FEDERAL GOVERNMENT'S ROAD SAFETY INITIATIVE

YOUNG DRIVER RESEARCH PROGRAM -

THE INFLUENCE OF AGE-RELATED AND EXPERIENCE-RELATED FACTORS ON REPORTED DRIVING BEHAVIOUR AND CRASHES

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Young Driver Research Program -
The Influence of Age-Related and Experience-Related Factors on Reported Driving Behaviour and Crashes

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Abstract

This study investigated the relative importance of youth and lack of driving experience as contributors to the over-representation of young drivers in traffic crashes. Interviews were conducted with drivers aged 16-29 to collect information on their personal characteristics, travel patterns and crash histories. After allowing for differences in exposure (time spent driving), crash involvement was found to be associated with lack of driving experience and with high levels of recklessness. Recklessness was higher amongst younger drivers. Drivers who obtain a licence relatively early were no more reckless than those who are licensed when somewhat older. Young males were significantly more reckless than young females but did not have higher crash risk (after controlling for exposure). Thus, skill levels may be higher among young males, compensating for their greater recklessness. Although experience was found to be more important than age in determining crash risk, the high correlation between the two means that the issue cannot be resolved beyond all doubt. Future research should directly address the skill and motivational variables relevant to crash risk, rather than relying on experience and age as proxies. The present study has taken an important step in this direction by demonstrating that recklessness is a better predictor of young driver crash involvement than age. The report concludes with recommendations for countermeasure development.

Keywords (IRRD)

Recently qualified driver, accident, age, driving experience, driving licence

CONTENTS

EXECUTIVE SUMMARY

The young driver problem - age or experience?

It has been widely confirmed that young drivers have a greater risk than other drivers of being involved in a traffic crash. The elevated crash risk of young drivers results not from greater distances driven (and thus greater exposure to risk) than other age groups, but from greater risk per unit exposure. A variety of factors may contribute to this high risk level, the most obvious of which is lack of driving experience, since driving skill, like most other skills, is probably acquired largely through practice. Research in Victoria has shown that the rate of casualty crash involvement per distance driven decreases steadily with increasing driving experience. However, experience is not the only correlate of age which may influence crash risk; other factors may be responsible, at least in part, for the decrease in crash rates with increasing age and experience. For example, it has been argued that young people around minimum licensing age are at a stage of life where they reject parental values, strive for independence, experiment with roles and become heavily influenced by their peer group and its values. Thus young people may be motivated to drive fast or take other risks in order to test their own abilities, to demonstrate independence from authority or to impress their peers.

Although driver age and experience are highly correlated, it has been seen as important to determine which is the better predictor of crash risk. The consequences for countermeasure design could be profound. A finding in favour of experience would strongly suggest that the young driver problem is primarily a result of skill deficits, which are gradually overcome with increasing experience of driving. In this case, further research and countermeasure development should concentrate on accelerating the development of those skills which are critical to safe driving. On the other hand, if age is the main predictor of crash risk, countermeasures should focus on age-related motivational and lifestyle factors.

Review of previous studies

There have been several major investigations into the "age versus experience" question during the last three decades. However, previous research in the area was found to be fraught with conceptual and methodological difficulties. Many of the studies reviewed had employed inadequate measures of driving experience, making it difficult to identify a relationship between experience and crash involvement. Such problems did not occur with age, however, which drivers are able to report much more accurately than their driving experience.

Previous studies generally entailed comparisons of the crash involvement of drivers of the same level of experience but different ages, and/or comparisons of drivers of the same age but different levels of experience. In effect, these studies compared drivers who acquired a licence at different ages. All relied on the unstated and untested assumption that differences in the crash risk among such drivers are due entirely to differences in age or experience; drivers who obtain a licence at different ages were assumed to differ in no other respect relevant to crash risk. No systematic attempt has previously been made to identify the factors associated with early licence acquisition and to determine their relevance to crash risk. This shortcoming throws doubt on the conclusions of all studies reviewed. Any tendency for individuals who obtain a licence earliest to have personal characteristics associated with elevated crash risk (independent of age and experience) would contribute to elevation of crash rates among first year drivers at the lowest ages, creating an exaggerated age effect and

biasing "age versus experience" comparisons towards a finding in favour of age. Conversely, any tendency for comparatively safe drivers to acquire a licence earliest would bias such studies towards a conclusion that experience is the dominant influence on crash involvement.

Information sources used in the study

Data from driver interviews conducted for a related investigation (also part of the Federal Office of Road Safety's "Young Driver Research Program") were used to examine the factors associated with early and late acquisition of a driver's licence in Australia. The interviews included a comprehensive selection of items expected to be relevant to crash risk, and information on the driving exposure of the respondents during the week before the survey. Drivers who had driven at least once in the previous month were interviewed at their homes in all six states of Australia. The sample was stratified by age group, sex, state and location type (metropolitan versus country). Interviews were obtained from a total of 1688 drivers in the age range 16-29 years. Further information was available from questionnaires administered to a sample of drivers stopped at Random Breath Testing stations in Melbourne and Adelaide. Questionnaires were completed by 371 drivers in the age range 16-29 years. These questionnaires included a substantial sub-set of the items used in the home interview series. The questionnaire data were used where possible to assess the reliability of results obtained from the analysis of the home interview data.

The above surveys did not include questions on crash involvement. In order to obtain crash data, a sub-set of the drivers who had been interviewed during the earlier home interview survey were re-interviewed by telephone. Some 800 interviews were obtained from drivers aged 16-29 years at the time of the home interview survey. Crash histories obtained during the telephone interviews were combined with the travel and personal characteristics collected in the home interview survey to form a single data set for joint analysis.

Age of licence acquisition

Principal components analysis was used to reduce the very large number of variables derived from the home interview data to a more manageable number of "factors" describing the drivers interviewed. Multiple regression was then used to identify the driver characteristics which made the largest independent contributions to prediction of the age at which a driver reported having obtained a licence. Early acquisition of a licence was associated with:

- living in a state with a low licensing age
- being young (although this result was at least in part an artefact of the sampling procedure)
- being male
- high scores on Factor 2 from the principal components analysis, which was interpreted as measuring the extent to which respondents had "settled down" (married with children and a mortgage)
- high scores on Factor 3 from the principal components analysis, indicating respondents who lived in rural areas, paid rent or board and did not speak a language other than English at home
- having completed some form of post-secondary education (tertiary, technical or trade).

There were some indications that drivers scoring high on Factors 2 and 3 may have tended to have relatively low risk of crash involvement. However, Factor 1 from the principal components analysis, which was interpreted as measuring the respondent's "recklessness" (willingness to take risks in driving and non-driving contexts), was the driver characteristic most strongly expected to indicate high crash risk. This factor was found not to be significantly related to age of licence acquisition.

Driver characteristics associated with crash involvement

Out of 800 respondents who were re-interviewed by telephone, one reported three crashes in the previous three years, 12 reported two crashes, 181 reported one crash, and the remaining 606 respondents reported no crashes. Analyses to identify the driver characteristics most strongly associated with crash involvement data were performed twice: once taking account of differences in quantity of exposure, and once without taking account of exposure.

When differences in quantity of exposure were not taken into account, logistic regression analysis revealed that reported crash involvement in the last three years was associated with:

- high recklessness (Factor 1),
- driving in a wide variety of conditions in the week before the home interview (Factor 4),
- having few years of driving experience, and
- being male.

After allowing for differences in exposure (time spent driving), crash involvement was associated with:

- having few years of driving experience, and
- high recklessness (Factor 1).

In both analyses, age was significantly correlated with crash involvement, but did not significantly improve prediction of crash involvement after driving experience had entered the prediction equation. However, in both analyses, as a result of the high correlation between age and experience, very similar probability values were obtained for these two variables during the logistic regression procedure.

None of the three main characteristics which predicted age of licence acquisition (Factors 2 and 3 and post-secondary education) was found to be significantly associated with reported crash involvement, after allowing for the effects of sex, age and experience.

Conclusions on the role of age, experience and related factors

The issue underlying this part of the Young Driver Research Program was that of "Age" versus "Experience" as determinants of young driver crashes. What, then, are the implications of the finding that the strongest predictors of crash risk were Experience and Recklessness?

Clearly, both skill and motivational factors are important elements in young driver crashes. The primary role of Experience in the regression equations indicates that skill deficits play a major role in crash causation among inexperienced drivers. Recklessness, the other main

driver characteristic predicting crash risk, was significantly correlated with age, confirming the additional contribution of age-related motivational factors.

Young males were considerably more likely to report crash involvement than were young females. However, after taking into account the much greater exposure of males, there was no significant difference in the overall crash risk of males and females, supporting the view that the greater crash involvement of young males is largely due to their greater exposure to risk as a result of more time spent driving. Nevertheless, young males were significantly more reckless than young females. This suggests that average skill levels may be higher among young males, compensating for their greater recklessness, and that skill deficits play a relatively greater role in the crashes of young female drivers. Such a conclusion is consistent with evidence from previous research that young females have poorer perceptual, cognitive and vehicle control skills. However, experience predicted the crash risk of both males and females, so skill deficits appear to be a problem for young drivers of both sexes.

The finding that experience is a more important determinant of young driver crash risk than age must be regarded as indicative rather than conclusive because of two unresolved, and to some degree irresolvable, difficulties. These are the high correlation between age and experience, and the possible effect of self-selection of age of licence acquisition on the interpretation of the results of this and similar studies. Moreover, there appears to be little prospect of future studies providing any better resolution of this issue as long as the question is posed in its present form: that is, as long as experience is used as an index for the whole spectrum of driving skills likely to be relevant to crash avoidance, and age is used an index of the relevant motivational factors.

To progress beyond our present level of understanding, it will be necessary for future research to address the relevant skill and motivational variables directly. The present study has taken an important step in this direction by demonstrating that "Recklessness", as constructed from the questionnaire data, is a better predictor of young driver crash involvement than is Age.

Future research and countermeasure development

The present study has found that both experience-related driving skills and age-related motivational factors contribute to the over-representation of young drivers in traffic crashes, with skill deficits appearing to play the major role. As a result, the following recommendations for future research and countermeasure development are made:

> *There is an urgent need to develop improved driver training programs and methods, to ensure that young and novice drivers are equipped with the skills required for safe driving.*
>
> *To provide a basis for the development of effective training programs, research is required into:*
>
> *(1) the nature of driving skills (incorporating perceptual, cognitive and motor components);*
>
> *(2) the basic perceptual and cognitive capacities required to allow the development of these skills (these may differ somewhat for males and females); and*
>
> *(3) the processes and stages by which young drivers develop these skills.*

This research, focussed on driving itself, should be supplemented by concurrent research to investigate relationships between particular components of driving skill and particular types of crash.

Graduated licensing schemes should be structured so as to emphasise to young drivers that there are more advanced aspects of driving skill than simple vehicle control. At the end of the prescribed probationary period, drivers should face a valid test of the "higher level" (perceptual and cognitive) components of driving skill. The driver should remain on a probationary or provisional licence indefinitely until he or she develops the proficiency required to pass the test.

Research is needed to investigate the ways in which driver attitudes associated with elevated crash risk interact with other variables in their effect on young driver behaviour, particularly behaviour associated with the types of crash in which young drivers are most over-represented.

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1. AGE, EXPERIENCE AND YOUNG DRIVER CRASHES

One of the most widely confirmed observations in the field of traffic safety is that, in any given year, young drivers have a greater risk than other drivers of being involved in a traffic crash. For example, the most recent figures for New South Wales show that in 1992 drivers aged 17-25 years held 16% of licences but accounted for 30% of drivers and riders killed in crashes and 35% of all driver and rider casualties (RTA-NSW, 1993). Similar reports from countries such as New Zealand, Britain, the United States, Canada and many others confirm that this problem is not confined to Australia, but applies to most, if not all, highly motorised jurisdictions around the world.

Attempts to reduce the crash risk of young drivers to levels comparable to rest of the driving population necessarily rely on identifying factors which make a large contribution to that risk. It is usual to model an individual's risk of being involved as a driver in a traffic crash as a function of the quantity of the individual's driving exposure and the riskiness of each unit of driving exposure. This model embodies the intuitively reasonable and empirically verifiable assumption that the more one drives, the greater is one's risk of being involved in a crash. Thus a first hypothesis to account for the elevated crash risk of young drivers might be that they have more crashes than other drivers because they drive more. However, studies which estimate the average distance driven annually by drivers in different age groups show that this is not the case. The youngest drivers in fact drive shorter distances per annum than drivers in middle age (Pelz and Schuman, 1971; Toomath and White, 1982), so that when distance driven is taken into account young drivers still appear more risky than their older counterparts. Hampson (1989) reported that the rate of fatal crash involvement per 100 million kilometres driven in Australia in 1984 and 1985 was over three times higher for young (16-25 year old) drivers than for drivers aged 32-59 years. For the USA, Williams (1985) reported that the rate of fatal crash involvement per 100 million miles driven was over four times as high for drivers aged 16 and 17 as for drivers aged 30-59 years.

In terms of the simple model of the previous paragraph, the elevated crash risk of young drivers results not from greater driving exposure than other age groups but from greater risk per unit exposure. The model can be extended by dividing factors which affect the risk of driving a given distance into those which would apply to any driver undertaking a particular trip and those which would vary for different drivers undertaking the same trip.

Factors which would apply to any driver making the trip are usually referred to as the qualities of exposure. They include time of day, weather and lighting conditions, road conditions, traffic density and characteristics of the vehicle driven. The qualities of exposure can greatly affect the risk associated with a given quantity of exposure. Darkness, rain, narrow, winding or poorly delineated roads and bald or under-inflated tyres and many other factors external to the driver can increase crash risk relative to ideal conditions. A second hypothesis to account for the elevated crash risk of young drivers might be that they do more of their driving under road, vehicle and environmental conditions which tend to increase risk. Consistent with this hypothesis, there is evidence that young drivers do more of their driving at night, which may contribute to their increased risk of crash, since crash rates are higher at night than in daytime. However, when exposure and crashes are disaggregated by time of day, it is found for both night-time and daytime driving that the crash rate per distance driven is far greater for young drivers than for middle aged drivers (Williams, 1985).

Night driving alone is therefore not sufficient to explain why crash risk is higher for young drivers than for other drivers. There is also evidence (e.g. Washington State Patrol, 1971, cited by Knapper, 1985) that young drivers tend to drive older vehicles, which may be in poor repair, and motorcycles, which offer less protection than cars against injury. Thus it seems likely that road, vehicle and environmental conditions do contribute to the elevated crash risk of young drivers, although the extent of that contribution is not known. However, as Knapper (1985) points out, in-depth studies (e.g. Sabey and Staughton, 1975) have consistently found that the contribution of these factor groups to crashes is far outweighed by the contribution of factors associated with the driver - the "human" factors. It seems likely, therefore, that human factors also have a substantial role to play in explaining the elevated crash rate of young drivers.

Factors associated with the particular driver undertaking the trip include the driver's level of skill, blood alcohol level, familiarity with the vehicle and the locality, the intensity of the driver's desire to avoid being involved in a crash, whether they are running late or emotionally upset, other motives they may wish to satisfy while driving, and many more. These factors have the potential to increase or decrease the riskiness of undertaking a particular trip for drivers of any age. Among these, the factor most likely to vary systematically with age is driving skill, since young drivers are necessarily less experienced (on average) than drivers in other age groups. Driving skill, like most other skills, is probably acquired largely through practice, so that less experienced drivers are likely (on average) to be less skilled than more experienced drivers. Thus a third hypothesis might be that the over-representation of young drivers in traffic crashes is a result of driving skill deficiencies, whether in vehicle control, hazard detection, conflict prediction or response selection. Consistent with this hypothesis, Drummond and Healy (1986) found in Victoria that the rate of casualty crash involvement per million kilometres driven decreases steadily with increasing experience of driving, measured in this case by the number of years since the driver obtained a licence.

Unfortunately, an explanation of the elevated crash rate of young drivers in terms of skill deficiencies is far from being the only possibility consistent with the data of Drummond and Healy (1986). Age and driving experience are known to be highly correlated. For example, almost 70 per cent of males in a study by Pelz and Schuman (1971) obtained a licence at age 16, the youngest age allowed by law in Michigan where the study was conducted. Male drivers of the same age are therefore likely to have held a licence for roughly the same number of years. Conversely, those who have held a licence for the same number of years are likely to be of the roughly the same age. A similar though perhaps weaker correlation would be expected for females. Thus the apparent effect of experience found by Drummond and Healy (1986) may in fact be an effect of age, or of some other attribute closely associated with age.

A variety of factors correlated with age, and therefore with driving experience, may contribute to the relationship between experience and crashes. The tendencies for young drivers to drive older vehicles and to drive more at night have already been mentioned above. Macdonald (1993*a*) has noted that increased crash risk would follow if young drivers were found to do less of their driving on freeways than other drivers. Young drivers are likely to be less experienced with the use and effects of alcohol than their older counterparts. There is evidence that young drivers stopped at random breath testing stations are less likely than other drivers to have been drinking alcohol, but that young drivers involved in crashes are more likely than other drivers to have been drinking alcohol (Deutsch, Healy and Strang, 1981).

This suggests that alcohol use may produce a greater increase in crash risk for young drivers than for other age groups. There may also be a strong association between age and various attitudes which affect the riskiness of an individual's driving. Deutsch *et al.* (1981) argued that young people around minimum licensing age are in a stage of life where they reject parental values, strive for independence, experiment with roles and become heavily influenced by their peer group and its values. Thus young people may be motivated to drive fast or take other risks in order to test their own abilities, to demonstrate independence from authority or to impress their peers. Summala (1985) argued that these "extra motives" decline in importance with increasing age, leading to a decrease in risk taking and in crash involvement.

While driver age and experience are highly correlated with one another, it is important to determine which of these two attributes is more closely associated with risk of traffic crash. The consequences for further research and for countermeasure design are profound. If crash risk is found to be influenced more by driving experience than by age, this will strongly suggest that the young driver problem is primarily a result of skill deficits which are gradually overcome as driving experience increases. In this case, further research should concentrate on identifying the specific skills which differentiate younger and/or unsafe drivers from older and/or safer drivers. Countermeasure development should then focus on finding ways to accelerate the development of the critical skills or restrict the exposure of drivers who have not yet developed those skills. If, on the other hand, age is found to be more important than experience, further research should attempt to determine which of the wide variety of factors known or suspected to be associated with age are contributing to the problem. In this case, countermeasure development should focus on restricting the exposure of the highest risk age group or offsetting the disadvantages arising from their lifestyle or developmental stage. Limiting young novice drivers to zero or near-zero blood alcohol levels is an important exposure restriction which has already been implemented in every Australian jurisdiction.

Owing to the importance of the problem for countermeasure directions, a number of major studies investigating the age versus experience question have been performed over the last three decades. The most significant and influential of these are reviewed in the next section. As will be seen, this question has proven difficult to investigate, and the studies reviewed are fraught with conceptual and methodological difficulties.

2. REVIEW OF PREVIOUS INVESTIGATIONS OF THE RELATIVE IMPORTANCE OF AGE AND EXPERIENCE

Past investigations of the relative importance of age and experience in determining crash rates have been based on data relating to large samples of drivers or entire driving populations, either for whole countries or for individual states or provinces. The most significant and influential reports appearing in the English language research literature are reviewed in this section.

2.1. California

The "Teen Aged Driver Study" (Ferdun, Peck and Coppin, 1967) was intended to provide the information required to decide whether to raise the licensing age in California from 16 to 18 years. Crash records were compared for over 6000 drivers in three month age brackets from 16 years to 19½ years. Driver age, sex, crash and violation history and experience (number of months since licence acquisition) were extracted from state licensing records. A questionnaire was used to collect information on each driver's training, exposure by day/night and freeways/other roads, and experience (lifetime mileage).

The mean number of officially reported crashes per driver per annum was found to be higher for males than for females, but not related to age for either sex. However, annual mileage was found to increase markedly with increasing age, especially for males. When annual mileage was taken into account, it was found that the crash rate per distance driven decreased markedly with increasing age for both sexes. The authors noted that crash rate per distance driven decreased with increasing annual mileage, and considered the possibility that this may have been responsible for the relationship between age and crash rate per distance driven. However, analysis by annual mileage brackets showed that even after controlling for annual mileage, a significant effect of age on crash rate remained for males (though not for females).

Using multiple regression to examine simultaneously the effects of all variables, it was found that crash frequency per driver per annum was best predicted by exposure (mileage last year and driving hours per week) and age for males, and by exposure (mileage last year) and experience (months since licence acquisition) for females. Proportion of driving at night and proportion of driving on freeways did not significantly improve prediction of crash frequency for either sex. The authors concluded that exposure was more important than age in crash prediction. For both sexes, increasing experience was associated with increasing frequency of violations. The authors speculated that increasing experience leads to increasing confidence, leading to disregard of traffic regulations. This tendency may be offset by an increase in skill, and therefore does not lead to an increase in crash frequency. However, it should be noted that the linear regression model used in this study was not appropriate, since it resulted in predicted crash risk becoming negative for very low levels of exposure; a multiplicative model would have been more appropriate.

The "Young Driver Follow Up Study" (Harrington, 1972) was an outgrowth of the Teen Aged Driver Study, and also investigated crash occurrence among drivers aged 16 to 19 years, this time using a longitudinal rather than cross-sectional design. One group of drivers was followed for four years, to provide "a more definitive analysis of the effects of age and experience on driver record" (Harrington, 1972, p 191). This study confirmed the results of the earlier Californian study in two important respects: there was little difference in crash frequencies between drivers aged 16-17 years and those aged 18-19 years; however, when

annual mileage was taken into account, crash rates generally fell over the four years of the study. Conviction rates per distance driven were found not to drop until the fourth year of driving. Like Ferdun *et al.* (1967) before him, Harrington saw this as evidence of an experience effect: he argued that the discrepancy between conviction rates and crash rates demonstrated that "young drivers learn a great deal about crash avoidance with increasing practice, but seem to show little change in attitudes toward the traffic laws until their fourth year of driving" (Harrington, 1972, p 234). The author did not attempt to determine whether age-related factors or experience had the greater influence on crash rates.

2.2. Michigan

Perhaps the most thorough and painstaking of all investigations of the relative importance of age and experience effects was carried out in Michigan by Pelz and Schuman (1971). This study will be described in some detail because of its far-reaching influence on subsequent work in the area of young driver safety. Almost 3000 drivers were interviewed in their homes in the suburbs of Detroit. Interview questions related to driving exposure, crashes and infringements (both warnings and ticketed violations) in the last year, life events, motivations and feelings related to driving. Male and female drivers aged 16-24 and 35-44 were included in the sample, with the younger males being deliberately over-sampled. Official records of crashes and violations in the last year were used to augment the interview data. Although the authors analysed both the crash and infringement records of drivers as a function of age, only results relating to crashes will be considered here.

For males, the mean number of crashes per driver in the past year was found to peak at ages 18 and 19, with lower values found for both younger and older drivers. For females, the mean number of crashes per driver was highest for ages 17 to 22, with lower values for 16 year olds and those aged 23 or more. These crash frequencies were not corrected for exposure (distance driven). Although Pelz and Schuman collected annual exposure data, they declined to simply divide crashes per annum by distance driven per annum to give crash rate per distance driven. The authors argued that such a calculation assumes that crashes increase as a linear function of mileage, and that as a matter of fact this turns out not to be true: higher annual mileage tends to be associated with lower per mile crash rates (this argument will be rebutted in Section 2.10 below). Instead, the authors accounted for annual mileage by two less usual methods, described below.

Firstly, mean crashes per driver per year was plotted for separate annual mileage groups. Results for females are not reported. For males, it was found that mean crashes per year peaked at age 18 or 19 for four out of the five annual mileage brackets used. On this basis, the authors concluded that even after allowing for annual mileage, 18 and 19 year old males still have more crashes than other groups. The exception was the 10,000-14,999 miles per annum bracket, for which mean crashes per year peaked at the youngest age, 16 years, and declined steadily until age 22, where a smaller secondary peak was observed. The authors did not report what proportion of their sample fell into this category. However, other data from Pelz and Schuman's report show that the mean distance driven for 18 year old males was just a fraction under 10,000 miles per annum, and that the mean distance driven was between 11,000 and 14,000 miles per annum for males at all ages greater than 18. Thus it is probable that a very substantial portion of all males in the sample fell into the one mileage bracket which did not conform to the generalisation proposed by the authors.

The second method of removing the effect of annual mileage was a procedure which the authors refer to as Multiple Classification Analysis (MCA), a variety of multiple regression especially adapted for non-linear effects by the categorical re-coding of continuous predictor variables. Residual mean crash scores were plotted against age after using MCA to remove the effects of annual mileage (grouped into 8 categories) and a number of other predictors including driving time per week, number of short trips last month, number of long trips last year, per cent night driving, per cent freeway driving. Results were reported in detail for young males only. Residual mean crash scores were found to peak at ages 18 and 19. When the analysis was repeated excluding crashes resulting in no injury and less than $100 damage, and giving double weight to crashes which resulted in either a vehicle being written off or a person admitted to hospital, similar results were obtained. For both analyses, the relationship of the residual crash score to age was statistically significant. The authors concluded that 18 and 19 years are the most dangerous ages for male drivers. The age effect for females was said to be smaller, later (around age 20 to 22) and not statistically significant. However, the sample size for females was far smaller than that for males, and this may have contributed to the lack of statistical significance.

Pelz and Schuman considered that two different types of explanation for the strong age effect in the crash records of young males were worthy of consideration. On the one hand, increased danger at ages 18 and 19 could result from biological maturation or from age-related social factors such as the transition to adulthood, finishing high school, getting a job, etc. On the other hand, driving experience is highly correlated with age, and the apparent effect of age may in reality be an effect of driving experience. Perhaps over-confidence sets in after 2 or 3 years of driving, leading to increased risk-taking. To discover whether their results were determined by factors related to age or experience, the authors needed to quantify the experience of males in the sample. Since almost 70% of these males acquired a licence at age 16 (the minimum in Michigan), the correlation between age and years since licence acquisition was very high. The authors therefore based their measure of driving experience on the age at which the respondent said he learned to drive. The authors again used their MCA procedure to plot residual mean crash scores against age for drivers who learned to drive at different ages. For males who learned to drive at 12-14 years of age (11% of young males in the sample), males who learned at 16 (45% of young males) and males who learned at ages 17-20 years (14% of young males), residual mean crash score peaked at age 18 and dropped over the next several years. These results led the authors to conclude that the crash peak was determined by age-related rather than experience-related factors. The peak for males who learned to drive at age 15 years (26% of young males) did not fit this pattern, occurring at ages 19 and 20. The authors were unable to explain this discrepancy. However, it appears to offer little support to explanations in terms of experience, since the peak for those who learned to drive at 15 occurred later (and therefore among drivers with greater experience) than the peak for the largest group, those who learned at 16.

Pelz and Schuman's main findings - that crash involvement for males is influenced more by age-related factors than by experience-related factors, and that crash involvement for males peaks at age 18 or 19 rather than at the very beginning of driving - have often been cited by subsequent authors. Their study appears to be regarded as something of a classic in the area. Despite the high regard in which the study has been held, some shortcomings are apparent:

(1) The sample was drawn entirely from a suburban area adjacent to a large city, and it is unknown whether the findings can be generalised to residents of either inner urban

("down town") or rural areas. Affluence, exposure patterns and perhaps social pressures can be expected to vary from one type of environment to another.

(2) The absence of a crash peak at ages 18 or 19 in the 10,000-14,999 miles per annum bracket (almost certainly the largest group in the sample) and also among drivers who learned to drive at age 15 (about one quarter of the sample) remains unexplained.

(3) Use of five annual mileage brackets is a rather crude method of allowing for the effect of exposure. Variations in annual exposure within mileage brackets will add unwanted variance to crash rates and tend to obscure the influence of other factors.

(4) Pelz and Schuman's data reveal that average annual mileage of male drivers increases steeply between ages 16 and 19. Therefore, to compare drivers of different ages with the same annual mileage is to compare possibly quite different types of driver. For example, annual mileage of 8000 miles would be almost three times the average for a 16 year old, but well below average for a 19 year old. Annual mileage is probably determined by a variety of social and economic factors. Variations in crash risk across ages among drivers with similar exposure may therefore be due to differences in these factors, rather than to the influence of age *per se*.

A number of further shortcomings of this study which are common to many other studies of age and experience will be discussed in Section 2.10 below, after other studies in the area have been reviewed.

2.3. Interpretation of the Michigan findings by subsequent authors

ALCOHOL

The significance of the findings of Pelz and Schuman (1971) for licensing practices in Australia was discussed by Cameron (1972) in a paper to the National Road Safety Symposium in Canberra that year. Despite Michigan's legal minimum age of 21 years for drinking alcohol, Cameron speculated that "there is a *prima facie* probability that more 18 to 20 year olds are drinking [alcohol] than 16 to 18 years old" (p 386). He believed that "the possible role of alcohol in creating the 'dangerous age' effect observed in these studies is at least a reasonable hypothesis" (p 386). A partly contradictory position was taken by a Canadian author, Jonah (1986), who evidently had more faith in the observance or enforcement of Michigan's legal drinking age. Jonah suggested that the onset of alcohol drinking may explain a smaller secondary peak in Pelz and Schuman's crash rates around the age of 21-22. Neither Cameron (1972) nor Jonah (1986) was able to cite any data on alcohol consumption patterns in Michigan in support of these hypotheses.

OVER-CONFIDENCE

In an attempt to explain the finding of Pelz and Schuman (1971) that crash experience peaks two or three years after people acquire a driving licence, Brown (1982) constructed a model in which crash experience results from over-confidence, which in turn is a result of the differential development of vehicle control skills and information processing skills. The model assumes that vehicle control skills (steering, gear changing, braking, etc.) are acquired relatively easily and quickly by the new driver, leading to a parallel increase in self-confidence. The new driver, however, fails to recognise the importance of the information processing skills involved in interactions with other road users. Much of the new driver's confidence is therefore over-confidence, leading the driver to take inappropriate risks and to

have crashes. As information processing skills improve, the mismatch between the driver's skills and his or her self-perception of those skills decreases, leading to improved driving safety.

Brown's model has been accepted by subsequent authors such as Jonah (1986), Summala (1987) and Hampson (1989), and further refinement has been added by Rumar (1985) and Perkins (1988). Rumar (1985) agreed that young male drivers are over-confident, and argued that over-confidence is a result of lack of feedback in the traffic situation when non-optimal behaviour is engaged in. Perkins (1988) supplied the link between the positions of Brown and Rumar, arguing that young drivers are pre-occupied with vehicle control skills rather than information processing skills because vehicle control has clearer criteria for success or failure and provides more frequent and more immediate feedback to the driver. Thus as the feedback from vehicle control behaviours more and more consistently indicates success, the driver's confidence will increase, while the driver fails to recognise more subtle signs that information processing performance may still be sub-optimal.

Most authors discussing Brown's model have failed to acknowledge that Pelz and Schuman (1971) themselves had specifically considered and rejected a simpler version of the same hypothesis. Defining experience as the elapsed time since the young male said he learned to drive, Pelz and Schuman showed that the crash peak occurred not after a fixed period of experience but at a fixed age. Thus if Pelz and Schuman's definition of experience and their method of controlling for exposure are accepted, their analyses appear to rule out an explanation of the crash peak in terms of over-confidence or any other experience-related factor.

INFORMATION OVERLOAD

Milech, Glencross and Hartley (1989) offered yet another interpretation of the crash peak at age 18 and 19 found for male drivers by Pelz and Schuman (1971). The new driver, they argued, has not yet automated his driving, but uses his knowledge at the rule-based level of functioning. Over the first couple of years of driving experience, the driver gradually becomes overloaded by his increasing knowledge of the driving task, leading to a crash rate even worse than that of the complete novice. As the driver progressively automates his driving behaviour, the overload is reduced and the safety record improves correspondingly. Unfortunately, this model, like that of Brown (1982), seeks to explain the crash peak of young males at ages 18 and 19 in terms of accumulation of experience, and fails to take into account Pelz and Schuman's demonstration that the peak occurs at a fixed age regardless of the driver's experience. This model also fails to explain why Pelz and Schuman (1971) obtained quite different results for males and females, with females not showing the peak of crash involvement after two or three years of driving.

