The accident risk of motorcyclists

Prepared for Road Safety Division, Department for Transport

B Sexton, C Baughan, M Elliott and G Maycock

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Executive Summary

This report contains the findings of a study conducted on behalf of Road Safety Division, Department for Transport. The objective of the study was to explore and quantify the interacting influences which determine motorcyclist accident (and casualty) liabilities.

The study first reviewed existing data sources to investigate the trends in motorcycling accidents over the last decade or so. Analysis of this trend data, along with other published national data showed no evidence that the emergence of a previously unrecognised risk factor is needed to explain the recent trends in motorcycle accidents. The data showed that the number of casualties either per motorcycle or per km travelled has been fairly stable over the last decade or so. Thus it would appear that the increase in the number of casualties is mainly due to the increased number of motorcycles and the increase in the distances being travelled.

The main part of the study was to carry out a survey of current motorcyclists designed to explore the relationship between accident (or casualty) risk and variables such as annual mileage, age, experience, journey type, training, personal characteristics of the riders, and the self-reported behaviours and attitudes of the riders.

After careful design and piloting, a questionnaire was sent to 30,000 motorcyclists who were current riders and whose motorcycle was privately owned. About 40% of recipients responded to the questionnaire mailing and this provided 11,360 responses for analysis. The questionnaire asked about riding experience, accidents (including minor spills and more serious accidents), whether the rider was to blame, and a number of 'psychological' measures related to the rider's behaviour and attitudes. The questionnaire also asked for basic data about the rider's age, sex, socio-economic status, and car driving experience.

Analysis of the data returned by respondents showed that male riders were in the majority; female riders constituted only 9% of the sample. Just over 11% of male riders and just over 15% of female riders were accident involved in their past 12-months of riding, the overall accident involvement for all riders being 11.7%.

The number of accidents reported by riders within the past 12-months of riding were modelled using generalised linear techniques to take into account factors such as mileage, age, experience, bike size and the conditions prevailing when they rode (summer/winter, wet/dry etc). The multivariate model found that all these factors were important in 'explaining' accident involvement. The sex of the rider, whether the rider had taken compulsory basic training, or whether he or she had 'taken a break from riding' did not enter the model as statistically significant variables. The findings may be summarised as follows:

Annual mileage – the relationship was non-linear in that accident liability was proportional to mileage$^{0.4}$.

Age and riding experience – accident liability fell with increasing age and increasing experience (number of years riding). The magnitude of the age effect was such that for a novice 'all season, all weather' rider with a single year's experience, accident liability fell from 0.65 at age 17 to 0.19 at age 60.

A *'rider dedication'* hierarchy showed that after mileage, age and experience differences had been allowed for, 'all season, and all weather riders' (Category 1) had the highest accident liabilities. 'Summer all weather' riders (Category 3) had liabilities which were 41% lower than Category 1 riders and 'Summer occasional' riders (Category 4, 5 or 6) had liabilities which were 59% lower.

Bike size – once mileage, age and experience had been allowed for in the model, riders of bikes over 125cc had accident liabilities (for 'all accidents') that were 15% lower than riders of smaller bikes. However, there appeared to be an effect of bike size on accident severity, such that the higher accident risk of bikes of 125cc and below was restricted mainly to the least severe accidents. This is consistent with previous work that has shown a risk per mile of fatal accidents that increases with engine size.

Two models of rider behaviour were developed using statistical modelling techniques. In these models attitudes/ motivations/perceptions and rider style influence rider behaviour, which in turn influence the likelihood of accident involvement. Age, sex and experience may influence both attitudes and behaviour, and may also have a direct influence on accidents. Accident risk is also directly influenced by the number of miles ridden in the past 12-months.

The reported frequency of errors was the most important behavioural contribution to accident involvement (once the mileage effect had been taken into account). Traffic errors (mostly associated with failures of hazard perception or observational skills) were the most consistent predictors. Control errors (mainly to do with difficulties of control associated with high speed, or errors in speed selection) were also important in some analyses. However, these errors occur in a context that suggests they may be closely linked with riding styles involving carelessness, inattention and excessive speed – i.e. styles that might be termed 'violational'.

When age and experience were not permitted to influence accidents directly in the model, stunt/high risk behaviours became significant predictors of accidents. This is consistent with the explanation that one of the risk-increasing characteristics of young or inexperienced riders is their tendency to indulge in overtly risky behaviours.

Riding style, getting pleasure from motorcycling, and a liking for speed were identified as predictors of behavioural errors (that were, themselves, predictors of accidents). These predictors were also inter-correlated. Such relationships lend support to the view that an important part of the motorcycle safety problem stems directly from the motivations for choosing to ride motorcycles. This presents a challenging problem for road safety.

The report makes a number of recommendations for improving the safety of motorcycle riders including the following:

- Young, inexperienced riders should continue to be a target group for safety interventions – they are at particularly high risk and they can be reached by the training/testing/licensing system. It would be useful to undertake research to develop and validate suitable interventions for these riders – which might include elements of graduated licensing as well as improvements in training and education.
- As motorcyclists become more experienced and develop improved riding skills they may make more demands on those skills as they continue to seek fun and excitement from motorcycling. There may be potential in the training and rider development provided by the advanced motorcycling organisations to promote a careful, safe, responsible riding style, perhaps by promoting alternative aspirations for motorcyclists – e.g. competence, wisdom and safety rather than excitement, 'progress' and speed.
- Although behavioural errors associated with lack of control skills show a consistent relationship with accident liability, they tend to be errors associated with an 'enthusiastic' riding style. This reinforces the by now well-recognised need for rider and driver training not to focus on control skill alone, but to improve insight into risk and self-limitations.
- There was no evidence that people returning from riding after a long break are at increased risk (though the study was not able to rule out a short term increase in risk). Nevertheless, returning riders increase the amount of motorcycling and the number of motorcycling accidents. Consideration should be given to developing training and educational material for these riders and to encouraging them to participate. This might be done in collaboration with manufacturers, insurers and motorcycling organisations.
- Given the very striking facts about the risks faced by motorcyclists, it would seem desirable to make sure that riders are actually aware of these risks. This might encourage riders to modify their riding behaviour or to take-up further training. Ways of communicating the risks of motorcycling should be explored, and riders' current understanding of these risks assessed.

1 Introduction

Motorcyclists are more at risk of being killed or injured in a road traffic accident than any other type of vehicle user. In 2001 there were over 580 motorcycle riders or passengers killed in road accidents, 7305 killed or seriously injured (KSI) and over 28,800 involved in reported injury accidents (all severities).

The risk depends on factors such as the rider's age, sex, experience, type of road, characteristics of the motorcycle and exposure. The assessment of risk is complicated by interactions between these and other factors. This report contains the results and findings of a study conducted on behalf of Road Safety Division, Department for Transport, with the objective of exploring the interacting influences of various factors upon the trends for motorcyclist casualties.

The current pattern of motorcyclist casualties is very different from that of a decade and more ago when young motorcyclists on smaller capacity machines accounted for most of them. This arises, at least in part, from the changes in the types of motorcycles being ridden. There has been a long term trend towards the use of the larger machines (over 500cc engine capacity) such that by 1996 they accounted for over two thirds of the motorcycle stock and nearly two thirds of fatalities (Elliott *et al.*, 2003). In addition, there have also been recent developments in the 'powered two-wheeler' market, with sales of motor scooters increasing.

In order to understand the reasons for the changes that have occurred in motorcycle accidents over the last decade or so, we need to know much more about the trends in the characteristics of the machines that motorcyclists choose to ride as well as the changes in the skills, experience and attitudes of the riders themselves. This report contains the findings from a study that collected such information and explored the interacting effects of these and other variables on accident risk with a view to identifying accident remedial measures.

The study included two tasks. The first was an analysis of existing data sources, such as STATS19 and the National Travel Survey, to identify trends and to assess, within the limitations of the available data, the influence of variables such as exposure, age, riding experience and sex on accident risk. The second task was to undertake a survey of current motorcyclists, so as to enable variables such as attitudes, personal characteristics, self-reported riding behaviours and level of experience and training to be explored as contributors to accident risk.

Section 2 summarises the main findings of the survey of trends using existing data sources. Sections 3 and 4 describe the survey; the development of the questionnaire is discussed in Section 3 and the characteristics of the sample of motorcyclists are described and illustrated in Section 4. Section 5 describes a multivariate analysis of the basic response data (excluding the psychological data) using a Generalised Linear Model. Section 6 describes a more complex model in which accident risk is related to the riders' self reported behaviour and attitudes; the model is fitted using a structural modelling approach. Section 7 reviews motorcyclists' risk factors in the light of the earlier analyses, and Section 8 summarises the study giving conclusions and recommendations. Appendix A is a copy of the questionnaire, Appendix B presents the factor analysis of the psychological data, and Appendix C some of the results obtained from the Structural Equation modelling.

2 Trends in motorcycling

This section of the report presents background information culled from a variety of existing sources to examine the trends in motorcycle accidents and in the characteristics of motorcycling.

2.1 Trends in motorcycle accidents

Motorcyclists are more at risk of being killed or injured in a road traffic accident than any other type of vehicle user. Statistics for fatal and serious injury accidents involving motorcyclists showed an increase of 7 per cent in 1999 and 7 per cent in 2000 with a reduction of 1% in 2001. There were, however, still over 580 motorcycle riders or passengers killed in 2001, 6724 seriously injured and over 28,800 in total involved in reported injury accidents. The trends in injury accidents over the last decade or so are shown in Figure 2.1.1

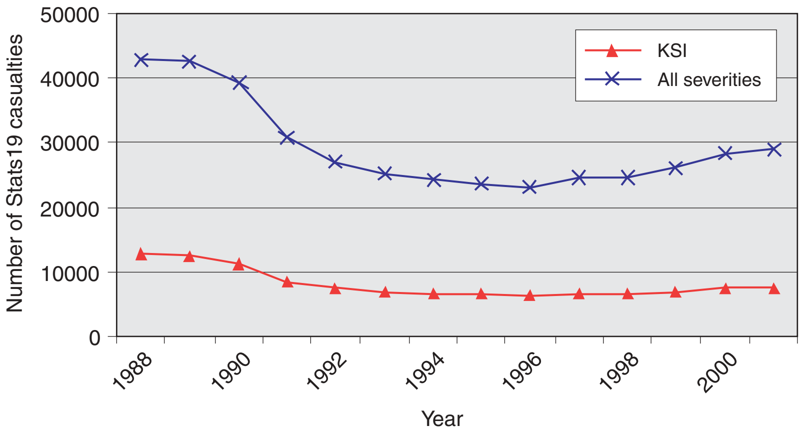

Figure 2.1.1 Number of casualties involving motorcyclists (and pillions)

2.2 Trends in motorcycle numbers and sizes

Figure 2.2.1 shows how the numbers of licensed motorcycles have changed since 1988. The curve for the total number of motorcycles shows that since 1995 there has been an increase in the number of registered motorcycles, such that the size of the motorcycle fleet in 2001 had increased to the level it was in 1989.

It would appear therefore that in simple terms, the upward trend in motorcycle numbers since 1995 is more than enough to account for the increase in casualties during the same period (Figure 2.2.1). This is shown more clearly in Figure 2.2.2 which shows the overall rate per 1,000 registered motorcycles from 1988 to 2001 for killed and seriously injured casualties (KSI) and all casualties. The rate per 1,000 registered bikes has generally been decreasing since 1991.

This simple conclusion is potentially complicated by the fact that during the same period, the mix of motorcycle engine sizes has been changing. Figure 2.2.1 shows a steady increase in numbers of machines over 500cc, and since 1997 a gradual increase in the number of smaller machines, this last trend being accounted for, at least partly, by the recent increase in popularity of motor scooters. Figure 2.2.3 shows trends in motorcycle casualties for each size of bike. Comparing Figure 2.2.1 with Figure 2.2.3 shows that for most sizes of bike, the trend in casualties is largely consistent with the trend in numbers of machines.

This is shown more clearly in Figure 2.2.4 which plots the casualties per 1000 motorcycles by size of bike. Unfortunately, only data up to 1996 are available for providing the detailed analysis by size of bike shown in Figures 2.2.3 and 2.2.4.

2.3 Motorcycle mileage

Although numbers of motorcycles provide a basic indication of exposure to risk, and thus a basic explanation of trends in accidents, a more direct measure of exposure is provided by mileage ridden. The change in motorcycle mileage estimated from traffic counts (Road Casualties Great Britain, 2002) between 1990 and 2001 is shown in Figure 2.3.1. The distance covered by motorcycles fell by 50% between 1990 and 1993, and then remained relatively stable until 1998 when it starting increasing. This pattern is broadly consistent with the casualty trend in Figure 2.1.1, though casualties did start to rise slightly earlier than the upturn in annual mileage.

More detail is given in Figure 2.3.2, which plots the number of motorcyclists who were killed or seriously injured (KSI) per 100 million kilometres ridden and the number of all-casualties per 100 million kilometres. It shows the rate dropped from 1990 to 1991 and since then has remained fairly stable.

This mileage information is not available by engine size but Broughton (1998) showed, using journey data collected

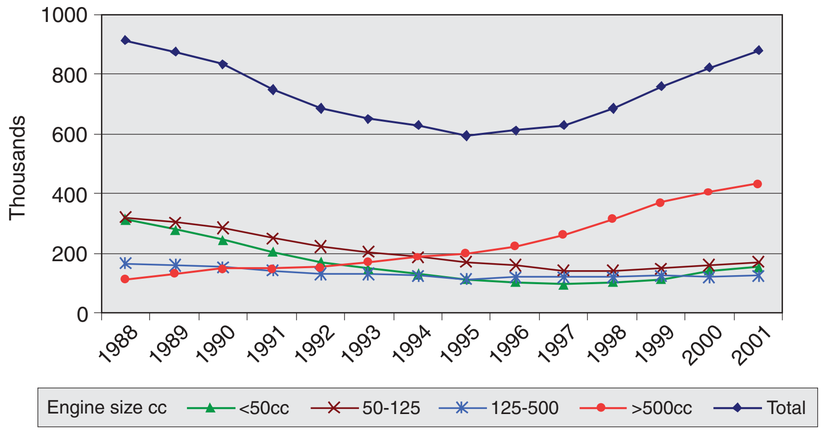

Figure 2.2.1 Number of motorcycles currently registered by engine capacity

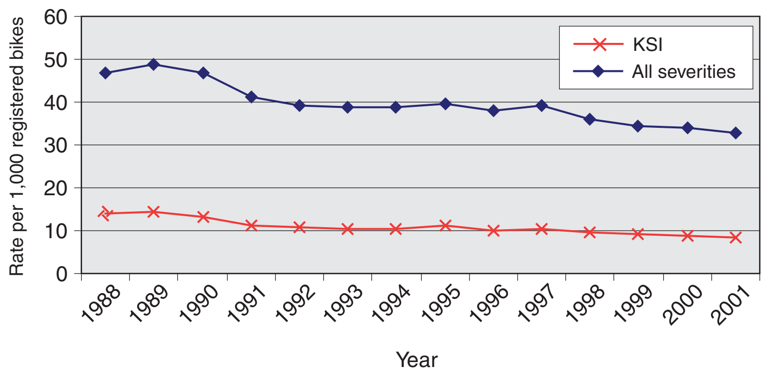

Figure 2.2.2 KSI and all casualties per 1,000 registered motorcycles

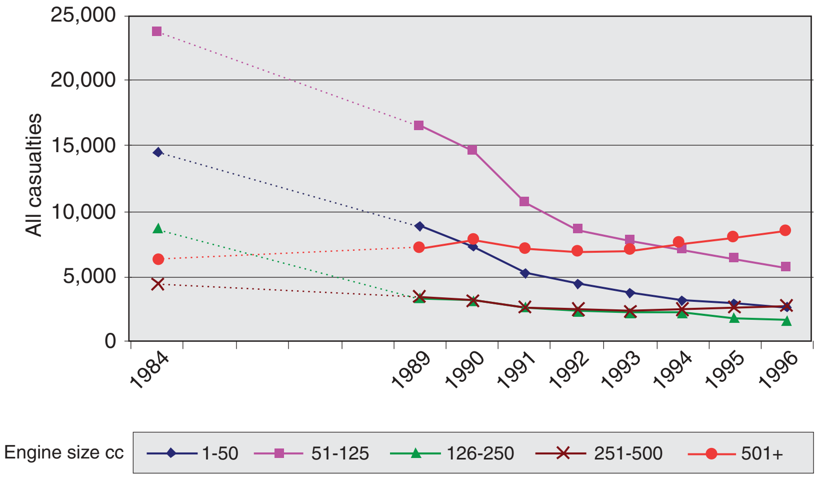

Figure 2.2.3 Number of motorcyclist casualties by engine size of bike

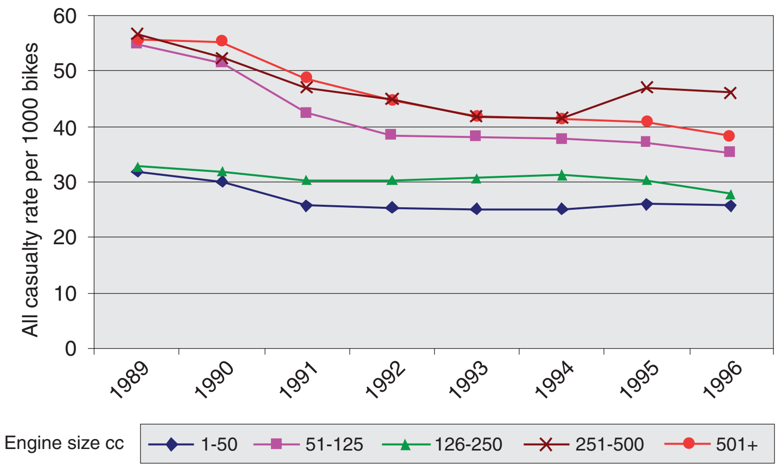

Figure 2.2.4 Casualties per 1,000 registered bikes

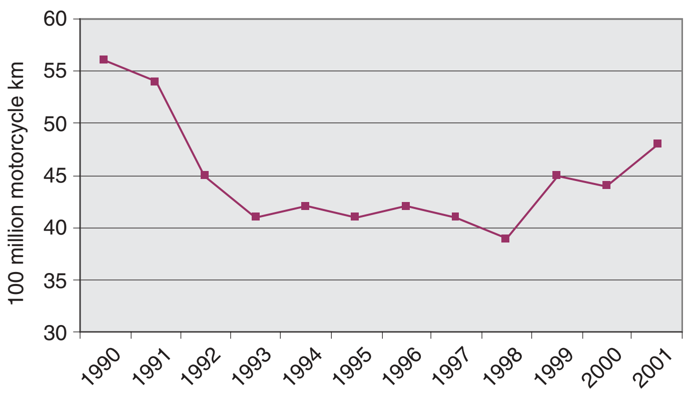

Figure 2.3.1 Distance travelled by motorcyclists

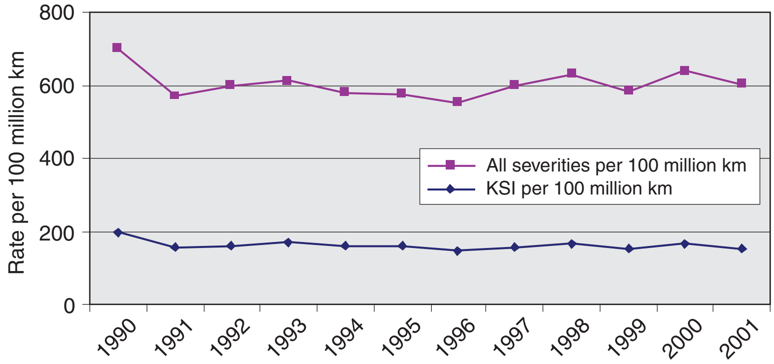

Figure 2.3.2 Rate of killed or seriously injured and all casualties per 100 million km

from the National Travel Survey in 1985/86, that annual mileage increases markedly with engine capacity. This was true also in the survey to be presented later in this report. Figure 2.3.3 plots the average annual mileage by the size of bike for those riders who were accident involved and for those riders who were not accident involved. It clearly shows that the bigger the bike the more miles are ridden. The effect of exposure to risk is demonstrated by the difference between the two plots in the figure.

Figures 2.2.2 and 2.3.2 show that the number of casualties either per motorcycle or per km travelled has been fairly stable over the last decade or so. This it would appear that the increase in the *number* of casualties is mainly due to the increased exposure to risk (measured by numbers of motorcycles or by annual mileage).

2.4 Rider age

Although trends in overall exposure to risk appear to be sufficient to explain accident trends, changes in the age distribution of casualties also need to be considered. Figure 2.4.1 shows the number of killed or seriously injured casualties (KSI) occurring each year since 1990. During the first half of the decade there was a significant

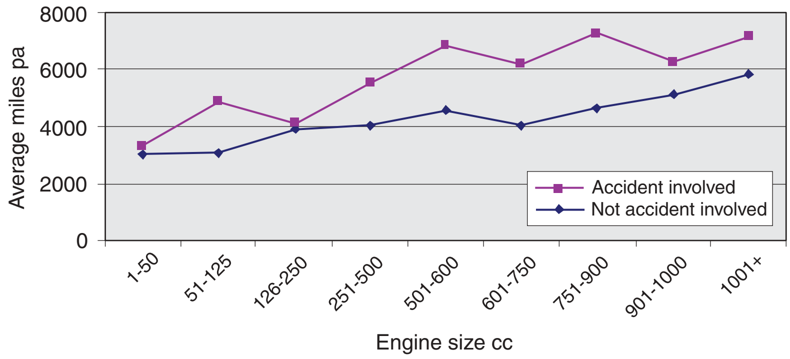

Figure 2.3.3 Average annual mileage by capacity of motorcycle

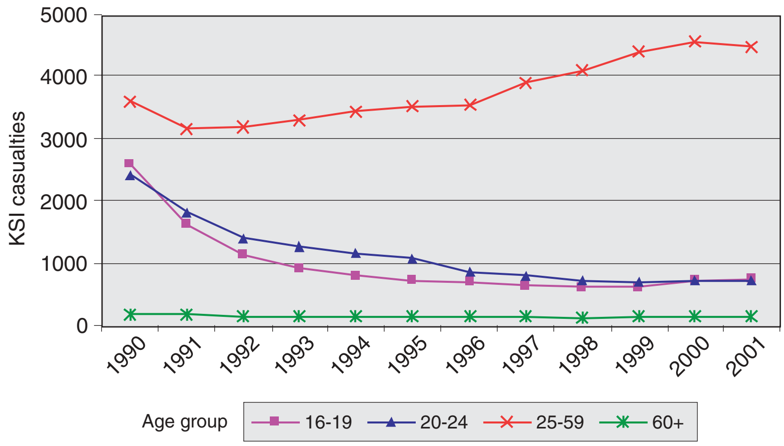

Figure 2.4.1 Motorcyclists killed or seriously injured by age group

fall in the number of young riders (aged 16-24yrs) being killed or seriously injured. However, for the 25-59 age group there was a steady rise in KSI numbers throughout most of the decade.

Whether this pattern can be explained simply in terms of changes in numbers and exposure of motorcyclists of different ages cannot be answered directly from published statistics. However, a trend in age can be confirmed by comparing age distributions of riders in the survey to be presented later in this report with the earlier survey of Taylor and Lockwood (1990). In the earlier survey about 15% of respondents were aged less than 20 years and had an average of 0.93 accidents per year. The current survey has only 4% of respondents under 20 years of age and they have an average of 0.58 accidents per year.

2.5 Implications of trends in motorcycling

The trends in motorcycle casualties presented in this section can be broadly explained in terms of changes in numbers and sizes of motorcycle, and the mileage that they cover. Changes in the age distribution of casualties are also broadly consistent with the available data on changes in the age distribution of riders. It would therefore appear that the increasing trend in motorcycle casualties since 1996 does not, in itself, indicate the emergence of new or previously unrecognised risk factors for motorcyclists.

