (formerly the Logging Industry Research Organisation). The research will be carried out by Mark Sullman from the Department of Human Resource Management at Massey University, in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD). The Supervisor of the research is Professor Philip Dewe from the Department of Human Resource Management. For further information on this study feel free to contact Mark Sullman on (06) 350-5799 (ext 2387) or Professor Dewe on (06) 350-5799 (ext 2360).

You are invited to participate in this survey. The survey will take between 20-35 minutes to complete. The completion and return of this questionnaire implies consent. You do not have to answer all the questions. Questionnaires are being sent out to managers in all logging, milk and petrol transportation companies and we are asking these people to distribute these questionnaires to all their drivers. No one will know whether you complete the questionnaire or not. The information you provide will be held in the strictest confidence at Massey University and will only be seen by the researcher and supervisor. Only summary data only will be used. The findings from this research may be published in professional or academic journal.

If you want to go into the draw to win on of; a \$120 Mitre 10 voucher, a \$50 Repco voucher, or a \$30 Whitcoulls voucher, please write your name and contact details at the back of the questionnaire.

INSTRUCTIONS

The purpose of this questionnaire is to survey you as a truck driver. Please respond to each statement as honestly as you can. There is no need to spend more than a few seconds on each question. If after making a response you change your mind, simply cross out your first answer, and indicate your preferred response. When you have completed the questionnaire, please return it in the pre-paid envelope provided

We would appreciate it if you could complete and return the questionnaire as soon as possible.
Thank you.

SECTION I: DEMOGRAPHICS

1. Are you (*tick one box*)?

Male ☐
Female ☐
2. What age are you? _____ Years
3. How many kilometres have you driven in the last year (*if you don't know please estimate*)?

4. What type of truck do you drive (e.g. Single truck, truck-trailer, Tractor Semi, A-Train, B-Train)?

5. How many years have you been driving trucks?

6. How many years have you been driving trucks in this industry?

7. Please list the training you have had to drive trucks (*including safety training*)?

8. What type of load do you normally carry (*circle one*)? Logs/Timber/Milk/Petrol
9. Are you:

☐
☐
☐
☐

a company employee driver
 an owner driver subcontracting to a transport company
 a free lance owner driver
 a driver working for an owner driver
 other (*please specify*) _____
10. Between what hours do you normally drive?

11. At what speed do you generally prefer to drive on:

the open road? _____ km/hr
 the country road? _____ km/hr
 busy main street? _____ km/hr
 a road through a residential area _____ km/hr

SECTION 2: DRIVING BEHAVIOUR

How often do you do each of the following?

For each item, you are asked to indicate how often this kind of thing has happened to you, using the following key. Base your judgements on what you remember of your driving over, say, the past year.

0 = never 1 = hardly ever 2 = occasionally 3 = quite often 4 = frequently 5 = all the time

| | never | | | | | all the time |
|---|-------|---|---|---|---|--------------|
| <i>please tick the most appropriate column for EACH item</i> | 0 | 1 | 2 | 3 | 4 | 5 |
| Hit something when reversing that you had not previously seen | | | | | | |
| Intending to drive to destination A, you "wake up" to find yourself heading for destination B, maybe because the latter is a more usual destination | | | | | | |
| Drive when you suspect you might be over the legal blood alcohol limit | | | | | | |
| Get into the wrong lane approaching a roundabout or an intersection | | | | | | |
| Queuing to turn left onto a main road, you pay such close attention to the main stream of traffic that you nearly hit the car in front | | | | | | |
| Fail to notice that pedestrians are crossing when turning into a side street from a main road | | | | | | |
| Sound your horn to indicate your annoyance at another road user | | | | | | |
| Fail to check your rear-view mirror before pulling out, changing lanes, etc. | | | | | | |
| Brake too quickly on a slippery road, or steer the wrong way in a skid | | | | | | |
| Pull out of an intersection so far that the driver with right of way has to stop and let you out | | | | | | |
| Disregard the speed limit on a residential road | | | | | | |
| Switch on one thing, such as the headlights, when you meant to switch on something else, such as the wipers | | | | | | |
| On turning left, nearly hit a cyclist who has come up on your inside | | | | | | |
| Miss "Give Way" signs, and narrowly avoid colliding with traffic having right of way | | | | | | |
| Attempt to drive away from the traffic lights in third gear | | | | | | |
| Attempt to overtake someone that you hadn't noticed to be signalling a right turn | | | | | | |
| Become angered by another driver and give chase with the intention of giving him/her a piece of your mind | | | | | | |
| Stay in a motorway lane that you know will be closed ahead until the last minute before forcing yourself into another lane | | | | | | |
| Forget where you left your truck in the truck park | | | | | | |
| Overtake a slow driver on the inside | | | | | | |
| Race away from traffic lights with the intention of beating the driver next to you | | | | | | |
| Misread the signs and exit from a roundabout on the wrong road | | | | | | |
| Drive so close to the car in front that it would be difficult to stop in an emergency | | | | | | |
| Cross an intersection knowing that the traffic lights have already turned against you | | | | | | |
| Become angered by a certain type of driver and indicate your hostility by whatever means you can | | | | | | |
| Realise that you have no clear recollection of the road along which you have just been travelling | | | | | | |
| Underestimate the speed of an oncoming vehicle when overtaking | | | | | | |
| Disregard the speed limit on the open road | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |

SECTION 3: SAFETY ATTITUDES

You will find below, statements about safety and your job. For each statement please indicate whether or not you personally agree (by ticking the appropriate box on each line).

| | Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |
|--|-------------------|-------|----------------------------------|----------|----------------------|
| Everyone has an equal chance of having an accident. | | | | | |
| In the normal course of my job, I do not encounter <u>any</u> dangerous situations | | | | | |
| People who do not take the necessary precautions are responsible for what happens to them. | | | | | |
| Safety works until we are busy then other things are done first | | | | | |
| If I worried about safety all the time I would not <u>get my job done</u> | | | | | |
| People who drive to safety procedures will always be safe | | | | | |
| I cannot avoid taking risks in my job | | | | | |
| Accidents will happen no matter what I do | | | | | |
| It is not likely that I will have an accident because I am a careful person | | | | | |
| Not all accidents are preventable, some people are <u>just unlucky</u> | | | | | |
| Everybody drives safely in my company | | | | | |
| All the safety rules and procedures in my workplace really work | | | | | |
| It would help me to drive more safely if my supervisor praised me on safe behaviour | | | | | |
| It would help me to drive more safely if safety procedures were more realistic | | | | | |
| When I have driven unsafely it has been because I didn't know what I was doing wrong at the time | | | | | |
| When I have driven unsafely it has been because I needed to complete the task quickly | | | | | |
| When I have driven unsafely it has been because the right equipment was not provided or wasn't working | | | | | |

SECTION 4: DRIVING STYLE

Thinking back over the last year could you please consider each of the driving behaviours listed below and indicate, using the six-point scale, how often you have driven in this way.

0 = never 1 = hardly ever 2 = occasionally 3 = quite often 4 = frequently 5 = all the time

| | never | | | | | all the time |
|--|-------|---|---|---|---|-----------------|
| <i>Please tick the most appropriate column for EACH item</i> | 0 | 1 | 2 | 3 | 4 | 5 |
| Followed too closely to a vehicle that has annoyed you in some manner (e.g. driving very slowly) | | | | | | |
| Tailgated a vehicle in front to alert them to the fact that you are there and they are holding you up. | | | | | | |
| Exceeded the speed limit. | | | | | | |
| Indicated too late | | | | | | |
| Failed to indicate at all | | | | | | |
| Held up vehicles stuck behind you by using a passing opportunity to overtake a slower vehicle which was holding you up | | | | | | |
| Failed to adequately clear debris (e.g. mud, stones, bark) from your truck or trailer before driving on public roads | | | | | | |
| Have not pulled over to the side to let faster vehicles past when you could have safety done so | | | | | | |
| Have not pulled off the road and stopped to let faster vehicles past when a large number are stuck behind you | | | | | | |
| Have not waited for other vehicles to go past before pulling out on to a road, when you know other drivers would have to slow down for you while you get up to speed | | | | | | |
| Been stuck behind a slow vehicle and made an overtaking manoeuvre that you were not 100% certain you could safely complete | | | | | | |
| Crossed the centre line while cornering | | | | | | |
| Driven for longer than the driving hours permit | | | | | | |
| Driven an overloaded truck | | | | | | |
| Failed to completely stop at a stop sign | | | | | | |
| Followed another truck close enough to make it difficult for other vehicles to over take either you or the other truck | | | | | | |
| Travelled too fast downhill | | | | | | |
| Increased your speed when another truck attempted to overtake | | | | | | |
| Have not let other vehicles into traffic when traffic was merging | | | | | | |
| Ensured that other vehicles obeyed the speed limit by slowing down in front of them | | | | | | |
| When unloaded, taken the right hand lane at the traffic lights to pass a loaded truck in the left lane | | | | | | |
| Moved into the right lane to avoid being cut off when two lanes are about to merge | | | | | | |
| Not pulled to the side until the very last moment when turning left | | | | | | |