2.4. Ontario

A major investigation of the young driver problem by Canada's Traffic Injury Research Foundation (Mayhew and Simpson, 1990) had as one of its major objectives "to examine the relative contribution of factors that are unique to youthful drivers and [those] common to all newly licensed drivers." The authors reviewed a wide range of US, Canadian and other literature pertinent to the age versus experience question, and concluded that both age-related factors and lack of driving experience contribute to the higher crash rates of young drivers, with the relative importance of these factors being unknown.

Mayhew and Simpson (1990) went on to examine Ontario's "Trace" database, a sub-set of the driver records system of that province, to shed further light on the question. Separate analyses of the Ontario data for males and females suggested once again that for both sexes both age and experience are related to crash involvement. However, age-related factors seemed to be more important than experience for both sexes, and completely masked any benefits of experience among young males. For older male drivers, among whom age-related factors may not be operative, increased experience was associated with lower crash involvement. Unfortunately, data on exposure (distance driven) were not available, so all crash data derived from the Ontario Trace database were crash involvements per 1000 drivers. Thus it is possible that the age and experience effects found were entirely due to differences in exposure between groups of drivers of different age and experience.

A conflicting finding for Ontario had previously been reported by Robertson (1983, cited by O'Connor, 1986). Robertson reported that the proportion of drivers in Ontario involved in crashes which were reported to the police decreased with increasing driver age, but was virtually independent of the age at which the driver obtained a licence (and therefore of years of driving experience at the time of the crash). O'Connor (1986) pointed out, however, that annual distance driven may increase with years of driving experience for drivers of all ages. In this case, constant crash rates per driver per annum would imply decreasing crash rates per distance driven as drivers accumulate experience. Other authors (e.g. Pelz and Schuman, 1971; Toomath and White, 1982) have reported that annual distance driven increases with age. However, the relationship of annual mileage to driving experience after controlling for the effects of age is not known.

2.5. Canada

An investigation by Mayhew, Warren, Simpson and Haas (1981, cited by Knapper, 1985) found that male drivers in Canada show no improvement in fatal crash rate in the first 3 years after the minimum licensing age (i.e. from ages 16 to 19), whereas fatal crash rate for females peaks at age 16 and declines thereafter. Thus it appears that for young males, age-related factors negate the presumed benefits of increasing experience of driving. Some or all of these age-related factors may be absent or of lesser importance for females. Knapper (1985) did not report whether the crash rates used by Mayhew *et al.* were per driver or per distance driven, so it is not clear whether age-related exposure differences contributed to the results obtained.

Mayhew *et al.* (1981, cited by Knapper, 1985) also reported that over "the past few years" there had been a shift of the young driver problem towards even younger drivers, with a slight decrease in crash involvement for 20-24 year olds and a corresponding increase for 15-19 year olds. It seems reasonable to suppose that the biological timetable of human maturation would be less likely to show a noticeable change over a brief period of a few years than would social and cultural influences, and the lifestyle and exposure patterns which they determine. Thus the changes in age-specific crash rates observed by Mayhew and colleagues are likely to be socially rather than biologically determined. It would be of interest to know whether this change was associated with an increase in the proportion of drivers acquiring a licence at or soon after the earliest possible age.

Jonah (1986) cites unpublished data collected by Stewart in or before 1984 which demonstrate that the relative risk of casualty crash in Canada "decreased linearly from a high of 3.73 at 16 to 1.40 at 23, increasing slightly to 1.66 for 24 year olds" (Jonah, 1986, p 257).

These findings appear to contradict the flat crash trend from ages 16 to 19 for Canadian males found by Mayhew *et al.* (1981, cited by Knapper, 1985). Unfortunately, Jonah (1986) gives no indication of the crash measure used by Stewart, so this apparent contradiction cannot be explained.

2.6. United States of America

An investigation by Levy (1990) attempted to address the age versus experience question directly. Levy examined fatality rates per head of population for drivers aged 15, 16 and 17 in 47 states of the USA over a period of nine years. He constructed a log odds ratio regression model to explain variations in fatality rates in terms of predictors supposedly related to age and driving experience, together with variables describing the applicability of mandatory driver education, night driving curfews and alcohol restrictions to each age cohort in each state in each of the years examined. Levy found that the fatal crash rate per head of population in an age cohort increased with increasing proportion of the cohort holding a licence, and noted that the rate of this increase was greater for 15 year old cohorts than for 16 and 17 year old cohorts. He interpreted this as showing that "the younger drivers [have] a substantially higher proclivity for fatal crashes" (Levy, 1990, p 332). He went on to note that the regression coefficient for the proportion of a cohort holding a licence was larger than the coefficient of his exposure-related variable, and concluded that the effect of driver age is far greater than the effect, if any, of experience. The author recommended that consideration should be given to raising the licensing age. However, the presence of serious flaws in Levy's study, as outlined below, means that his conclusions are not justified and do not contribute to understanding of the young driver crash problem.

The design of Levy's study provided little opportunity for driving experience to emerge as an important influence on crash rates, because the study did not employ any measure of the driving experience of drivers involved in crashes. Instead, the two measures of experience employed in the study both related to the average driving experience of the entire age cohort. The first of these was the number of first year drivers in the cohort as a proportion of the total cohort size, and the second was a dummy variable set to 1 if the age of the cohort was the minimum licensing age for that state and set to 0 otherwise. These two variables were not even very highly correlated with each other (r=0.47), suggesting that they would have little value as measures of driving experience. Furthermore, some missing values for the experience variables were replaced by averages, tending to further reduce the strength of the relationship with crash rates. The author himself notes that "the experience effect warrants further research due to measurement difficulties" (Levy, 1990, p 334). The age data, on the other hand, were of much higher quality, since the ages of drivers actually involved in fatal crashes were obtained directly from the Fatal Accident Reporting System maintained by the US National Highway Traffic Safety Administration.

Levy's interpretation of his results also appears seriously flawed. His conclusion that the effect of age on crash rates is greater than that of experience is based on the observation that the regression coefficient of his age-related variable is larger than the coefficient of the experience-related variable. Firstly, this observation is unsupported by any statistical test, so the probability of obtaining a similar result from another data set is unknown. Secondly, and much more importantly, it is clear from one of the author's footnotes that the coefficients compared were regression coefficients for raw score variables, and that the large coefficient for the age-related variable is a direct result of the very small values of the variable. If this

variable had been scaled differently, with larger values, a smaller coefficient would have been obtained and the relationship with the exposure coefficient may have been reversed. This problem could have been avoided by comparing coefficients of standardised variables rather than coefficients of raw score variables. Thirdly, Levy's claim that younger drivers have a higher "proclivity" for fatal crashes rests on the observation that the rate of increase of the fatality rate within a cohort with increasing proportion of the cohort holding a licence is greater for 15 year old cohorts than for 16 and 17 year old cohorts. This interpretation is particularly puzzling in view of the presence in the regression equation of age-specific dummy variables intended to capture age-related effects. Inspection of the regression coefficients of these age-specific dummy variables shows that, contrary to Levy's interpretation, fatal crash rate per head of population actually increases with increasing age, presumably as a result of the increase in annual mileage over the first few years of driving which has been reported by other authors (e.g. Pelz and Schuman, 1971; Toomath and White, 1982).

2.7. United Kingdom

Rolls, Hall, Ingham and McDonald (1991) used generalised linear modelling to construct a predictive equation for the number of self-reported crashes of a total sample of approximately 340 drivers, including both sexes and three different age groups: 17-20 years, 21-25 years and 31-40 years. Potential explanatory variables were collected from three sources: observation of the subject's driving behaviour while driving a set course in Southampton and neighbouring villages and rural roads; a one week or two week trip diary, including distances, times, trip purpose, passenger details, radio use and various ratings; and a questionnaire covering various aspects of driving behaviour, exposure, experience, crashes, violations and attitudes as well as basic demographic and socio-economic data. Two measures of experience were used - years since obtaining a licence and lifetime mileage driven. The model was built up by stepwise entry of variables which significantly improved prediction of a driver's risk of crash in a one year period.

The resulting model predicted that a driver's risk of crash will increase approximately in proportion to the square root of annual distance driven. Crash risk was also predicted to decrease with increasing age and increasing lifetime mileage driven. Crash risk decreased with increasing years since licence acquisition for the youngest age group, but increased with increasing years since licence acquisition for the other two age groups. Risk increased with increasing self-reported frequencies of driving violations and the observed frequency of following too closely on the set course, and decreased with increasingly safe ratings by an observer of the subject's driving safety over the set course. After taking annual mileage and all other significant predictors into account, crash risk was found to be higher for females than for males. On the basis of this model, the authors concluded that:

> "For the same level of exposure, the youngest group has a very high initial crash frequency at low experience, but this falls rapidly with increasing experience. The 21-25 year old group, however, has a low initial crash frequency which rises modestly with increased experience. It may be that some drivers in this group become over-confident. For the oldest group (31-40 years), experience has little effect on crash frequency" (Rolls *et al.*, 1991, pp 75-76).

Unfortunately, owing to the presence of a number of weaknesses in this study, some of which will be discussed here, interpretation of the results is difficult or impossible and the authors'

conclusions regarding the effects of experience cannot be relied upon. Shortcomings of the study include the following:

(1) Well over 100 potential explanatory variables are listed in an appendix to the report. The authors state that these variables, together with their interactions with sex and age group, were tried in the model, and those which had significant effects were retained; a significance level of 5% was apparently used. Under these conditions, it is likely that a number of variables quite unrelated to crash risk would be retained in the model merely by chance, and that a similar study with a new sample would yield quite a different prediction equation. A sample of only 340 drivers is clearly far too small to support modelling with such a large number of predictor variables.

(2) Estimated lifetime mileage was entered twice into the model, once in its own right and once as the numerator of the average annual mileage since licence acquisition. The number of years since licence acquisition was also entered into the model. Thus the effect of experience was split over several terms in the model, and the total effect of experience on crash risk cannot be ascertained.

(3) Lifetime mileage was estimated simply by multiplying the number of years the driver had held a licence by the average of the self-reported mileages over the last five years. Many drivers would have little idea of their mileage in any year, so that large errors in the estimates of lifetime mileage are likely. Other studies (e.g. Pelz and Schuman, 1971; Toomath and White, 1982) have shown that annual mileage increases rapidly over the first few years of driving, so the magnitude of errors in estimates of lifetime mileage probably differs between the three age groups used in the study.

(4) Respondents were asked how many crashes they had been involved in since beginning to drive, rather than over a fixed period (the last year, say). Thus drivers in the oldest age group were asked to remember crashes over a greater number of years than drivers in the other age groups, and were probably more likely to forget some crashes. This bias may have contributed to the age group effect found. Inclusion of all crashes since beginning to drive also means that the model constructed by the authors estimated the average crash risk over the driver's entire driving career, rather than the risk at the driver's current age and experience level.

2.8. South Australia

O'Connor (1986) reported that young drivers aged 16-19 years have over three times as many property damage crashes per distance driven and over four times as many casualty crashes per distance driven when compared with drivers aged 25 years or more. Thus not only did the young drivers have a higher crash rate, but their crashes were also more severe on average than those of older drivers.

Unfortunately, O'Connor found that it was not possible to investigate the relationship between crash risk and driving experience from official records in South Australia, due to inconsistencies between reported age and driving experience of crash-involved drivers. Between 5 and 11% of drivers aged 16-19 years involved in crashes in South Australia in 1985 had more reported years of driving experience than was legally possible given South Australia's then minimum licensing age of 16 years. It appears that the experience data used in this investigation may have been the number of years of driving experience reported to police by crash-involved drivers. Inaccuracies are to be expected in data obtained by this means.

2.9. New Zealand

In New Zealand, Toomath and White (1982) used exposure data gathered from over 6000 face-to-face interviews to investigate the relationship between crash rate and age. Annual exposure (distance driven) of different age groups was estimated by extrapolating from detailed data on trips undertaken by survey respondents in the three days preceding their interview. Crash involvement of each age group was taken from officially reported casualty crashes. The authors found that, for both males and females, crash rate per distance driven rises from New Zealand's minimum licensing age of 15 to a peak at age 16 and then drops sharply to a plateau between approximately the ages of 25 and 65, after which the rate begins to climb again.

Toomath and White also examined the relationship of crash rate to years of driving experience (since obtaining a licence) for groups of drivers licensed at different ages. For drivers licensed at age 15 and also for drivers licensed at 16, crash rate (per distance driven) was higher in the second year of driving than in the first. Rates then decreased with each succeeding year. It therefore appears that crash rate peaked at approximately ages 17 and 18 for these two groups respectively. Drivers licensed at age 17 had their peak crash rate in the first year of driving, meaning that their peak also occurred at approximately age 18. Drivers licensed at age 18 or more also had their peak crash rate in the first year of driving. Thus crash rates for all groups peaked at ages 17, 18 or more. These figures are clearly inconsistent with the results of the earlier analysis of the entire sample, which showed a peak at age 16. The authors did not comment on this inconsistency; however, it seems likely that self-reported crash data from the face-to-face interviews would have been used in the analysis by age of licence acquisition, rather than officially reported casualty crash data which were used in the earlier analysis. Since age and driving experience were measured only to the nearest year, rounding errors may also have contributed to the discrepancy.

The peak crash rate was clearly lower for drivers who obtained a licence at age 15 than for other groups, and the authors concluded that there was no evidence that any safety benefits could be expected if New Zealand's comparatively low licensing age were to be raised. They did not comment on the relative importance of age and years of driving experience in determining crash rates. Nor did they comment on the possible causes of the delayed crash rate peak for drivers licensed at ages 15 and 16. However, the absence of any delayed peak for drivers licensed at ages 17 or more appears to rule out an explanation in terms of a build up of over-confidence after the first year or so of driving experience. Thus the data appear to suggest the operation of age-related factors sufficiently powerful to negate the presumed advantage of increasing experience among those licensed at the youngest ages. The nature of these factors is not clear from Toomath and White's study. It is possible that those licensed at the youngest ages could not afford to own a car, and may have been forced to use cars belonging to their parents. This may have led to extra care being taken while driving. Toomath and White's finding that 15 and 16 year olds have the lowest annual exposure (distance driven) offers some support for this hypothesis. Alternatively, youthful strivings for independence and recognition may peak in the late teenage years, leading to a corresponding peak in risk-tasking while driving. A third possibility is that the proportion of driving which is performed under high risk conditions (e.g. at night and/or while affected by alcohol) may be greater for 18 year olds than for the very youngest drivers.

2.10. Shortcomings of previous investigations

Conceptual and/or methodological drawbacks have been discussed in relation to several of the studies reviewed in the preceding sub-sections. However, in addition to the problems already described, several fundamental flaws were common to many of the studies reviewed. These relate to the measurement of driving experience, to the treatment of driving exposure and to assumptions underpinning comparison of drivers licensed at different ages.

INACCURATE MEASUREMENT OF DRIVING EXPERIENCE

Studies comparing the effects of age and experience on crash involvement often start with a bias in favour of age, simply because the age of crash-involved drivers is usually far more accurately known than their driving experience. Most, if not all, jurisdictions routinely record the age of crash-involved drivers as part of any crash report. Driving experience is usually not reported, but in some jurisdictions can be estimated later by ascertaining when the driver's licence was issued. Allowance for prior driving experience in another jurisdiction is usually not possible. Perhaps the most extreme example of this bias occurred in the study of Levy (1990), which did not employ any measure at all of the driving experience of drivers involved in crashes. Rather, two different measures of the average experience of drivers in each age cohort were employed. By contrast, the ages of crash-involved drivers were taken directly from the US Fatal Accident Reporting System. Another extreme case was that of O'Connor (1986), who was unable to compare the effects of age and experience because his experience data contained too many errors to be used.

Other studies have used questionnaire items to elicit self-reports of experience from drivers. Rolls *et al.* (1991) asked drivers to "estimate the number of miles you have driven in each of the following years? 1985? 1986? 1987? 1988? 1989?" (p 98), while Ferdun *et al.* (1967) simply asked "Approximately how many miles would you estimate you have driven during the entire time you have had a license?" (p 33). Many drivers simply will not know the answers to these questions, and the resulting errors will add a great deal of "noise" to experience variables, diminishing their correlation with other variables in the study. Furthermore, the size of the errors is likely to be correlated with age and experience, since older drivers will have to base their estimates on more years of driving than will younger drivers.

The bias towards finding significant effects of driver age was perhaps best summarised by Evans (1987):

> "the reason so much research ends up identifying the young male as a particular problem is that crash data sets typically contain only two demographic variables - sex and age. It is accordingly not possible to focus on other variables which may be of the utmost importance." (Evans, 1987, p 73).

INAPPROPRIATE MEASURES OF DRIVING EXPERIENCE

Apart from problems with availability and accuracy of experience data, there have also been problems in the way experience has been conceived. Experience measures in safety research are mainly valuable not for their own sake but as an index of driving skills (including not only vehicle control but also perceptual and decision making skills). If a substantial decrease in crash rates with increasing experience even after allowing for the influence of age could be established, this would suggest a need to improve one or more aspects of the skills of novice

drivers before issuing licences or as soon as possible thereafter. The most useful measure of experience is therefore one which measures the driver's opportunity to practise and improve his or her driving skills. Such opportunities occur almost exclusively while the driver is actually driving. Little or no benefit is likely to accrue from the mere passing of time if driving practice does not occur. A measure of experience should therefore be a measure of the amount of driving done - either the total distance driven or the total time spent driving since licence acquisition. As Mayhew and Simpson (1990) pointed out, "relevant skills/processes are acquired and/or improved with experience (practice), presumably indexed by the number of hours behind-the-wheel, or the distance driven, or the variety of traffic/driving conditions and circumstances encountered" (p 83).

Unfortunately, due partly to the difficulty of collecting measures of behind-the-wheel experience, many of the studies reviewed above measured experience by the elapsed time since the driver obtained a licence. While this is presumably correlated with the amount of driving done, the wide individual variability in annual exposure means that this measure is far from ideal. Furthermore, since annual exposure increases with age, the relationship of time since licence acquisition to amount of behind-the-wheel experience is probably non-linear, serving to further reduce correlations with other variables. An even less appropriate measure of driving experience was adopted by Pelz and Schuman (1971), who estimated experience by asking drivers at what age they had learned to drive. Over a third of all males reported that they had learned to drive before the age of 16 years, the minimum licensing age for Michigan, and some had learned as early as 12 years. These drivers are unlikely to have gained substantial behind-the-wheel experience until they obtained a licence at age 16 years or more.

ANALYSIS OF CRASH FREQUENCIES INSTEAD OF CRASH RATES

It was noted in Section 1 above that a driver's risk of involvement (as a driver) in a traffic crash in any year increases with the amount of driving the driver does in that year. In the extreme case, it is clear that an individual who does no driving at all has zero risk of crash involvement as a driver. Thus it is not surprising that the models of crash risk per driver per year constructed by Ferdun *et al.* (1967) and Rolls *et al.* (1991) predict that crash risk for drivers of any age can be reduced by reducing driving exposure. This is already understood, but does not provide a useful basis for the design of socially acceptable countermeasures. Driving serves a variety of essential functions in all developed societies; its elimination is too high a price to pay for increased safety. Traffic safety research must assume that driving will continue to occur, and identify factors which influence the safety of driving. Models of crash risk per distance driven (or other measure of exposure) will be more useful in identifying the particular types of exposure which should be limited, the skills which need to be improved or the attitudes which need to be changed.

Acknowledging that increased annual exposure increases crash risk (per driver per year), some authors have tried to remove the effect of exposure by means other than use of crash rates per distance driven. Pelz and Schuman (1971) conducted separate analyses for drivers in various annual mileage brackets, while Ferdun *et al.* (1967) and Rolls *et al.* (1991) entered annual mileage into their models as an explanatory variable. However, in doing so, these authors discarded much of the very information which they should have examined. All three of these studies found that, while crash risk increased with annual exposure, the risk increase was less than would be expected in a proportional relationship. As Ferdun *et al.* (1967) put it, "individuals who drove less...had a higher crash and violation rate per mile driven" (p 42). Rather than being statistically removed, this effect is deserving of the closest attention. If one

individual can drive a given distance more safely than another, it is the business of traffic safety research to find out why.

At least two possible explanations for this effect are relevant in the present context. On the one hand, the lower crash rates (per distance driven) of drivers with high exposure may be a benefit of extra driving experience. Experience, as measured by lifetime distance driven, will of course be correlated with the distance driven in the last year, so the drivers with the highest levels of exposure may be the most experienced and highly skilled drivers. On the other hand, lower crash rates of drivers with high exposure may reflect an age effect, since the youngest drivers typically have lower annual exposure than middle aged drivers (Williams, 1985; Toomath and White, 1982). To decide between these explanations, it is essential to examine crash rates per distance driven without statistically removing the effect of annual exposure. Furthermore, due to the correlation between experience and exposure, controlling for exposure removes a large part of any experience effect which may be present, thus weakening the effect of the nominal "experience" variable and biasing the study towards a finding that age effects predominate.

SELF-SELECTION OF AGE OF LICENCE ACQUISITION

The studies reviewed above have sought to compare the effects of age and experience on crash risk by comparing the crash risk of drivers of the same age but different levels of experience (or the same level of experience at different ages). These studies are in effect comparing drivers who acquire a driving licence at different ages. It has been assumed that differences in the crash risk of such drivers are due entirely to differences in age or driving experience; drivers who obtain a licence at different ages are assumed to differ in no other respect relevant to crash risk. This assumption may not be warranted. It is certainly plausible that differences in age of licence acquisition may be associated with differences in socio-economic status, the locality in which a person lives (inner city, suburban, rural or remote), their educational level (go to college or get a job straight out of school) and other factors which may be relevant to risk of crash.

The assumption that drivers who obtain a licence at different ages do not differ in other respects relevant to crash risk has occasionally been questioned. Hampson (1989) suggested that the highest risk drivers may be among the first to obtain their licences when they reach licensable age. Mercer, in a personal communication quoted by Mayhew and Simpson (1990), described licence acquisition as a "self-selection" process. He argued that:

> "The 16 year old who chooses to get a licence is arguably a different kind of person to the kind who waits till he/she is 19. For example, it may be that 19 year olds are not less aggressive than 16 year olds, but that the more aggressive adolescents try to obtain a licence at an earlier age." (Mercer, quoted by Mayhew and Simpson, 1990, p 88)

Despite these speculations, no systematic attempt has been made to identify the factors associated with early licensing, to determine their relevance to crash risk or to make allowance for them in studies of the relationship of crash risk to age and experience. This serious shortcoming throws doubt on the conclusions of all of the studies reviewed in this section.

2.11. Re-examination of the Michigan data

As noted earlier, the finding of Pelz and Schuman (1971) that crash involvement of male drivers in Michigan peaks at ages 18 and 19 has been influential among subsequent authors. Authors including Cameron (1972), Brown (1982) and Milech *et al.* (1989) offered a variety of explanations for the peak. But are these explanations really needed? Some important shortcomings in Pelz and Schuman's study have been discussed above, several of them relating to Pelz and Schuman's handling of the influence of annual exposure on crash frequency. Would the peak at ages 18 and 19 still have been found if exposure had been handled more appropriately? Fortunately, Pelz and Schuman reported their results in sufficient detail that some re-examination of their data is possible.

TABLE 2.11a

CRASH FREQUENCY, EXPOSURE AND CRASH RATE BY AGE, MALES ONLY

Crash frequencies from Pelz and Schuman (1971), Table 1.
Annual exposure from Pelz and Schuman (1971), Figure 3.

Age (mid-year)	Mean crashes (past year)	Mean mileage (past year)	Crashes per 1000 miles
16	.19	2800	.068
17	.27	6300	.043
18	.45	9700	.046
19	.46	11800	.039
20	.34	12200	.028
21	.27	11200	.024
22	.33	12800	.026
23	.21	13300	.016
24	.29	13700	.021
35-39	.16	13700	.012
40-44	.09	13100	.007

The mean number of crashes in the past year for drivers of various ages is given by Pelz and Schuman (1971) in their Table 1. Their data for males only are reproduced here in the second column of Table 2.11a. It can be seen that the mean number of crashes per driver per year for males peaks at ages 18 and 19. Pelz and Schuman show the average annual mileage driven at each age in their Figure 3. Values for males only are reproduced here in the third column of Table 2.11a. It can be seen that the average annual exposure of male drivers increases steeply with age until age 19, roughly the age of the crash peak, and varies relatively little from that age onwards. This suggests that the rapid increase in crash involvement of males from age 16 to a peak at ages 18 and 19 might be largely a result of the similarly rapid increase in exposure over the same age range. From about age 19 onwards, when exposure remains relatively constant, the effect of increasing experience (or perhaps maturity) on crash risk would become evident and crash involvement would begin to fall again. To test this hypothesis, the expected effect of exposure on crash involvement was removed by calculating crash rates per distance driven, shown in the fourth column of Table 2.11a. Despite some small hiccups, it is apparent that crash rate per distance driven generally declines with

increasing age, with the youngest age group having by far the highest rate. Thus it appears that explanations for a crash peak among male drivers at a particular age or after the first few years of driving experience are unnecessary. The relationship of crash risk to age, after taking exposure into account, is relatively simple: crash risk is at its highest for the youngest drivers, and gradually declines with increasing age. Without access to appropriate experience data, however, it is not possible to determine whether this decline should be ascribed directly to increasing age or to the associated increase in experience or to a combination of the two.

2.12. Conclusions from previous work

Section 2.11 re-examined the data of Pelz and Schuman (1971) for male drivers. This clearly showed that crash rate per distance driven decreases with increasing age, when experience is not taken into account. A study conducted in Victoria by Drummond and Healy (1986) showed equally clearly that crash rate declines with increasing experience (measured by years since licence acquisition), when age is not taken into account. But age and experience are necessarily correlated. Is the apparent effect of age on crash rates merely a consequence of the correlation of age with driving experience? Alternatively, is the apparent effect of experience merely a consequence of its correlation with age? Or do both age and experience independently affect crash rates? If so, which has the greater influence? Although these questions have been examined by investigators around the world, little progress has been made towards finding reliable answers. Not only have different authors reached conflicting conclusions, but all of the studies reviewed contained conceptual and methodological shortcomings which cast doubt on their findings.

Most of the studies reviewed were deficient in their treatment of the effect of driving exposure on crash involvement. Some of the studies reviewed did not have access to exposure data. Other studies statistically controlled or removed the effect of exposure on crash frequency, unfortunately also removing much of the effect of experience and biasing those studies towards finding greater influence of age.

One shortcoming common to all the studies reviewed was the unfounded assumption that differences in crash involvement between groups of drivers who obtain a licence at different ages can be ascribed purely to differences in their age and/or driving experience. There is a need to test this assumption by identifying the factors associated with early and late licence acquisition and determining the relevance of those factors to risk of crash involvement. Until such an investigation has been performed, no comparison of the effects of age and experience can be interpreted with confidence.

An interesting finding common to both Ferdun *et al.* (1967) and Pelz and Schuman (1971) was that crash rate per distance driven decreases with increasing annual distance driven. (A similar finding by Rolls *et al.* [1991] cannot be relied upon, because distance driven was incorporated into two different terms in their model.) Unfortunately, it is possible to develop plausible explanations for this finding based on either the effect of age or the effect of experience. Explanations not relevant to the age versus experience debate could also be constructed: for example, drivers with high annual exposure may drive a greater proportion of their mileage on freeways and other high standard roads. This finding certainly warrants further investigation, since it can potentially contribute to identifying differences between comparatively safe and unsafe drivers, with important implications for the development and implementation of crash countermeasures.

3. INVESTIGATION OF FACTORS INFLUENCING AGE OF LICENCE ACQUISITION

3.1. Addressing self-selection in age versus experience studies

Past investigations of the relative contribution of inexperience and other age-related factors to the elevated crash risk of young drivers, reviewed in Section 2 of the present report, have relied on comparisons of the crash involvement of drivers who obtain a licence at different ages. It has been assumed that a finding that crash risk varies with age for drivers of the same experience level may be taken to indicate a contribution of age-related factors (other than experience) to the young driver problem, while a finding that crash risk varies with driving experience for drivers of the same age may be taken to indicate a contribution of experience. This reasoning is based on the assumption, usually unstated and perhaps often unnoticed, that drivers who obtain a licence at different ages differ in no other respect relevant to crash risk.

In order to assist in the interpretation of the findings of the studies reviewed above, it is important to discover whether the assumption of equivalence of drivers who acquire a licence at different ages is correct. Past work in Victoria, the United States and Britain has indicated that males tend to acquire a licence earlier than females (Deutsch *et al.*, 1981; Lund, Preusser and Williams, 1987; Forsyth, 1992). Lund *et al.* (1987) in the United States also found that students with higher grades in school and those whose parents were better educated tended to obtain a licence earlier than other teenagers. Beyond this, little is known about the factors related to age of licence acquisition. Licensing patterns in Australia may not reflect those in the United States, with its generally lower minimum licensing ages.

Mercer (cited by Mayhew and Simpson, 1990) has pointed out that licence acquisition does not occur randomly but is a "self-selection" process. That is, the age at which a person chooses to acquire a licence is determined by various characteristics of the individual. Are any of these characteristics relevant to crash risk? There appears to be little justification for the assumption that they are not. It could be expected *a priori* that more self-confident, impulsive or adventurous individuals might attempt to acquire a licence at an earlier age; these personality traits may well contribute to over-confidence behind the wheel, and therefore to high levels of risk taking and crash involvement. Mercer suggested that more aggressive adolescents may choose to acquire a licence earlier than their less aggressive peers; this trait might also be expected to contribute to risk taking and crash involvement. On the other hand, adolescents who live in the country may have earlier need of a car than those who live in urban areas well served by public transport; living in the country may be associated with relatively low crash risk per distance driven, since rural driving provides fewer opportunities than urban driving for collision with other road users. Social and economic factors may also influence age of licence acquisition. Those whose parents have two cars may have greater opportunity to borrow a car from their parents, and therefore greater incentive to obtain a licence before they can afford to purchase their own car. Those who get a job after leaving school may be able to afford a car earlier than those who go into post-secondary education. The influence of the last two mentioned factors on crash risk is not easily deduced, but may not be negligible.

If individuals with relatively stable personal, social or economic characteristics which are associated with elevated crash risk tend to acquire a driver's licence at a younger age on average than other people, then crash rates among first year drivers should be highest at the lowest ages, creating an illusory age effect. In comparisons among drivers of the same age

with differing levels of experience, any benefit of increasing experience might be partly or wholly concealed by the tendency for the most experienced drivers also to be those whose other characteristics resulted in relatively high crash risk. A finding that high risk drivers tend to acquire a licence first would therefore suggest that age effects have been over-estimated and experience effects under-estimated in previous investigations of the age versus experience issue. By similar reasoning, if individuals with stable characteristics associated with elevated crash risk tend to acquire a licence later than others, then past studies may have under-estimated the effect of age and over-estimated the effect of experience. In comparisons among drivers of the same age, the tendency for the most experienced drivers also to be those whose personal, social and economic characteristics result in relatively low crash risk might result in the exaggeration of any benefits of increasing experience. Among drivers with the same level of experience, the effect of age on crash risk might be partly or wholly concealed by the tendency for the youngest drivers also to be those with the safest characteristics.

The availability of data from a very extensive series of interviews conducted for a related investigation provided an excellent opportunity to examine the factors associated with early and late acquisition of a driver's licence in Australia. The interviews included a comprehensive selection of items expected to be relevant to crash risk. Most importantly, they also included the driver's age and experience in years since licence acquisition, allowing age at licence acquisition to be calculated. The initial interviews were carried out for an investigation of the on-road driving exposure of young drivers (Crettenden, Yeo and Drummond, 1994), also part of the Federal Office of Road Safety's "Young Driver Research Program".