This is not the same as saying that motorcyclists' accident risk is acceptable, or that no action is needed to improve motorcycle safety. First, any situation in which the absolute numbers of KSI casualties are increasing merits attention from the road safety perspective. Secondly, motorcycle user accident risk is far higher than that of the car user. This is particularly true for accidents resulting in serious injury or death, where the casualty rate per 100 million vehicle kilometres is nearly 30 times higher for two wheeled vehicle users than for car users (Road Casualties GB, 2002)[1]. Thirdly, current trends involving increased recreational riding on powerful motorcycles, and increased use of scooters by young riders, may well continue. Indeed they may tend to accelerate as disposable income (for recreational riding) rises, and as traffic congestion and congestion charging increase. Fourthly, the gap in relative risk between cars and motorcycles seems likely to widen as improvements in primary and secondary safety become incorporated in the car fleet.

Clearly, therefore, it is highly desirable to find ways of improving motorcyclists' safety – and to do this an understanding of the factors underlying motorcyclists' accident risk is needed. Such factors potentially include the age and experience of the rider, 'rider type', attitudes, motivations, riding style, skills, and behaviours such as errors and violations. In addition, the size and type of motorcycle, and the purposes for which it is used, are potentially important. The survey to be presented in the remainder of this report aims to provide further insight into many of these issues.

3 The design of the motorcycle survey

3.1 Introduction

This section describes a survey of current motorcyclists, intended to enable variables such as attitudes, personal characteristics, self-reported riding behaviours and level of experience and training to be explored as contributors to accident risk. Originally the study was intended to focus on injury accidents only. It was to compare a random sample selected by DVLA of current motorcyclists with a sample of motorcyclists who were known (through STATS19) to have been involved in one or more injury accidents. The analysis would then apply a technique developed by TRL that was used in a study of work-related road accidents (Broughton *et al.*, 2003).

In practice however, this research design could not be used for the present study because of difficulties in getting permission to have questionnaires sent to riders with STATS19 injury records. Instead, a single large random sample of 30,000 current motorcyclists was obtained through access to the file of motorcycle keepers held by DVLA, and the questionnaire itself was used to identify riders who had been accident-involved. This, of course, meant that many of the accidents reported in the survey were 'damage-only'. All the motorcycles in the sample were privately owned so that there were no motorcycles in the sample belonging to motorcycle training organisations, motorcycle retailers or motorcycle courier firms. Respondents were required to be 'active' motorcyclists and so only owners of bikes which had been road taxed within the past 12 months were included. A questionnaire was developed (see Section 3.2) which was sent to the selected sample in the last two weeks of June 2002. Reminders were sent a month later by which time 8,500 had been returned (30% response rate). The survey was closed in early September by which time the number of returns was 11,360 (40% response rate).

3.2 The questionnaire

The questionnaire used in the survey was designed to tap those variables regarded as likely to influence accidents involving motorcycle riders and which could be measured using self-reported questionnaire scales. Its coverage was therefore guided by the model of motorcycle behaviour discussed in Section 6. The questionnaire was pre-piloted using focus groups of motorcycle riders, and later piloted using a postal survey.

The focus groups included motorcyclists of differing ages from a range of backgrounds with varying levels of motorcycle riding experience. There were three groups in all, each comprising five or six motorcyclists and two TRL researchers. Participants were encouraged to talk about their involvement in motorcycling and the accidents they had experienced. They were asked for their views on the questionnaire. Their comments were incorporated into a revised version of the questionnaire which was then piloted.

The pilot sample consisted of about 1,000 motorcyclists and was drawn at random by DVLA. The questionnaire was further revised as a result of the pilot survey; in particular, the factor analysis to the pilot survey responses allowed the questionnaire to be shortened while still measuring the underlying factors with adequate reliability. The questionnaire, which is presented in Appendix A consisted of four sections (Sections A-D) as described below.

3.2.1 Section A: The rider's riding experience

Section A consisted mainly of descriptive variables. These were:

- Whether or not the rider had ridden in the last year.
- Various aspects of the rider's experience.
- An estimate of the mileage ridden on public roads in the last 12 months. Respondents were asked to state their overall annual mileage as well as the mileage ridden of each type of motorcycle used by the respondent split by summer and winter.
- The engine size of bike most often ridden on public roads split by summer and winter use.
- How often a motorbike had been ridden on public roads by road type and journey purpose – also split by summer and winter.
- A comparison between the amount of motorcycle use in the current year compared to the year before by road type and trip purpose.
- The number of licence endorsement points accumulated whilst riding a motorcycle (not including minor infringements).
- Information about the training courses the respondent had taken.
- Whether or not the respondents belonged to a motorcycling organisation or club.

3.2.2 Section B: Accidents

Section B of the questionnaire elicited information about respondents' road accidents and 'near misses'. Respondents were first asked how many road accidents (including minor spills) they had been involved in while riding a motorbike on a public road in the last 12 months. Those respondents who reported having been accident involved were then asked for the following information relating to their 3 most recent accidents:

- The date the accident(s) occurred.
- An indication of 'what happened first' in the accident(s) (i.e. the primary point of impact).
- Whether or not the accident(s) was a minor spill or a low speed manoeuvring accident.
- The type of road on which the accident(s) occurred.
- The road and weather conditions at the time of the accident(s).
- The severity of the injuries sustained by respondents and other road users as a result of the accident(s).
- The extent of the damage caused to the motorbike and to other vehicles in the accident(s).
- The type of motorbike being ridden at the time of the accident(s).
- The purpose of the journey being made when the accident happened and the time of day.
- The extent to which respondent felt to blame for the accident(s).

Riders were finally asked to estimate how many times they had had the impression of only just avoiding an accident (a 'near miss').

3.2.3 Section C: Rider behaviour, motivation and attitudes

Section C of the questionnaire consisted of items intended to quantify the riders' behaviour and attitudes. This information was collected in order to build a statistical model which would help to provide some understanding of the psychological antecedents of motorcycle accidents. The rationale for the choice of these variables and how they were to be incorporated into a behavioural model will be described in Section 6.

There were two 'mini-questionnaires' embedded into this part of the main questionnaire. One was a 'Motorcycle Rider Behaviour Questionnaire' (MRBQ) and the other a 'Motorcycle Rider Motivation Questionnaire' (MRMQ). Also included were items relating to the wearing of safety equipment, accident causes, riding skills, accident involvement with other riders and a motorcyclists 'riding style' scale.

The 'Motorcycle Rider Behaviour Questionnaire' (MRBQ) required respondents to rate how often (on a 6-point scale from 'never' to 'nearly all the time') they engage in certain behaviours while riding a motorbike. The MRBQ was based on the Driver Behaviour Questionnaire (DBQ) developed at Manchester University (Reason *et al.*, 1990). Of the original 50 DBQ items, those that applied to motorcyclists or could be modified to do so were retained, and the rest dropped. Some new items were added. Focus groups were used to refine the items, 50 of which were then selected for use in the pilot survey. Following factor analysis of the pilot survey data, this pool was reduced to 43 items, loading onto five underlying factors which are described in Section 6. The detailed factor analysis of the MRBQ for the main survey sample is presented in Appendix B.

The Motorcycle Rider Motivation Questionnaire (MRMQ) was designed to assess the motivations of motorbike riders, and was based on the work of Schulz and colleagues (e.g. Schulz *et al.*, 1991). This part of the questionnaire required respondents to rate on a 5-point scale, how strongly they agreed or disagreed with a number of statements about motorcycling. The final version of the MRMQ used in this study contained 24 items. The starting point for developing the MRMQ was a 57 item questionnaire translated from German, and reported by Brendicke 1991. Further items judged to measure Brendicke's 12 rider motivations were devised and added to the pool, as were items designed to measure two further motivations – 'economic' and 'convenience' – identified by Elliott *et al.* (2003). After refinement by the focus groups 40 items were included in the pilot survey. Factor analysis identified three underlying factors (pleasure motives, speed motives and convenience/economic motives) and 24 items to measure these factors were retained for the main questionnaire. The MRMQ is discussed further in Section 6 and Appendix B includes a detailed factor analysis of the MRMQ for the main survey sample.

In addition to the MRBQ and the MRMQ items, the following sets of questionnaire items were incorporated into Section C of the questionnaire:

- Respondents were asked about the causes of accidents involving motorbikes. To assess opinions on accident causes, respondents rated on 5-point scales how much they agreed or disagreed with a number of statements such as 'accidents involving motorbikes are often caused by motorcyclist going too fast', or by 'drivers not noticing motorcyclists'. Factor analysis showed that this set of items represented two underlying factors, one related to accidents caused by the behaviour of the motorcyclists themselves and the other related to accidents caused by the behaviour of car drivers.
- Respondents were asked to assess how much better or worse they consider themselves compared to other motorcycle riders in terms of a number of riding skills. Five items, each requiring a response on a 5-point rating scale were used, including 'controlling the motorbike', 'spotting hazards' and 'anticipating what other road users are going to do'. Factor analysis showed that these items, together with a question asking riders to assess how likely or unlikely they were to be involved in an accident while riding a motorbike, were indicators of a single underlying factor related to self-assessed riding skill.
- Respondents were also asked to rate how often they used various pieces of safety equipment (e.g. protective and/or highly visible clothing) using a 6-point scale that ranged from 'never' to 'nearly all the time'. Factor analysis showed that these items were indicators of a single underlying factor.
- A riding style scale was also used. This was based on the driving style scale reported by Guppy *et al.* (1989), but worded in terms of motorcycle riding as opposed to car driving. It required respondents to rate their own riding style on twelve, 7-point semantic differential scales anchored at the ends – for example 'attentive – inattentive', 'selfish – considerate' and 'nervous – confident'.

This scale has proved to be useful in the past to predict car driver accidents (e.g. Maycock and Forsyth, 1997). The items represent three underlying factors, as described in Section 6.

3.2.4 Section D: Personal data, car driving experience

In the fourth and final section of the questionnaire information was obtained about the respondents' age, sex and socio-economic status. In this section, respondents were also asked whether they had driven a car or van in the last 12 months and if so, how many miles they had driven in a car/van in that time. They were also asked how many accidents, if any, they had while driving a car/van in the last 3 years.

4 The motorcycle survey data

4.1 Characteristics of the respondents

In the questionnaire, respondents were asked questions about themselves, their motorbike(s) and their biking habits. Space does not allow a complete tabulation of the extensive data, but the following paragraphs give an indication of the key characteristics of the sample.

4.1.1 Age

The distribution of the sample by age and sex is shown in Table 4.1.1. The mean age of all respondents was 43 years (44 for male and 38 for female riders) and the range from 15 to 94 years. The majority (90.9%) of respondents were male. The age distribution is fairly similar for males and females, with a peak for male respondents aged around 36-40, and a peak for female respondents aged 31-35. Clearly age, per se, has no causal implication in motorcyclist accidents; it is some psychological correlate of age which influences accident liability as the years pass. This is investigated in later sections of the report. However it is of interest to look at the distribution of age and sex within the sample and perhaps to note that there were 245 respondents who were aged over 70 years (2.2%).

Table 4.1.1 Number of respondents by age and sex

	Sex					
Age group (years)	*Male*		*Female*		*Total*	
	Count	*Col %*	*Count*	*Col %*	*Count*	*Col %*
16-20	421	4.1	106	10.4	527	4.7
21-25	317	3.1	73	7.1	390	3.5
26-30	663	6.5	121	11.8	784	7.0
31-35	1301	12.7	173	16.9	1474	13.1
36-40	1723	16.8	170	16.6	1893	16.8
41-45	1643	16.0	115	11.3	1758	15.6
46-50	1199	11.7	80	7.8	1279	11.4
51-55	1167	11.4	75	7.3	1242	11.0
56-60	781	7.6	50	4.9	831	7.4
61+	1028	10.0	59	5.8	1087	9.6
Total	10243	100.0	1022	100.0	11265	100.0

4.1.2 Miles ridden

The respondents reported having ridden an average of 4677 miles in the last 12 months (4823 for male and 3109 for female riders). Table 4.1.2 shows the distribution. The most frequently reported annual mileage range for both male and female respondents was 1001-2000. Very few respondents (2.6%) reported mileage of 15,000 and over. Males tended to ride higher mileages than females, relatively few of whom reported annual mileages of more than 3,000 miles.

4.1.3 Experience

Respondents were asked how long in total they had been riding on public roads, ignoring any long periods when they had taken a break from riding. The results are shown

Table 4.1.2 Annual motorcycling mileage by sex

Total bike miles	Sex: Male Count	Male Col %	Female Count	Female Col %	Total Count	Total Col %
None	2	0.0	0	0.0	2	0.0
1-500	805	8.2	169	18.6	974	9.1
501-1000	949	9.7	167	18.4	1116	10.4
1001-2000	1726	17.6	184	20.2	1910	17.9
2001-3000	1537	15.7	151	16.6	1688	15.8
3001-4000	1123	11.5	62	6.8	1185	11.1
4001-5000	973	9.9	52	5.7	1025	9.6
5001-7500	1061	10.8	56	6.2	1117	10.4
7501-10000	896	9.2	37	4.1	933	8.7
10001-15000	452	4.6	19	2.1	471	4.4
15001+	261	2.7	13	1.4	274	2.6
Total	9785	100.0	910	100.0	10695	100.0

in Table 4.1.3. They reported a mean level of experience of 15 years (16 for male and 8 for female riders) ranging from less than a year's experience to 73 years experience.

Table 4.1.3 Total years of motorcycling experience by sex

Experience (years)	Sex: Male Count	Male Col %	Female Count	Female Col %	Total Count	Total Col %
0-1	213	2.3	70	8.3	283	2.8
>1-2	726	7.7	168	19.9	894	8.7
>2-5	1643	17.5	224	26.5	1867	18.3
>5-10	1781	19.0	141	16.7	1922	18.8
>10-15	1085	11.6	77	9.1	1162	11.4
>15-20	986	10.5	83	9.8	1069	10.5
>20-25	895	9.5	40	4.7	935	9.2
>25-30	746	8.0	19	2.3	765	7.5
>30-35	406	4.3	10	1.2	416	4.1
35+	893	9.5	12	1.4	905	8.9
Total	9374	100.0	844	100.0	10218	100.0

Tables D1 and D2, in Appendix D, show the relationship between age and experience for male and female riders respectively. The tables show, as expected, that most young motorcyclists only have a few years of experience, whereas the older the rider the larger the range of experience. However, it is interesting to note that around 16% of men and 30% of woman over 40 have less than five years experience. The 41-45 age groups in particular have a large proportion of relatively inexperienced riders, with 21% of men and 49% of women reporting less than 5 years riding experience.

4.1.4 Breaks from riding

Respondents were asked if they had taken breaks of 12 months or more from riding and, if so, when they had returned to riding following their most recent break. Recent riding experience (as distinct from total riding experience shown in Table 4.1.3) was calculated from the time riding was resumed after the most recent break.

Female riders reported relatively few breaks and so their recent riding experience was similar to that shown in Table 4.1.3. In fact, only 24.2% of female riders reported that they had taken a break from riding.

In the case of male riders the most frequently reported band for recent riding experience was 2-5 years. In fact, for male riders there was almost an equal split between those who had taken a break from riding on public roads and those who had not, the figures being 49.3% and 50.7% respectively.

Overall nearly 70% of riders who took a break ceased riding for 5 years or more.

4.1.5 Size of bike

Respondents were asked what size of motorcycle they used most often 'last summer' and 'last winter'. Last summer the most popular bike size for male riders was 501-600cc (17.5%); for females it was 1-50cc (31.6%). Males tend to ride larger bikes than females. The proportions of male respondents reported riding bikes of 901-1000cc and over 1001cc was 10.2% and 14.4% respectively, whereas the corresponding figures for females were considerably lower (1.9% and 3.4% respectively). Few respondents, males or females, reported riding bikes with an engine size in the range 126 -250cc (5.5% and 5.4% respectively).

4.1.6 Bike use

Respondents were asked how often they had ridden different types of motorcycle last summer and last winter and to state the total mileage they had ridden on each type of bike. For each type of bike, the respondent was asked to tick one of the 'frequency-of-use' categories (daily, weekly or monthly). Generally, respondents were riding motorcycles less frequently last winter than last summer, though use depended to some extent of the type of bike. For example, 52.2% of sports motorcycles were used at least weekly last summer and 28.3% last winter. In the case of 'commuting/roadster' and 'scooter' use there was a significant proportion of respondents who reported 'daily' use (13-15%), regardless of season.

In the case of 'sports', 'touring' and 'commuting/ roadster' motorcycles, the most frequently reported mileage figure for the last 12 months was, 1001-2000 miles. However, the most frequently reported mileage category for 'off-road', 'classic', 'scooter' and 'moped' categories of motorcycle was 1-500 miles in the year. Very high mileages of 10,000+ miles were reported and mainly by respondents riding sports, touring and commuting / roadster motorcycles.

4.1.7 Bike use in previous year

Two thirds of respondents reported that the amount they had ridden on public roads in the last 12 months was about the same as the amount they rode on public roads the 12 months before that. Of the other respondents some reported an increase in riding activity and some a decrease. Hence there was little overall change in riding activity. Some items however did show some noteworthy changes; there were fairly large net increases in the amount of riding in built-up areas, and on country and rural roads and for pleasure/leisure purposes. There were also fairly large decreases in riding in fog or snow and ice, which may have just been a reflection of the prevailing weather conditions.

4.1.8 Training

Respondents were asked what training, if any, they had undergone in motorcycle riding. The course most commonly taken was Compulsory Basic Training; 50% of the respondents said that they had taken this. The next most taken course was the Direct/Accelerated Access course, and 15.2% of respondents reported having taken this course. 3.8% of the respondents reported taking an Advanced riding test.

30.4% of male riders and 19.2% of female riders reported being a member of a motorcycling organisation or club. Overall 29.4% of respondents were members.

4.1.9 Other

The majority of male respondents (94.4%) reported not having any licence endorsements for motorcycling offences in the last 12 months. 4.3% of the male respondents reported receiving 3 licence point endorsements in the last 12 months, and 0.8% 6 points or more. 98.0% of female respondents reported no licence endorsements in the last 12 months. 1.7% of female respondents reporting having 3 licence points and the remaining 0.3% received 6 points.

Respondents were asked whether they had driven a car or van in the last 12 months, approximately how many miles they had driven and whether they had had any accidents whilst doing so. Most respondents, (89.0%), had driven a car or van in the last 12 months. Males were more likely to have driven than females: 91% compared to 72%.

Most of the respondents (87.9%) reported having no accidents whilst driving a car or van in the last 3 years. 10.9% of the respondents reported 1 accident in the last 3 years and 1.2% reported 2 or more accidents whilst driving in the last 3 years. The proportions of male and female drivers reporting accidents were almost identical.

Respondents were also asked to indicate which occupational category best described their present work situation or, if retired, their main work situation prior to retiring. Overall, 21% reported being senior managerial, administrative or professional, 11% were middle managerial, and 23% were junior managerial. 30% reported being 'skilled manual workers', 9% 'semi skilled'.

4.2 Accidents

4.2.1 Numbers of accidents

Section B of the questionnaire asked respondents about any accidents (including minor spills) they had in the past 12 months while riding on a public road. Respondents were also asked for the date(s) of the accident(s). The survey had been sent out in June 2002 and the last questionnaires accepted were in early September. Table 4.2.1 shows the numbers of accidents that fell in the required 12-month period.

Table 4.2.1 Number of accidents in a 12-month period (according to the dates supplied)

	Males		*Females*		*Total*	
Accidents	*Number*	*%*	*Number*	*%*	*Total*	*%*
0	8663	88.7%	796	84.6%	9459	88.3%
1	922	9.4%	118	12.5%	1040	9.7%
2	144	1.5%	24	2.6%	168	1.6%
3	27	0.3%	0	0.0%	27	0.3%
4+	10	0.1%	3	0.3%	13	0.1%
Number of accidents	1331		178		1509	
Number of accident involved riders	1103	11.3%	145	15.4%	1248	11.7%

4.2.2 Accident characteristics

It will be seen from Table 4.2.1 that in all, 1509 accidents dated within the 12 month period were reported. Respondents were asked for details on the 'most recent accident', the 'next most recent accident' and the 'one before that'. This means that for those drivers who reported having 4 or more accidents in the past 12 months, only details of the three most recent accidents would have been obtained. Thus, details of a few accidents (<0.5%) would have been excluded.

Of the 1495 accidents for which some details were available 629 involved damage only, 664 involved injury to the rider involved in the accident and 187 involved a serious injury or a fatality. (The remaining 15 of the 1495 did not have enough information to make this classification.) Accident-involved respondents were asked 'To what extent do you think you were to blame for the accident(s)?' with possible responses of 'not at all', 'a little', 'quite a lot' and 'entirely'. Overall, riders felt that they were 'not at all' to blame in 57% of accidents, to blame 'a little' in 20% of accidents, to blame 'quite a bit' in 6% of accidents and 'entirely' to blame in 17% of accidents. The riders' opinions on blameworthiness of course depended on the type of accident and the circumstances attending the accident. In the paragraphs which follow, the phrase 'mainly to blame' represents the sum of the categories 'quite a bit' and 'entirely' to blame.

Riders were asked to indicate whether the regarded the accident as 'a minor spill' or 'a low speed manoeuvring accident'. 1126 accidents were classified as 'minor spills', 590 as 'low speed manoeuvring' and 345 were not assigned to either category. Some accidents were classified in more than one way, which accounts for the fact that the total of the above three figures is 2061, more than the total number of accidents reported.

Riders were asked to state what happened first in the accident – with 9 response categories being offered (question 16a).

The most frequently reported category (apart from 'other', which applied to 25% of accidents) was the bike leaving the road without colliding with any other object

(23%). The riders considered themselves mainly to blame in 36% of these accidents. The next highest category was that in which another vehicle collided with the rider (20%). The riders only consider themselves mainly to blame in 7% of these cases. In accidents in which the rider collided with another vehicle (17%), 22% or riders considered themselves to be mainly to blame. No other classification in this question exceeded 5%.

Most accidents (68%) were classified as occurring in built-up areas. The riders considered that they were mainly to blame for 19% of these accidents. 28% of accidents were classified as occurring on country/rural roads and riders considered themselves to be mainly to blame for 33% of these accidents.

Most accidents (57%) occurred in fine conditions, and 21% of these were considered to be mainly the riders' fault. The next most frequent condition in which accidents occurred was in the rain or on a wet road. This category accounts for 19% of accidents, and 25% of riders considered themselves mainly to blame for this category of accidents. Just over three-quarters of accidents (76%) happened during daylight hours.

Over half of the accidents reported (55%) occurred during commuting or work related riding, and it is likely that most of these would have been in built-up areas. Riders considered themselves not to blame for 59% of these accidents. 42% of accidents occurred when riding for pleasure, and 29% of these were thought to be mainly the rider's fault.

Sports and sports tourer bikes account for the largest group of accidents with scooters accounting for the next largest group. Just over 50% of sports and sports tourer bikes were being used for pleasure purposes when the accident occurred, whereas about 60% of scooters and commuting/roadster bikes were being used for commuting purposes when the accident occurred. These three types of bike (i.e. scooter, commuting/roadster and sports/sports tourer) account for two thirds of the bikes in the sample of accidents.

Riders were asked to specify whether there were any injuries sustained to themselves or to others as a result of the accidents and whether the injuries were slight, serious or, in the case of other road users, fatal. 'Seriously injured' was defined in the questionnaire as 'e.g. needing hospital care', 'slight injury' was defined as 'e.g. cuts and bruises'. Riders were also asked about the damage to their motorcycle or other vehicles involved in the accident. The data showed that 11% of accidents did not involve damage to the riders' bike, 68% involved slight damage and 21% involved serious damage. The corresponding figures for damage to other vehicles were 73%, 24% and 3%. In 46% of accidents the motorcycle rider was slightly injured and in 12% of accidents the rider was seriously injured. The corresponding figures for injuries to other road users were 4% and 1%.

The severity of injury sustained in an accident will tend to be related to the extent of the damage to the riders' bike and/or other vehicle(s) involved. The data show that where the bike was seriously damaged, then a third of the riders (33%) were seriously injured. In accidents where an 'other' vehicle was seriously damaged then over half of the riders (52%) were seriously injured.

