Individual and Group Differences in Driving Behaviour

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Summary

Road traffic accident involvement rates show that younger males are over represented in accidents. A number of studies have shown individual differences in accident involvement. Questionnaire-based methods to investigate individual and group differences in driver stress and risk perceptions reported in chapter 2 and 3 revealed that neuroticism was associated with; heightened perception of personal risk, driver stress, and inefficient coping strategies. Younger drivers and female drivers reported higher levels of stress. Young male drivers assessed their personal risk and driving abilities less realistically than did other age and sex groups. Driving simulator-based methods reported in chapter 4 revealed that young drivers and male drivers; drive faster, overtake more often, and commit more 'high risk' overtakes than do other age and sex groups. Middle-aged and elderly drivers were poorer at maintaining a fixed distance from a lead 'vehicle'. Older drivers adopt a slower, more cautious driving style, but appear to be worse at controlling distance from a 'lead' vehicle. Results are consistent with individual and group differences in accident involvement rates. Findings are discussed with reference to the implementation of driver education programs to reduce stress, the adoption of more realistic perceptions of risk among younger drivers, and the training of compensation strategies to counteract age-related changes in older drivers.

Keywords: Driving behaviour, driver stress, age differences, sex differences, personality, driving simulator

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Dedication

I would like to dedicate this thesis to my mother from both myself and my sister in recognition of her dedication to us.

Table of Contents

List of Tables and Figures

Chapter 1: Introduction

The Criterion versus Predictors Issue of Accident Involvement

Accidents result from a multitude of factors but can be regarded as being caused by interactions between vehicles, drivers, and the road environment (weather, other traffic, etc). Thus, there are many problems associated with the analysis of variables involved and with subsequent efforts at road traffic accident prevention.

The measurement of accident involvement is concerned with various operational problems which are the concern of researchers when attempting to relate the criterion of accident involvement rates to any single predictor. For example, rear-end shunting may stem from a different set of psychological events than an accident which occurs during a high speed overtake. Other concerns are the period of time over which accidents are observed and recording processes. Different agents may have different requirements when recording an accident. Naatanen and Summala (1976) note that official statistics on numbers of people injured in road accidents are unreliable. Zylman (1972) suggests that researchers should use official records with caution when attempting to find predictors of accident involvement as there may be many artifactual reasons why many accidents and convictions go unrecorded. There is considerable underreporting of non-fatal casualties when official statistics based on police reports are compared with medical authorities or driver interviews (Natanaan and Summala, 1976).

Accidents are not often meaningfully categorised by agencies for research purposes. For example, behavioural antecedents such as 'feeling stressed' go unrecorded. When official records and self-report data are combined, a more accurate accident involvement rate may be obtained (Smith, 1976). These issues have obvious research implications if attempts are made to relate driving behaviour for particular groups to accident involvement statistics, and should be considered. For example, typically low correlations between accident rates and driver variables such as personality have been reported and the unreliability of accident rates may be a contributory factor here.

Shinar (1978) estimates that 'driver error' is either a definite or probable contributory factor in over 90% of road accidents. Therefore, theoretical approaches to road accident causation have focussed on human factors. Much of the research in this area has investigated demographic data such as age, sex, personality, social, cognitive, and attitudinal variables. Goldstein (1962) found rather small correlations between various predictors such as reaction time, cognitive measures, sensory-perceptual and psychomotor tests. Other studies have shown that certain measures, such as switching attention show more significant relationships with 'accidents' in driving simulators (Barrett and Thornton, 1968; Barrett, Thornton and Cabe, 1969; Mihal and Barrett, 1976).

Research into the human factor of accident involvement can be categorised into three main areas (Mayer and Treat, 1977); stress, risk-taking, and information processing. On the basis of findings from previous research, the research presented here is concerned with investigating more fully individual and group differences which may contribute to these three areas.

Although several studies have found an association between stress and accident involvement, there have been no investigations of individual differences in driver stress. Previous studies have shown group differences in driver stress (Gulian *et al*, 1989a) with young drivers reporting greater levels of stress compared with older male drivers. However, sex differences have not previously been found. Chapter Two attempts to elucidate relationships between personality, coping and driver stress and reports results from a study of sex and age differences in driver stress.

There is reason to suppose that personality may be linked with an individual's predisposition to give higher ratings of their likelihood of being involved in a road traffic accident. Several studies show clear age differences with respect to risk perception but sex differences between risk perception and perceived driving abilities have been relatively neglected. Chapter Three then, is concerned with individual and group differences in risk perception. In chapter Four, sex and age differences in simulated driving performance are reported.

Driver Stress and Accident Involvement

The experience of stress during driving is due to many factors such as cognitive, emotional and physiological responses to traffic (Stokols and Navaco, 1981). A number of studies show that life stress predicts incidence and frequency of road accidents (Selzer and Vinokur, 1974; Brenner and Selzer, 1969). Cox (1978) suggests that stress results from a perceived imbalance between coping abilities and task and situational demands. Subjective driver stress may be explained by a transactional model (Lazarus and Folkman, 1984). According to this model, driving stress results when the perceived demands of the driving task are appraised by the driver as exceeding his/her ability to cope with them. Driver stress is also associated with stressful life events.

With reference to the transactional model, there are several causal routes through which personality and driver stress may come to be correlated. First, personality traits appear to influence appraisal (Martin, 1985) and cognitive coping strategies (McCrae and Costa, 1986) and therefore personality may directly influence evaluations of traffic situations. Personality may be linked to low-level emotional and behavioural reactions to driving, associated with individual differences in neural function. For example, personality may be associated with individual differences in arousal and preferred level of stimulation (Eysenck, 1967). Second, personality may be associated with more generalised stress syndromes, possibly due to life events. Individuals high in neuroticism may exhibit stress reactions during driving. Third, personality may be directly affected by driving experiences. For example, an individual who is consistently exposed to frustrating driving experiences as a commuter, may suffer adverse effects on personality such as becoming increasingly hostile. The study presented here does not address whether one or more of these causal routes are theoretically plausible, rather, the aim is to uncover whether there are indeed individual differences in driver stress.

There is strong evidence that frequency of accidents is predicted by stress associated with life events such as personal conflicts, work and financial difficulties, and health problems (Selzer & Vinokur, 1975; Isherwood, Adam & Hornblow, 1982). Several researchers (McMurray, 1970; Rahe, 1969; Finch and Smith, 1970) have found that external stress is related to road traffic accidents. For example, McMurray (1970) found that drivers who were going through a divorce had higher rates of accident involvement and violation rate than a control group. Another study by Finch and Smith (1970) found that 80% of 25 drivers killed had suffered one or more significant stressors within 24 hours of their accidents, whereas only 12% of a control group had suffered such stress. Selzer, Rogers and Kern (1968) found that 20% of their sample of drivers who had been killed in a road traffic accident had been involved in some sort of quarrel 6 hours prior to the accident.

According to Glendon *et al* (1989) driver stress emerges as one of the major factors in driving performance. Task performance can be affected by stressful events which reduce an individual's ability to cope with task and situational demands and result in a greater likelihood of errors being made. Moreover, the quality of an individual's performance may be quite different under different types of stressful situation (Coyne and Lazarus, 1980) for example, whether the situation is challenging or threatening. Jordan (1968) argues that risk-conscious drivers perform less efficiently than those who see no threat. Stokols *et al* (1978) suggested that stress experienced when driving, as well as the emotional demands of driving, may result in performance impairment and cause an adverse effect at home and at work. Stokols *et al* (1978) designed the Driving Habits Questionnaire (DHQ) which comprised 16 items giving two alternative choices associated with the Type A/B personality characteristics. Studies using the DHQ showed that traffic congestion increased levels of stress in relation to time and distance of exposure to the congestion.

The inclusion of cognitive factors in models of driver stress have added weight to determining how stress affects driver behaviour and performance. Thus, motivational factors (Naatanen and Summala, 1976), subjective risk appraisal (Fuller, 1984) and negative experience of road environment have been integrated into models of driver behaviour. Perceived risk level increases when cognitive abilities are taxed such as in the presence of other vehicles (Rockwell and Snider, 1965), as a function of driver fatigue (Handschman and Vass, 1979) and overtaking (Brown, 1965). Given this, it is likely that dimensions of driver stress are related to driver performance.

Gulian *et al* (1988, 1989a) describe the development of the Driver Behaviour Inventory (DBI). Analyses of 33 DBI items revealed five factors which were labelled : 'Driving Aggression', 'Irritation when overtaken', 'Driving Alertness', 'Driving dislike/enjoyment', and 'Frustration when failing to overtake' as well as a 'General driving stress scale' from a one-factor solution. These factors are somewhat similar to other descriptions of driving behaviour outlined in previous studies. For example, Goldstein and Mosel's (1958) and Parry's (1968) 'Driving aggression' and Synodinos and Papacostas (1985) 'Usurption of right of way' is similar to the DBI's 'Driving Aggression' factor. Stokols *et al*'s (1978) description of traffic-related cognitions and behaviour corresponds to the DBI's 'Dislike of driving' factor. Two further scales from Synodinos and Papacostas (1985) namely the 'Externally-focussed frustration' scale and 'Destination-activity orientation' can also be likened to the DBI's 'Frustration at failing to overtake' and with 'Driving alertness' respectively.

Gulian *et al* (1989a) report two factor analyses of the DBI which arrived at similar factor structures. One criterion for the number of factors extracted, indicated a general factor in both studies, associated with the overall appraisal of driving as positive or negative. The majority of items loaded at 0.3 on this factor. Other criteria for factor analysis converged on a five factor solution. Scales were developed for Driving Aggression (AGG:eg. "Driving usually makes me feel aggressive"), Dislike of Driving (DIS: "In general I do not enjoy driving"), Alertness (AL: "I increase my concentration on a difficult road"), Irritation when Overtaken (IO: "I feel angry when overtaken at a junction"), and Overtaking Tension (OT: "I feel tense when overtaking another vehicle"). The AGG, DIS and AL scales have 7-9 items; the rather narrow IO and OT scales 3 items each. The General Stress scale (GEN) comprises the 13 highest loading items on the general factors of the Gulian *et al* (1989a) studies. The five scales are moderately positively intercorrelated (range of correlations - 0.01 to +0.34). All scales except AL tend to be substantially positively correlated with the GEN scale, perhaps because AL deals with cognitive rather than emotional elements of driving. Gulian *et al* (1989a) report internal consistencies of 0.66 - 0.71 for the five factorial scales, and 0.82 for GEN. The GEN scale is mostly comprised of emotional items. Glendon *et al* (1992) report 5-month test-retest reliabilities ranging from 0.59 to 0.76 for the six scales, suggesting that an appreciable part of the variance is stable over time.

Risk Perception, Risk Taking and Accident Involvement

It has been widely argued (Nataanen and Summala, 1974; Watts and Quimby, 1980; Wilde, 1981; Fuller, 1984) that drivers modify their behaviour according to their perception of risk. Risk-taking behaviour is thought to be cognitively mediated by risk perception, risk utility and a driver's confidence in their own driving skills. Risk taking is considered to be a major factor in the higher accident involvement of younger drivers and many risky behaviours are interlinked so that individuals who run yellow lights are also more likely to speed, accept shorter temporal gaps etc. Young drivers speed more often (Harrington and McBride, 1970), adopt shorter headways (Evans and Wasielewski, 1983) and have a higher approach speed to signals (Konecni, Ebbesen and Konecni, 1976) than older drivers do. Younger drivers drive through crossroads faster than older drivers do (Koneci, Ebbesen and Koneci, 1976), have a narrower gap acceptance when pulling away from an intersection (Bottom and Ashworth, 1978) and are involved in more rear-end collisions than older drivers (Lalonde, 1979). Watts and Quimby noted that drivers under 25 and over 64 had smaller safety indices than drivers aged between 25 and 64. They attributed these differences as due not only to a slower response to hazards on the part of the elderly driver but also to faster speeds on the part of the younger driver.

Young male drivers appear to take more risks than other groups of drivers do. Young males accept shorter temporal gaps when entering traffic, speed more often, wear safety belts less often, drive through amber lights more often and run red lights more often than other age and sex groups do (Lawson, 1991). This excessive risk-taking could be due to younger male drivers' inability to see hazardous situations as dangerous or their willingness to take greater risks than older drivers do.

For the individual, different types of risky activities or situations can be viewed as uncertainties that arise from either personally determined or environmentally determined factors. Perceived risk may be differently weighted by different individuals. Brown and Copeman (1975) showed that young males rated over 30 traffic offences as less serious than older drivers did. Hodgdon, Bragg and Finn (1981) showed that the over representation of young males in collisions could not be explained by reference to less experience or poorer mechanical condition of their vehicles. The driving behaviour and in particular risk perception of the young male driver appears to be the greatest determinant of their greater accident involvement rates.

Relatively few studies of risk perception have been undertaken with respect to women drivers. Of the few studies reported, an in-car observational study by Soliday and Allen (1972) found that young women were less likely than older women to report mobile traffic hazards such as an oncoming car. Static roadway hazards such as a bridge were more likely to be reported by the younger female driver.

The study of risk perception or risk misperception has been a fruitful method of investigating the greater risk taking of the younger male driver. Using different methodologies, Matthews and Moran (1986) and Finn and Bragg (1986) found that younger drivers perceive less risk than older drivers do. Moreover, younger drivers may believe that they have better driving skills so that they can avoid an accident if a hazardous situation were to arise.

Some research shows that younger drivers overestimate the risk of being involved in a road traffic accident (Berger and Persinger, 1980; Finn and Bragg, 1986) leading one to suppose that younger drivers *should* drive more cautiously. The fact that they do not, has lead researchers to suppose that they disregard risk (Groeger and Brown, 1989). However, it may well be that objectively risky situations may not appear risky to the younger male driver. Thus, for the young male driver speeding or tail-gating for example, may be judged as less dangerous than in real-life. Soliday (1974) found that older drivers perceived relatively more danger from moving objects, whilst younger drivers erroneously perceived more danger from non-moving objects. Soliday (1974) argued that the greater exposure to driving for the older subjects had led to a greater awareness of the dangers of traffic.

Brehmer (1987) and Watts and Quimby (1980) report that estimation of accident frequency at particular locations correlates with the observed accident data for those locations. Groeger and Brown (1990) found that taking into account traffic flow through junctions, speed is related to estimated frequency of accidents. In actuality, speed through junctions is significantly related to both actual accident frequency and even more strongly related to accident likelihood. Therefore, drivers generally appear to have fairly accurate objective hazard perception. Other research has shown that in some respects at least, drivers are inaccurate with regards to objective risk. For example, Giscard (1966) found that more than half of a sample of 832 drivers thought driving at night was less risky than driving in the daytime when in fact night-time driving is several times more risky.

There are two major factors which may help to determine what makes an individual driver take risks. Objective high risk levels may depend on a driver overestimating driving skill or underestimating the difficulty of the driving task. Objective high risk may also be a conscious acceptance to drive under high risk situations. In the first instance, risk-taking is the result of misperception and in the second instance, the result of the drivers' decision-making criteria and attitude towards risk. It is therefore possible that drivers low in skill may still be safe drivers if they are realistic in their perceptions and compensate for their lower driving skills. The component of skill and control is important in the experience of risk. Research in probabilistic assessments suggests that people are generally too optimistic and overconfident in their risk perception by reducing the importance of relatively low risk of being involved in an accident (Slovic, Fischloff and Lichenstein, 1977).

Risk Utility

According to Wilde (1976, 1982) if the perceived risk or target level of objective risk is at an acceptable level then driving behaviour shows no change. However, if perceived risk increases then drivers may reduce speed. Conversely, if perceived risk decreases, then drivers may increase speed in order to maintain an optimum level of risk. The implications for Risk Homeostasis Theory (Wilde, 1976) is that the introduction of safety measures would ultimately cause greater risk taking and at least partly cancel out the benefit of any safety interventions. According to Wilde (1976, 1982), in order to reduce risky behaviour, the utility of risk needs to be altered so that cautious behaviour carries greater incentives. The evidence for the associations between risk perception, risk utility and risk taking is complex, sparse and often contradictory (Jonah, 1986). Jonah (1986) suggests that there may be different utilities attached to risk taking behaviour for the younger driver. For example, for the young male driving may be an outlet for stress, aggression, expression of independence, impressing others etc. Jonah and Dawson (1982) find that compared with older drivers, younger drivers rated the importance of car safety features of lower importance than car appearance when buying a car.

Driving Performance, Information Processing and Accident Involvement

Age and sex differences in accident involvement may reflect group differences in the information-processing elements of the driving task as well as driver stress and risk perception. For example, novice drivers perform less well on a number of relevant measures, compared with experienced drivers. These measures include: visual search (Mourant and Rockwell, 1970; Mourant and Donahue, 1977), visual attention and direction (Soliday, 1974; Renge, 1980), reaction time (Welford, 1980; Colbourne, Brown and Copeman, 1978), speed adjustment (Sten, 1979; Konecni, Ebbesen and Konecni, 1976) and driving performance (Maeda, Irie, Hidaka and Hishimura, 1977).

The ability to switch attention and refocus to task-relevant stimuli, ie; when the car in front breaks sharply, is crucial. Investigations of the relationship between attentional abilities and accident rates typically find correlations of about .30 (Kahneman, Ben-Ishai and Lotan, 1973; Gopher and Kahneman 1971). Studies of several information processing measures have shown significant correlations of between .13 and .43, with lower level performance correlating with greater accident involvement. However, McKenna, Duncan and Brown (1986) found small or no relationship between information processing and accident involvement. Arthur *et al* (1991) suggest that the major oversight of many previous investigations is that they have failed to check whether predictors in combination may improve accident involvement prediction. For example, a combination of cognitive, personality and information processing factors may result in a stronger incremental validity (Hansen, 1989). In an attempt to settle the issue of which information processing measures are more predictive of accident involvement, Arthur, Barrett and Alexander (1991) used a meta-analysis to combine scores from several studies for three types of information processing measures, namely selective attention, perceptual style and choice and complex reaction time. Four types of personality variables were also analysed; level of distress, general activity level, regard for authority and locus of control. Age and education were also included. Results showed that selective attention accounted for the largest part of the variance (57%). Results for the personality measures were marginally favourable for general activity, regard for authority and locus of control. However, findings for the demographic variables were unfavourable. The main drawback for such research is that neither the criterion nor the predictors were identical across studies. This inconsistency obviously weakens the conclusions that can be drawn from the results.

Normal feedback cues of movement are quite different when travelling by car compared to movement cues when walking. Drivers may show speed adaptation, such as inaccurate assessment of other vehicles' speeds, and time saved by driving faster (Svenson, 1978). Such speed misjudgements are apparent in following distances and speed choices. Svenson (1978) finds that people falsely believe that they can save more time than is possible, yet even when given accurate information, the misconception persists.

A study by Mourant and Rockwell (1972) found that novice drivers tend to search the roadway close to the front of the car and toward the roadside suggesting that the attention of younger drivers may be directed towards keeping their vehicle on the road so that there is little attentional capacity to process information about potential hazards ahead.

Given the difficulty of criterion measurements, Arthur *et al* (1991) suggest that performance in simulators may be the way forward. Simulation allows for a more careful operationalization of the measurement of accident involvement within a shorter time period. For example, Ranney and Pulling (1989, 1990) employed a driving simulation paradigm whereby drivers were engaged in several typical driving tasks such as responding to traffic signals during a 30-minute run. Such designs permit criterion refinements and may prove invaluable in future driving research.

Individual Differences and Accident Causation

In order to find predictors of accident involvement, McKenna (1983) suggests that rather than search for personality traits, researchers should attempt to explain human error as it relates to accident involvement, in particular by focussing on information processing and task performance. McKenna (1983) questioned the interpretation of accident data showing differential initial liability to become accident involved as being due to accident proneness. Quite apart from the statistical artefacts based on such an assumption, the concept of accident proneness tends to neglect what it is about the individual that makes them accident prone. The challenge for the research presented here is to uncover some of the factors which may be responsible for an individual's liability to be involved in an accident.

The Role of Personality in Accident Causation

Tillman and Hobbs (1949) began research into individual differences in accident involvement using groups of psychiatric patients. Their study investigated the role of personality in accident causation by comparing low and high accident-involved drivers on a number of dependent measures. Compared with low accident-involved drivers, the high-accident involved had more sociopathic problems. Later, using normal samples, McGuire (1956a, 1956b) administered a battery of personality measures to military personnel and found (for example) that compared with the low accident-involved driver, the high accident-involved driver was less mature, had a lower aspiration level, and expressed 'poorer' attitudes towards the law and driving.

Conger *et al* (1959) showed that compared with non-accident drivers, the accident-involved drivers were less able to manage hostility, were self-centred, 'stimulus-bound', more angry and resentful of people viewed as depriving them of love and support and less able to tolerate tension. In a later study, McGuire (1972) found that the more accidents the driver had been involved in, the more likely the driver was to be hostile, aggressive, prestige-seeking, authoritarian and to prefer less intellectually-oriented interests. Smith (1976) found that an accident-repeater group of drivers were significantly more extraverted and aggressive than their accident free peers. The group of drivers with no self-reported convictions had received more education, were less aggressive and had been involved in fewer accidents than had their convicted counterparts.

Attempts to relate Rotter's (1966) scale internality-externality to driving accidents has met with little success (Gulian *et al*, 1989b). Montag and Comrey (1987), however, suggest that such results may reflect the generality of this measure of personality and that by targeting locus of control to driving, significant associations may be found. Indeed, 'Driving internality' was negatively associated and 'driving externality' positively associated with fatal car accidents (Montag and Comrey, 1987).

There are grounds for supposing that all three Eysenckian dimensions may predict driving behaviour and incidence of road traffic accidents. Several studies have shown a higher incidence of accidents in extraverts (eg Shaw & Sichel, 1971; Loo, 1978): extraverts also report more convictions for traffic offences and show longer response times to slides of traffic signs embedded in street scenes (Loo, 1978). Loo (1979) attributes these results to the impulsivity rather than the sociability component of extraversion. However, Powell, Hale, Martin and Simon (1971) found that extraverts reported more accidents in a work setting than did introverts, even though the frequency of such accidents was the same. This suggests that extraversion may be associated with reporting bias. Neuroticism may also predict accident involvement (Shaw and Sichel, 1971) although findings are inconsistent (see Loo, 1978). Eysenck (1970) suggests that high E and N scores may be associated with traffic accidents.

Smith and Kirkham (1981) found that high extraversion and neuroticism scores were related to accident involvement and violation records. Extraversion was particularly related to non-intersection accidents.

The relationship between accident involvement and psychoticism has not been fully addressed. However, characteristics associated with high P such as aggressiveness, impulsiveness and social maladjustment, predict occurrence of accidents (Conger, Gaskill, Glad, Rainey and Sawyer, 1959; Mayer and Treat, 1977). High stimulation seekers will often take risks to heighten their level of arousal whereas low stimulation seekers avoid risks (Zuckerman, 1979). Zuckerman (1979) found that sensation-seeking is at its height during late adolescence and has been correlated with speeding on the open road (Clements and Jonah, 1984; Zuckerman and Neeb, 1980). Little is known about the so called 'joy-riding' propensity of the young adult, but it is likely that sensation-seeking element of this crime is a major factor in its commission.

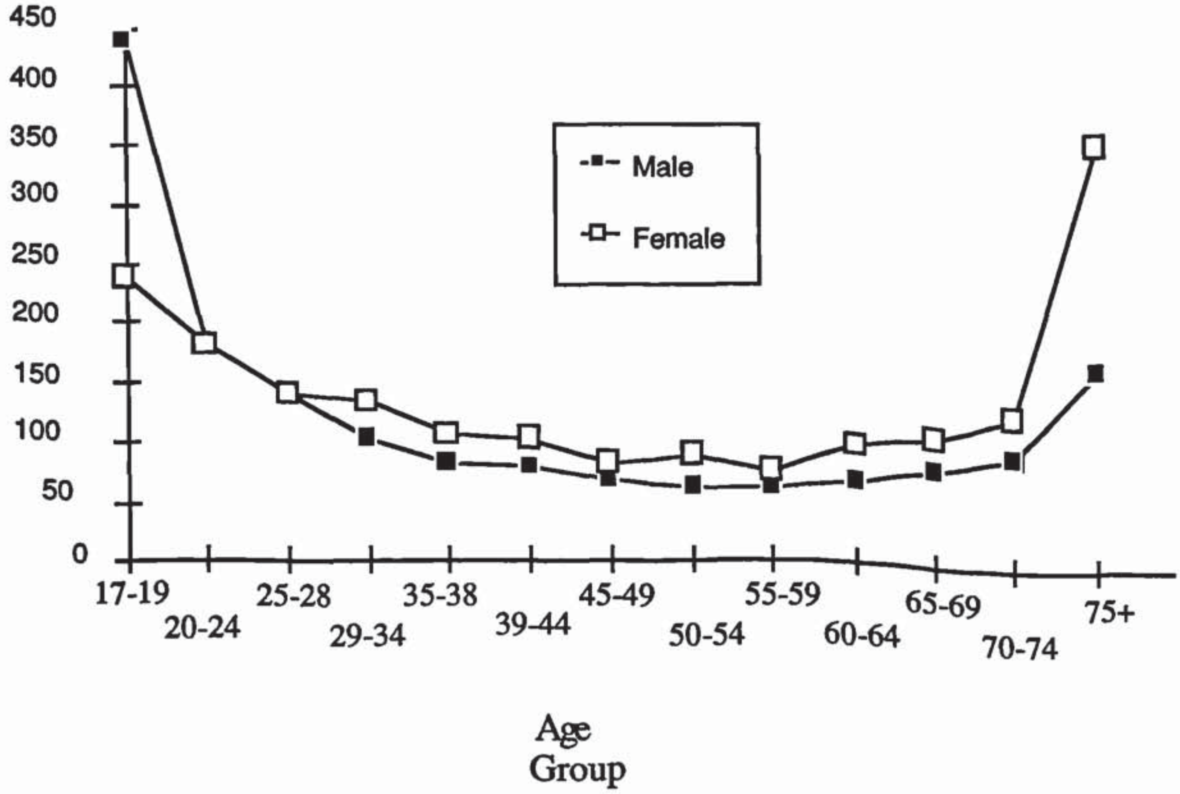
Jessor (1984) describes risk taking as theoretically encompassing personality proneness, environmental proneness and behavioural proneness. A combination of these factors results in a psychosocial proneness toward problem behaviour. A discovery of the perceived utilities of risk behaviour on the part of the youthful driver would be the first step in attempting to instil a more cautious mode of driving.

Group Differences in Accident Causation and Traffic Violations

A number of observational studies suggest that women take fewer risks when driving than do men (for example, Ebbesen and Haney, 1973; Katz, Zaidel and Elgrishi, 1975). Normann (1944), in an observational study, found that male drivers broke the speed limit more frequently than did women and older drivers respectively. Treat *et al* (1977) suggest that excessive speed is a contributory cause in about 17% of all accidents. Edwards and Hahn (1964) filmed male drivers for 5 minutes without their knowledge and found that; 87% of the drivers speeded, 80% changed lanes without signaling, 63% failed to stay in lane and 46% turned without signalling.