3.2. Collection of the home interview data

A series of interviews was conducted during December 1992 by an experienced national market research company. Drivers aged 16 to 50 years who had driven at least once in the last month were interviewed at their homes in both metropolitan and country areas in all six states of Australia (but not the two territories). The sample was stratified by age group, sex, state and location type (metropolitan versus country). Interviews were obtained from a total of 3008 respondents during the survey (approximately 0.03% of all licensed drivers in Australia). Interview questions included in the survey related to a variety of topics which might be expected to be related to crash risk and/or to the age at which an individual first acquires a licence to drive, including driving exposure in the last week (broken down by day/night and work/non-work), attitude to driving and to safety measures, driving style, personality and socio-economic variables. The questionnaire completed by the interviewers on the basis of information obtained from the respondents is shown in Appendix 1.

Data from this survey were also analysed in an investigation of on-road exposure of young drivers (Crettenden *et al.*, 1994) also conducted for the Federal Office of Road Safety as part of the Young Driver Research Program; the report of the exposure project provides a more detailed account of the content and execution of the survey.

3.3. Preparing the data for analysis

The age of respondents at the time of first licence acquisition was not directly asked in the survey. Age of licence acquisition was therefore calculated by subtracting the number of years since the respondent first obtained a licence from the respondent's age.

Cases from both metropolitan and rural areas of all six states were included in the analyses. To allow for the differences in licensing regulations between the states, a new variable was added to the data set which recorded the legal minimum licensing age of the state in which the driver was interviewed.

After elimination of cases for which the recorded age was invalid (outside the range of 16-50 years specified in the survey brief) and cases for which the calculated age at licence acquisition was invalid (impossibly young for the state in which the respondent lived), 2881 cases remained.

Errors in the variable "Years since first licensed" (and hence in the critical variable "Age at licensing") were expected to be larger for older drivers. It was also believed that socio-economic factors influencing the age at which a driver first obtains a licence may vary slowly over the years, so that the factors which influenced the licensing age of today's mature and older drivers may not be identical to those operating on today's younger drivers. For these reasons, analysis was restricted to drivers aged no more than 29 years. After applying this restriction, 1688 cases remained.

Answers to some of the survey questions placed limits on the range of valid responses which could be given to other questions. For example, if a respondent reported having driven for only one hour in the preceding week, this would not be consistent with a reported distance driven of 300 kilometres. Consistency checks similar to this example were carried out wherever possible. In general, consistency checks were possible for most of the variables related to the respondent's driving during the week before the survey, but for very few other variables. Hundreds of cases containing inconsistencies between variables were identified in the data. Inconsistencies were reported to the market research contractor, which investigated all reports and supplied corrections where errors had occurred in data entry. Most inconsistencies did not result from data entry errors, and therefore could not be corrected. After all possible corrections had been made, approximately 16% of respondents still had inconsistent, and therefore invalid, data for the "travel" variables - those relating to the respondent's driving in the previous week. Problems appear to have arisen mainly from:

(i) errors made by interviewers in converting hours of driving to minutes of driving;

(ii) imprecise estimates by interviewees of times and/or distances driven; and

(iii) confusion among interviewers about which of the questions on driving in the previous week were relevant to each respondent.

With hindsight, it is obvious that a number of improvements could have been made to the interviewer's questionnaire form to reduce the incidence of incorrect and inconsistent responses.

Consistency checks were not possible for most questions other than those relating to driving in the previous week. The proportion of invalid data for non-driving items is therefore not known, but is likely to be considerably lower than for driving questions, since the non-driving questions were mostly simple rating scales and choices from a small number of alternatives. Non-driving items generally did not require estimation of quantities or recall of past events, and so were not subject to the judgemental errors on the part of respondents which are typically associated with these tasks.

3.4. Analytical procedures and results

3.4.1 Choice of statistical analysis

The aim of the statistical analysis was to determine the relationship between the a continuous variable - the age at which a respondent first obtained a driver's licence - and a wide variety of continuous and discrete variables obtained from the home interviews. Multivariate linear regression was the most appropriate analytical tool to reveal the simultaneous influence of all the other variables on age of licence acquisition. To facilitate interpretation of the results, stepwise regression, which yields a regression equation containing only the significant predictors, was preferred to standard regression, which yields an equation containing all the predictors.

3.4.2 Division of the data into two sub-samples

Stepwise regression is affected by chance relationships in the data to a greater extent than other methods (Tabachnick and Fidell, 1989). It is therefore desirable to assess the reliability of equations derived by stepwise regression. The available data were therefore pseudo-randomly divided into two sub-samples. The first sub-sample (N=1322) contained 80% of all cases, and was used for the derivation of the regression equation for age of licence acquisition. The second sub-sample (N=366), containing 20% of cases, was used for confirmation of analyses carried out in the first sub-sample.

3.4.3. Formation of summary variables

The interview data contained almost 200 variables describing the driving exposure patterns, driving style, opinions, personality and socio-economic characteristics of the drivers sampled. However, not all of these could be used as independent variables in the regression. In order to achieve reliable results using multiple regression, the number of cases (which in this analysis means interview respondents) must be at least 20 to 40 times the number of independent variables (Tabachnick and Fidell, 1989). It was therefore necessary greatly to reduce the number of independent variables before regression could be performed. This was also expected to facilitate interpretation of the regression results.

In the first stage of the reduction of the number of independent variables, twelve "summary" variables were formed by summing closely-related items from the interviews. Each interview variable was divided by its standard deviation before being included in a sum, to ensure that arbitrarily chosen measurement scales did not result in some interview variables contributing far more variation than others to the resulting summary variable. It was necessary to multiply some of the interview variables by -1 before inclusion in the sums, to ensure consistency within each summary variable. Appendix 2 lists the 12 summary variables created and the 48 interview variables from which they were derived. These summary variables were then used in further analyses in place of the interview variables from which they had been formed.

Apart from the 52 questions related to the respondent's driving in the previous week, the majority of interview questions consisted of rating scales with 10 discrete response values. Some of the remaining interview questions were (or were redefined to be) choices between two alternatives. Strictly regarded, when discrete variables were summed, the resulting summary variable was also discrete. However, the number of possible values for these

summary variables was usually large, and it was considered feasible to treat them as continuous scales in later analyses.

3.4.4. Principal components analysis

After the formation of the summary variables, it was still necessary to achieve a further substantial reduction in the number of independent variables before a multiple regression analysis could be performed. Principal components analysis was therefore performed in order to derive a small number of principal components which could be used in place of the larger number of variables from which they had been derived.

Three variables - the driver's age and sex and the legal minimum licensing age of the state where the driver was interviewed - were considered to be important in their own right as predictors of the age at which the driver first acquired a licence. These variables were therefore excluded from the principal components analysis, since they were to be entered directly into the regression equation for age of licence acquisition along with the principal components extracted from the remaining variables.

Almost 4% of drivers in the sample reported that they had not driven in the week preceding the survey, and so most variables related to driving in the previous week were missing for these drivers. A further 16% of drivers reported times or distances driven which were in some way inconsistent or invalid. Thus inclusion in the principal components analysis of the variables relating to each respondent's driving during the previous week would have resulted in the loss of approximately 20% of cases from the sample. To enable the inclusion of all respondents in the analysis, variables related to driving in the previous week were therefore excluded from the principal components analysis. These variables were replaced by flags indicating whether the driver had driven in the last week, had driven at night, had driven for work or had driven during the last weekend.

Many of the variables to be included in the analysis had markedly skewed or otherwise non-normal distributions, a condition which is likely to lead to attenuation of correlations and a degraded factor solution (Tabachnick and Fidell, 1989). To minimise such problems, variables were transformed where necessary before the principal components analysis was performed. Variables whose distributions were unimodal but significantly skewed were subjected to logarithmic or power transformations to correct the skewness. Variables with bimodal distributions and also those with distributions which peaked at either the minimum or maximum of the range of the variable were transformed to dichotomous variables by splitting the distribution at the median. No correction for skewness was possible for dichotomous variables. Appendix 3 indicates which variables were transformed and which dichotomised.

Mahalanobis' distance was calculated for each case (using the SPSS REGRESSION program) to determine whether there were any outliers among the data which might be expected to have a disproportionately large influence on the principal components analysis. A number of significant outliers were found. Trial and error revealed that the presence of outliers was linked with the inclusion in the data set of a number of extremely skewed dichotomous variables. Three dichotomous variables with more than 90% of cases in one category (and hence less than 10% of cases in the other) were therefore excluded from analysis. When this had been done there were no remaining significant outliers.

Principal components analysis was then performed in the first sub-sample (containing 80% of cases). Because principal components analysis is very similar to factor analysis, and also for the sake of simplicity, the principal components extracted are generally referred to as "factors" in the descriptions below. Variables included in the analysis are shown in Appendix 3. After some trial and error, it was established that the "best" (i.e. most easily interpretable) solution was obtained when six factors were extracted. Orthogonal rotation was employed, since (i) oblique rotation yielded no improvement in the interpretability of the factors, and (ii) oblique rotation yielded factors which were only very slightly correlated. Five variables which did not load above 0.3 on any factor were excluded from the analysis. A further three variables were excluded to improve the interpretability of the resulting factors. The final principal components analysis yielded six factors from 26 variables, accounting for 42.4% of the variance in the data. The factors resulting from this analysis are shown in Table 3.4.4a. The rotated factor matrix, showing the loadings of each of the factors on each of the 26 independent variables, is reproduced in Appendix 3A.

TABLE 3.4.4a

RESULTS OF PRINCIPAL COMPONENTS ANALYSIS

Factor	% of variation accounted for	Interpretation
Factor 1	11.9	recklessness
Factor 2	7.1	settled down
Factor 3	6.6	rural
Factor 4	6.2	variety of exposure
Factor 5	5.5	financial value of car
Factor 6	5.1	importance of cars and driving

The first factor had its highest loadings on variables related to the individual's propensity to take chances or risks or act on the spur of the moment, either in driving or more generally, and to engage in unsafe driving behaviour. This factor was interpreted as a measure of the "recklessness" of the individual. The emergence of this factor first is not surprising, given that the interviews from which the data were obtained contained a large number of questions relating to chance-taking and unsafe behaviours.

The second factor had its highest loadings on variables specifying whether the respondent was married (including *de facto* relationships), whether the respondent had a child and whether the respondent had a mortgage. This factor was interpreted as a measure of the extent to which the respondent had "settled down" - that is, the extent to which the individual had relinquished the freedom and flexibility of early adulthood in favour of the ties and responsibilities often associated with the middle years of life.

The third factor was the hardest of the six to interpret. Its highest loadings were for a variable indicating whether the respondent's home address was metropolitan (i.e. in a state capital city) or rural, and for variables indicating whether any language other than English was spoken in the respondent's home and whether or not the respondent was paying rent or board. The correlations between these variables were such that rural respondents were more likely than metropolitan respondents to be renting and less likely to speak a language other than English. Loadings above 0.3 also occurred for long trips and mortgages, with rural people being less

likely to have a mortgage and more likely to have undertaken a long trip in the last year. This factor was labelled "rural", in recognition of its most salient characteristic.

The fourth factor was plainly linked to the respondent's driving exposure. Its highest loadings occurred for variables indicating night time driving in the last week, weekend driving in the last week, a long trip undertaken in the past year and the number of parking tickets received in the past year. This factor was not a measure of the quantity of the respondent's exposure in terms of either distance driven or time spent driving; rather, it appeared to reflect the variety of different conditions under which the respondent drove.

The fifth factor had its highest loadings on the age of the respondent's car and whether it was comprehensively insured or not. A loading above 0.3 also occurred for a variable indicating whether or not the car was modified. This factor was interpreted as a measure of the financial value of the respondent's car.

The sixth and last factor appeared to indicate the degree of importance the respondent attached to cars and driving. Its highest loadings were on the respondent's degree of interest in cars, the frequency of waxing and polishing the car, whether the car was modified and the respondent's enjoyment of driving. A loading above 0.3 also occurred for the respondent's tendency to feel tired when driving.

The factor score coefficients derived from the principal components analysis in the first sub-sample were then used to create the above six factors in the second sub-sample (the remaining 20% of cases) for use in later analyses. No principal components analysis was performed in the second sub-sample, which contained many fewer cases and therefore would not be expected to yield the same factor structure.

3.4.5. Regression equation for age of licence acquisition

A stepwise multiple regression was performed in the first sub-sample (80% of cases) to determine the driver characteristics most associated with obtaining a licence at an early age. The predictor variables used in the regression were age; sex; legal minimum licensing age; the factors emerging from the principal components analysis; and the variables which had been excluded from the principal components analysis due either to low correlation with the factors or difficulty in interpreting the factors. Details of all variables used in the regression are shown in Appendix 4, and the correlation matrix for all variables is shown in Appendix 5. The prediction equation resulting from the regression is shown in Table 3.4.5a.

Not surprisingly, the (transformed) age at which respondents first obtained a licence was influenced by the minimum legal age for obtaining a licence in the state in which they lived: the higher the minimum legal age, the greater the average age of licence acquisition for respondents from that state. This was the first variable to enter the regression equation, having the greatest (zero-order) correlation with age of licence acquisition.

The second variable to enter the equation was the (transformed) age of the respondent, and in the final equation this variable accounted for the largest amount of variation in age of licence acquisition. Older respondents tended to have obtained their first licence later in life than younger respondents. This effect is at least in part an artefact of the sampling procedure - only licensed drivers were included in the sample. Thus young people (under age 22, say) who had not yet obtained a licence at the time of the survey but would have done so later in

life were systematically excluded, whilst older people who obtained a licence relatively late were able to be included in the sample.

The sex of the respondent was the third variable to enter the regression equation. The zero-order correlations showed that males were licensed younger on average than females, and the regression coefficients confirmed that this remained true after the effects of the other significant predictors had been taken into account.

Factor 2 from the principal components analysis (measuring the degree to which the respondent had "settled down") entered the regression equation as a "suppressor" variable: that is, its contribution to prediction of age of licence acquisition was not what would have been expected on the basis of the zero-order correlations. While the correlations showed that the more settled respondents tended to have been licensed later, the regression coefficients showed that after taking into account the effects of the other significant predictors this relationship was reversed. The explanation for this reversal was found in the relationship between Factor 2 and age, which are correlated such that older respondents tend to be more settled down. For respondents of any given age, those who are more settled tend to have been licensed earlier than those who are less settled. In other words, early acceptance of the responsibilities commonly associated with mature adulthood (partner, children, mortgage) tends to be associated with early licensing. Among respondents of different ages, however, the effect of Factor 2 is masked by the much larger effect of age: respondents who are more settled tend to be older and therefore to have been licensed later.

TABLE 3.4.5a

RESULTS OF MULTIPLE REGRESSION FOR AGE OF LICENCE ACQUISITION

B = regression coefficients for unstandardised variables
beta = regression coefficients for standardised variables

Predictor	B	beta	correlation	probability
LEGAL	0.3536	0.3595	0.3822	0.0000
AGE	0.2702	0.4266	0.3690	0.0000
SEX	0.0966	0.1154	0.1156	0.0000
Factor 2	-0.0533	-0.1274	0.0787	0.0000
Factor 3	-0.0380	-0.0908	-0.0831	0.0001
EDUC	-0.0463	-0.0539	0.0389	0.0248

Factor 3 from the principal components analysis also contributed significantly to prediction of age of licence acquisition, with "rural" respondents having been licensed earlier on average than metropolitan respondents.

The final significant predictor was the respondent's highest educational level. This was another suppressor variable. The zero-order correlations indicated that those with tertiary, technical or trade education tended to have been licensed slightly later than those with only secondary education. However, the regression coefficients show that when the other significant predictors are taken into account, this relationship was reversed. Once again, age appears to be implicated. Among respondents of a given age, post-secondary education (tertiary, technical or trade) is associated with earlier licensing. However, post-secondary

education is more common among older respondents, who tend to have been licensed later, and this effect masks the relatively minor effect of education within age groups.

This regression equation was found to account for only 30.4% of the variation in the dependent variable, suggesting that there are other important factors helping to determine the age at which a driver acquires his or her first licence which were not taken into account in the analysis. The questionnaire completed by the home interviewers was not specifically designed for an examination of age of licence acquisition, and hence did not include variables such as parents' income, availability of public transport services near the respondent's home and place of work or education and other factors which might be expected to be relevant to decisions about obtaining a licence to drive.

Other factors likely to contribute to the rather low proportion of variation accounted for by the regression equation include the following:

(i) many predictors were made dichotomous because of gross non-normality of their distributions, and thus a great deal of information from the original variables was lost;

(ii) there was up to one year of random error in the criterion variable ("age at licensing") because it was created by subtracting "years since first licensed" from "age", each of which was subject to up to half a year of random error; and

(iii) age at licence acquisition was more variable for older drivers than for younger drivers; this problem, known as "heteroscedasticity", was reduced but not eliminated by the transformation which was used to correct the skewness of "age at licensing".

The suppression relationship between Factor 2 and age suggested the possibility that these two variables may have interacting effects on age of acquisition. This possibility was tested by creating a new variable equal to the product of age and Factor 2 and including this variable in the regression analysis. After age and Factor 2 had already been entered into the regression equation, their product was found not to significantly improve prediction of age of licence acquisition ($p=0.197$). It was concluded that age and Factor 2 do not significantly interact in their effects on age of licence acquisition.

The regression equation derived in the first sub-sample was then used to predict age of licence acquisition of drivers in the second sub-sample, in order to verify the reliability of the equation, and was found to account for 28.1% of the variance in age of licence acquisition, just slightly less than the proportion of variation accounted for by the same equation in the first sub-sample.

A further check on the reliability of the regression equation was performed by conducting a new regression to predict age of licence acquisition in the second sub-sample, using as predictors just those variables which had proven to be significant predictors in the first sub-sample. The regression coefficients derived from this analysis are shown under the heading "Second sub-sample" in Table 3.4.5b. The hypothesis of an identical relationship between age of licence acquisition and the predictors in the two sub-samples was tested by comparing the regression coefficients for each of the six predictors in the two sub-samples. The column labelled "probability" in Table 3.4.5b shows, for each variable, the probability that the two sub-samples came from populations with the same regression coefficient for that variable. To obtain a significance level of $\alpha = 0.05$ for the overall test, the significance level for each of the six comparisons was set at $\alpha = 0.0085$ ($= 1 - 0.95^{1/6}$). At this significance level, none of

the six predictors had regression coefficients which differed reliably between the two sub-samples. The hypothesis that the relationship between age of licence acquisition and the six predictors was the same in the two sub-samples was therefore accepted.

TABLE 3.4.5b

COMPARISON OF REGRESSION COEFFICIENTS FROM FIRST AND SECOND SUB-SAMPLES

Predictor	First sub-sample		Second sub-sample		Probability
	B	std error	B	std error	
LEGAL	0.3536	0.0231	0.3605	0.0418	0.115
AGE	0.2702	0.0174	0.2056	0.0324	0.078
SEX	0.0966	0.0196	0.0636	0.0352	0.413
Factor 2	-0.0533	0.0113	0.0009	0.0200	0.018
Factor 3	-0.0380	0.0099	-0.0008	0.0198	0.092
EDUC	-0.0463	0.0206	-0.0144	0.0377	0.458

3.4.6. Driving exposure in the previous week

A major part of the information available from the home interview survey concerned the respondents' driving exposure during the previous week - the "travel" variables. Because invalid travel information had been recorded for some respondents, these variables were not included in the initial analyses. The regression equation developed in Section 3.4.5 was found to account for only 28.1 per cent of the variation in the age at which respondents obtained a driver's licence. This indicates that a substantial proportion of the variation in age of licence acquisition was associated with factors which were not included in the regressions. To determine whether the additional information on respondents' driving in the previous week would significantly improve prediction of age of licence acquisition, further analyses incorporating this information were conducted.

In order to include information on respondents' travel in the analyses, it was necessary to exclude respondents who had not driven in the week before the home interview and respondents for whom invalid or inconsistent travel data had been recorded. In total, just over 19% of respondents were to be excluded. In order to determine the effects of this restriction of the sample available for analysis of the travel data, respondents included in the analyses were first compared on a range of variables with respondents excluded. Student's t test was used for all continuous variables, and a chi square test was used for SEX. The results of these comparisons are shown in Table 3.4.6a. The table shows that respondents excluded from the analyses of the travel data had significantly lower scores on Factor 4 ("variety of driving exposure") than respondents included. This result was expected, since respondents who had not driven in the week before the home interview survey, who were among those excluded, naturally scored lowest on "variety of driving exposure". The table also shows that respondents excluded from the analyses of the travel data had significantly higher scores on Factor 3 ("rural") and Factor 6 ("importance of cars and driving") than respondents included. There was no significant difference in age of licence acquisition (AGELIC) or any of the other variables examined. Thus, the exclusion of respondents who not driven in the week before the home interview survey necessarily produced some distortion of the sample, but the

absence of a significant difference in AGELIC suggested that this would not invalidate the use of the sample for prediction of AGELIC.

TABLE 3.4.6a

COMPARISON OF RESPONDENTS INCLUDED IN AND EXCLUDED FROM ANALYSES OF TRAVEL DATA

Variable	Exclusion associated with...	Test	Probability
AGE	-	t	.071
YRSLIC	-	t	.063
AGELIC	-	t	.757
LEGAL	-	t	.405
Factor 1	-	t	.974
Factor 2	-	t	.126
Factor 3	less "rural"	t	.026*
Factor 4	less "variety of exposure"	t	.001**
Factor 5	-	t	.875
Factor 6	greater "importance attached to cars and driving"	t	.000***
SEX		chi square	.281

TABLE 3.4.6b

RESULTS OF MULTIPLE REGRESSION WITH ADDITION OF DATA ON RESPONDENTS' DRIVING DURING THE PREVIOUS WEEK

B = regression coefficients for unstandardised variables
beta = regression coefficients for standardised variables

Predictor	B	beta	correlation	probability
LEGAL	0.3520	0.3572	0.3649	0.0000
AGE	0.2713	0.4248	0.3540	0.0000
SEX	0.0900	0.1079	0.1253	0.0001
Factor 2	-0.0509	-0.1228	0.0790	0.0001
Factor 3	-0.0395	-0.0938	-0.0643	0.0005
EDUC	-0.0505	-0.0589	0.0335	0.0307
FKMWORK	-0.0787	-0.0942	-0.0692	0.0004

Multiple regression was performed in the first sub-sample to determine whether the availability of information related to the respondent's driving during the week preceding the survey improved prediction of age of licence acquisition. Only those cases with non-missing, valid travel data were included in this new regression. Significant predictors from the regression previously carried out in the whole of the first sub-sample (i.e. the predictors listed in Table 3.4.5a) were firstly entered into the equation, followed by a stepwise procedure to determine whether any of the travel variables significantly improved prediction. Details of all travel variables used in the regression are shown in Appendix 6. The results of this regression are shown in Table 3.4.6b. FKMWORK was the only travel variable to enter the prediction

equation: the higher the fraction of kilometres driven in the last week which were driven for work purposes, the earlier were drivers licensed. The improvement in prediction, although statistically significant, was small, with the proportion of variation accounted for by the prediction equation increasing from 28.6% to 29.5%.

In order to test the reliability of the regression equation shown in Table 3.4.6b, significant predictors from the equation were entered into a regression in the second sub-sample, and the regression coefficients for each variable estimated from the two sub-samples were compared. Once again, only cases with valid, non-missing travel data were included. To obtain a significance level of α=0.05 for the overall test, the significance level for each of the seven comparisons was set at α=0.0073 (= 1 - $0.95^{1/7}$). Results of these comparisons are shown in Table 3.4.6c, which shows that the prediction equations from files the first sub-sample and the second sub-sample were significantly different: both age and Factor 2 make significantly less contribution to prediction in the second sub-sample than in the first sub-sample.

TABLE 3.4.6c

COMPARISON OF REGRESSION COEFFICIENTS FROM FIRST AND SECOND SUB-SAMPLES

Predictor	First sub-sample		Second sub-sample		Probability
	B	std error	B	std error	
LEGAL	0.3520	0.0260	0.4052	0.0436	0.2951
AGE	0.2713	0.0197	0.1649	0.0340	0.0069
SEX	0.0900	0.0221	0.0958	0.0368	0.8924
Factor 2	-0.0509	0.0126	0.0181	0.0214	0.0054
Factor 3	-0.0395	0.0112	-0.0282	0.0208	0.6321
EDUC	-0.0505	0.0233	-0.0120	0.0397	0.4026
FKMWORK	-0.0787	0.0222	0.0063	0.0371	0.0491

In an attempt to obtain a reliable regression equation utilising the travel data, a new regression was conducted in the first sub-sample. This time, the significant predictors from Table 3.4.5a (the regression in the first sub-sample when cases with missing or invalid travel variables were included) were not forced into the equation. Variables entered the equation only if they significantly improved prediction of age of licence acquisition among drivers with valid, non-missing travel data. This allowed the regression equation to reflect changes in the relationship between age of licence acquisition and the predictors which resulted from the exclusion of cases with missing or invalid travel data. The results of this regression are shown in Table 3.4.6d. This equation differs from that shown in Table 3.4.6b only in that Factor 5 ("financial value of car") enters the equation in place of EDUC (highest educational level). Respondents with more valuable cars tended to have been licensed earlier than those with less valuable cars.

Once again, the reliability of this equation was tested by entering the significant predictors from this equation into a regression in the second sub-sample. The results of this regression are shown in Table 3.4.6e. To obtain a significance level of α=0.05 for the overall test, the significance level for each of the seven comparisons was again set at α=0.0073 (= 1 - $0.95^{1/7}$). Once again, a significant difference was found between the equations estimated in the two

sub-samples: higher values of Factor 2 ("settled down") were associated with earlier licence acquisition in the first sub-sample, but with later licence acquisition in the second sub-sample. It was concluded that the relationship between age of licence acquisition and the various predictors differs between the two sub-samples when the travel variables were used to aid prediction and analysis was restricted to those cases with valid, non-missing travel data. Thus the equation estimated in the first sub-sample could not be considered reliable; the relationship between age of licence acquisition and the various predictors may be different in a new sample.

TABLE 3.4.6d

RESULTS OF MULTIPLE REGRESSION WITH TRAVEL DATA USING STEPWISE ENTRY ONLY

Predictor	B	beta	correlation	probability
LEGAL	0.3547	0.3594	0.3661	0.0000
AGE	0.2655	0.4158	0.3542	0.0000
SEX	0.0996	0.1192	0.1266	0.0000
Factor 2	-0.0484	-0.1168	0.0795	0.0001
FKMWORK	-0.0786	-0.0941	-0.0688	0.0004
Factor 3	-0.0375	-0.0890	-0.0651	0.0008
Factor 5	-0.0318	-0.0750	-0.0247	0.0046

TABLE 3.4.6e

COMPARISON OF REGRESSION COEFFICIENTS FROM THE TWO SUB-SAMPLES

Predictor	First sub-sample		Second sub-sample		Probability
	B	std error	B	std error	
LEGAL	0.3547	0.0260	0.4058	0.0435	0.3135
AGE	0.2655	0.0193	0.1645	0.0329	0.0080
SEX	0.0996	0.0221	0.0984	0.0368	0.9777
Factor 2	-0.0484	0.0125	0.0175	0.0210	0.0069
FKMWORK	-0.0786	0.0222	0.0057	0.0369	0.0505
Factor 3	-0.0375	0.0112	-0.0315	0.0209	0.8001
Factor 5	-0.0318	0.0112	-0.0220	0.0173	0.6343

Since a reliable prediction equation for age of licence acquisition could not be estimated from the first sub-sample, the two sub-samples were combined, with cases with missing or inconsistent travel data still being excluded, and a new regression for age of licence acquisition was conducted in the combined sample. Variables were entered into the prediction equation only if they significantly improved prediction of age of licence acquisition; no variables were forced into the equation. The resulting regression equation is shown in Table 3.4.6f. This equation is in most respects very similar to the corresponding equation estimated in the first sub-sample only (Table 3.4.6d). Since no other data were available for comparison, this equation may not be reliable. It is nevertheless the best

available estimate of the relationship between age of licence acquisition and the predictor variables when the travel variables are included.

TABLE 3.4.6f

RESULTS OF MULTIPLE REGRESSION FOR BOTH SUB-SAMPLES COMBINED, USING STEPWISE ENTRY ONLY

Predictor	B	beta	correlation	probability
LEGAL	0.3620	0.3734	0.3829	0.0000
AGE	0.2455	0.3937	0.3547	0.0000
SEX	0.0995	0.1210	0.1257	0.0000
Factor 3	-0.0343	-0.0808	-0.0649	0.0005
Factor 5	-0.0307	-0.0750	-0.0281	0.0012
Factor 2	-0.0356	-0.0886	0.1031	0.0009
FKMWORK	-0.0598	-0.0727	-0.0534	0.0017

Finally, both univariate and multivariate analyses were performed to identify the driver characteristics associated with greater and lesser quantities of driving exposure. MINTOT (total reported minutes of driving in the week preceding the home interview) was selected as the most appropriate measure of exposure. The results of the univariate analyses are shown in Table 3.4.6g. For continuous predictor variables, tests of significance were based on the correlation of the predictor with MINTOT, while t tests were used for dichotomous predictors. The table shows that exposure was significantly correlated with the number of years since the respondent obtained a driving licence: drivers who had held a licence for longer reported more minutes of exposure in the week before the home interview. Older respondents also tended to report higher levels of exposure, as expected on the basis of previous research, but this correlation did not reach statistical significance ($p=0.157$). Males and respondents with post-secondary education reported significantly more minutes of exposure than females and respondents without post-secondary education, respectively. Greater exposure was also associated with higher levels of Factor 1 ("recklessness") and Factor 6 ("importance of cars and driving") and lower levels of Factor 3 ("rural"). All predictors in Table 3.4.6g were entered into a multiple regression to determine their independent contributions to prediction of total minutes of driving exposure. The results of the regression are shown in Table 3.4.6h. The table shows that all predictors which were significant in the univariate tests also made significant independent contributions to prediction of MINTOT in the multivariate test.

TABLE 3.4.6g

PREDICTION OF TOTAL EXPOSURE TIME DURING THE WEEK PRECEDING THE HOME INTERVIEW: UNIVARIATE TESTS

Variable	Greater driving exposure associated with...	Test	Probability
AGE	-	Pearson's r	.157
YRSLIC	more years driving experience	Pearson's r	.021*
AGELIC	-	Pearson's r	.338
LEGAL	-	Pearson's r	.165
Factor 1	greater "recklessness"	Pearson's r	.000***
Factor 2	-	Pearson's r	.636
Factor 3	less "rural"	Pearson's r	.003**
Factor 5	-	Pearson's r	.959
Factor 6	greater "importance attached to cars and driving"	Pearson's r	.000***
SEX	males	t	.000***
EDUC	post-secondary education	t	.000***

TABLE 3.4.6h

REGRESSION EQUATION FOR PREDICTION OF TOTAL DRIVING EXPOSURE TIME

B = regression coefficients for unstandardised variables
beta = regression coefficients for standardised variables

Predictor	B	beta	correlation	probability
SEX	-0.2296	-0.1885	-0.2386	0.0000
Factor 1	0.0595	0.0993	0.1526	0.0003
Factor 3	-0.0498	-0.0792	-0.0803	0.0029
Factor 6	0.0536	0.0879	0.1286	0.0012
EDUC	0.0807	0.0644	0.0971	0.0168
YRSLIC	0.0584	0.0606	0.0633	0.0234

3.4.7. Driver characteristics and behaviours associated with increased crash risk

Whilst the home interview survey did not collect any information concerning crash involvement, it included many questions concerning driver behaviours and characteristics expected to be related to crash risk. Previous research has established or suggested contributions to the elevated crash risk of young drivers by factors including inappropriate speed choice and attitudes to speed (e.g. Goldstein, 1972; Jonah, 1986; Catchpole, Cairney and Macdonald, 1994); optimism or over-confidence (e.g. Brown, 1982; Finn and Bragg, 1986; Perkins, 1988); recklessness (e.g. Harrington, 1972); and a high proportion of driving performed at night (e.g. Williams, 1985; Drummond and Healy, 1986). The home interview survey provides an opportunity to answer two important questions about these risk-related characteristics and behaviours.