4.3 Univariate accident relationships

Many interacting factors affect the accident liability of riders, and a multivariate approach is required in order understand the contribution of each in explaining accident risk. This multivariate analysis is explored in Section 5. However, the relationship between single variables and accident risk is first presented. It must be emphasised, however, that such univariate analyses can be misleading if we are trying to understand the factors that influence accident risk and devise countermeasures to reduce it. For example, age and rider experience are clearly related and to look at one without taking into account the other may produce misleading conclusions.

4.3.1 Exposure to risk

Exposure to risk, which consists of not just mileage, but the type of roads used and journeys undertaken, is clearly an important factor in the likelihood that a rider will be accident involved. The relationship between the annual miles ridden and accident involvement during the past 12-months is shown in Figure 4.3.1. The figure shows as

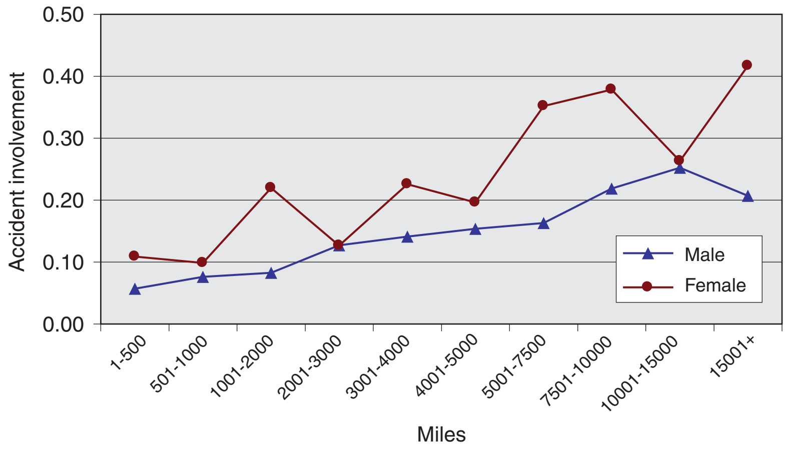

Figure 4.3.1 Miles ridden and the probability of accident involvement

expected that as the number of miles ridden increases then the likelihood of being involved in an accident increases. It also shows that the probability of being accident involved at most levels of mileage is higher for females than for males.

4.3.2 Rider age and experience

The relationship between age and accident involvement is shown in Figure 4.3.2. The figure shows that those in the 16-20 years old age group have a high likelihood of being accident involved compared to the 21-25 year olds, and a very high involvment compared to the 40+ year olds. The younger males and females have a similar accident involvement, whereas the older females seem to have a higher involvement than the older males – and it needs to be borne in mind that differences in annual mileage have not been taken into account in Figure 4.3.2.

Rider experience (the length of time a rider has been riding a motorcycle) is also a key accident predictor. The effect of experience is difficult to disentangle from that of age, since the two variables are correlated. But studies that have succeeded in estimating the separate effects of age and experience have shown that experience on its own has an important influence on accident risk (e.g. Maycock *et al.* (1991), Taylor and Lockwood (1990).

Experience for motorcyclists is difficult to quantify because riders often take long breaks from riding. Their experience therefore may consist of a period when they were young and learning to ride followed after a break of some years by a period when they returned to riding. The questionnaire asked about any breaks from riding and asked respondents to estimate their overall riding experience (in years) excluding any breaks they may have had from riding. Respondents were also asked when they last restarted riding after a break of over 12 months (if they had one) and an estimate of 'recent experience' since the most recent such break was then computed. Recent experience for those that had not taken a long break was the same as total experience.

Figure 4.3.3 shows the relation between accident involvement and these two measures of experience. Both plots show a strong trend for accident involvement to decrease as experience increases – though a part of this apparent experience effect will be associated with age differences. For riders with more than 5 years of experience, Figure 4.3.3 shows very similar levels of accident involvement regardless of how experience is measured, but at lower levels of experience the two plots diverge. This divergence is to be expected since the group with very low recent experience will include many older riders with substantial total experience (and a correspondingly low accident involvement in keeping with their age and experience) who have recently taken up riding again.

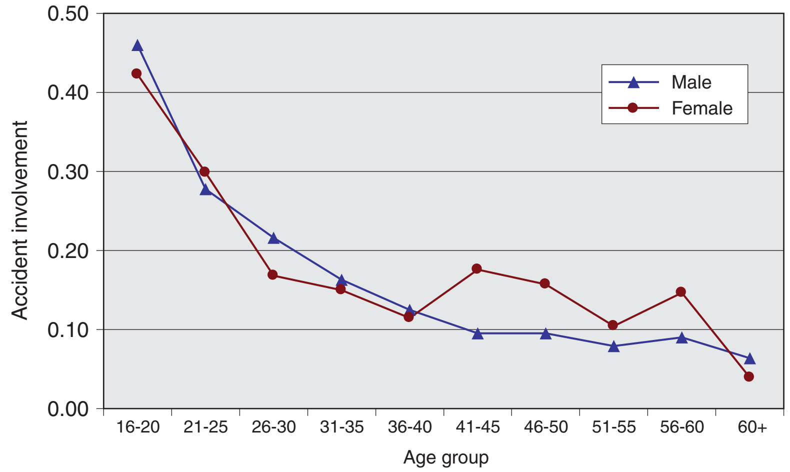

Figure 4.3.2 Age group, and probability of accident involvement

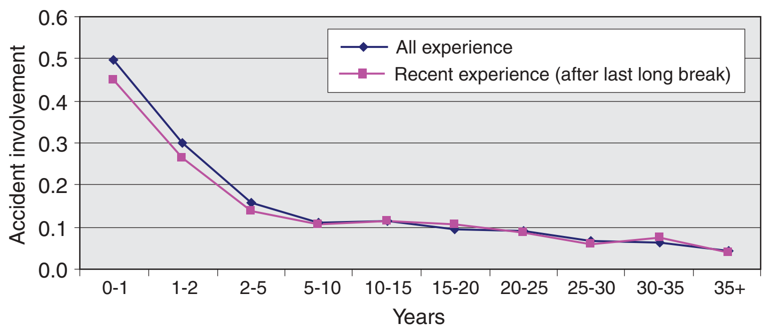

Figure 4.3.3 Rider experience and accident involvement

4.3.3 Engine size and type of bike

Another factor that is potentially an important influence on accident involvement is the 'size' of bike being ridden ('size' in this context refers to engine size). The situation is complex because engine size and power (and power to weight ratio) are not simply related. Generally speaking, up to 600cc the larger the engine size of the bike the more powerful the machine. Beyond 600cc however, power will depend upon the type of bike. For example, 600cc sports bikes develop as much or more power than 1200cc cruiser bikes. To complicate matters further, there are also likely to be interactions between bike size and the characteristics of the riders. For example, learners are likely to use bikes up to 125cc, but 50cc bikes (mainly scooters), are also likely to be used by commuters with varying levels of experience. The relationship between bike engine size and accident involvement is shown in Figure 4.3.4.

Figure 4.3.4 shows separate plots for 'all accidents' reported in the survey, 'non-minor' accidents (those not classified by the respondent as a minor spill or a low speed manoeuvring accident), 'no-injury' accidents, 'slight injury' accidents (i.e. accidents resulting in cuts and bruises) and 'serious injury' accidents (e.g. those needing hospital care). These categories are not all mutually exclusive. For 'all accidents', riders of motorcycles with engines up to 125cc have a much higher probability of accident involvement than riders of larger motorcycles, but beyond 125cc there is no obvious relationship between engine size and accident involvement. However, the excess accident involvement for bikes up to 125cc decreases as accident severity increases, such that for 'non-minor' accidents and 'serious injury' accidents there is no clear relationship between engine size and accident involvement across the whole range of bike size. Of course even if an apparent relation between accident involvement and bike size exists, this does not imply a causal link between the two because other factors, such as type of use, exposure, and rider age and experience are all associated with the size of bike ridden as well as with accident involvement. These effects, and the interaction between bike size and accident severity shown in Figure 4.3.4 will be returned to later.

A measure of accident involvement for the different engine sizes, adjusted for annual mileage is shown in Figure 4.3.5. The falling line in the figure shows the average number of accidents x 10^4/ the average annual mileage$^{0.4}$. This mileage exponent was derived from a

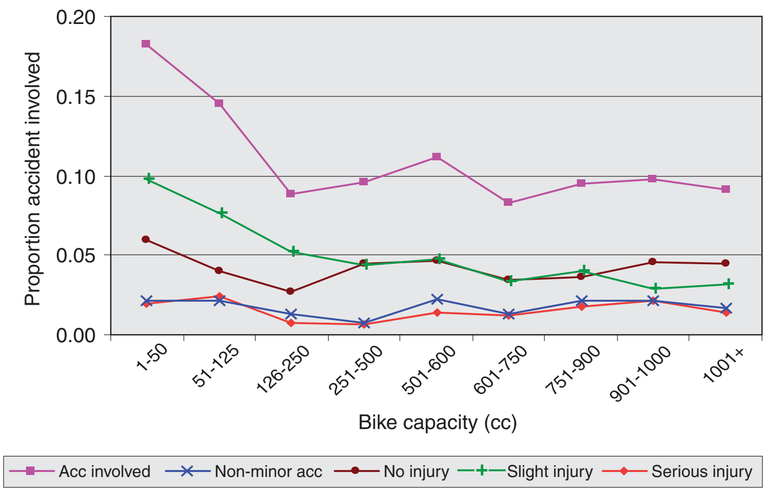

Figure 4.3.4 Bike engine size and accident involvement

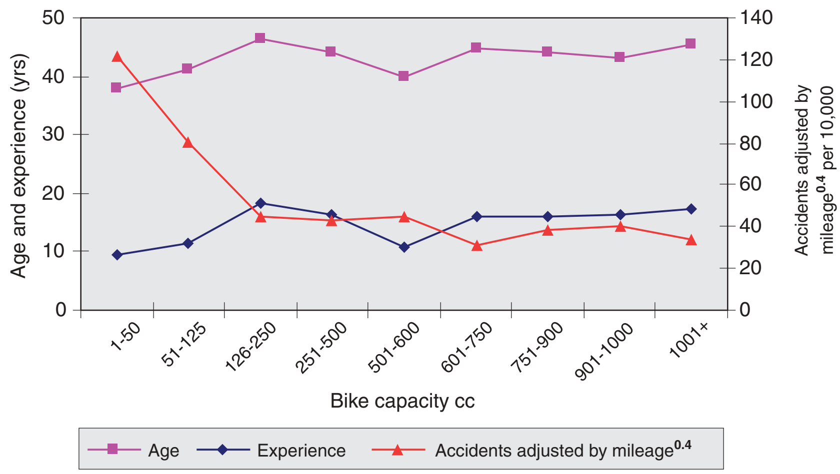

Figure 4.3.5 Age, experience and mileage adjusted accidents for different capacity of bikes

regression of mileage with accidents and is used to provide an accident liability index that adjusts realistically for mileage effects. The other lines in Figure 4.3.5 represent the average age and experience of the riders riding the various bike sizes. The mileage-adjusted accident rate for bikes over 125cc is half that for 51-125cc bikes, and a third of that for bikes of 50cc and below. The relative inexperience and youth of riders of smaller bikes is also shown. It remains to be seen whether the shape of the accident rate graph in Figure 4.3.5 can be explained by the differences in age and experience or not. This will be one of the key functions of the multivariate analysis.

Figure 4.3.6 shows similar information for the various categories of motorcycle. Clearly, moped and scooter riders have the highest adjusted (for mileage) accident risk and tend to be ridden by those riders with least experience

4.3.4 Training

Table 4.3.1 shows the probability of a rider being accident involved for riders who had (or had not) taken various levels of motorcycle training – specifically Compulsory Basic Training (CBT), Direct/accelerated access and a range of 'advanced' courses including the IAM Advanced Motorcycle Test, the RoSPA Advanced Riding Test, the Blue Riband Advanced Rider award, GNVQ 'Advanced' in Motorcycle Riding and some other (unspecified) advanced courses. The accident involvement figures have not been adjusted for mileage, though as the table shows average mileages differed little between the first three rows of the table. Note that in Table 4.3.1 riders are classified by the highest level of training taken, so that the Advanced level includes some riders who have also taken Direct Access training or CBT.

Table 4.3.1 Training level, accident involvement and mileage

	Number of riders	*%*	*Average mileage*	*Accident involvement*
None	5366	47%	4,616	0.08
CBT	3893	34%	4,508	0.16
Direct access	1665	15%	4,716	0.14
Advanced	436	4%	6,685	0.11

Nothing can be concluded from this univariate analysis about the effect of training on safety. The apparently anomalous result for those who have taken no training (i.e. respondents who did not tick any of the training options) may at least partly be explained by the age and experience of riders who learned to ride before CBT was introduced in 1990. This is explored further in Section 5.1.3.

4.3.5 Type of experience/exposure

The average accident involvement of riders classified by variables such as frequency of use (monthly, weekly, daily), type of road (built-up, country/rural roads, and motorways/dual carriageways), weather and lighting conditions and seasonal effects (winter/summer) was calculated from the raw data. This simple univariate analysis does not however yield easily interpretable results because of the complex interactions between these variables and the age, experience and exposure variables already considered. Thus for example, accident involvement may be higher for those riding in winter than in summer – but whether this is simply a reflection of increased annual mileage, or whether it indicates that winter riding is intrinsically more risky than summer riding, cannot be ascertained from such a simple analysis.

In an attempt to facilitate the interpretation of the data relating to the type of experience to which a rider is exposed, a typology of riders was defined. The underlying concept for this typology was to produce a hierarchy of 'rider dedication' ranging at one extreme from riders who ride in all circumstances including riding in the wet or dark during winter to those who ride only monthly, and only in the summer at the other. The hierarchy, consisting of 6 categories of riders, is shown in Table 4.3.2 together with the average mileage and the average probability of accident involvement in each of the groups.

The table shows that numerically speaking there are two main groups of riders – Category 1, those who ride in all

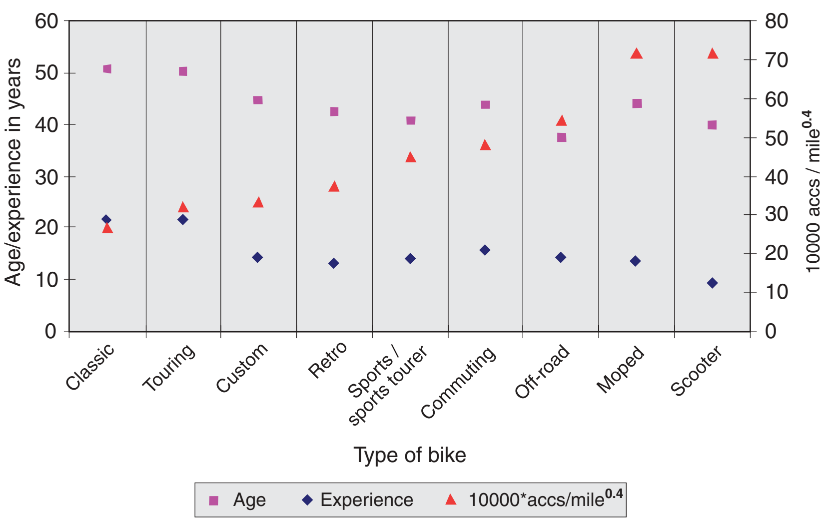

Figure 4.3.6 Age, experience and accident involvement for different types of bike, controlling for mileage

Table 4.3.2 Rider 'dedication' categories – a hierarchy of bike usage

Category	*Conditions the rider is willing to ride in*	*Number of riders*	*%*	*Average mileage*	*Probability of being accident involved*
1	Ride at least daily or weekly in the wet and/or dark during Winter, i.e. ride in all conditions	5154	45%	6,070	0.16
2	Ride at least daily or weekly during the Winter but not in the dark or wet	877	8%	4,300	0.11
3	Ride in all conditions during the Summer months but not ride in the Winter	3405	30%	3,690	0.07
4	Ride daily during the Summer, but not ride in the wet or dark or during the Winter	64	<1%	1,980	0.05
5	Ride weekly during the Summer, but not ride in the wet or dark or during the Winter	520	5%	2,330	0.04
6	Ride monthly during the Summer, but not ride in the wet or dark or during the Winter	462	4%	2,050	0.03
	Not definable or not known	878	8%	2,630	0.09

conditions throughout the year, and Category 3, those who ride in all conditions during the summer, but do not ride in the winter. The former have a much higher probability of accident involvement than the latter but, again, this does not tell us whether there is a particularly high risk from all-year riding, or whether the effect is explained by the differences in annual mileage and rider characteristics.

5 Modelling the survey data

An important focus of the project was to identify factors influencing motorcycle accident risk so that they can be used (a) to help explain trends in accident numbers and (b) to help identify priorities for remedial countermeasures. To accomplish this, given the inter-relationships between the possible explanatory variables, multivariate analysis is needed. Two approaches were taken: first, the generalised linear modelling method used extensively in earlier studies was used to investigate the relationship between accidents and variables such as rider age, experience, exposure, and bike size; these models are presented in this section. Secondly, a hybrid approach, using elements of structural equation modelling, factor analysis and generalised linear modelling was used to provide an insight into the contribution of rider-centred variables (attitudes, motivations, behaviours) to accident risk. These hybrid models will be described in Section 6.

5.1 Age, experience, mileage, training, bike size and 'rider dedication' as risk factors

Generalised linear modelling is a regression technique in which the dependent variable can be drawn from a range of non-Normal populations. In the present case, the dependent variable is the number of accidents that a rider has reported in a year, and this variable is assumed to follow a Poisson distribution. A statistical model can then be built using the statistical programme GLIM (Generalised Linear Interactive Modelling) which relates the number of accidents experienced by riders to a range of explanatory variables. The quantity predicted by such a model is the 'accident liability' of the rider which is the statistically expected number of accidents per year the rider will have. Accident liability in the case of motorcyclists is up to about 0.7 expected accidents per year.

In previous TRL studies of accidents (Taylor and Lockwood 1990, Maycock *et al.*, 1991, Maycock and Forsyth, 1997) a multiplicative model of the following form has been found to be suitable:

$$\begin{aligned} &\text{Log}_e \text{ (accident liability)} \\ &= b_0 + b_1 \log_e \text{(miles)} + b_2 \text{ f (age)} \\ &+ b_3 \text{ f (experience)} + b_4 \text{ f (other factors)} + \ldots. + \text{error} \end{aligned}$$

Where b_0, b_1, b_2, etc are coefficients to be estimated for the different functions of miles, age, experience etc., and 'error' is the residual error that is not accounted for by the fitted model.

Reciprocal age and experience functions have been found to be appropriate in previous studies (Taylor and Lockwood, 1990), and were again used in this analysis. It is also possible in these models to fit variables which are not continuous (as age, experience and mileage are) but are simple categories (like bike size). In this case, GLIM estimates a set of coefficient values, one for each level of the category variable.

GLIM estimates parameter values using maximum likelihood techniques and calculates for any particular model a 'goodness of fit' statistic called 'deviance' which is a measure of the discrepancy between the observed values and values predicted by the model. The statistical measure used to determine the importance of any specific variable within a model, is the 'deviance difference'; it is the difference between the deviance of a model which contains the variable in question and one which does not. It is thus a measure of how much better the model fits the observed data when the additional variable is included in the model. The 'deviance difference' statistic is distributed as a chi-squared variable and it can be used to test whether the additional variable is effecting a statistically significant improvement to the model fit.

Table 5.1.1 shows the model fitted to the motorcycle accident data. It will be seen from the table that in addition to annual mileage (miles), age and experience (both in reciprocal form), the model includes 2-level categorical variables for training and bike size, and a 6-level categorical variable for rider dedication (as defined in Section 4.3.5 above). In the case of the categorical variables one of the levels of the variable is taken to be a 'reference level' (see table). The coefficients for the other levels then quantify the

Table 5.1.1 Model variables fitted and parameters derived

Parameter	*Level*	*Estimate*	*Standard error*	*z-statistic*	*Deviance explained*
Constant, b_0	–	-6.647	0.219	30.39	–
Loge (miles), b_1	–	0.403	0.024	16.64	285.6 on 1df
1/(age+9), b_2	–	50.86	4.143	12.28	338.8 on 1df
1/(exper+6), b_3	–	6.028	0.680	8.86	51.6 on 1df
Training, b_4	Non-CBT	0.000	Reference level	–	3.8 on 1df
	CBT	0.078	0.045	1.71	
'Rider dedication', b_6	1 Winter wet/dark	0.000	Reference level	–	82.3 on 5df
	2 Winter	-0.103	0.081	1.27	
	3 Summer wet/dark	-0.521	0.055	9.47	
	4 Summer daily	-0.988	0.495	2.00	
	5 Summer weekly	-0.896	0.165	5.44	
	6 Summer monthly	-0.912	0.188	4.88	
Size of bike, b_5	Up to 125cc	0.000	Reference level	–	6.6 on 1df
	126+cc	-0.162	0.045	3.63	

differences between these other levels and the reference level (whose coefficient is nominally 0).

The model does not include the sex of the rider nor does it include a variable corresponding to 'taken a long break from riding' because neither of these factors were statistically significant[2].

The table shows the variables used as explanatory variables in the model, the coefficients and their standard errors estimated by the GLIM fitting process. The table also shows a z-statistic (the coefficient's value divided by its standard error) which is a convenient way of assessing the statistical significance of individual coefficients. If the 'z' value is greater than 1.96 then there is a 95% chance or better that the coefficient is different from zero. Deviance difference (which applies to complete terms, not necessarily to the individual coefficients of a category variable) is also given. If the deviance difference is greater than 3.84 for 1df (degree of freedom) or 11.07 for 5df, then there is a 95% chance or better that the variable is contributing to the explanation of some of the variation between observations.

By way of example, the model can be used to predict the accident liability of a rider who covers 4,000 miles per year, is aged 32, has five years' riding experience, has no CBT, is in 'dedication' category 3, and who rides a 600cc bike:

$\log_e$ (accident liability)
$= -6.647 + 0.403\log_e (4000) + 50.86/(32 + 9)$
$+ 6.028/(5 + 6) + 0.0 – 0.521 – 0.162 = -2.20$

Therefore, accident liability = 0.111

The model shown in Table 5.1.1 explained just 19.6% of the non-Poisson variance[3] and showed that the age of the rider was the most important predictor in terms of variation explained, closely followed in importance by the number of miles ridden. The experience of the rider was next most important (even though age had been taken into account), then the type of use in Summer/Winter and/or wet/dark conditions. The terms included in the model will now be evaluated briefly in the order they are presented in the table.

5.1.1 Mileage

The model parameter for the mileage effect is associated with the logarithm of mileage and so the modelled relationship between mileage and accident liability is represented by the following equation:

$\log_e$(accident liability) = -6.65 + 0.403 $\log_e$(miles)
+ other factors

This translates to:

accident liability = $0.0013 \times \text{miles}^{0.403} \times$ other factors

and indicates that the mileage effect is non-linear. This means, for example, that a motorcyclist riding 5,000 miles per year, would not be expected to have double the number of accidents that a motorcyclist who rides only 2,500 miles per year would have. Rather, the expected liability of the higher mileage rider would only be $2^{0.403}$ = 1.32 times that of the lower mileage rider – i.e. a 32% difference.

5.1.2 Age and experience

Figure 5.1.1 illustrates the modelled age and experience effects. The blue curve represents the accident liabilities of 'novice' riders of differing ages (a 'novice' rider in this context is one who has been riding for 1 year only). Thus the left-hand end of this curve is the accident liability of a 17 year old rider with 1 year riding experience (i.e. he or she started riding at 16), whilst the right-hand end of the curve is the accident liability of a 60 year old rider with 1 years riding experience (i.e. he or she started to ride at 59).

The red and green curves in the figure represent the accident liabilities of riders who started to ride at ages 16 and 39 (and whose accident liabilities after the first year of riding correspond with the upper curve at ages 17 and 40). Their experience then increases in step with their age.