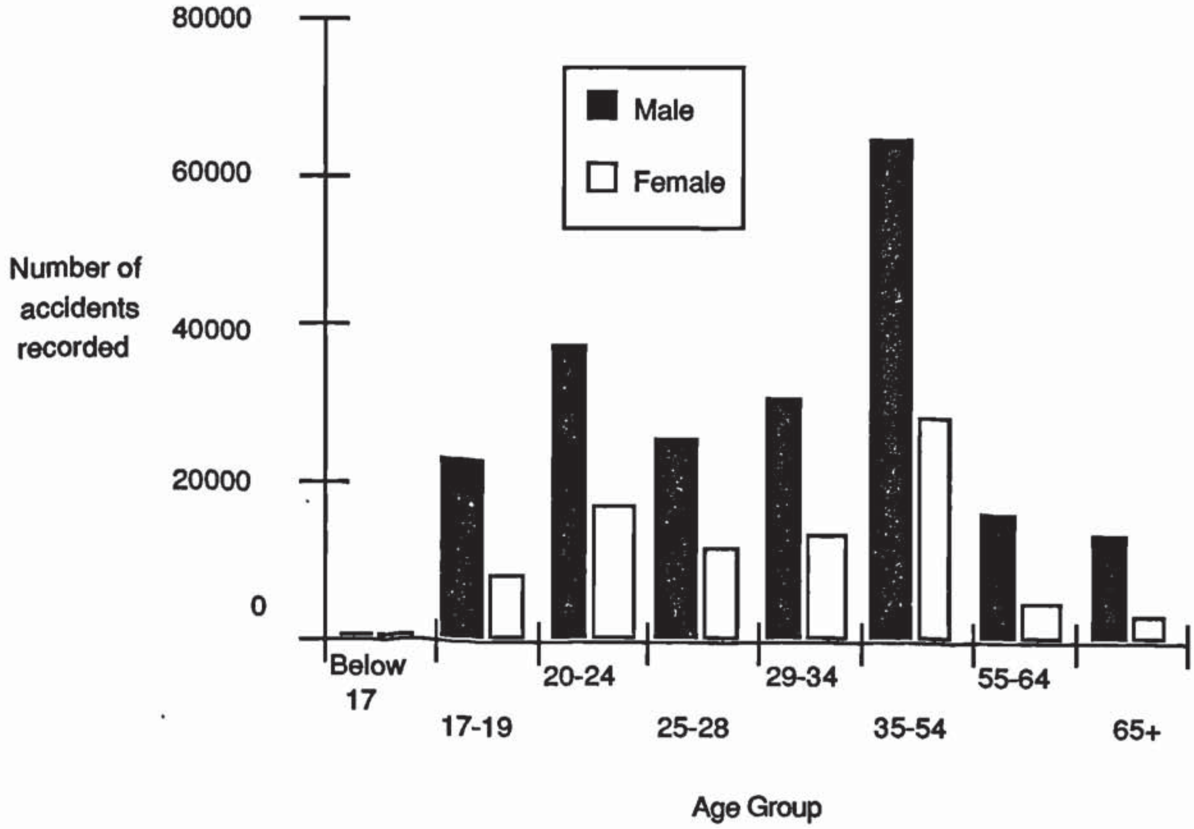
Both age and sex appear to affect likelihood of road accident involvement and traffic violation rates. Age data are clear-cut: mileage-adjusted reported accident rates are much higher for younger compared with older drivers, (falling to a minimum for the 34-54 age group) before rising with age. Thus, car-car and intersection accidents are more likely to be incurred by drivers who are 65 years and older than by younger drivers. Early studies of sex differences in road accident involvement indicated that women had fewer serious accidents, though sometimes more minor ones (for a review, see Hale and Glendon, 1987). However, more recent evidence from large-scale studies conducted in Britain (Jones, 1976) and in the USA (Lee, Glover and Eady, 1980) suggests that when mileage is controlled for, accident involvement rates are higher for older women than for older men. Recent accident statistics for Great Britain (Department of Transport, 1986) support the view that accident involvement rates per 100 million km driven are higher for 17-28 year-old males (253.33) than for females in the same age range (186.66). However, for older males (aged 44-58 years) accident involvement rates are *lower* than those for females (65.60 vs 83.66). See Figure 1.1.

Figure 1.1: Accident Involvement (UK, 1986) Rate per 100 million vehicle kms



Recent accident involvement rates by age and sex (Department of Transport, 1990) uncorrected for mileage are shown in Figure 1.2. Figure 1.2 demonstrates actual number of recorded accidents for drivers of both sexes of several age groups. The data clearly show that male drivers are more likely than female drivers to be involved in an accident at all ages. Figure 1.2 shows that whilst male drivers under the age of 25 are overrepresented in accident statistics, the middle-aged male driver is more likely than other age and sex groups to be involved in a road traffic accident. However, middle-aged male drivers drive more miles per annum.

Figure 1.2: Sex and Age differences in Accident Involvement Rate (Department of Transport, 1990)



There is a great deal of similarity between sex and age differences in accident involvement rates and sex and age differences in traffic citations (Harrington and McBride, 1970). However, Kirkham and Landauer (1985) believe that such violation records distort the true picture of traffic citations for sex and age groups. They recorded all instances of traffic law enforcement during a two-week period in Australia categorized by type of offence and by the age and sex of offender and found that even after allowing for exposure, young men were over represented and women were under represented in the enforcement figures. Kirkham and Landauer (1985) reported that women hold 40% of all licences, have 38% of all accidents and drive about 25% of the total mileage. Yet men have 62% of all casualty accidents and drive about 72% of the total mileage, account for nearly 91% of all traffic law enforcement citations for infringements and 81% of all cautions. Kirkham and Landauer (1985) suggest that one of the factors which may account for these findings is that male drivers are many times more likely than female drivers to be charged , perhaps because law enforcement agents are more suspicious and pay closer attention to male drivers. They suggest that such agents should charge drivers in proportion to their accident involvement, although, operationally this seems an impossible task.

A major study of traffic violation citations carried out by Harrington and McBride (1970) found that the number of violations per 1000 drivers for speeding, equipment violation and failure to stop for traffic signs and signals decreases markedly with age. Harrington and Mcbride (1970) found that mileage-adjusted figures show that speed and equipment violations are most common among the younger driver whereas sign and turning violations are more common for the 65+ driver. Mileage adjusted figures also dramatically reduce the sex differences with males having a higher rate than females for speed, equipment, passing and major violations, but females have a higher rate than males for sign and right of way violations which may reflect a lack of attention according to Harrington and McBride (1970).

Few differences were found with respect to turning violations in this study. Overall, mileage-adjusted figures show that the violation rate for male drivers is only 1.2 times that for female drivers. Both mileage-adjusted figures and actual data show that turning violations increase with age. There were also strong sex differences for all types of violations. Males commit three times as many violations as females. However, there is some variability in individual types of violations, for example, males commit seven times more equipment violations but only twice as many right of way violations than women do.

Sex by age interactions are also apparent. The sex difference decreases with age. Males under 25 years average four times as many violations as females. For drivers over 70 years the ratio drops to one-and-three quarters-to-one. For males, the averages for each type of violation decrease markedly with age, except right of way violations which show no change for single males. Harrington and McBride (1970) reported a curvilinear relationship with age for major violations such as vehicular manslaughter, with middle-aged males having the highest average. Harrington and McBride (1970) also found that for women, speed and equipment violations decrease with age, whilst passing and right of way violations show no change, and as with males, major violations show a curvilinear relationship with age with middle-aged women having the highest average. Harrington and McBride (1970) showed that older women were more frequently cited for turning, right of way and sign violations than were older men. This suggests a similar age-sex interaction to that observed for mileage-adjusted accident involvement rates.

Age and sex of driver are obvious important determinants of traffic violation rates and driving behaviour. The change in the pattern of violation rates suggests that the younger driver may be engaging in risk-taking behaviour especially evident in increased speed. This tendency seems to decrease dramatically with age. However, for the 65 years + driver, there is an increase in the sign, passing, turning and right of way violation rate. Harrington and McBride (1970) interpret this as due to decrements in perception and psycho-physical skills. Equipment violations also show a decrease with age, reflecting the tendency for younger drivers to drive cars which are in a poorer condition. Such cars are likely to attract the attention of law enforcement agencies

Old Age and Accident Risk

Recent statistics show that amongst drivers, the 65+ age group are now a fairly substantial segment of the driving population (The Lex report on motoring, 1991). In the UK and in the US, more than 11% of drivers are aged 65+. However, in the US, when controlling for mileage, accident rates for the 65 years + driver is higher than for all other age groups (National Research Council, 1988). Harrington and McBride (1970) analysed traffic violation data and showed that among the elderly, sign violations are the most frequently received citation. This is followed by turning and right of way violations.

Closer examination reveals that there are distinct differences between the types of accident that older drivers are involved in, and their citation rate for traffic violations. It has been shown that older drivers are more frequently involved in accidents which are due to failure to heed signs, give way or turn into a road safely (Huston and Janke, 1986; Planek, 1973). Similarly, with respect to traffic violations, Brainin (1980) documents that older drivers are over-represented in citations related to unsafe left turns (or right turns in the UK), inattention and failure to yield right of way. This has lead researchers to suspect that specific components of the driving task may be creating greater demands on older drivers in the face of their declining abilities.

Edwards *et al* (1977) found that the most consistent predictor of simulated driving performance was age; the greater the age the poorer the performance on a number of simulator measures. Years of experience with age partialed out did not predict simulator performance. Low correlations between prior violations and accident records and the simulator measures were found. Laux and Brelsford (1990) explain that age differences in accident involvement rate may be due to beliefs about the controlability of accidents. Increasing age is associated with more external control belief about accidents which may be reflected in safety changes when driving.

Either older drivers process information more slowly or they may be more cautious in making decisions, preferring to gather more information than younger drivers (Mourant and Mourant, 1979). Van Wolffelaar, Ruthengatter and Brouwer (in press) find that older drivers need 50% more time than younger drivers to observe and decide when to emerge from a junction. Self-report data indicate that older drivers drive more slowly (Case *et al*, 1970; Rackoff, 1974). Brehmer (1990) states that accident probability is lowest for cars travelling at or around the mean and increases as drivers move away from the mean in either direction. Perhaps the slower speeds of the older driver make them more vulnerable to accident involvement as well as compensating for age-related decrements.

In an attempt to predict accident involvement for the elderly, research in the US has focussed on The Useful Field of View (UFOV) task which is a combination of dynamic vision and perceptual window approaches, but with additional features, UFOV is the spatial area that is needed for a specific visual task which measures binocularly involving detection, localization and/or identification of suprathreshold targets in complex displays. It tests the ability of stimuli to attract our attention and orient us in space. Many studies report that the UFOV reduces with age for detection, localization and identification (Sekuler and Ball, 1986; Scialfa *et al* 1987; Ball *et al* 1988; Ball *et al*, 1990). It incorporates several measures relating to the interaction of visual and attentional parameters, as is the case during driving. Indeed older drivers who scored low on this test had 3-4 times as many accidents (Owsley, Ball, Sloane, Roenker and Bruni, in press). This rate increased to 15 times more predictive when accounting for intersection accidents. UFOV may be a more accurate measure of predicting future successful driving performance. It is clear that such an approach may prove fruitful in attempting to explain the perceptual and cognitive mechanisms which are likely to contribute to accident involvement in the elderly.

Experience and Exposure

Brown (1982) concludes that experience and exposure are often confounded in studies of accident involvement. Experience is often measured as time elapsed from commencement of learning to drive or obtaining a driving licence. Type of driving experience is also an important factor - eg the time and location of travel, travel patterns etc. Exposure is often measured as number of miles driven per annum. Many studies fail to control for experience and exposure when comparing young and older drivers so that much of the difference between the age groups may be differences due to experience and exposure rather than age per se. However, age and experience are inextricably confounded so that attempts to disentangle the two may prove difficult or meaningless. However, as with age and exposure, experience and exposure are often confounded as to gain driving experience drivers must be exposed to driving. There is also the question of sex differences in experience and exposure. Typically, results of several studies show that when experience is controlled for, any sex differences in illusory perceptions of driving skills, for example, disappear (McKenna *et al*, 1991).

Some researchers argue that experience is more important than age (Michels and Schneider, 1984). This argues against the notion of the reckless youth being the major factor in their over-involvement in the accident rates. But youthfulness may affect several aspects of road user behaviour from type of vehicle characteristics preferred to their greater need to seek sensation. Jonah (1986) and Mayhew *et al* (1986) have concluded that younger drivers' risk of involvement in casualty accidents is higher for younger drivers compared with older drivers, even when the amount and type of exposure to such risk is statistically controlled.

The over representation of younger drivers in accident involvement data may reflect their lack of driving experience as their driving skills are not fully developed. Several studies suggest that inexperienced drivers exhibit different traffic identification behaviours. For example, compared with experienced drivers, novice drivers have different visual fixation and scanning patterns (Mourant and Rockwell, 1972), show less effective use of steering cues which help to direct gaze (McLean and Hoffman, 1971), are poorer at identifying distant hazards (Brown, 1982), and tend to concentrate on static objects in the road system (Soliday and Allen, 1972). Such findings demonstrate that the younger driver has a less efficient method of collecting environmental traffic information which may affect cognitions and therefore driving behaviour.

Spolander (1982) studied the effect of experience on self-assessment of driving ability. Spolander (1982) found that drivers with three years driving experience judged themselves to be better than the average driver and also reported driving faster and overtaking more than did drivers with one years experience. Groeger and Brown (1988) suggest that with experience, drivers develop a repertoire of schemata based on previous memories for events and that these schemata are fitted into the ever-changing traffic environment, in order to perceive, influence or accept risk. The novice driver then, has a smaller repertoire of schematas. Brown and Groeger (1988) suggest that younger drivers may misperceive risk due to their relative lack of experience and advocate accident countermeasures based on more training for effective hazard identification, evaluation of hazards, a more realistic self-assessment of driving abilities and the teaching of more realistic risk perception to learner drivers.

The major drawback of objective information data on specific behaviours which have led to an accident, is that there is no account of the 'exposure data'. In other words, no data are collected on the number of times such behaviours are exhibited *without* such behaviours resulting in an accident. Are the decisions to engage in risky driving manoeuvres based on subjective or objective risk? According to the Department of Transport road traffic accident statistics in 1986, one male driver in 300 and one female driver in 850 will be killed while driving a car. About 47% of male drivers and 29% of female drivers will be involved in an accident at some time in their lives. Such figures represent fairly low levels of risk considering the number of occasions that drivers are exposed to risk when driving.

The more driving one does the more likely one is to be involved in an accident. In men, increasing exposure heightens risk perception and reduces risk-taking behaviour. Several researchers have shown the relationship between age and exposure corrected for accident risk (Fell, 1984; Lee, Glover and Eady, 1980; Foldvary, 1979) and found a similar pattern. For example, Stewart and Sanderson (1984) and Lawson and Stewart (1982) found that by dividing the percentage of casualty accidents accounted for by each group by the percentage of the total distance travelled, the relative risk of casualty accident was highest for the 16-19 year old driver and thereafter decreased until age 65 when risk increased for elderly drivers. Stewart and Sanderson (1984) also found that when controlling for quantity and quality of exposure to risk (eg driving at high risk locations) young drivers are still at the greatest risk of casualty accident involvement. So far the relative contributions of age, experience and exposure and their relative effect on accident risk remain somewhat obscure.

For the series of studies on group differences presented here, no attempt was made to analyse effects of experience or exposure on sex and age differences. It was felt that since age and sex differences appear to reflect differential accident involvement, it was actual sex and age differences which were seen as being pertinent to the aims of the investigations.

Introduction Summary

There are several methodolical problems associated with measurement of accident involvement. It was decided that, given these difficulties, to study individual and group differences in driving behaviour rather than accident involvement. It is clear from the accident involvement rates that there is likely to be distinct differences in driving behaviour according to sex and age of driver. Perhaps by shedding light on these differences, differential accident involvement rates may be better understood.

The research to be presented, focusses on three main areas of interest within the realms of psychology of road user behaviour which attempt to understand the link between personality and driver stress, risk perception and driving performance. The role of personality and driving behaviour is little understood and few studies have attempted to identify the realtionship between accident involvement and personality. There are some grounds for supposing that a relationship may exist, however, given research conducted in the 70's and earlier. Recently, such an approach has been neglected, perhaps due to the fact that even if a relationship was reliably found, the possibilities for the introduction of driver education programs are limited. McKenna (1983) suggested that it would be unethical to change personality (even if it were possible) in order to influence driving behaviour. Nevertheless, a more thorough academic understanding of the relationship between personality and driving behaviour may prove fruitful. For example, applications for such research may be to help in the selection of professional drivers.

The research to be presented on group differences in driving behaviour also concentrates on the same three main areas. Namely, driver stress, risk perception and driving performance. Several studies have suggested a link between stress and driving, although research has failed to provide a reliable and valid measure of driver stress until recently (Gulian *et al*, 1989a,b). It is widely believed that drivers modify their driving according to their perception of risk. If this is so, then a thorough investigation of group differences in risk perception may be appropriate. Hitherto, research has tended to concentrate on male drivers without reference to female drivers. For all the studies presented, female as well as male sample are taken, in order to understand the nature of sex as well as age differences in driving behaviour. Finally, group differences in driving performance are presented which attempt to identify differences in the information processing elements of the driving task using the Aston Driving Simulator.

Experimental Hypotheses

There are several hypotheses to be investigated based on the findings of previous research. First, that there will be individual and group differences in driver stress. Previous studies suggest that there may be a relationship between neuroticism and driver stress, given neurotics predisposition to report greater levels of stress generally. Findings for group differences in driver stress may reflect the fact that women tend to report higher levels of stress generally, for example, women report greater levels of stress than men when taking an exam. It is also expected that younger drivers will report greater level of driver stress than older drivers.

Second, that there will be individual and group differences in risk perception. It is expected that neuroticism will be associated with a heightened perception of risk given research which suggests that high neuroticism is associated with an increased perception of threat. It is also expected that younger and male drivers will show a less realistic perception of risk that older and female drivers.

Third, group differences in simulated driving performance are expected to show that male and younger drivers take more risks than do female and older drivers. It is also expected that older drivers will exhibit age-related decrements in driving performance.

Methodology

There are two basic methods adopted in order to investigate these hypotheses; questionnaire and self-report based methods and driver simulator measures of driver performance. The first method is a tried and tested approach in psychology generally and driving-related research in particular. There are two standard questionnaires used; the Eysenck Personality Inventory and Questionnaire and the Driver Behaviour Inventory. Both questionnaires have been found to be reliable and stable measures of personality (Eysenck, 1970) and driver stress (Glendon *et al*, 1992) respectively. Other questionnaires have been adapted for use in the series of studies presented in chapters Two and Three. The Risk Perception Questionnaire and ratings for videotapes sequences of driving scenarios requires participants to report the likelihood of being involved in an accident, and driving performance ratings for themselves and other target groups. The questions were adapted from a study by Matthews and

Moran (1986). Similar approaches to the study of risk perception have been widely adopted and have provided a valuable insight into the cognitive and perceptual processes during driving behaviour.

The second method employed the use of the Aston Driving Simulator (ADS). The ADS is a computer generated 3D view of a road with accelerator and brake pedals to control speed and a steering wheel to control lateral placement of the vehicle on the track. Several driving researchers have adopted this method given the advances in computer-based simulation in recent years. However, there are several disadvantages associated with such a methodology. First, there is a lack of fidelity, a restricted field of view and the question of whether participants approach a simulated driving task in much the same way as they would real driving, given that poor judgement in a simulator does not have the same serious consequences that it might on the road. Despite these difficulties, the ADS was able to discriminate between groups of drivers and has been validated (Matthews *et al*, 1992). In the future, such a method is unlikely to suffer from the first two disadvantages outlined above as technological progress continues. It is therefore important that researchers use simulation as a method of measuring driving performance within the context of an actual driving task, rather than concentrating on self-reports and questionnaire methods may suffer the major disadvantage of biased responses.

Chapter 2: Individual and Group Differences in Driver Stress

Study 1: Personality Correlates of Driver Stress

Introduction

A Measure of Driver Stress

There are several causal routes through which personality may be linked to susceptibility to driver stress. A validated measure of driver stress, the Driving Behaviour Inventory (DBI: Gulian, Matthews, Glendon, Davies and Debney, 1989a) includes a general factor of driver stress and five specific dimensions. Three studies are reported here concerned with the link between personality and driver stress.

Studies of the validity of the DBI have identified several correlates of the measure, including stressful life-events both at home and at work (Gulian *et al*, 1989a), cardiac activity (Robertson, 1988), coping strategies (Gulian *et al*, 1989b), and mood and attentional experiences (Matthews, Dorn and Glendon, 1991). However, the five specific dimensions differ in their predictions of such criteria, for example, aggression during driving is more predictive of 'tailgating' (Gulian *et al* , 1989b). Test-retest reliability and correlational analyses, revealed the five scales to be reliable over time (Glendon *et al*, 1992)

Personality and Driver Stress

It is likely that the relationship between driver stress and personality depends on the nature of the driving environment. Therefore, given that extraverts prefer higher levels of arousal than do introverts (Eysenck and

Eysenck, 1985), then introverts should be most stressed by driving in stimulating environments, such as driving in heavy traffic under time pressure. On the other hand, extraverts should be relatively more stressed by driving in boring situations, such as a long motorway drive with little traffic. It is important to note that correlational studies of this nature can only indicate general trends, but that the extent of the association between driver stress and personality may change under different types of driving situations.

Study 1 aims to relate driver stress to major dimensions of personality: extraversion (E), neuroticism (N) and psychoticism (P) (Eysenck and Eysenck, 1975). Eysenck and Eysenck's (1985) dimensions have been associated with both stress and driver performance. The strongest single predictor of stress is probably N. Several studies have shown relationships between N and different measures of stress-related emotions, cognitions and performance. Neuroticism has been associated with unpleasant emotions (Matthews *et al*, 1990), poor mental health and behavioural problems (Eysenck, 1970), poor job adjustment (Cooper and Payne, 1967) and to cognitive failures (Matthews and Wells, 1988). Extraversion has also been linked with stress resistance. Several studies show, for example, that extraverts are less sensitive to threat signals (Gray, 1981), less reactive to aversive stimuli (Stelmack, 1981), make more use of rational, problem-oriented coping strategies (McCrae and Costa, 1986) and are more tolerant of high levels of arousal (Eysenck and Eysenck, 1985). The relationship between psychoticism and stress is less clear-cut. Eysenck and Eysenck, (1975) report that psychoticism can be regarded as blunted affect which may indicate low susceptibility to stress. Alternatively, antisocial behaviour may expose an individual to more stress-inducing events.

Therefore, it is predicted that high N should be the strongest predictor of stress, followed by low E. It is also predicted that the specific dimensions of driver stress would differ in their relationship to personality. For example, P should predict driving aggression more strongly than the other scales, given that aggression is a core feature of psychoticism (Eysenck and Eysenck, 1976).

The underlying causal factor associated with the relationship between personality and accident involvement could be due to any one (or more) of a number of factors. For example, the higher accident involvement of extraverts could be attributed to their tendency to have poor sustained attention (Davies and Parasuraman, 1982), to risk-taking and impulsive behaviour (Eysenck and Eysenck, 1985), or to high habitual alcohol use (Jackson and Matthews, 1988). As with stress, personality correlates of driving behaviour may vary with the type of driving situation. For example, extraverts' driving behaviour may deteriorate markedly over long time intervals, but their performance is improved by extraneous stimulation such as listening to the car radio (Fagerstrom and Lisper, 1977).

Previous research predicts that high DBI driver stress, high E, high N and possibly P should be associated with higher incidence of accidents and convictions.

Method

Participants

The 159 participants, 78 men and 81 women, were recruited by personal contact and advertisements. Ninety-nine were members of the general population, in a wide variety of occupations. Thirty were Aston University students and 30 were academic, technical and secretarial staff at Aston. Mean number of years since obtaining a driving licence was 10.5 (range 0-42). This measure of driving experience was highly correlated with age (r=0.85), precluding any meaningful attempt to distinguish between age and experience.

Measures

Participants completed the EPQ (Eysenck and Eysenck, 1975) and a shortened version of the DBI (Gulian *et al*, 1989a). Participants also supplied demographic information, the year they obtained their driving licence and details of their current driving experience and habits. Participants were also asked whether they had ever been involved in an accident, and its severity. They were asked to state too whether they had been convicted for speeding, dangerous driving and other motoring offences. Descriptive statistics for the EPQ scores are given in Table 2.1.

Table 2.1: Descriptive statistics for EPQ scores (N=159)

EPQ Scale	Mean	SD
E	13.7	5.6
N	11.4	6.1
P	5.0	5.4
L	7.9	4.5

Results

Age was a strong confounding factor within the data. Age was significantly negatively correlated with all but two of the DBI scales: older drivers reported lower general stress, lower aggression and fewer negative reactions to overtaking and being overtaken. Age was significantly positively correlated with driving alertness. These age data are consistent with previous findings that younger people report more daily driver stress during commuting (Gulian *et al*, 1989b, 1990). On the personality measures, older drivers tended to be lower in E, N and P, consistent with Eysenck and Eysenck's (1975) standardisation data. Age was also associated with mileage, but not with the types of roads usually driven on. For example, age correlated at 0.36 ($P < 0.001$) with ratings of the frequency of driving. Effects of age are controlled where appropriate in the data presented below. Sex differences were rather weaker. There were no sex differences on any of the DBI scales, although women were higher in N [$t\ (156) = 2.28$, $p < .05$] and in E [$t\ (157) = 1.99$, $p < .05$]. Women tended to drive less than men, as shown by ratings of annual mileage [$t\ (156) = 3.76$, $p < .001$] and of frequency of car use [$t\ (156) = 2.28$, $p < .05$].

Table 2.2 shows correlations between DBI and EPQ scores, together with corresponding partial correlations, controlling for age. The strongest EPQ predictor of driver stress was N, which was positively correlated with AGG, DIS and GEN. P was significantly positively correlated with AGG in both analyses but the significant correlation between P and GEN did not survive partialing out age. L and E were unrelated to driver stress when age was controlled for, although the uncorrected correlations show small but significant associations between E and two of the DBI scales, AGG and OT.

Table 2.2: Correlations between DBI and EPQ scores, uncorrected and corrected for age (N=159)

	EPQ Scale			
DBI scale	E	N	P	L
AGG	.19* (.08)	.39*** (.29***)	.34*** (.20*)	-.04 (-.03)
DIS	-.13 (-.12)	.26** (.29***)	-.06 (-.05)	.14 (-.14)
AL	.07 (.14)	.00 (.06)	-.10 (-.02)	.13 (.14)
IO	.02 (-.05)	.11 (.04)	-.04 (-.14)	-.10 (-.09)
OT	.19* (.15)	.15 (.11)	.00 (-.07)	.01 (.02)
GEN	.14 (.04)	.41*** (.34***)	.21** (.07)	-.07 (-.06)

* $p < .05$; ** $p < .01$; *** $p < .001$

NB: partial correlations, controlling for age, are given in parentheses.

With age controlled, none of the DBI or EPQ scales were strongly correlated with ratings related to quantity of driving. No scales predicted annual mileage. AL was significantly positively correlated with frequency of use of car ($r = .22$, $p < .01$). The only correlate of GEN was greater use of country roads ($r = .24$, $p < .01$). AGG and DIS were unrelated to any of the variables associated with quantity of driving. The only EPQ correlate of these variables was P, which was significantly negatively correlated with frequency of car use ($r = -.20$, $p < .05$).

Responses to DBI items concerning accidents and convictions were unsuitable for correlational analysis because of their dichotomous response formats. The basic approach adopted was to use analysis of variance to determine whether, for example, the group of accident-involved subjects differed from the non-accident involved subjects in mean level of driver stress. Age group was included as a second factor to provide some control for age. Participants were classified as younger (aged 17-29, N = 83) or older (30-60, N = 77), so that age group was treated as a between-subjects factor with two levels. Narrower age-bands would have been desirable, but because of the relatively low numbers of participants reporting certain kinds of accident involvement and speeding convictions, use of these wide bands was necessary to obtain sufficient cell numbers for analysis. Accident involvement was treated as a between-subjects factor with three levels - no accident involvement (N=74), involvement in minor a accident (N=52) and involvement in a moderate or serious accident (N=30). Speeding convictions was treated as between-subjects factor with two levels - convicted (N=20) and unconvicted (N=138).