Firstly, are behaviours and characteristics that are likely to increase crash risk (such as speeding) more closely associated with youth or with lack of driving experience? The number of years since the respondent obtained a driver's licence was used as an approximate index of driving experience. As expected, age and number of years since licence acquisition were found to be closely related, having a correlation coefficient of 0.874 in the study sample. Regression analyses were performed to determine which of the two was more closely related to characteristics and behaviours expected to be associated with increased crash risk. The respondent's sex was included as an additional predictor in all of the regression analyses, since many of the reported behaviours and characteristics were expected to differ markedly between the sexes.

Secondly, it is important to determine whether the sort of individual who obtains a driver's licence relatively early in life is also the sort of individual who is predisposed, for reasons other than age and driving experience, to higher or lower than average crash risk. The number of years for which the respondent had held a licence was again used as an approximate index of experience. Because of the need to remove the effects of age and experience, it was not possible to compare age of licence acquisition directly with the risk-related behaviours and characteristics in question. After removing the effects of age and experience, any remaining variation in age of licence acquisition would be meaningless, being merely the result of the different non-linear transformations that were applied to the three variables. Regression analyses were therefore performed to determine the relationship of the respondents' risk-related behaviours and characteristics to the main predictors of age of licence acquisition after allowing for the effects of sex, age and experience. The predictors used were Factor 2 ("settled down"), Factor 3 ("rural") and EDUC (highest educational level) - i.e., the significant predictors from Table 3.4.5a, with the exception of age and sex, whose effects were explicitly removed by prior entry into the prediction equations, and the legal minimum licensing age in the respondent's home state, which was not expected to be linked to the various risk-related behaviours and characteristics after controlling for age and experience.

3.4.7.1. SPEED

Regressions were performed to determine whether the variables related to the respondent's reported speed behaviours and attitudes were significantly predicted by the age of the respondent or the number of years for which a licence had been held. The respondent's sex was included as an additional predictor, to account for expected differences in speed behaviours between males and females. An overview of the results of these regressions is given in Table 3.4.7.1a. For all speed variables, the proportion of variation accounted for by age, years driving experience and sex was negligible. Of these three predictors, sex was by far the most important determinant of self-reported attitudes and behaviours related to speed. Compared with females, males reported that they speed more often, whether in built up areas or on the open road, whether during daytime or night-time, that they have greater enjoyment of driving faster than other traffic and that they have a faster driving style.

Age and years driving experience did not contribute significantly to the prediction of any speed-related variables except frequency of speeding in built up areas. Respondents who had held a licence for longer tended to report higher frequency of speeding in built up areas. Age was a significant suppressor in the prediction equation: while it was essentially uncorrelated with frequency of speeding in built up areas, this turned out to be a result of the close link between age and number of years driving experience. After controlling for number of years

driving experience, there was a significant negative partial correlation between age and speeding in built up areas. That is, among drivers with a given number of years driving experience, the younger drivers tended to report a higher frequency of speeding in built up areas than did the older drivers.

TABLE 3.4.7.1a

SUMMARY OF REGRESSION RESULTS FOR VARIABLES RELATED TO SPEED

Variable	Self-rating of ...	Significant predictors	R^2
SPEDBUA	how often speed in built up area	sex, yrslic, age	.03
SPEDOPEN	how often speed on open road	sex	.04
SPEDDAY	speed during daytime	sex	.03
SPEDNITE	speed during night-time	sex	.03
ENJFAST	enjoyment of driving faster than traffic	sex	.04
FAST	fast driving style	sex	.02
SPEED	(weighted sum of the above)	sex	.05

Further regression analyses were then conducted to determine the relationship between the seven speed variables and the predictors of age of licence acquisition, after removing the effects of sex, age and years driving experience. The results of these regressions are summarised in Table 3.4.7.1b. The table shows that Factor 2 ("settled down") was significantly associated with only one of the speed-related variables, namely speeding in built up areas. The negative beta weight for Factor 2 in this relationship shows that, after controlling for sex, age and years driving experience, respondents who had lower scores on Factor 2 (i.e. were less "settled down") reported speeding in built up areas more often than respondents with high scores on Factor 2. When combined with the association between early acquisition of a driver's licence and high scores on Factor 2 (*see* Table 3.4.5a), this finding suggests that the sort of individual who acquires a licence relatively early in life may also be the sort of individual who, after allowing for the effects of sex, age and years of driving experience, is less likely to speed in built up areas. Table 3.4.7.1b also shows that Factor 3 ("rural") was significantly associated with five of the speed-related variables examined, with a negative beta weight in each case. After allowing for sex, age and years driving experience, respondents with low scores on Factor 3 reported significantly higher frequencies of speeding in built up areas, speeding during the day and speeding at night. They also reported greater enjoyment of driving faster than other traffic and had higher scores on the speed summary variable. Since high scores on this factor were associated with early acquisition of a driver's licence, the findings for Factor 3 were consistent with those for Factor 2 in suggesting that drivers who obtain a licence early in life are less likely to speed than those who are licensed later, after removing the effects of sex, age and years driving experience. However, there were mixed findings for EDUC (the highest educational level attained by the respondent). A significant negative beta weight was obtained for EDUC in the regression for FAST, indicating that respondents with only secondary education reported a faster driving style than respondents with post-secondary (tertiary, technical or trade) education. On the other hand, a positive beta weight was obtained for EDUC in the regression for SPEED, a weighted sum of all the speed-related variables. However, the beta weights shown for EDUC in Table 3.4.7.1b are smaller in absolute magnitude than those of Factor 2 and Factor 3, indicating that EDUC is less strongly related to speed-related attitudes

and behaviours than are these two factors. Inspection of the beta weights in Table 3.4.5a shows that EDUC is also less strongly related to age of licence acquisition than are Factors 2 and 3. In view of the consistent findings for Factors 2 and 3 and the weaker links of EDUC to both speeding and age of licence acquisition, it is clear that the weight of evidence favours the proposition that, after allowing for the effects of sex, age and years driving experience, drivers who acquire a licence relatively early in life are less likely to drive excessively fast than are drivers who are licensed later.

TABLE 3.4.7.1b

RELATIONSHIP OF SPEED VARIABLES TO THE PREDICTORS OF AGE OF LICENCE ACQUISITION, AFTER ALLOWING FOR SEX, AGE AND YEARS DRIVING EXPERIENCE

For interpretation of the speed variables, see Table 3.4.7.1a.
"n.s." = not significant.

Beta = regression coefficients for standardised variables

Variable	Beta weights for significant predictors		
	Factor 2	Factor 3	EDUC
SPEDBUA	-0.0747	-0.1314	n.s.
SPEDOPEN	n.s.	n.s.	n.s.
SPEDDAY	n.s.	-0.0995	n.s.
SPEDNITE	n.s.	-0.1084	n.s.
ENJFAST	n.s.	-0.1045	n.s.
FAST	n.s.	n.s.	-0.0554
SPEED	n.s.	-0.0967	0.0616

3.4.7.2. OPTIMISM

An overview of the relationship of sex, age and years driving experience to variables related to optimism is given in Table 3.4.7.2a. Two of the interview items, YDSKIL and YDRISK, were asked only of respondents aged 25 years or less; regressions were of course restricted to respondents who answered the relevant question. The regression equations accounted for a negligible proportion of variation in each case. Sex contributed significantly to prediction of three of the four variables: males reported themselves to be more skilful and to take more risks than females, and males aged 25 or less reported taking more risks than did females of the same age. Years driving experience contributed significantly to the prediction of the skill ratings but not the ratings of risk taking: drivers licensed for longer considered themselves to be more skilful, both in relation to their peers and in relation to older drivers of the same sex, than did drivers licensed for shorter periods. Age contributed significantly to prediction of only one variable: among drivers aged 25 years or less, the driver's rating of his or her own driving skills in relation to those of drivers of the same sex but aged over 30 years tended to increase with the age of the respondent.

Table 3.4.7.2b summarises the relationships between variables related to optimism and the main predictors of age of licence acquisition. After allowing for the effects of sex, age and years driving experience, neither Factor 2 nor EDUC was significantly related to any of the optimism variables. Factor 3 was a significant predictor in three out of the four regression equations. The negative beta weights indicate that drivers who had low scores on Factor 3

rated themselves as taking significantly more risks than did drivers with higher scores on Factor 3. Among drivers aged 25 years or less, those with low scores on Factor 3 rated themselves as more skilful and taking more risks in comparison with drivers of the same sex but aged 30 years or more than did drivers with higher scores on Factor 3. Since high scores on Factor 3 were associated with early acquisition of a driver's licence, these findings suggest that, after allowing for the effects of sex, age and years driving experience, drivers who obtain a licence relatively early may be less "optimistic" about their driving than drivers who are licensed later in life.

TABLE 3.4.7.2a

SUMMARY OF REGRESSION RESULTS FOR VARIABLES RELATED TO OPTIMISM

Variable	Self-rating of ...	Significant predictors	R^2
SKIL	driving skill v same sex/same age	sex, yrslic	.04
RISK	risk taking v same sex/same age	sex	.02
YDSKIL	driving skill v same sex/over 30	yrslic, age	.08
YDRISK	risk taking v same sex/over 30	sex	.02

TABLE 3.4.7.2b

RELATIONSHIP OF OPTIMISM VARIABLES TO THE PREDICTORS OF AGE OF LICENCE ACQUISITION, AFTER ALLOWING FOR SEX, AGE AND YEARS DRIVING EXPERIENCE

For interpretation of the optimism variables, see Table 3.4.7.2a.
"n.s." = not significant.

Variable	Beta weights for significant predictors		
	Factor 2	Factor 3	EDUC
SKIL	n.s.	n.s.	n.s.
RISK	n.s.	-0.1256	n.s.
YDSKIL	n.s.	-0.0912	n.s.
YDRISK	n.s.	-0.0928	n.s.

3.4.7.3. RECKLESSNESS

The regression of Factor 1 ("recklessness") against sex, age and years driving experience is summarised in Table 3.4.7.3a. Both sex and age were found to contribute significantly to prediction of recklessness, with males and younger respondents having higher scores on this factor than females and older respondents. However, the proportion of variation in Factor 1 accounted for by sex and age was small.

TABLE 3.4.7.3a

SUMMARY OF REGRESSION RESULTS FOR RECKLESSNESS

Variable	Interpretation	Significant predictors	R^2
Factor 1	recklessness	sex, age	.05

Since an orthogonal rotation was employed in the principal components analysis by which the six "factors" were extracted from a large number of interview variables, the factors were necessarily uncorrelated with each other. After removing the effects of sex, age and years of experience by prior entry to the regression equation, Factors 2 and 3 were still found to make no significant contribution to prediction of Factor 1 ("recklessness"), and a similar result was obtained for EDUC, the other main predictor of age of licence acquisition. Thus there was no evidence of any differences in recklessness among drivers obtaining a licence at different ages, other than those differences attributable to differences in sex, age and years of driving experience.

3.4.7.4. PROPORTION OF DRIVING AT NIGHT

Previous research has shown that young drivers do more of their driving at night, when crash risk is known to be substantially higher than in the daytime, than do other drivers (Williams, 1985), and this is believed to contribute to the over-representation of young drivers in crashes. The increased risk of night-time driving has been confirmed locally by Drummond and Healy (1986). In view of its well-documented relationship to crash risk, the factors associated with night driving were explored further. Variable FMINNITE was created to represent the proportion of the respondent's driving time in the previous week which was done at night (defined as the period between 7 p.m. and 6 a.m.). This variable was defined as

$$FMINNITE = MINTOTN / (MINTOTD + MINTOTN)$$

where MINTOTN represents total night-time minutes of driving and MINTOTD represents total daytime minutes of driving in the previous week.

FMINNITE was found to have a distribution which could not be made approximately normal by means of any transformation, so the variable was dichotomised by splitting the distribution at its median. Respondents with a high proportion of night driving were then compared with those with a low proportion of night driving, to determine whether they differed on sex, age, years of driving experience, the "factors" which emerged from the principal components analysis or the variables which were excluded from the principal components analysis. Factor 4 was excluded from these comparisons, since it was already known to have its highest factor loading on TRAVELN, another variable indicating night time driving. Student's t tests were used for all continuous variables, and chi-square tests were used for discrete variables. The results of these tests are shown in Table 3.4.7a.

The univariate tests revealed that respondents with a high proportion of night-time driving differed significantly in a number of respects from those with a low proportion of driving at night. Table 3.4.7.4a shows that respondents with a high proportion of driving at night were significantly younger, had held a licence fewer years, were less settled (Factor 2) and less rural in lifestyle (Factor 3) than those with a low proportion of night-time driving. A tendency for drivers with a high proportion of night driving also to be relatively high on Factor 1 ("recklessness") did not reach statistical significance at the conventional 0.05 level. There were no reliable differences on perception of danger in driving (DANGER), value of the respondent's car (Factor 5) or the importance the respondent attached to cars and driving (Factor 6). Table 3.4.7.4a also shows that a high proportion of night-time driving was significantly more likely to be found among males, among respondents who believe driving is easier at night than in the daytime, among respondents who reported receiving one or more parking tickets in the past year, among respondents who had driven on a weekend in the past week and among respondents who participate in organised sport, compared with the

respective complementary groups. There were no reliable differences based on education level, total satisfaction, whether the respondent wore glasses, whether the respondent was a smoker or whether the respondent had undertaken a trip over 200 km in length during the past year.

TABLE 3.4.7.4a

COMPARISON OF RESPONDENTS WITH HIGH AND LOW PROPORTIONS OF NIGHT-TIME DRIVING: UNIVARIATE TESTS

Variable	High proportion of night driving associated with...	Test	Probability
AGE	lower age	t	.000***
YRSLIC	fewer years of experience	t	.000***
Factor 1	-	t	.097
Factor 2	less "settled down"	t	.000***
Factor 3	less "rural"	t	.002**
Factor 5	-	t	.390
Factor 6	-	t	.585
DANGER	-	t	.960
SEX	males	chi square	.007**
LONGTRP	-	chi square	.552
PARKTICK	one or more parking tickets in past year	chi square	.017*
TRAVELW	some weekend driving in past week	chi square	.000***
EDUC	-	chi square	.214
SMOKE	-	chi square	.923
TOTSAT	-	chi square	.664
EASYDAY	believe easier to drive at night	chi square	.001***
GLASSES	-	chi square	.659
SPORT	participate in organised sport	chi square	.000***

TABLE 3.4.7.4b

LOGISTIC REGRESSION EQUATION FOR PREDICTION OF PROPORTION OF NIGHT-TIME DRIVING

Entry order	Predictor	Coefficient	Probability
1	TRAVELW	1.4404	.000***
2	Factor 2	-0.4069	.000***
3	Factor 3	-0.2557	.000***
4	EASYDAY	0.2971	.011*
5	SPORT	0.2916	.012*
6	LONGTRP	0.2789	.038*

A logistic regression was performed to determine the joint influence of these predictors on proportion of night-time driving. Results of the logistic regression are shown in Table 3.4.7.4b. A high proportion of driving performed at night was found to be associated with

having driven on the weekend before the interview, with low values of Factor 2 ("settled down") and Factor 3 ("rural"), with a belief that driving is easier at night than in the daytime, with participation in organised sport and with having undertaken a trip of 200 km or more in the last year. This function correctly classified 63.2% of respondents into high and low night-time driving groups. LONGTRP (whether the respondent had undertaken a trip of 200 km or more within the past year) contributed significantly to the logistic regression equation despite not being significantly related to the proportion of night-time driving in the univariate test (Table 3.4.7.4a). LONGTRP was correlated with Factor 3 such that respondents who had undertaken a trip of 200 km or more in the past year tended to have high values for Factor 3 ("rural"), which were in turn associated with a lower proportion of night-time driving. This appears to have masked in the univariate test by the relationship between LONGTRP and proportion of night-time driving.

It is noteworthy that neither AGE nor YRSLIC (years of driving experience) appears in the logistic regression equation in Table 3.4.7.4b, although these variables were significantly associated with night driving in the univariate tests (Table 3.4.7.4a). The regression equation for proportion of night driving included two variables related to other aspects of the respondent's exposure patterns (TRAVELW and LONGTRP) and a variable which indicated the respondent's opinion of night driving (EASYDAY). It is not surprising that these variables were significantly related to FMINNITE, but the inclusion of these predictors in the equation may have obscured the relationship between night driving and the respondent's age and years of driving experience. TRAVELW, LONGTRP and EASYDAY were therefore dropped from predictor set and a new logistic regression was carried out. Table 3.4.7.4c shows that age and years of driving experience still did not contribute significantly to prediction of proportion of night driving. Both AGE and YRSLIC became non-significant predictors when Factor 2 ("settled down") entered the equation. This suggests that the association of both youth and inexperience with a high proportion of night-time driving is mediated by the association of all of these conditions with being less "settled down". The logistic regressions suggest that a high proportion of night-time driving is determined by a range of lifestyle factors for drivers of all ages and experience levels. The link between youthfulness and night driving appears to be a result of the prevalence of less settled lifestyles among younger (and less experienced) drivers.

TABLE 3.4.7.4c

LOGISTIC REGRESSION EQUATION FOR PREDICTION OF PROPORTION OF NIGHT-TIME DRIVING, AFTER DROPPING SOME PREDICTORS

Entry order	Predictor	Coefficient	Probability
1	Factor 2	-0.3923	.000***
2	Factor 3	-0.1765	.003**
3	SPORT	0.3039	.007**

To ensure that the relationship between night driving and Factors 2 and 3 did not result from confounding with other variables, a new regression was performed in which the effects of sex, age and number of years driving experience were removed by prior entry into the regression equation. Table 3.4.7.4d shows that after allowing for sex, age and years of driving experience, Factors 2 and 3 were still significant predictors, with low values on these factors being associated with a high proportion of driving at night. Low values of Factor 2 and Factor 3 were found in earlier analyses (Table 3.4.5a) to be associated with early acquisition

of a driver's licence. EDUC, the other main predictor of age of licence acquisition, did not contribute significantly to prediction of night driving. The association between a high proportion of night driving and low scores on Factors 2 and 3 suggests that the type of individual who obtains a licence relatively late in life is also likely to do a greater than average proportion of driving at night.

TABLE 3.4.7.4d

RELATIONSHIP OF PROPORTION OF NIGHT DRIVING TO THE PREDICTORS OF AGE OF LICENCE ACQUISITION, AFTER ALLOWING FOR SEX, AGE AND YEARS DRIVING EXPERIENCE

"n.s." = not significant.

Variable	Coefficients for significant predictors		
	Factor 2	Factor 3	EDUC
FMINNITE	-0.3543	-0.1820	n.s.

3.5. Confirmation using data from questionnaires administered at RBT stations

As noted earlier, the driver interview data analysed above were originally collected for an investigation of differences between young drivers on the roads in daytime and night-time. Further data available from this other study consisted of responses to questionnaires administered to a sample of drivers stopped at Random Breath Testing (RBT) stations in Melbourne and Adelaide. Because these questionnaires included a substantial sub-set of the items used in the home interview series, it was possible to assess the reliability of prediction equation for age of licence acquisition estimated from the home interview data by performing similar analyses on the RBT station questionnaire data.

3.5.1. Data collection

The questionnaires were administered by staff of Monash University Accident Research Centre during February 1993. Some 595 questionnaires were completed, comprising 501 completed at police RBT stations at 22 sites in Melbourne, 85 completed at police RBT stations at 6 sites in Adelaide and 9 cases where the city was not recorded. Variables from the RBT station questionnaire data which were utilised in the present investigation are outlined in Appendices 7, 8 and 9. A more complete description of the collection of the questionnaire data is contained in the report of the day-night exposure investigation (Crettenden *et al.*, 1994) also conducted for the Federal Office of Road Safety as part of the Young Driver Research Program, for which the data were originally collected.

3.5.2. Procedures and results

Since the purpose of the analysis was to confirm (or disconfirm) the findings from the home interview survey, the procedures applied to the RBT station questionnaire data duplicated as far as possible those which had been applied to the home interview data. The duplication was not complete, since some questions asked in the home interviews did not appear in the RBT station questionnaire. Items from the home interview survey which were not present on the questionnaire included all questions relating to the respondent's driving in the previous week.

It was necessary to exclude cases for which the city (Melbourne or Adelaide) was unknown, since the minimum legal licensing age differs between Victoria and South Australia. For comparability with the earlier analyses, drivers aged 30 years or more were also excluded from the analyses. After these exclusions, 371 cases remained for analysis.

3.5.2.1. FORMATION OF SUMMARY VARIABLES

Summary variables were formed using linear combinations of the same questionnaire variables as in the home interview data wherever possible. As before, each questionnaire variable was divided by its standard deviation before being included in the sum, and variables were multiplied by -1 where necessary for consistency within a summary variable. The summary variables and the questionnaire variables from which they were formed are listed in Appendix 7. As can be seen by comparing Appendix 7 with Appendix 2, two of the summary variables formed during the analysis of the home interview data (DANGER and SAFERATE) could not be duplicated in the analysis of the RBT station questionnaire data, since they were derived from questions which were included in the home interviews but not in the RBT station questionnaires. Of the remaining ten summary variables, three were formed by combining a smaller number of questionnaire variables than in the home interview data, due again to the absence of certain items from the RBT station questionnaires.

3.5.2.2. PRINCIPAL COMPONENTS ANALYSIS

As in the analysis of data obtained during home interviews, some variables were found to have grossly skewed or otherwise non-normal distributions. As before, these problems were corrected by means of transformations wherever possible. Where no suitable transformation was possible, variables were made dichotomous by splitting the distribution at the median. Variables dichotomised and transformed are shown in Appendix 8.

All variables which had been entered into the principal components analysis of the home interview data were entered into a principal components analysis of the RBT station data, with the exception of variables derived from questions which were omitted from the questionnaires administered at RBT stations. Once again, the driver's age and sex and the legal minimum licensing age in the state where the questionnaire was administered were omitted from the principal components analysis, since they were to be entered directly into the regression for age of licence acquisition. Variables included in the analysis are shown in Appendix 8.

Three very clear factors emerged from the analysis. Once again, variables which were not correlated above r=0.3 with any of the factors were dropped from the analysis, as were three variables (SMOKE, EDUCN, TOTSAT) which complicated the interpretation of the factors. Results of the principal components analysis are shown in Table 3.5.2.2a. The three factors extracted from the RBT station questionnaire data have been labelled Factor 1, Factor 2 and Factor 6, in recognition of their strong resemblance to the factors of the same names extracted from the home interview data. The three factors extracted accounted for 35.5% of the variation in the data.

TABLE 3.5.2.2a

RESULTS OF PRINCIPAL COMPONENTS ANALYSIS

Factor	% of variation accounted for	Interpretation
Factor 1	15.2	recklessness
Factor 2	11.5	settled down
Factor 6	8.7	importance of cars and driving

The three factors extracted from the RBT station questionnaire data bore a striking resemblance to three of the factors (Factors 1, 2 and 6) extracted from the home interview data. The seven variables on which Factor 1 had its highest loadings were all among the nine variables on which the corresponding factor in the home interview data had its highest loadings. The four variables on which Factor 2 had its highest loadings included the three highest loading variables for the corresponding factor from the home interviews. Finally, the four variables on which Factor 6 had its highest loadings were all among the five highest loading variables for the corresponding factor from the home interview data.

Nothing in the data from the RBT station questionnaires corresponded to Factors 3, 4 and 5 extracted from the home interview data. This was expected, since these factors had their highest loadings on variables derived from interview questions which were not included in the questionnaire administered at the RBT stations.

In summary, the principal components analysis of the data from questionnaires administered at RBT stations appeared to provide strong confirmation of three of the factors extracted from the home interview data. Because of differences between the content of the RBT station questionnaire and the doorknock interviews, it was not possible to evaluate the reliability of the remaining three factors.

3.5.2.3. REGRESSION EQUATION FOR AGE OF LICENCE ACQUISITION

As with the home interview data, multiple regression was used to predict age of licence acquisition from the factors extracted in the principal components analysis and the variables excluded from the principal components analysis, including legal minimum licensing age, age and sex. Details of all variables used in the regression are shown in Appendix 9. Age of licence acquisition was first transformed to correct skewness in its distribution. Unlike the home interview data, transformation was not necessary for age or for legal minimum licensing age. Results of the regression are shown in Table 3.5.2.3a

TABLE 3.5.2.3a

RESULTS OF MULTIPLE REGRESSION FOR AGE OF LICENCE ACQUISITION

Predictor	B	beta	correlation	probability
LEGALAGE	0.2009	0.3760	0.4155	0.0000
AGE	0.0322	0.4097	0.3519	0.0000
Factor 2	-0.0339	-0.1347	0.0451	0.0089
Factor 6	0.0336	0.1331	0.0524	0.0049
TOTSAT	0.0570	0.1131	0.1232	0.0140
SEX	0.0531	0.1053	0.0319	0.0243

The regression equation for age of licence acquisition estimated from the RBT station questionnaire data (Table 3.5.2.3a) was compared with the equation which had been estimated from the home interview data (Table 3.5.3a). Note that comparisons with the home interview data refer to the regression equation estimated without the use of variables relating to respondent's driving in the week preceding the interview, because these items were not included in the questionnaire administered at RBT stations. A high degree of similarity was observed between the regression equations from the two data sets. In both analyses, it was found that:

- Legal minimum licensing age was the first predictor to enter the regression equation and the second most important predictor (behind driver age) in the final equation, with drivers living in states with a relatively high minimum licensing age tending to acquire a licence later in life than drivers living in states with a lower minimum licensing age;
- Driver age was the second predictor to enter the regression equation and the most important predictor in the final equation, with older drivers having been licensed later on average than younger drivers;
- Sex was a significant predictor, with males being licensed on average earlier than females;
- Factor 2 ("settled down") was a suppressor variable - the zero order correlations indicated that more settled individuals tended to have been licensed later, but after removing the effect of age this relationship was reversed; and
- The product of age and Factor 2 did not significantly improve prediction after age and Factor 2 had already entered the equation, indicating that age and Factor 2 did not significantly interact in their relationship to age of licence acquisition.

In addition to these qualitative similarities, the beta weights (that is, the regression coefficients obtained when all variables are expressed in standard score form) shown in Table 3.5.2.3a for LEGALAGE, age, Factor 2 and sex are of very similar magnitude to the corresponding beta weights shown in Table 3.5.3a. Thus the role of the four most important predictors of age of licence acquisition in the home interview data (i.e. the four predictors in Table 3.5.3a with the largest beta weights) was found to have been both qualitatively and quantitatively confirmed by the analysis of the RBT station questionnaire data.

A number of differences between the regression equations for age of licence acquisition in the two data sets were also noted:

- The role of the fifth predictor in Table 3.5.3a, Factor 3 ("rural"), could not be confirmed because this factor was based on questions which were omitted from the RBT station questionnaire (all of the interviews were conducted at RBT stations in metropolitan areas - Melbourne and Adelaide - and it is therefore likely that most of the respondents were metropolitan residents);
- The sixth and final predictor in Table 3.5.3a, EDUC (highest educational level), did not make a significant contribution to prediction of age of licence acquisition in the RBT station questionnaire data; and
- Factor 6 ("importance of cars and driving") and TOTSAT (satisfaction level) also contributed significantly to prediction of age of licence acquisition in the RBT station questionnaire data, although they were not significant predictors in the home interview data.

3.5.3. Summary

The three factors extracted from the RBT station questionnaire data by means of principal components analysis provided striking confirmation of three of the factors extracted from the home interview data - namely Factor 1 ("recklessness"), Factor 2 ("settled down") and Factor 6 ("importance of cars and driving"). Confirmation (or disconfirmation) of the remaining three factors was not possible, due to the absence from the questionnaire administered at RBT stations of most of the questions on which these factors were based.

The four most important predictors of age of licence acquisition in the home interview data - namely, minimum licensing age in the driver's home state, driver's age, sex and Factor 2 ("settled down") - were confirmed both qualitatively and quantitatively by the analysis of the RBT station questionnaire data. Some discrepancies between the interview and questionnaire data were noted among the minor predictors. It was not possible to verify the relationship of age of licence acquisition with variables relating to the respondent's driving in the previous week, since these variables were absent from the RBT questionnaire data set.

3.6. Discussion of factors related to age of licence acquisition

Analyses of data from the home interviews and from questionnaires administered to drivers stopped at Random Breath Testing (RBT) stations showed that the age at which a driver acquires a licence is related to a number of the variables examined. What do these relationships reveal about the expected crash risk of the very youngest drivers? Do these relationships tend to increase the crash risk of the youngest drivers, thereby increasing the apparent effect of age on crash risk? Or do the safest drivers tend to acquire licences first, thereby increasing the apparent benefit of extra experience at any given age?

Not surprisingly, age of licence acquisition was found in both samples in the present investigation to be influenced by the minimum licensing age of the state in which the driver lived, with drivers acquiring a licence earlier in states with a lower minimum age. This means that the effect of driver age on crash risk may be greater in a jurisdiction such as New Zealand with a relatively low minimum licensing age (15 years) than in a jurisdiction such as Victoria with a relatively high licensing age (18 years).

DRIVER AGE

The older drivers in both samples were found to have acquired a driver's licence later in life (on average) than the younger drivers. It cannot be concluded that there has been a shift towards earlier licensing in recent years, however, since the apparent influence of age is at least in part an artefact of the sampling procedures used. Only licensed drivers were included in the sample. Thus young people who had not yet obtained a licence at the time of the survey but would have done so later in life were systematically excluded, whilst older people who obtained a licence relatively late were able to be included in the sample. This difficulty was unavoidable; including people who had not yet obtained a licence in the samples would not have helped, since it would not have been possible to know at what age (if ever) they would eventually obtain a licence. It is not clear whether there was any relationship between respondents' present age and the age at which they obtained a licence, beyond that which was due to this sampling problem.

MALE VERSUS FEMALE DIFFERENCES

Males were found to acquire a driver's licence earlier on average than females in both the home interviews and the RBT station questionnaires, confirming similar findings of Deutsch *et al.* (1981), Lund *et al.* (1987) and Forsyth (1992). Thus the proportion of males amongst the very youngest drivers is higher than in the driving population generally. It is not clear from previous research whether this would be expected to produce an increase in the rate of crash involvement per distance driven for the youngest drivers. The rate of involvement in *fatal* crashes seems to be considerably higher for young males than for young females (Williams, 1985; Hampson, 1989). However, conflicting findings have been reported for the risk of involvement in a crash of *any* severity: the rate of crash involvement per distance driven has been reported to be higher for young males by Toomath and White (1982), Chipman, MacGregor, Smiley and Lee-Gosselin (1992) and Stutts and Martell (1992); the rate has been reported higher for young females by Mercer (1988); and finally, rates for young males and females were reported to be about equal by Ferdun *et al.* (1967) and Drummond and Healy (1986). Without knowing the influences responsible for the differences between these findings, the only available course appears to be to tentatively accept the majority finding - that crash rates per distance driven appear to be higher for young males than for young females. Consistent with this tentative conclusion, males were found in the present study to report a variety of characteristics and behaviours which would be expected to increase crash risk, including higher frequency of speeding than females, greater optimism about their driving, higher levels of recklessness (Factor 1) and a higher proportion of driving at night-time. Thus the tendency for males to acquire a licence younger than females may produce some elevation in crash rates for the very youngest drivers, but only in investigations such as those of Toomath and White (1982) and Levy (1990) which analysed a combined data set for male and female drivers. The majority of investigations of the relative importance of age-related and experience-related factors have conducted separate analyses for the two sexes or have reported analyses for males only (*see* Section 2 above).