Figure 5.1.1 shows that increasing age alone has a dramatic effect on a rider's accident liability, liability falling by 70% over the age range. The effect of riding experience alone is to reduce accident liability by 52% as experience increases from 1 to 44 years. If this view of the age and experience effects of motorcycle riding is compared to that of car drivers (Maycock *et al.,* 1991) it will be seen that the experience effect for motorcyclists, though clearly important, is not nearly as large relative to the age effect as it is in the case of car drivers.

5.1.3 Training

The 2-level training variable distinguished only between riders who had taken Compulsory Basic Training (CBT) and those that had not. (A training variable with more than two levels was not appropriate because of small number of riders with other types of training). Non-CBT riders will generally be older and more experienced than those who had taken CBT because they will have started riding before CBT was introduced. However, the age and experience terms in the model should have taken these effects into account. The training term in the model just fell short of statistical significance at the 5% level and the coefficient of the CBT level was far from statistically significant. This implies that the apparently negative effect of CBT noted in Section 4.3.4 is explained by the age and experience of non-CBT riders. No positive effect of training was detected, but the study cannot provide a powerful test of the effects of training. One reason for this is that effects of CBT might be expected to diminish as riders gain experience, and so become diluted in this sample. It should also be noted that some types of training may indeed have a negative effect on safety – by improving control skills but not ability to judge risk and self-limitations, thereby giving riders a false impression of their competence.

5.1.4 Rider dedication

The 6-level 'rider dedication' term included in the model is the hierarchy presented in Section 4.3.5 above. Table 5.1.1 shows that all the coefficients in this term other that the reference (Category 1) are negative – i.e. riders in Categories 2-6 have lower accident liabilities than those in Category 1. Put the other way round, the model shows that those who ride on a regular basis during the winter irrespective of the weather have a higher accident liability that the other categories of riders even when age, experience and mileage effects have been allowed for. People who ride in all weather conditions in the summer only (Category 3) have an accident liability which is exp(-0.521) = 0.59 times that of Category 1 riders (i.e. 41% lower). Those who avoid bad weather conditions even in the summer (Categories 4, 5 and 6) have an accident liability which is approximately exp(-0.9) = 0.41 times that of Category 1 riders (i.e. 59% lower) and exp(-0.9+0.521) = 0.68 times that of Category 3 riders (i.e. 32% lower).

Since these accident liability differences have been estimated taking into account annual mileage differences, the higher accident involvement associated with riding in winter and in poor conditions may be a reflection of the adverse riding conditions encountered in these circumstances (wet roads, icy roads, and darkness). Differences between types of rider, and types of journey undertaken, may also be important.

5.1.5 Bike size

The 'size of bike' variable used in the GLIM model was a 2-level variable identifying riders of bikes with an engine capacity of greater than 125cc and bikes of 125cc and below. This is a different cut-off point from the earlier work of Taylor and Lockwood (1990) where the cut-off point was 500cc. However, the statistical evidence from the present survey is that a 125cc boundary provided the most meaningful grouping. The model suggests that once age, experience, annual mileage and 'rider dedication' has been allowed for, riders of bikes with an engine capacity of over 125cc had an accident liability which was on average exp(-0.162) = 0.85 times that of the smaller bikes (i.e.15% lower).

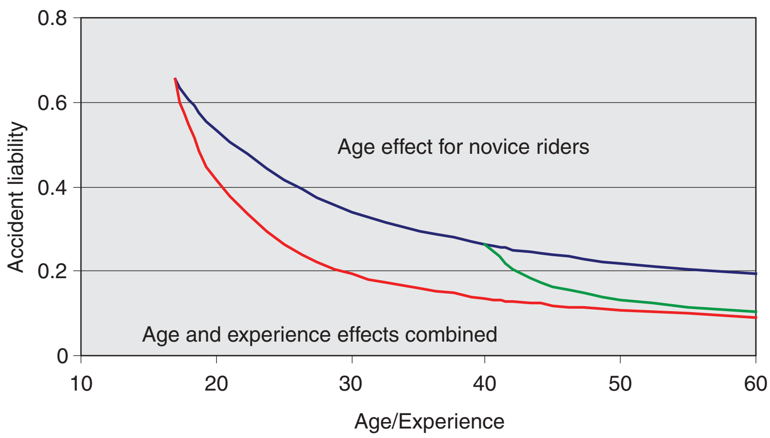

Figure 5.1.1 Illustrating the modelled age and experience effects for riders riding 4677 miles per year (the average), riding a bike whose engine size is 125cc or less and who rides in all conditions (rider dedication category 1)

5.1.6 Injury accidents

The model presented in Table 5.1.1 above used ‘all accidents’ as the dependent variable. Table 5.1.2 shows by age group the proportion of riders who were accident involved and injured in their accidents. The final column shows that on average 58% of accidents involved injury to the rider. Although there is some variation in the percentage across the age groups, the differences are not large.

It would therefore be expected that the effects predicted by the model of Table 5.1.1 for all accidents will apply reasonably well to injury accidents – and this was confirmed by fitting a parallel model to the injury accidents reported in the survey.

Table 5.1.2 Accident and injury involvement by age-group

Age group	*Number in age-group*	*Proportion of age-group accident involved*	*Proportion of age-group injured*	*% of accident involved who were also injured*
16-20	527	0.380	0.254	67%
21-25	390	0.247	0.169	69%
26-30	784	0.181	0.108	60%
31-35	1474	0.141	0.076	54%
36-40	1894	0.110	0.060	54%
41-45	1758	0.086	0.044	51%
46-50	1279	0.082	0.043	53%
51-55	1243	0.066	0.039	59%
56-60	831	0.066	0.043	66%
61+	1088	0.049	0.022	45%
Total	11268	0.116	0.067	58%

An alternative approach to the estimation of age and experience effects for injury accidents was also taken, using data from the national injury accident database (STATS19). The method is described for car drivers in Maycock (2002). The calculations used the motorcycle injury accidents by age of rider reported to the police in the three years 1999-2001, combined with estimates of the age/experience structure of the riding population using data from motorcyclists in the present survey. The results are shown in Figure 5.1.2 drawn to be directly comparable to Figure 5.1.1. It is clear that the two figures are to a great extent consistent. Although the age effect in the STATS19 model (Figure 5.1.2) is somewhat stronger than it is in the case of the survey analysis (mainly because a simpler age function was used in the STATS19 modelling), the absolute liabilities are consistent (bearing in mind the ‘all accidents’ to ‘injury accident’ factor suggested by Table 5.1.2) and the relative strengths of the age and experience effects are very similar.

6 Motorcyclist attitudes, behaviours and accidents

6.1 Introduction

In thinking about the different factors contributing to motorcycle accidents, it is useful to consider motorcycling as a system involving three elements: the motorcycle, the environment in which rider rides (e.g. traffic, road type and weather conditions), and the rider.[4] A great deal is known about the first two of these elements (see Elliott *et al.*, 2003), but relatively little is known about how the riders’ characteristics – in particular the behaviour and attitudes of the riders – influence safety. Previous studies in which the human element in motorcycle accidents has been modelled have focused on variables such as riders’ age, sex and other demographic characteristics (e.g. Broughton, 1988; Taylor and Lockwood, 1990). Although this approach has provided much descriptive information, these studies have provided little insight into which aspects of a rider’s behaviour or attitudes it might be useful to modify in the interest of safety. The present survey explores those ‘psychological’ variables that mediate the relationship between the descriptive characteristics and the motorcycle riders’ accident liability.

6.2 The behavioural variables

One of the most influential pieces of work relating to car driving behaviour published in the last 15 years was that by Reason *et al.* (1990). Using a self-completion questionnaire (known as the Driver Behaviour Questionnaire – DBQ), Reason *et al.* classified aberrant

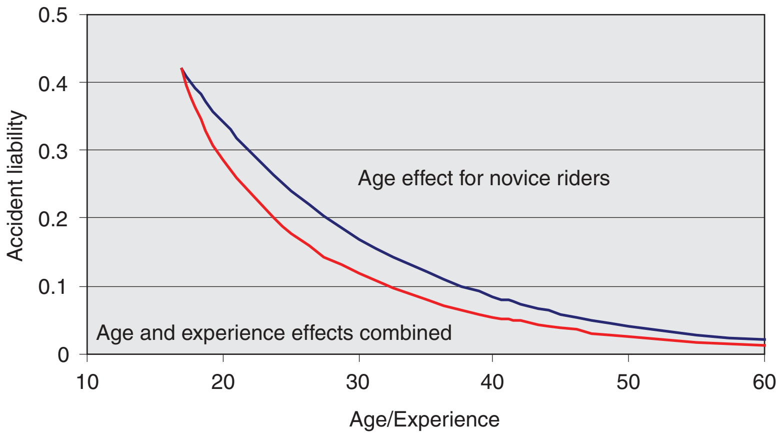

Figure 5.1.2 Age and experience effects estimated for injury accidents using STATS19 data

driving behaviours in terms of a system of errors and violations. Violations were defined as "deliberate deviations from those practices believed necessary to maintain the safe operation of a potentially hazardous system" (Reason *et al.*, 1990). Errors were broadly defined as the "failure of planned actions to achieve their intended consequences". These findings have been replicated in further studies in the UK (Parker *et al.*, 1995a; Parker *et al.*, 1995b) and in other countries (e.g. Blockley and Hartley, 1995). These researchers found that male drivers, younger drivers and high mileage drivers consistently score higher on DBQ violations than do female drivers, older drivers and low mileage drivers. They also found that people who score high on DBQ violations are statistically more likely to have been involved in accidents in the past (Parker, Reason, Manstead and Stradling, 1995a) and to be involved in the future (Parker, West, Stradling and Manstead, 1995b). There is also some evidence to suggest that self-reported driving errors are also related to accidents (e.g. Parker *et al.*, 1995a).

Given that the DBQ self reported driving behaviours have proved to be useful in the past in terms of predicting car drivers' accident involvement, a similar approach was used in the present study. Of course, given the difference between the two modes of transport, comparable results to those obtained for car drivers were not necessarily expected. After all, motorcycle riding is inherently much more demanding than car driving with respect to certain aspects of control skills, and errors that are made tend to be more difficult to recover from safely.

In the present survey, key aspects of behaviour have been measured using the Motorcycle Rider Behaviour Questionnaire (MRBQ) outlined in Section 3.2.3 The MRBQ consisted of 43 items which were factor analysed to provide five measures of behaviour for use in the modelling to be described in the following sections.

The five behaviour factors identified were:

- TRAFFIC ERRORS – e.g. 'fail to notice that pedestrians are crossing when turning into a side street from a main road'; 'attempt to overtake someone that you hadn't noticed to be signalling a right turn'.
- SPEED1 – speeding behaviours – e.g. 'exceed the speed limit on a residential road'; race away from traffic lights with the intention of beating the driver/rider next to you'; 'open up the throttle and just go for it on country roads'.
- STUNT – performing stunts and other high risk behaviours – e.g. 'attempt to do, or actually do, a wheelie'; 'intentionally do a wheel spin'.
- SAFETY – use of safety equipment / clothing – e.g. 'wear a protective jacket (leather or non-leather)'; 'wear body armour…'
- CONTROL ERRORS – e.g. 'run wide when going round a corner'; 'brake or throttle back when going round a corner or bend'; ' find that you have difficulty in controlling the bike when riding at speed (e.g. steering wobble)'

Higher scores in these variables mean that the relevant behaviour occurs more of the time. The factor analysis is presented in Appendix B. In terms of the distinction between errors and violations found to be significant in the work of Reason *et al.*, there are two errors factors (TRAFFIC ERRORS and CONTROL ERRORS), and two violations factors (SPEED1 and STUNT). However, it will be argued later that this distinction is not clear cut, since many of the error items are errors occurring in a violational context.

6.3 Attitudes, motivations and perceptions

Although behavioural factors such as violations and errors might prove useful in terms of explaining why motorcycle accidents occur, to explain why people behave in these ways requires the psychological determinants of behaviour to be explored. There is a range of underlying cognitive processes such as information processing ability and selective attention which are likely to have a role in certain aspects of behaviour, but unfortunately these variables cannot be measured in self-completion questionnaire surveys. Other types of underlying cognitive components, however, can be so measured. Drivers' attitudes, motivations and perceptions about safety, for example, have been assessed in research studies in the past, and have proved to be useful predictors of driving behaviour (e.g. Baughan and Sexton, 2001; Maycock and Forsyth, 1997; Quimby *et al.*, 1999).

Psychological research carried out into motorcycling in Germany also seems to be particularly relevant for identifying general social cognitive processes underlying motorcyclist behaviour. The researchers identified twelve motivational aspects of motorcycle riding as follows:

Hedonism: The desire for pleasurable experiences from motorcycling. (Battmann, 1984; Koch, 1990; Schulz *et al.* 1989 and Hobbs *et al.* 1986).

Escapism: Getting away from it all, forgetting everyday worries and 'letting off steam'. (Nowak, 1979; Schulz *et al.* 1989).

Dynamic aspects of biking: The experience of acceleration, speed, power, mobility and cornering. (Rheinberg *et al.*, 1986; Schulz *et al.*, 1989).

Performance aspects of biking: Mastering the vehicle and testing the performance limits of oneself and the machine (Rheinberg *et al.*, 1986; Schulz *et al.*, 1989; Walters, 1982).

Exhibition riding: Showing-off, demonstrating riding skills to other road users. (Brendicke, 1991).

Rivalry: Being faster and better than others. (Schulz *et al.*, 1991; Dellen and Bliersbach, 1978; Brendicke, 1991).

Thrill and adventure seeking: A need to seek out risky situations and activities (thrills). (Zuckerman, 1984; Dellen and Bliersbach, 1978; Brendicke, 1991; Hobbs *et al.*, 1986).

Flow states: Riders can be motivated to achieve 'flow states' where "the self loses meaning, nothing disturbs the flow of action and complete control over the course of events seems to be present in highly practised, intrinsically motivated and competently executed activities" (Csikszentmihalyi, 1988). See also Hobbs *et al.*, 1986 and Brendicke, 1991.

Identifying with the bike: Riding is a way of life. (Brendicke, 1991; Hobbs *et al.*, 1986; Dellen and Bliersbach, 1978; Schulz *et al.*, 1991).

Safety behaviour: Behaviour such as wearing protective equipment or efforts to safe riding behaviour in traffic. (Schulz *et al.*, 1989).

Control beliefs: The belief that the rider can control themselves, the vehicle, other road users and the situation all of the time. (Schulz and Kerwien, 1990).

Social aspects: Motives deriving from the desire to form part of a group and through the involvement in group activities. (Schulz, 1990; Brendicke, 1991).

Schulz *et al.* (1991) found that the 12 motivational aspects outlined above could be grouped into three broad categories as indicated by the inter-correlations between the questionnaire items designed to measure the various motivations. These three categories were labelled:

- Biking for pleasure (escapism, hedonism, flow, identification with the bike, social aspects).
- Biking as a fast competitive sport (dynamic aspects, performance aspects, exhibition riding, thrill seeking and rivalry).
- Control over the motorbike (control beliefs and safety behaviour).

These motivational factors seem to provide a reasonably comprehensive account of the motivations of motorcyclists and appear to tap a number of potentially useful social psychological constructs which may provide some explanation of why different types of behaviour (e.g. violations and errors) are engaged in when riding.

In the present survey these aspects of attitudes and motivations were measured using the 24 items of the Motorcycle Rider Motivation Questionnaire (MMRQ) (see Section 3.2.3). The data were factor analysed to yield the following three factors:

- PLEA – pleasure derived from riding motorcycles (1=agree, 5=disagree).
- SPEED2 – enjoy the dynamic aspects of performance from motorcycles (1=agree, 5=disagree).
- CONV – the convenience and economic aspects of motorcycling (1=agree, 5=disagree).

Included in the same factor analysis were a number of other question items, which yielded a further three factors:

- SKILL – self perceived riding skill as compared to others (1=better, 5=worse).
- MCFAU – beliefs about motorcyclists causing accidents, by going too fast or not anticipating (1=agree, 5=disagree).
- CAFAU – beliefs about car drivers causing accidents due to not looking or seeing (1=agree, 5=disagree).

In addition, the riding style items in the questionnaire provided three factors:

- RS1 – rider style of careful, safe and responsible (1=careful/safe, 7=careless/risky).
- RS2 – rider style of tolerant, patient and considerate (1=tolerant/patient, 7= intolerant/impatient).
- RS3 – rider style of decisive, confident and fast (1=slow/indecisive, 7=fast/decisive).

6.4 Statistical modelling – a hybrid approach

6.4.1 The methodology

There are four basic elements in a structural equation model – the observed variables (sometimes called indicator variables – the Vs in Figure 6.4.1), the latent factors (latent because they are not directly measured – the Fs), the errors on the indicator variables (the Es), and the errors on the latent factors (the Ds). In the present study, the indicator variables will be the individual psychological variables which have been measured by means of the items in Section C of the questionnaire. The 'background variables' shown in Figure 6.4.1 are not fundamental to the structural model but are variables which are likely to be relevant to many of the other variables in the model. In the present study the background variables would be age, experience and annual mileage. The arrows in the figure are linear regression relations; correlations between variables can

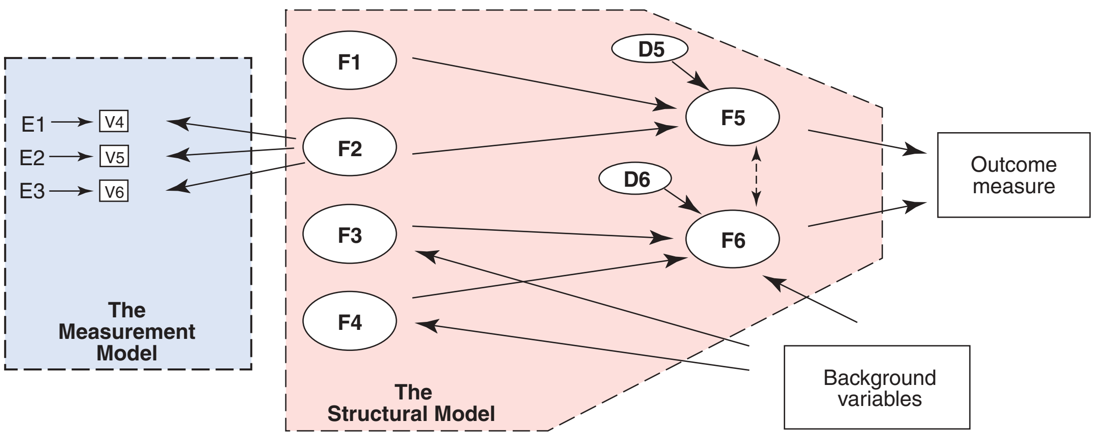

Figure 6.4.1 Illustrating the principles of a structural equation model

also be incorporated into the model. The sets of indicator variables and their associated regression relations form the 'measurement model', because they calibrate the first level of latent variables (F1, F2 and F3) in terms of the observed indicators. The structural part of the model is the relationship between the latent factors. In Figure 6.4.1 the structural model is a 'second order' model in that the first level of latent variables determines a second level (F4 and F5) which in turn determine the outcome variable.

Structural equation modelling software such as the MPlus package used in this study can, in principle, deal with the full model shown in Figure 6.4.1. However, the analysis reported here took a slightly different approach. First, to avoid very long processing times, it was decided to use factor analysis to define the attitude and behaviour latent variables outside MPlus. In terms of Figure 6.4.1, this is equivalent to establishing the measurement model by conventional factor analysis and using the factor scores so computed as direct inputs to the structural part of the model. The results of these factor analyses have already been described in Sections 6.2 and 6.3.

Secondly, it was found that including the outcome variable (accidents) in the SEM calculations produced anomalous results, with some parameters being assigned values outside their permitted ranges. The explanation is not at present known – it may have to do with the fact that accidents were dealt with as a categorical variable in the model. This was done because accidents follow a Poisson distribution whereas SEM procedures require variables to be distributed Normally. Defining the number of accidents as a categorical variable is one way round this difficulty, but relies on the assumption that there is an underlying continuous latent variable which is Normally distributed. The appropriateness of this procedure for modelling accident data requires further investigation.

To avoid these problems, it was decided to use generalised linear modelling to investigate the relationship between accidents and the behavioural, descriptive and mileage variables. Structural equation modelling would then be used to explore the links between attitudes/motivations and the behavioural factors. (Strictly speaking, SEM used in this way is a Path Analysis).

6.4.2 The model structure

Two versions of the basic model were examined – they are both illustrated in Figure 6.4.2.

The dotted line joining the descriptive (background) variables to the attitudes/motivations/perceptions box are correlations – both models allow inter-correlations between these two sets of variables. Both models also include the primary set of dependencies – those between attitudes/motivations/perceptions and behavioural factors (L4) and between behaviours factors and accident risk (L1). Both models also assume that there is a direct relationship between accident risk and annual mileage (L5).

The difference between the two models relates to the link L2 (shown as a broken line). Model I allows for age and experience to influence directly both accident risk (link L2) and the behavioural factors (L3). Model II assumes that age and experience variables do not influence accidents directly, but only through the mechanism of an attitude, motivation or behaviour (i.e. the L2 link is omitted).

Using a model that allows age or experience to influence accident risk directly (Model I) should produce a model with a better statistical fit than a model in which age and experience only influence behaviours or attitudes (Model II). This is because the direct link could be acting as a proxy for the effect of unmeasured variables that do not appear in the model. However, it is important to evaluate Model II because allowing the direct link runs the risk of artificially distorting the magnitude of the effects of the behavioural variables that are included in the model.

As described above, the approach taken was to use generalised linear modelling to investigate links L1, L2 and L5. Structural equation modelling/path analysis was then used to explore link L4 and L3.

Separate analyses were conducted for three overlapping classes of accident as the dependent variable:

- The total number of accidents that a rider reported being involved in during the past 12 months.
- Non-minor accidents (i.e. all accidents that were not classified by the respondent as a 'minor spill' or a 'low speed manoeuvring accident').
- All accidents where the rider accepted some blame.

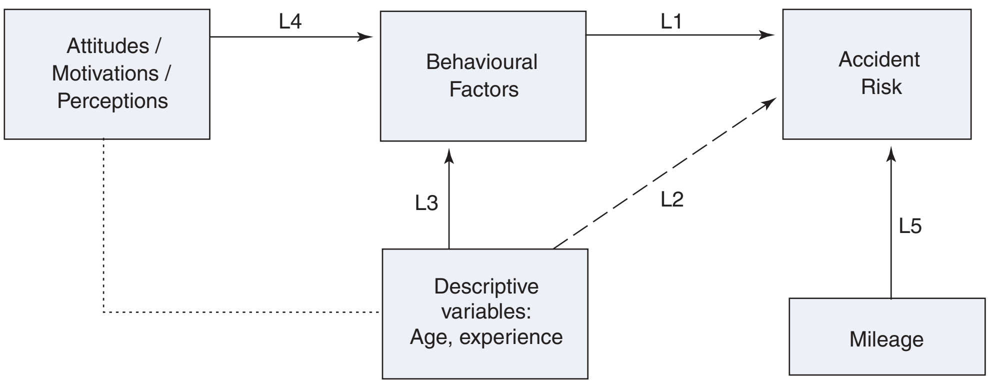

Figure 6.4.2 Factors affecting the accident risk of motorcyclists – Model I & II

6.4.3 Results of the modelling

6.4.3.1 GLIM analysis of links L1, L2 and L5

Tables 6.4.1 a to c show the estimated parameters for the links between accidents and the five behaviour factors, age, experience and mileage. Six sets of results are shown – i.e. for Models I and II each applied to each of the three categories of accidents.