To test for effects of driver stress and personality on accident involvement, a series of 10 3 x 2 (accident involvement x age group) regression model ANOVAs, with each of the six DBI and four EPQ scales used in turn as a dependent variable was conducted. A similar series of 10 2 x 2 ANOVAs (speeding conviction x age group) was conducted to test relationships between DBI and EPQ scales and speeding convictions. Table 2.3 gives cell means for main effects of accident involvement and of speeding convictions, together with values and significances of the F ratios for these effects. Main effects of age were largely as expected from the correlational analysis. There were no significant interactions between age and the other between-subjects factors.

Table 2.3 shows that GEN varied with both accident involvement and speeding convictions. The highest level of GEN was shown by participants reporting minor accident involvement, with participants reporting no or major accident involvement showing similar, relatively low levels of GEN. A similarity between the pattern of results for younger and older groups was also observed [the effect of age group here was also significant; $F(1,150) = 10.69$, $p < .001$].

Table 2.3: Mean values for DBI and EPQ scales, for participants classified by (1) previous accident involvement and (2) speeding conviction (N=159)

	Accident Involvement				Speeding Convictions		
DBI	None	Minor	Moderate/ Serious	F(2,150)	No	Yes	F(1,153)
AGG	37.7	44.5	35.8	6.5**	40.7	32.1	2.5
DIS	41.9	44.0	42.0	0.4	43.5	36.6	4.1*
AL	76.1	78.9	80.7	1.3	77.1	83.4	5.5*
IO	47.8	48.9	38.5	1.2	45.7	33.8	5.1*
OT	45.1	47.9	35.7	4.3*	48.9	30.3	5.7*
GEN	43.9	48.9	39.4	5.1*	46.1	35.1	6.4*
EPQ							
E	13.8	14.2	12.5	0.5	13.8	12.9	0.0
N	11.8	12.2	9.2	1.4	11.8	8.1	3.3
P	5.6	5.0	3.4	0.5	5.4	2.7	2.5
L	8.6	7.0	7.8	2.4	8.1	6.5	2.5

* p < .05; ** p < .01; *** p < .001

Although general driver stress was associated with minor accident involvement, levels of GEN were lower in participants reporting a speeding conviction. Data for the five factorial scales show that different scales are associated with accident involvement and speeding. Minor accident involvement was associated with elevated AGG and OT, speeding convictions with lowered DIS, OT and IO, and elevated AL. None of these scales appear to discriminate between no accident involvement and moderate/serious accident involvement or speeding conviction.

Discussion

The findings are consistent with the idea that general personality traits, particularly neuroticism, are one of several types of factor predisposing the person to susceptibility to driver stress, although driver stress may also affect some aspects of personality. The data also show the importance of distinguishing between different dimensions of driver stress. As predicted, high N drivers were also high in general driver stress, particularly as expressed in AGG and DIS. As expected also, P was specifically related to the AGG scale, although P was a weaker predictor than N of this scale. Relationships between E and driver stress were very weak: as argued previously, the role of E may depend strongly on the kind of driving situation evoking stress.

The analyses of accident and conviction data show that the DBI is a stronger predictor of these indices of driver behaviour than is the EPQ. Not surprisingly, driving-related traits were more strongly related to reported driver behaviour than were general personality traits. Accident involvement and conviction for speeding appear to be associated with rather different aspects of driver stress. Elevated levels of AGG and OT were found in those drivers who had been involved in a minor accident, but not in those reporting a more serious accident. This result contrasts with previous studies showing high pre-crash stress in drivers involved in fatal accidents (Brenner and Selzer, 1969; Brown and Bohnert, 1968).

Previous studies of this kind, using prospective designs, suggest that driver stress has a causal effect on behaviour (eg Selzer and Vinoker, 1974). For example, the driver high in aggression may be sufficiently impatient to risk a 'bump', but not a severe collision. Other evidence suggests that different situational factors predispose drivers to major and minor accidents. At work, minor accidents are more likely to occur during routine repetitive activities compared with serious ones which are more likely to occur during rest breaks, unusual activities or when engaged in unauthorised activities or horseplay (Powell *et al*, 1971; Glendon and Hale, 1986).

The speeding conviction data show, in contrast with some previous research (Jeffrey, Foley and Waller, 1973), that driver stress is negatively related to this relatively minor traffic violation. AGG was the only one of the five factorial scales, which did not show this effect. It is hard to see how being convicted could lower driver stress, so the presumption here is that driver stress may have a causal effect on speeding, although heightened alertness could well be a result of being caught speeding. It is possible that drivers who find driving unpleasant and anxiety-inducing (high DIS) rather than frustrating (high AGG) slow down to reduce the demands made by the driving task, and so are less likely to break the speed limit. Such drivers may also be more prone to be irritated with faster drivers who overtake them (high IO).

This study demonstrates that individual differences in self-reported driver stress are related to individual differences in personality. General driver stress is associated with higher levels of neuroticism. The most sharply discriminated scales appear to be AGG and DIS, although there were few unique correlates of the AL, OT and IO scales, although this result in part may reflect the moderate reliabilities of the AL and OT scales. Finally, the correlational methods used in this study have obvious limitations. It is difficult to make any inferences about causal relationships between driver stress and personality, although it seems plausible that general personality characteristics such as neuroticism have a stronger causal effect on disposition to driver stress than vice versa. Self-reports are also unreliable as indicators of actual driving behaviour so the present data require supplementation with experimental studies of driving performance. In spite of these difficulties, the present results suggest that at least some part of the variance in the specific episodes of driver stress is likely to be associated with general characteristics of the person.

Study 2: The 'Big Five' and Driver Stress

Introduction

The aim of this study was to correlate the DBI scales with measures of the 'Big Five' personality dimensions, which provide an alternative model of personality structure to the Eysenck scales (McCrae and Costa, 1987). There has been some debate over what the major dimensions of personality are. Recently, individual differences researchers are beginning to accept that rather than there being just three dimensions, namely, extraversion, neuroticism and psychoticism, there appear to be five dimensions. From self-report data Brand and Egan (1989) suggests that these five are:

1. Extraversion vs introversion
2. Autonomy vs agreeability
3. Neuroticism/emotionality vs stability/equanimity
4. Conscientiousness vs impulsiveness/casualness/expedience
5. Tender mindedness/openess/culture vs toughmindedness/practicality/

realism

According to McCrae and Costa (1986) there are grounds for supposing that ways of coping with stress and individual differences are linked. Enduring aspects of the individual such as neuroticism may be associated with a preference to cope with stress in a particular way. McCrae and Costa (1986) found that neuroticism was associated with increased use of hostile reaction, escapist fantasy, self-blame, sedation, wishful-thinking, withdrawal, passivity and indecisiveness. Extraversion on the other hand was associated with increased rational action, positive thinking, substitution and restraint. Tender-mindedness was associated with the use of humour when dealing with stress whereas tough-minded individuals were more likely to rely on faith.

From their factor analysis of coping, McCrae and Costa (1986) drew a distinction between neurotic coping and mature coping, with neurotic coping being strongly linked with neuroticism and mature coping to be associated with extraversion. There are grounds for supposing that ways of coping with driver stress may be linked with personality in much the same way.

Method

Participants

Two fresh samples of drivers completed the DBI. In the present study, the DBI was scored for general driver stress, plus specific dimensions of driving aggression, dislike of driving and alertness, ignoring two short scales associated with reactions to overtaking, which were only weakly related to personality in Study 1. The first sample of 60 drivers (33 men, 27 women: mean age 28.8) completed a semi-ipsative adjective checklist of personality descriptors developed by Brand and Egan (1989), and Cattell, Eber and Tatsuoka's (1970) 16PF questionnaire. The second sample of 54 drivers (28 men, 26 women: mean age 28.9) completed a normative version of the checklist. On the semi-ipsative checklist, there are 24 'items' comprising six adjectives. For each one, the participant indicates the most and least applicable. On the normative version, the participant rates the applicability of each of the 144 adjectives on an 8-point scale. In the present study, scoring was based on a factor analysis of a further sample (N=323) of scales similar to those used by Brand and Egan (1989) were used. The normative version of the checklist was used because correlations obtained with ipsative scales are subject to artifact (Johnson, Wood and Blinkhorn, 1988). The first five principal components from the 16PF were extracted for the purpose of this study, as in previous studies using the 16PF (see Brand and Egan, 1989). Major scale loadings for extraversion included outgoingness, venturesomeness and low self-sufficiency. For neuroticism, loadings were low ego strength, guilt proneness and ergic tension. For will dominance, loadings were suspiciousness and forthrightness. For conscientiousness, loadings were superego and self-sentiment, and for affection they were tender-mindedness and bohemianism. Factor scores were used in the correlational analysis.

Results and Discussion

Correlations between the four DBI scales analysed and the three measures of the Big Five are shown in Table 2.4. In study 2, measures of the 'Big Five' derived from normative and semi-ipsative versions of an adjective checklist and from the 16PF, were related to driver stress. Driver stress was primarily associated with high neuroticism and low affection, though possibly for different reasons. As in study 1, neuroticism was positively related to driver stress, and to both aggression and dislike of driving, although there was some inconsistency across the personality measures with respect to the specific DBI scales. The data extend the results of study 1 by showing that all three measures of affection were negatively related to driver stress generally, and in two cases, to driving aggression in particular. Correlations between the other three personality dimensions and the DBI were inconsistent across measures, and may not be reliable. The data suggest that both neuroticism and low affection predispose to driver stress, but the effect of neuroticism may be mediated by a general tendency towards negative reactions to driving, whereas the effect of affection is specifically associated with hostile social reactions towards other drivers.

Table 2.4: 'Big Five' personality correlates of the DBI driver stress scales, for a normative and semi-ipsative adjective rating and 16PF personality measures

	Extraversion			Neuroticism		
DBI Scale	N	SI	16PF	N	SI	16PF
AGG	ns	ns	ns	ns	ns	.36**
DIS	ns	ns	ns	.29*	ns	.39**
AL	.35**	ns	ns	ns	ns	ns
GEN	ns	ns	ns	.28*	.29*	.48**

		Will			Conscience	
DBI	N	SI	16PF	N	SI	16PF
AGG	ns	ns	ns	ns	ns	-.45**
DIS	ns	ns	ns	-.28*	ns	ns
AL	ns	ns	ns	ns	ns	.33*
GEN	ns	ns	.29*	ns	ns	-.27*

	Affection		
DBI	N	SI	16PF
AGG	ns	-.43**	-.29*
DIS	ns	ns	ns
AL	ns	ns	ns
GEN	-.31*	-.30*	-.26*

* $p < .05$; ** $p < .01$; *** $p < .001$

Study 3: Personality and Coping with Driver Stress

Introduction

The transactional model of stress, emphasises cognitive appraisal of events as determining stress response. According to this model, psychological stress is the result of the transactional process between a person and his/her environment in which tasks and/or situational demands are appraised as exceeding a persons' resources or ability to cope (Coyne and Lazarus, 1980).

Folkman and Lazarus (1980) argue that two critical processes mediate the person-environment relationship, these being cognitive appraisal and coping. Cognitive appraisal is a process which evaluates why and to what extent a transaction between the person and environment is stressful. Coping on the other hand is a process through which the individual manages the demands of the situation and the emotions it engenders.

Coyne and Lazarus (1980) define coping as 'cognitive and behavioural efforts to monitor, reduce or tolerate the internal and/or external demands that are created by the stressful transaction'.

Cohen and Lazarus (1979) define five main coping strategies. These being:

1. To reduce harmful environmental conditions and enhance prospects of a recovery;
2. To adjust negative realities;
3. To maintain a positive self image;
4. To maintain an emotional equilibrium;
5. To continue to satisfy relationships with others.

Common to these coping tasks is a distinction between problem-focussed coping and emotion-focussed coping. Problem-focussed coping involves altering the troubled person-environment relation causing the distress. Emotion-focussed coping on the other hand involves regulating stressful emotions. The first type of strategy is often directed at defining the problem, generating alternative solutions to the problem, choosing the solution and carrying out a plan of action to solve the problem. Cohen *et al* (1986) consider coping not only as a problem-solving device but also as a problem generator. George (1974) describes how cognitive stress arises from decision makers' awareness of their own limited problem solving abilities. According to this rationale-choice model, high stress levels reduce problem solving abilities especially when dealing with complicated tasks such as driving.

Lazarus summarised four problem-focussed and emotion-focussed strategies. The problem-focused strategies are confrontive coping, accepting responsibility, planful problem-solving and self-controlling coping. The emotion-focussed coping include distancing, seeking social support, escape avoidance and positive reappraisal. Both emotion-focussed and problem-focussed forms of coping are interdependent in that they impede and facilitate each other (Folkman and Lazarus, 1980). For instance, heightened emotion will interfere with the cognitive activity needed for problem-focussed coping. Similarly, Brewin (1988) showed that cognitive factors may influence a person's emotional response to a particular stressor.

Driver stress, personality and coping

Frese (1985) identifies the nature of coping as a moderator (in that the relationship between the stressor and reaction to stress is reduced by individual coping styles) and he also describes coping as a mediator (when coping links the stressor to the stress reaction). Thus, the mediator or moderator effect of coping may either enhance or disturb psychophysiological functioning. However, Frese (1985) fails to consider coping as a process as opposed to a trait. He also fails to acknowledge how coping changes as the encounter unfolds. The transactional theory of coping shifts emphasis away from coping as a personality trait and what a person *usually* does in response to a stressful encounter. Instead, transactional theory focuses on what a person actually thinks and does in a specific encounter and how this changes as the encounter changes.

Glendon *et al* (1989) in a series of studies, found that a variety of coping strategies were related to driver stress. That is, efficient coping strategies were employed when stress was low (eg slowing down in bad weather). Inefficient coping strategies were used during periods of high stress (eg aggressive driving after being caught in a traffic jam). Favouring one or the other type of coping depends on the drivers' mood, personality, motivation, the situation and/or a combination of these. Driver stress then is the culmination of emotional and physiological responses to traffic events, resulting from a continual interaction of factors both intrinsic (eg fatigue) and extrinsic (eg family problems).

The next study then, attempts to investigate the relationship between the use of coping strategies within everyday stressful situations and within the context of driving and personality traits. Previous studies have suggested a relationship between stress, personality and coping strategies. There is some evidence that coping is not only related to types of driving scenarios but also to personality. McCrae and Costa (1986) suggest that neurotics use ineffective coping strategies, which might explain their apparent predisposition to driver stress.

Method

Participants

50 Drivers participated with a mean age of 33.6 of which 24 were men and 26 were women.

Procedure and Design

Participants completed a battery of questionnaires, including the EPQ, and Folkman *et al*'s (1986) Ways of Coping (WOC) questionnaire, which is scored to give eight coping scales. Participants were asked to complete the questionnaire for three types of stressful encounter, associated with threat, loss and challenge respectively. In fact, coping scales were quite highly correlated across the three types of encounters (mean alpha .80: range .68 -

.88), so scores were averaged across encounter type. Participants also completed a questionnaire on coping with driver stress. This comprised eight diverse 'scenarios'. These were stressful, commonly-met driving situations, such as being stuck in a traffic jam. Participants were asked to recall the last time they experienced the scenario, and to rate their emotional reactions, and the way they coped with the situation. Tension, fatigue and annoyance were rated on 100 mm visual-analogue scales: this taxonomy of stressful emotion is based on Matthews, Jones and Chamberlain's (1990) mood studies. Participants were also provided with descriptions of how the eight WOC coping strategies might be applied to driving situations, and asked to rate their use of each of the eight strategies described on a four-point scale. For example, instances of the WOC 'planful problem-solving' strategy included slowing down in bad weather and changing route. Ratings were acceptably internally consistent across the eight stressful scenarios for scores to be averaged, for both emotion ratings (mean alpha: .67: range .57 - .79), and coping ratings (mean alpha: .77: range .66 - .88).

Results and Discussion

Table 2.5: Personality correlates of the WOC and driving scenario measures of coping, and of emotion ratings

Coping	Measure	N	E	P	L
Confrontation	WOC	.24	.37**	ns	-.34*
	Driving	.30*	ns	ns	-.36*
Planful Problem-Solving	WOC	ns	.37**	ns	ns
	Driving	ns	.32*	ns	ns
Escape-Avoidance	WOC	.54**	ns	ns	ns
	Driving	.34*	ns	ns	ns
Distancing	WOC	ns	ns	ns	ns
	Driving	ns	ns	ns	ns
Self-Control	WOC	ns	ns	ns	ns
	Driving	ns	ns	ns	ns
Accepting Responsibility	WOC	.28*	ns	ns	-.36*
	Driving	ns	ns	ns	ns
Positive Reappraisal	WOC	ns	ns	ns	ns
	Driving	ns	ns	ns	ns
Seeking Social Support	Driving	.37**	ns	ns	-.28*
	Tension	.37**	ns	ns	ns
Emotion Ratings	Fatigue	.30*	-39**	ns	ns
	Annoyance	.40**	ns	ns	ns

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 2.5 compares the coping correlates of the EPQ for the standard WOC, and the driving scenario measures. The magnitude of correlations between N and coping were reasonably consistent across the two types of measure, implying that more neurotic participants have distinctive coping strategies which they bring to bear across different situations. For driving, high N participants reported significantly greater use of aggressive, confrontive coping, seeking social support (from a passenger in the car), and attempts to escape or avoid unpleasant emotion. These correlates are comparable with those reported by McCrae and Costa (1986) in their more extensive research. Their data suggest that strategies favoured by more neurotic subjects, such as hostile reaction and escapist fantasy, are also rated as less effective. Hence, the relationship between neuroticism and driver stress may in part be mediated by use of ineffective coping strategies. E was positively correlated with planful problem solving on both coping measures, a result also consistent with McCrae and Costa's (1986) data. However, extraverts' greater reported use of confrontive coping and social support on the standard WOC did not generalise to driving, implying that perhaps relationships between E and coping are more context-dependent than those involving N. L was negatively correlated with both confrontive coping measures, and P was unrelated to coping. Table 2.5 also shows that, as expected, high N subjects reported greater emotional stress on all three scales.

Study 4: Group Differences in Driver Stress

Introduction

Physiological comparisons between men and women's stress responses under various psychosocial conditions have revealed consistent sex differences in adrenal-medullary activity (reviewed by Frankenhaeuser, 1978). Under rest and relaxation conditions, sex differences are only marginal. It is only in stressful and challenging situations that consistent sex differences appear which show less reactivity of the adrenal-medullary system in females compared with males (Johansson and Post, 1974; Frankenhaeuser, Dunne and Lundberg, 1976). Frankenhaeuser (1978) tested adrenal-cortical activity during a six-hour matriculation exam. Under such highly stressful conditions, males showed a significant elevated level of both catecholamine and cortisol excretions compared with females.

The question of whether neuroendocrine sex differences are mediated by differences in perceived performance level is an interesting one. Despite males showing a stronger physiological response to stress, females consistently score higher than males on self-reported levels of negative emotions. Generally, the strategy for measuring perceptions of stress, health and related outcomes and coping has relied on self-report measures. In such studies, women typically report more stressful life events and health symptoms (eg Georgas and Giakoumaki, 1984; Lester, Posner and Leitnes, 1986). There is a major problem of interpretation here, as women are more open than men and more willing to report negative emotions (Hatch and Leighton, 1986) which might be regarded either as a coping strategy in itself, a report artifact (Levenson, Hirschfeld, Hirschfeld and Dzubay, 1983) or a consequence of sex-role expectation (Buck, 1981).

With respect to age, studies typically find that younger subjects report greater levels of stress than older subjects (Gadzella et al, 1990). For driving, it might be expected that women and younger subjects report greater levels of driver stress than men and older subjects. Recently, a study has shown that general and daily driver stress is mediated by age, with younger drivers (under 35 years) reporting higher daily stress levels (Gulian *et al* 1989a, 1990). Older drivers also coped more efficiently and were more relaxed in traffic jams, but reported higher levels of mid-week stress than younger drivers did, and displayed fewer inappropriate behaviours and emotions. It was concluded that for older drivers, weekends were a time for relaxation, whereas younger drivers are more likely to use their weekends as occasions for more active entertainment, therefore stress levels may rise in anticipation.

Method

Participants

Participants were chosen from members of staff (academic and non-academic) and students of Aston University. 158 participants completed the DBI (Gulian *et al*, 1989a) in the first sample which was divided into three age groups. The young age group comprised 84 participants aged between 18 and 30 of whom 39 were male and 45 were female. There were 53 participants in the middle-aged group aged between 30 and 49 of whom 28 were male and 25 were female. For the older age group, 21 participants were over 50 years of age of whom 11 were male and 10 were female. For the second sample there were 71 participants divided into three age groups. The younger group comprises of 30 participants aged between 18 and 30 of whom 15 were female and 15 were male. The older group comprised of 30 participants aged between 45 and 60 of whom 15 were males and 15 were females. The elderly group comprised of 11 males aged between 65 and 82.

Design and Procedure

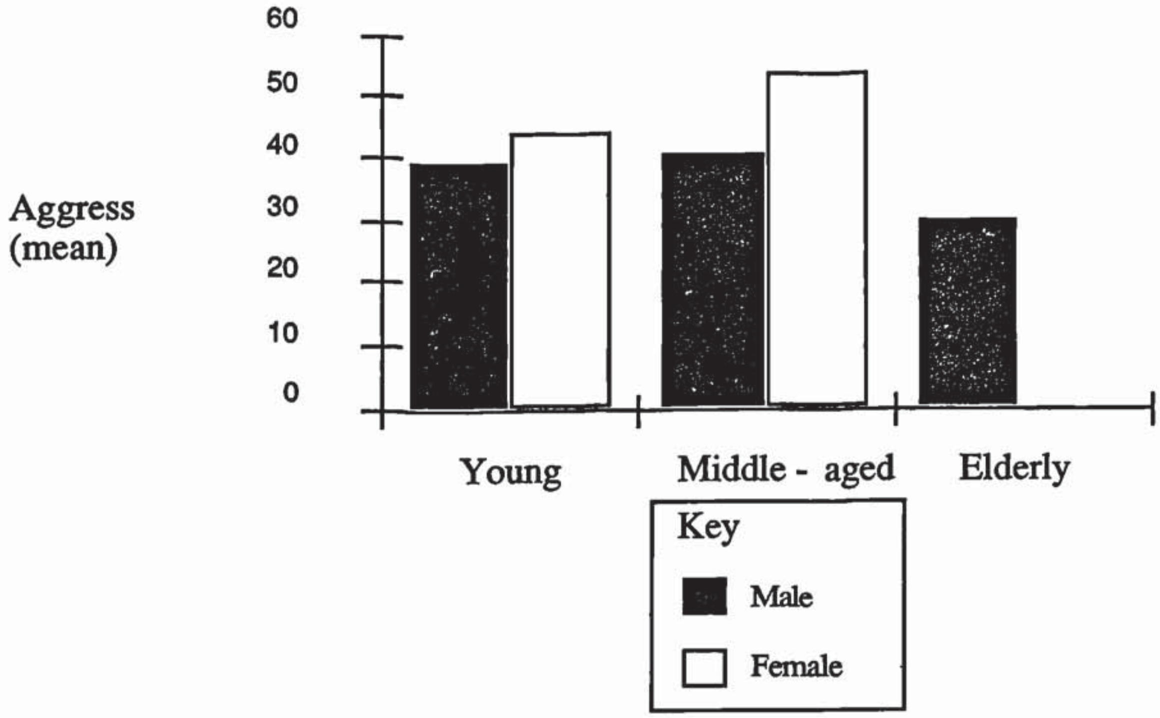
This study used a 3 X 2 ANOVA with age (young, middle-aged and old) and sex (male, female) as between-subjects factors. Mean scores for the 6 dimensions of driver stress were the dependent measures. Participants completed the DBI as in Study 1,2 and 3.

Results and Discussion

For the series of figures which follow, mean scores are charted which may not show significant differences which were found as a result of analysis of variance. For ANOVA tables, the author refers the reader to the Appendix.

There was a main effect of sex for driving aggression. Young female drivers reported higher levels on this dimension of driver stress ($F= (3, 157)\ 12.89\ p < .001$). This result is inconsistent with previous findings (Gulian *et al* 1989a) and may suggest a response bias. Perhaps female drivers are more willing to report aggressive reactions to driving situations.

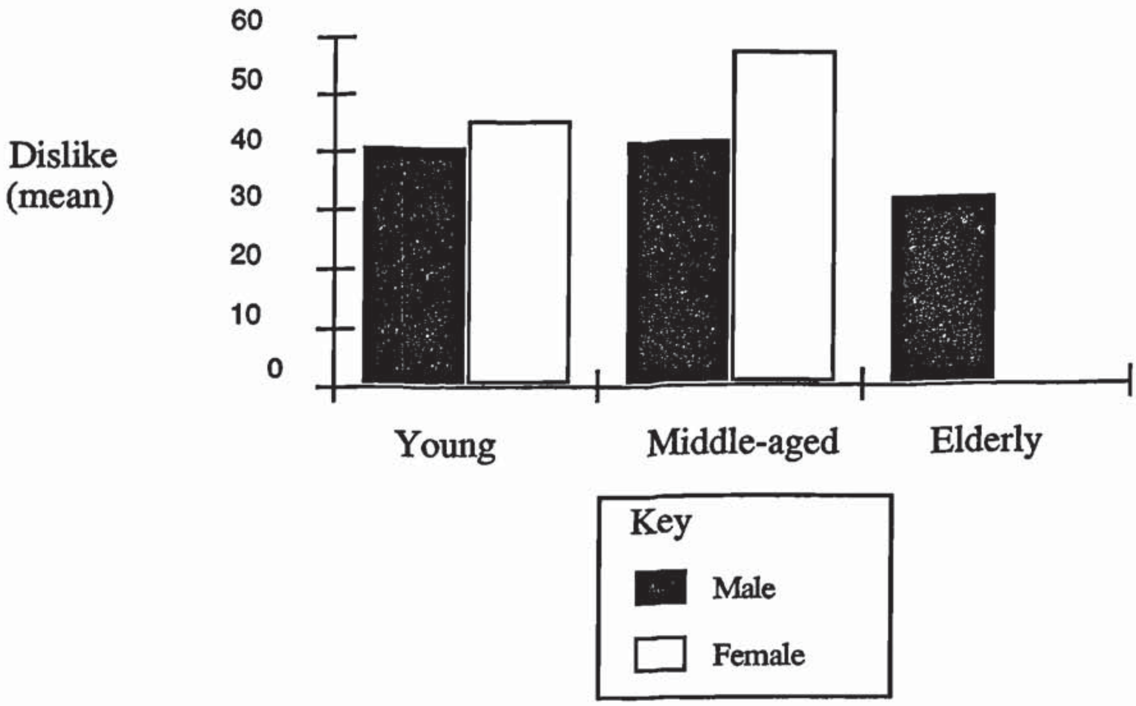
Figure 2.1: Old-Age Differences in Driving Aggression



*NB See Appendix for Anova table

A main effect of sex was also observed for the second sample shown in Fig 2.1 ($F=(2,67)$ 6.47 $p < .05$). Women reported greater levels of aggression whilst driving than men did. There were no main effects of age.