SETTLED LIFESTYLE

In both the home interviews and the RBT station questionnaires, Factor 2 ("settled down") was found to be correlated with the age at which a respondent obtained a driver's licence, with more settled individuals having been licensed later on average. However, this was found to be a consequence of the correlation of Factor 2 with age, and the relationship was reversed when the effect of age was removed: for drivers of a given age, those who indicated that they were more "settled down" (had a partner, children and a mortgage) tended to have been licensed earlier than drivers who were less settled. The effect of Factor 2 appeared to apply to the entire age range sampled (16-29 years), since the interaction of Factor 2 and age was found not to be significant in either the interview data or the questionnaire data.

Factor 2, measuring the extent to which respondents had "settled down" at the time of the interview or questionnaire, may also provide an indication of the age at which respondents began to "settle down", since for drivers of a given age, those who were more settled at the time of the interview or questionnaire would usually have been those who earliest began to settle down. Thus the association between Factor 2 and age of licensing may represent a general maturity effect: those who began to drive earliest were also the earliest to accept the responsibilities often associated with mature adulthood. As a consequence of their general maturity and/or their family responsibilities, individuals with high scores on Factor 2 may also be among the first to adopt mature, low-risk exposure patterns and a mature, low risk

driving style. They may therefore be comparatively low risk drivers. Little evidence concerning this hypothesis is available from past studies. Lack of maturity and lack of responsibility were reported by McGuire (1976, cited by Drummond, 1989) to be associated with crash involvement, but that study appears not to have controlled for driver age. The suggested association between a mature, "settled" lifestyle and a mature, low-risk driving style would, if valid, link early acquisition of a driver's licence with comparatively safe exposure patterns and driving style.

Alternatively, it may be that Factor 2 is linked to socio-economic status (SES), with individuals who marry, have children and take on a mortgage while comparatively young perhaps having lower SES than individuals who postpone these responsibilities until they are somewhat older. The likely effect on crash risk of such a relationship between Factor 2 and SES is not clear from previous research, which has yielded conflicting results on this question. Harrington (1972), for example, reported that a worse crash record was positively correlated with attributes such as being unemployed, lower educational achievement, lower occupational goals and lower social status relative to that of parents. On the other hand, Rolls and Ingham (1992) reported that members of a "safe" group of young male drivers were less likely to have stayed at school beyond age 16 years and more likely to have manual occupations than a comparison group of "unsafe" drivers.

Examination of the relationship between Factor 2 and driver behaviours and characteristics believed to be associated with crash risk revealed that, after allowing for the effects of sex, age and years of driving experience, respondents with low scores on Factor 2 reported speeding in built up areas significantly more often and did a greater proportion of their driving at night than did respondents with higher scores on Factor 2. Thus the evidence from the present study favoured the proposition that low scores on Factor 2 are associated with elevated risk of crash. Whether this is due to the effects of general maturity, socio-economic status or some other unidentified influence is not known.

OTHER FACTORS

Analysis of data from the home interviews revealed that drivers who scored high on Factor 3 ("rural") tended to acquire a licence relatively early. This relationship could not be confirmed by examination of the RBT station questionnaire data, because the most important questions making up Factor 3 did not appear in the questionnaire. A high score on this factor was largely determined by living outside state capital cities, paying rent or board and not speaking any language other than English in the home. The relationship between crash involvement rate and paying rent or board or speaking a language other than English is unknown. However, rural driving provides far fewer opportunities than urban driving for collisions with other road users, and rates of crash involvement per distance driven are lower outside the state capitals. For example, in New South Wales in 1991 56% of all vehicular travel occurred in the Sydney Statistical Division (Australian Bureau of Statistics, 1992) but 67% of reported crashes occurred in the same area (NSW Roads and Traffic Authority, 1992). Similarly, in South Australia in 1991 the Adelaide Statistical Division accounted for 67% of vehicular travel (Australian Bureau of Statistics, 1992) but 82% of reported crashes (SA Office of Road Safety, 1992). Drivers living outside the state capitals would naturally be expected to do a higher proportion of their driving outside the capitals and therefore to have lower crash rates per distance driven than drivers living in the capital cities. Thus the available information suggests that drivers scoring high on Factor 3 may have lower crash involvement rates than other drivers. Consistent with this proposition, lower scores on Factor 3 were found in the

present study, after controlling for sex, age and years of driving experience, to be significantly associated with a higher frequency of speeding, a greater degree of optimism about driving and a higher proportion of driving at night. All of these characteristics and behaviours would be expected to contribute to increased crash risk.

In the home interview data, the final significant predictor of age of licence acquisition was educational level. Respondents with post-secondary education (tertiary, technical or trade) were found to have acquired a licence significantly earlier, after allowing for the effects of the other predictors, than respondents with only secondary education. As already mentioned, the relationship between educational level and crash record is not clear from previous research, with for example Harrington (1972) finding that greater educational achievement was associated with fewer crashes and Rolls and Ingham (1992) reaching the opposite conclusion. Evidence from the present study was also equivocal. Educational level was found not to be significantly related to optimism, recklessness or proportion of driving at night. Post-secondary education was significantly associated with a faster self-reported driving style, but with lower values of the speed summary variable. Thus it was not clear what, if any, effect post-secondary education may have on crash risk. In any case, educational level had the smallest beta weight of the significant predictors of age of licence acquisition, and was therefore the least important in determining the linkage between age of licence acquisition and crash risk. Furthermore, the relationship found in the home interview data between education and age of licence acquisition was not confirmed by analysis of the RBT station questionnaire data, where education was found not to contribute significantly to prediction of age of licence acquisition.

The evidence of an association between employment and early licence acquisition was also unreliable. When using stepwise multiple regression, it is desirable to confirm regression results using an independent sample, due to the tendency for results to be influenced by chance relationships in the data. The home interview sample was therefore divided into two sub-samples. Analysis of the first sub-sample (80% of the cases) suggested that respondents who had driven a higher proportion of their kilometres in the last week for work purposes (including commuting to and from work) had been licensed earlier than respondents whose driving was less often related to work. However, analysis of the second sub-sample (the remaining 20% of cases) failed to confirm this finding. When the two sub-samples were combined and the analysis repeated, early licence acquisition again appeared to be associated with high proportions of driving for work purposes, but no further data were available to confirm this relationship. Verification using the RBT station questionnaire data was not possible, since questions about driving during the previous week were not included in the questionnaire. Thus the present study provides some evidence that both employment and post-secondary education are associated with early acquisition of a driver's licence. Each of these findings is subject to a degree of doubt, and it would be desirable to confirm them in a future investigation. If valid, however, these findings lead to the speculation that those who delay acquiring a driver's licence tend to be those with little involvement in either education or employment. This might arise partly from a lesser need for transport and partly from the financial difficulty of purchasing a car when unemployed or under-employed.

High levels of interest in cars and driving, indicated by time spent working on cars, talking about cars or driving for fun, have been reported to be associated with elevated crash risk (again on a per driver basis) among young drivers (Harrington, 1972; Goldstein, 1972; Rolls and Ingham, 1992). In the present study, the level of importance the respondent attached to

cars and driving was represented by Factor 6 emerging from the principal components analysis. Unfortunately, the home interviews and the RBT station questionnaires yielded conflicting results for Factor 6. The home interview data showed a significant correlation between Factor 6 and age of licence acquisition, with respondents more interested in cars and driving having acquired a licence earlier. However, Factor 6 was also correlated with sex, males having more interest in cars than females. After allowing for the effect of sex and the other significant predictors, Factor 6 was found to be virtually unrelated to age of licence acquisition. In the RBT station questionnaire data, however, Factor 6 was more strongly related to age of licence acquisition than was sex and the effect of Factor 6 remained significant after allowing for the effects of the other significant predictors. Drivers who attached high levels of importance to cars and driving tended to be later than average to acquire a licence, suggesting that the earliest licensed drivers may be less crash involved than those licensed later. However, in view of the conflict between the results from the interview data and the questionnaire data, this result cannot be regarded as reliable, and confirmation in a future investigation would be desirable.

Both Harrington (1972) and Rolls and Ingham (1992) found that high crash risk on a per driver basis was associated with high levels of recklessness among young drivers, and it seems likely that this association would persist even after taking exposure into account. Thus the relationship of licensing age to Factor 1 ("recklessness") would be expected to give some indication of the relationship of licensing age to crash risk. In the present study, Factor 1 ("recklessness") and age of licence acquisition were found to be correlated in both the home interviews and the RBT station questionnaire responses, with more reckless individuals acquiring a licence on average earlier than less reckless individuals. However, Factor 1 was significantly related to both driver age and sex, with males reporting higher levels of recklessness than females and younger drivers reporting greater recklessness than older drivers. After taking into account the effects of age and sex, the relationship between recklessness and age of licence acquisition all but disappeared, and was no longer statistically significant in either the interview data or the questionnaire data.

SUMMARY

In summary, several driver characteristics were found to contribute to prediction of the age at which a driver first acquired a licence. For reasons discussed above, the effects of three of these (the statutory minimum licensing age in the state in which the driver lived; the driver's age; and the driver's sex) were not relevant to interpretation of the findings of earlier studies comparing the influence of age and driving experience on crash risk. However, consideration of the remaining predictors of age of licence acquisition suggests that the first drivers to acquire a driver's licence after reaching the minimum licensable age may have lower crash risk than other young drivers.

- Early licensing was found to be associated with being more "settled down", and therefore probably with earlier commencement of the settling down process. After controlling for sex, age and years of driving experience, more settled individuals were found to speed less often in built up areas and to do a lower proportion of their driving at night.

- In the home interview data, the earlier-licensed drivers were more likely than their later licensed peers to live in rural areas, where crash rates per distance driven are lower than in the capital cities. Respondents with lower scores on Factor 3 were also found to speed

less frequently, to be less optimistic about their driving and to do a greater proportion of their driving at night.

- In the RBT station questionnaire data but not in the home interview data, the earlier-licensed drivers tended to attach less importance to cars and driving than their later-licensed peers. This characteristic too is expected on the basis of previous research to be associated with lower crash risk.

While none of these indications was conclusive in its own right, they were all consistent in suggesting that drivers licensed comparatively early in life may be those with lower crash risk for reasons other than their greater driving experience. As against the accumulated evidence for this proposition, Factor 1 ("recklessness"), which would be expected on the basis of past research to be correlated with crash risk, varied as expected with sex and age but did vary systematically with age of licence acquisition in either the home interview responses or the questionnaire responses.

If, as most of the evidence seems to suggest, drivers who acquire a licence relatively early tend to be those with comparatively low risk of crash relative to other drivers of the same age and sex, then comparisons among drivers of different ages with the same level of experience will tend to under-estimate the effect of age on crash risk, since the youngest drivers at a given experience level (i.e. those licensed earliest) will be those who tend to be comparatively safe for reasons other than age or experience. Likewise, comparisons among drivers of the same age with different levels of experience will tend to over-estimate the benefit of increasing experience, since those with the greatest experience (i.e. those who were licensed earliest) will again be those who tend to be comparatively safe for reasons other than age or experience. Thus the present findings suggest that past investigations comparing the importance of age and experience in determining the crash risk of young drivers may have erred by attaching too little importance to the effect of driver age and too much importance to the effect of driving experience. However, this conclusion is contingent upon a number of assumptions regarding the relationship between crash risk and the factors related to age of licence acquisition. The investigation of factors associated with crash involvement reported in the next section sets out to test these assumptions.

4. INVESTIGATION OF CRASH INVOLVEMENT

4.1. The telephone interviews

Using information from the home interview survey, a number of driver characteristics were identified as being associated with early acquisition of a driver's licence. In order to determine the relationship between these factors and crash risk, it was desirable to obtain crash involvement data from a sub-set of the drivers from whom the socio-economic, personality, attitude and exposure data had been obtained in the home interviews. Since few questions were to be asked, the most cost-effective means of collecting this information was by telephone.

During October 1993, a second interview was conducted by telephone with a sub-set of the drivers who had been interviewed face-to-face during the earlier home interview survey, in order to gather data on the crash histories of the drivers concerned. The interview questions are shown in Appendix 10. Telephone interviews were conducted by the same market research company which had conducted the home interview survey. Some 800 interviews were obtained. Crash data from the telephone interviews were combined with the travel and personal characteristics collected in the home interview survey to form a single data set for joint analysis.

4.2. Sampling procedures

The market research contractor was commissioned to obtain 800 interviews. Since some respondents to the earlier home interview survey were expected to have moved or be uncontactable or unwilling to participate in the telephone survey, it was necessary for the size of the initial sample to be considerably larger. A sample of 1560 case numbers from the home interviews (92% of all respondents to the home interview survey in the age range 16 to 29 years) was supplied to the market research contractor. The sample was stratified in order to neither over- nor under-represent (relative to the home interview survey) respondents for whom valid, non-missing data relating to driving in the last week were available from the home interviews. Metropolitan and country respondents in all six states were included in the sample.

The contractor first attempted to contact 800 drivers selected randomly from the sample supplied. If no phone number had been recorded for a person during the home interview survey; if the interviewer was informed that the required person had moved and was uncontactable; if the required person was contacted but refused to take part in the survey; or if the response to the phone call was unintelligible, then the case was abandoned and another substituted. If the phone was engaged or was not answered or the required person was out or unavailable to come to the phone, a further attempt to contact the required person was made on a later day. If after 3 phone calls the required person had still not been interviewed, that case was abandoned and another substituted. Calls ceased when the target of 800 interviews had been achieved, at which time approximately 98.5% of the supplied sample of case numbers had been exhausted. Results of all telephone calls are shown in Table 4.2a. The table shows that 250 persons in the sample were not telephoned. Of these, approximately 20 persons were not required because the quota of 800 interviews had been met, and the remaining 230 could not be telephoned because no phone number was recorded for them during the home interviews. The market research contractor succeeded in obtaining interviews from approximately 52% of persons whom they attempted to contact (including

those for whom it was found that no phone number was available) or 61% of those for whom phone numbers were available and one or more calls were made.

TABLE 4.2a

RESULTS OF ALL TELEPHONE CALLS

Result	Call 1	Call 2	Call 3	Overall
Interview obtained	396	203	201	800
Refused to be interviewed	2	3	1	6
Moved - unable to contact	161	44	16	221
Unintelligible response	16	5	1	22
No answer	327	227	145	145
Engaged	84	45	27	27
Unavailable	324	208	89	89
Total persons called	1310	735	480	1310
Persons not called				250
Total sample size				1560

4.3. Tests for bias due to losses from the sample

There were two sources of potential bias in the telephone interview data which must be considered. Firstly, approximately 15% of cases in the sample could not be contacted because no phone number was recorded for that respondent during the original face-to-face interview in the home interview survey in December 1992. The reasons for telephone numbers not being recorded are not known, but presumably include respondents not having a telephone in the house. Telephone numbers were unavailable in approximately 230 cases. Secondly, of respondents to whom telephone calls were made, 504 out of 1310 (38%) could not be contacted, most often because they had moved or were never home when the interviewers rang. As can be seen from Table 4.2a, only six persons who were contacted by telephone refused to be interviewed about their crash history, so refusals were not a major source of bias.

Losses from the sample may have been related to the age or driving habits or other relevant characteristics of the drivers concerned, threatening the validity of analyses carried out. For example, drivers who drive a lot in the evenings might be under-represented among those interviewed by telephone because they would be more likely to be out when the interviewer telephoned. In order to check for the presence of such bias, drivers interviewed were compared with drivers in the sample who were not interviewed. Chi square tests were used to test for differences between interviewed and not-interviewed drivers on sex; whether they had driven at night in the week before the home interview; and whether they had driven during the last weekend before the home interview. Student's t tests were used to test for differences on age; years of driving experience; age of licence acquisition; and the six factors which emerged from the principal components analysis of the home interview data. The results of all tests are shown in Table 4.3a.

It can be seen from Table 4.3a that drivers who were interviewed by telephone were found to have significantly lower scores on Factor 3 ("rural") than drivers who were not interviewed by

telephone. There were also non-significant tendencies for drivers who were interviewed by telephone to be younger; to have acquired a licence when younger; to be lower on Factor 6 ("importance attached to cars and driving"); and, surprisingly, to be more likely to have driven at night in the week before the home interview than those who were not interviewed by telephone. Since none of these tendencies was statistically significant, they may well have arisen by chance.

The association between having been interviewed and low scores on Factor 3 was investigated further by examining the three variables which had the highest loadings on Factor 3 in the principal components analysis of the home interview data. Chi square tests were used to test for differences between interviewed and not-interviewed drivers from the sample of case numbers supplied to the market research contractor. The results of these tests are shown in Table 4.3b. The table shows that drivers who were interviewed were significantly more likely than not-interviewed drivers to live in a state capital city and significantly less likely to be paying rent or board. There was no significant difference on whether the respondent spoke a language other than English at home.

TABLE 4.3a

COMPARISON OF RESPONDENTS WHO WERE OR WERE NOT INTERVIEWED

Variable	Having been interviewed was associated with...	Test	Probability
AGE	-	t	.067
YRSLIC	-	t	.223
AGELIC	-	t	.081
Factor 1	-	t	.182
Factor 2	-	t	.446
Factor 3	less "rural"	t	.000***
Factor 4	-	t	.642
Factor 5	-	t	.110
Factor 6	-	t	.056
SEX	-	chi square	.169
TRAVELN	-	chi square	.051
TRAVELW	-	chi square	.571

TABLE 4.3b

FURTHER COMPARISON OF RESPONDENTS WHO WERE OR WERE NOT INTERVIEWED: CHI-SQUARE TESTS

Variable	Having been interviewed was associated with...	Probability
METRU	living in a capital city	.033*
RENT	not paying rent/board	.000***
LANG	-	.964

Separate analyses were then conducted for drivers living in state capitals and in country areas, and RENT was still found to be associated with being interviewed: in both metropolitan and

country areas, respondents not paying rent or board were significantly more likely to have been interviewed. However, when separate analyses were conducted for respondents who were and were not paying rent or board, neither METRU nor any variable listed in Table 4.3a was significantly associated with whether the driver was interviewed. It was therefore concluded that the major predictor of whether the market research contractor succeeded in interviewing a driver in the sample was whether or not the driver was paying rent or board. The significant associations of METRU and Factor 3 with being interviewed (shown in Tables 4.3a and 4.3b) therefore appear to be explainable in terms of the correlation between these variables and RENT.

Several interpretations of the apparent bias against the telephone interviewing of drivers who were paying rent or board are possible. One possibility is that people living in rented accommodation may be less likely than other people to have a telephone in the house. In order to test this hypothesis, drivers to whom telephone calls were made were compared with drivers who were not telephoned. This comparison is shown in Table 4.3c. Unfortunately, it was not possible to separate drivers for whom no telephone number was recorded (approximately 90 per cent of drivers not telephoned) from drivers who did not need to be contacted after the interview quota of 800 had been reached, since this information was not supplied by the contractor. The table shows that drivers paying rent or board were less likely than other drivers to be telephoned by the market research contractor. This difference, which was statistically significant (chi square=16.148, d.f.=1, $p<0.001$), is consistent with the hypothesis that drivers in rented accommodation are less likely to have a telephone in the house. However, other factors are clearly also at work, since Table 4.3d shows that even among drivers to whom telephone calls were made by the contractor, the proportion of drivers who provided a telephone interview was substantially lower among drivers who pay rent or board than among other drivers. This difference too was statistically significant (chi square=48.072, d.f.=1, $p<0.001$).

A possible explanation for the lower proportion of interviews obtained among drivers paying rent or board, as shown in Table 4.3d, is that people living in rented accommodation may have been more likely to move house or change telephone numbers during the ten month period between the home interviews and the telephone interviews. It is also possible that people living in rented accommodation may less often be home to answer the telephone. To test these two hypotheses, the final result of the three calls was compared for drivers who were and were not paying rent or board. If on any call an interview was obtained, that was the final result for that driver, and no further calls were made. Similarly, if any call resulted in a refusal, an unintelligible response or information that the driver had moved and could not be contacted, then that was the final result for that driver and no further calls were made. In all other cases, the final result was the result of the final (i.e. third) call. Table 4.3e compares drivers who were found to have moved and be uncontactable with all other drivers. It can be seen that the proportion who had moved was higher among drivers paying rent or board than among other drivers; this difference was statistically significant (chi square=17.971, d.f.=1, $p<0.001$). Table 4.3f compares drivers who were out when the final call was made (either the call was not answered at all or it was answered by a person who said that driver in question was not home) with all other drivers. The table shows that the proportion of drivers who were out was significantly higher among drivers paying rent or board than among other drivers (chi square=12.360, d.f.=1, $p<0.001$).

TABLE 4.3c

COMPARISON OF DRIVERS IN THE SAMPLE
WHO WERE OR WERE NOT TELEPHONED
(Row percentages in parentheses)

Paying rent/board	Telephoned		Not telephoned		Total	
Yes	738	(80.8)	175	(19.2)	913	(100.0)
No	572	(88.4)	75	(11.6)	647	(100.0)
Total	1310	(84.0)	250	(16.0)	1560	(100.0)

TABLE 4.3d

COMPARISON OF DRIVERS TELEPHONED
WHO DID OR DID NOT PROVIDE AN INTERVIEW
(Row percentages in parentheses)

Paying rent/board	Interviewed		Not interviewed		Total	
Yes	390	(52.8)	348	(47.2)	738	(100.0)
No	410	(71.7)	162	(28.3)	572	(100.0)
Total	800	(61.1)	510	(38.9)	1310	(100.0)

TABLE 4.3e

COMPARISON OF DRIVERS WHO HAD MOVED AND COULD NOT BE
CONTACTED WITH ALL OTHER DRIVERS TELEPHONED
(Row percentages in parentheses)

Paying rent/board	Final result of telephone calls					
	Moved		All others		Total	
Yes	153	(20.7)	585	(79.3)	738	(100.0)
No	68	(11.9)	504	(88.1)	572	(100.0)
Total	221	(16.9)	1089	(83.1)	1310	(100.0)

TABLE 4.3f

COMPARISON OF DRIVERS WHO WERE OUT
WITH ALL OTHER DRIVERS TELEPHONED
(Row percentages in parentheses)

Paying rent/board	Final result of telephone calls					
	No answer/not home		All others		Total	
Yes	156	(21.1)	582	(78.9)	738	(100.0)
No	78	(13.6)	494	(86.4)	572	(100.0)
Total	234	(17.9)	1076	(82.1)	1310	(100.0)

In summary, drivers from whom telephone interviews were obtained were found to form a biased sub-set of the drivers in the sample of case numbers supplied to the market research

contractor. They were significantly more likely to live in a state capital city and had significantly higher values for Factor 3 than drivers from whom interviews were not obtained. Further investigation revealed that drivers paying rent or board were significantly less likely than other drivers to have been interviewed, and that differences in location (metro/rural) and Factor 3 appeared to be consequences of the association of these variables with paying rent or board. It appears that drivers paying rent or board were less often home when the interviewers telephoned and more likely to have moved house without leaving a forwarding number than other drivers. The available information was also consistent with the possibility that drivers living in rented accommodation less often have a telephone in the house, although other interpretations of the data cannot be ruled out. When interpreting the information obtained during the telephone interviews, it will be necessary to make allowance for the under-representation of drivers paying rent or board among those interviewed.

4.4. Driver characteristics associated with crash involvement

Out of 800 respondents who were re-interviewed by telephone, one reported three crashes in the previous three years, 12 reported two crashes and 181 reported one crash; thus 194 respondents (or 24% of those interviewed by telephone) reported one or more crashes in the previous three years, and the remaining 606 respondents reported no crashes. A variety of statistical tests were carried out to determine whether any personal characteristics, attitudes or lifestyle factors of the drivers were associated with an elevated probability of reporting a crash. Driver-related factors may affect crash risk by affecting the quantity of the driver's on-road exposure (distance driven or time spent driving); by affecting the riskiness of the conditions under which the exposure occurs (e.g. day versus night, urban versus rural); or by affecting the riskiness of the driver's behaviour while exposed (e.g. speed choice and gap acceptance). All three types of effect contribute to differences in reported crashes per driver per annum. In order to distinguish effects of quantity of exposure from effects of driving conditions and driving behaviour, crash involvement data were analysed twice: once taking account of differences in quantity of exposure, and once without taking account of exposure.

4.4.1 No control for exposure

In Table 4.4.1a, respondents reporting one or more crashes in the previous three years are compared on a number of variables with respondents not reporting crashes, without taking account of differences in exposure. Student's t tests were used for continuous variables, and chi square tests for categorical variables. The table shows that drivers who reported one or more crashes in the last three years were significantly younger and had held a licence for significantly fewer years than drivers who reported no crashes. The greater crash involvement of the younger, less experienced drivers is particularly noteworthy, since many of the youngest drivers had been licensed for less than three years, and therefore had reduced opportunity to be involved in a crash compared with older, more experienced drivers. It was suggested in Section 3.4.7 that drivers with high scores on Factor 1 ("recklessness") would have greater crash risk than other drivers, and Table 4.4.1a shows that this expectation was confirmed by the information obtained from the telephone interviews. The table shows that respondents reporting crashes were also significantly lower on Factor 2 ("settled down"), higher on Factor 4 ("variety of exposure") and more likely to be male than respondents reporting no crashes. No significant differences were found on age of licence acquisition, Factor 3 ("rural"), Factor 5 ("financial value of car"), Factor 6 ("importance of cars and driving") and EDUC (highest educational level achieved).

TABLE 4.4.1a

RESPONDENTS REPORTING ONE OR MORE CRASHES VERSUS RESPONDENTS REPORTING NO CRASHES

Variable	Reported crashes associated with...	Test	Probability
AGE	younger drivers	t	.005**
YRSLIC	fewer years driving experience	t	.008**
AGELIC	-	t	.708
Factor 1	more "reckless"	t	.002**
Factor 2	less "settled down"	t	.008**
Factor 3	-	t	.564
Factor 4	greater "variety of exposure"	t	.005**
Factor 5	-	t	.103
Factor 6	-	t	.555
SEX	males	chi square	.002**
EDUC	-	chi square	.630

TABLE 4.4.1b

LOGISTIC REGRESSION EQUATION FOR PREDICTION OF SELF-REPORTED CRASHES

Entry order	Predictor	Coefficient	Probability
1	Factor 1	-0.2259	.010
2	Factor 4	-0.2772	.004
3	YRSLIC	0.3746	.005
4	SEX	0.8699	.037

A number of the variables shown in Table 4.4.1a to be associated with self reported crashes were known to be correlated with each other (for example, AGE and YRSLIC, SEX and Factor 1). To determine the major independent contributions to prediction of crash involvement, a logistic regression was performed, using as predictors the variables listed in Table 4.4.1a. The results of the logistic regression are shown in Table 4.4.1b. The highest probability of crash involvement was found to be associated with high recklessness (Factor 1), a wide variety of driving exposure in the previous week (Factor 4), few years of driving experience and being male. Age and Factor 2 ("settled down"), which were significantly associated with crash involvement in the univariate tests, no longer contributed significantly to multivariate prediction of crash involvement after YRSLIC (number of years driving experience) had entered the equation. The significant results for these variables in the univariate tests appear to have resulted from their correlation with YRSLIC. Despite significant contributions to the regression from four variables, the estimated probability of a crash being reported did not exceed 0.5 for any respondent, so all respondents with crashes were mis-classified by the regression function.

Only 13 drivers reported more than one crash in the last three years, 12 reporting two crashes and one reporting three crashes. The results of univariate comparisons between drivers

reporting two or three crashes and those reporting one crash are shown in Table 4.4.1c; no significant differences were found. Drivers reporting more than one crash had, on average, been licensed slightly younger than those with exactly one crash, but this difference did not reach significance (p=0.064). When logistic regression was used to compare drivers reporting more than one crash with those reporting exactly one crash, no variables significantly contributed to prediction of crash involvement. The lack of significant results is not surprising, in view of the very small number of respondents reporting more than one crash in the last three years.

TABLE 4.4.1c

RESPONDENTS REPORTING ONE CRASH VERSUS RESPONDENTS REPORTING MORE THAN ONE CRASH

Variable	Reported crashes associated with...	Test	Probability
AGE	-	t	.417
YRSLIC	-	t	.917
AGELIC	-	t	.064
Factor 1	-	t	.650
Factor 2	-	t	.599
Factor 3	-	t	.339
Factor 4	-	t	.195
Factor 5	-	t	.251
Factor 6	-	t	.724
SEX	-	chi square	.218
EDUC	-	chi square	.450

TABLE 4.4.1d

ADDITIONAL COMPARISONS BETWEEN RESPONDENTS REPORTING ONE OR MORE CRASHES AND RESPONDENTS REPORTING NO CRASHES

Variable	Reported crashes associated with...	Test	Probability
SPEED	faster driving preference	t	.001**
SKIL	-	t	.401
RISK	riskier driving style	t	.000***
RENT	-	chi square	.944
TRAVFLAG	-	chi square	.241
TRAVELN	night driving	chi square	.019*
TRAVELW	-	chi square	.286

On the basis of various analyses of the home interview data and other considerations, it was argued in Section 3.6 that the type of individual who acquires a driver's licence relatively early in life may also be the type of individual who, for reasons independent of age and driving experience, tends also to be a relatively safe driver. This hypothesis was tested against the crash data obtained in the telephone interviews by performing a logistic regression to predict whether a respondent reported a crash in the previous three years. The confounding

effects of sex, age and years driving experience were removed by first entering these three variables into the equation. The probability that each of the main predictors of age of licence acquisition (Factor 2, Factor 3 and EDUC) could contribute to prediction of reported crashes was then examined. None of these three predictors was found to have a significant effect, and indeed none approached statistical significance ($p>0.3$ for all three variables).

In addition to an association between crashes and high scores on Factor 1 ("recklessness"), it was suggested in Section 3.4.7 that drivers with a preference for fast driving, drivers who were optimistic about their driving and those who do a high proportion of their driving at night would also have greater crash risk than other drivers. The results of tests of these and several other hypotheses are shown in Table 4.4.1d. The table shows that the expectations for speed and night driving were confirmed. Drivers who reported crashes were found to be significantly higher on SPEED (the summary variable formed from a number of speed-related items from the home interviews) and were significantly more likely to have driven at night during the week preceding the home interview than drivers reporting no crashes. However, results for optimism were less clear: drivers who reported crashes had significantly higher values for RISK (self-rated riskiness of driving style) than drivers who did not report crashes, but there was no significant difference on SKIL (self-rated driving skill, compared with other drivers of the same age and sex).

It was found in Section 4.3 that the sample of drivers who were interviewed by telephone was significantly biased against inclusion of drivers who reported in the home interview survey that they were paying rent or board. Apparent reasons for this bias included drivers in the sample being out when the interviewers phoned and having moved to other accommodation during the period between the face-to-face home interviews and the telephone interviews. Significant differences between interviewed and not-interviewed drivers on two other variables (Factor 3 and METRU) appeared to be a consequence of their correlation with RENT. It can be seen from Table 4.4.1d that there was no significant difference on the RENT variable between drivers who did and did not report crashes in the telephone interviews. On the assumption that this lack of association would also be true among drivers who were not interviewed by telephone, it therefore appears likely that the bias against inclusion in the telephone interviews of drivers paying rent or board would have had little impact on the relationship between crash involvement and the other variables examined.

Table 4.4.1d also shows that respondents who reported crashes and respondents who did not report crashes did not differ significantly on TRAVFLAG (whether valid, non-missing data on the respondent's driving in the previous week were available from the home interview survey). This result was critical for the validity of the analyses reported in the next section.