Model I

It will be seen from the tables that in Model I the factors influencing accident involvement are the background variables, (i.e. annual mileage, the age of the rider and the experience of the rider) and the frequency of self-reported TRAFFIC ERRORS. Where some blame is accepted by the rider for the accident, then riders who score highly on SPEED1 (speed related behaviours & violations) and on CONTROL ERRORS tend to have slightly increased likelihood of accidents. For non-minor accidents, the importance of the TRAFFIC ERRORS factor increases, but the CONTROL ERRORS factor now has a negative relationship with accidents. This inconsistency may be due to correlation between the control errors and traffic errors

Table 6.4.1a Parameter estimates for links L1, L2 and L5 between accidents and background or behaviour factors (all accidents)

	Model I - All accidents			*Model II - All accidents*		
Behaviour or descriptive variable	*Estimate*	*s.e.*	*Sig. level*	*Estimate*	*s.e.*	*Sig. level*
TRAFFIC ERRORS (mistakes, lapses or slips in traffic)	0.800	0.200	<0.001	0.647	0.201	<0.001
SPEED1 (speed related behaviours & violations)	0.124	0.091	ns	0.018	0.093	ns
STUNT (stunt and high risk behaviours)	-0.137	0. 100	ns	0.168	0.094	<0.04
SAFETY (clothing etc)	0.002	0.061	ns	-0.115	0.060	<0.03
CONTROL ERRORS (lack of control skills)	0.221	0.187	ns	0.677	0.188	<0.001
IAGE (1/(age + 9)	53.55	7.06	<0.001		Not present in Model II	
IEXPER (1/(experience + 6)	7.59	1.07	<0.001			
LMILES (log of miles)	0.504	0.041	<0.001	0.550	0.041	<0.001

Table 6.4.1b Parameter estimates for links L1, L2 and L5 between accidents and background or behaviour factors (some rider blame accidents)

	Model I - To blame accidents			*Model II - To blame accidents*		
Behaviour or descriptive variable	*Estimate*	*s.e.*	*Sig. level*	*Estimate*	*s.e.*	*Sig. level*
TRAFFIC ERRORS	1.039	0.263	<0.001	0.899	0.264	<0.001
SPEED1 (speed related behaviours & violations)	0.298	0.120	<0.01	0.199	0.122	ns
STUNT (stunt and high risk behaviours)	0.002	0.124	ns	0.251	0.116	<0.02
SAFETY (clothing etc)	-0.086	0.081	ns	-0.197	0.080	<0.01
CONTROL ERRORS	0.593	0.243	<0.01	1.085	0.244	<0.001
IAGE (1/(age + 9)	41.56	9.462	<0.001		Not present in Model II	
IEXPER (1/(experience + 6)	9.648	1.466	<0.001			
LMILES (log of miles)	0.400	0.055	<0.001	0.446	0.055	<0.001

Table 6.4.1c Parameter estimates for links L1, L2 and L5 between accidents and background or behaviour factors (non-minor accidents)

	Model I - Non-monor accidents			*Model II - Non-minor accidents*		
Behaviour or descriptive variable	*Estimate*	*s.e.*	*Sig. level*	*Estimate*	*s.e.*	*Sig. level*
TRAFFIC ERRORS	1.799	0.491	<0.001	1.683	0.493	<0.001
SPEED1 (speed related behaviours & violations)	0.286	0.221	ns	0.185	0.224	ns
STUNT (stunt and high risk behaviours)	-0.037	0.236	ns	0.305	0.219	ns
SAFETY (clothing etc)	-0.113	0.146	ns	-0.273	0.144	<0.03
CONTROL ERRORS	-1.213	0.484	<0.01	-0.788	0.485	ns
IAGE (1/(age + 9)	66.25	17.74	<0.001		Not present in Model II	
IEXPER (1/(experience + 6)	4.657	2.743	<0.05			
LMILES (log of miles)	0.769	0.110	<0.001	0.830	0.109	<0.001

factors, causing the modelling process to have difficulty in assigning predictive power between them.

Model II

Model II allowed the mileage variable to affect accidents directly but excluded a direct link between age, experience and accidents. Age and experience were allowed to affect only the behavioural and attitudinal/motivational variables. As in Model I, mileage, age, experience, and TRAFFIC ERRORS were significant predictors of accident liability. CONTROL ERRORS were significant predictors of ‘all accidents’ and ‘to blame’ accidents. It is noteworthy that in Model II, once the direct link between age, experience and accidents is excluded, STUNT behaviour and the factor SAFETY (wearing of safety clothing etc) enter the model as significant predictors – people scoring highly on SAFETY had a decreased liability for all three classes of accident, and those reporting more STUNT behaviour had an increased liability for ‘all accidents’ and ‘to blame’ accidents. The fact that these types of behaviour do not appear as significant predictors in Model I implies that their predictive power is taken up by the age and experience variables.

6.4.3.2 SEM / path analysis: links L3 and L4

Table 6.4.2 shows the links between behaviours and motivations/attitudes etc derived by fitting a path analysis model in ‘MPlus’. Only variables with parameter estimates greater than 0.2 are shown.

The parameter estimates are given as ‘standardised’ coefficients – i.e. the coefficients have been adjusted in relation to the absolute scales of the variables so that they give an unbiased assessment of the relative magnitudes of the strengths of the various effects in the model; standardised regression coefficients can be thought of as correlation coefficients. The parameter and correlation estimates do not depend on which category of accidents is being modelled since the relationships do not directly involve any accident variable. The estimates of the various inter-correlations are given in Appendix C. Figure 6.4.3 shows the basic structure for the potential links between factors. It only shows the strongest links, but indicates the complexity of the relationship between behaviours and attitudes.

The analysis shows that the most important predictor of TRAFFIC ERRORS was the rider’s score on the riding style factor ‘careful, safe and responsible’ (RS1); riders who saw themselves as careful, safe and responsible being less likely to report making such errors. Riders with a liking for speed, and/or a confident and fast riding style, were more likely than others to report CONTROL ERRORS. STUNT behaviour tended to be reported by riders who are younger, and/or like speed, and/or, have a careless, risky riding style. Those who cover a high annual mileage, and/or are strongly motivated by the pleasure they get from riding, tended to score highly on the factor SAFETY (wear safety clothing).

The inter-correlations between the motivational/style variables are instructive. In particular the association between getting pleasure from riding, liking speed, having a confident, fast riding style, paint a picture of motorcycling for pleasure that may have important implications for safety – a point that is taken up in Section 8.2.

7 Motorcycling risk factors

This section summarises the main factors identified in the present study and other research as influencing motorcyclists’ accident risk.

7.1 Rider age and experience

The Generalised Linear Modelling reported in Section 5 found a strong age effect of age and experience on accident liability. The age effect alone means that a 26 year old novice rider would have an accident liability about 40% lower than that of a 17 year old novice who rode the same number of miles in the same conditions. A novice who was aged 40 years would have an accident liability 60% lower than the 17 year old novice.

The effect of experience alone means that a rider with 10 years of experience would have an accident liability 38% lower than a rider of the same age but with only one year’s experience.

Operating together, the effects of age and experience mean that a 17 year old rider with one year of experience would see his accident liability fall by about 50% by the time he had accumulated 6 years of experience at age 22

Table 6.4.2 Parameter estimates from path analysis for links L3 and L4 between attitude, background and behaviour factors (values >0.2)

Behaviour, (description of high scorer)	*Attitude/style/background (description of high scorer)*	*Parameter*
TRAFFIC ERRORS (makes errors in traffic situations)	RS1 (careless/risky/irresponsible/inattentive)	0.258
SPEED1 (makes speed related violations)	SPEED2 (does not like dynamic aspects of riding)	-0.553
STUNT (likes pulling stunts)	SPEED2 (does not like dynamic aspects of riding)	-0.363
	RS1 (careless/risky/irresponsible/inattentive)	0.205
	IAGE = 1/(age+9)	0.234
SAFETY (safety conscious with clothing)	PLEA (does not get pleasure from riding)	-0.229
	LMILES (log miles)	0.225
CONTROL ERRORS (makes control errors)	SPEED2 (does not like dynamic aspects of riding)	-0.208
	RS3 (indecisive/nervous/slow/inexperienced)	-0.208

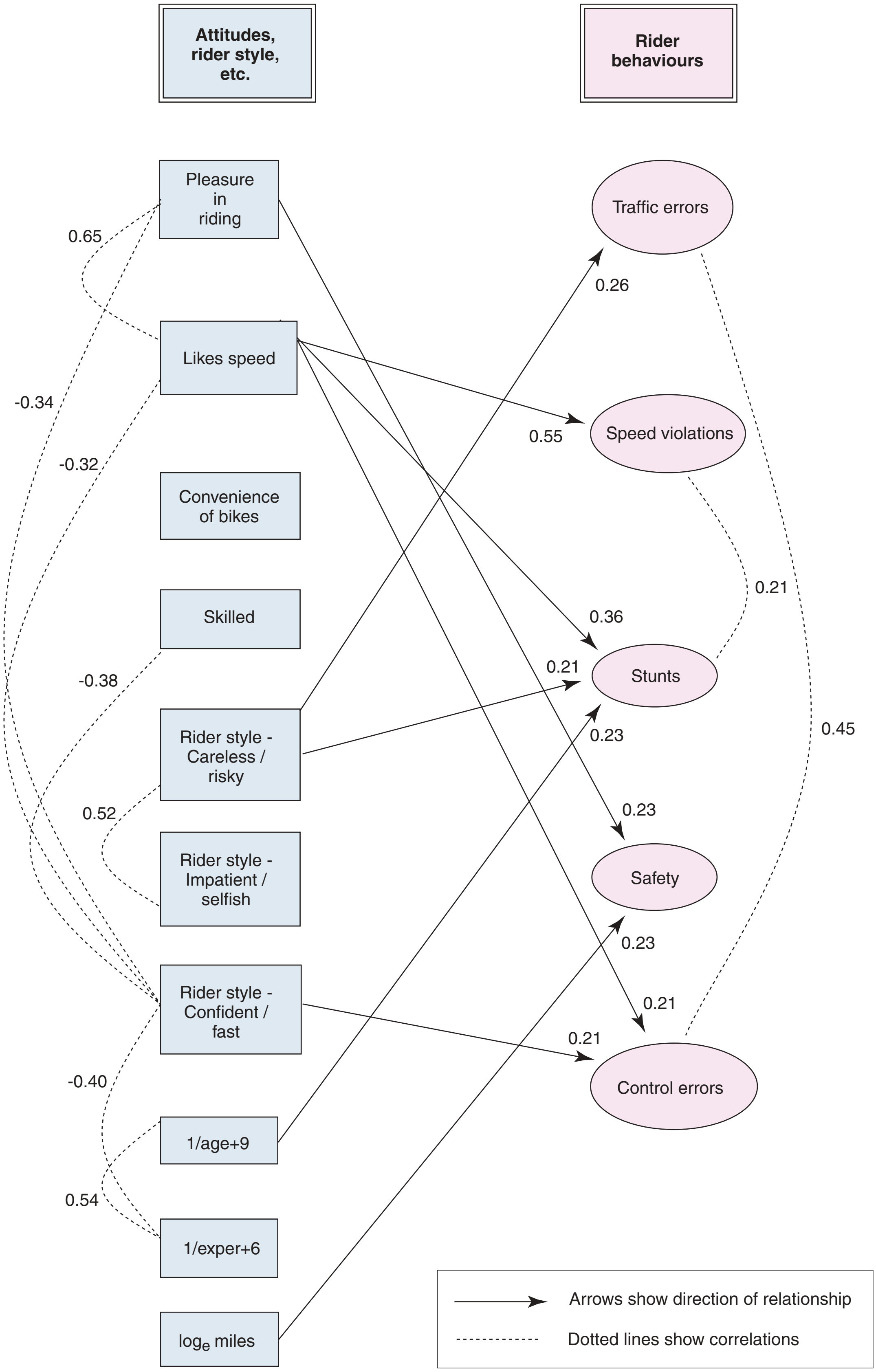

Figure 6.4.3 Path analysis model of relationship between attitudes/styles and behaviours (showing the more significant paths)

years, and by 65% by the time he reached 27 with 11 years experience.

The results are similar to those found by Taylor and Lockwood, although the absolute accident frequencies are lower than those predicted in 1988. The effect of age is still very strong on accidents. Clearly, then, age and experience (or, rather, youth and inexperience) are important risk factors in motorcycling as they have been shown to be in car driving.

7.2 Rider type, attitude and behaviour

Of the behavioural factors investigated, it was self-reported errors that most consistently predicted accident liability. TRAFFIC ERRORS figured in both models and for all three categories of accidents; CONTROL ERRORS were significant predictors in some of the analyses. The 'violations' factors STUNT behaviour and SPEED1 also appeared as predictors in some analyses

The apparent dominance of errors over violations as predictors of accidents distinguishes the motorcyclists in this study from the car drivers who have been the subject of most previous studies of factors underlying accident liability (e.g. Reason *et al,* 1990; Parker, 1995a and 1995b). Typically, in those studies, violations were much more important than self-reported errors as predictors of accident liability. One possible explanation of this difference is that motorcycles are more demanding to control and less forgiving of errors than are cars – that is, the relative instability of motorcycles means that error recovery is more difficult, so that an error is more likely to lead to an accident. It also seems possible that difficulty of error recovery, and vulnerability to injury, will make motorcyclists more aware of their errors than car drivers are of theirs, and therefore more able to report them.

The distinction between errors and violations should not be taken too far, however. Examination of the items making up the TRAFFIC ERRORS factor suggests that many of them are to do with a careless, inattentive, rider style, not particularly focussed on safety. They include failing to notice pedestrians, missing give-way signs, riding too close, and overtaking someone without noticing they are signalling a right turn. Similarly, many of the CONTROL ERRORS are to do with inability to cope with the consequences of riding too fast (e.g. 'ride so fast into a corner that you feel like you might lose control', or 'find you have difficulty in controlling the bike when riding at speed'). It appears, then, that these errors (failures of hazard perception skills and control skills) are closely linked to underlying riding styles – styles that could properly be described as violational in that they depart from good normative rules of safe riding. The link between traffic errors and the careful/safe/responsible rider style factor (RS1) reinforces this interpretation.

When age and experience are not permitted to influence accidents directly (Model II), stunt/high risk behaviours become significant predictors of accidents. This is consistent with the explanation that one of the risk-increasing characteristics of young or inexperienced riders is their tendency to indulge in overtly risky behaviours.

Riding style, and a liking for speed were identified as predictors of behavioural errors (that were, themselves, predictors of accidents). These predictors were also inter-correlated. Such relationships lend support to the view that an important part of the motorcycle safety problem stems directly from the motivations for choosing to ride motorcycles. This presents a challenging problem for road safety.

The appearance of SAFETY (wearing safety clothing) as a significant predictor of accident liability in Model II is interesting. Some of this effect may be a direct effect on accidents of the improved conspicuity provided by some safety clothing. The factor may also be acting as a proxy in the model for other variables, for example the increasing judgement that comes with maturity. Wearing protective clothing would also be expected to reduce the severity of accidents, and perhaps therefore reduce the likelihood of the accident being serious enough to remember and report.

7.3 Taking a break from motorcycling: is there a 'returned rider' effect?

It is sometimes suggested that riders who return to motorcycling after taking a long break may carry a particularly high level of risk. Clearly this is an important possibility, given the trend for people to return to motorcycling as a leisure pursuit. If substantiated, it could suggest the need for measures designed to improve the skills of riders returning to riding after a break, or to reduce their risk in other ways.

Table 7.3.1 shows the key characteristics of riders who had taken a break of at least a year for each engine size. For the 'break' and 'non-break' riders in each engine size category, the table gives the mean age, mean experience in years since the most recent long break, the adjusted proportion of accident-involved riders during the 12 months preceding the survey[5], and the mean mileage during that period. It can be seen that for all sizes of machine except one (900-1000ccs), the group of riders who had taken a break were less likely to be accident involved than those who had not taken a break.

Table 7.3.1 certainly gives no support to the hypothesis that riders who return to riding after a break are at increased risk. However, it does not provide a definitive test of the hypothesis since the figures do not take age or annual mileage into account, and riders who take a break tend to be older than those who do not and to have a lower annual mileage. These differences will tend to reduce the accident involvement of people who have taken a break.

To explore this further, Figure 7.3.1 shows, for the different age groups, the mileage-adjusted accident rates of respondents who have, and have not, taken a long break (of more than12 months). The mileage adjustment was derived from the GLIM analysis as reported in Section 5. For respondents aged 16-20, those who had taken a break had a lower accident rate than those who had not taken a break. This difference was statistically significant at the 1% level ($p < 0.01$), but as there were only 30 non-break riders in this age group the size of the difference shown in Figure 7.3.1 is not reliable. The only other statistically

Table 7.3.1 Taking a break from motorcycling – age, experience, accidents, mileage and bike size.

	Percentage of sample		*Mean age in years*		*Adjusted average annual mileage*		*Mean experience since last long break (yrs)*		*Adjusted proportion accident involved*	
	Taken a break?		*Taken a break?*		*Taken a break?*		*Taken a break?*		*Taken a break?*	
Engine size cc	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
1-50	4.8%	14.6%	47.9	35.0	2800	3400	5.7	8.6	0.05	0.22
51-125	10.8%	16.3%	46.8	38.0	3300	3600	6.6	10.9	0.09	0.18
126-250	6.8%	4.9%	48.6	43.9	3200	5200	8.0	21.3	0.07	0.11
251-500	11.8%	10.2%	47.1	41.0	4000	4500	7.8	17.2	0.09	0.10
501-600	18.5%	16.8%	42.7	37.0	4800	5300	5.5	10.5	0.09	0.14
601-750	14.8%	11.2%	46.9	41.8	4000	4800	7.2	17.1	0.07	0.10
751-900	9.5%	7.5%	45.7	42.3	5000	5200	7.2	18.4	0.08	0.11
901-1000	8.8%	7.8%	45.1	41.3	5000	5800	7.3	18.7	0.10	0.10
1001+	14.2%	10.7%	46.6	43.7	5700	6800	7.6	20.0	0.08	0.11
Total	100.0	100.0	46.0	39.6	4400	4800	6.9	14.8	0.08	0.14
Sample	4509	4880	4509	4880	4509	4880	4509	4880	4509	4880

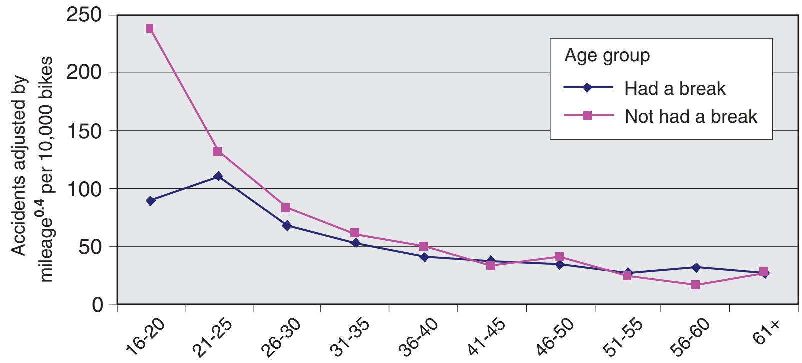

Figure 7.3.1 Mileage-adjusted accident rates for riders who took a break of more than 12 months sometime in their riding career v non-break riders

significant difference (at $p < 0.05$) was for riders aged 56-60, who showed a somewhat higher accident rate if they have taken a break.

It appears, therefore, that the relatively low accident involvement of returning riders shown in Table 7.3.1 is largely explained by the age and mileage effects taken account of in Figure7.3.1. However, any effects of taking a break are likely to fade over time, as experience is gained after the break. On average, respondents reported that their last long break was 7 years ago – so that many of the 'break' riders represented in Figure 7.3.1 and Table 7.3.1 will have built up considerable experience after their break. The above analyses may not therefore reflect the effect of taking a recent break.

Figure 7.3.2 is the equivalent of 7.3.1, but shows separately those riders who have returned from a long break within the two year period preceding the survey[6]. It shows no strong evidence that riders returning from a recent long break have a higher mileage-adjusted accident rate than riders who have not taken a long break. Indeed, Figure 7.3.3 which focuses on riders of bikes over 500cc, shows that riders of the larger bikes who return to riding after a break tend to be at lower risk than those who have not taken a break.

These simple analyses provide little evidence of any unwanted 'returning rider effect' – a conclusion supported by the multivariate modelling described in Section 5, which did not find taking a long break (recently or ever) from riding to be a significant predictor of accident liability when the effects of age, experience, annual mileage, type of riding, training, and size of bike were taken into account. It is of course possible that a finer-grained analysis, able to look at the accident liability of returning riders very soon after their break, or at riders who had taken a much longer break from riding, might find an effect – but this would require a more extensive survey. Clearly, for very long breaks, and/or for riders with very little pre-break experience and training, the returning rider is in many respects a novice. He or she is likely to have an elevated accident liability as a result – at least in comparison with other riders of the same age. However, in general, it appears that returning to riding after a long break is not an important risk factor.

This is not the same as saying that a trend for people to return to motorcycling is unimportant from a road safety standpoint. Returnees increase total motorcyclist numbers, and total mileage, and hence total motorcycle accidents. It

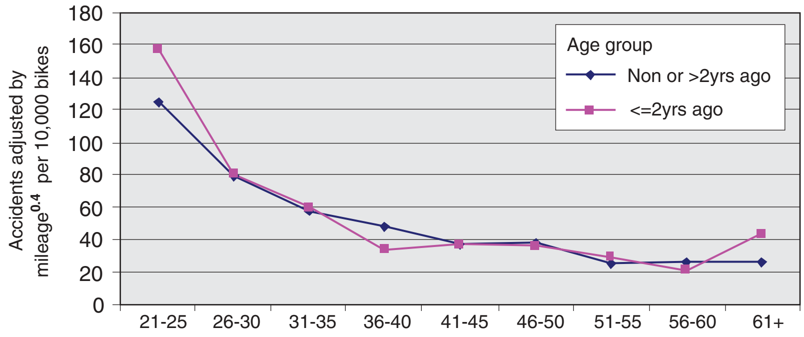

Figure 7.3.2 Mileage adjusted accident rates for riders who returned within the past 2 years from taking a break of more than 12 months

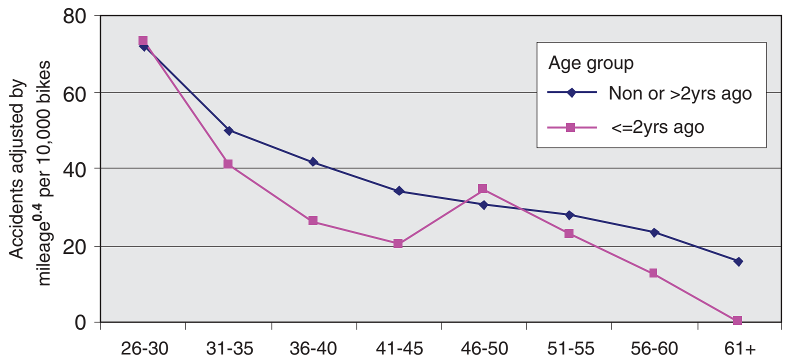

Figure 7.3.3 Mileage adjusted accident rates for riders who returned within the past 2 years from taking a break of more than 12 months (bikes over 500cc)

would be highly desirable to reduce their accident liability if ways could be found of doing this. Returnees might well form a good target group for countermeasures such as training, since (a) they tend to be easily identifiable – for example, when they purchase a new motorcycle, (b) it is possible to deliver training literature (and even offers of free training courses) along with the new machine and (c) returnees may often be well motivated to improve their safe riding skills.

7.4 Bike 'size' as a risk factor

The steady rise in the numbers of motorcycles of over 500cc (Figure 2.2.1), the rise in casualty numbers for these machines (Figure 2.2.3), and the emergence onto the market of very high performance motorcycles, has led to some speculation and concern that powerful machines might pose a particularly high risk. The possibility of placing limits on engine size, power, or some other index of performance such as power to weight ratio, has been considered in the past by the European Commission.

Broughton (1988) analysed STATS19 injury accidents alongside other data, and found that engine capacity was related to the rate of injury accidents per million-kilometres; in particular, motorcycles with a capacity greater than 125cc had a much lower risk than those of up to 125cc. However, there was a strong relationship between engine size and rate of fatalities per million-kilometres, with the rate for motorcycles over 250cc being twice the average rate, and the rate for motorcycles over 500cc being about 40% higher than the average. The study was unable to take into account rider experience and age in the statistical modelling because the data were not available. The fact that smaller bikes tend to be ridden by younger and inexperienced riders will therefore have inflated the apparent risk of these machines. Also, the study could use only a linear 'accidents per mile' accident rate, rather than a rate based on a power function of mileage. This will also have tended to cause the study to overestimate the risk of smaller motorcycles as compared to larger ones.