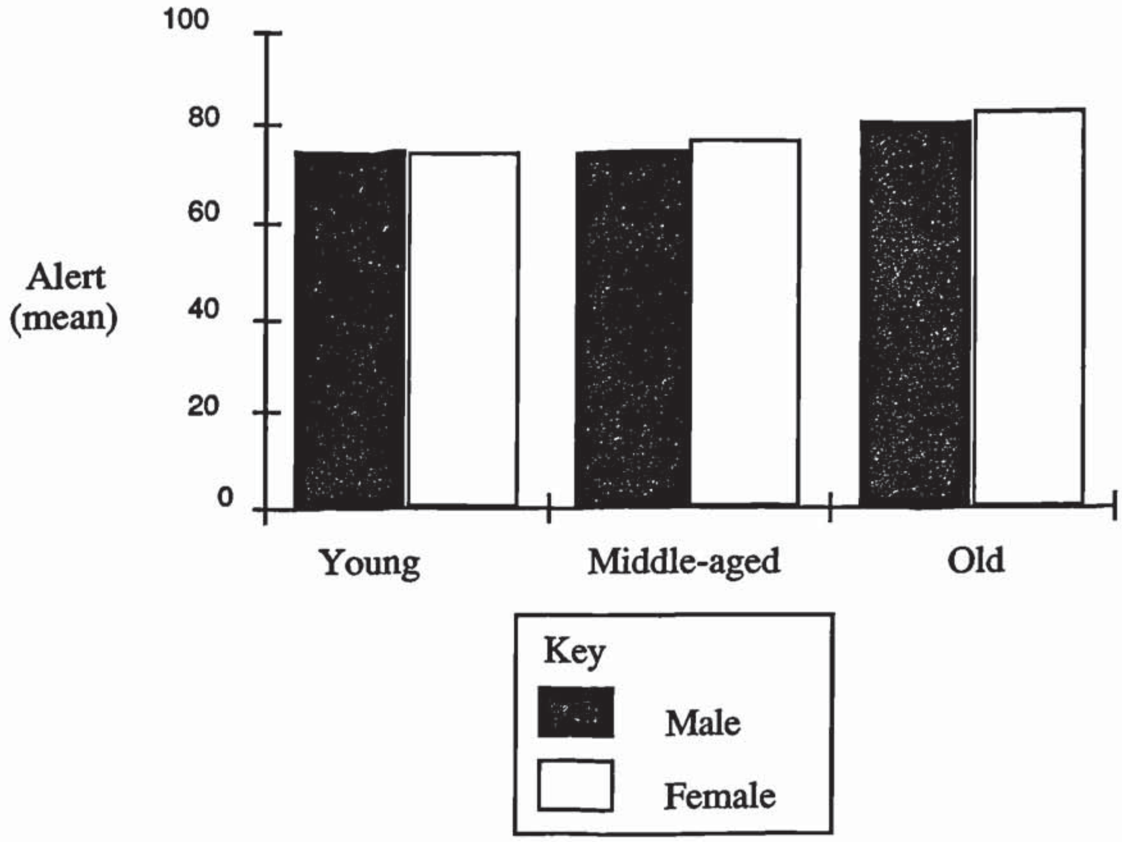
Figure 2.2: Old-Age Differences in Dislike of Driving



*NB See Appendix for Anova table

A main effect of sex was found for self-report levels of dislike of driving in the second sample shown in Fig 2.2 ($F=(1,67)$ 8.30 $p < .01$) with women reporting a greater dislike of driving. This finding was not found for the first sample.

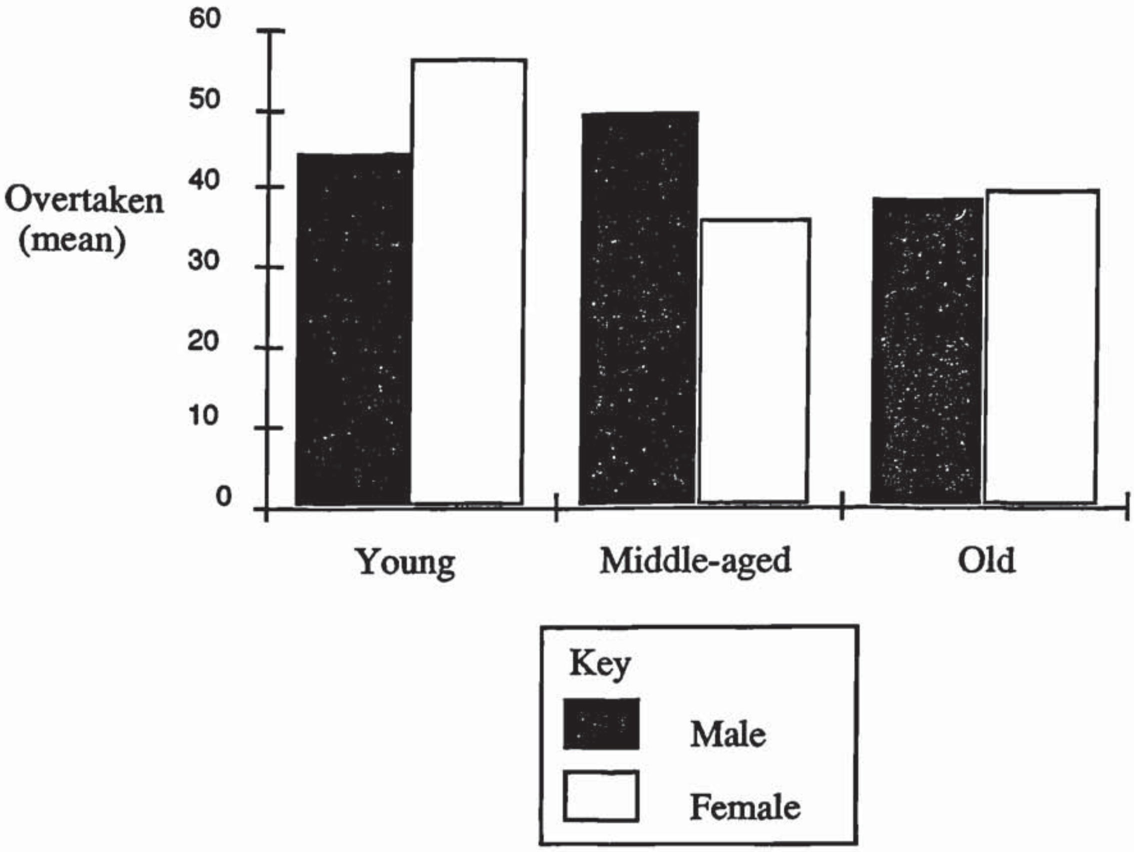
Figure 2.3: Sex and Age Differences in Driving Alertness



*NB See Appendix for Anova table

Figure 2.3 illustrates main effects of age (F= (3,157) 3.72 $p < .05$) and sex (F= (3,157) 5.45 $p < .01$) for the self-reported 'Alert' dimension of driver stress. Older drivers report higher levels of alertness whilst driving. This finding may be interpreted with reference to age-related decrements. Perhaps older drivers, in an effort to compensate for deterioration in cognitive and visual faculties, find it necessary to be more vigilant whilst driving than younger drivers do. This causes older drivers to experience and report greater stress. This effect only appears with the older group of drivers who have less exposure to the driving task. The main effect of sex shows that female drivers report somewhat higher levels of alertness whilst driving than male drivers do. Given that women are less exposed to the driving task than men, this finding may reflect their relative lack of experience causing this group to concentrate more on the driving task.

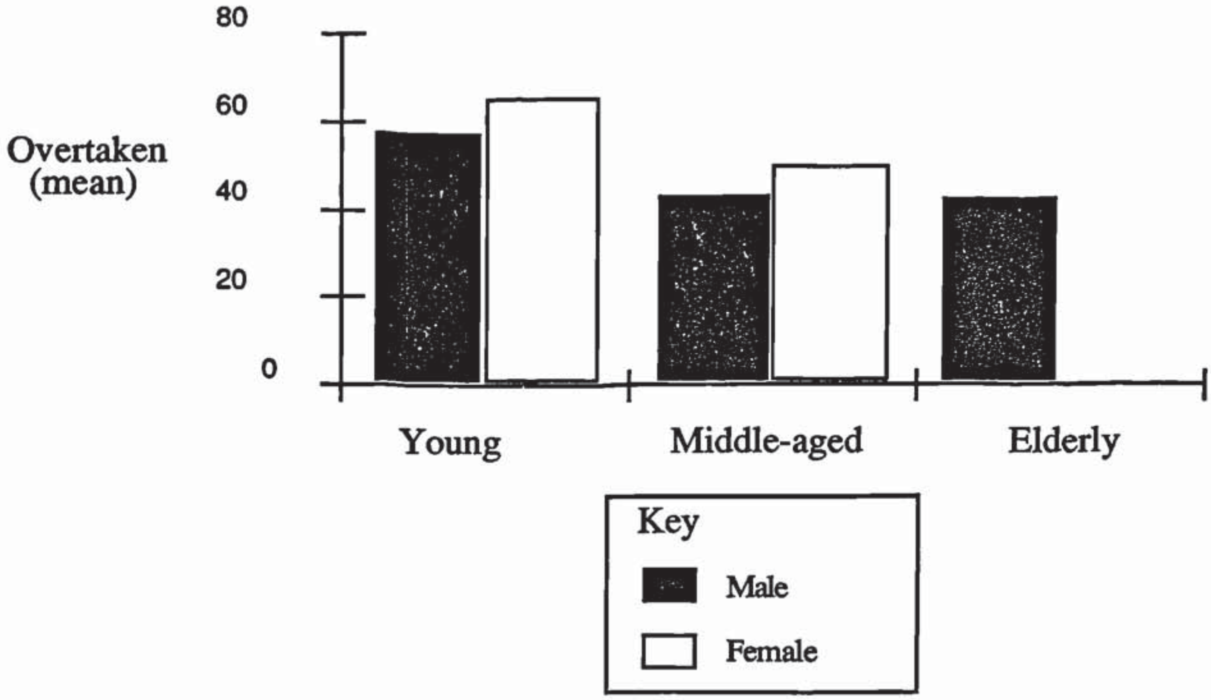
Figure 2.4: Sex and Age Differences in Being Overtaken



*NB See Appendix for Anova table

Figure 2.4 illustrates significant sex differences in tension when being overtaken ($F= (3,158)\ 3.09\ p < .05$), marginal age differences ($p < .10$) and a significant interaction of age and sex ($F= (2,158)\ 4.67\ p < .01$). The sex difference reveals that female drivers report greater irritation when being overtaken than male drivers do. There is also a tendency for younger drivers to report greater irritation on this dimension than middle-aged and older drivers do. The age by sex interaction indicates that whilst young females report greater irritation when being overtaken than young males do, the position is reversed for the middle-aged sample with females reporting less irritation than males. This finding could be interpreted as due to the fact that young females drive slower and overtake less thus more frequently experience being overtaken. This may lead to greater irritation than that experienced by the young male driver.

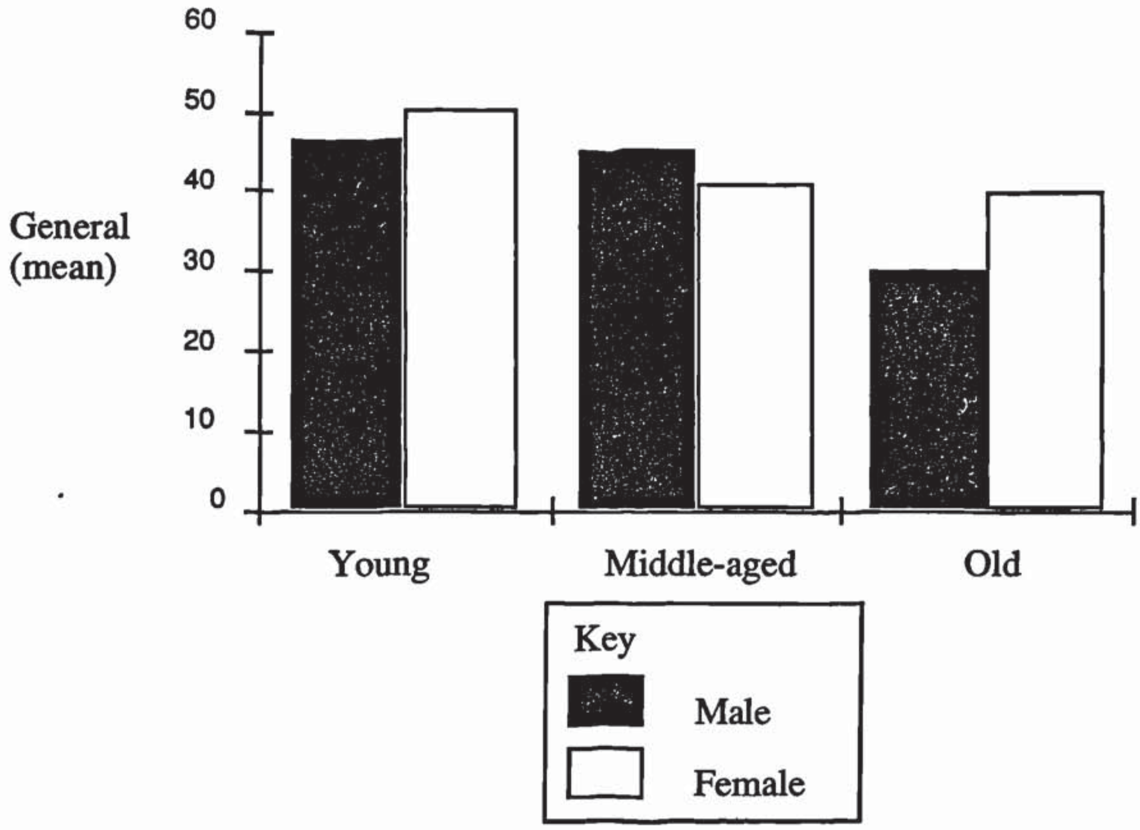
Figure 2.5: Old-Age Differences in Being Overtaken



*NB See Appendix for Anova table

There was a main effect of age with respect to self-reported levels of stress experienced when being overtaken for the second sample shown in fig 2.5 ($F=(2,67)$ 8.45 $p < .001$) with younger drivers reporting greater levels than older drivers and middle-aged and old-aged drivers reporting similar levels on this dimension of driver stress.

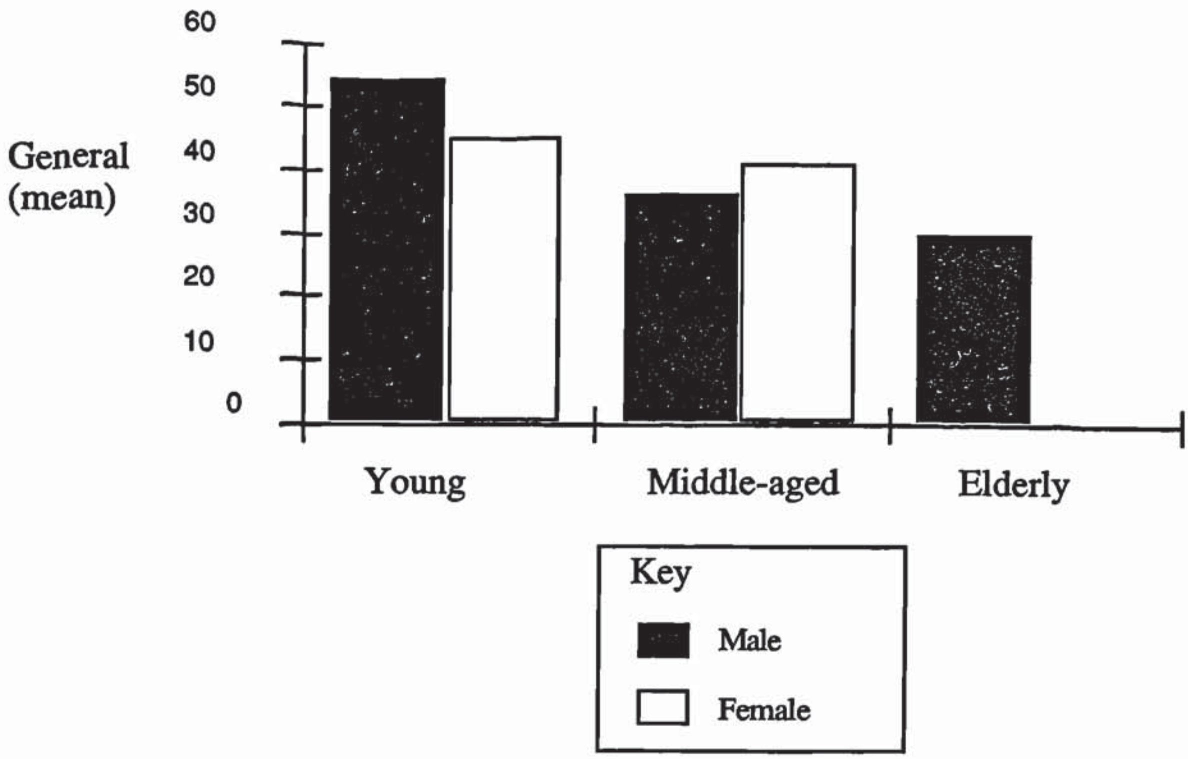
Figure 2.6: Sex and Age Differences in General Driver Stress



*NB See Appendix for Anova table

Figure 2.6 reveals significant age (F= (3,157) 7.05 $p < .001$) and sex (F= 2, 157) 9.97 $p < .001$) differences with respect to the general dimension of driver stress. There was also a marginally significant age by sex interaction ($p < .09$). Females report greater levels of driver stress than do males and younger drivers report greater levels of stress than do older drivers. Young females report the highest levels of stress.

Figure 2.7: Old Age Differences in General Driver Stress



*NB See Appendix for Anova table

There was a main effect of age for self-reported levels of general driver stress ($F=(2,67)$ 9.68 $p < .001$) for the second sample with younger drivers reporting greater levels than middle-aged drivers do, who in turn reported greater levels than old-aged drivers do (see Fig 2.7). The general findings from this study show that younger drivers report greater levels of stress than do older drivers, with women reporting greater levels than men. Moreover, it would appear that elderly male drivers report lower levels of stress generally than do other age groups.

In summary, group differences in driver stress revealed that females report greater levels of driver stress than do males. This finding is consistent with previous research which shows that females are more willing than males to report emotional reactions to stressful situations. Research by Frankenhaeuser (1978) suggests that males have a stronger physiological reaction to stressful situations and are yet unwilling to report subjective negative emotions. It is clear that there are obvious limitations to self-report measures if such psychological processes are in operation. A clearer picture of sex differences in driver stress may emerge if studies were to measure physiological reactions to simulated driving situations.

It might be assumed that women who have adopted male roles may be more likely to show male-like physiological stress responses. Collins and Frankenhaeuser (1978) found that results from such a sample in an achievement situation revealed that adrenaline secretions were almost as high as males. Moreover, Rosenfield (1989) finds that when familial demands are equal, there are no sex differences in mental health symptoms. Perhaps the multiple roles of women in today's society may be contributing to their readiness to report stress (Coverman, 1989). Such findings are quite suggestive of cultural factors as being a determinant of stress and coping responses.

The finding that younger drivers report higher levels of driver stress has been replicated. However, it is possible that the interpretation of this result may suffer from the same limitations as interpretation of the results for sex differences in driver stress. It is possible that older drivers may be unwilling to report negative emotional reactions to the driving task because this may reflect badly on their driving performance. There is a tendency for older drivers not to admit to age-related changes and adverse psychological reactions to driving (AA Report, 1988). Interestingly, elderly male drivers report relatively low levels of driver stress, perhaps for the same reasons. Physiological reactions to simulated driving may provide a clearer picture of age differences in driver stress. Despite this, Frankenhaeusser (1978) suggests that subjective psychological feelings of stress may have a greater bearing on behaviour than physiological measures, so that self-report measures may be a more accurate assessment of emotional reactions to stress than physiological measures.

There were some inconsistent findings between sample 1 and 2, for example, sex differences in aggression and dislike of driving were only found in sample 2. However, generally, the pattern of responses remained the same across samples with younger drivers and female drivers reporting higher levels of driver stress.

Conclusion

In summary then, it would appear that there are clear individual and group differences in driver stress as anticipated. Three studies reported here investigated the link between personality and driver stress. In study 1 results show that general driver stress was positively correlated with the EPQ N scale and with minor accident involvement. In study 2, measures of the 'Big Five' derived from normative and semi-ipsative versions of an adjective checklist and from the 16PF, were related to driver stress. Driver stress was primarily associated with high neuroticism and low affection, though possibly for different reasons. In study 3 the EPQ was related to measures of coping with stress: results suggested that N is associated with use of relatively ineffective coping strategies. For studies 4 and 5, group differences in driver stress are reported which show that younger drivers report greater levels of stress than do older drivers. Results also show that women drivers report greater levels of stress than male drivers do.

These findings support the experimental hypotheses, showing that neuroticism is associated with higher levels of driver stress as predicted. Previous research has pointed to neuroticism as being the strongest single predictor of stress. Several studies have shown relationships between neuroticism and different measures of stress-related emotions. It is therefore not surprising that driver stress should be associated with this dimension of personality. Moreover, the findings for group differences in driver stress support the hypotheses that younger and female drivers would report greater levels of stress than older and male drivers. Interpretation of sex differences in driver stress is difficult given the greater willingness of females to report stress reactions.

It is likely that there are higher levels of stress experienced in real driving which may accentuate any effects of stress. Drivers who may be predisposed to express emotional reactions to certain driving situations may also be at increased risk in the behavioural manifestation of driver stress. Stokols *et al* (1978) suggested that the emotional demands of driving may result in performance impairment and increased the risk of being involved in an accident. A study by Schaeffer *et al* (1988) examined the effects of morning-rush-hour commuting on drivers and assessed the mediation of stress by two sources of control in the commuting situation. Among participants with a high impedance route, commuting was associated with significant increases in blood pressure and decreases in behavioural performance.

Whilst some drivers may be motivated to actively prevent stress reactions from affecting driving performance, others may possess relatively ineffective coping strategies. It is therefore important to ascertain whether individual and group differences with respect to risk perception operate in a similar way to individual and group differences in driver stress. If the same driver characteristics are shown to be related to a less realistic perception of risk, then some of the important underlying processes which may operate during driving behaviour may be better understood. Driver stress may be cognitively mediated by risk perception and affect risk-taking propensity. The next series of studies is concerned with individual and group differences in risk perception.

Chapter 3: Individual and Group Differences in Risk Perception

Study 1: Individual Differences in Risk Perception

Introduction

Perception of risk, like risk itself, appears to be somewhat diverse and dissaggregated. Lichtenstein *et al* (1978) asked participants to estimate the number of deaths per annum that are attributable to various hazards. They discovered that the subjective estimates were consistent across several methods of elicitation and correlated reasonably well with actual estimates of frequency. A comparison of objective and subjective estimates revealed two biases however. The primary bias refers to the common tendency to overestimate infrequent causes of death whilst underestimating more frequent causes. A secondary bias refers to the observation of an overestimation of deaths caused by dramatic and sensational events and an underestimation of deaths caused by unspectacular events (Slovic, Fischhoff and Lichtensein, 1982). There is also a 'scale truncating ' bias in operation whereby individuals have a reduced perceptual range compared with objective statistics. Such biases do not seem to govern perception of risk of road traffic accidents as estimates of deaths tend to be fairly accurate. Lichenstein *et al* (1978) suggested that these errors could be caused by media attention to spectacular events.

Sheppard (1975) found that many drivers think that they could be involved in a serious road traffic accident. Many fear that in such an accident their vehicles might catch fire or overturn. The study presented here suggests that there may be an additional explanantion; that overestimation of risk may be related to individual differences. Perhaps fear of a road traffic accident is associated with the personality trait neuroticism.

Individual differences in risk-taking have been widely reported. Studies reveal that achievement (McClelland and Watson, 1973), aggression (Begum and Dhar, 1984), dominance (Michael and McDavid, 1972) and extraversion (Cutter, Green and Handford, 1973) are positively related to risk-taking. Other characteristics of personality are found to be negatively associated with risk-taking, such as rigidity and conservatism, affiliation (McClelland and Watson, 1973; Begum and Dhar, 1984) and nurturance, deference and abasement (Begum and Dhar, 1984).

More recently, several studies have shown that young adults are reckless (eg Arnett, 1989; Donovan, Jessor and Costa, 1988; Elster, Ketterlinus and Lamb, 1989). Individuals who engage in one type of risky behaviour often engage in other types. For example, Arnett (1991b) found that young adults who tend to drive at high speeds are also less likely to wear seatbelts, either while driving or as a passenger. For some, there may be a persistance in the egocentric belief in exemption from the consequences of driving recklessly. Sensation-seeking and egocentrism tend, among others, to be related to such reckless behaviour. By the mid-20s this behaviour starts to wane, which is clearly reflected in accident statistics. Arnett (1991a) suggests that this decline is due to many factors, among which may be a developmental change as the individual accepts the responsibilities of the adult role.

There is evidence that both sensation-seeking and anxiety are related to the tonic activity of the central norepinephrine (NE) system (Zuckerman *et al*, 1983). Under conditions that increase anxiety, the NE system may be an adaptive response to overrride the paralyzing effects of the behavioural inhibition system. Therefore, if high sensation-seekers do not perceive anxiety to the same degree, then they do not learn to fear to the same extent as low sensation-seekers. Therefore, the tendency to secrete NE in anxiety-provoking situations results in high sensation-seekers perceiving less anxiety, fear and risk than low sensation-seekers (Franken *et al*, 1992)

The alternative to believing oneself to be immune to the dangers posed by driving, is the belief that one is very likely to be involved in an accident. In a similar way in which low risk perception is related to sensation-seeking, egocentrism and extraversion, it is possible that heightened risk perception is related to neuroticism. Williams *et al* (1988) discuss individual differences in selective attention to threat and anxiety. Evidence points to neurotics showing greater susceptibility to threatening stimuli.

Method

Participants

Fresh samples of drivers were used in a series of three studies. Sample 1 comprised 93 drivers - 46 female and 47 male aged between 18 and 30 years. Sample 2 comprised 73 drivers. Of these, 60 participants, 30 male and 30 female were divided into two age groups. The younger group were aged between 18 and 25 and the older group were aged between 45 and 60 years. The remaining 13 participants were all male drivers aged between 65 and 82 years. For sample 3, there were 60 drivers, 30 males and 30 females. Of the 30 males, 15 were aged 18-30 years and 15 were aged between 45-60 years. Similarly, of the 30 females 15 were aged between 18-30 and 15 were aged between 45-60.

Design and Procedure

Each sample of participants completed the Risk Perception Questionnaire. The RPQ is divided into two parts. In Part A, participants used 100 mm visual analogue scales (anchored by zero and 100) to estimate the likelihood of being involved in a road traffic accident in the year ahead. They made this estimation in respect of themselves, their peer group and the three remaining target groups participating in the experiment; thus younger men, for example, estimated the likelihood of a traffic accident for themselves, for other young male drivers in the 18-25 age group, for male drivers in the 45-60 age group, for female drivers in the 18-25 age group and for female drivers aged between 45 and 60 years. An accident was defined as a collision involving other vehicles and/or objects. Participants also completed the EPI (Eysenck, 1975).

Results and Discussion

Table 3.1: Personality Correlates of Risk Perception (Samples 1, 2 and 3)

	EPI Scale		
Sample 1 (N=93) DBQ Rating	E	N	L
Acc (self)	ns	.24*	ns
Acc (YF)	ns	.25*	ns
Acc (OF)	ns	.26*	ns
Acc (YM)	ns	.30**	ns
Acc (OM	ns	.28**	ns
	EPI Scale		
Sample 2 (N=73) RPQ Rating	E	N	L
Acc (self)	ns	.24*	ns
Acc (YF)	ns	.24*	-.26*
Acc (OF)	ns	.25*	ns
Acc (YM)	ns	.24*	ns
Acc (OM	ns	.27*	ns
	EPI Scale		
Sample 3 (N=60) RPQ Rating	E	N	L
Acc (self)	ns	.30*	ns
Acc (YF)	ns	ns	ns
Acc (OF)	ns	ns	ns
Acc (YM)	ns	ns	ns
Acc (OM	ns	ns	ns

* $p < .05$; ** $p < .01$; *** $p < .001$

For sample 1 (N=93) significant associations between N and ratings for accident likelihood for self and other target groups were found. This finding was replicated in sample 2 (N=73). However, for sample 3 (N=60), the only correlation to reach significance was that between N and rating for accident likelihood for self. Perhaps the smaller number of participants in this sample contributed to the non-significant associations for accident risk for other target groups.

The relationship between risk perception and neuroticism indicates that neuroticism may be associated with increased perception of risk and threats when driving. The findings of Williams *et al* (1988) which shows that neurotics are more susceptibile to threatening stimuli has been confirmed. The complete lack of an association between extraversion and risk perception is not surprising. It might be expected that extraversion would be related to risk-taking rather than the belief that one is likely to be involved in an accident.