4.4.2 Controlling for exposure

Whereas high levels of on-road driving exposure would be expected to result in high crash frequencies on a "per driver" basis, a risky style of driving (such as might be associated with youthful impetuosity or lack of driving experience) would be expected to result in a high crash rate per unit exposure. However, it was not meaningful to calculate crash rates per unit exposure for respondents in the telephone interviews, since most respondents reported no crashes. To detect differences in crash risk per unit exposure, it was therefore necessary first to remove the effect of exposure before comparing drivers who reported crashes with those who did not. Respondents could only be included in these analyses if they had driven in the previous week and had no invalid or inconsistent values among the variables relating to

driving in the previous week. The non-significant result for TRAVFLAG in Table 4.4.1d shows that this restriction did not significantly affect the proportion of respondents who reported crashes in the previous three years.

All measures of day and night on-road exposure during the previous week were entered into a logistic regression to determine which exposure measure best predicted whether a driver reported having been involved in a crash. The association between crash involvement and each exposure measure, before any variable had entered the regression equation, is shown in Table 4.4.2a. Definitions of the predictors used may be found in Appendices 2 and 6. All exposure variables except TRAVELW (the flag indicating whether the respondent had driven at all on the weekend preceding the home interview) were significantly related to reported crashes, with greater exposure being associated with an increased probability of reporting a crash. The table shows that MINTOT (the respondent's total minutes of driving time in the previous week) was more closely associated with reported crashes than was any other exposure variable. The finding that crashes are more closely linked to driving time than to distance driven suggests that crash rates may be lower in circumstances which permit higher speeds (e.g. rural driving and freeways) than in circumstances which require lower speeds (e.g. urban driving and lower standard roads). This is consistent with the New South Wales and South Australian data cited in Section 3.6, which showed that crash rates (per distance driven) are lower in non-metropolitan areas than in state capital cities. At the completion of the logistic regression procedure, it was found that after MINTOT had entered the regression equation, no other exposure variable made a significant additional contribution to prediction of reported crashes. Variable MINTOT was therefore selected as the most appropriate measure to use when controlling for the effect of exposure in later analyses.

TABLE 4.4.2a

ASSOCIATION BETWEEN REPORTED CRASHES IN THE LAST THREE YEARS AND VARIOUS MEASURES OF EXPOSURE

Variable	Reported crashes were associated with...	Probability
MINTOT	more time driving	.0001***
MINTOTD	more time driving in daytime	.0003***
MINTOTN	more time driving at night	.0019**
KM	greater distance driven	.0003***
KMDAY	greater distance driven in daytime	.0009***
KMNITE	greater distance driven at night	.0007***
TRAVELN	some night driving	.0404*
TRAVELW	-	.5109

In order to assess the relationship of various driver characteristics to crash risk after taking into account the effect of exposure, a logistic regression was performed to predict whether a respondent reported a crash in the previous three years. MINTOT was entered first into the equation, and then the probability that each remaining predictor could contribute to prediction of reported crashes was examined. The results of this procedure are shown in Table 4.4.2b; they are generally similar to those in Table 4.4.1a where driving exposure was not taken into account, except that SEX and Factor 4 were no longer significant after taking exposure into account. Factor 4 ("variety of exposure") was naturally correlated with MINTOT, being

higher for respondents with higher quantities of exposure, and it is therefore not surprising that this factor no longer showed significant effects after allowing for the effect of MINTOT. Of greater interest is the non-significant result for the sex of the respondent, suggesting that the greater crash involvement of males shown in Table 4.4.1a is largely due to their greater driving exposure, rather than to higher crash risk per unit exposure.

The results shown in Table 4.4.2b were obtained after the first step of a logistic regression procedure, when only MINTOT (and a constant) had been entered into the prediction equation. Several of the significant predictors shown in the table were known to be correlated with each other. To determine which of these were most closely linked with reported crash involvement, the results of the completed logistic regression were examined after all significant predictors had entered the equation. These results are shown in Table 4.4.2c. As expected, MINTOT was highly significant, with greater driving exposure being associated with greater probability of reporting a crash. Of the four variables in Table 4.4.2b which were significantly associated with reported crashes, only two appeared in the final prediction equation. These were YRSLIC and Factor 1, with reported crashes being associated with fewer years of driving experience and higher levels of recklessness. Neither age nor Factor 2 ("settled down") contributed significantly to prediction of reported crashes after YRSLIC (years of driving experience) had entered the prediction equation.

TABLE 4.4.2b

RESPONDENTS REPORTING ONE OR MORE CRASHES VERSUS RESPONDENTS REPORTING NO CRASHES, AFTER REMOVING THE EFFECT OF EXPOSURE (MINTOT)

Variable	Reported crashes associated with...	Probability
AGE	lower age	.004**
YRSLIC	fewer years of experience	.004**
AGELIC	-	.838
Factor 1	greater "recklessness"	.010**
Factor 2	less "settled down"	.039*
Factor 3	-	.820
Factor 4	-	.466
Factor 5	-	.174
Factor 6	-	.851
SEX	-	.120
EDUC	-	.978

TABLE 4.4.2c

LOGISTIC REGRESSION EQUATION FOR PREDICTION OF *SELF-REPORTED CRASHES, AFTER REMOVING* THE EFFECT OF EXPOSURE (MINTOT)

Entry order	Predictor	Coefficient	Probability
1	MINTOT	0.5540	.000***
2	YRSLIC	-0.3963	.006**
3	Factor 1	0.2254	.014*

It was argued in Section 3.6 that the type of individual who is likely to obtain a driver's licence relatively early in life may also be the type of individual who, for reasons independent of age and driving experience, tends to be a relatively safe driver. However, analysis of the self-reported crash data from the telephone interviews did not support this hypothesis when the effect of differences in driving exposure was ignored. To determine whether the factors associated with early licence acquisition affect crash risk per unit exposure, this analysis was repeated taking exposure into account. A logistic regression was performed to predict crash involvement, with exposure (MINTOT), sex, age and years of driving experience first entered into the equation. After allowing for the effects of these variables, none of the main predictors of age of licence acquisition (Factor 2, Factor 3, EDUC) was found to contribute significantly to prediction of reported crashes. Once again, none of the effects approached statistical significance ($p>0.5$ in each case).

Table 4.4.2d shows the results of several additional comparisons between respondents who *did and did not report crashes which were performed in order to test particular hypotheses.* With the exception of TRAVELN, these results are similar to corresponding results in Table 4.4.1d, where exposure was not taken into account. RENT was not associated with reported crashes even after allowing for exposure, confirming that the bias in the telephone interview sample is unlikely to have affected the proportion of respondents reporting crashes. As expected, a preference for faster driving (SPEED) and a riskier self-reported driving style (RISK) were both associated with reported crashes even after taking account of differences in driving exposure. The one exception was TRAVELN (whether the respondent had driven at night during the week before the home interview), which was no longer significantly associated with reported crashes after taking account of exposure. This difference was expected, since TRAVELN reflects one aspect respondents' exposure, and was correlated with MINTOT (total driving time in the week before the home interview), the measure used in controlling for exposure.

TABLE 4.4.2d

ADDITIONAL COMPARISONS BETWEEN RESPONDENTS REPORTING AND NOT REPORTING CRASHES, AFTER REMOVING THE EFFECT OF EXPOSURE (MINTOT)

Variable	Reported crashes associated with...	Probability
SPEED	preference for faster driving	.007**
SKIL	-	.896
RISK	riskier driving style	.000***
RENT	-	.824
TRAVELN	-	.279
TRAVELW	-	.702

4.5. Relating crash characteristics to information from the home interviews

Drivers who reported crashes with particular characteristics were compared with drivers who reported crashes with complementary characteristics, and in some cases with drivers who reported no crashes, to determine whether particular types of driver were likely to be involved in particular types of crash. Because so few drivers reported more than one crash (1.6% of drivers interviewed, 6.7% of those reporting any crashes), only the characteristics of the most recent crash were considered.

4.5.1. Crash type

Drivers whose most recent crash was a single vehicle crash (N=35) were compared with drivers whose most recent crash involved a collision with a vehicle, cyclist or pedestrian (N=159). Table 4.5.1a shows that drivers whose most recent crash involved only a single vehicle were significantly higher on Factor 3 ("rural") and Factor 6 ("importance of cars and driving") and more likely to be male than drivers whose most recent crash involved a collision with another road user. There were no significant differences on age; years driving experience; age of licence acquisition; and Factors 1, 2, 4 and 5. A logistic regression showed that only Factor 3 ("rural") and years driving experience contributed significantly to prediction of crash type, with single vehicle crashes being associated with high values of Factor 3 and a low number of years since licence acquisition.

TABLE 4.5.1a

RESPONDENTS REPORTING ONE OR MORE CRASHES: CHARACTERISTICS OF MOST RECENT CRASH: SINGLE VEHICLE VERSUS COLLISION WITH OTHER ROAD USER

Variable	Single vehicle crashes associated with...	Type of test	Probability
AGE	-	t	.214
YRSLIC	-	t	.127
AGELIC	-	t	.794
Factor 1	-	t	.093
Factor 2	-	t	.530
Factor 3	more "rural"	t	.000***
Factor 4	-	t	.288
Factor 5	-	t	.149
Factor 6	greater "importance attached to cars and driving"	t	.011*
SEX	males	chi square	.029*

Compared with drivers reporting no crashes, univariate tests showed that drivers involved in single vehicle crashes were significantly higher on Factor 3 ("rural") and Factor 6 ("importance of cars and driving"); Factor 3, sex and years driving experience all contributed significantly to discrimination between these groups by logistic regression. Drivers involved in collisions with other road users did not differ significantly on these factors from drivers reporting no crashes in univariate tests, nor did these factors contribute significantly to discrimination between these groups by logistic regression.

4.5.2. Speed zone

Drivers whose most recent crash occurred in a speed zone with a limit of 60 km/h or less (N=152) were compared with drivers whose most recent crash occurred in a speed zone with a limit of more than 60 km/h (N=38). Table 4.5.2a shows that drivers whose most recent crash occurred in a speed zone with a limit of more than 60 km/h were found to attach significantly more importance to cars and driving (Factor 6) than drivers whose most recent crash occurred in a speed zone with a limit of 60 km/h or less. No significant differences between the groups were found on age; years driving experience; age of licence acquisition; Factors 1 to 5; and sex. Only Factor 6 (importance of cars and driving) was found to contribute to prediction of speed limit by logistic regression.

Drivers reporting crashes in low speed zones (not more than 60 km/h) and high speed zones (greater than 60 km/h) were also compared with drivers who reported no crashes. Drivers reporting crashes in high speed zones attached significantly more importance to cars and driving than did drivers reporting no crashes, while drivers reporting crashes in low speed zones did not differ significantly on this factor from drivers reporting no crashes.

TABLE 4.5.2a

RESPONDENTS REPORTING ONE OR MORE CRASHES: SPEED ZONE OF MOST RECENT CRASH: <= 60 KM/H VERSUS >60 KM/H

Variable	Higher speed zones associated with...	Type of test	Probability
AGE	-	t	.109
YRSLIC	-	t	.174
AGELIC	-	t	.762
Factor 1	-	t	.413
Factor 2	-	t	.810
Factor 3	-	t	.625
Factor 4	-	t	.699
Factor 5	-	t	.591
Factor 6	greater "importance attached to cars and driving"	t	.034*
SEX	-	chi square	.458

4.5.3. Day versus night

Drivers whose most recent crash occurred at night (N=55) were compared with drivers whose most recent crash occurred in daytime (N=139). Univariate tests revealed no significant differences between the daytime and night-time crash groups on age; years driving experience; age of licence acquisition; Factors 1 to 6; and sex. The results of these tests are summarised in Table 4.5.3a. None of these variables contributed significantly to prediction of daytime versus night-time crashes by logistic regression.

TABLE 4.5.3a

RESPONDENTS REPORTING ONE OR MORE CRASHES: CHARACTERISTICS OF MOST RECENT CRASH: *DAYTIME VERSUS NIGHT-TIME*

Variable	Night-time crashes associated with...	Type of test	Probability
AGE	-	t	.782
YRSLIC	-	t	.693
AGELIC	-	t	.662
Factor 1	-	t	.981
Factor 2	-	t	.778
Factor 3	-	t	.914
Factor 4	-	t	.374
Factor 5	-	t	.410
Factor 6	-	t	.470
SEX	-	chi square	.247

4.5.4. Severity

Drivers whose most recent crash resulted in at least one casualty (N=34) were compared with drivers whose most recent crash resulted in property damage only (N=160). The results of the univariate comparisons are shown in Table 4.5.4a. Drivers involved in casualty crashes were found to have been licensed significantly younger than drivers involved in property damage only crashes. No differences between the groups were found on age, years driving experience, Factors 1 to 6 and sex. A logistic regression showed that only age of licence acquisition contributed significantly to prediction of crash severity.

TABLE 4.5.4a

RESPONDENTS REPORTING ONE OR MORE CRASHES: SEVERITY OF MOST RECENT CRASH: CASUALTY VERSUS PROPERTY DAMAGE

Variable	Casualty crashes associated with...	Type of test	Probability
AGE	-	t	.409
YRSLIC	-	t	.942
AGELIC	licensed younger	t	.044*
Factor 1	-	t	.692
Factor 2	-	t	.703
Factor 3	-	t	.075
Factor 4	-	t	.528
Factor 5	-	t	.536
Factor 6	-	t	.911
SEX	-	chi square	.300

Casualty and property damage groups were also compared with drivers who reported no crashes. Drivers reporting casualty crashes appeared to have been licensed somewhat earlier than drivers who reported no crashes, but this difference did not quite reach significance in a univariate test (p=0.059). Drivers reporting property damage crashes and drivers reporting no crashes did not differ in age of licence acquisition.

4.5.5. Number of passengers

Drivers whose most recent crash occurred with passengers in the vehicle (N=92) were compared with drivers whose most recent crash occurred with no passengers in the vehicle (N=102). Table 4.5.5a shows that no significant differences between the groups were found on age; years driving experience; age of licence acquisition; Factors 1 to 6; and sex. None of these variables contributed significantly to prediction of presence of passengers by logistic regression. Drivers carrying passengers were then divided into those carrying exactly 1 passenger and those carrying more than 1 passenger. No significant differences were found between drivers carrying no passengers, 1 passenger and more than one passenger; drivers carrying no passengers appeared somewhat more likely to be male than drivers carrying exactly one passenger, but this difference did not reach significance (p=0.085). Logistic regressions between pairs of groups confirmed that there were no significant differences

between the groups, except that drivers carrying no passengers were significantly more likely to be male than drivers carrying one passenger (p=0.049).

Passenger and no passenger groups were also compared with drivers who reported no crashes. A univariate test showed that drivers who reported a crash with no passengers in the vehicle were significantly more likely to be male than drivers who reported no crashes; logistic regression also showed that sex contributed significantly to discrimination between these two groups. There was no difference in sex distribution between drivers who reported a crash with passengers present and drivers who reported no crashes.

TABLE 4.5.5a

RESPONDENTS REPORTING ONE OR MORE CRASHES: CHARACTERISTICS OF MOST RECENT CRASH: PASSENGERS VERSUS NO PASSENGERS

Variable	Presence of passengers associated with...	Type of test	Probability
AGE	-	t	.419
YRSLIC	-	t	.696
AGELIC	-	t	.429
Factor 1	-	t	.328
Factor 2	-	t	.437
Factor 3	-	t	.478
Factor 4	-	t	.357
Factor 5	-	t	.080
Factor 6	-	t	.994
SEX	-	chi square	.144

4.5.6. Trip origin and destination

Drivers who reported one or more crashes were classified according to the reported origin and destination of the trip they were undertaking when their most recent crash occurred. There were high rates of missing data for trip origin (95 cases; 49% of drivers reporting one or more crashes) and destination (74 cases; 38% of drivers reporting one or more crashes).

The results of a series of univariate comparisons by trip origin and intended destination are shown in Table 4.5.6a. Analysis of variance revealed that only recklessness (Factor 1) was significantly related to trip origin [F(5,90)=3.1391, p=0.012]. Table 4.5.6b shows that drivers travelling from a sporting or leisure activity or the home of a friend at the time of the crash had higher mean recklessness than did other drivers. Age; years driving experience; age of licence acquisition; Factors 2 to 6; and sex were not significantly related trip origin. None of the variables tested was significantly related to trip destination.

TABLE 4.5.6a

RESPONDENTS REPORTING ONE OR MORE CRASHES: CHARACTERISTICS OF MOST RECENT CRASH: TRIP ORIGIN AND INTENDED DESTINATION

Variable	Type of test	Probability (Trip Origin)	Probability (Destination)
AGE	ANOVA	.529	.682
YRSLIC	ANOVA	.767	.505
AGELIC	ANOVA	.504	.755
Factor 1	ANOVA	.012*	.299
Factor 2	ANOVA	.552	.211
Factor 3	ANOVA	.658	.348
Factor 4	ANOVA	.449	.471
Factor 5	ANOVA	.319	.504
Factor 6	ANOVA	.714	.561
SEX	chi square	.625	.298

TABLE 4.5.6b

FACTOR 1 ("RECKLESSNESS") BY TRIP ORIGIN (WHERE KNOWN) FOR MOST RECENT CRASH

Trip origin	Frequency	Mean Factor 1 ("recklessness")
home	46	-0.444
work	15	-0.187
shop	8	-1.082
friend	11	0.446
sport	8	0.186
other	11	-0.061
Total	99	-0.267

4.6 Discussion of factors associated with crash involvement

The home interviews contained a large number of socio-demographic variables probably related to the travel behaviour of respondents. These included sex, marital status, educational status, place of residence (metropolitan or rural), home ownership, involvement in sport and many others. Attributes such as these would be expected to strongly influence the conditions under which respondents drive (e.g. day versus night, urban versus rural), and these various driving conditions are known to be associated with different levels of crash risk per unit exposure. The available socio-demographic variables would also be expected to be closely related to respondent's total amount of on-road driving exposure, which in turn would influence the crash risk per respondent per annum. Other questions in the home interviews were related to the respondent's behaviour behind the wheel (e.g. willingness to speed, willingness to drive after drinking alcohol), and these behaviours are also likely to affect the risk associated with each unit of driving exposure. In order to identify variables which increase crash risk, either through increased exposure or through increased risk per unit

exposure, two sets of analyses of the crash involvement data collected in the telephone interviews were performed. The first examined crash risk on a 'per driver' basis, in order to reveal the effects of exposure differences associated with some socio-demographic variables. In the second set of analyses, the effect of total exposure was removed to allow the identification of variables which increase risk per unit exposure. All of the available measures of exposure were based on the respondents' driving in the week before the home interviews, which was assumed to be highly correlated with total exposure over the whole three year period for which crash involvement data were collected. Among the available measures, the respondent's total reported minutes of driving time was found to be the most closely associated with crash involvement, and was therefore selected for use in this second set of analyses.

The youngest and least experienced drivers interviewed by telephone had not held a licence for the full three year period covered by the interviews, and therefore had reduced opportunity to be involved in a crash. Respondents with more years of driving experience were also found in the analysis of the home interview data to have significantly more minutes of driving exposure during the week preceding the interview than drivers with fewer years of driving experience; a similar trend for exposure to increase with age was not statistically significant (Table 3.4.6h). However, despite their considerably reduced exposure to the possibility of a crash, both in terms of years since licence acquisition and minutes on the road, young and inexperienced drivers were still found to be significantly more likely than older and more experienced drivers to report having been involved in a crash in the last three years. This was true not only after removing the effect of exposure differences but also on a simple 'per driver' basis. These results were a powerful reminder, if any were needed, of the magnitude of the difficulties facing young and inexperienced drivers and the problems facing authorities attempting to reduce the crash risk of this segment of the driving population.

When the effects of age and years of driving experience on reported crash involvement were compared in a multivariate test, the effect of experience was found to be the stronger of the two, both on a 'per driver' basis and also after allowing for the effect of total driving exposure. When different types of crash were considered separately, logistic regression analyses revealed that the respondent's number of years of driving experience contributed significantly to prediction of involvement in single vehicle crashes but not to prediction of involvement in collisions with other road users. Age did not contribute significantly to logistic regression equations for prediction of either crash type. The results of the present study are likely to underestimate the effect of driving experience on accident risk since, as was argued in Section 2.10, the number of years a driver has held a licence is far from being an ideal measure of driving experience. This measure was used because it was not feasible to expect respondents to provide accurate information concerning either the total time they have spent driving or of the total distance they have driven in their lifetime. If a more accurate measure of on-road driving practice could have been obtained, it seems likely that an even more pronounced effect of experience on accident risk would have been found.

The analysis of the home interview data in Section 3 revealed that early acquisition of a driver's licence was associated with high scores on Factor 2 ("settled down") and Factor 3 ("rural") and with completion of some form of post-secondary (tertiary, trade or technical) education. It was argued in Section 3.6 that these attributes are likely to be associated with lower crash risk, and that drivers who acquire a licence relatively early in life are therefore likely to have lower risk of crash involvement, after allowing for the effects of sex, age and

years of driving experience. However, tests in Section 4.4 failed to confirm these expectations. After removing the confounding effects of sex, age and years of driving experience, the probability of a reported crash was found not to be significantly related to Factor 2, Factor 3 or EDUC (educational level achieved). A similar result was obtained after also allowing for differences in total time spent driving during the week before the home interview. Thus the crash involvement data collected in the telephone interviews provided no evidence of differences in crash risk between drivers who acquire a licence at different ages.

On a per driver basis, males were found to be substantially more likely than females to report having been involved in a crash in the past three years. This difference remained significant even after taking account of the greater recklessness (Factor 1) and greater variety of driving exposure (Factor 4) reported by males. When total quantity of driving exposure (minutes of driving in the week before the home interview survey) was taken into account, however, the difference in reported crash involvement between males and females was no longer significant. This suggests that the greater crash involvement of males, frequently reported in previous research, is largely due to their greater exposure to risk as a result of more time spent driving, although it remains possible that there are differences between male and female crash risk per unit exposure which were too small to be detected by the present study.

5. GENERAL DISCUSSION AND CONCLUSIONS

5.1. Measurement issues in "age versus experience" investigations

EXPERIENCE AND DRIVING SKILLS

As Jonah (1986) pointed out, it is reasonable to suppose that the over-representation of young drivers in traffic crashes is at least to some extent a result of inadequate driving skills and knowledge on the part of young, necessarily inexperienced drivers. This proposition has been very difficult to establish conclusively, however, not only because the relevant skills and knowledge are likely to be very difficult to measure, but also because it is not at all clear which skills and knowledge should be measured. There are many more skills involved in driving than those obviously required for vehicle control (steering, braking, gear changing and so on). Driving on a public road shared with a variety of other road users also requires the driver to visually scan the environment; to detect and monitor not only other road users but also fixed hazards such as curves; to predict the movements of other road users; to judge speeds, distances and gaps in traffic flows; to plan routine manoeuvres; and to quickly choose appropriate responses to unexpected events.

It is not known which of these skills and abilities make the difference between being involved or not involved in traffic crashes. Whilst it may appear, *a priori*, that all of the skills listed are essential to safe driving, it is also possible that drivers may be able to compensate at least partially for deficiencies in some of these areas. This might be achieved by limiting driving exposure to low risk times and places; by adopting a low risk driving style which involves exaggerated margins for error; and/or by minimising the number of relatively high risk manoeuvres undertaken, such as right turns.

Many researchers have tried to avoid the difficulties involved in identifying and measuring the skills and knowledge required for crash-free driving by measuring driving experience instead. This strategy is based on the plausible assumption that the critical skills and knowledge, whatever they may be, improve with increasing driving experience. Based on this assumption, the most appropriate measure of driving experience must reflect the driver's opportunity to accumulate driving-related skills and knowledge. Plainly, the best opportunity to improve driving skills - whether in vehicle control, in visual monitoring and hazard detection or in decision making - is by practising those skills while driving. Thus the most appropriate index of experience must be the amount of driving performed, either in terms of the total amount of time spent driving or the total distance driven over the individual's lifetime.

Unfortunately, it is not possible to obtain an accurate measure of driving experience, either in terms of time or distance driven, simply by asking drivers directly. Many, if not most, drivers simply will not know the answers to these questions. Nor are there any alternative measures available against which driver estimates of lifetime time or distance driven could be checked for accuracy. As a result of these difficulties, it was necessary in the present study, as in many previous investigations by other authors, to employ a manifestly less appropriate measure of driving experience - namely, the number of years for which the respondent had held a driver's licence. Clearly, there will be a great deal of variation between individuals in the amount of driving performed during the course of a year, and therefore in the individual's opportunity to accumulate driving-related skills and knowledge. This unaccounted-for variation necessarily reduced the correlation between the experience measure and other

variables of interest in the present study, therefore reducing the opportunity for statistical analysis to reveal the relationship between experience and other attributes, including crash involvement.

Little information was available from the interview and questionnaire surveys in the present study concerning the changes which might be expected to accompany increased experience of the driving task. In particular, it was not possible to test driving skills. Even if it had been possible to identify the skills and knowledge critical to crash avoidance, they could only have been measured in a driving or simulated driving situation, which would have severely restricted the number of drivers who could have been studied and therefore compromised the generalisability of the results. The use of information supplied by the drivers themselves enabled a large number of drivers to be studied, thus ensuring that results for the study sample would be representative of the wider driving population. Thus the study was completely reliant on experience (measured by the number of years since the driver acquired a licence) as an index of driving-related skills and knowledge.

AGE AND RELATED CHARACTERISTICS

Apart from lack of driving experience, other attributes closely associated with youthfulness are also widely believed to contribute to the poor safety record of young drivers. At around the age of commencing to drive, young people are likely to be motivated to drive fast and take risks in order to test their own abilities, to demonstrate their independence from authority or to impress their peers (Deutsch, Healy and Strang, 1981). The busy lifestyle of this age group often results in a high proportion of their driving being performed at night, when crash risk is known to be considerably higher than during the day. Beginning drivers are also in many cases just beginning to consume alcohol regularly, and have not yet become familiar with the changes in their behaviour and skilled performance which result from alcohol consumption. It seems very likely that these and other age-related factors contribute to the elevated crash risk of young drivers. For reviews of research in this area, see Jonah (1986) and Macdonald (1994*b*).

Just as driving experience has been used as an approximate index of driving skills and knowledge, so the age of drivers has been used in many studies, including the present one, as a convenient index of those aspects of emotional and social maturity and related economic characteristics which are believed to be related to crash involvement. Once again, this introduces unaccounted-for variation into the study data, since drivers of the same age can differ markedly in the relevant aspects of maturity.

Fortunately, it was possible in the present study to collect a good deal of information about the drivers studied in addition to their age. The interview and questionnaire surveys covered a range of personal characteristics, including social, demographic and lifestyle attributes of the driver (marital status, languages spoken at home, educational level, involvement in organised sport, etc.); risk taking while driving (speeding, driving after drinking, etc.); attitudes on various issues related to road safety; and non-driving behaviours such as smoking and getting drunk. Information about the respondent's driving exposure in the week preceding the interview was also collected in the home interviews. Overall, a great deal of information was available concerning age-related driver attributes believed to be related to crash involvement, so that the study was not reliant on age alone as a measure of these factors.

5.2. Age of licence acquisition

Investigations of the relative contribution of youth-related and inexperience-related factors to young driver over-representation in road crashes have relied on comparisons of the crash involvement of drivers of the same age but different levels of experience, or on comparisons of drivers of different ages with the same level of experience. In either case, interpretation of these studies has relied on the untested assumption that drivers who acquire a licence at different ages do not differ in other ways relevant to crash risk. Such an assumption may not be valid, since the age at which an individual chooses to obtain a licence is likely to be influenced by a variety of socio-economic and personality factors. One of the aims of the present study was to test this important assumption.

Results from the driver interviews reported in Section 3 showed that age of licence acquisition was significantly related to several driver characteristics potentially relevant to crash risk. In a multiple regression analysis, early licence acquisition was found to be associated with high scores on Factor 2 ("settled down") and Factor 3 ("rural") and with having post-secondary (tertiary, trade or technical) education. In the RBT station questionnaire responses, but not in the information collected in the home interviews, early licence acquisition was associated with low scores on Factor 6 ("importance of cars and driving").

It seems reasonable to speculate that the mature, responsible lifestyle indicated by high scores on Factor 2 may be associated with a mature, responsible driving style and therefore with relatively low crash risk, although empirical evidence concerning this hypothesis is not available from previous research. In support of this hypothesis, it was found in the present study after allowing for the effects of sex, age, and years of driving experience that high scores on Factor 2 were associated with less frequent speeding in built up areas. High scores on Factor 2 were also found to be associated with a low proportion of night-time driving, which would be expected to further reduce accident risk. High scores on Factor 3 ("rural") may also be associated with low levels of accident risk, since examination of published crash statistics from New South Wales and South Australia showed that crash rates per distance travelled are higher in metropolitan than in rural areas. High scores on Factor 3 were found in the present study, after controlling for sex, age and years of driving experience, to be significantly associated with a low frequency of speeding, a low degree of optimism about driving and a low proportion of driving at night. Finally, findings from past research suggest that drivers who attach little importance to cars and driving (Factor 6) may have lower crash risk than drivers for whom cars and driving are more important. Thus, the available evidence from the home interview and questionnaire results was consistent in suggesting that the type of individual who chooses to obtain a licence while relatively young may be less likely to be involved in crashes than one who obtains a licence when somewhat older, for reasons other than differences in age, experience and sex.

However, analysis of information obtained from the telephone interviews reported in Section 4 failed to confirm any link between crash involvement and the characteristics associated with early acquisition of a driver's licence. There was no link between EDUC (educational level achieved) and crash involvement. Drivers with high scores on Factor 3 ("rural") were more often involved in single vehicle crashes, presumably due to the greater opportunity for such crashes under rural road and traffic conditions, but Factor 3 was not related to total crash risk. Drivers who were less "settled down" (Factor 2) were more likely to have been involved in a

crash, but this effect disappeared once the effect of experience had been taken into account. After controlling for sex, age and years of driving experience, none of these attributes (Factor 2, Factor 3, EDUC) was significantly associated with crash involvement. A similar result was obtained in a further test in which driving exposure in the week before the home interview was also taken into account. In fact, after controlling for the effect of Amount of Exposure and the effect of Experience, only Factor 1 ("recklessness") was found to be significantly related to crash risk. Factor 1 had been found in analysis of the home interview data not to contribute to prediction of age of licence acquisition. Thus it appears that any influence on crash risk of factors associated with age of licence acquisition is very small in relation to the effects of the other factors examined.

5.3. Driver characteristics related to crash risk

The four driver characteristics found by multivariate testing (logistic regression) to be predictors of reported crash risk were Experience (years since licence acquisition), Recklessness (Factor 1), Variety of Exposure (Factor 4) and Sex (*see* Table 4.4.1b). After controlling for differences in Amount of Exposure, the effects of Variety of Exposure and of Sex dropped out, leaving just Experience and Recklessness as significant predictors (*see* Table 4.4.2c). These and related findings from earlier analyses are discussed below.

5.3.1. Experience and Age

The basic question underlying the present investigations concerned the relative importance of age-related factors versus experience-related factors as determinants of young drivers' crash risk. Accordingly, the effects of Age and Experience on crash risk are considered together.

The youngest and least experienced drivers had held a driver's licence for less than three years, and also had fewer minutes of driving exposure in the week before the home interview; both these characteristics, and particularly the former, indicate a reduced opportunity for crash involvement, compared with older, more experienced drivers. Despite their lesser exposure, univariate tests showed that both young drivers and inexperienced drivers were more likely than older and more experienced drivers to report a crash during the previous three years.

Age and Experience, shown in the univariate tests to be significantly related to crash involvement, were known to be highly correlated with each other. It was therefore possible that only Age was causally related to crash involvement, and that the statistical relationship between Experience and crash involvement resulted partly or even mainly from the close correlation between Experience and Age rather than from a direct causal link between Experience and crash involvement. Conversely, it was possible that only Experience was causally related to crash involvement, with the link between Age and crashes being partly or mainly correlational rather than causal. The multivariate tests, employing logistic regression, were intended to determine which of Age and Experience was more closely related to crash involvement, and therefore more likely to be causally linked to crashes. In the multivariate tests, both in the analysis which took account of differences in Exposure and in the analysis which did not, Experience was found to be the more closely related to reported crash involvement. In each case, Age, being highly correlated with Experience, did not significantly improve prediction of crash involvement after Experience had entered the regression equation. When single-vehicle crashes were considered separately, Experience was again a significant predictor, and again Age was not.