The fatality rates above include fatalities to pillion passengers. Larger bikes were more likely to carry a pillion passenger, and this will have contributed to the relatively high fatality rates for these machines. Broughton also found that as bike size increased, so did the proportion of accidents involving overtaking or riding round a bend, (which were two of the manoeuvres most commonly involved in accidents), injury severities for these two types of accident, the proportion of accidents with two or more other vehicles and the proportion of accidents at night.

Taylor and Lockwood (1990) using a postal survey of self-reported accidents were able to incorporate age and experience in the analysis model, and to use a non-linear mileage function. Their study, unlike Broughton's, but like the present one, included damage-only accidents.

Adjusting for mileage, age, experience etc. the fitted model found that, on open-roads, bikes with bigger engines (>500cc) tend be involved in fewer accidents than other bikes (≤500cc). There was no significant effect of bike size in built-up areas.

In a further analysis of the same dataset combined with information on the engine power of the respondents' motorcycles, Lockwood *et al.* (1998) compared engine size, engine power and power to weight ratio as indices of motorcycle size/performance. They found that the relationship between power and accident risk was similar to that between engine size and accident risk, and that adding power to weigh ratio as a predictor in a model that already contained power, did not improve the fit of the model.

A literature review commissioned by the European Commission (TNO, 1997), which examined the above studies and others, concluded that there was 'no scientific evidence that engine size is a major factor in motorcycle accidents; engine size does not emerge as a risk factor.' Taken together, the evidence reviewed by TNO indicates that (a) accident risk per year increases with engine size (mainly because larger bikes have a higher annual mileage), (b) accident risk per mile does not increase with engine size, and (c) risk of fatality per mile may increase with engine size.

In the present study Figure 4.3.4 (Section 4) shows that for 'all accidents' (i.e. total self-reported accidents), motorcycles with engines up to and including 125cc have much higher involvement per year than other motorcycles, but that above 125cc there is no clear relationship between engine size and accident involvement. This is in contrast to the above findings that risk per year increases with engine size. However, the relatively high accident involvement for bikes of 125cc and below is confined to the less severe accidents – i.e. those with slight or no injuries.

The relationship between engine size and numbers of accidents per year does not, in itself, tell us anything about the intrinsic risk of riding different sizes of machine. Bikes of different sizes cover different mileages, for different purposes, and have riders of different ages and experience levels. Figure 4.3.5 shows the average age, experience and mileage adjusted accidents (using the method described and used earlier) for different capacity bikes. The mileage-adjusted accident rate for respondents with bikes over 125cc is half that of respondents with 51-125cc capacity bikes, and a third of the rate for those with bikes of 50cc and below.

Figure 4.3.5 also shows that rider age and experience are relatively low for small bikes – which will go at least some way to explaining their higher mileage-adjusted accident rates. The multivariate modelling described in Section 5 examined the effect of engine size on accidents once a number of variables, including age, experience, mileage, training etc. had been taken into account. Engine size (up to 125cc vs 126cc and over), was found to have a small but statistically significant effect on accident liability, such that once the effects of mileage, age, experience, training and 'rider dedication' had been allowed for, riders of bikes of over 125cc had an accident liability 15% lower than riders of smaller bikes.

The above may be summarised as follows:

- Small bikes tend to have more minor accidents (and total accidents) per year than bigger bikes, but for higher severity accidents STATS19 data shows that this relationship reverses direction.
- Small bikes tend to be ridden by younger, less experienced riders, and to cover fewer miles per year, than bigger bikes.
- After adjusting for these differences, there is a tendency for bigger-engined motorcycles to have a lower mileage-adjusted 'all accident' rate than smaller motorcycles. Note, however, that in the present study the important division was between motorcycles of up to 125cc and those over 125cc.
- The increase in accident severity with bike size means that, for severe accidents, the mileage-adjusted accident rate may be higher for bigger bikes than for smaller bikes. Broughton's study indicates that in 1986 this was true for fatal accidents, but not for the totality of injury accidents reported in STATS19 or, indeed, for accidents involving serious injury. In the present study, as Figure 4.3.4 shows, for 'non-minor' accidents and 'serious injury' accidents there was little relationship between bike size and accidents per bike, implying that the mileage-adjusted accident rate would decrease with bike size for these classes of accident.

7.5 All-year riding

Another variable that the Generalised Linear modelling showed to be related to accidents was that labelled 'rider dedication' – effectively a measure that distinguished summer riders from people who ride in all conditions throughout the year.

The analysis described in Section 5.1 found that people who ride all year round, irrespective of the weather, have a much higher accident liability than other riders, even when age, experience and mileage differences have been adjusted for. For example, the all-year-all-weather riders have an accident liability 1.7 times that of people who ride only in the summer, and 2.5 times higher than people who avoid riding in bad weather even in the summer. How much of this is due to the actual riding conditions, and how much to differences between riders or types of journey is not at present known.

For some riders, their apparent dedication will be largely involuntary – imposed, for example, by lack of access to alternative forms of transport or a need to minimise travel costs. It would be worthwhile investigating whether the excess accident risk applies to this group, the group of voluntary 'all conditions' riders, or to both groups. Countermeasures for the involuntary group might include training; whereas the voluntary group might benefit more from measures designed to improve their insight into the risks they run.

8 Summary and conclusions

8.1 Summary

8.1.1 Accident trends

Examination of the trends over recent years shows that although there has been a worrying increase in numbers of motorcycle casualties, this fact does not imply the emergence of a previously unrecognised risk factor for motorcyclists. The trends are consistent with changes in the numbers of larger (over 500cc) machines and the mileages they cover – indeed, the mileage-adjusted accident risk of motorcycling fell in 1991 and has remained fairly constant since. However, motorcycle riders still face much higher levels of risk than car drivers. This is particularly true for accidents resulting in serious injury or death, where the casualty rate per mile is 30 times higher for two wheeled vehicle users than for car users (Road Casualties GB, 2002). Moreover, the upward trend in the numbers of larger machines on the road, and mileages ridden mean that motorcycle accidents are likely to make an increasing contribution to national casualty figures.

8.1.2 The survey

A key part of this study was a new survey of motorcyclists. After careful design and piloting, a questionnaire was sent to 30,000 motorcyclists who were current riders and whose motorcycle was privately owned. About 40% of recipients replied to the questionnaire mailing and this provided 11,360 responses for analysis. The questionnaire covered riding experience, accidents in which the rider had been involved, the riders' behaviour and attitudes, and questions about the riders' age, sex, socio-economic status, and car driving experience.

8.1.3 Accidents reported

Of those who responded to the questionnaire, male riders were in the majority; female riders made up only 9% of the sample. Just over 11% of male riders and just over 15% of female riders had been involved in an accident in their past 12-months of riding; the overall accident involvement for all riders was 11.7%.

The most common types of accident were those in which the bike left the road without colliding with any other object (23%). Riders felt that they were mainly to blame for 36% of this type of accident. The next most common situation was where the rider was in collision with another vehicle (20%); the rider accepted some blame for this type of accident in just 18% of cases.

Riders were asked to indicate whether they regarded the accident as 'a minor spill' or 'a low speed manoeuvring accident'. 1126 accidents were classified as 'minor spills', 590 as 'low speed manoeuvring' and 345 were not assigned to either category. Some accidents appeared in both categories. Of the 345 generally more serious accidents, riders stated that they had no blame for 71%. For 'all accidents', riders reported that only in 43% of instances did they accept some element of blame.

8.1.4 Multivariate analysis of the accident data

8.1.4.1 Basic risk factors and accidents

Clearly, with many related factors influencing accidents a multivariate analysis was required. First, the number of accidents reported by riders within the past 12-months was modelled using a generalised linear technique. The following factors were shown to be important in 'explaining' accident involvement:

- Annual mileage – the relationship was non-linear in that accident liability was proportional to mileage$^{0.4}$.
- Age and riding experience – accident liability fell with increasing age and increasing experience (number of years riding). The magnitude of these effects was such that for a novice 'all season, all weather' rider with a single year's experience, accident liability fell from 0.65 at age 17 to 0.19 at age 60. Experience was also important, though the experience effect was not as large in relation to the age effect as has been found for car drivers.
- A rider dedication hierarchy showed that after mileage, age and experience differences had been allowed for, 'all season, and all weather riders' (Category 1) had the highest accident liabilities. 'Summer all weather' riders (Category 3) had liabilities which were 41% lower than Category 1 riders and 'Summer occasional' riders (Category 4, 5 or 6) had liabilities which were 59% lower.
- Bike size – once mileage, age and experience had been allowed for in the model, riders of bikes over 125cc had accident liabilities (for 'all accidents') that were 15% lower than riders of smaller bikes.

The sex of the rider, whether the rider had taken compulsory basic training, or whether he or she had 'taken a break from riding' did not enter the model as statistically significant variables.

8.1.4.2 Motivations, behaviours and accidents

Two versions of a model of rider behaviour were developed. In these models attitudes/motivations/ perceptions and rider style influence rider behaviour, which in turn influence the likelihood of accident involvement. Age, sex and experience may influence attitudes and behaviour, and may also have a direct influence on accidents (i.e. an influence on accidents that is not mediated by the attitudes and behaviours included in the model). Accident risk is also directly influenced by the number of miles ridden in the past 12-months.

The reported frequency of errors was the most important behavioural contribution to accident involvement (once the mileage effect had been taken into account). Traffic errors (mostly associated with failures of hazard perception or observational skills) were the most consistent predictors. Control errors (mainly to do with difficulties of control associated with high speed, or errors in speed selection) were also important in some analyses. Stunt and speeding behaviours (i.e. 'violational' behaviours) also appeared as predictors of accident liability in some analyses.

The relative importance of the errors and violations found in the survey is in apparent contrast with findings from previous research on car drivers, in which self-reported violations are the stronger predictor of accident liability. This may result from the fact that motorcycles are more demanding to control than cars, and less forgiving of errors. However, the errors may themselves be closely linked with riding styles involving carelessness, inattention and excessive speed – i.e. styles that might be termed 'violational'.

When age and experience are not permitted to influence accidents directly (Model II), stunt/high risk behaviours become significant predictors of accidents. This is consistent with the explanation that one of the risk-increasing characteristics of young or inexperienced riders is their tendency to indulge in overtly risky behaviours.

Riding style, getting pleasure from motorcycling, and a liking for speed were identified as predictors of behavioural errors (that were, themselves, predictors of accidents). These predictors were also inter-correlated. Such relationships lend support to the view that an important part of the motorcycle safety problem stems directly from the motivations for choosing to ride motorcycles. This presents a challenging problem for road safety.

8.2 Conclusions and recommendations

The upward trends in motorcycle casualties over recent years do not in themselves indicate the presence of a new risk factor – the trends are broadly consistent with trends in motorcycle numbers and motorcycle mileage. However, motorcyclists face much higher levels of risk than car drivers, and their contribution to national casualty figures is increasing. Reducing motorcycling accidents is an important task for road safety policy.

The survey found a very strong effect of age on accident liability. Young riders are at much higher risk of accidents than older riders. This suggests that changes to the testing/training/licensing system to protect young riders are warranted.

In addition to reducing with age, motorcyclists' accident risk reduces as they gain experience, indicating that they are learning something useful during their early riding. This reinforces the belief that there is scope for improving safety by enhancing the learning process and/or attempting to control risk in some other way until the learning has taken effect.

Clearly, young and inexperienced riders must continue to be a target group for safety interventions – they are at particularly high risk, they can be reached by the training/testing/licensing system, and they have the potential for improvement. The challenge is to devise effective countermeasures for this group. It would therefore be useful to undertake research to develop and validate suitable interventions for young and inexperienced riders. These might include introducing further elements of graduated licensing, as well as improvements to training and education.

The effect of experience on motorcyclists' accident liability, though significant, is relatively weak in comparison with that of age – a finding that contrasts with the situation for car drivers. A speculative explanation is that, as motorcyclists become more experienced and develop improved riding skills they also tend to make more demands on those skills, buying faster, more demanding machines, riding faster, and generally continuing to have fun and excitement from motorcycling. If this were true, one way forward might be to assess whether there is further potential in the training and rider development provided by the advanced motorcycling organisations to promote a careful, safe, responsible riding style. The link, identified in the survey, between a 'careless/risky/irresponsible' riding style and accidents also suggests that a change of this kind might be useful.

This could be taken forward by inviting the advanced motorcycling organisations to collaborate in a study to assess how riders might be encouraged to adopt 'safer' riding styles. The findings of the present survey will be highly relevant, as will the findings of other research commissioned by DfT following the recommendations of the earlier scoping study on motorcycle safety (Elliott *et al.*, 2003).

Self-reported behavioural errors showed a consistent relationship with accident liability. Taken at face value, this suggests that interventions based on improving traffic skills such as hazard perception, and control skills associated with cornering and speed, would be effective at improving safety. However, the link between these errors and accidents may be as much to do with a careless, inattentive riding style and excessive speed as it is with lack of skill. For example, the control errors factor is dealing largely with errors and skills deficiencies that come into play when the motorcycle is being ridden enthusiastically (e.g. 'ride so fast into a corner that you feel like you might lose control', or 'find you have difficulty in controlling the bike when riding at speed'). Improved skills (hazard perception, speed selection, control) should better enable riders to cope with such situations, but a more sedate riding style would reduce the need for such skills. Certainly, attempting to improve control skills without a concomitant attempt to improve insights into risk and self limitations may increase rather than decrease accidents. As is now becoming well recognised in the field of driver and rider training research, motorcycle training should not focus on skills alone, but needs to improve insight into risk and self-limitations.

Riding style, and a liking for speed were identified as predictors of behavioural errors (that were, themselves, predictors of accidents). Such relationships lend support to the view that an important part of the motorcycle safety problem stems directly from the motivations that lead people to ride motorcycles in the first place. This presents a challenging problem for road safety. There may, however, be further scope for post and perhaps pre-test training to promote alternative aspirations for motorcyclists (e.g. competence, wisdom and safety, rather than excitement, 'progress' and speed). There may also be merit in trying to persuade the motorcycling press to promote such aspirations more widely.

The relationship between engine size and accident risk is a complex one. The survey showed that mileage-adjusted 'all-accident' rates for bikes up to 125cc is significantly higher than that for larger capacity bikes even when the effects of rider age and experience have been adjusted for. However, this does not apply to severe accidents, since accidents involving bigger bikes tend to be more severe than those involving smaller machines. For fatal accidents, Broughton (1988) found that bikes over 250cc had a much higher risk per mile than smaller bikes. Such an effect of bike size on accident severity is not surprising, given the likely higher speeds and impact energies of bigger motorcycles. The fact that they are more likely to carry pillion passengers also contributes to the casualty rates of the bigger machines.

This, together with the continuing upward trend in the numbers of bigger machines on the road, and the fact that as people trade-up to bigger machines their annual mileage (i.e. exposure to risk) is likely to increase as well, means that attention needs to be given to devising safety interventions for riders of bigger motorcycles. It would be valuable to explore how to use the purchase of a new bike as a way of targeting safety interventions for these users.

Riders who ride all year round, including in the wet and dark, were found to be at much higher risk than those who ride only in the summer, even when the effects of annual mileage, age, experience, training and bike size been corrected for. Presumably this is at least partly due to differences in the type of journey as well as to adverse weather and lighting conditions, though rider differences may play a part as well. The reasons for the excess risk of all-year-all-conditions riders merit further investigation, since they might indicate measures that could mitigate this risk.

There was no evidence of a 'returned rider effect' whereby people returning from riding after long breaks are at increased risk (though the study was not able to rule out a short term increase in risk immediately after a return to riding or following very long breaks). This is not to say that the trend towards people taking up motorcycling after a long break is irrelevant to road safety. Returning riders increase the amount of motorcycling, and therefore total number of motorcycling accidents. They may also form a receptive target group for interventions based on training and education, since they can be easily reached (i.e. when they purchase a motorcycle). Consideration should be given to developing training and educational interventions suitable for people returning to motorcycling, and to finding ways of encouraging returnees to participate. This might be done in collaboration with manufacturers, insurers and/or motorcycling organisations.

Given the very striking facts about the risks faced by motorcyclists, it would seem desirable to make sure that riders are actually aware of these risks. This might possibly reduce the numbers of people taking up or returning to motorcycling, and it might also encourage riders to modify their riding behaviour or to take-up further training. Ways of communicating the risks of motorcycling should be explored, and riders' current understanding of these risks assessed.

This survey has concentrated on rider-centred aspects of motorcycle safety. Safety interventions concerning the motorcycle itself, the road environment, and the behaviour and skills of car drivers, were also discussed in Elliott *et al.* (2003) scoping study, and remain worthy of consideration.

9 Acknowledgements

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Notes

[1] Given that cars carry more passengers than motorcycles do, the true risk ratio for individual users is likely to greater than 30.

[2] The training term was retained in the table because it approaches significance, and is of interest for discussion. Several ‘break from riding’ terms were tried, including returning from a break from riding after 12 months, but were not significant.

[3] On average a Poisson data set will provide one unit of generalised chi-square for every degree of freedom. The difference between the initial values of chi-square and the number of degrees of freedom can thus be regarded

as the non-Poisson variation in the data to be explained by the model. The final values indicate the magnitude of the residual non-Poisson variation that remains after the model has been fitted. The percentage of non-Poisson variation explained is then calculated from these values. The standard errors of the estimates take into account a scale parameter based on the mean deviance.

[4] It is also acknowledged that other road users (e.g. car drivers) have a role to play in road traffic accidents involving motorcyclists. This study, being centred on a survey of motorcyclists, focused on the rider, though some questions were asked about car drivers' role in motorcycle accidents.

[5] The proportion accident involved and the average mileage were adjusted to correct for the fact that some riders will have returned from their break during the 12 month accident reporting period. The figures have been inflated by a factor derived from the average recent experience under the assumption that those who have returned to riding within the past year will on average have been riding for 6 months.

[6] The mean length of break for those riders was 11 years, 40% of them had taken a break of over 10 years.

A SURVEY OF MOTORCYCLISTS

Please complete this questionnaire by ticking the appropriate boxes and filling in the spaces as required. It will only take about 20 minutes to complete and not all questions may apply to you. Any information you provide will be treated in the **strictest confidence** and used for research purposes only. No comments you make will be linked to you as an individual or passed on to any third party.

NOTE: THE RESULTS FROM THIS QUESTIONNAIRE ARE COMPLETELY ANONYMOUS

Please note: The word 'motorbike' is used to refer to a motorcycle, scooter or moped.

SECTION A: YOUR MOTORBIKE AND RIDING EXPERIENCE

Q1 Have you ridden a motorbike on a public road in the last 12 months?

Yes ☐

No ☐ ➡ *If **No**, please go to **Q27***

Q2 How long have you been riding motorbikes on public roads for?
(Do NOT include long periods when you never rode)
(Please write in the number of years and months)

_________ years _________ months

Q3 Between the time you first started riding motorbikes and now, did you have a break from riding motorbikes on public roads (i.e. were there any long periods of time when you did not ride a motorbike, i.e. more than a year)?

Yes ☐

No ☐ ➡ *If **No**, please go to **Q6***

Q4 When did you start riding motorbikes again on public roads, following your most recent long break?
(Please write in the month and year - e.g. July 1998)

____________________ month ____________________ year

Q5 How long was your most recent break of more than a year from riding motorbikes on public roads?
(*Please write in the number of years and months*)

_________ years _________ months

Q6 Approximately, how many miles have you ridden in the last 12 months on public roads?
(*Please include the amount you have ridden IN TOTAL ON ALL MOTORBIKES*)

____________________ miles

Q7 What is the engine size of the bike you rode MOST OFTEN on public roads during last:

(a) Summer? _________ cc **(b)** Winter? _________ cc

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TRR **m**

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Q8 For this question, please answer sections (A), (B) and (C)

	(A) Last SUMMER how often did you ride the following types of motorbikes? (Tick ONE box on each line)				(B) Last WINTER how often did you ride the following types of motorbikes? (Tick ONE box on each line)				(C) In the last 12 MONTHS overall how many miles did you ride on each type of bike? (please write in)
At least once per:	*Month*	*Week*	*Day*	*Never*	*Month*	*Week*	*Day*	*Never*	
Sports or Sports-Touring Motorcycle									
Touring Motorcycle									
Commuting/Roadster									
Off road/Trials Motorcycle									
Custom Motorcycle									
Classic Motorcycle									
Retro Motorcycle									
Moped									
Scooter									
Other (please specify) ________									

Q9 For this question, please answer sections (A) and (B)

	(A) How often did you ride a motorbike on public roads last SUMMER? (Tick ONE box on each line)				(B) How often did you ride a motorbike on public roads last WINTER? (Tick ONE box on each line)			
At least once per:	*Month*	*Week*	*Day*	*Never*	*Month*	*Week*	*Day*	*Never*
In built-up areas								
On country/rural roads								
On motorways or dual carriageways with 70mph speed limits								
In the dark								
In the rain/wet								
In fog								
On snow or ice								
For pleasure/leisure purposes								
For commuting purposes								
Use during the course of work (e.g. courier, police rider)								
Sporting purposes (e.g. Track days/ Scrambling, Rallying, etc)								

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Q10 Compare the amount you rode on public roads in the last 12 months with the amount you rode on public roads in the 12 months before that.
How much more or less have you ridden:

(Tick ONE box on EACH line)

	More in last 12 months (1)	About the same (2)	Less in last 12 months (3)
In built-up areas	☐	☐	☐
On country/rural roads	☐	☐	☐
On motorways or dual carriageways with a 70mph speed limit	☐	☐	☐
In the dark	☐	☐	☐
In the rain/wet	☐	☐	☐
In fog	☐	☐	☐
On snow or ice	☐	☐	☐
For pleasure/leisure purposes	☐	☐	☐
For commuting purposes	☐	☐	☐

Q11 Not including minor infringements (e.g. parking offences), how many endorsement points have you had on your license in the last 12 months for riding a motorbike? (*Please write in*)

__________________ points

Q12 What motorcycle training courses/tests have you (a) taken and (b) passed?

(Please tick ALL THAT APPLY for part (a) and part (b))

	(a) Training courses taken (1)	(b) Training courses passed (2)
Compulsory Basic Training	☐	☐
Direct/Accelerated Access	☐	☐
IAM Advanced Motorcycle Test	☐	☐
RoSPA Advanced Riding Test	☐	☐
Blue Riband Advanced Rider award	☐	☐
GNVQ 'Advanced' in Motorcycle Riding	☐	☐
Other (please specify) ____________________	☐	☐

Q13 Do you belong to a motorcycling organisation or club?

Yes ☐

No ☐

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SECTION B: ACCIDENTS

Q14 How many road accidents (including minor spills) have you been involved in while riding a motorbike on public roads in the last 12 months?

(*Tick ONE box*)

None ☐ ➡ *If* ***None****, please go to* ***Q17***

One ☐

Two ☐

Three ☐

More than three ☐

Q15 In what month and year did your most recent accident(s) occur? (e.g. Dec/2001)

Most recent accident _ _ _ / _ _ _ _

Next most recent _ _ _ / _ _ _ _

One before that _ _ _ / _ _ _ _

Q16 We are interested in the types of road accidents you have been involved in while riding a motorbike on public roads over the last 12 months (including minor spills).
Please answer each of the following questions by ticking the appropriate boxes.

(*Tick ONE box for EACH accident involved in*)

	Most recent accident (1)	Next most recent (2)	One before that (3)
(a) What happened first in the accident(s)?			
Another vehicle hit your vehicle while it was parked	☐	☐	☐
Your vehicle collided with a pedestrian	☐	☐	☐
Your vehicle collided with a cyclist	☐	☐	☐
Your vehicle collided with the rear or side of another vehicle	☐	☐	☐
Another vehicle collided with the rear or side of your vehicle	☐	☐	☐
There was a collision between your vehicle and another oncoming vehicle	☐	☐	☐
Your vehicle collided with a roadside object	☐	☐	☐
Your vehicle left the road without colliding with any other object	☐	☐	☐
Other (*please specify*) ________________	☐	☐	☐
(b) Would you describe the accident as a:			
Minor spill	☐	☐	☐
Low speed manoeuvring accident	☐	☐	☐

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Please answer each of the following questions by ticking the appropriate boxes.