No studies have been conducted to test for personality differences in risk perception, although several have linked individual differences to risk-taking propensity. Results suggest that drivers high in neuroticism may believe themselves to be at greater risk of an accident than those low in neuroticism. This result can be interpreted in the light of the findings for individual differences in driver stress. Perhaps the association found between neuroticism and driver stress may be mediated by risk perception. If neurotics believe that there is an imminent threat of being involved in a road traffic accident, then it is likely that such drivers would report greater levels of stress.

This finding has implications for recruitment selection for drivers. An over-pessimistic view of personal risk may be deleterious to driving performance. Alternatively, heightened perception of risk may result in drivers taking greater care on the road. Driving simulator studies which attempt to relate individual differences to driving performance may be useful in helping to understand the relationship between neuroticsm and driving behaviour.

Study 2: Group Differences in Risk Perception

Introduction

The high accident rate amongst young male drivers is thought to be partly due to the increased risk-taking in this group (Jonah, 1986). Summala (1987) suggests that during the first 50,000 km, novice drivers gradually develop improved driving practices and hazard control skills. However, he maintains that over-confidence among younger drivers arises from early mastery of basic car-control skills, while their hazard control skills remain defective. Brown (1982) argues that younger drivers may be less able to recognise a hazardous situation when it arises and therefore are more likely to take risks on the road. Most drivers consider themselves to be more competent and safer than the 'average' driver (Schioldborg, 1979; Svensson, 1981), this being particularly true for males shortly after passing their driving test (Spolander, 1983a). The more skilled drivers consider themselves to be, the greater the average speed preferred, the higher the rate of overtaking and the greater the amount of aggression displayed in driving (Spolander, 1983a). McKenna, Stanier and Lewis (1991) found that in a wide range of scenarios, it was clear that drivers rated their own skill as superior to that of other drivers. Subjects tended to adopt a positive-self bias rather than a negative-other bias, as ratings for the competence of other drivers was about average rather than poor. In this study, men showed greater self-enhancement biases across all driving skills, whereas women showed less bias in skill such as reversing, parking, judging the width of vehicles and navigating while in unfamiliar surroundings. However, when the effect of experience is taken into account, sex differences are non-significant.

Age and sex differences in accident involvement may reflect group differences in the information-processing elements of the driving task as well as risk perception. For example, compared with experienced drivers, novice drivers perform less well on a number of relevant measures. These measures include: visual search (Mourant and Rockwell, 1970; Mourant and Donahue, 1977), visual attention and direction (Soliday, 1974; Renge, 1980), reaction time (Welford, 1980; Colbourne, Brown and Copeman, 1978), speed adjustment (Sten, 1979; Konecni, Ebbesen and Konecni, 1976) and driving performance (Maeda, Irie, Hidaka and Hishimura, 1977). However, novice drivers may lack awareness of these performance differences, causing them to over-estimate their ability and under-estimate risk. Studies which have assessed drivers' perception of risk under various driving situations have reported that drivers underestimate certain traffic hazards and overestimate their own driving abilities (Svensson, 1981; McCormick, Walkey and Green, 1986; Finn and Bragg, 1986; Groeger and Brown, 1989). Matthews and Moran, 1986 found that risk perception among males and confidence in driving abilities is dependent on age. Using both a questionnaire and a series of videotaped sequences of various driving behaviours, young and old males gave ratings of vehicle-handling, driving reflexes and driving judgement for themselves and for other target groups. The results showed that compared with older drivers, young drivers gave higher estimations of future accident involvement, but gave lower ratings of accident risk for driving which required fast driving reflexes or vehicle-handling skill. Younger drivers believed that compared with themselves, their peers were significantly more at risk and possessed poorer abilities. Young drivers were more confident than older drivers in their own driving abilities.

Matthews and Moran (1986) concluded that for younger male drivers there was a general dissociation between perceived and actual driving abilities. The questionnaire data showed no significant correlation between ratings for risk and ratings for driving ability among younger drivers. However, data for the older drivers showed significant positive correlations between risk ratings and ratings for ability, reflexes, judgement and vehicle-handling skill. Risk was strongly inversely related to ability ratings for the videotape data for both young and old groups.

The study reported here is a replication and extension of Matthews and Morans' (1986) study to include sex as well as age of raters and of 'target groups' of drivers rated. Risk perception amongst women has been generally neglected in previous studies. As in Matthews and Moran's (1986) study, ratings from a general questionnaire and for videotaped sequences of specific manoeuvres were obtained. Effects on ratings of both the between-subjects variables of age and sex of target groups or ratees were analysed. The complexity of the design poses difficulties in presentation. To clarify the results, the types of bias tested for were allocated to four distinct categories described below.

Age and sex differences in risk perception such as those identified by Matthews and Moran (1986) are instancies of a general demographic bias in perceptions of raters which generalise across a variety of traffic situations. Operation of demographic bias is demonstrated empirically by effects on ratings of between-subjects variables of age and sex of rater. A specific aim was to test whether there are interaction effects of age and sex on risk perception which correspond with age and sex effects on accident likelihood, which in turn might help to explain higher accident rates among older women.

A second type of bias is the operation of stereotypes of particular target groups. For example, there are general societal tendencies for older people and women to be rated as less competent than younger people and men respectively (eg Avolio and Barrett, 1987). Hence, women and older drivers may be seen by raters in general as being more likely to be involved in an accident than other groups. The operation of stereotypes is indicated by effects of within-subjects variables, age and sex of ratee. Stereotypes could be influenced by genuine differences in risk-proneness and performance of the kinds discussed above and by culturally-derived prejudices unrelated to actual driving behaviour.

The third type of bias is the occurrence of group-specific biases. Particular rater groups may show bias in their perception of particular target groups. For example, in occupational settings, younger raters of job aptitude show greater age stereotyping than do older raters (see Avolio and Barrett, 1987). Younger raters might assign higher risk ratings to older ratees than would older raters. Such bias is manifested by interactions between rater and ratee variables.

Finally, bias in self-appraisal and the extent to which it varies with rater characteristics can be tested for. The most striking effects of the Matthews and Moran (1986) study, showed that younger male drivers over-estimate their own ability relative to that of their peers, while older drivers do not.

Method

Participants

Participants, drawn from Aston University students and members of staff (academic and non-academic), were recruited by advertisements placed in a university newspaper. Sixty drivers participated in the experiment, and were paid for their services. They were divided into four equal groups of 15: younger and older men and younger and older women. The younger groups were aged between 18 and 25 years and the older between 45 and 60 years. Information was collected on driver age, driving experience, defined as the time elapsed since a full driving licence was obtained, and on exposure, defined as the number of miles estimated to have been driven during the previous 12 months. This information is presented in Table 3.2.

Table 3.2: Group means showing age, experience and exposure for four target groups (young and old males, young and old females)

	Young Males	Older Males	Young Females	Older Females
Age	24.9	51.7	22.0	50.0
Years since licence	5.9	29.7	3.7	24.3
Miles driven in last 12 mths	9,650	11,150	7,650	8,650

Materials

The experiment was divided into three parts. Participants completed the Risk Perception Questionnaire for part A of the study. Part A is fully described in study 1 of this chapter; participants were required to give ratings of accident risk for both themselves and other target groups. In part B, participants were asked to make ratings of two aspects of driver performance: driving skill and driving judgement. These ratings were again made for themselves, for their peer group and for the three other target groups in a similar way to accident likelihood. Driving skill was defined as the driver's skill in vehicle-handling and in controlling the speed and direction of the car and driving judgement was defined as the driver's ability to assess the traffic situation and to choose a manoeuvre which would be safe in that particular situation. A panel of five judges gave ratings for these measures of driving competence and was able to distinguish between driving skill and driving judgement. In part C, the materials employed consisted of 19 videotaped driving sequences, all in colour, ranging in duration from 11 to 48 seconds. Each sequence depicted a target vehicle in a real-life driving situation. The sequences focused on the actions of the target vehicle, which was required to take avoiding action in order to prevent an accident, and provided the viewer with an overall perspective of the road and prevailing traffic conditions. Sequences were copied with permission from various sources onto a master tape. Thirteen sequences were taken from a UK Transport and Road Research Laboratory (TRRL) training film, one from other driver education films and five were produced by the experimenters, through the courtesy of the City of Birmingham Department of Transport. Of the 19 sequences, one was a practice sequence and the remaining 18 comprised six sequences involving either high, medium or low risk. A panel of five judges graded each sequence for the degree of risk involved using TRRL Guidelines for traffic conflict. Following the practice sequence, the order of the presentation of the remaining 18 sequences was block randomised according to the degree of risk involved. The following types of driving situations were shown on the video taped sequences: (1) target vehicle emerges from T-junction into path of an oncoming vehicle; (2) target vehicle emerges from a junction at a crossroads and causes other vehicles to take avoiding action; (3) target vehicle tail-gates other vehicle when approaching a roundabout; (4) target vehicle is shown speeding and taking corners sharply.

Procedure

Participants were tested in groups ranging in size from three to eight. They performed parts A, B and C in the same session, which lasted for approximately 60 minutes. The order in which the ratings were requested were block randomised so as to avoid, as much as possible, respondents applying set rules when rating accident involvement and driving competence for self and other target groups. Participants began by completing parts A and B in the presence of the experimenter. For part C the experimenter showed the videotaped sequences on a U-matic videotape machine and monitor. For each sequence, participants were instructed to focus on the target vehicle and, using the same 100 mm visual analogue scale as in parts A and B, to rate: (1) the likelihood of an accident occurring in the situation for themselves and for each of the target groups as driver; (2) their confidence in their own driving skill and driving judgement in the situation depicted in the sequence; and (3) to make the same confidence ratings of judgement and skill with respect to each of the target groups. Participants were thus required to make a series of 18 ratings for each of the videotaped sequences. For example, a young male driver would first estimate the likelihood of being involved in an accident if he had to avoid emerging from a T-junction, as shown in 10 of the sequences. He would then make estimates for other young male drivers, older male drivers, young female drivers and older female drivers. Subsequently he would make confidence ratings of his own driving skill and judgement in that situation and finally would make ratings for each of the other four groups.

The visual analogue rating scale required participants to give ratings based on the following semantically different anchor points for skill ratings: very high skill/very low skill, for judgement ratings: very good judgement/very poor judgement and for the likelihood of having an accident: not at all likely/extremely likely. These anchor points were taken from the study by Matthews and Moran (1986) although it is likely that these labels may lead to a truncating effect of the visual analogue scale or interpretations of these labels may differ from participant to participant.

Design

Questionnaire data for target groups were analysed in a 2 X 2 X 2 X 2 ANOVA with sex and age of rater as between-subjects factors; sex and age of 'ratee' as within-subjects factors. Data were further analysed in a 2 X 2 X 2 ANOVA with age and sex of rater as between-subjects factors, and group (self or peer group) as within-subjects factors.

Ratings of the video sequences for target groups were analysed in a 3 (risk level: low, medium and high) X 2 (age of rater) X 2 (sex of rater) X 2 (age of ratee) X 2 (sex of ratee) ANOVA. Age and sex of rater were between-subjects factors, and risk level and age and sex of ratee were within-subjects factors. Ratings were also obtained for self , peer group and the video driver under three levels of risk. These were analysed in a 3 (risk level) X 3 (group: self, peer group and video driver) X 2 (age of rater) X 2 (sex of rater) ANOVA, with the first two being within-subjects factors and the other two being between-subjects factors.

Results

Given the complexity of the design of this study, the results are organised by hypothesis to determine whether demographic, stereotyping, group-specific or self biasing effects are found within questionnaire and video data.

Demographic Bias

The first anticipated outcome was significant effects of sex and age of rater on ratings of accident likelihood and driving competence. Results were: for the questionnaire, though not for the video data, a main effect of sex of rater ($F(1,56) = 5.11$ $p < .05$) indicates that women gave significantly higher ratings of accident likelihood overall.

Table 3.3: Questionnaire ratings (mean values) of accident likelihood during the coming year made by four groups of drivers (young and old males, young and old females) in respect of four target groups (young and old males, young and old females)

	Rater			
Ratee	Young Male	Older Male	Young Female	Older Female
Young Male	44.67	46.27	60.00	61.00
Older male	34.67	22.67	44.33	44.00
Young Female	27.00	28.00	36.33	32.33
Older Female	32.00	34.00	33.33	28.93
Self	26.33	31.67	27.67	20.67

Main effects of sex of rater for ratings of skill and judgement were also observed for questionnaire ratings (skill: $F(1,56) = 10.26$ $p < .01$; judgement: $F(1,56) = 7.18$ $p < .01$). Female participants gave significantly higher ratings for both these aspects of driver competence than did male participants.

There were no main effects of age of rater apparent in either the questionnaire or the video data.

Table 3.4: Questionnaire ratings (mean values) of driving skill made by four groups of drivers (young and old males, young and old females) in respect of four target groups (young and old males, young and old females)

	Rater			
Ratee	Young Male	Older Male	Young Female	Older Female
Young Male	55.67	62.67	62.33	59.00
Older Male	53.67	61.33	67.00	68.33
Young Female	49.00	47.67	55.33	61.33
Older Female	44.67	38.00	58.33	66.67
Self	63.33	67.33	61.67	64.67

Table 3.5: Questionnaire ratings (mean values) of driving judgement made by four groups of drivers (young and old males, young and old females) in respect of four target groups (young and old males, young and old females)

	Rater			
Ratee	Young Male	Older Male	Young Female	Older Female
Young Male	49.67	47.00	54.33	50.00
Older Male	56.00	64.00	67.33	65.67
Young Female	54.67	51.00	56.33	63.00
Older Female	47.67	43.67	59.67	67.00
Self	71.67	73.33	66.67	62.67

Stereotyping

The second anticipated outcome was that there would be evidence of ratee bias. For the questionnaire, but not for the video data, there was a main effect of ratee sex ($F(1,56) = 41.66$ $p < .001$) on accident ratings. Male drivers were rated as more likely than female drivers to be involved in an accident. For both the questionnaire and the video data, there was a main effect of age of ratee for accident ratings (questionnaire: $F(1,56) = 18.59$ $p < .001$; video: $F(1,56) = 20.42$ $p < .001$) and a significant interaction of sex and age of ratee (questionnaire: $F(1,56) =35.24$ $p < .001$; video: $F(1,56) = 11.39$ p . 001). The main effect shows that younger drivers were rated as more likely than older drivers to have an accident. The interaction indicates that younger male drivers were rated as much more likely to be involved in an accident in the next twelve months than were other target groups.

There were also ratee effects on ratings of skill and judgement. The video sequence ratings for judgement showed a significant effect of age of ratee ($F(1,56) = 7.40$ $p < .01$) with younger drivers being rated as having poorer judgement than older drivers.

Table 3.6: Video-taped sequence ratings (mean values) of driving judgement made by 60 drivers in respect of four target groups (young and old males, young and old females) under three levels of risk

	Risk Level		
	Low	Medium	High
Young Male	53.59	47.61	44.41
Older Male	57.30	57.30	50.67
Young Female	55.56	49.66	47.46
Older Female	56.71	50.57	47.22

For questionnaire skill ratings there was a significant main effect of sex of ratee ($F(1,56) = 17.28$ $p < .001$) with women being rated as lower in driving skill. However, for the video ratings for skill, the main effect of sex of ratee obtained ($F(1,56) = 4.95$ $p < .05$) indicated that women were rated as *superior* in skill compared with men. In the video, significant interaction effects were between risk level and sex of ratee ($F(2,112) = 7.87$ $p > .001$), age of ratee and sex and age of ratee ($F(2,112) = 12.33$ $p < .001$) for skill ratings. Here, women were rated as superior to men in skill at each level of risk, as were younger drivers compared with older drivers. The interaction between risk, and sex and age of ratee, indicates that younger women were rated as superior in skill compared with other target groups.

Group-specific bias

The third anticipated outcome was that there would be rater by ratee interactions demonstrating rater bias against those being rated. Results were: for both questionnaire and video data significant sex of rater by sex of ratee interactions were found with respect to accident ratings (questionnaire: $F(1,56) = 9.75$ $p < .01$); video: $F(1,56) = 5.64$ $p < .025$). Women drivers were rated as more likely than men drivers to be involved in an accident by females.

Results for ratings of driver competence with respect to group-specific bias were: for both questionnaire and video data, there were significant interactions of sex of rater by sex of ratee for skill, though not for judgement ratings ($F(1,56) = 5.52$ $p < .01$; video: $F(1,56) = 4.27$ $p < .05$). Men rated women as lower in skill, while women rated men as lower than women in skill.

Self-appraisal bias

With respect to the forth anticipated outcome, that raters would show bias in rating self compared with peers, the findings were: for both questionnaire and video data there was a main effect of group (questionnaire: $F(1,56) = 5.69$ $p < .05$; video: $F(1,56) = 31.94$ $p < .001$) indicating that peer group (and driver in the video sequences) were rated as more likely to be involved in an accident than themselves (questionnaire; peer: 33.15 vs self: 26.58. video; driver; 60.44 peer: 53.64 self: 49.96).

For questionnaire, though not for the video data, a significant age by group interaction was obtained ($F(1,56) = 6.35$ $p < .05$), indicating that younger drivers rate their peers as much more likely than themselves to be involved in an accident (self: 27.00; peer: 40.50), confirming the findings of Matthews and Moran (1986). The age by sex by group interaction ($F(1,56) = 5.99$ $p < .05$) indicates that while younger men, younger women and older women rated themselves as less likely than their peers to be involved in an accident, older men rated their likelihood as being greater than that of their peers.

For the video sequence ratings, a significant risk level by sex of rater by group interaction was obtained ($F(2,112) = 3.13$ $p < .05$) indicating that as risk level increased, accident involvement ratings rose more sharply for male than for female drivers.

Table 3.7: Video-taped sequence ratings (mean values) for accident likelihood made by four groups of drivers (young and old males, young and old females) in respect of self, peer and driver of target vehicle, at three levels of risk (low, medium and high).

	Rater			
Group	Young Males	Young Females	Older Males	Older Females
Driver	58.94	57.78	60.49	64.63
Self	47.47	51.19	52.16	49.01
Peer	54.43	53.09	55.40	51.65

With respect to ratings of driver competence, there were significant main effects of group on skill and judgement ratings for both questionnaire (see tables 3.3 and 3.4) and video data (questionnaire; skill $F(1,56) = 5.38$ $p < .01$; judgement $F(1,56) = 17.99$ $p < .001$; video: skill $F(1,56) = 4.28$ $p < .05$; judgement $F(1,56) = 14.36$ $p < .001$) indicating that participants rated themselves as higher in these driving abilities than either their peers, or the driver depicted in the video sequences.

For the questionnaire, though not for the video data, there was a significant sex by group interaction ($F(1,56) = 8.19$ $p < .01$) for judgement ratings. the difference between self and peer ratings was much greater for males (self: 72.50; peer 58.83) than for female participants (self: 64.67; peer: 61.50). A significant age by group interaction for judgement ratings ($F(1,56) = 9.54$ $p < .01$) was also obtained. This indicates that although both older and younger participants rated themselves as higher in driving judgement, the difference was much greater for younger (self: 69.17; peer: 58.83) than for older participants (self: 67.50; peer: 65.50).

Finally, with respect to video ratings, a significant risk level by group interaction was also obtained ($F(4,224) = 9.40$ $p < .001$). The rated likelihood of having an accident involvement rose with risk level for all three groups, but much more steeply for the driver than for self or peer.

For skill ratings there was also a significant sex of rater by age of rater by group interaction ($F(2,112) = 5.39$ $p < .01$). This interaction shows that older males rated themselves as only marginally better in skill than their peers (49.39 vs 46.17), compared with other raters who rated themselves as much higher in skill than their peers (eg. young male: 55.78 vs 47.31). For judgement, the sex of rater by age of rater by group interaction was marginally significant ($F(2,112) = 2.99$ $p < .06$).

For both target group and self-rating data, Pearson correlations were computed within and between questionnaire and video-sequence ratings. Correlations were computed separately for male and female raters and for younger and older raters ($N = 30$ in each case). Three principal outcomes were predicted, First, that driver competence ratings for both the questionnaire and video sequences would intercorrelate positively and significantly; that is, skill and judgement would be viewed as being related. Second, it was predicted that there would be a significant correlation between accident likelihood ratings for the questionnaire and the video sequences. Finally, it was predicted that driver competence ratings would be significantly negatively correlated with accident likelihood ratings, so that drivers who were assigned high ratings for skill and judgement would also be rated as less likely to be involved in an accident.

With respect to the first predicted outcome, ratings of driver competence for target groups were highly intercorrelated, suggesting that these measures of perceived driver ability are strongly related. With respect to the second anticipated outcome, there appears to be little agreement between accident likelihood ratings for the questionnaire and video sequences. Finally, with respect to the third predicted outcome for the video sequences, significant correlations were obtained between accident likelihood ratings and driver competence ratings for self and target groups.

Discussion

This section begins by summarising the principal findings for each of the four types of bias. Methodological shortcomings will also be discussed and the relevance of risk perception data to explaining accident causation. The practical applications of such research will also be outlined.

Types of rater bias

Demographic bias

Effects of rater characteristics on perception of risk and driver competence were relatively weak and confined to the questionnaire data. Females tended to see accident involvement as being more probable than did men, except where older women were concerned. Yet, females also rated driver competence more highly overall. Females may see driving as more demanding than do males, calling for higher levels of driving competence, but associated with greater accident likelihood. This effect fails to generalise to the video data however. Moreover, support for Matthews and Moran's (1986) finding that younger drivers perceive driving as generally more hazardous than older drivers do cannot be given on the grounds of this study, although there is a trend in this direction for male raters and ratees. In general, different groups appear to give fairly similar estimates of the risks of driving. Brown (1982) suggests that younger drivers may be less able to perceive hazardous situations. The findings reported here seem to generally confirm this conclusion.

Stereotypes

Stronger evidence was obtained for biasing through general stereotyping effects. Main and interactive effects of age and sex of ratee were obtained for accident likelihood and driver competence ratings on both questionnaire and video. Although there was a tendency for older people and women to receive more favourable ratings, the strongest effect was the age by sex interaction, which reached significance for all but one of the six dependent measures. Younger men were seen as the most 'accident-prone' group on both types of rating, although the effect was stronger in the questionnaire data. Similar findings were apparent for driver competence ratings. Younger men were assigned the lowest ratings for competence with the exception of the video ratings of driving skill. Here, older men were rated as being low on skill under high risk situations in particular. Differences between the other three groups varied with the type of rating. The data presented here suggest that Matthews and Moran's (1986) finding that older people are rated as being at lower risk for accident involvement, and higher on driver competence ratings, is limited to male drivers only. On both questionnaire and video sequence data, older women tended to be given *lower* driver competence ratings than younger women. Rated age differences in accident likelihood between young and old women drivers were weak. Therefore, participants appear to possess distinct stereotypes of drivers based on sex and age.

Do such stereotypes correspond with actual accident data for different demographic groups? If younger men and older women are more prone to accidents, as suggested by the accident statistics presented in the introduction to this chapter, are these two groups rated accordingly? For younger men, the answer is clear. Indeed, this group are seen as higher in risk and lower in driving competence. For older women, the operation of such a stereotype is difficult to assess. Older women were seen as more likely to have an accident than older men in the video data, but not in the questionnaire data. However, older women were rated as less competent drivers than older men in the questionnaire data, but not in the video data. Perhaps people have difficulty rating this group of drivers due to the fact that absolute accident frequency is low because of low mileage. Nevertheless, mileage-adjusted figures reveal a high accident rate (Jones, 1976; Lee *et al*, 1980). However, older women do tend to receive less favourable ratings and the difference in ratings between older men and older women is quite clear. Older men are rated as 'better' drivers.

Group-specific biases

Age group bias evidence was examined first of all. Do younger drivers give more favourable ratings to their own age group relative to their older counterparts and vice versa? The data revealed no such bias as interactions failed to reach significance. However, sex-related bias evidence was apparent. All the questionnaire measures showed significant sex of rater by sex of ratee interactions, as did the video ratings with the exception of driving judgement. Female raters judge male drivers to be more accident-prone on both types of measures, whereas on the questionnaire, male raters judge male drivers to be only slightly more at risk, and to be less accident-prone than women drivers on the video sequences. Comparable results were obtained with those competence measures where the effect reached significance, though again, with minor differences between questionnaire and video sequence measures. It is clear then: drivers rate their own sex more highly than the opposite sex, but there is no evidence of any age-related bias. It is not possible to conclude which sex group is correct in their assessment, if any.

Self-appraisal biases

A general tendency was found across all measures for raters to perceive themselves as being of higher competence and at lower risk than their peers, consistent with several previous studies (eg Svensson, 1981; Groeger and Brown, 1989). This discrepancy increases with risk level, so that under high risk situations, raters believe that they are even *less* likely to have an accident and show *greater* driving competence. A more interesting question is whether this bias in self-appraisal varies with age and sex of rater. A number of relevant significant interactions between rater characteristics and group (driver, self or peer) were found, although the nature of the interactions differed between the two measures.

For the questionnaire measure of accident likelihood, similar results to those of Matthews and Moran (1986) for male drivers were obtained. Young males saw themselves as much less likely than their peers to be involved in an accident, but this effect did not extend to older males. Among female participants the pattern of results was different. Both young and old females saw themselves as being at less risk than their peers, although to a lesser degree than did young males. As in Matthews and Moran (1986) these effects were less apparent in the video data. The expected age by group interaction was obtained for ratings of driving judgement, with younger participants showing a greater over-estimate of judgement relative to their peers compared with older participants. In contrast to the accident likelihood data, there was no further interaction with sex of rater. There was, however, a separate sex by group interaction, suggesting that males may be more prone than females to over-estimate their own driving judgement. For the video sequence measure, older male participants estimated their driving judgement as being only marginally better than that of their peers, whereas the other three groups gave much higher ratings to themselves than to their respective peers. Younger males showed the greatest mismatch between self and peer ratings. males rated themselves as more skilled than their peers, but females did not.

Overall, reasonable support was obtained for Matthews and Moran's (1986) contention that younger male drivers tend to see themselves as less at risk than their peers, although there are some inconsistencies. There are also sex effects with respect to such self-appraisal biasing.

Methodological Issues

There are several possible shortcomings of the present study. The first problem concerns the relatively small sample sizes (N=15 per target group) and the ability to generalise the results reported to the larger population of each target group. Most of the findings, however, are significant beyond the 1% level, which is unlikely to represent chance level. Nevertheless, some caution should be observed in drawing conclusions from those findings obtained at the 5% level.

The second problem is that a few of the significant findings are found only in the questionnaire or in video sequence data, but not in both. Discrepancies of this kind were found for the main effects of sex of rater and sex of ratee. On the other hand, age of ratee by sex of ratee interactions and sex of rater by sex of ratee interactions do generalise well across the two types of measure. There are two possible explanations for the discrepancies between questionnaire and video sequence ratings. First, the questionnaire may be measuring rather general beliefs, which may not in fact influence measurable appraisal of specific driving situations. Second, the video sequences, particularly at the highest risk level, may not have been unrepresentative of ordinary driving. Both interpretations point to a need for further research to look more closely at risk perception within specific types of driving situations. However, the effect of varying driving situations as a function of risk, does not appear to have strongly modified age and sex effects. It may be that qualitative differences between driving situations are more important. For example, Bragg and Finn (1982) found that although age was positively related to accident risk, younger drivers rated some specific behaviours such as speeding and tail-gating as less risky than did older drivers. The importance of situational factors is also shown by the rather weak intercorrelations of accident likelihood for the questionnaire and video sequence ratings.