On the basis of the logistic regression results, it appeared that Experience was more likely to be causally related to crash involvement, and that the association between Age and crashes may be partly or wholly a result of the correlation between Age and Experience. However, two points need to be borne in mind when interpreting these results.

Firstly, the probability values obtained during the logistic regression procedure for Age and Experience were very similar. Since Experience had slightly the lower probability value, it entered the prediction equation before Age in both analyses. Due to its high correlation with Experience, Age then offered little or no further improvement in prediction. However, very slight perturbations of the data could easily have resulted in Age having the lower probability value and therefore entering the regression equation before Experience. The high correlation between the two would then have ensured that Experience offered little or no further improvement in prediction. Because the probability values for Age and Experience were so similar, the final regression results must be regarded as indicative, rather than as conclusive proof of the causal role of Experience in young driver crashes.

Secondly, both in the analysis which took account of differences in Exposure and in the analysis which did not, Recklessness (Factor 1), which was significantly correlated with Age, was found also to be a significant predictor of crash involvement. Thus, age-related motivational characteristics, along with driving experience, play a role in determining young driver crash risk. The findings on Recklessness are discussed in greater detail in the next section.

5.3.2. Recklessness

RECKLESSNESS AND CRASH INVOLVEMENT

Along with Experience, "Recklessness" (Factor 1 from the principal components analysis) was the strongest predictor of crash involvement, after taking account of Amount of Exposure. This factor incorporated information on drivers' "Speed" (various speed-related attitudes and behaviours); attitudes and behaviours related to some other (non-speeding) violations; and "Optimism" (self-perceived driving skill and risk taking). Also included were three personality variables based on factors H, L and Q3 from Cattell's 16 factor personality test (Cattell, 1979, cited by Hilakivi, Veilahti, Asplund, Sinivuo, Laitinen and Koskenvuo, 1989), which were found by Hilakivi *et al.* to be associated with crash risk among young males.

Recklessness was significantly higher in young drivers and in males. After Experience and Recklessness had entered the regression equations predicting crash involvement, Age and Sex did not significantly improve prediction. These results suggest that it is willingness to take risks, rather than Age (or Sex) *per se*, which, in combination with the lower levels of driving skill necessarily resulting from lack of driving experience, is responsible for the elevated crash rates of young drivers.

In the analysis which did not take account of differences in Amount of Exposure, Recklessness was found to be more closely related than Experience to crash involvement. However, when differences in Amount of Exposure were taken into account, Experience was found to be the first and most important predictor of crash involvement. The decrease in the importance of Recklessness as a predictor of crashes when Amount of Exposure was taken into account suggests that a part of the link between Recklessness and crash risk is due to an

association between Recklessness and Amount of Exposure rather than to riskier driving behaviour. This was confirmed by both the univariate and multivariate analyses of Amount of Exposure, which showed in each case that higher levels of Recklessness were significantly associated with higher levels of Exposure. Recklessness is therefore revealed as a very important determinant of total crash involvement, more reckless drivers having both greater driving exposure and greater crash risk while exposed.

When drivers reporting one or more crashes were classified according to the reported origin and destination of their most recent crash-related trip, analysis of variance revealed a significant relationship between Recklessness and trip origin. Drivers travelling at the time of the crash from a sporting or leisure activity or from the home of a friend were higher on Recklessness than crash-involved drivers with other trip origins (home, work, shops). There were no significant differences associated with trip destination. This finding may relate to differences in exposure patterns of drivers differing in Recklessness; they may make such trips more often than other drivers. However, the lack of a significant difference for trip destination suggests an additional influence of the activities at the type of venue from which they were returning at the time of their crash. That is, drivers higher in Recklessness appear to be more likely to take part in leisure activities which increase their crash risk on the return journey. The causes of this increase are unclear, but influences such as fatigue, alcohol and/or passengers may be implicated.

Recklessness and the concept of "Young Problem Drivers"

It was Recklessness rather than Age or Sex which appeared in the regression equations predicting crash involvement. Recklessness represents many of the "risk taking" characteristics which have been seen as major contributors to the elevated crash risk of young drivers. This finding confirms that motivational factors play a major role in young drivers' elevated crash risk. Proponents of the "young problem driver" view of young drivers' elevated crash risk might see this as evidence of a sub-group of "reckless" young drivers who are largely responsible for the problem. Indeed, the emergence of a "Recklessness" factor from the principal components analysis of home interview responses might itself be seen by some as evidence for the reality of a "young problem driver" sub-group.

However, the nature of the factors emerging from such statistical analyses of questionnaire data is inevitably limited by the content of the questionnaires. In this case, a high proportion of questions concerned issues potentially related to "risk-taking" or "recklessness". The emergence of a factor such as Recklessness from the principal components analysis is not surprising; it simply indicates some association between different types of "risky" behaviour.

Similarly, Jonah (1990) reported data from telephone interviews with Canadian drivers in which correlations between various "risky behaviours" were of the order of 0.2 for young drivers. Jonah's "risky behaviours" included several different measures of drinking-related and drug-related behaviour, which could be expected to show correlations simply because the behaviours measured were so similar, as well as various types of aggressive on-road behaviour. To interpret such findings, as Jonah did, as evidence of a "risky behaviour syndrome" in the context of Problem-Behaviour Theory, seems to imply more than is warranted, given the very limited nature of the data. The reality of this "syndrome" is based on the existence of correlations which are small in absolute terms. While this is statistically acceptable, the medical connotation of such labelling implies the existence of a sub-population of people who "suffer from" the syndrome.

The present study produced no evidence for the existence of an identifiable sub-population of "reckless" drivers. Appendix 11 shows distributions of Recklessness, plotted separately for young males and females. Of course some drivers scored higher on Recklessness than others, but it can be seen from the histograms that scores on this factor in the present study were broadly and continuously distributed across the whole sample of young drivers. Young males cannot reasonably be singled out as the "problem" group. Whilst Recklessness was higher on average amongst males, the histograms show that the distributions of scores for males and females on this factor overlap to a very large extent.

It is clear that motivational factors are a major determinant of young drivers' elevated crash risk. However, there is no evidence of a defined sub-population of "young problem drivers", but rather a continuous variation from low to high risk among the young driver population generally.

5.3.3. Sex

SEX AND RISKY DRIVING BEHAVIOUR

There was evidence of riskier driving behaviour by males than by females, in terms of both speed and optimism (self-perceived skill and risk taking). Males reported speeding more often, both in built-up and higher-speed areas, both during the day and at night; they were more likely to enjoy speeding; and they reported having a faster driving style. Such differences are consistent with those found in many previous studies (e g. Knapper, 1985; Cooper, 1987; Carsten *et al.*, 1989; Tränkle *et al.*, 1990; Parker *et al.*, 1992; *see* Macdonald, 1994*b* for a review). Among drivers aged 25 and under, males were more likely than females to report themselves as being more skilful and taking more risks than other drivers of the same sex and age. They were also more likely than females to report that they took more risks than same-sex drivers aged over 30 years.

Findings of male/female differences, being based on *reported* behaviour, might be interpreted simply as evidence of a greater willingness of young males to report, perhaps even to exaggerate, risky behaviour. However, there is evidence from the United Kingdom that self-reports of driving behaviour provide a useful indication of actual behaviour. West, Elander and French (1992) collected information about driving behaviour both by self-report and by direct in-car observation. They concluded that self-reports of speed could be used as a surrogate for direct observations of speed. They also found modest but significant correlations between self-reports and observations of other aspects of driving behaviour.

SEX AND CRASH INVOLVEMENT

The problem of young driver over-representation in road crashes has been described by many authors as predominantly a young male driver problem. Crash involvement data collected in the present study confirmed that young males were considerably more likely to report involvement in a crash than were young females. Being male remained a significant predictor even after taking account of Recklessness (Factor 1) and Variety of Exposure (Factor 4), both of which were significantly higher in males and were also predictors of crash risk. Males were also more likely to report that their most recent crash was a single-vehicle one.

However, after taking into account the much greater on-road exposure of males, there was no significant difference in the overall crash risk of males and females. This finding is consistent with results from an earlier Australian study which used very different methods

(Drummond and Healy, 1986). Thus, whilst a variety of findings on this question have been reported in overseas studies (*see* the discussion in Section 3.6 above), the present result lends support to the view that, at least for current Australian conditions, the greater crash involvement of young males relative to young females is largely due to their greater exposure to risk as a result of more time spent driving.

Significantly higher speeds among male drivers would be expected to result in crashes of greater severity. In the present study, no such difference was found; however, it should be noted that only 34 of the 194 crashes involved injury, so numbers were too small to expect statistical significance unless the expected male/female difference in crash severity was very large. It should be noted that the present crash data were self-reported, and therefore contained a high proportion of crashes resulting in property damage only. Property damage crashes are usually greatly under-represented in official databases, so that studies based on official crash data, and therefore mainly on casualty crashes, may show a different relationship between the crash risk of young males and young females.

SEX AND DRIVING SKILL

As remarked above, it was not possible to obtain direct measures of the driving skills of respondents in the present study. However, in view of the reported faster and riskier driving style of young males compared with young females, the finding that young males were not significantly more likely to report crash involvement (after taking account of exposure differences) suggests that average levels of driving skills were higher among males, compensating for the extra risks taken. There is a variety of supporting evidence for this contention from previous research, discussed by Macdonald (1994*b*), including findings that male drivers have greater skills both in vehicle control (Cooper, 1987; Carsten *et al.*, 1989; Reason *et al.*, 1990; Forsyth and Kompfner, 1991) and in perceptual/cognitive tasks such as in judging and accepting gaps in traffic streams (Halpern, 1986, cited by Tränkle *et al.*, 1990; Carsten *et al.*, 1989; Tränkle *et al.*, 1990).

5.3.4. Variety of exposure

Factor 4 ("variety of driving exposure") was found to be a significant predictor of crash risk. However, when *amount* of exposure was controlled for, the influence of variety became non-significant. The measures of these two different aspects of exposure to crash risk, one reflecting its quantity and one its "quality", had significant overlap and were correlated; it appears that in the absence of data on amount of exposure, Factor 4 represented the contribution to crash risk of overall exposure, both its quantity and nature.

5.3.5. Proportion of night-time driving

Previous research has consistently shown that young drivers have a higher proportion of their crashes at night than do other age groups, and night-time driving is therefore of particular interest within the present Young Driver Research Program. Drivers reporting more driving at night were shown by univariate test to have a higher probability of crash involvement; however, Proportion of Night-time Driving did not enter the multivariate regression equation predicting crash risk, presumably due to its overlap and correlation with Variety of Exposure, which was a significant predictor.

Univariate tests revealed that drivers who do a high proportion of their driving at night are characterised by a wide range of attributes, including youth, inexperience, being less "settled down" (Factor 2), being more "rural" (Factor 3), being male, participation in organised sport, a belief that driving at night is easier than during the day, having driven on the weekend preceding the home interview and having undertaken a long trip in the previous year. The first three of these attributes were known to be correlated with each other. When multivariate tests were performed to determine which attributes made the greatest contribution to prediction of night driving, Factor 2 ("settled down") entered the prediction equation first, with more settled drivers doing less of their driving at night. After inclusion of Factor 2 in the equation, Age and Experience offered no significant improvement in prediction. There was no significant association between Recklessness (Factor 1) and proportion of night-time driving in either univariate or multivariate tests. The general conclusion emerging from these results is that young people who drive more at night differ from those driving less at night primarily in terms of lifestyle and environmental factors, which affect the quantity and quality of their exposure to risk; there appears to be no evidence that young people driving more at night are inherently "riskier" drivers per unit of exposure than other drivers of the same age.

Analyses of mass crash databases reported by Macdonald, Bowland and Hancock (1994) suggested differences between day and night crash-involved driver populations, in terms of both vehicle age and proportion of non-licensed drivers, but such differences applied equally to both young and older drivers. A more important causal factor underlying the generally higher crash risk at night may be an increase in travel speeds. Such a phenomenon is implied by various changes in the characteristics of night-time versus daytime crashes (*see* Macdonald *et al.*, 1994). It is also consistent with a finding reported by Parker *et al.* (1992) that drivers have more permissive attitudes towards speeding at night. Differences in speed behaviour between daytime and night-time driving also appear not to be specific to young drivers but to apply to drivers of all ages.

5.3.6. Conclusions

The issue underlying this part of the Young Driver Research Program was that of "Age" versus "Experience" as determinants of young driver crashes. What, then, are the implications of the finding that the strongest predictors of crash risk were Experience and Recklessness?

Clearly, both skill and motivational factors are important elements in young driver crashes. The primary role of Experience in the regression equations indicates that skill deficits play a major role in crash causation among inexperienced drivers. Recklessness was the other main driver characteristic predicting crash risk, confirming the significance of age-related motivational factors as well as experience-related skill factors.

The predictive power of Experience implies that deficits in young drivers' skills are important determinants of their high crash risk. Although young males were found to be more Reckless than young females, they did not differ significantly in crash risk after taking account of differences in Amount of Exposure. This suggests that skill deficits play a relatively greater role in young female driver crashes. Such a conclusion is consistent with evidence from the literature that young females are poorer in their perceptual, cognitive and vehicle control skills. However, Experience predicted the crash risk of both males and females, so skill deficits appear to be a significant problem for young drivers of both sexes.

The finding that Experience is a more important determinant of young driver crash risk than Age must be regarded as indicative rather than conclusive because of two unresolved, and to some degree irresolvable, difficulties. These are the high correlation between Age and Experience, and the possible effect of self-selection of age of licence acquisition on the interpretation of the results of this and similar studies. Moreover, there appears to be little prospect of future studies providing any better resolution of this issue as long as the question is posed in its present form: that is, as long as Experience is used as an index for the whole spectrum of driving skills likely to be relevant to crash avoidance, and Age is used an index of the relevant motivational factors.

To progress beyond our present level of understanding, it will be necessary for future research to address the relevant skill and motivational variables directly. Possible approaches are discussed in the next section. The present study has taken an important step in this direction by demonstrating that "Recklessness", as constructed from the questionnaire data, is a better predictor than Age of young driver crash involvement.

5.4. Implications for future research and countermeasure development

Measures which have been suggested by previous authors to reduce young driver crash involvement include improved driver training, graduated licensing schemes, night driving curfews and an increase in the minimum age at which a licence can be obtained. What do the findings of the present study suggest about the likely success of such countermeasures? What further research is needed to support the development of new or improved countermeasures? The wider implications of the present findings are considered below.

According to the model of crash risk outlined by Macdonald (1994a), a driver's level of crash risk is determined by the interacting effects of two broad categories of factors: the driver's exposure to crash risk, including both including both quantitative and qualitative dimensions; and the driver's performance of the driving task. The major factor groups affecting driving performance are driving skills and motivational factors. Implications of the present results for further research and countermeasure development are discussed within the framework suggested by Macdonald's model: improvement of driving skills, improvement of motivation and measures to reduce exposure to risk.

5.4.1 Facilitation of skill development

The present findings indicate that the elevated crash risk of young drivers is due, to a major extent, to incomplete development of driving skills. This finding applies to both males and females, but seems to be particularly important for the latter. The obvious countermeasure is to develop a more effective system to facilitate the development of young drivers' skills.

Existing education or training courses are generally unsuccessful in decreasing subsequent crash risk relative to that of young drivers who have received no formal training. This common finding was reported most recently by Gregersen (1994) describing a large, well-controlled Swedish study. It appeared that an important reason for the ineffectiveness of the training in this case was its failure to take appropriate account of inexperienced drivers' very limited capacity to process information while driving during the first year or so after obtaining a licence. Thus it is clear that improved driver training does not simply mean more driver training. Information must be presented to the trainee at the appropriate stage in the development of their driving expertise or they will not be able to take advantage of it.

Current driver training courses have an inadequate basis: we have insufficient knowledge of the nature of the skills which are critical to safe driving, of the stages of development at which these skills can be acquired, and of the processes which might be most effective in facilitating their development. In the absence of such fundamental information about the nature of driving as a complex, skilled activity, it is not surprising that attempts to train people in this skill are generally ineffective relative to informal, trial-and-error learning.

> *There is an urgent need to develop improved driver training programs and methods, to ensure that young and novice drivers are equipped with the skills required for safe driving.*
>
> *To provide a basis for the development of effective training programs, research is required into:*
>
> *(1) the nature of driving skills (incorporating perceptual, cognitive and motor components);*
>
> *(2) the basic perceptual and cognitive capacities required to allow the development of these skills (these may differ somewhat for males and females); and*
>
> *(3) the processes and stages by which young drivers develop these skills.*

A recent report to the AUSTROADS Novice Car Driver Competencies Specification Project (Macdonald 1994*c*) outlined current knowledge on the first of the above topics: the nature of driving skills, incorporating perceptual, cognitive and motor components in accord with an information-processing view of the driving process. Incorporated within this information-processing framework was a view of driving as a complex skill which gradually becomes more "automatised", with implications for the availability of attentional resources and allocation strategies at different stages of skill development. Driving behaviour was also described within the framework of Michon (1979) as consisting of behaviours at three hierarchical levels: operational, tactical and strategic. The amalgamation of these three approaches appears to provide an appropriate theoretical basis for research on the development of driving skills.

From this starting point, a considerable amount of research is needed to explore the processes and stages of skills development (point 3 above), and the effects on skill development of varying levels of the basic perceptual and cognitive capacities intrinsic to these skills (point 2 above).

As more is learned about driving skill, research into methods of facilitating its development should be undertaken; however, it would seem unwise to focus on driver education and training without first determining the appropriate content and temporal structure of such courses, based on improved knowledge of driving skill and its development.

> *The above research, focussed on driving itself, should be supplemented by concurrent research to investigate relationships between particular components of driving skill and particular types of crash.*

For example, Catchpole, Cairney and Macdonald (1994) argued, on the basis of detailed analyses of crashes involving young drivers, that conflict detection and prediction are of critical importance in avoidance of collisions with other road users. It follows that research should focus particularly on the nature of the perceptual and cognitive skills involved in conflict detection and prediction, and the processes by which these skills develop. In the case of collisions with pedestrians, Catchpole *et al.* identified perceptual overloading as a significantly greater contributory factor for young drivers than for older ones. This suggests that having inadequate attentional resources is an important cause underlying such collisions. This and other aspects of young drivers' skill deficits identified as critical in crash avoidance, need to be much more thoroughly investigated, in order to develop more effective training courses.

> *Graduated licensing schemes should be structured so as to emphasise to young drivers that there are more advanced aspects of driving skill than simple vehicle control.*

The primary aim of most graduated licensing systems has been to reduce young driver crashes by limiting their exposure to risk. Given the role played by skill deficits in young driver crashes, graduated licensing systems should be modified to place greater emphasis on skills development. Progression through such a system should not be contingent only on the passing of a specified time as a probationary licence holder. If little exposure occurs during this period, driving skills critical to safety may not adequately develop in the prescribed time. At the end of the prescribed probationary period, drivers should face a valid test of the "higher level" (perceptual and cognitive) components of driving skill. This was recommended by Macdonald (1987), and Victorian licensing authorities have been pursuing the development of such a test. For maximum effect, the driver would remain on a probationary or provisional licence indefinitely until he or she had developed the proficiency required to pass the test. Training programs would need to be developed to facilitate the acquisition of these "higher level" skills. Strong incentives to acquire the skills needed to pass the test and graduate to a full licence could be provided by zero-BAC laws and perhaps via adjustments to vehicle or third party insurance premiums.

5.4.2 Measures to address on-road "recklessness"

Motivational factors are a major determinant of young drivers' elevated crash risk. In the present study, the factor labelled "Recklessness" was a significant predictor of crash risk, along with Experience. This finding applied to both males and females, but was particularly important for the former. Major components of Recklessness were attitudes and reported behaviours related to violations, particularly speed-related ones, self-perceived skill, attitudes towards risk taking, and some more general "personality" variables. Clearly, the values, beliefs and attitudes underlying "Recklessness" are complex: most are probably the product of interactions between individual characteristics and a wide range of social influences.

Attempts to change behaviour by changing related motivational variables are notoriously difficult. In the present case, a wide range of socially-determined attitudes which are influenced by many different factors would need to be changed. Long-term educational programs may make a contribution to such changes. However, the extent of change achievable in the short term by means of public education or advertising campaigns is likely to be very small, particularly in the case of this specific set of attitudes which incorporates "personality" variables related to individual independence and unwillingness to take advice.

A more achievable objective, at least in the short to medium term, might be to develop measures to counteract the influence of Recklessness on driver behaviour, rather than attempt to reduce levels of Recklessness *per se*. For example, Catchpole *et al.* (1994) found that motivational factors, including excessive speed, contributed to a significantly higher proportion of young drivers' single vehicle crashes than to older drivers' single vehicle crashes. Furthermore, young drivers are more over-represented in single vehicle crashes than in crashes of other types. The problem could be approached by investigating the operation of the various determinants of speed choice in such situations, of which motivational variables associated with "Recklessness" are only one type. Countermeasures should then be developed to target whichever variables are most amenable to successful modification.

As in the case of improving young drivers' skills, a better description of the nature of the problem is a necessary prerequisite to the development of countermeasures for high levels of Recklessness. In this case, that means that research is needed to investigate young drivers' driving-related beliefs, values and attitudes, and their changes with increasing age and driving experience. However, given the difficulty of changing behaviour by means of changing attitudes, such research should not be given the highest priority.

> *More importantly, research is needed to investigate the ways in which driver attitudes associated with elevated crash risk interact with other variables in their effect on young driver behaviour, particularly behaviour associated with the types of crash in which young drivers are most over-represented.*

5.4.3 Reducing exposure to risk

The measures discussed in the two preceding sections have dealt with measures needed to decrease the risk associated with the nature of young drivers' on-road behaviour. The final area to be considered concerns possible measures to reduce young drivers' exposure to risk, whether by reducing their total amount of driving or by reducing the riskiness of the conditions under which they drive.

One proposal to reduce the driving exposure of young people has been to increase the minimum age at which a person becomes eligible to obtain a licence. Such a measure would be intended to keep young people off the road during the later years of adolescence, when they are often subject to a variety of intense motivations which may conflict with the requirements of safe driving. However, Recklessness was found in the present study to be a more important determinant of crash risk than Age *per se*. Whilst these two variables were significantly correlated, the magnitude of the correlation was a modest 0.07. Thus an increase in the minimum licensing age would unnecessarily limit the mobility of those young people who are low on Recklessness, while at the same time failing to address the risk posed by many older but more reckless drivers.

Curfews preventing late night driving by the youngest and/or least experienced drivers have been proposed by some authors, since crash risk is higher at night than in the daytime and young drivers have a higher proportion of their crashes at night than do older drivers. Results from the present study indicated that after allowing for the effect of Amount of Exposure there was no significant relationship between crash involvement and night-time driving. People who drove at night were found to differ from those who did not on a number of lifestyle factors, but there was no indication that they were higher risk drivers, after allowing for Amount of Exposure; in particular, people who drove at night were not significantly more

reckless than those who did not. Thus the present study did not provide any evidence to support the introduction of a night-time curfew for young drivers.

There is no doubt that crash reductions, including crashes involving young drivers, could be achieved by measures which limit driving exposure or which manipulate the "qualities" of exposure so as to reduce risk. The cost of reduced exposure, however, is reduced mobility, with all its social and economic consequences, and most communities have been reluctant to make this trade. This issue transcends road safety considerations, requiring an assessment of broader community values.

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APPENDIX 1: HOME INTERVIEWS - INTERVIEWER'S QUESTIONNAIRE

WELLS AUSTRALASIA

395 NEPEAN HIGHWAY
FRANKSTON VIC 3199

PHONE: (03) 783 7200

START TIME	FINISH TIME	TOTAL INT MIN

PROJECT NAME: 11-5371

PROJECT: DRIVING HABITS

DATE: NOVEMBER 1992

Good morning/afternoon/evening, I'm ... (***FULL NAME***) from Wells Australasia, the market research company. We are conducting a national survey on driving habits. May I please speak to the youngest licensed car driver in your home who is under 51 years of age and has driven a car in the past month.
CHECK AGE QUOTAS: UNDER 21 -- 1 21-25 -- 2 26-50 -- 3 / MALE --- 1 FEMALE --- 2

Q1a. Firstly a few questions about the car you usually drive. How old is it? (DK = 0000) [ ] YEARS

b. How many seat-belts does it have? [ ] # BELTS

c. Does it have a personalised number plate?
YES ---------- 1
NO ---------- 2

d. What type of insurance cover does this car have?
COMPREHENSIVE ---------- 1
3RD PARTY ---------- 2
3RD PARTY PROPERTY ---- 3
..... OTHER (SPECIFY) ------- 4

e. How do you get your car serviced (oil/grease)? ***(NOT MAJOR REPAIRS)***
SELF ---------- 1
FRIEND/RELATIVE ---------- 2
GARAGE/SERVICE STATION/WORKSHOP --- 3
DOESN'T GET SERVICED ---------- 4

		Q1f.	Q1g.
f.	How often does it usually get washed? ***RECORD IN COLUMN Q1f.***		
g.	And how often does it usually get waxed or polished? ***RECORD IN COLUMN Q1g.***		
	WEEKLY ---------- 1	-- 1	
	FORTNIGHTLY ---------- 2	-- 2	
	MONTHLY ---------- 3	-- 3	
	EVERY 2 TO 3 MONTHS ---------- 4	-- 4	
	LESS OFTEN ---------- 5	-- 5	
	NEVER ---------- 6	-- 6	

h. Has the car been modified in any way?
NO ---------- 1
YES - BODY ---------- 2
YES - MECHANICAL ---------- 3
YES - WHEELS/TYRES ---------- 4

i. Did you have a car before you had your driver's licence?
YES ---------- 1
NO ---------- 2

Q2a. And now some questions about your driving in the past 7 days. [***SHOW CARD A***] We would like to know how many hours, approximately, you spent driving on each day during the day and during the night after 7 pm. Let's start with yesterday - how many hours did you drive yesterday day time between 6 am and 7 pm?
DO NOT INCLUDE TODAY - WORK BACK FROM YESTERDAY

	MON	TUE	WED	THUR	FRI	SAT	SUN	TOTAL
DAY 6 AM - 7 PM								
NIGHT 7 PM - 6 AM								

b. How many hours of your driving last week during daytime/night-time is work related.
INCLUDE TIME COMMUTING TO/FROM WORK AND ANY DRIVING AS PART OF JOB
DAY HRS/WEEK ------ [ ] HR
NIGHT HRS/WEEK ---- [ ] HR

c. During the time you spent driving in the past seven days, approximately how many kilometers in total did you travel
DAY HRS/WEEK ------ [ ] KM
NIGHT HRS/WEEK ---- [ ] KM

d. And how many of the kilometers you travelled last week during daytime/night-time were work related?
INCLUDE DISTANCE COMMUTING TO/FROM WORK ANY DRIVING AS PART OF JOB
DAY HRS/WEEK ------ [ ] KM
NIGHT HRS/WEEK ---- [ ] KM

e. How long ago did you last drive a long trip of more than 200 km?
LAST WEEK ---------- 1
LAST MONTH ---------- 2
LAST YEAR ---------- 3
OVER 1 YEAR ---------- 4
NEVER ---------- 5

f. ***IF CODE 1-4***: Was this trip work related?
YES ---------- 1
NO ---------- 2

INTERVIEWER CHECK Q2a./Q2b. AND CIRCLE BELOW FOR TYPE OF DRIVING UNDERTAKEN PAST WEEK. ASK Q3a. TO Q3g. FOR EACH TYPE CIRCLED.

SINGLE PERSONS ONLY

The next few questions are about specific aspects of the driving you do. Firstly, thinking about the driving you usually do during *[DAYTIME/NIGHT-TIME]* for *[NON-WORK/WORK TRIPS]* ...		DAY 6 AM - 7 PM		NIGHT 7 PM - 6 AM	
		NON-WORK TRIPS 1	WORK TRIPS 2	NON-WORK TRIPS 3	WORK TRIPS 4
Q3a. Whose car do you drive?	OWN	1	1	1	1
	FAMILY	2	2	2	2
	COMPANY	3	3	3	3
	FRIENDS	4	4	4	4
	OTHER	5	5	5	5
b. Do you ever just go for a drive? *[READ OUT]*	REGULARLY	1	1	1	1
	SOMETIMES	2	2	2	2
	OR NEVER	3	3	3	3
c. For those *[DAYTIME/NIGHT-TIME] [NON-WORK/WORK]* trips, how familiar are you with the routes you take. Would you consult the street directory or follow directions given to you? *[READ]*	ALWAYS	1	1	1	1
	MOST OF TIME	2	2	2	2
	OCCASIONALLY	3	3	3	3
	NEVER	4	4	4	4
d. On these trips, are you under time pressure to get to your destination? *[READ]*	ALWAYS	1	1	1	1
	SOMETIMES	2	2	2	2
	NEVER	3	3	3	3
e. On these *[DAYTIME/NIGHT-TIME] NON-WORK/WORK]* trips, how many passengers do you usually carry?	NONE	1	1	1	1
	ONE	2	2	2	2
	TWO+	3	3	3	3
f. *IF 1 OR MORE PASSENGERS*: Are they usually ... *[READ]*	FEMALE	1	1	1	1
	MALE	2	2	2	2
	BOTH	3	3	3	3
g. *IF 1 OR MORE PASSENGERS*: What is their relationship to you?	PARTNER/SPOUSE	1	1	1	1
	FAMILY	2	2	2	2
	FRIENDS	3	3	3	3
	WORK COLLEAGUES	4	4	4	4
	OTHER	5	5	5	5

NOW ASK Q3a. - Q3g. FOR NEXT TRAVEL TYPE CIRCLED

We would like to know how often you do various things while driving *[SHOW CARD B]*. To assist you, here is a card with a scale running from NEVER to ALWAYS. As I read out each statement, please indicate how often you do it by pointing to a position on the scale.

INTERVIEWER: GIVE BREAKFAST EXAMPLE.

Q4. Firstly, how often do you ... *[RECORD CLOSEST NUMBER]*

01	WEAR YOUR SEATBELT WHILE DRIVING	
02	DRIVE MORE THAN 10 KM/HR ABOVE THE SPEED LIMIT IN BUILT-UP AREAS	
03	STOP AT STOP SIGNS	
04	FEEL TIRED WHEN DRIVING AT NIGHT-TIME	
05	DRIVE MORE THAN 10 KM/HR ABOVE THE SPEED LIMITS ON OPEN ROADS	
06	GET ANGRY AT THE ACTIONS OF OTHER DRIVERS	
07	DRIVE MORE THAN 10 KM/HR ABOVE THE SPEED LIMIT DURING DAYTIME	
08	DRIVE AFTER HAVING A FEW DRINKS	
09	ENJOY DRIVING	
10	PREFER NOT TO WEAR A SEATBELT	
11	DRIVE MORE THAN 10 KM/HR ABOVE THE SPEED LIMIT AT NIGHT-TIME	
12	FEEL TIRED WHEN DRIVING DURING THE DAY	
13	ENJOY DRIVING FASTER THAN OTHER TRAFFIC	

Q5. *[SHOW CARD C]* Here is a similar scale running from STRONGLY AGREE to STRONGLY DISAGREE. As I read out a statement, please indicate how much you AGREE or DISAGREE with it by pointing to a position on the scale.

1.	I THINK THAT IT IS EASIER TO DRIVE AT NIGHT THAN DURING THE DAY	
2.	I PREFER TO DRIVE RATHER THAN BE A PASSENGER IN A CAR	
3.	I PREFER TO USE PUBLIC TRANSPORT RATHER THAN DRIVE	

Q6a. In the past 12 months, how many times have you been ....