SECTION 5: CONSCIENTIOUSNESS

Here is a list of things people are tempted to do from time to time. How likely is it that you would do these things if you were completely certain of getting away with it? Please tick the most appropriate column for each item.

| | Not at all likely | Quite likely | Very likely |
|---|-------------------|--------------|-------------|
| Ride on public transport without paying a fare | | | |
| Park on (dashed) yellow lines | | | |
| Earn cash payments without paying tax on them | | | |
| Leave a shop with goods that you have not paid for | | | |
| Make a fraudulent insurance claim | | | |
| Drive down the hard shoulder of a motor-way when the other lanes are jammed | | | |
| Keep a \$20 note you have found in the street | | | |
| Hit someone who has annoyed or upset you | | | |
| Own and watch a TV without having a licence | | | |
| Take time off work sick when you have something more interesting to do | | | |

SECTION 6: ACCIDENTS

We would now like you to tell us about all kinds of road accidents that you have been involved in as a truck driver, over the last three years. By accident we mean any incident which involved injury to another person or yourself, damage to property, damage to another vehicle or damage to the truck you were driving. Please include all accidents, regardless of how they were caused, or how slight they were.

Please remember your answers will be treated in strict confidence

1. How many accidents have you been involved in as a truck driver in the last three years?

2. As best you can recall, how many accidents have you been involved in during your truck driving career?

3. Please describe briefly how and where each accident happened including your approximately speed at the time of the accident and the speed limit in force in the area at the time.

Most recent

Next most recent

One before that

If you want to go into the draw to win one of: a \$120 Mitre 10 voucher, a \$50 Repco voucher, or a \$30 Whitcoulls voucher, please write your name and contact details below.

OPTIONAL

First name: _____

Address: _____

Phone number: _____

If you have any further comments to make, please make them in the space provided below:

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THANK YOU FOR YOUR PARTICIPATION

Appendix 6

Structured Interview Questions

Structured Interview Questions

What do you believe is the biggest threat to the safety of drivers?

When you were out driving last time, can you think of a time when something seriously annoyed you? **Y/N** What happened?

Why did this annoy you?

What best describes selfish driving behaviour?

Thinking about your own driving, what sorts of behaviours would you describe as selfish?

What do you think other drivers do that best describes selfish driving behaviour?

Are there any selfish behaviours which you would say are specific to log/milk/petrol truck/tanker drivers? **Y/N** What are they?

Do you think log/milk/petrol truck/tanker drivers are able to get away with more selfish behaviours than other drivers? **Y/N**

If yes, what sorts of selfish behaviours do they get away with?

If no, why not?

If you were to develop a training scheme to help log/milk/petrol truck/tanker drivers eliminate selfish driving behaviours, what sorts of things would you include in that training scheme?

Appendix 7

Cover Letter

Truck Driver Survey

Dear Driver,

The aim of this research is to gather information to improve our understanding of heavy vehicle accidents. The research is being conducted in association with Transport Engineering Research New Zealand Limited (TERNZ) and Liro - Forestry Solutions (formerly the Logging Industry Research Organisation). The research will be carried out by Mark Sullman from the Department of Human Resource Management at Massey University, in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD). The Supervisor of the research is Professor Philip Dewe from the Department of Human Resource Management.

We would greatly appreciate it if you would take some of your time out of your busy schedules to participate in this survey. The survey will take between 20-35 minutes to complete. The completion and return of this questionnaire implies consent. You do not have to answer all the questions. Questionnaires are being sent out to managers in all logging, milk and petrol transportation companies and we are asking these people to distribute these questionnaires to all their drivers. No one will know whether you complete the questionnaire or not. The information you provide will be completely confidential and will only be seen by the researcher and supervisor.

Please complete the attached questionnaire and return it in the freepost envelope. If you want to go into the draw to win one of; a \$120 Mitre 10 voucher, a \$50 Repco voucher, or a \$30 Whitcoulls voucher, please write your name and contact details at the back of the questionnaire. Please note that the provision of your name is not a requirement for completing this questionnaire, it is only if you want to go into the prize draw.

If you have any questions or comments, feel free to contact Mark Sullman on (06) 350-5799 (ext 2387) or Professor Dewe on (06) 350-5799 (ext 2360).

Yours sincerely,

Mark Sullman
Department of Human Resource Management
Massey University.