A fourth problem is the possibility of rating scale artifacts. For example, the ratings given to accident likelihood suggest that participants were not responding with literal accident probabilities. Participants may also have been influenced by a perceived need to respond consistently across different items. Moreover, the possibility cannot be ruled out that apparent demographic effects, such as womens' higher questionnaire accident likelihood ratings, may simply reflect group differences in the use of the scales. However, other effects, such as the difference between male and female raters in the rank ordering of the sexes' competence levels, are harder to explain on this basis.

Conclusions

There are several main points that can be made from the studies presented in this chapter. The first study shows that there are consistent individual differences in self ratings for accident likelihood. High scores on Eysenck's (1975) neuroticism dimension are associated with increased perception of risk of road traffic accidents. This finding is interpreted with reference to neurotics' greater susceptibility to threat.

The second study showed that effects of rater characteristics were generally confined to the questionnaires. Younger men were perceived as most likely to experience an accident and were judged to be lower than other groups in driving competence. Younger groups showed little bias against older groups and vice versa, but sex-related bias was apparent. The findings of Matthews and Moran (1986) were generally confirmed.

Self assessments of driving performance tend not to reflect driving ability very accurately (Groeger and Brown, 1987; Rabbitt, 1990; Wagenaar and Reason, 1990). Therefore, it is important that researchers do not confine themselves to self-report. The next series of experiments are conducted using the Aston Driving Simulator.

Chapter 4: Group Differences in Driving Performance

Introduction

One approach to the study of driving performance has been the use of driving simulators. A number of vehicle simulators have been developed (see for example, O'Hanlon, 1977; Blaauw, 1979; Watts and Quimby, 1979). Two major problems associated with this method are the correspondence between the behaviour of the human operator in the simulator and real-life driving situations and the physical correspondence between both systems. The major problem with early simulators is that they used an open-loop rather than a closed-loop system. In other words, the responses of the human operator had no effect on the driving situation depicted. Such a lack of feedback is unrepresentative of real-life driving in which drivers see the direct effect of their actions and can make corrections accordingly.

There are several ways in which behaviour correspondence can be measured:

1. Comparing real and simulated driving during identical tasks.
2. Measuring physiological variables during simulated driving.
3. Assessing subjective criteria by simulator 'drivers'.
4. Evaluating transfer effectiveness.

All measures give parameters which help to determine how valid simulated driving is. When real driving performance differences and simulator performance differences are similar, then the systems are said to have relative validity. If the numerical values are about equal, for example if the average speed on an open road in simulated driving is approximately equal to real driving on the open road then the simulator can be said to have absolute validity.

Wierwille and Fung (1975) suggests that using a properly pre-programmed motion picture display simulator need not compromise experimental results. Similar results were found in Wierwille and Fung's (1975) study of both motion-picture simulation and a computer-generated display simulator. Blaauw (1982) reports good relative and absolute validity for longitudinal vehicle control (velocity), while lateral vehicle control offered good relative validity. The diminished perception of lateral translation meant that lateral control performance lacked absolute validity due to the absence of kinesthetic feedback from the fixed-base simulator used for the study.

Allen *et al* (1990) report simulated driving performance differences between fatigued and alcohol intoxicated groups showing degraded performance compared with controls. Allen *et al* (1990) discuss the possibilities that microcomputers offer in the use of simulated presentations. Improvements in software and hardware have increased computational speed. High speed display processor cards permit fast update rates of complex visual scenes giving a smooth animation. Sound processors give realistic auditory feedback. Vehicle control simulators have control inputs and commands applied to models of vehicle dynamics and kinematics resulting in computed vehicle motions. The computed motions are then processed with visual and auditory display computations that generate commands for the display system. The feedback to the operator forms the basis for control actions. Dramatic advances in visual display have been made in the last few years, with more display transformation and processing being handled by the peripheral processor, freeing up the microcomputer's main processor for more realistic screen resolution for example.

Validation studies have been carried out to look at the relationship between actual driving performance and simulated driving performance. Edwards *et al* (1977) recorded 14 categories of driving errors in an observation of taxi-drivers (unbeknown to them). The taxi-drivers were later invited to take part in a open-loop driving simulator study. Correlations between on-the-street errors and simulator errors were low and insignificant. Edwards *et al* (1977), however, suggested that this lack of significance could reflect inadequacies in the on-the-street measures but advises that there is a need for caution in extrapolating data from simulators to on-the-street behaviour. Edwards *et al* (1977) do concede, however that more sophisticated interactive simulators may achieve more encouraging results.

The Transport and Road Research Laboratory (Watts and Quimby, 1979) carried out a validation study of their fixed-based motion-picture simulator using three techniques. First they compared risk assessments of real driving and simulated driving. They found that ratings were significantly correlated. Second they measured physiological responses to hazards when 'driving' the simulator and found that emotional responses occurred during simulated hazardous incidents. Finally, in a questionnaire, most participants rated the realism of the simulator as very high.

In order to validate the results of the ADS studies, a more detailed questionnaire than that used in the Watts and Quimby (1979) study was designed in order for participants to rate the realism of each component of the simulator and simulated driving tasks. Second, participants were asked to rate their likelihood of having an accident in the simulated task and for a similar situation on the road. Using a sample of 70 drivers, it was found that risk assessments for ADS simulated driving and on-the road driving were significantly correlated showing that participants viewed the hazards of driving and simulated driving in much the same way.

One of the major criticisms of driving simulation is that it cannot carry the same degree of threat as real driving. Therefore, participants must inevitably approach driving simulation in a less serious way. Analysis of ratings for risk perception in a simulated environment and actual driving revealed a significant correlation of .34 ($p < .01$) supporting the findings of Watts and Quimby (1979). The conclusions that can be drawn from this relationship are somewhat limited. Whilst the association may reflect a purely artifactual event, it may also point to this sample of drivers approaching the simulation as they would real driving, given that the instructions to participants stressed that they must 'drive' the ADS as they would a real car. Therefore, drivers may have also perceived their simulated accident likelihood in a similar way to real-life driving.

It can be seen from Table 4.1 that, on average the simulator components were given an unfavourable rating. However, some components were rated more favourably than others, in particular the accelerator and brake. Driving on the open road was given the most realistic rating whereas overtaking another vehicle was rated most unrealistically. One of the major difficulties with the overtaking task is loss of perspective fidelity. Due to processing limitations of the simulation hardware, an oncoming car can only be represented as a single pixel on the horizon which increases in size as a function of speed on the road. In real-life, the driver is afforded greater perceptual cues and other information which cannot be simulated given the limitations of the ADS. It is likely that participants responses reflects some of these limitations.

Table 4.1: Percentages of respondents rating the Aston driving simulator components as realistic (N=60)

Simulation Component	Very High/ High	Fair	Very low/ low
Accelerator	28%	33%	38%
Brake	27%	28%	27%
Steering	10%	22%	68%
Positioning	8%	42%	48%
Open Road	25%	43%	30%
Following	5%	33%	62%
Overtaking	8%	22%	70%

The validation study presented here supports the findings of Blaauw (1982). Participants had greater difficulty in executing the overtaking and following task which may have been due, in part, to a lack of perceptual information resulting in these tasks being especially difficult to perform. It is likely that the low ratings for realism reflect this. In Blaauw's (1982) study, positioning was given favourable ratings. In the study presented here, few respondents rate positioning as high in realism but a large percentage rate this aspect of the task as fair.

Generally, behaviour correspondence rather than physical correspondence is assumed to be more important, as just part-task simulation can lead to reliable transfer to the real-world (Rolfe et al, 1970; Mudd, 1968). Blaauw (1982) found that longitudinal control indices discriminated between groups of experienced and inexperienced drivers. Accelerator usage provided an even more pronounced effect of the differences between the groups than velocity did. Drivers rated the simulator less favourably than real driving however, with the exception of longitudinal vehicle control. Drivers subjective reports suggested that lateral vehicle control had a higher task difficulty. Participants have to pay closer attention to this aspect of the simulated task due to a lack of relevant information. Blaauw (1982) concludes that the simulator was more sensitive to differences of driving experience than an instrumented car on the road.

The focus for the following studies then is not to decide whether participants believe the ADS to be realistic, but whether they approach the simulated driving tasks in much the same way as they would real driving. The evidence to be presented shows that, given the limitations of any simulation, simulated driving behaviour appears to map on to observed driving behaviour for different groups of drivers.

Based on the group differences reported and given the observational and statistical evidence for sex and age differences in accident involvement, it is likely that there will be group differences in driving performance.

Study 1: Group Differences in Driving Performance on the Open Road

Introduction

Wilson and Greensmith (1983) used a drivometer originally developed by Greenshields and Platt (1967) which records several driving performance measures such as speed changes, steering reversals, accelerator and brake applications. Accident-free drivers made more fine steering wheel reverals, drove at lower speeds, overtook other drivers less frequently and were overtaken more frequently than accident-involved drivers. Compared with female drivers, male drivers had a shorter run time, drove at higher mean speeds, had a higher frequency of both moderate and strong lateral acceleration, made fewer fine steering reversals, overtook other drivers more frequently and were passed by other drivers less frequently than females. Therefore, drivometer variables suggest that accident-involved drivers drive faster, overtake more and move about in traffic more than accident-free drivers. When sex is added to the analysis, it appears that accident-involved females make relatively more fine steering movements and more brake applications, but fewer strong lateral acceleration than other sex and age groups. When exposure is added to the analysis, Wilson and Greensmith (1983) find that both moderate-exposure accident-free male and female drivers show relatively low mean speeds and infrequent overtaking. Although Wilson and Greensmith (1983) found no difference in speed between accident-free high-exposure males and accident-involved high-exposure males, the former appear to adjust their speeds to correspond to changing conditions by using gear changes, accelerator and brakes.

Typically, older participants in performance-based experiments show slower responses to stimuli. According to a report published by the TRRL in 1988 the involvement of older drivers in accidents at junctions increases with age, and is greater in rural areas, yet another report (AA, 1988) shows that elderly divers do not consider themselves to be at risk at junctions. Nevertheless, a small percentage of elderly drivers admitted a worsening of driving ability compared with when they were in their 50's. The respondents cited headlamp glare, long-distance driving, night driving, driving when tired or upset and driving in poor weather conditions as being the main change in driving ability. However, 4/5ths of the respondents believed that their reaction time, ability to make quick decisions, ability to absorb information were excellent or good. The report suggests that elderly drivers are less able to recognise or more able to deny their personal deterioration in physical abilities and skills related to driving. There may be a general reluctance to accept the ravages of advancing age. Cooper (1990) in an analysis of a database of accidents in which middle-aged and elderly drivers were involved, it was found that drivers were more often at fault than interviews and questionnaire measures suggested. Elderly drivers in particular held an incongruent view of the cause of the accident in which they were involved.

There have been virtually no studies of sex differences in driving performance using a driving simulator. However, a study by Hagen (1975) found sex differences using a driving simulator which measured two parameters, lateral placement of the vehicle and speed. Position was controlled by a steering wheel and speed was controlled by an accelerator pedal and brake. Hagen's (1975) results showed that compared with female drivers, male drivers drove closer to the centre line, drove faster, had a greater accelerator input and displayed greater variability in accelerator operation.

Oei and Kerschbaumer (1990) argue that it is not surprising that few or no sex differences have been found among driving related skills such as reaction time, as participants are not required to perform the skills necessary for driving in such studies. Oei and Kerschbaumer (1990) used a driving simulator which measured participants' highest speed obtained and number of errors made during the experimental trial. Errors were defined as hitting a billboard, crossing the centre line, colliding with another vehicle and number of risky overtakes. They found that males drove significantly faster than females and made more errors. In a pilot study preliminary support for Hagen was found with respect to most of these measures except mean accelerator input (Taylor *et al*, 1990).

Little research has been carried out with respect to age differences in simulated driving performance, but several studies show that older drivers take fewer risks (eg Jonah, 1986). A study by Soliday (1974) found that steering wheel reversals and speed changes measured on-the-road did not differ significantly with age. In a simulated study, Ellingstaad (1979) found that 'better' drivers maintained a higher rate of speed and changed speed more frequently in response to changing conditions than did 'poorer' drivers.

The aim of this study was to replicate and extend the work of Hagen (1975) by including age group as well as sex of driver.

Method

Participants

For studies 1 and 2, participants were drawn from Aston University and the Birmingham area, recruited by advertisements and personal contact. Sixty drivers participated in the experiment, and were paid for their services. They were divided into four equal groups of fifteen: younger and older men and younger and older women. The younger groups were aged between 18 and 25 years and the older groups were aged between 45 and 60 years. Information was collected on driver age, driving experience - defined as time elapsed since a full driving licence was obtained, and on exposure - defined as the number of miles estimated to have been driven during the previous 12-month period. This information is presented in Table 4.2.

Table 4.2: Sample characteristics - age, experience and exposure (N=15 in each group)

	Young Male	Young Female	Older Male	Older Female
Mean age	22.75	25.53	52.67	49.64
Years since licence	6.44	4.80	29.13	24.82
Miles driven in last 12 mths	7,975	7,500	13,000	4,300

Materials

Design of the simulator

The Aston Driving Simulator (ADS) was based on an Acorn Archimedes personal computer with 2 megabytes of memory to facilitate a high ratio of processor speed and comprehensive operating system which enables high speed manipulation of graphic images. Control was via a steering wheel and accelerator and brake pedals. The pedals and steering wheel were attached to a simple mock-up of the driver's position. By pressing these pedals, the operator causes the generation of voltages proportional to the positions. These voltages are fed to an analogue-to-digital converter. The control feel is represented by a simple spring-loading.

The view of the road is supplied by a large (22-inch) computer monitor. The road is presented within a rectangle, 320 pixels wide by 50 pixels high. Above this is a representation of the sky, and below it the dashboard with a simulated speedometer, clock and fuel guage. The screen presents a view of the road which can show oncoming traffic and traffic travelling in the same direction. The cars abide by a perspective mathematical model when passed by the 'driver' of the ADS. The vehicle response model, visual display transformation and performance measurement are carried out by the main processor. A sound processor generates speed cue information (change of sound frequency as a function of increasing or decreasing speed). Alarms are also sounded when either another vehicle or the kerb is hit. A range of performance measures is collected for a specified time window. Another problem with earlier simulators is that error recording is mostly discrete rather than continuous which may cause some errors to go undetected. For the purpose of the studies reported here, all performance measures described below were logged every 500 milliseconds. As well as the main simulator program there are programs to design road layouts, and roadside objects. Other programs allowed the controls to be calibrated and read and summarize results from the data log files.

The track along which the participants travelled was drawn to include straight runs, curves and sharp bends. In the visual scene, perspective transformations are applied to the roadway, signs and interactive traffic. The driver is required to control speed and steering.

Driving performance measures were:

Speed	Mph (mean and sd)
Position on track	Number of metres from centre line (mean and sd)
Steering wheel position	From centre (mean and sd)
Braking	Brake pedal input (mean and sd)
Accelerating	Accelerator pedal input (mean and sd)

Design

This study used a 2 X 2 ANOVA with sex (male and female) and age (young and old) as between-subjects factors. The dependent measures are described above.

Procedure

Participants were tested individually. They were asked to seat themselves comfortably in a driving simulator, adjusting the seat if necessary. The instructions were then read to the participants as follows:

'In this experiment you will be required to 'drive' this simulator as you would a normal automatic car. The road ahead will appear on the screen in front of you and you will need to press your foot firmly on the accelerator in order to travel along the road. The brake is situated as it

would be in a normal car but there is no clutch. The steering wheel will respond to your actions as in the normal way.

When the road appears on the screen in front of you, you should start driving immediately for a 10-minute practice session at your preferred speed (the maximum possible speed is 70 mph). During this practise session you should familiarise yourself with the feel of the simulator whilst driving. If you touch the kerb an alarm will sound and you will slide around the track. If you hit another vehicle your windscreen will 'smash' and you will be re-positioned further up the track in order for you to continue driving immediately. It is important that you try as much as possible to avoid either hitting the kerb or another vehicle. If there are any questions ask the experimenter now.'

The practise trial was followed by a 10-minute experimental trial. Instructions for the 'open road' task were as follows;

'We will now begin the experimental trial. When the road appears on the screen, your first trial has begun. During this trial you will be required to travel along the road at your preferred speed until the screen shows a 'trial over' message. If there are any questions ask the experimenter now.'

When the experimenter was satisfied that the instructions were understood, both open road and following conditions began. For both the open road and following conditions, traffic was oncoming only.

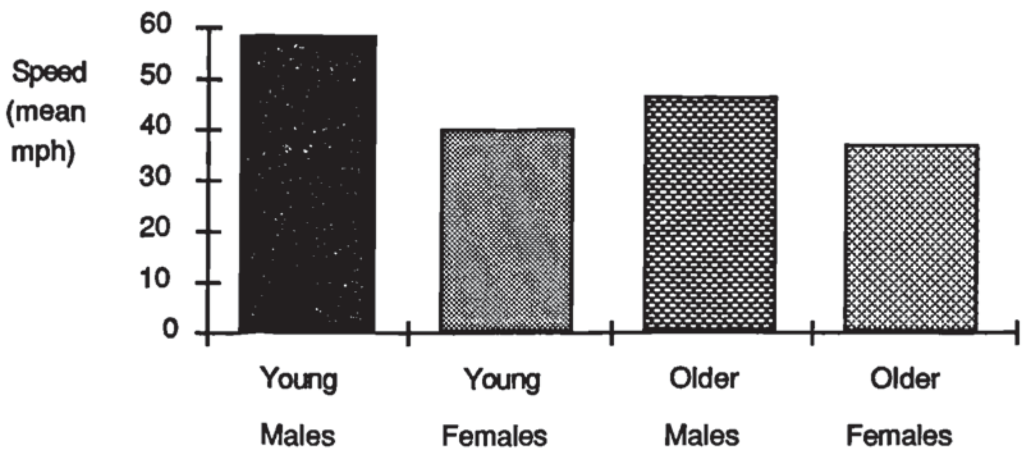
A 10-minute practise trial preceded the 10-minute experimental trial. Participants were required to travel along the road at their preferred speed.

Results and Discussion

For the series of figures which follow, mean scores are charted which may not show significant differences which were found as a result of analysis of variance. For ANOVA tables, the author refers the reader to the Appendix.

Speeding and Acceleration

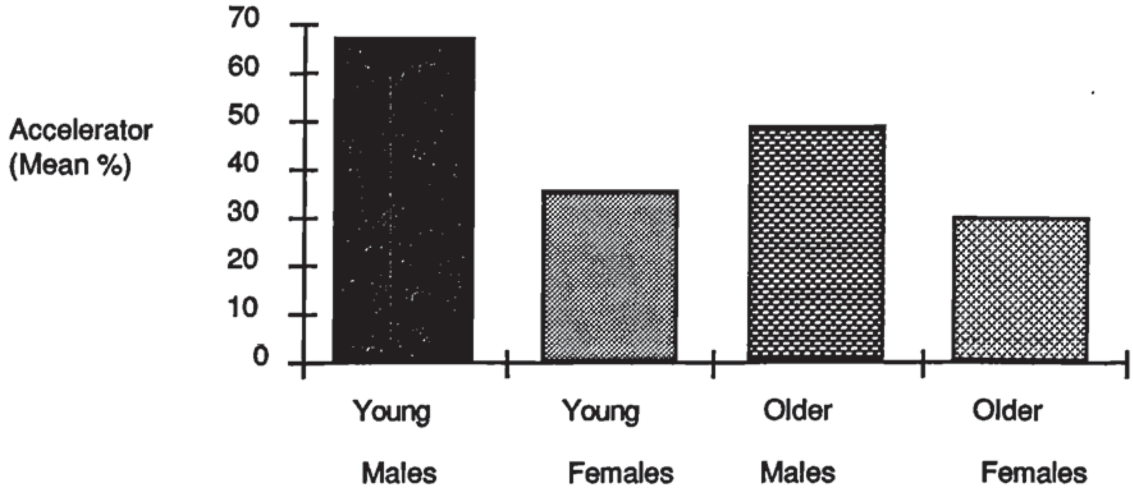
Figure 4.1: Group Differences in Mean Speed



*NB See Appendix for Anova table

A main effect of sex was observed with respect to mean speed during the open road task ($F= (1,53)\ 6.15\ p <.05$). Figure 4.1 shows that males 'drove' faster than females (52.89 mph vs 38.56 mph) confirming the findings of Hagen (1975). A main effect of age on speed was also obtained ($F= (1,53)\ 24.21\ p <.001$). Younger drivers drove faster than older drivers did (49.41 mph vs 42.06 mph).

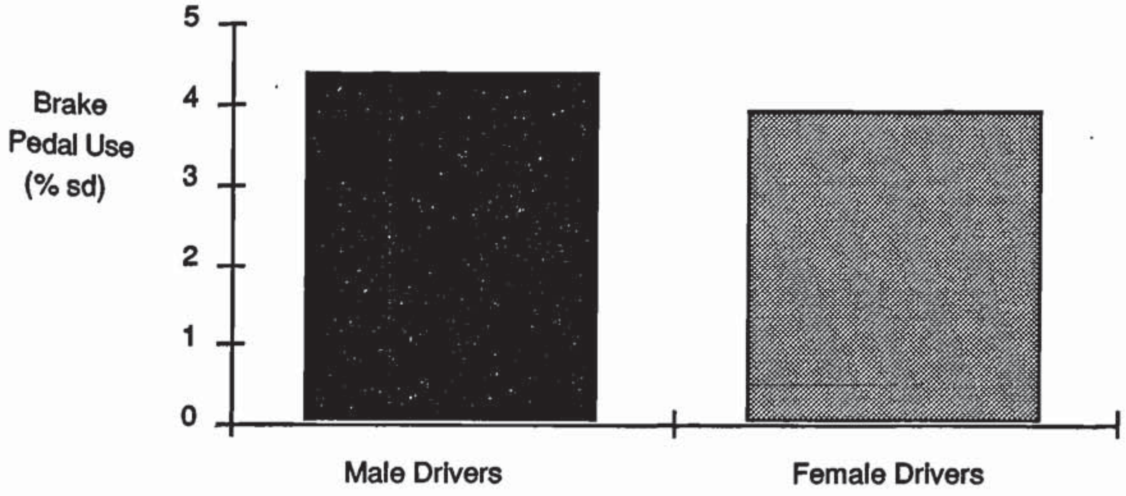
Figure 4.2: Group Differences in Accelerator Mean



*NB See Appendix for Anova table

Significant main effects of both sex of driver (F= (1,53) 5.92 p<.025) and age of driver (F= (1,53) 25.93 p<.001) were found with respect to acceleration on the open road. Figure 4.2 indicates that mean acceleration for male drivers was greater than that for female drivers (58.81 vs 33.30). The age difference indicates that mean acceleration for younger participants was greater than that for older participants (52.14 vs 39.97). The use of the accelerator pedal directly effects speed. The findings with respect to speed and acceleration may indicate that younger particpants and male participants may be changing their use of the accelerator pedal in response to changing road conditions

Figure 4.3: Sex Differences in Braking Variability



*NB See Appendix for Anova table

Braking

There was a marginally significant main effect of sex on braking variability ($F=(1,53)$ 3.69 $p<.06$). The braking variability (expressed as SD) for male drivers was greater than that for female drivers (4.41 vs 3.98) - see Figure 4.3.

Steering and Positioning

Analysis of the variability of steering performance for the different groups during the open condition revealed a main effect of sex ($F=(1,53)$ 4.60 $p<.05$). Variance in steering was greater for male drivers than for female drivers (3.45 vs 3.21).

Discussion

From the results of the open road study, it can be seen that some of Hagen's findings have been confirmed. Significant sex differences were found with respect to mean speed. Men drove faster than women and showed greater accelerator input. However, this study failed to confirm Hagen's finding that males drove closer to the centre line or that they showed greater positioning variability. However, males did show greater steering variance than did females. With respect to braking, compared with females, males tended to be more variable in their operation of the brakes.

There were also significant age differences. Younger drivers drove faster than older drivers and showed greater accelerator input. This finding tends to confirm the increased risk taking of younger drivers (Jonah, 1986), and the more cautious behaviour of older drivers. However, another interpretation of this driving behaviour is that younger drivers are 'reading' the road more accurately. Without oncoming traffic, danger of accident involvement is minimal and therefore greater acceleration and speed under such road conditions may not be regarded as taking risks. Future studies might investigate whether speed and acceleration is greater for this group of drivers regardless of potential hazards on the road. It is nevertheless intereating to note that under optimum road conditions free from traffic, older drivers 'drove' the simulator more cautiously than younger drivers did.

Study 2: Group Differences in Driving Performance when Following

Introduction

Studies of traffic accident causation suggest that impairment of information processing, in particular lapses of attention, may be important in certain types of collisions such as 'rear-end shunts'. According to Treat *et al* (1977), the most common form of inattention is to traffic stopping or slowing ahead. By training participants to follow a preceding vehicle driving at a constant speed, ability to negotiate the road and follow a car safely may provide some indication of information processing deficits within sex and/or age groups. The ability to process changes in the road, distance of vehicle ahead and monitor the vehicles' speed, may place information processing demands on the driver which are dependent on sex and age group. Finn and Bragg (1986) found that young drivers perceive tailgating as less hazardous than older drivers did - supporting the findings of Evans *et al* (1982) who showed that younger drivers follow other vehicles more closely.

No studies have yet investigated whether the complex task of driving places greater demands on men or women, if at all, under a simulated environment. With respect to age of driver, Korteling (1990) found that in a simulated following task, older drivers had greater difficulty than younger drivers did in reproducing the speed of the car in front. Korteling (1990) interpreted this finding by reference to an age-related decrease in speed of information processing. The aim of this study was to extend the work of Korteling (1990) by including sex as well as age group.

Distance from the preceding vehicle gives a measure of both risky behaviour and attentional performance whilst close following. A mean difference between the sex and age groups may show that one group of drivers prefers to follow more closely than others. Given that such driving behaviour can lead to rear-end collisions, mean distance from the car in front can give a measure of risky driving behaviour. Conversely, a large variance in the distance from the preceding vehicle may indicate attentional deficits in the performance of this task.

Method

Participants

The same participants were used as in study 1.

Materials

For the following task the ADS logged the variables described in study 1 every 500 msecs. In addition to the simulated driving performance measures described in study 2, this task also logged distance from the preceding vehicle measured in metres (mean and sd).

Design

The experiment used a 2 X 2 ANOVA with sex (male and female) and age (young and old) as between-subjects factors. The speed of the car in front was maintained at a constant speed of 30 mph. This speed was chosen because few drivers drove the simulator at a lower speed than 30 mph during pilot trials. It was necessary for participants to follow the car at a steady comfortable pace.

Procedure

Participants were tested individually and asked to seat themselves comfortably in a driving simulator, adjusting the seat if necessary. The instructions were then read to the participants as follows:

'When the road appears on the screen, you should start driving for a 10-minute practise session. During this session you should follow the car in front of you at a distance of about 15 metres. You must not overtake the car. You must simply travel close to the preceding vehicle safely. If there are any questions ask the experimenter now.'

After the practice session the participants were then instructed:

'When the road appears on the screen in front of you the experimental trial has begun. You must follow the car in front of you as practised until the screen shows a "trial over" message. If there are any questions ask the experimenter now.'