1.	ISSUED WITH A PARKING INFRINGEMENT TICKET	
2.	ISSUED WITH A TRAFFIC INFRINGEMENT TICKET OR CHARGED BY POLICE FOR A TRAFFIC OFFENCE	
3.	WARNED BY A TRAFFIC OR POLICE OFFICER	

b. When you have your radio/cassette on while driving, what volume level would you usually turn it to?

SOFT	1
MODERATE	2
LOUD	3
DON'T TURN ON	4

c. *[SHOW CARD D]* This card contains four scales related to people's driving style. For each scale, please rate your driving style by pointing to a position on the scale.

CAUTIOUS	
PATIENT	
FAST	
NERVOUS	

d. *[SHOW CARD E]* Please use this scale to rate the degree of danger you believe is involved in driving in the following conditions, during the day between 6 am and 7 pm.

CITY DRIVING ----------
COUNTRY DRIVING ----------
CARS FOLLOWING TOO CLOSE --------
RAIN ----------

e. Using the same scale, please rate the degree of danger you believe is involved in driving in the following conditions, during the night between 7 pm and 6 am.

CITY DRIVING ----------
COUNTRY DRIVING ----------
CARS FOLLOWING TOO CLOSE --------
RAIN ----------

f. *[SHOW CARD F]* Do you support or oppose the following as methods of improving safety on Australian Roads? Please point to a position on the scale.

RANDOM BREATH TESTING ----------
SPEED RADAR/SPEED CAMERAS -------

[SHOW CARD G FOR Q6g. TO Q6l.]

g. Using this scale, how would you rate your driving skills compared to other drivers of your age and sex.

h. ***IF 25 YRS OR UNDER***: How would you rate your driving skills compared to other drivers of the same sex, but older than you (i.e. over 30 years of age? ***NOW SKIP TO Q6j.***

i. ***IF OVER 25 YES***: How would you rate your driving skills compared to other drivers of the same sex, but younger than you (i.e. under 26 years of age)?

j. How would you rate your risk-taking level compared to other drivers of your age and sex?

k. ***IF 25 YRS OR UNDER***: How would you rate your risk-taking level compared to other drivers of the same sex but older than you (i.e. over 30 years of age) ***NOW SKIP TO Q7.***

l. ***IF OVER 25 YRS***: How would you rate your risk-taking level compared to other drivers of the same sex but younger than you (i.e. under 26 years of age).

Q7. This card [***SHOW CARD H***] contains factors that other people say are important for safe driving. Would you please read through the list of factors ..... [***PAUSE***] ... which one do you believe is most important. ***REPEAT FOR SECOND AND THIRD MOST IMPORTANT***

MOST IMPORTANT -------
SECOND MOST IMPORTANT -
THIRD MOST IMPORTANT --

Finally, a few questions about yourself ...

Q8a. What is your age? [ ] (REFUSED = 99)

b. SEX: MALE -------- 1 FEMALE ------ 2

		YES	NO
c.	Are you married/in a de facto relationship	1	2
d.	Do you have children under 12 years of age?	1	2
e.	Do you speak any language other than English at home?	1	2
f.	Do you pay rent/board?	1	2
g.	Do you pay a mortgage?	1	2
h.	Do you have regular access to a car?	1	2
i.	Do you participate in organised sports?	1	2
j.	Do you wear glasses or contact lenses when driving?	1	2
k.	Do you smoke?	1	2

Q9a. What is the highest level of education you have achieved?

SECONDARY ---------- 1
UNIVERSITY/TERTIARY -------- 2
TRADE/TECHNICAL COLLEGE ---- 3
OTHER ---------- 4

b. What is your main occupation: .....

c. How many years have you been a licensed driver? [ ] YEARS (DK = 99)

d. Would your annual income be over or under $21,000? ***IF OVER***: Would it be over or under $41,000?

UNDER $21,000 ---------- 1
$21,000 - $40,000 ---------- 2
$41,000 ---------- 3
REFUSED ---------- 4

Q10. ***[SHOW CARD C]*** Please indicate how much you AGREE or DISAGREE with the statements I will read out by pointing to a position on the scale.

01	I LIKE MY LIFE TO BE PLANNED AND ORGANISED	[ ]
02	NOTHING MUCH WORRIES ME	[ ]
03	WHEN I'M WITH FRIENDS, I HAVE A BETTER TIME IF I DRINK ALCOHOL	[ ]
04	ON THE WHOLE, I'M SATISFIED WITH MYSELF	[ ]
05	I GET ANNOYED WHEN I'M NOT ALLOWED TO DO WHAT I WANT TO DO	[ ]
06	I DON'T LIKE TAKING CHANCES	[ ]
07	I LIKE TO DO THINGS ON THE SPUR OF THE MOMENT	[ ]
08	IT'S O.K. TO OCCASIONALLY GET VERY DRUNK	[ ]
09	I PREFER TO DO THINGS MY OWN WAY	[ ]
10	I'M SATISFIED WITH MY LIFE IN GENERAL	[ ]
11	I THINK PEOPLE WHO DRINK TOO MUCH ARE STUPID	[ ]
12	I DON'T DO ANYTHING WITHOUT FIRST CONSIDERING THE CONSEQUENCES	[ ]
13	I LIKE TAKING ADVICE FROM OTHER PEOPLE	[ ]

SYDNEY ----- 01	MELBOURNE -- 03	BRISBANE --- 05	PERTH ---- 07	ADELAIDE --- 09
OTHER NSW -- 02	OTHER VIC ---04	OTHER QLD -- 06	OTHER WA - 08	OTHER SA --- 10
				TAS -------- 11

RESPONDENT NAME: _____

ADDRESS: _____

TELEPHONE NO.: (STD) _____ POSTCODE: [ ][ ][ ][ ]

INTERVIEWER NAME: _____ PAYROLL: [ ][ ][ ][ ]

SIGNATURE: _____ DATE: _____

CHECKED BY: _____ VALIDATED BY: _____

APPENDIX 2: HOME INTERVIEWS - FORMATION OF SUMMARY VARIABLES

Summary variable name	Interview variable name	Interview variable description
ALCOHOL	ALCBETT	When I'm with friends, I have a better time if I drink alcohol
	DRINKOK	It's OK to occasionally get very drunk
	ALCSTUP	I think people who drink too much are stupid
DANGER	NITECITY	Perceived danger of driving between 7 pm and 6 am - city driving
	NITECTRY	Perceived danger of driving between 7 pm and 6 am - country driving
	NITECLOS	Perceived danger of driving between 7 pm and 6 am - cars following too close
	NITERAIN	Perceived danger of driving between 7 pm and 6 am - rain
	DAYCITY	Perceived danger of driving between 6 am and 7 pm - city driving
	DAYCTRY	Perceived danger of driving between 6 am and 7 pm - country driving
	DAYCLOS	Perceived danger of driving between 6 am and 7 pm - cars following too close
	DAYRAIN	Perceived danger of driving between 6 am and 7 pm - rain
DRIVTIRE	TIREDAY	How often do you feel tired when driving during the day?
	TIRENITE	How often do you feel tired when driving during the night-time?
ENJDRIVE	NERVOUS	Is your driving style nervous or relaxed?
	ENJOY	How often do you enjoy driving?
	PREFDRV	I prefer to drive rather than be a passenger in a car
	PREFTRAN	I prefer to use public transport rather than drive
FACTORH	SPURMOM	I like to do things on the spur of the moment
	PLANNED	I like my life to be planned and organised
	CONSEQ	I don't do anything without first considering the consequences
FACTORL	CHANCES	I don't like taking chances
	WORRY	Nothing much worries me
FACTQ3	ADVICE	I like taking advice from other people
	ANNOY	I get annoyed when I'm not allowed to do what I want to do
	OWNWAY	I prefer to do things my own way

Summary variable name	Interview variable name	Interview variable description
INTEREST	SERVICE	How do you get your car serviced?
	WASH	How often does your car usually get washed?
	PERPLATE	Does your car have a personalised number plate?
SAFERATE	SKIL	How would you rate your driving skill compared to other drivers of your age and sex?
	RISK	How would you rate your risk-taking level compared to other drivers of your age and sex?
	PATIENT	Is your driving style patient or impatient?
	CAUTIOUS	Is your driving style cautious or impulsive?
	FAST	Is your driving style fast or slow?
TOTSAT	SATISFY	On the whole, I'm satisfied with myself
	LIFESAT	I'm satisfied with my life in general
UNSAFACT	TRAFFICK	In the past 12 months, how many times have you been issued with a traffic infringement ticket or charged by police for a traffic offence?
	WARN	In the past 12 months, how many times have you been warned by a traffic or police officer?
	WEARBELT	How often do you wear your seatbelt while driving?
	STOP	How often do you stop at stop signs?
	DRINK	How often do you drive after having a few drinks?
	SPEDBUA	How often do you drive more than 10 km/h above the speed limit in built up areas?
	SPEDOPEN	How often do you drive more than 10 km/h above the speed limit on open roads?
	SPEDDAY	How often do you drive more than 10 km/h above the speed limit during daytime?
	SPEDNITE	How often do you drive more than 10 km/h above the speed limit at night-time?
UNSAFATT	ENJFAST	How often do you enjoy driving faster than other traffic?
	NOBELT	How often do you prefer not to wear a seatbelt?
	RBT	Do you support or oppose Random Breath Testing to improve safety on Australian roads?
	RADAR	Do you support or oppose speed radar/speed cameras to improve safety on Australian roads?

APPENDIX 3: HOME INTERVIEWS - VARIABLES INCLUDED IN PRINCIPAL COMPONENTS ANALYSIS

Variable name	Variable description	Transformation
ALCOHOL	Positive view of alcohol (*Summary variable*)	Dichotomized: 'Low' versus 'high'
ANGRY	Frequency of getting angry at actions of other drivers	Dichotomized: 'Low' versus 'high'
CARAGE	Age of car	CARAGE $^{0.65}$
CHILD	Any children under 12 years old	Dichotomized: 'Yes' versus 'no'
DRIVTIRE	Frequency of feeling tired when driving (*Summary variable*)	Dichotomized: 'Less' versus 'more often'
ENJDRIVE	Enjoyment in driving (*Summary variable*)	Dichotomized: 'Less' versus 'more'
FACTORH	Adventurous/impulsive (*Summary variable*)	FACTORH $^{1\ 3}$
FACTORL	Easygoing/chance-taking (*Summary variable*)	(No transformation needed)
FACTQ3	Self-control (*Summary variable*)	FACTORQ3 $^{1\ 3}$
INSUR	Type of car insurance	Dichotomized: 'Comprehensive' versus 'other'
INTEREST	Interest in car (*Summary variable*)	Dichotomized: 'Less' versus 'more'
LANG	Language other than English spoken at home	Dichotomized: 'Yes' versus 'no'
LONGTRP	Last trip of over 200 km	Dichotomized: 'In past year' versus 'over one year ago'/'never'
MARDEF	Respondent in a married/de facto relationship	Dichotomized: 'Yes' versus 'no'
METRU	Respondent lives in metropolitan/rural area	Dichotomized: 'Metropolitan' versus 'rural'
MODIF1	Modifications to car (body, mechanical, wheels/tyres)	Dichotomized: 'Yes' versus 'no'
MORT	Respondent pays a mortgage	Dichotomized: 'Yes' versus 'no'

Variable name	Variable description	Transformation (if any)
PARKTICK	Number of parking tickets in past 12 months	Dichotomized: 'None' versus 'one or more'
RENT	Respondent pays rent or board	Dichotomized: 'Yes' versus 'no'
SAFERATE	Safe driving self-ratings (*Summary variable*)	(No transformation needed)
TRAVELN	Night travel undertaken in last week	Dichotomized: 'None' versus 'some'
TRAVELW	Weekend travel undertaken last week	Dichotomized: 'None' versus 'some'
UNSAFACT	Unsafe driving actions (*Summary variable*)	Dichotomized: 'Low' versus 'high'
UNSAFATT	Unsafe driving attitudes (*Summary variable*)	Dichotomized: 'Low' versus 'high'
VOLUME	Volume of radio/cassette when driving	Dichotomized: 'Off'/'soft' versus 'loud'
WAXPOL	Frequency car waxed or polished	Dichotomized 'At least every 3 months' versus 'less often'

APPENDIX 3A: HOME INTERVIEWS - ROTATED FACTOR MATRIX

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
SAFERATE	-.66694	.03216	.05869	-.09560	.05037	.06530
UNSAFACT	.62556	-.03662	-.12099	.18595	-.06085	.01293
UNSAFATT	.56438	.03695	-.18904	.07545	-.08112	.10946
FACTORH_	-.54662	.16604	-.25090	.01618	-.03353	.06825
VOLUME	.51198	-.18019	.02577	.01652	.04667	.03486
ALCOHOL	.47668	-.13206	.20843	.01056	-.03850	-.01253
ANGRY	.46207	.07400	-.05659	-.01361	-.11207	.01566
FACTQ3_	.41246	.02664	.16880	-.18434	.04409	-.12124
FACTORL	.36106	-.10410	.15730	.06415	.14793	.08468
MARDEF	-.13204	.82427	.10717	-.03305	.03573	.02160
CHILD	-.13057	.73571	.21599	-.05149	-.11496	-.00513
MORT	-.05003	.63418	-.34131	.02689	.18942	-.03191
LANG	-.15994	-.03804	-.63217	-.05109	.01092	.15526
METRU	-.08342	.17206	.55675	-.09717	-.02581	.04374
RENT	.01507	-.20978	.52922	.09177	-.21747	.15607
TRAVELN	.02738	-.07629	-.00438	.77948	.07975	.03688
TRAVELW	.02127	-.00334	.07247	.77793	.01880	-.01576
LONGTRP	.17994	.15101	.33963	.35864	.09807	.22010
PARKTICK	.14650	-.03619	-.27562	.33108	-.11784	-.10004
CARAGE_	.02282	-.02952	.04292	-.02690	-.81293	.02833
INSUR	-.02844	.02880	-.07914	.04816	.77304	.09499
INTEREST	.03818	.08132	-.12793	-.05336	-.01167	.70805
WAXPOL	-.13764	-.01222	-.02577	.02948	.15475	.55861
MODIF1	-.19946	-.03141	.00561	-.06725	.36146	-.51566
ENJDRIVE	.07322	-.06295	.25821	.06336	.01180	.46095
DRIVTIRE	.29009	.12210	-.12748	.15434	-.01207	-.31744

APPENDIX 4: HOME INTERVIEWS - VARIABLES USED IN REGRESSION ANALYSIS

Variable name	Variable description	Transformation (if any)
AGE	Age of respondent	$(AGE-16)^{0.5}$
AGELIC	Age when licensed	ln (AGELIC-15.9)
CARFIRST	Had a car prior to getting licence	Dichotomized: 'Yes' versus 'no'
DANGER	Driving danger ratings (*Summary variable*)	$DANGER^{2.1}$
EASYDAY	Easier to drive at night than during day	Dichotomized: 'Agree' versus 'disagree'
EDUC	Educational level obtained	Dichotomized: 'university/trade/technical college' versus 'Secondary/other'
FACTOR1	Recklessness (*from Principal Components Analysis*)	
FACTOR2	Settled down (*from Principal Components Analysis*)	
FACTOR3	Rural (*from Principal Components Analysis*)	
FACTOR4	Variety of exposure (*from Principal Components Analysis*)	
FACTOR5	Financial value of car (*from Principal Components Analysis*)	
FACTOR6	Importance of cars and driving (*from Principal Components Analysis*)	
GLASSES	Respondent wears glasses/contact lenses when driving	Dichotomized: 'Yes' versus 'no'
LEGAL	State minimum legal licensing age	$(LEGALAGE-16.5)^{0.75}$
SEX	Sex of respondent	Dichotomized: 'Male' versus 'female'
SMOKE	Respondent smokes	Dichotomized: 'Yes' versus 'no'
SPORT	Respondent participates in organized sports	Dichotomized: 'Yes' versus 'no'
TOTSAT	Satisfaction total (*Summary variable*)	Dichotomized: 'Low' versus 'high'

APPENDIX 5: HOME INTERVIEWS - CORRELATION MATRIX FOR VARIABLES USED IN REGRESSION ANALYSIS

	AGELIC	LEGAL	AGE	SEX	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
AGELIC	1.000	.382	.369	.116	-.061	.079	-.083	-.009	.000
LEGAL	.382	1.000	.042	-.018	.011	-.035	-.066	.049	.041
AGE	.369	.042	1.000	.030	-.069	.490	.058	.083	.066
SEX	.116	-.018	.030	1.000	-.218	.068	.020	-.095	.065
FACTOR1	-.061	.011	-.069	-.218	1.000	.001	.001	.000	.000
FACTOR2	.079	-.035	.490	.068	.001	1.000	-.001	-.001	-.001
FACTOR3	-.083	-.066	.058	.020	.001	-.001	1.000	-.002	-.001
FACTOR4	-.009	.049	.083	-.095	.000	-.001	-.002	1.000	-.001
FACTOR5	.000	.041	.066	.065	.000	-.001	-.001	-.001	1.000
FACTOR6	-.056	-.053	.010	-.263	.000	.000	-.003	-.001	.000
TOTSAT	.019	.035	.065	-.046	-.062	.068	.078	-.025	.069
GLASSES	.050	.011	.098	.086	-.020	.011	-.063	.036	.065
SPORT	-.088	.008	-.112	-.148	.068	-.114	-.061	.057	.103
CARFIRST	.022	.037	.005	-.080	.064	.056	.049	.050	-.093
EDUC	.039	.066	.156	-.078	.054	-.032	-.079	.134	.108
SMOKE	.032	-.006	.110	-.031	.139	.114	.158	.036	-.151
EASYDAY	.001	-.005	.019	.136	-.073	.069	.030	-.001	.021
DANGER	.033	.007	.044	.104	-.152	.057	-.029	.007	-.009

APPENDIX 5 continued

	FACTOR6	TOTSAT	GLASSES	SPORT	CARFIRST	EDUC	SMOKE	EASYDAY	DANGER
AGELIC	-.056	.019	.050	-.088	.022	.039	.032	.001	.033
LEGAL	-.053	.035	.011	.008	.037	.066	-.006	-.005	.007
AGE	.010	.065	.098	-.112	.005	.156	.110	.019	.044
SEX	-.263	-.046	.086	-.148	-.080	-.078	-.031	.136	.104
FACTOR1	.000	-.062	-.020	.068	.064	.054	.139	-.073	-.152
FACTOR2	.000	.068	.011	-.114	.056	-.032	.114	.069	.057
FACTOR3	-.003	.078	-.063	-.061	.049	-.079	.158	.030	-.029
FACTOR4	-.001	-.025	.036	.057	.050	.134	.036	-.001	.007
FACTOR5	.000	.069	.065	.103	-.093	.108	-.151	.021	-.009
FACTOR6	1.000	.039	-.030	.075	.118	.005	.095	-.111	.002
TOTSAT	.039	1.000	-.001	.006	-.034	.033	-.005	-.004	.059
GLASSES	-.030	-.001	1.000	-.047	-.003	.048	-.038	.048	.041
SPORT	.075	.006	-.047	1.000	-.026	.029	-.074	.004	.043
CARFIRST	.118	-.034	-.003	-.026	1.000	-.014	.082	-.052	-.064
EDUC	.005	.033	.048	.029	-.014	1.000	-.140	-.008	-.002
SMOKE	.095	-.005	-.038	-.074	.082	-.140	1.000	-.039	-.008
EASYDAY	-.111	-.004	.048	.004	-.052	-.008	-.039	1.000	.119
DANGER	.002	.059	.041	.043	-.064	-.002	-.008	.119	1.000

APPENDIX 6: HOME INTERVIEWS - VARIABLES RELATING TO RESPONDENTS' DRIVING IN THE PREVIOUS WEEK

Variable name	Variable description	Formula (if any)
FAMIL	Occasionally consulted directory/followed directions	Dichotomized: 'Never' versus 'at least sometimes'
FKMNITE	Proportion of kilometres at night	KMNITE ÷ (KMDAY + KMNITE)
FKMWORK	Proportion of work-related kilometres	(KMDAYW + KMNITEW) ÷ (KMDAY + KMNITE)
FMINNITE	Proportion of night-time driving minutes	MINTOTN ÷ (MINTOTN + MINTOTD)
FMINWEND	Proportion of weekend driving minutes	(Total minutes driven for Friday night, Saturday day and night and Sunday daytime) ÷ (MINTOTD + MINTOTN)
FMINWORK	Proportion of work-related driving minutes	(MINWORKD + MINWORKN) ÷ (MINTOTD + MINTOTN)
FRIEND	Sometimes carried friends as passengers	Dichotomized: 'Yes' versus 'no'
JUST	Sometimes just went for a drive	Dichotomized: 'Never' versus 'at least sometimes'
KM	Total number of kilometres driven	$(KMDAY + KMNITE)^{0.2}$
KMDAY	Kilometres driven during day	$KMDAY^{0.29}$
KMDAYW	Work-related kilometres driven during day	
KMNITE	Kilometres driven at night	
KMNITEW	Work-related kilometres driven at night	
KMW	Total work-related kilometres driven	KMDAYW + KMNITEW
MINTOT	Total number of driving minutes	MINTOTD + MINTOTN

Variable name	Variable description	Formula (if any)
MINTOTD	Total number of daytime driving minutes	MINTOTD $^{0.33}$
MINTOTN	Total number of night-time driving minutes	
MINWORK	Total number of work-related driving minutes	MINWORKD + MINWORKN
MINWORKD	Total number of work-related daytime driving minutes	
MINWORKN	Total number of work-related night-time driving minutes	
NPAS	Number of passengers usually carried	Dichotomized: 'None' versus 'some'
OTHERCAR	Regularly drove a car not respondent's own	Dichotomized: 'Solely drive own car' versus 'regularly drive other car'
PRES	Usually under time pressure when driving	Dichotomized: 'Never' versus 'at least sometimes'
SPD	Average speed of driving (km/h)	$[(KM \div MINTOT) \times 60]^{0.6}$

APPENDIX 7: RBT SURVEY - FORMATION OF SUMMARY VARIABLES

Summary variable name	Questionnaire variable name	Questionnaire variable description
ALCOHOL	ALCBETT	When I'm with friends, I have a better time if I drink alcohol
	DRUNKOK	It's OK to occasionally get very drunk
	ALCSTUP	I think people who drink too much are stupid
DRIVTIRE	TIREDAY	How often do you feel tired when driving during the day?
	TIRENITE	How often do you feel tired when driving during the night-time?
ENJDRIVE	ENJOY	How often do you enjoy driving?
	PREFDRV	I prefer to drive rather than be a passenger in a car
	PREFTRAN	I prefer to use public transport rather than drive
FACTORH	SPURMOM	I like to do things on the spur of the moment
	PLANNED	I like my life to be planned and organised
	CONSEQ	I don't do anything without first considering the consequences
FACTORL	CHANCES	I don't like taking chances
	WORRY	Nothing much worries me
FACTORQ3	ADVICE	I like taking advice from other people
	ANNOY	I get annoyed when I'm not allowed to do what I want to do
	OWNWAY	I prefer to do things my own way
INTEREST	SERVICE	How do you get your car serviced?
	WASH	How often does your car usually get washed?
	CUSTOM	(Investigator does visual check for personalised number plate)
TOTSAT	SATISFY	On the whole, I'm satisfied with myself
	LIFESAT	I'm satisfied with my life in general

Summary variable name	Questionnaire variable name	Questionnaire variable description
UNSAFACT	WEARBELT	How often do you wear your seatbelt while driving?
	STOP	How often do you stop at stop signs?
	DRINK	How often do you drive after having a few drinks?
	SPEDBUA	How often do you drive more than 10 km/h above the speed limit in built up areas?
	SPEDOPEN	How often do you drive more than 10 km/h above the speed limit on open roads?
	SPEDDAY	How often do you drive more than 10 km/h above the speed limit during daytime?
	SPEDNITE	How often do you drive more than 10 km/h above the speed limit at night-time?
UNSAFATT	ENJFAST	How often do you enjoy driving faster than other traffic?
	NOBELT	How often do you prefer not to wear a seatbelt?

APPENDIX 8: RBT SURVEY - VARIABLES USED IN PRINCIPAL COMPONENTS ANALYSIS

Variable name	Variable description	Transformation (if any)
ALCOHOL	Positive view of alcohol (*Summary variable*)	Dichotomized: 'Low' versus 'high'
ANGRY	Frequency of getting angry at actions of other drivers	Dichotomized: 'Low' versus 'high'
CHILD	Any children under 12 years old	Dichotomized: 'Yes' versus 'no'
DRIVTIRE	Frequency of feeling tired when driving (*Summary variable*)	Dichotomized: 'Less' versus 'more often'
ENJDRIVE	Enjoyment in driving (*Summary variable*)	Dichotomized: 'Less' versus 'more'
FACTORH	Adventurous/impulsive (*Summary variable*)	
FACTORL	Easygoing/chance-taking (*Summary variable*)	
FACTORQ3	Self-control (*Summary variable*)	
INTEREST	Interest in car (*Summary variable*)	Dichotomized: 'Less' versus 'more'
LEGALAGE	State minimim legal licensing age	
MARDEF	Relationship status of respondent	Dichotomized: 'Single' versus 'other'
MODIF	Modifications to car (body, suspension, mechanical, wheels)	Dichotomized: 'Yes' versus 'no'
MORT	Respondent pays a mortgage	Dichotomized: 'Yes' versus 'no'
RENT	Respondent pays rent or board	Dichotomized: 'Yes' versus 'no'
UNSAFACT	Unsafe driving actions (*Summary variable*)	Dichotomized: 'Low' versus 'high'
UNSAFATT	Unsafe driving attitudes (*Summary variable*)	Dichotomized: 'Low' versus 'high'
VOLUME	Volume of radio/cassette when driving	Dichotomized: 'Off'/'soft'/'moderate' versus 'loud'
WAXPOL	Frequency car waxed or polished	Dichotomized: 'At least every 3 months' versus 'less often'

APPENDIX 9: RBT SURVEY - VARIABLES USED IN REGRESSION ANALYSIS

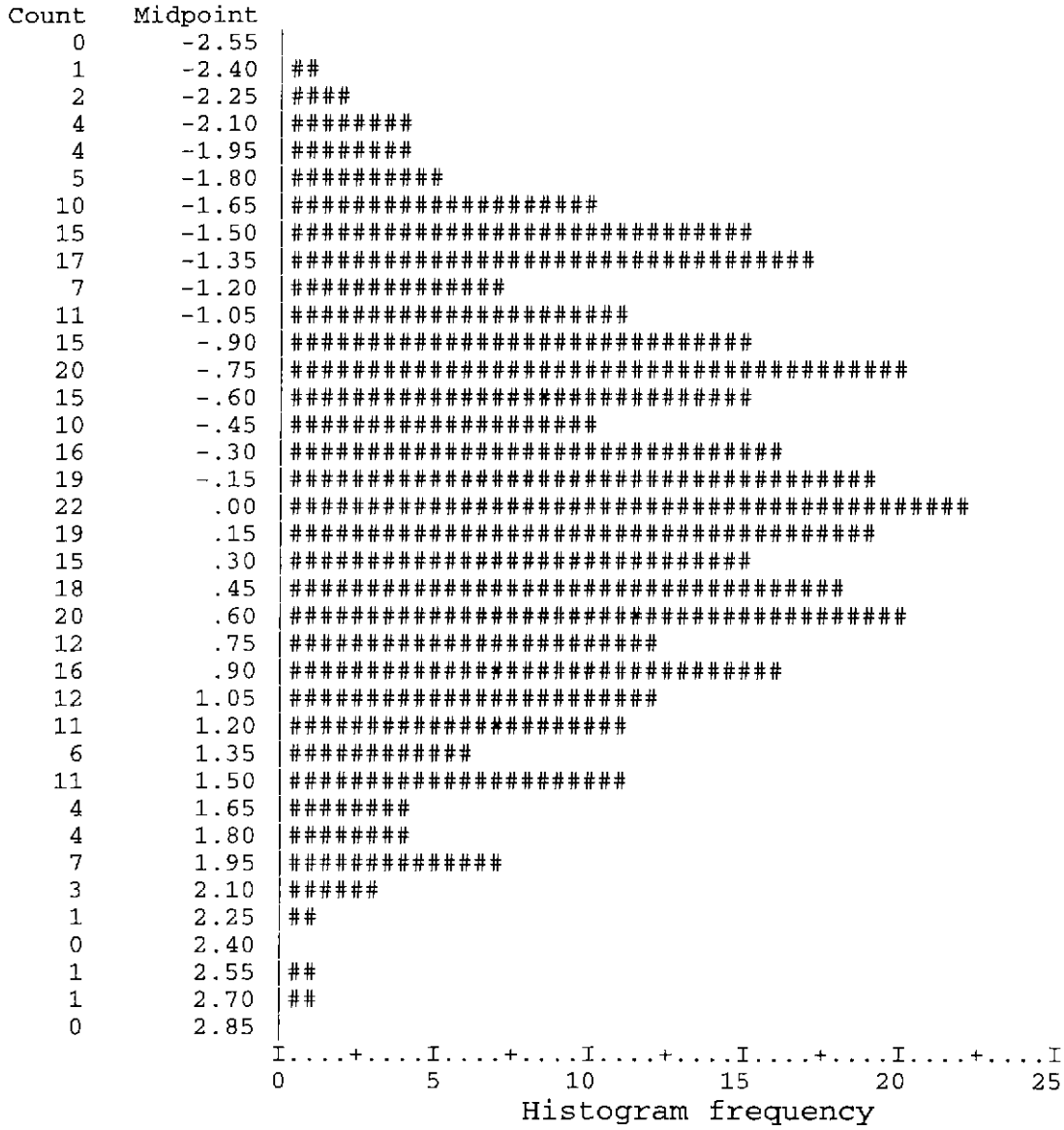
Variable name	Variable description	Transformation (if any)
AGE	Age of respondent	
AGELIC	Age when licensed	ln (AGELIC-14)
EASYDAY	Easier to drive at night than during day	Dichotomized: 'Agree' versus 'disagree'
DRIVSEX	Sex of respondent	Dichotomized: 'Male' versus 'female'
EDUCN	Educational level attained	Dichotomized: 'Secondary'/'other' versus 'university'/'trade'/'technical college'
FACTOR1	Recklessness (*from Principal Components Analysis*)	
FACTOR2	Settled down (*from Principal Components Analysis*)	
FACTOR3	Rural (*from Principal Components Analysis*)	
METRU	Respondent lives in metropolitan/rural area	Dichotomized: 'Metropolitan' versus 'rural'
SMOKE	Respondent smokes	Dichotomized: 'Yes' versus 'no'
TOTSAT	Satisfaction total (*Summary variable*)	Dichotomized: 'Low' versus 'high'

APPENDIX 10: TELEPHONE SURVEY - ALL VARIABLES

Variable name	Variable description
ACCYEAR	Year in which the crash occurred
ACCMTH	Month in which the crash occurred
ANYACC	Any motor vehicle crashes in last three years in which the respondent was driving?
CASLTY	Did any casualties result from the crash?
DAYNITE	Did the crash occur during day or night
FROM	Origin of trip during which the crash occurred
NACC	Number of crashes in last 3 years in which the respondent was driving
PASS	Number of passengers in the respondent's vehicle when the crash occurred
OBJHIT	Object or road user hit by the respondent's vehicle
PASSACC	Were passengers present in the respondent's vehicle when the crash occurred?
SPDLIM	Speed limit at the site of the crash
TO	Destination of trip during which the crash occurred

APPENDIX 11: HISTOGRAM OF FACTOR 1 ("RECKLESSNESS")

Male respondents aged 20 or less



APPENDIX 11 (continued)

Factor 1 ("recklessness")

Female respondents aged 20 or less