	Most recent accident (1)	Next most recent (2)	One before that (3)
	(Tick ONE box for EACH accident involved in)		
(c) On what type of road did the accident(s) occur?			
On a road in a built up-area	☐	☐	☐
On a country/rural road	☐	☐	☐
On a motorway or dual carriageway with a 70mph speed limit	☐	☐	☐
	(Tick ALL boxes that apply for EACH accident)		
(d) What were the conditions like at the time of the accident(s)?			
Fine	☐	☐	☐
Rain or wet roads	☐	☐	☐
Snow or ice	☐	☐	☐
Fog	☐	☐	☐
Bad road surface	☐	☐	☐
Slippery due to diesel spill	☐	☐	☐
	(Tick ONE box for EACH accident involved in)		
(e) What injuries did YOU sustain as a result of the accident(s)?			
None	☐	☐	☐
Slight injuries (e.g. cuts and bruises)	☐	☐	☐
Serious injuries (e.g. needing hospital care)	☐	☐	☐
	(Tick ONE box for EACH accident involved in)		
(f) What injuries did other people sustain as a result of the accident(s)?			
None	☐	☐	☐
Slight injuries (e.g. cuts and bruises)	☐	☐	☐
Serious injuries (e.g. needing hospital care)	☐	☐	☐
Fatal injuries	☐	☐	☐
	(Tick ONE box for EACH accident involved in)		
(g) What damage was done to the motorbike you were riding?			
None	☐	☐	☐
Slight damage (e.g. dents and scratches)	☐	☐	☐
Serious damage	☐	☐	☐
(h) What damage was done to other vehicles?	*(Tick ONE box for EACH accident involved in)*		
None	☐	☐	☐
Slight damage (e.g. dents and scratches)	☐	☐	☐
Serious damage	☐	☐	☐

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Please answer each of the following questions by ticking the appropriate boxes.

	Most recent accident (1)	**Next most recent** (2)	**One before that** (3)
(i) What type of motorbike were you riding when the accident(s) happened?	*(Tick ONE box for EACH accident involved in)*		
Sports or Sports-Touring motorcycle	☐	☐	☐
Touring motorcycle	☐	☐	☐
Commuting/Roadster motorcycle	☐	☐	☐
Off road/Trials motorcycle	☐	☐	☐
Custom motorcycle	☐	☐	☐
Classic motorcycle	☐	☐	☐
Retro motorcycle	☐	☐	☐
Moped	☐	☐	☐
Scooter	☐	☐	☐
Other (*please specify*) ________________	☐	☐	☐
(j) What was the purpose of your journey?			
I was riding for pleasure/leisure purposes	☐	☐	☐
I was commuting to/from work	☐	☐	☐
I was riding during the course of my work	☐	☐	☐
Other (*please specify*) ________________	☐	☐	☐
(k) Did the accident(s) occur during:			
Daylight	☐	☐	☐
Dawn or dusk	☐	☐	☐
Hours of darkness	☐	☐	☐
(l) To what extent do you think you were to blame for the accident(s)?			
Not at all	☐	☐	☐
A little	☐	☐	☐
Quite a lot	☐	☐	☐
Entirely	☐	☐	☐

(m) If you would like to give us more details of the accident(s), please do so in the box below.

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Q17 Many riders have had the impression of only just avoiding an accident (i.e. of having a near miss). How many times has this happened to you in the last 12 months while riding a motorbike on a public road?

(*Tick ONE box*)

Never ☐ On 1 or 2 occasions ☐ On 3 to 5 occasions ☐

On 6 to 10 occasions ☐ On more than 10 occasions ☐

SECTION C: YOUR ATTITUDES AND RIDING BEHAVIOUR

Q18 Please indicate how much you agree or disagree with the following statements.

(*Tick ONE box on EACH line*)

Accidents involving motorbikes are often caused by…	**Strongly agree** (1)	**Agree** (2)	**Neither** (3)	**Disagree** (4)	**Strongly disagree** (5)
(a) Drivers pulling out in front of motorcyclists	☐	☐	☐	☐	☐
(b) Drivers not noticing motorcyclists	☐	☐	☐	☐	☐
(c) Motorcyclists going too fast	☐	☐	☐	☐	☐
(d) Car drivers driving too fast	☐	☐	☐	☐	☐
(e) Motorcyclists not looking far enough ahead	☐	☐	☐	☐	☐
(f) Car drivers not looking properly	☐	☐	☐	☐	☐
(g) Motorcycles being relatively less stable in an emergency situation	☐	☐	☐	☐	☐

Q19 When riding, how often do you:

(*Tick ONE box on EACH line*)

	Never (1)	**Hardly ever** (2)	**Occas-ionally** (3)	**Quite often** (4)	**Frequently** (5)	**Nearly all the time** (6)
(a) Wear a leather one-piece suit?	☐	☐	☐	☐	☐	☐
(b) Wear a protective jacket (leather or non-leather)?	☐	☐	☐	☐	☐	☐
(c) Wear protective trousers (leather or non-leather)?	☐	☐	☐	☐	☐	☐
(d) Wear body armour (elbow pads, shoulder pads, knee pads, etc)?	☐	☐	☐	☐	☐	☐
(e) Wear riding boots?	☐	☐	☐	☐	☐	☐
(f) Wear gloves?	☐	☐	☐	☐	☐	☐
(g) Wear bright/fluorescent clothing?	☐	☐	☐	☐	☐	☐
(h) Wear bright/fluorescent strips/patches on your clothing?	☐	☐	☐	☐	☐	☐
(i) Use dipped headlights on your bike?	☐	☐	☐	☐	☐	☐
(j) Wear no protective clothing?	☐	☐	☐	☐	☐	☐
(k) Have trouble with your visor or goggles fogging up?	☐	☐	☐	☐	☐	☐

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Q20 Compared with other motorbike riders your age and sex, how likely or unlikely do you think it is that YOU will be involved in an accident while riding a motorbike on a public road in the next 12 months? (*Tick ONE box*)

- Much more unlikely to be involved in an accident ☐
- More unlikely to be involved in an accident ☐
- As likely to be involved in an accident ☐
- More likely to be involved in an accident ☐
- Much more likely to be involved in an accident ☐

Q21 Compared with other motorbike riders your age and sex, how much better or worse do you think you are at each of the following while riding? (*Tick ONE box on EACH line*)

	Much better (1)	Better (2)	About the same (3)	Worse (4)	Much worse (5)
(a) Controlling the motorbike (i.e. vehicle control skills)	☐	☐	☐	☐	☐
(b) Spotting hazards	☐	☐	☐	☐	☐
(c) Getting out of a hazardous situation safely	☐	☐	☐	☐	☐
(d) Anticipating what other road users are going to do	☐	☐	☐	☐	☐
(e) Avoiding hazardous situations	☐	☐	☐	☐	☐

Q22 When riding, how often do each of the following things happen to you? (*Tick ONE box on EACH line*)

	Never (1)	Hardly ever (2)	Occas-ionally (3)	Quite often (4)	Frequently (5)	Nearly all the time (6)
(a) Queuing to turn left on a main road, you pay such close attention to the main traffic that you nearly hit the vehicle in front	☐	☐	☐	☐	☐	☐
(b) Fail to notice that pedestrians are crossing when turning into a side street from a main road	☐	☐	☐	☐	☐	☐
(c) Exceed the speed limit on a residential road	☐	☐	☐	☐	☐	☐
(d) Miss "Give Way" signs and narrowly avoid colliding with traffic having the right of way	☐	☐	☐	☐	☐	☐
(e) Attempt to overtake someone that you hadn't noticed to be signalling a right turn	☐	☐	☐	☐	☐	☐
(f) Race away from traffic lights with the intention of beating the driver/rider next to you	☐	☐	☐	☐	☐	☐
(g) Ride so close to the vehicle in front that it would be difficult to stop in an emergency	☐	☐	☐	☐	☐	☐
(h) Exceed the speed limit on a motorway	☐	☐	☐	☐	☐	☐
(i) Ride between two lanes of fast moving traffic	☐	☐	☐	☐	☐	☐
(j) Ride so fast into a corner that you scare yourself	☐	☐	☐	☐	☐	☐
(k) Exceed the speed limit on a country/rural road	☐	☐	☐	☐	☐	☐
(l) Ride when you suspect you might be over the legal limit for alcohol	☐	☐	☐	☐	☐	☐
(m) When riding at the same speed as other traffic, you find it difficult to stop in time when a traffic light has turned against you	☐	☐	☐	☐	☐	☐

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Q23 When riding, how often do each of the following things happen to you?

(Tick ONE box on EACH line)

	Never (1)	Hardly ever (2)	Occas-ionally (3)	Quite often (4)	Frequently (5)	Nearly all the time (6)
(a) Distracted or pre-occupied, you belatedly realise that the vehicle in front has slowed and you have to brake hard to avoid a collision	☐	☐	☐	☐	☐	☐
(b) Pull out on to a main road in front of a vehicle that you hadn't noticed, or whose speed you have misjudged	☐	☐	☐	☐	☐	☐
(c) Disregard the speed limit late at night or in the early hours of the morning	☐	☐	☐	☐	☐	☐
(d) Not notice a pedestrian waiting to cross at a zebra crossing, or a pelican crossing that has just turned red	☐	☐	☐	☐	☐	☐
(e) Not notice someone stepping out from behind a parked vehicle until it is nearly too late	☐	☐	☐	☐	☐	☐
(f) Fail to notice or anticipate that another vehicle might pull out in front of you and have difficulty stopping	☐	☐	☐	☐	☐	☐
(g) Get involved in unofficial 'races' with other riders or drivers	☐	☐	☐	☐	☐	☐
(h) Attempt to do, or actually do, a wheelie	☐	☐	☐	☐	☐	☐
(i) Unintentionally do a wheel spin	☐	☐	☐	☐	☐	☐
(j) Intentionally do a wheel spin	☐	☐	☐	☐	☐	☐
(k) Pull away too quickly and your front wheel comes off the road	☐	☐	☐	☐	☐	☐
(l) Open up the throttle and just 'go for it' on country roads	☐	☐	☐	☐	☐	☐
(m) Driver deliberately annoys you or puts you at risk	☐	☐	☐	☐	☐	☐

Q24 How much do you agree or disagree with these following statements?

(Tick ONE box on EACH line)

	Strongly agree (1)	Agree (2)	Neither (3)	Disagree (4)	Strongly disagree (5)
(a) It is important to me that my motorbike is economic in fuel consumption	☐	☐	☐	☐	☐
(b) It is important to me that my motorbike is stable and easy to control	☐	☐	☐	☐	☐
(c) One of the best things about riding a motorbike is that it is easy to park	☐	☐	☐	☐	☐
(d) A motorbike is only a means of getting from A to B	☐	☐	☐	☐	☐
(e) One of the best things about riding a motorbike is that you can get through traffic jams more easily	☐	☐	☐	☐	☐
(f) One of the best things about my motorbike is that it is easy to manoeuvre in traffic	☐	☐	☐	☐	☐
(g) Motorbike riding is exciting	☐	☐	☐	☐	☐
(h) Riding a motorbike makes me feel good	☐	☐	☐	☐	☐
(i) When riding, it is a good feeling when you overtake others	☐	☐	☐	☐	☐

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Q24 (*continued*)

How much do you agree or disagree with these following statements?

(*Tick ONE box on EACH line*)

	Strongly agree (1)	Agree (2)	Neither (3)	Disagree (4)	Strongly disagree (5)
(j) When riding a motorbike, I feel a sense of freedom	☐	☐	☐	☐	☐
(k) I prefer to ride slowly	☐	☐	☐	☐	☐
(l) It is important to me that my motorbike has a high top speed	☐	☐	☐	☐	☐
(m) It is important to me that my motorbike has fast acceleration	☐	☐	☐	☐	☐
(n) When I am with my friends, we often talk about motorbikes	☐	☐	☐	☐	☐
(o) I enjoy riding my motorbike at high speeds	☐	☐	☐	☐	☐
(p) I like to corner at high speed	☐	☐	☐	☐	☐
(q) I enjoy going on long motorbike rides	☐	☐	☐	☐	☐
(r) Riding a motorbike is a good social activity	☐	☐	☐	☐	☐
(s) When riding a motorbike, I often feel as if I am at one with the machine	☐	☐	☐	☐	☐
(t) Motorcycling is safe, as long as you know what you are doing	☐	☐	☐	☐	☐
(u) I think that 60 mph on a rural road is too slow	☐	☐	☐	☐	☐
(v) Without motorbikes, my life would be less interesting	☐	☐	☐	☐	☐
(w) Without a certain level of thrill, motorbike riding would be boring	☐	☐	☐	☐	☐
(x) It is fun to ride a motorbike	☐	☐	☐	☐	☐

Q25 When riding, how often do each of the following things happen to you?

(*Tick ONE box on EACH line*)

	Never (1)	Hardly ever (2)	Occas-ionally (3)	Quite often (4)	Frequently (5)	Nearly all the time (6)
(a) Ride so fast into a corner that you feel like you might lose control	☐	☐	☐	☐	☐	☐
(b) Change gear when going round a corner	☐	☐	☐	☐	☐	☐
(c) Skid on a wet road or manhole cover	☐	☐	☐	☐	☐	☐
(d) Run wide when going round a corner	☐	☐	☐	☐	☐	☐
(e) Find that you have difficulty controlling the bike when riding at speed (e.g. steering wobble)	☐	☐	☐	☐	☐	☐
(f) Brake or throttle back when going round a bend	☐	☐	☐	☐	☐	☐

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Q26 We would like to know what kind of rider you think you are by putting a tick somewhere on each of the lines below.

At either end of each line there is a word that describes a way of driving, and these words are opposites. Put your tick nearer to the word that best describes your driving. The closer your tick is to the word, the more you agree with this description of the way you drive.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Attentive								Inattentive
Careful								Careless
Decisive								Indecisive
Experienced								Inexperienced
Irritable								Placid
Nervous								Confident
Patient								Impatient
Responsible								Irresponsible
Safe								Risky
Selfish								Considerate
Slow								Fast
Tolerant								Intolerant

SECTION D: OTHER INFORMATION ABOUT YOU

Q27 Are you:

Male ☐

Female ☐

Q28 How old were you on your last birthday?

_______________ years old

Q29 Have you driven a car/van in the last 12 months?

Yes ☐

No ☐ ➡ *If **No**, please go to **Q32***

Q30 Approximately, how many miles have you driven in a car/van in the last 12 months?

_______________ miles

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Q31 How many accidents have you had while driving a car during the past 3 years?

None	☐	1
One	☐	2
Two or more	☐	3

Q32 Please tick the box that best describes your work situation.
If you are retired, please tick the box best describing your main work situation before retirement.

Senior managerial, administrative or professional	☐	1
Middle managerial, executives in large organisations	☐	2
Junior managerial, administrative or professional, supervisory and clerical	☐	3
Skilled manual worker	☐	4
Semi-skilled or unskilled manual worker	☐	5
Student, housewife/househusband, unemployed	☐	6

SECTION E: ANY OTHER COMMENTS

Thank you very much for your help.
Please put your questionnaire in the pre-paid envelope provided and return it to the NFER.

Appendix B: Producing the psychological scales

B.1 Factor analysis

First a series of principal components analyses with varimax and oblique rotations were conducted. Principal axis analyses, again with varimax and oblique rotations, were also conducted. For the sake of clarity, the results obtained from the principal components analyses with varimax rotations are reported below. However, it should be noted that corroborating results were found across all factor analyses conducted. After the factor analyses were conducted, mean scores for the items loading on to each factor were calculated to produce composite scales for use in subsequent data analysis. These procedures are described in more detail below.

B.1.1 Behaviour items

All of the items that comprised the Motorcycle Rider Behaviour Questionnaire (MRBQ) scale (Q22, Q23 & Q25; see Section 3.2.3 of this report for a description of this scale) were factor analysed along with the items concerning the use of safety equipment (Q19). The scree plot indicated that the data were best fitted by a 5 factor solution. The rotated factors accounted for 41.2% of the variance. Items loading onto factors 1, 2, 3 and 5 were those items that comprised the MRBQ[1]. Items loading on to factor 4 comprised the items concerned with using safety equipment. The results of the analysis are summarised in Table B.1.

Thirteen items loaded on to factor 1, which accounted for 10.4% of the variance. All thirteen items related to what Reason *et al.* (1990) defined as errors (slips and lapses, and mistakes), and were used to calculate the composite scale for this factor – termed 'errors'.

Of the twelve items that loaded on to factor 2, which accounted for 9.4% of the variance, most were related to speed violations. Only two items that loaded on to this factor could not be considered in this way. These were 'wear bright/fluorescent clothing' (-0.45) and wear bright/ fluorescent strips/patches on your clothing' (-0.34). These items were excluded from the composite scale calculated for this factor which was labelled 'speed behaviour' (not only because they caused interpretation difficulties but also because they lowered the Cronbach's Alpha value for the scale – see Section A.2 for a description of scale reliabilities).

Seven items loaded on factor 3, which accounted for 8.1% of the variance. Only one of these items could not be interpreted as belonging to a general category of extreme risk behaviours involving performing stunts (e.g. wheelies and wheel spins), racing other riders or drivers and other high speed examples of behaviour (e.g. 'open up the throttle and just 'go for it' on country roads'). This item, 'wear a leather one-piece suit' (0.39), was excluded from the composite scale calculated for this factor which was labelled 'performing stunts and other highly risky behaviours' (this item also substantially lowered the internal reliability of the scale).

As mentioned above, items concerned with using safety equipment (e.g. wearing protective clothing and using dipped headlights on the motorbike) loaded on to factor 4, which accounted for 7.5% of the variance. Only one item loaded on to this factor which was not related to the use of safety equipment – 'exceed the speed limit on a motorway' (0.35). This item was excluded from the composite scale produced for this factor structure. The remaining eight items loading on to this factor were used to calculate the composite scale which was labelled 'using safety equipment'[2].

Factor 5 accounted for 5.9% of the variance. All nine items loading on to this factor related to errors. This factor has, for convenience, been called 'control error', although it actually describes making errors through lack of control skills.

B.1.2 Attitude/motivation/perception items

With the exception of the driving style scale (Guppy *et al.,* 1989) which was factor analysed separately (see below), the questionnaire items used to measure riders' attitudes / motivations / perceptions (Q18, Q20, Q21, Q24) were factor analysed. The scree plot indicated that the data were best fitted by a 6 factor solution. The rotated factors accounted for 52.2% of the variance. Items loading onto factors 1, 2, and 3 were those items that comprised the rider motivation questionnaire (RMQ) scale (Q24; see Section 3.2.3 of this report for a description of this scale). The other attitude type items loaded on to other factors. Table B.2 summarises the results of the factor analysis.

Items loading onto factor 1 (which accounted for 14.1% of the variance) were mostly those that were designed to measure the following rider motivations: 'hedonism', 'escapism', 'identifying with the bike', 'flow effects', and 'social aspects'. These findings are in line with those reported by Schulz *et al.* (1991), who termed this category 'riding for pleasure'. This label also seemed a suitable one to describe the first attitude/motivation factor found in this study. All items loading on to this factor were used to produce the 'riding for pleasure' composite scale.

Factor 2, accounting for 11.8% of the variance, comprised the questionnaire items designed to measure the motivations which Schulz and colleagues termed 'dynamic aspects of biking, performance aspects of biking', 'thrill and adventure seeking', 'exhibition riding' and 'safety behaviour'. Schulz *et al.* (1991) reported similar findings to this in that questionnaire items designed to measure these motivations grouped together to form one

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[1] In all factor analyses reported in this report, the value of 0.3 was used as a cut-off point for item loadings

[2] Seven of these eight items loaded positively on factor 4. The item 'wear no protective clothing' loaded negatively on to this factor. Therefore, before the composite scale for this factor was produced, scores on this item were reversed so that higher scores indicated a greater frequency of safety equipment.

Table B.1 Principal components analysis (Varimax Rotation): Behaviour items

Item	*TRAFFIC ERROR*	*SPEED1*	*STUNT*	*SAFETY*	*CONTROL ERROR*
Queuing to turn left on a main road, you pay such close attention to the main traffic that you nearly hit the vehicle in front (Q22a)	**0.59**	-0.01	0.03	-0.05	0.15
Fail to notice that pedestrians are crossing when turning into a side street from a main road (Q22b)	**0.66**	-0.01	0.04	-0.05	0.06
Exceed the speed limit on a residential road (Q22c)	0.21	**0.67**	0.07	0.00	0.11
Miss 'Give Way' signs and narrowly avoid colliding with traffic having the right of way (Q22d)	**0.60**	0.04	0.02	-0.08	0.00
Attempt to overtake someone that you hadn't noticed to be signalling a right turn (Q22e)	**0.56**	0.22	0.08	0.10	0.08
Race away from traffic lights with the intention of beating the driver/rider next to you (Q22f)	0.14	**0.54**	0.28	0.04	0.16
Ride so close to the vehicle in front that it would be difficult to stop in an emergency (Q22g)	**0.35**	**0.38**	0.03	0.00	0.22
Exceed the speed limit on a motorway (Q22h)	0.00	**0.71**	0.22	**0.35**	-0.02
Ride between two lanes of fast moving traffic (Q22i)	0.24	**0.46**	0.26	0.02	0.03
Ride so fast into a corner that you scare yourself (Q22j)	0.26	**0.38**	0.23	0.12	0.44
Exceed the speed limit on a country/rural road (Q22k)	0.04	**0.75**	0.28	0.26	0.04
Ride when you suspect you might be over the legal limit for alcohol (Q22l)	0.14	0.21	0.00	-0.17	0.06
When riding at the same speed as other traffic, you find it difficult to stop in time when a traffic light has turned against you (Q22m)	**0.49**	0.05	-0.12	-0.05	0.30
Distracted or pre-occupied, you belatedly realise that the vehicle in front has slowed and you have to brake hard to avoid a collision (Q23a)	**0.59**	0.12	-0.05	-0.07	0.30
Pull out on to a main road in front of a vehicle that you hadn't noticed, or whose speed you have misjudged (Q23b)	**0.63**	0.06	0.00	-0.01	0.19
Disregard the speed limit late at night or in the early hours of the morning (Q23c)	0.15	**0.72**	0.23	0.08	0.05
Not notice a pedestrian waiting to cross at a zebra crossing, or a pelican crossing that has just turned red (Q23d)	**0.64**	0.10	0.02	-0.02	0.07
Not notice someone stepping out from behind a parked vehicle until it is nearly too late (Q23e)	**0.65**	0.03	0.04	0.00	0.05
Fail to notice or anticipate that another vehicle might pull out in front of you and have difficulty stopping (Q23f)	**0.60**	0.11	0.05	-0.01	0.17
Get involved in unofficial 'races' with other riders or drivers (Q23g)	0.08	0.42	**0.58**	-0.01	0.08
Attempt to do, or actually do, a wheelie (Q23h)	-0.03	0.18	**0.81**	-0.05	0.07
Unintentionally do a wheel spin (Q23i)	0.08	0.06	**0.60**	0.05	0.18
Intentionally do a wheel spin (Q23j)	0.00	0.11	**0.75**	-0.09	0.08
Pull away too quickly and your front wheel comes off the road (Q23k)	0.01	0.22	**0.77**	0.06	0.11
Open up the throttle and just 'go for it' on country roads (Q23l)	0.05	**0.54**	**0.46**	0.09	0.16
Driver deliberately annoys you or puts you at risk (Q23m)	0.14	0.15	0.23	0.14	0.18

Continued ....