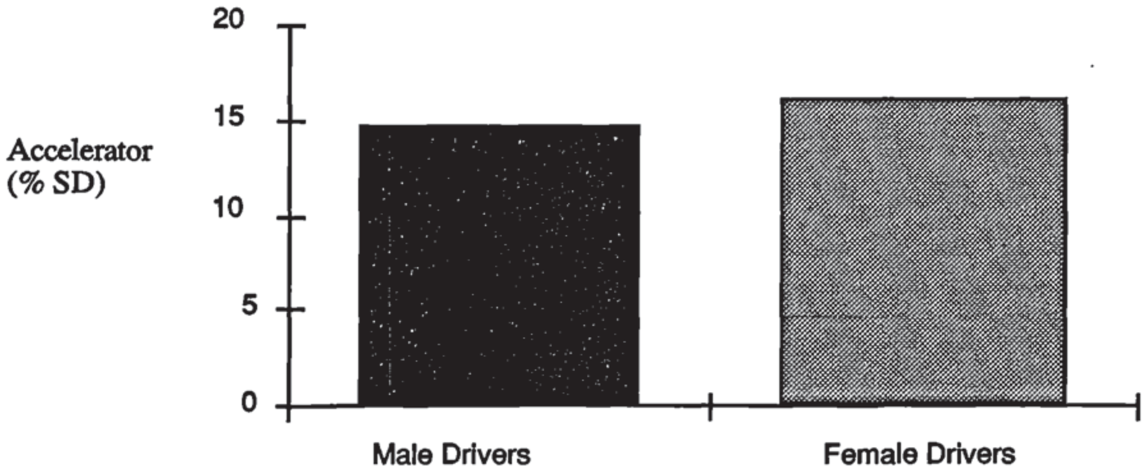
The 10-minute practice trial was then followed by a 10-minute experimental trial.

Results and Discussion

For the series of figures which follow, mean scores are charted which may not show significant differences which were found as a result of analysis of variance. For ANOVA tables, the author refers the reader to the Appendix. The data were analysed using two-tailed tests of significance as it was felt that no specific predictions could be made based on previous research.

Speeding and Acceleration

Figure 4.4: Sex Differences in Acceleration Variability

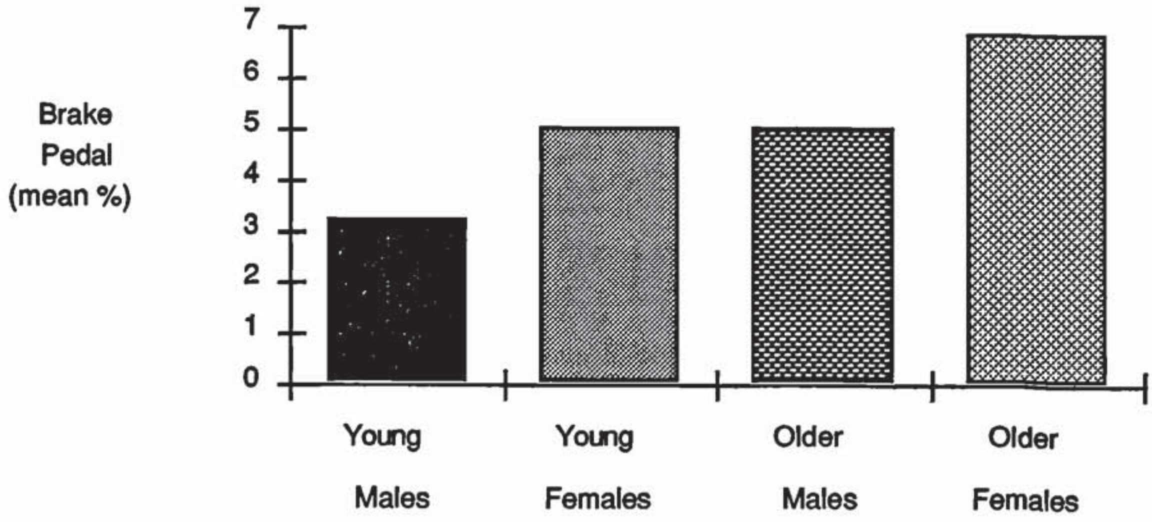


*NB See Appendix for Anova table

Figure 4.4 indicates a main effect of sex for acceleration variability variance whilst following a lead vehicle (F=(1,51) 7.45 p<.01). Females showed greater variability in accelerating than did males (16.34 vs 14.92).

Braking

Figure 4.5: Group Differences in Mean Braking



*NB See Appendix for Anova table

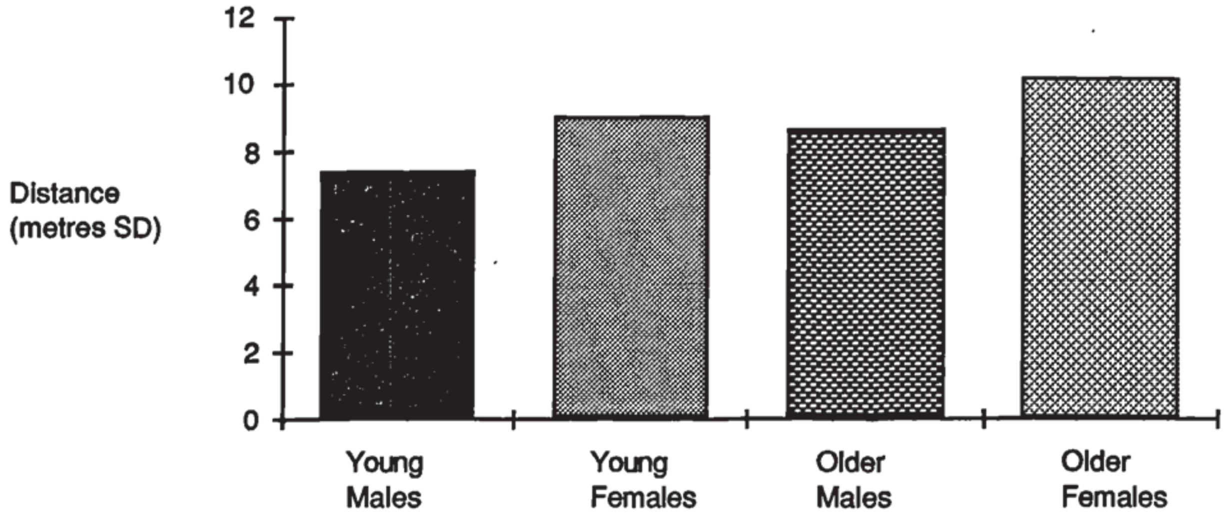
Braking when following showed marginally significant main effects of sex of driver (p <.06) and age of driver (p <.07). Males tended to use the brake less than females did (3.31 vs 6.93) and younger participants tended to use the brake less than older participants did (3.26 vs 6.99) - see Figure 4.5.

Steering and Positioning

A main effect of age on position variance on the road was found (F=(1,50) 8.38 p <.01). Younger participants showed greater variance in positioning the vehicle on the track than did older participants (.84 vs .78).

Distancing

Figure 4.6: Group Differences in Distance Variability



*NB See Appendix for Anova table

Analysis of the standard deviations of the distance from the preceding vehicle gave a marginally significant main effect of sex ($p < .07$) and a significant main effect of age ($F = (1,51)\ 6.13$ $p < .025$). The marginal sex difference indicates that women maintained a more variable distance behind the preceding vehicle than males did (10.29 vs 7.23). The significant age difference shows that older drivers maintained a more variable distance behind the preceding vehicle than younger drivers did (9.92 vs 7.60) (see Figure 4.6).

For the following task, there were significant sex differences with respect to accelerator variance. Here, females showed greater variability than did males. There was also a marginal sex difference with respect to distance variability from the preceding vehicle ($p < .07$) and mean brake input rate ($p < .06$). Again, distance variability was greater for women compared with men, and women tended to use the brake more. This suggests that women may have had greater difficulty in tracking the speed of the vehicle ahead - perhaps the task placed relatively greater attentional demands on women.

Younger participants showed greater variance than older participants in positioning their vehicle on the track when following a lead vehicle. This suggests that younger drivers may have 'cut corners' rather than positioned the vehicle in the centre of the road on bends and curves. The significant age difference in distance variability from the preceding vehicle indicates that older drivers may have greater difficulty in maintaining a constant distance from the vehicle ahead. This may be due to attentional deficits and supports the findings of Korteling (1990). Older participants in this study also showed greater difficulty in reproducing the speed of the preceding vehicle.

Study 3: Old Age Differences in Driving Performance

Introduction

Driving is a complex skill involving a series of dynamically interactive tasks involving sequential and parallel processing. Safe driving therefore relies heavily on an efficient and accurate attentional and sensori-motor system. A consequence of ageing is, generally speaking, declining abilities for tasks requiring such skills. Such declines present increased risk for older drivers which appears to be little compensated for by their increased driving experience.

According to Federal authorities in the US, about 70% of 70-year-old women are licenced compared with 90% of similar aged males. Given the 'crossover' effect of accident involvement rates showing that older women are disproportionately involved in road traffic accidents, sex differences in simulated driving performance for the older females may be apparent. Unfortunately, insufficient numbers of elderly female drivers could be recruited, the analysis is concerned with old-aged differences amongst male drivers only.

Shinar (1978) suggested that improper lookout, a factor in a large proportion of accidents, is a failure of selective attention. Improper lookout is cited as the main cause of accidents at junctions, which are known to be an accident black-spots for all drivers, but particularly older ones. Other attention related accidents are 'rear-end' collisions. This is thought to be due to inattention which is associated with failures of sustained attention. As they are more likely to be cited for innattention-related traffic violations than all other age groups, this failure may be a particular problem for older drivers.

It is unclear whether inattention is associated with being distracted or simply not being vigilant. Prolonged driving may be subject to vigilance decrements and may be a factor in certain traffic conditions such as monotonous motorway driving. Here, unchanging predictable stimuli may be prone to habituation so that critical events go unnoticed. The relationship between vigilance and driving performance amongst older drivers has remained relatively unexplored, and has often been investigated in terms of fatigue. Nevertheless, laboratory findings report vigilance decrements among the aged, leading one to assume that such a relationship may be a factor in their accident involvement rate.

Studies investigating the relationship between divided attention and driving are also fairly scarce. However, Ponds *et al* (1988) found decreased ability in an elderly sample to divide attention on a simulated driving task. Moreover, older drivers report finding this aspect of driving increasingly difficult compared with other age groups (Avolio *et al*, 1985; Parasuraman 1989; Ranney and Pulling, 1989). Reading signs at night whilst driving is more difficult for elderly drivers (Sivak, Olson and Pastalan, 1981). Perceiving and reacting to roadway hazards also declines with age.

Age differences in attention are much greater when processing places high demands on attentional capacity. Age limits are minimal or non-extistent for automatic processing (Hasher and Zachs, 1979; Huyer and Plude, 1980). However, attentional demands increase with heavy traffic, or when difficult roundabouts or junctions are to be negotiated. Such conditions may overreach the capacity of the older driver (Hancock, Wulf, Thom and Fassnacht, 1989) and result in collisions.

Method

The same materials and procedure were used for study 3 as were used for studies 1 and 2.

Participants

The two groups of 15 young and 15 older male drivers in studies 1 and 2 were compared with a sample of 11 elderly (65 to 85 years) male drivers for this study. The elderly drivers were recruited via personal contact and from a pool of volunteer participants for University research. Information was collected on driver age, driving experience - defined as time elapsed since a full driving licence was obtained, and on exposure - defined as the number of miles estimated to have been driven during the previous 12 months. This information is presented in Table 4.3.

Table 4.3: Sample characteristics - age, experience and exposure

	Young Male	Middle-aged Male	Old-aged Male
mean age	22.75	52.67	71.62
Years since licence	16.44	29.13	44.56
Miles driven in last 12 mths	7,975	7,500	7,970

Results

For the series of figures which follow, mean scores are charted which may not show significant differences which were found as a result of analysis of variance. For ANOVA tables, the author refers the reader to the Appendix.

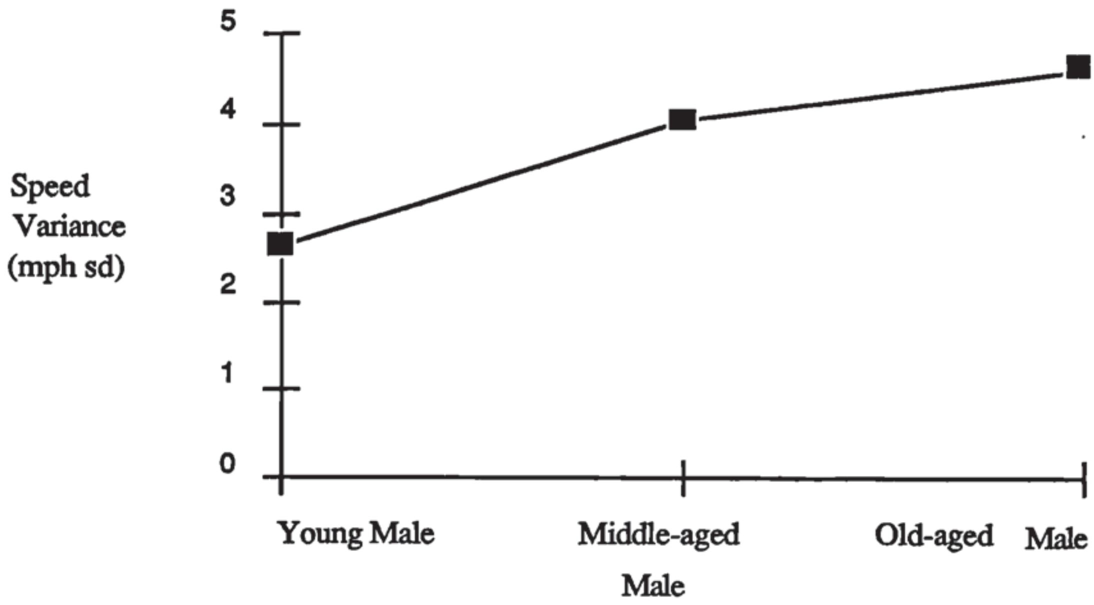
Speeding

Figure 4.7: Old Age Differences in Speeding

*NB See Appendix for Anova table

A main effect of age was found with respect to speed during the open road condition (F=(2,41) 19.15 p <.001) shown in Figure 4.7. Young male drivers' preferred speed was greater during this condition than that of middle-aged and old-aged drivers (young male: 58.89; middle-aged male: 39.76; old-aged male: 37.81).

Figure 4.8: Old Age Differences in Speeding Variability



*NB See Appendix for Anova table

For the following condition, Figure 4.8 shows a marginally significant main effect of age on speed variability (F=(2,41) 3.06 p <.06). Old-aged males showed greater speed variance in this condition than younger and middle-aged drivers did (old-aged male: 4.65; middle-aged male: 4.04; Young male: 2.63)

Accelerating

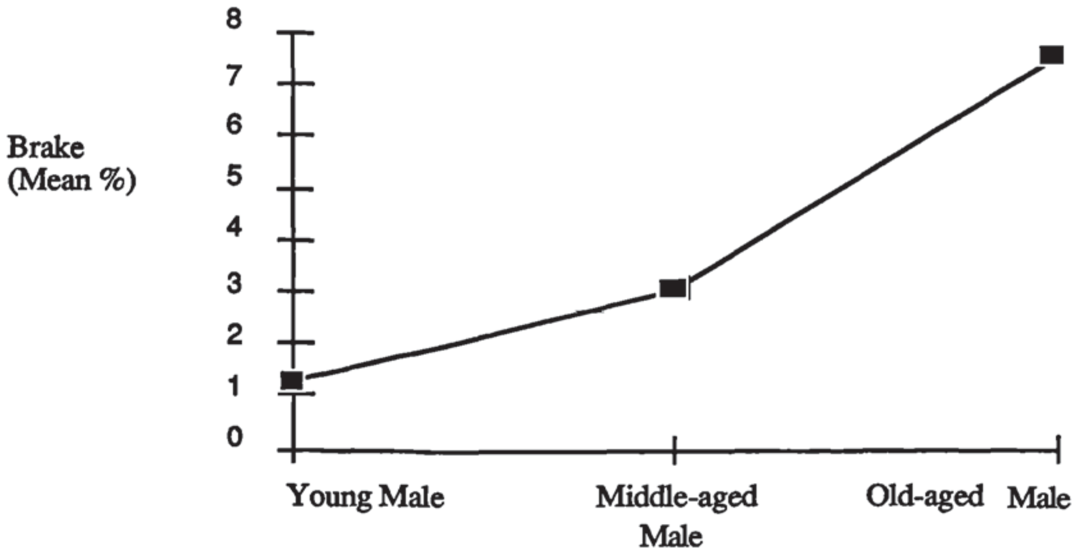
Figure 4.9: Old Age Differences in Acceleration

*NB See Appendix for Anova table

Figure 4.9 shows that for the open road condition, a main effect of age was found for accelerating (F=(2,41) 19.32 p <.001). Here, younger drivers showed greater acceleration than middle-aged and older drivers did (young male: 68.22; middle-aged male: 36.07; old-aged male: 33.23). There was a marginally significant effect of age on accelerating variability during the following condition (F=(2,41)3.07 p < .06). Old-aged drivers showed greater variance in accelerating than younger and middle-aged drivers did (old-aged male: 17.23; middle-aged male: 15.10; young male: 12.48).

Braking

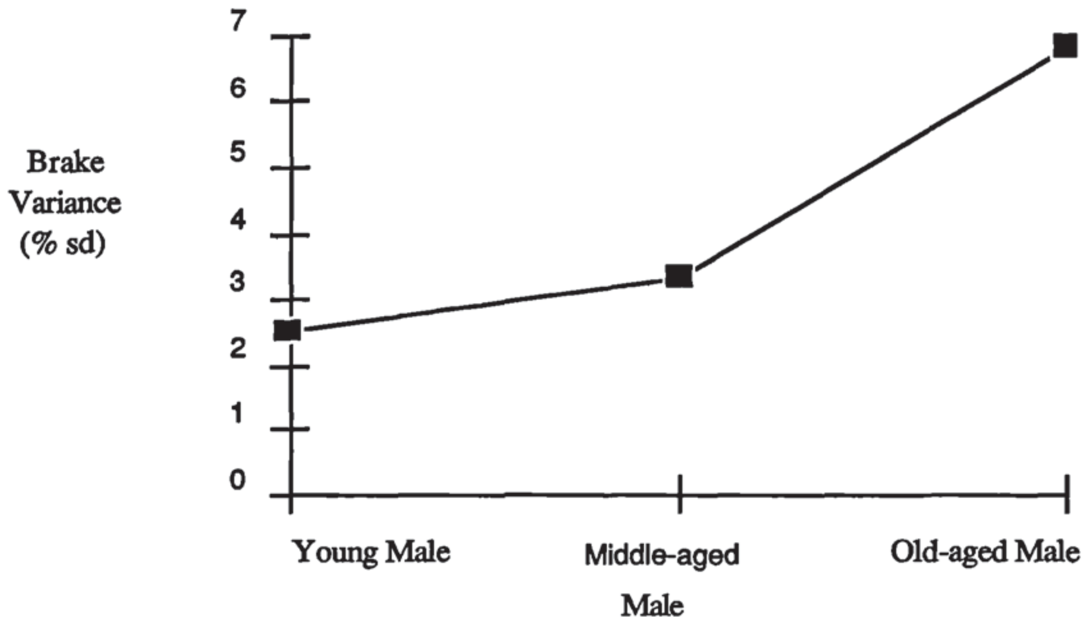
Figure 4.10: Old Age Differences in Braking



*NB See Appendix for Anova table

With respect to braking during the open road condition, a marginally significant effect of age was found (F=(2,41) 3.01 $p < .06$) shown in Figure 4.10. Old-aged drivers used the brake more during this condition than younger and middle-aged drivers did (old-aged male: 7.61; middle-aged male: 3.08; young male; 1.26).

Figure 4.11: Old Age Differences in Braking Variability



*NB See Appendix for Anova table

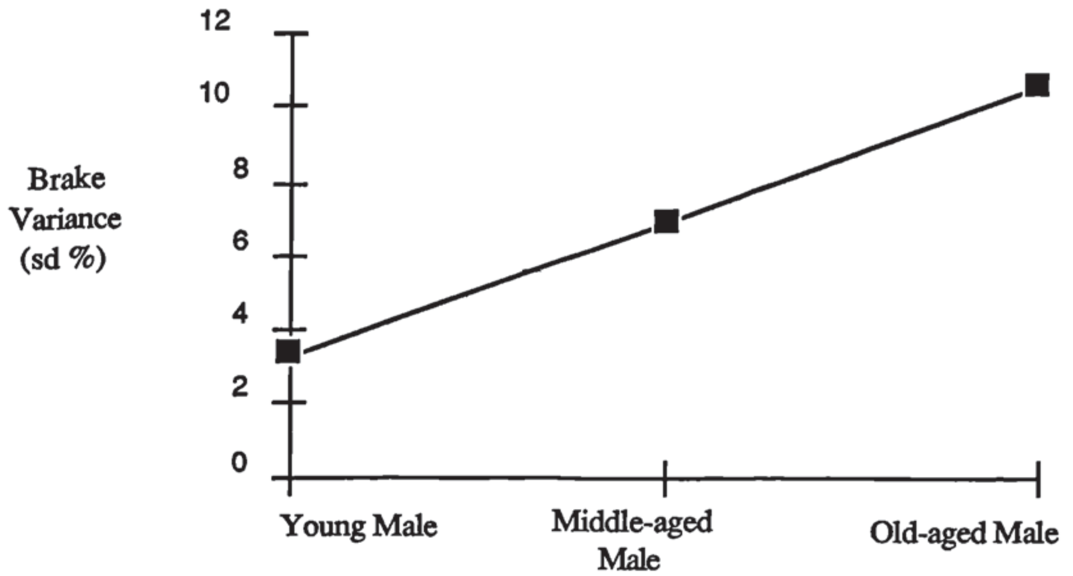
Figure 4.11 shows similar findings for braking variability for the open road condition. A marginally significant main effect of age was found ($p < .09$) showing that old-aged participants tended to be more variable in their use of the brakes (old-aged male: 6.89; middle-aged male: 3.37; young male: 2.48).

Figure 4.12: Old Age Differences in Braking when Following a Lead Vehicle

*NB See Appendix for Anova table

For the following condition, main effects of age were apparent with respect to braking. Figure 4.12 shows a main effect of age on braking (F=(2,41) 3.82 $p < .05$). As with the open road condition, during the following condition, old-aged drivers used the brake more than their younger counterparts did (old-aged male: 11.36; middle-aged male: 4.91; young male: 1.59).

Figure 4.13: Old Age Differences in Braking Variability when Following a Lead Vehicle



*NB See Appendix for Anova table

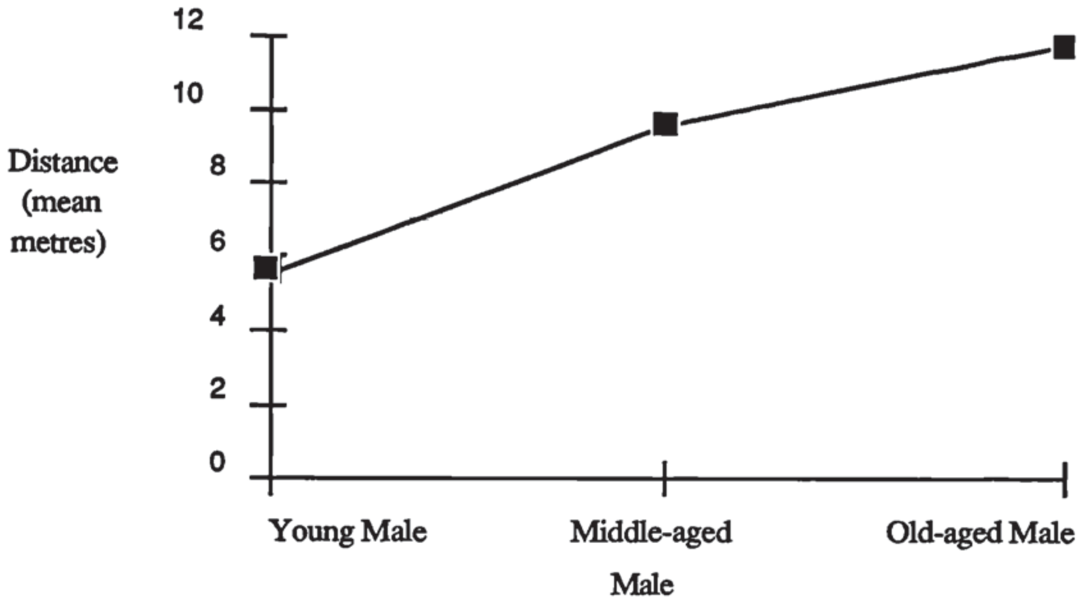
There was also a main effect of age on braking variability during the following condition shown in Figure 4.13 ($F=(2,41)$ 3.84 $p < .05$). Again, old-aged participants show greater variance in braking than middle-aged and younger participants do (old-aged male: 10.59; middle-aged male: 6.84; young male: 3.25).

Positioning

With respect to position on road during the following condition, main effects of age were observed for both mean position ($F=(2,41)$ 3.67 $p < .05$) and variance position ($F=(2,41)$ 4.28 $p < .025$). For mean position, old-aged drivers drove closer to the kerb than did young and middle-aged drivers. For position variability, middle-aged drivers showed significantly greater variance in their road position than did other age groups.

Distancing

Figure 4.14: Old Age Differences in Distance Variability when Following a Lead Vehicle



*NB See Appendix for Anova table

Finally, a significant age difference was observed with respect to distance variance from the preceding vehicle in the following condition ($F=(2,40)$ 3.78 $p < .05$). Figure 4.14 indicates that old-aged males showed greater distance variability than younger and middle-aged males did (old-aged males: 11.71; middle-aged males: 9.64; young males: 5.56).

Discussion

This study suggests that on the open road, elderly drivers drive more cautiously. Elderly drivers drive closer to the kerb, apply the brakes more and with greater variability perhaps in response to the demands of the task. By tracking these measures over time, analyses has shown that elderly drivers adjust their speed in response to curves in the track and apply the brakes, whereas younger and middle-aged drivers (to a lesser extent) tend to maintain their speed on curves. A recent study investigated driver performance on curves using a driving simulator (Gawron and Ranney 1990). It was found that curve-entry speed increased as the radius of the curve increased. Lateral position error was greatest on the curve with the smallest radius and least on the curve with the shortest length. Results were attributable to the absence of lateral-acceleration cues in the driving simulator. Therefore interpretation of driving performance in response to curvature on the track in these studies may prove difficult given the limitations of the driving simulator method.

For the following task, elderly drivers have greater difficulty in maintaining a fixed distance from the preceding vehicle and apply the brakes more and with greater variability than other age groups. This finding confirms much of the literature with respect to ageing and attentional performance. It is likely that whilst some drivers are aware of cognitive deficits which may affect driving performance, others are not (Ball, Owsley and Beard, 1990; Flint, Smith and Rossi, 1988).

It is important to emphasise the large individual differences that are in evidence amongst older drivers (Ball, Roenker and Bruni, 1990). Therefore researchers must not take a pessimistic view of older drivers as a group, but focus on which aspect of the driving task is difficult for the aged. For example, by providing icons rather than text on roadsigns (Babbitt-Kline, Ghali, Kline and Brown, 1991) older drivers may be able to process this information more quickly whilst driving. The aim in older driver research should be to help prolong their mobility by training, education and a fair licencing procedure.

Study 4: Sex Differences in Driving Performance; Risk Homeostasis and Driving Utility

Introduction

Risk homeostasis theory holds that there are possible mechanisms by which a change in intrinsic safety can be negated (Wilde, 1989). Therefore, improvements such as introducing advanced braking systems to cars may intrinsically mean that the driver is safer. However, behaviour changes in response to these improvements may show a shift to risk. Such behaviour changes may negate the improvements. The extent to which behaviour compensation depends on the factor of utility is not known, although utility is assumed to be logically necessary. In other words, is a payoff necessary for compensation to take place, or does risk operate independently?

RHT can take into account individual differences such as risk perception, motor skills and target levels of risk. However, the role of group differences has not been examined with respect to the theory of risk homeostasis. It is feasible that one sex may systematically over-compensate whereas the other may systematically under-compensate, so that accident loss remains constant despite some change in intrinsic risk. The aim of this study then is to operationalize intrinsic risk and the utility attached to driving and to test for sex differences. This study also tests for sex differences in overtaking behaviours in a simulated environment.