Table B.1 (Continued) Principal components analysis (Varimax Rotation): Behaviour items

Item	*TRAFFIC ERROR*	*SPEED1*	*STUNT*	*SAFETY*	*CONTROL ERROR*
Ride so fast into a corner that you feel like you might lose control (Q25a)	**0.30**	0.25	0.15	0.09	**0.54**
Change gear when going round a corner or bend (Q25b)	0.00	0.14	0.09	0.07	**0.50**
Skid on a wet road or manhole cover (Q25c)	0.23	0.03	0.20	0.03	**0.44**
Run wide when going round a corner (Q25d)	0.31	0.13	0.03	0.04	**0.63**
Find that you have difficulty controlling the bike when riding at speed (e.g. steering wobble) (Q25e)	0.29	0.04	0.15	-0.02	**0.45**
Brake or throttle-back when going round a corner or bend (Q25f)	0.03	0.03	-0.03	-0.10	**0.64**
Wear a leather one-piece suit? (Q19a)	-0.04	0.03	0.39	0.21	-0.12
Wear a protective jacket (leather or non-leather)? (Q19b)	-0.02	0.05	-0.12	**0.67**	0.09
Wear protective trousers (leather or non-leather)? (Q19c)	-0.04	0.04	0.00	**0.73**	-0.02
Wear body armour (elbow pads, shoulder pads, knee pads, etc) (Q19d)	-0.05	0.07	0.20	**0.64**	-0.02
Wear riding boots? (Q19e)	-0.08	0.18	0.05	**0.73**	-0.01
Wear gloves? (Q19f)	-0.10	0.03	-0.01	**0.48**	0.06
Wear bright/fluorescent clothing? (Q19g)	0.14	**-0.45**	0.11	0.18	-0.14
Wear bright/fluorescent strips/patches on your clothing? (Q19h)	0.13	**-0.34**	0.05	**0.37**	-0.09
Use dipped headlights on your bike? (Q19i)	-0.02	0.02	0.10	0.35	0.01
Wear no protective clothing? (Q19j)	0.07	0.06	0.04	**-0.63**	-0.01
Have trouble with your visor or goggles fogging up (Q19k)	0.17	0.00	0.00	0.00	0.24

Figures in bold indicate factor loadings of 0.3 or better (values of 0.3 or better that are not in bold indicate that the item of concern was not used in producing the composite scale which it loaded on to).

Key to column headings:
TRAFFIC ERROR = Mistakes and lapses/slips in coping with traffic and pedestrians.
SPEED1 = Speed behaviour.
STUNT = Performing stunts and other highly risky behaviours.
SAFETY = Using safety equipment.
CONTROL ERROR = Control errors mainly associated with fast riding.

Table B.2 Principal components analysis (Varimax Rotation): Attitude/motivation/perception items

Item	*PLEA*	*SPEED2*	*CONV*	*SKILL*	*MCFAU*	*CAFAU*
Riding a motorbike is a good social activity (Q24r)	**0.74**	0.02	-0.04	0.06	-0.10	0.09
When riding a motorbike, I often feel as if I am at one with the machine (Q24s)	**0.72**	0.10	-0.01	0.16	-0.01	0.01
Riding a motorbike makes me feel good (Q24h)	**0.72**	0.29	0.05	0.01	0.04	0.06
I enjoy going on long motorbike rides (Q24q)	**0.69**	0.13	-0.05	0.07	-0.08	0.06
It is fun to ride a motorbike (Q24x)	**0.69**	0.18	0.04	0.04	-0.01	0.08
When I am with my friends, we often talk about motorbikes (Q24n)	**0.66**	0.17	-0.10	0.06	-0.08	0.07
When riding a motorbike, I feel a sense of freedom (Q24j)	**0.65**	0.12	0.11	0.03	0.04	0.09
Without motorbikes, my life would be less interesting (Q24v)	**0.64**	0.17	-0.03	0.06	-0.05	0.00
Motorbike riding is exciting (Q24g)	**0.64**	**0.37**	0.13	0.00	0.03	0.07
A motorbike is only a means of getting from A to B (Q24d)	**-0.47**	-0.18	**0.38**	0.00	0.04	-0.06
Motorcycling is safe, as long as you know what you are doing (Q24t)	**0.36**	-0.13	0.21	0.28	-0.16	0.00
I enjoy riding my motorbike at high speeds (Q24o)	**0.32**	**0.76**	-0.06	0.03	-0.06	0.03
I like to corner at high speed (Q24p)	**0.30**	**0.73**	-0.12	0.07	-0.11	0.03
It is important to me that my motorbike has fast acceleration (Q24m)	0.19	**0.71**	0.04	0.03	-0.02	0.04
It is important to me that my motorbike has a high top speed (Q24l)	0.09	**0.67**	0.04	0.03	-0.02	0.00
I prefer to ride slowly (Q24k)	-0.06	**-0.64**	0.10	0.00	0.13	0.00
When riding, it is a good feeling when you overtake others (Q24I)	0.25	**0.63**	0.16	-0.07	0.06	0.01
I think that 60mph on a rural road is too slow (Q24u)	0.18	**0.54**	-0.03	0.06	-0.21	0.04
Without a certain level of thrill, motorbike riding would be boring (Q24w)	**0.44**	**0.49**	0.00	0.00	0.00	-0.01
It is important to me that my motorbike is economic in fuel consumption (Q24a)	-0.11	**-0.40**	**0.52**	0.03	0.06	0.00
One of the best things about my motorbike is that it is easy to manoeuvre in traffic (Q24f)	0.06	0.20	**0.77**	0.07	-0.04	0.07
One of the best things about riding a motorbike is that it is easy to park (Q24c)	-0.04	-0.12	**0.72**	0.04	0.05	0.03
One of the best things about riding a motorbike is that you can get through traffic jams more easily (Q24e)	0.04	0.36	**0.70**	0.02	-0.04	0.08
It is important to me that my motorbike is stable and easy to control (Q24b)	0.10	-0.25	**0.34**	0.07	0.08	0.11
Spotting hazards compared to others (Q21b))	0.05	0.11	0.00	**0.82**	0.04	0.07

Continued ....

Table B.2 (Continued) Principal components analysis (Varimax Rotation): Attitude/motivation/perception items

Item	*PLEA*	*SPEED2*	*CONV*	*SKILL*	*MCFAU*	*CAFAU*
Anticipating what other road users are going to do compared to others (Q21d)	0.04	0.08	-0.01	**0.81**	0.05	0.08
Avoiding hazardous situations compared to others (Q21e)	0.05	0.03	0.00	**0.81**	0.07	0.05
Getting out of a hazardous situation safely compared to others (Q21c)	0.10	0.06	0.08	**0.80**	-0.03	0.03
Controlling the motorbike (i.e. vehicle control skills) compared to others (Q21a)	0.11	0.06	0.08	**0.70**	-0.07	0.03
Chance of being accident involved compared to others (Q20)	0.03	-0.15	0.03	**0.51**	0.01	-0.05
Motorcyclists going too fast causes accidents (Q18c)	-0.03	-0.10	-0.02	-0.01	**0.79**	0.02
Motorcyclists not looking far enough ahead causes accidents (Q18e)	0.00	-0.01	-0.06	0.11	**0.67**	0.00
Car drivers driving too fast causes accidents (Q18d)	0.02	-0.27	0.12	0.05	**0.61**	0.17
Motorcycles being relatively less stable in an emergency situation (Q18g)	-0.16	-0.04	0.07	-0.08	**0.58**	-0.07
Drivers not noticing motorcyclists causes accidents (Q18b)	0.08	0.04	0.06	0.02	-0.01	**0.83**
Drivers pulling out in front of motorcyclists causes accidents (Q18a)	0.11	0.00	0.07	0.04	-0.04	**0.79**
Car drivers not looking properly causes accidents (Q18f)	0.13	0.04	0.04	0.10	0.12	**0.68**

Figures in bold indicate factor loadings of 0.3 or better (values of 0.3 or better that are not in bold indicate that the item of concern was not used in producing the composite scale).

Key to column headings:

PLEA = Riding for pleasure.
SPEED = Speed motivations.
CONV = Convenience/economical motivations.
SKILL = Self perceived riding skill compared with others.
MCFAU = Accidents caused by motorcyclists/the motorcycle.
CAFAU = Accidents caused by car drivers.

motivational category which was labelled 'Biking as a fast competitive sport'. The only difference between the findings of the present study and those reported by Schulz *et al.* (1991) is that in the study reported by Schulz and colleagues the questionnaire items used to measure safety behaviour comprised an independent motivational category on their own. In this study, only one questionnaire item was used to measure 'safety behaviour' (other questionnaire items were designed to measure this motivation but were dropped following the pilot study). Given this item: 'I prefer to ride slowly' could be thought of as tapping into a speed element of motorcycle riding, it is not surprising that this item loaded (negatively) onto the same factor as other items designed to measure dynamic and performance aspects of riding, which also tap into the speed element of motorcycle riding. Factor 2 was labelled 'speed motivations' given all items loading on to the factor were related in some way to being motivated by speed.

Factor 3 accounted for 6.3% of the variance. Items loading on to this factor were those which were designed to tap into the convenience and economic aspects of riding. All items loading on to this factor were used to produce the composite scale which was named 'convenience/economic motivations'.

Items loading on to factor 4, which accounted for 9.6% of the variance, were those items which required respondents to rate their riding skill (e.g. being able to control the motorbike) compared with other motorbike riders their age and sex. All these items were used to produce the composite scale which was labelled 'self-perceived riding skill compared with others'.

Factor 5 comprised the questionnaire items that were concerned with beliefs about motorcyclists, or the motorcycle, causing accidents involving motorcycle riders. This factor accounted for 5.3% of the variance and was labelled 'accidents caused by motorcyclists/the motorcycle'. One item loading onto this factor was not concerned with motorcycle riders or the motorcycle being the cause of accidents involving motorcyclists. This item was, 'car drivers driving too fast causes accidents' (0.61). However, this item was not excluded from the composite scale that was produced from the items loading on to this factor structure. This was because removal of this item resulted in a substantial reduction in internal reliability of the scale (see Section 5.2 for a description of scale reliabilities).

Finally, factor 6 comprised those items concerned with beliefs about car drivers causing the accidents involving motorcycle riders. This factor accounted for 5.1% of the variance and all three items which comprised the factor were used to produce the composite scale which was labelled 'accidents caused by car drivers'.

The results from the factor analysis of the items comprising the driving style scale (Guppy *et al.*, 1989) (Q27) are summarised in Table B.3. Three factors with Eigen values greater than 1 emerged from the data and the rotated factors accounted for 62.6% of the variance. Factor 1 accounted for 24.9% of the variance. The items loading strongly on to this first factor (0.69 or better) were the 'attentive / inattentive', 'safe / risky', 'responsible / irresponsible', and 'careful / careless' items. The

Table B.3 Principal components analysis (Varimax Rotation): Driving style scale (Guppy, 1989; Q26)

Item	*Riding style 1*	*Riding style 2*	*Riding style 3*
Careful / careless	**0.80**	0.25	0.03
Safe / risky	**0.76**	0.29	-0.04
Responsible / irresponsible	**0.73**	0.36	0.05
Attentive / inattentive	**0.69**	0.07	-0.24
Decisive / indecisive	0.58	0.04	**-0.53**
Irritable / placid	-0.01	**-0.83**	0.08
Tolerant / intolerant	0.24	**0.78**	0.01
Patient / impatient	0.29	**0.77**	0.08
Selfish / considerate	-0.27	**-0.70**	0.08
Nervous / confident	-0.01	-0.24	**0.77**
Slow / fast	0.22	0.23	**0.67**
Experienced / inexperienced	0.38	0.04	**-0.60**

Figures in bold indicate factor loading of 0.3 or better (values of 0.3 or better that are not in bold indicate that the item of concern was not used in producing the composite scale which it loaded on to).

'experienced / inexperienced' and the 'decisive / indecisive' items also loaded on to this factor but less strongly (0.38 and 0.58 respectively). The following items loaded strongly on to factor 2 (0.70 or better): 'irritable / placid', 'patient / impatient', 'tolerant / intolerant' 'selfish / considerate'. The item 'responsible / irresponsible' also loaded on to factor 2, but less strongly (0.36). Factor 2 accounted for 23.1% of the variance. Finally, the following items loaded strongly on to factor 3 (0.5 or better): 'nervous / confident', 'slow / fast', 'experienced / inexperienced', and 'decisive / indecisive'. Factor 3 accounted for 14.6% of the variance. These findings are broadly in line with those found for car drivers, (Maycock & Forsyth, 1997). Three scales were produced from this analysis of the driving style scale. The items used to produce the three scales are indicated in Table B.3.

B.2 Reliability analysis and descriptive statistics

As mentioned earlier, mean scores for the questionnaire items loading on to each factor found in the factor analyses (with the exceptions of those items reported in the sections above) were calculated to produce composite scales for use in subsequent data analyses. The properties of the scales produced are shown in Table B.4. All scales had acceptable to high internal consistency as indicated by Cronbach's Alpha statistics.

Table B.4 Properties of the self reported scales

Scale identifier	*Description*	*Items*	*Cronbach's Alpha*
TRAFFIC ERROR	Errors made while in traffic	13	0.84
SPEED1	Speed behaviour	11	0.87
STUNT	Performing stunts and other highly risky behaviours	6	0.81
CONTROL ERROR	Lack of control skill resulting in errors	9	0.73
SAFETY	Using safety equipment	8	0.70
PLEA	Riding for pleasure motivations	13	0.87
SPEED2	Speed motivations	11	0.85
CONV	Convenience/economical motivations	6	0.63
SKILL	Perceived riding skill compared with others	5	0.87
MCFAU	Beliefs that accidents are caused by motorcyclists/the motorcycle	4	0.61
CAFAU	Beliefs that accidents are caused by car drivers	3	0.69
RIDING STYLE 1	Careful/Careless, Safe/Risky, Responsible/Irresponsible, Attentive/Inattentive	4	0.82
RIDING STYLE 2	Irritable/Placid, Tolerant/Intolerant, Patient/Impatient, Selfish/Considerate	4	0.81
RIDING STYLE 3	Decisive/Indecisive, Nervous/Confident, Slow/Fast, Experienced/Inexperienced	4	0.60

Appendix C: Structural equation modelling: correlations

Table C1 shows the correlations between the attitudes, behaviours and background variables for Model I and Model II, the correlations with values greater than 0.3 have been emboldened. Only correlations that are significantly different from zero and have a value greater than 0.2 have been given.

Table C.1 Correlations between attitude, background and behaviour factors (values >0.2)

Measure 1	*Measure 2*	*Correlation*
TRAFFIC ERRORS	CONTROL ERRORS	**0.452**
SPEED1	STUNT	0.205
PLEA	SPEED2	**0.647**
	RS3	**-0.339**
	LMILES	-0.244
SPEED2	MCFAU	-0.215
	RS1	-0.252
	RS2	-0.278
	RS3	**-0.315**
	IAGE	-0.211
	LMILES	-0.244
SKILL	RS1	0.281
	RS3	**-0.375**
MCFAU	IAGE	0.208
RS1	RS2	**0.515**
	RS3	-0.275
	IAGE	0.276
RS2	IAGE	0.250
RS3	IEXPER	**-0.400**
	LMILES	0.245
IAGE	LEXPER	**0.544**

Appendix D: Relationship between age and experience

Table D1 shows the relationship between age and experience for male respondents and Table D2 for female respondents.

Table D1a Male motorcyclists in survey by age and experience

Counts

Males	*Experience grouped*										*Total*
	0-1	*>1-2*	*>2-5*	*>5-10*	*>10-15*	*>15-20*	*>21-25*	*>26-30*	*>31-35*	*35+*	
Age group	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*
16-20	58	117	91	4	0	0	0	0	0	0	270
21-25	27	64	107	67	4	0	0	0	0	0	269
26-30	30	113	196	144	104	2	0	0	0	0	589
31-35	31	134	314	329	192	209	3	0	0	0	1212
36-40	21	115	293	375	211	257	337	7	2	0	1618
41-45	23	68	234	286	177	167	278	318	3	1	1555
46-50	12	43	161	200	137	108	94	173	193	5	1126
51-55	6	36	136	201	116	88	79	95	107	221	1085
56-60	3	19	63	109	74	74	47	65	47	225	726
61+	1	11	45	65	67	77	53	87	52	434	892
Total	212	720	1640	1780	1082	982	891	745	404	886	9342

Table D1b Male motorcyclists in survey by age and experience (row %)

Percentage by row

Males	*Experience grouped*										*Total*
	0-1	*>1-2*	*>2-5*	*>5-10*	*>10-15*	*>15-20*	*>21-25*	*>26-30*	*>31-35*	*35+*	
Age group	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*
16-20	21%	43%	34%	1%	0%	0%	0%	0%	0%	0%	100%
21-25	10%	24%	40%	25%	1%	0%	0%	0%	0%	0%	100%
26-30	5%	19%	33%	24%	18%	0%	0%	0%	0%	0%	100%
31-35	3%	11%	26%	27%	16%	17%	0%	0%	0%	0%	100%
36-40	1%	7%	18%	23%	13%	16%	21%	0%	0%	0%	100%
41-45	1%	4%	15%	18%	11%	11%	18%	20%	0%	0%	100%
46-50	1%	4%	14%	18%	12%	10%	8%	15%	17%	0%	100%
51-55	1%	3%	13%	19%	11%	8%	7%	9%	10%	20%	100%
56-60	0%	3%	9%	15%	10%	10%	6%	9%	6%	31%	100%
61+	0%	1%	5%	7%	8%	9%	6%	10%	6%	49%	100%
Total	2%	8%	18%	19%	12%	11%	10%	8%	4%	9%	100%

Table D1c Male motorcyclists in survey by age and experience (column %)

Percentage by column

Males	*Experience grouped*										*Total*
	0-1	*>1-2*	*>2-5*	*>5-10*	*>10-15*	*>15-20*	*>21-25*	*>26-30*	*>31-35*	*35+*	
Age group	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*
16-20	27%	16%	6%	0%	0%	0%	0%	0%	0%	0%	3%
21-25	13%	9%	7%	4%	0%	0%	0%	0%	0%	0%	3%
26-30	14%	16%	12%	8%	10%	0%	0%	0%	0%	0%	6%
31-35	15%	19%	19%	18%	18%	21%	0%	0%	0%	0%	13%
36-40	10%	16%	18%	21%	20%	26%	38%	1%	0%	0%	17%
41-45	11%	9%	14%	16%	16%	17%	31%	43%	1%	0%	17%
46-50	6%	6%	10%	11%	13%	11%	11%	23%	48%	1%	12%
51-55	3%	5%	8%	11%	11%	9%	9%	13%	26%	25%	12%
56-60	1%	3%	4%	6%	7%	8%	5%	9%	12%	25%	8%
61+	0%	2%	3%	4%	6%	8%	6%	12%	13%	49%	10%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table D2a Female motorcyclists in survey by age and experience

Counts

Females	*Experience grouped*										*Total*
	0-1	*>1-2*	*>2-5*	*>5-10*	*>10-15*	*>15-20*	*>21-25*	*>26-30*	*>31-35*	*35+*	
Age group	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*	*Count*
16-20	22	29	17	0	0	0	0	0	0	0	68
21-25	8	23	16	5	0	0	0	0	0	0	52
26-30	11	29	35	16	7	0	0	0	0	0	98
31-35	7	36	53	38	14	9	0	0	0	0	157
36-40	9	25	45	21	16	16	13	0	0	0	145
41-45	7	15	26	22	8	12	8	1	0	0	99
46-50	3	3	15	16	8	8	5	2	2	0	62
51-55	2	4	10	18	11	14	1	2	2	1	65
56-60	0	2	7	4	6	10	6	3	3	1	42
61+	0	2	0	1	6	14	6	11	3	10	53
Total	69	168	224	141	76	83	39	19	10	12	841

Table D2b Female motorcyclists in survey by age and experience (row %)

Percentage by row

Females	*Experience grouped*										*Total*
	0-1	*>1-2*	*>2-5*	*>5-10*	*>10-15*	*>15-20*	*>21-25*	*>26-30*	*>31-35*	*35+*	
Age group	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*	*Row %*
16-20	32%	43%	25%	0%	0%	0%	0%	0%	0%	0%	100%
21-25	15%	44%	31%	10%	0%	0%	0%	0%	0%	0%	100%
26-30	11%	30%	36%	16%	7%	0%	0%	0%	0%	0%	100%
31-35	4%	23%	34%	24%	9%	6%	0%	0%	0%	0%	100%
36-40	6%	17%	31%	14%	11%	11%	9%	0%	0%	0%	100%
41-45	7%	15%	26%	22%	8%	12%	8%	1%	0%	0%	100%
46-50	5%	5%	24%	26%	13%	13%	8%	3%	3%	0%	100%
51-55	3%	6%	15%	28%	17%	22%	2%	3%	3%	2%	100%
56-60	0%	5%	17%	10%	14%	24%	14%	7%	7%	2%	100%
61+	0%	4%	0%	2%	11%	26%	11%	21%	6%	19%	100%
Total	8%	20%	27%	17%	9%	10%	5%	2%	1%	1%	100%

Table D2c Female motorcyclists in survey by age and experience (column %)

Percentage by column

Females	*Experience grouped*										*Total*
	0-1	*>1-2*	*>2-5*	*>5-10*	*>10-15*	*>15-20*	*>21-25*	*>26-30*	*>31-35*	*35+*	
Age group	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*	*Col %*
16-20	32%	17%	8%	0%	0%	0%	0%	0%	0%	0%	8%
21-25	12%	14%	7%	4%	0%	0%	0%	0%	0%	0%	6%
26-30	16%	17%	16%	11%	9%	0%	0%	0%	0%	0%	12%
31-35	10%	21%	24%	27%	18%	11%	0%	0%	0%	0%	19%
36-40	13%	15%	20%	15%	21%	19%	33%	0%	0%	0%	17%
41-45	10%	9%	12%	16%	11%	14%	21%	5%	0%	0%	12%
46-50	4%	2%	7%	11%	11%	10%	13%	11%	20%	0%	7%
51-55	3%	2%	4%	13%	14%	17%	3%	11%	20%	8%	8%
56-60	0%	1%	3%	3%	8%	12%	15%	16%	30%	8%	5%
61+	0%	1%	0%	1%	8%	17%	15%	58%	30%	83%	6%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Abstract

This report contains the findings of a study to explore and quantify the interacting influences which determine motorcyclist accident liabilities. It was conducted on behalf of Road Safety Division, Department for Transport.

The study first reviewed existing data sources to investigate the trends in motorcycling accidents over the last decade or so. The main part of the study was to carry out a survey of nearly 30,000 current motorcyclists in order to explore the relationship between accident risk and variables such as annual mileage, age, experience, journey type, training, personal characteristics of the riders, and the self-reported behaviours and attitudes of the riders.

The numbers of accidents reported by riders within the past 12-months of riding were modelled using generalised linear techniques to take into account factors such as mileage, age, experience, bike size and the conditions prevailing when they rode.

Models of rider behaviour were developed using other statistical modelling techniques. These models investigated how attitudes/motivations/perceptions and rider style influence rider behaviour, and how rider behaviour influences the likelihood of accident involvement. The influence of age, sex and experience on attitudes and behaviours, and as direct or indirect influences on accidents were also investigated. Accident risk was also directly influenced by the number of miles ridden in the past 12-months.

The report makes a number of recommendations for improving the safety of motorcycle riders.

Related publications

TRL582 *Work-related road accidents* by J Broughton, C Baughan, L Pearce, L Smith and G Buckle. 2003 (price £25, code AX)

TRL581 *Motorcycle safety - A scoping study* by M Elliott, C Baughan, J Broughton, B Chinn, G Grayson, J Knowles, L Smith and H Simpson. 2003 (price £25, code AX)

TRL 325 *The factors that influence a driver's choice of speed - a questionnaire study* by A Quimby, G Maycock, C Palmer and S Buttress. 1999 (price £35, code H)

TRL275 *Cohort study of learner and novice drivers. Part 4: Novice driver accidents in relation to methods of learning to drive, performance in the driving test and self-assessed driving ability and behaviour* by G Maycock and E Forsyth. 1997 (price £35, code H)

RR315 *The accident liability of car riders* by G Maycock, C R Lockwood and J Lester. 1991 (price £20, code C)

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