Little research exists on overtaking on the open road in simulated driving, however, observational studies indicate that younger male drivers tend to overtake more frequently than other groups of drivers (Crawford, 1963; Jeffcoate, Skelton and Smeed, 1973; Ahman, 1968). However, Best's (1970) study of overtaking on UK A roads with a speed limit of 70 mph shows that a high percentage of overtaking involves short temporal gaps. Other overtaking observations were 'piggy-backing' (overtaking at the same time as another driver overtakes) leaving the second driver with even shorter gaps than would be otherwise acceptable when overtaking on their own. Drivers often 'lane-share' when failing to get back in lane after overtaking, and often cut in too close after overtaking.

Method

The same materials and procedure was used for study 4 as was used for study 2 and 3.

Participants

Participants were chosen from staff and students of Aston University. 94 participants took part, 47 females and 47 males. Sample characteristics are given in table 4.4.

Table 4.4: Sample characteristics Study 4 - age, experience and exposure

	Male Drivers	Female Drivers
mean age	21.6	23.9
Years since licence	4.0	5.2
Miles driven in last 12 mths	9,480	9,575

Materials

The same driving performance variables as were used in study 2 were logged every 500 msecs. In addition, number of slides (hitting the kerb), crashes (hitting another vehicle) and overtakes (overtaking the vehicle ahead) were logged over the experimental trial.

Design

Participants were randomly allocated to one of three conditions. The first of these groups were told that they would be driving a car simulator fitted with an advanced braking system (ABS true). The braking system on the simulator was modified so that the braking system was operational at a lower pedal pressure than normal. The second group were given the same instruction although this information was false - an ABS had not in fact been fitted (ABS false). Finally a control group were given no information about the braking system. This group 'drove' the simulator without the ABS braking system.

A second factor was analysed within-subject. The utility of driving had two levels; distance and time. For the distance condition, participants were required to drive for a distance of 7.2 miles. On the time condition, participants were required to drive for a period of 10 minutes. For the distance condition, a utility was assumed to be attached to risky behaviour, whereas on the time condition, no such utility would exist. Therefore a 2 X 3 X 2 ANOVA was used on the data with sex (male and female) as a between-subjects factor and intrinsic risk (ABS true, ABS false and control) as between-subjects factor. Utility was analysed within-subjects for two levels (distance and time).

Procedure

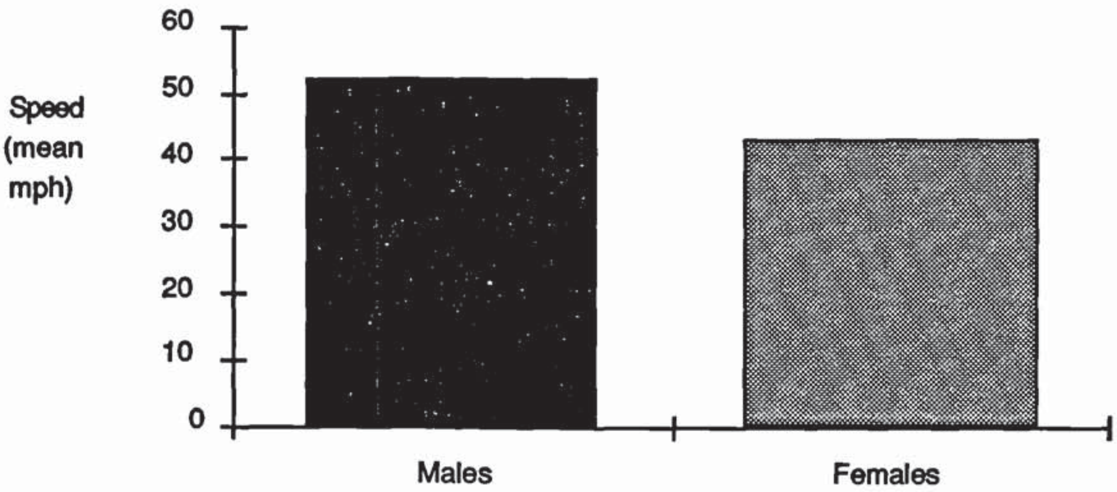
The study involved three separate driving sessions lasting 10 minutes each. The first trial was a practice session in order to familiarise participants with the simulator. The participants were then randomly allocated to either the distance or the time condition first.

Results and Discussion

For the series of figures which follow, mean scores are charted which may not show significant differences which were found as a result of analysis of variance. For ANOVA tables, the author refers the reader to the Appendix.

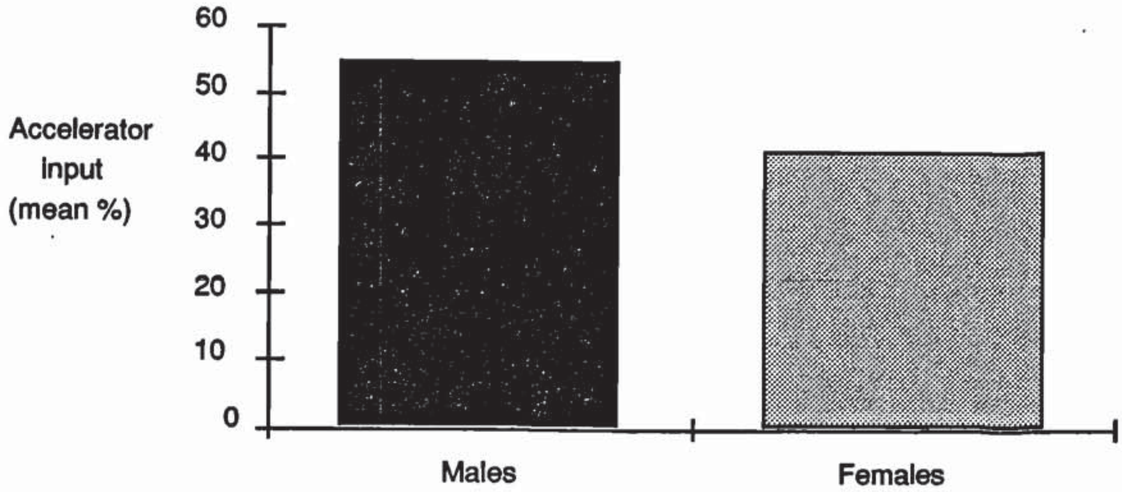
Speeding and Acceleration

Figure 4.15: Sex Differences in Speeding



*NB see appendix for Anova table

Figure 4.16: Sex Differences in Acceleration

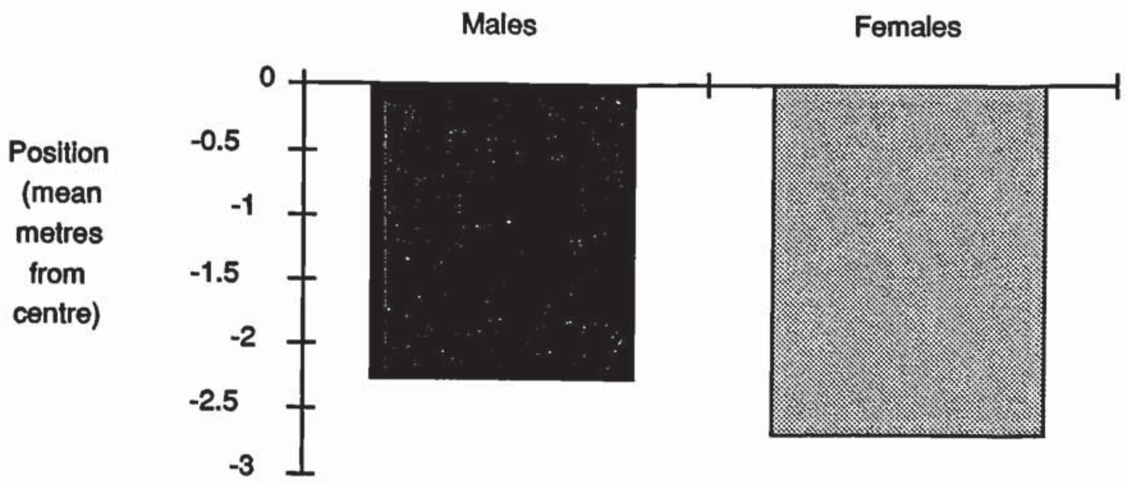


*NB see appendix for Anova table

Results given in Figure 4.15 and 4.16 show that, as in Study 1, men drove faster (F=(1,87) 35.72 $p < .001$) and showed greater accelerator input than did women (F=(1,89) 12.76 $p < .001$).

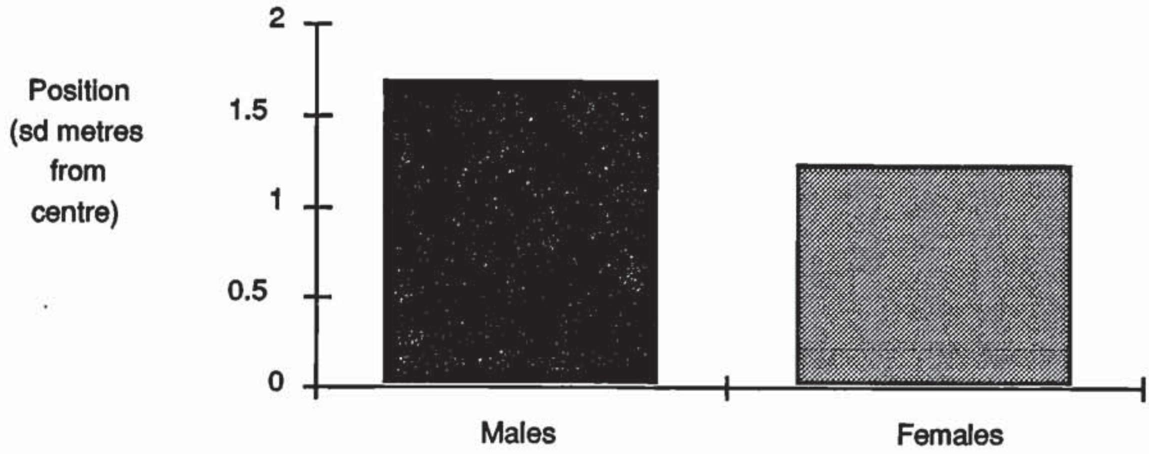
Steering and Positioning

Figure 4.17: Sex Differences in Positioning



*NB see appendix for Anova table

Figure 4.18: Sex Differences in Position Variability

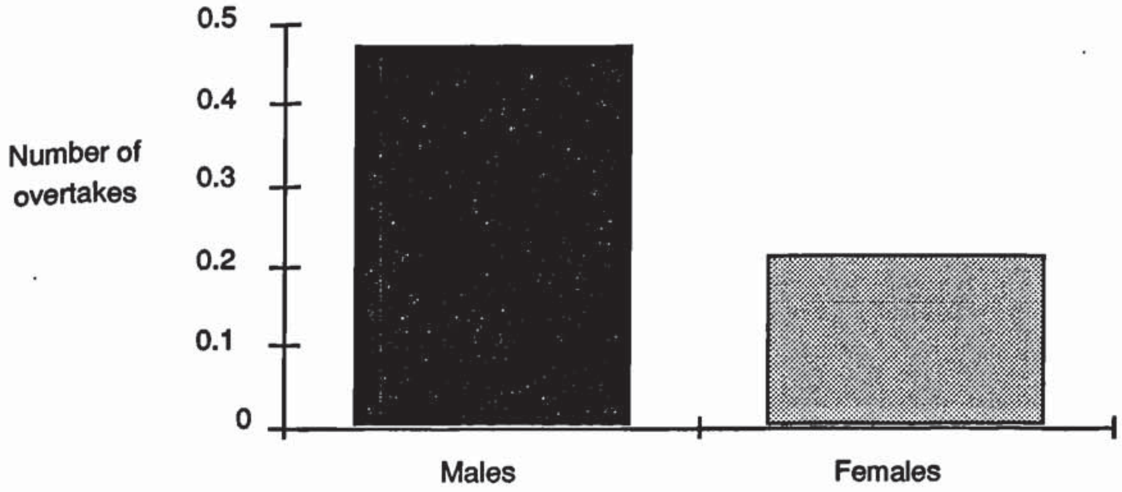


*NB see appendix for Anova table

The findings of Hagen (1975) were replicated in this study but not in Study 1 or 2. Men drove closer to the centre line than women did (F= (1,89) 9.06 P < .01). Men also showed greater positioning variance than did women (F=(1,89) 18.19 p < .01) - a similar finding to that of study 2 (see Figure 4.17 and 4.18).

Overtaking

Figure 4.19: Sex Differences in Mean Number of Overtakes



*NB see appendix for Anova table

Figure 4.19 indicates that number of overtakes in the experimental trial showed a significant main effect of sex. Men overtook other vehicles more than women did ($F=(1,89)$ 14.49 $p < .001$). There were also significant sex differences with respect to the number of risky overtakes performed. For frequency of overtaking with less than a four second headway before collision, there was a significant main effect of sex ($F=(1,89)$ 8.00 $p < .01$)

Discussion

The findings of Studies 1 and 2 were more or less confirmed in Study 3, men drove faster than women and showed greater accelerator input. Men drove closer to the centre line and showed greater positioning variability. The significant main effect of sex on overtaking in this study provides further support for the increased risk taking of male drivers. However, there were no sex differences with respect to kerb or vehicle collisions, despite the increased speed and overtaking on the part of male drivers.

However, results failed to find significant interactions with sex on intrinsic risk or the utility attached to driving. This finding can be reconciled with RHT as it points to both sexes equally compensating for a change in intrinsic risk, confirming that RHT operates at a population level.

Many theorists of road accident causation attribute a vital role to risk perception (Wilde, 1982; Fuller, 1984; Naatanen and Summala, 1974, 1976). Wildes' RHT seems to suggest that a cost-benefit analysis of behaviour in a dangerous environment will always lead to the acceptance of a certain amount of risk. Therefore, when conditions are made safer, such as the introduction of an ABS, as in this study, the costs associated with risk-taking behaviours will be less, making them more acceptable. Therefore, preventative measures will result in behavioural adaptations which may go some way to remove the benefit of such interventions. Alternatively, Naatanen and Summala (1974, 1976) propose the zero-risk theory claiming that drivers distort the perceived risks such that their contribution to the subjective costs of behaviour is reduced to zero. Therefore, the essential difference between these two theories is that Wilde puts forward a cost-benefit analysis and subsequent risk acceptance as underlying many traffic accidents. Naatanen and Summala on the other hand, suggest that within their model, that it is the adaptation to risk which causes drivers to distort their risk perception. The outcomes for these two theories are quite different. For Wilde, to enforce lower speeds would only lead to drivers accepting other costs resulting in increased risk-taking in other areas. For Summala (1988) imposing speed limits is a necessary condition for a reduction in accidents because drivers simply misperceive the dangers of high speeds.

Although sex differences in driving performance to test the claims of RHT were the main focus of attention, it is also worth noting here the findings with respect to the whole sample for behavioural compensation and the role of utility in a simulated driving environment. If, as Wildes' theory proposes, utility is logically necessary for compensation to take place, it would be expected that an interaction between utility and the between-subjects manipulation of the installation or absence of ABS would take place. This study showed that whilst main effects of risk was found on speed variance and several measures of driving performance showed a main effect of utility, no interactions between risk and utility were in evidence. On the basis of these findings, it can be argued that utility may not always be logically necessary for behavioural compensation to take place in response to a change in environmental risk. Clearly then, some aspects of Wilde's theory has, in part, been supported.

There is also evidence to show that in everyday driving situations, accidents hardly ever happen, so that the driver may reject or distort all risk considerations (Wagenaar and Reason, 1990). Hendrickx and Vlek (1990) demonstrate that by providing drivers with accurate information about the chances of being involved in an accident at blind curves, drivers adjust their speed in response to this information. It can thus be argued that drivers <u>are</u> capable of accomodating risk information into existing notions of risk, such that behavioural alterations can be made so that target levels of risk can change, contrary to Wilde's theory. In response to such evidence, Wilde would argue that the effect takes place at a population level, therefore it is not possible to extrapolate the evidence from studies which use small samples from the population. Besides, the effect of such information on driving behaviour may dissipate over time, and the drivers may shift the risk to other areas such that there is no overall benefit.

Conclusions

This series of experiments reports a number of interesting results which confirm several studies and breaks new ground in providing evidence for sex and age differences in driving performance. The most consistant finding is that men and younger drivers drive faster than women or older drivers. It is worth noting here, that the fact that speed limits are exceeded on a given stretch of road does not necessarily mean that it is inappropriate and/or unsafe to do so. A driver adjusts speed according to traffic and road conditions. Therefore, as Study 1 depicts a road free from oncoming traffic, it could be argued that the younger male driver is 'reading' the road accurately and travelling at a speed at which they feel confident they can avoid a collision. Some might argue that such driving behaviour demonstrates skill. However, it is also evident in Study 4 that young males drive faster than young females in the presence of oncoming traffic. Despite the risks of a simulated collision and loss of self-esteem, young male drivers overtake more often and commit more risky overtakes.

Hagen (1975) reported that male drivers drove closer to the centre line than did female drivers which was not replicated in either Study 1 or 2, however, in Study 3, it was found that elderly drivers drove closer to the kerb than other age groups with younger driver driving closer to the centre line in comparison. Perhaps younger male drivers only show a tendency to position their vehicle more in the centre of the lane comparatively, but such a preference would be unlikely to lead to serious accidents (other than glancing blows) and cannot be regarded as risky behaviour. Overall, it is clear that the increased risk-taking on the part of the younger male driver has been demonstrated in simulated driving, supporting much of the literature in this area.

The cautious driving performance of older drivers shown in their much slower preferred speed in a simulated driving task suggests that such drivers may be compensating for a decline in driving ability, or a realistic perception of the subjective risks of driving at speed.

There has only been limited evidence to show attentional deficits in driving performance, usually concentrating on the older driver. It is confirmed here that older drivers appear to have difficulty in maintaining a fixed distance from the vehicle ahead, and showed a tendency to use the brake more in an effort to maintain a constant distance. This may point to a decline in attentional performance with age. More interestingly, female drivers also had a greater distance variance and used the brake more when following compared with male drivers. The mechanisms causing such an attentional deficit of this nature, may differ for these two groups of drivers, however. For the older driver, it may be that age-related changes have meant a 'slowing-down' of information processing speed. For female drivers though, the finding may point to 'attentional wandering' given the demands of the task.

A factor analysis of two separate studies of the driving performance factors was also conducted post hoc. In the first study (N=105), using young and older drivers, participants drove along an open road with no other traffic. In the second study (N=100), using just young drivers, there was oncoming traffic and participants overtook if preferred. The performance measures were factor analysed, using a valid criterion for deciding on the number of factors to extract. In both studies, a 3-factor solution was obtained, with one factor associated with mean accelerator use and speed, one with steering variability and one with pedal control. The great majority of alpha coefficients computed across blocks were in the range .85 to .99. The following components were extracted in the two studies. Acceleration was defined by high loadings (.6+) on mean and maximum accelerator pressure and was highly correlated with mean speed (.8+). Steering control was defined by large negative loadings on steering variability, steering minimum (furthest clockwise) and steering maximum (furthest anti-clockwise). Low scorers tended to weave from curb to the centre-line of the track and thus appear to have difficulty in controlling the lateral placement of the vehicle. Pedal control was related to mean, maximum and variability of brake position, and to variability of accelerator pressure. Low scorers tend to be erratic and heavy-footed. The single most significant finding in the performance studies overall was a sex difference in acceleration. Analysis of sex and age differences revealed no effects on steering or pedal variability, but women were slower in both studies and older participants were slower in the mixed-age group study.

Chapter 5: Discussion

For the research presented here on individual and group differences in driving behaviour, two basic methods of investigation were employed. The first method assesses cognitive and affective processes which may influence driving behaviours, in particular driver stress and the perceptions of driving risks, using questionnaire and self-report measures. The second method employs a driving simulator for logging driving performance measures to evaluate the nature of group differences in driving behaviour.

Results from this research show that measures of driver stress, perception of risk and driver performance may be used to predict certain aspects of behaviour for drivers of differing personalities and biographical groups. The research concentrates on driving behaviour rather than accident involvement prediction as an accident can be caused by many factors, it was therefore decided not to search for such predictors. However, Study 1 in Chapter 2 attempted to relate driver behaviour to accident involvement and it was found that drivers who report high levels of driver stress are more likely to report being involved in minor accidents in the last 12 months.

Driver Stress

One factor contributing to road traffic accidents appears to be driver stress, which is affected by occupational stress, and by the demands of work-related driving (Gulian *et al*, 1989b). Researchers have taken many different approaches in an attempt to understand driving behaviour, but virtually no studies have shown how the mechanisms which mediate stress can contribute to accident involvement. Therefore, the research presented here takes a novel approach by addressing this issue.

The questionnaire, developed to measure dimensions of driver stress, showed that in respect of group differences younger drivers reported higher levels of driver stress than older drivers did and females reported greater levels of driver stress than males did. Studies of individual differences in driver stress revealed that neuroticism, and to a lesser extent psychoticism, was associated with driver stress. Moreover, neurotics appear to possess less effective coping strategies for driving under stressful conditions.

Risk perception and accident causation

With respect to group differences in risk perception, young male drivers have the least realistic assessment of their personal risk and driving abilities. Overall, people's ratings of accident likelihood for other drivers map relatively well onto actual accident involvement rates, in that young males are seen as the riskiest group.

Matthews and Moran (1986) sketch out a model describing the role of risk perception in accident causation. They suggest that decisions about driving action are influenced both by risk perception, and by the desirability or utility of the risk (a factor not investigated here). Risk perception is affected by beliefs about the risks of various driving situations and the driver's ability to perform driving actions within these situations, as well as immediate perceptual feedback. This analysis suggests several possible explanations for group differences in risk perception, and hence in driver behaviour and accident frequency.

Matthews and Moran (1986) point out that groups may differ in their appraisal of the riskiness of driving in general or in specific driving situations. Drivers also differ in the extent to which they over-estimate personal competence. On the basis of the strengths of stereotypes and group-specific biases demonstrated in this study, a further explanation may be added. Risk perception may be influenced by appraisal of dangers posed by other drivers. The various influences on risk perception may explain the higher mileage-adjusted accident rates of younger men and older women. Hugenin's (1988) contention that prognosis based upon general theories within psychology are inferior to a theory of action, which takes into account the social aspects and risk characteristics of driving, is also supported here.

The data confirm that this group underestimates their own personal risk, and overestimate their competence compared with their peers. Younger males are particularly prone to over-rate their judgement relative to that of their peers. Compared with older males, younger males showed a qualitative difference to their under-estimation of their judgement relative to that of their peers. Compared with older males, younger males showed a qualitative difference in their under-estimation of their own accident risk on the questionnaire. However, the difference between younger males and younger females was quantitative: both groups gave lower self than peer ratings. Younger males estimated their peers' accident risk to exceed their own by 69.7%: the corresponding figure for younger females was 31.3%. This difference suggests that risk perception contributes to the sex difference in accident risk among young people. The data also showed that age differences in risk perception described by

Matthews and Moran (1986) were confined to men: younger and older women under-estimated their personal accident risk to a similar degree.

The data provide some evidence that perception of personal risk plays a role in the greater accident liability of older women compared with older men. Unlike the latter, older women may over-estimate their personal safety relative to that of their peers. It is unclear whether this is a cohort effect or a developmental effect: men may learn over time to rate themselves as they do their peers, whereas women may not. However, in contrast with younger men, if older women have a rosy view of their accident risk, it is not because they have a high opinion of their own driving abilities. For example, older females gave particularly low questionnaire ratings of their judgement relative to their peers. To explain the sex difference in personal risk perception within older participants, more detailed examination of their beliefs about driving will be necessary. Speculatively, older women may believe that they adopt a slow, cautious mode of driving which protects them against accidents in spite of their relative lack of confidence in their judgement.

Stereotypes and group-specific biases may also play a role in accident causation. A driver can often detect the sex and approximate age of another driver, which in turn may influence appraisal of the likely risks posed by that driver. Negative beliefs about other drivers may be protective. For example, a modification of driving in order to reduce risk may increase safety around young male drivers. Conversely, over-estimating other drivers' ability may increase accident risk. The data suggest that this risk may be associated with encounters with drivers of one's own sex. An over-reliance on prior beliefs in evaluating other drivers may also be unwarranted. As is frequently the case where age and sex differences are concerned, it is likely that the overlap between groups in the distribution of driving ability considerably exceeds differences between group means. Even if stereotypes are accurate with respect to mean group differences, they will be unreliable predictors of individuals' driving behaviour. However, although the role of beliefs of this kind in accident causation deserves more attention, it is unlikely that they explain the high accident risks of younger men and older women. Group-specific biases depend on the sex of the driver but not on age.

Moreover, there are stereotyping effects based on sex and age of driver. Men see women as more accident-prone and less skillful than men, but women believe that men are poorer drivers. Men also tend to have a poorer opinion of older drivers.

The relationship between neuroticism and risk perception also achieved significance, showing that high scores on Eysencks' N scale were related to a heightened perception of personal risk. Neurotics belief in their greater susceptibility to threat replicated across three samples of participants. Such a belief may cause neurotics to drive more carefully, alternatively, a heightened perception of risk may lead to inconsistent driving behaviour which is may lead to an accident. Driving simulator studies of individual differences in driving behaviour may help to elucidate the relationship between personality and driving behaviour more comprehensively.

Driving Performance

Four studies using the ADS are presented here. The first is concerned with sex and age differences in driving performance in an open road task free from traffic. Results show that men 'drive' faster than women confirming the findings of Hagen (1975). The second study is concerned with sex and age differences in driving performance when following a lead vehicle and shows that women and older drivers have greater difficulty in maintaining a fixed distance from the car in front. The third study is concerned with old-age differences in open-road and following behaviour which shows that elderly drivers drive slower and have greater dificulty in maintaining a fixed distance from the preceding vehicle than other age groups do. The fourth study tests for sex differences in risk homeostasis and the utility attached to the driving task. No significant sex differences were found, which suggests that risk homeostasis operates at a population level. This study also showed that male drivers overtook more than female drivers did.

For the second method there were three basic tasks on the ADS, free driving, overtaking and following a preceding vehicle. For the free driving, in which drivers can choose their own speed, with the presence or absence of other vehicles, the data can give some indication of choice of strategy that a driver adopts. Results for the free open road driving revealed the consistent finding that young drivers, and male drivers, drive faster than older drivers and female drivers. Young male drivers drive faster, use the accelerator more and use the brake less compared with other sex and age groups. With other cars present, men overtake more often.

For following tasks, the individual's choice is reduced as the driver is instructed to follow the driver ahead at a fixed distance. For the second basic task of following, efficiency of vehicle control was measured by the variability of driving performance. Poor control can be observed by reference to the variance in drivers' lateral position on the road. Poor control is also demonstrated when the variability in the distance from the car in front is high. Results for this task showed that age of driver was a more important factor than sex of driver. Middle-aged and elderly drivers were poorer at maintaining a fixed distance and showed greater variability in lateral position of the vehicle.

The studies presented here suggest that men are greater risk-takers in simulated driving than are women. There is also evidence to suggest that older drivers and to a lesser extent women, may find driving attentionally more demanding than do younger drivers or male drivers. However, there is no evidence that the sexes differ in their homeostatic behaviour. Therefore, within the context of simulated driving, according to RHT theory, a negation of intrinsic safety improvements is equally likely regardless of sex of driver.

Methodological Limitations

It is important to point out the methodological limitations of the simulator method. There are two disadvantages in opting for a fixed-base simulator. One is lack of fidelity. Some participants remarked on the fact that the simulator does not 'feel' like a real car, indeed many participants assessed the simulator as only fairly realistic. These perceptions may lead to behavioural adjustments so that simulated driving may be quite different from real-life driving. A second disadvantage is that the discrepancy between visual and proprioceptive information can cause motion sickness in some participants. About one in thirty of participants appeared to be affected.

Another major disadvantage with the design of the ADS is the restricted field of view. Seen from the driving seat, the computer monitor gives a smaller window than that seen from a normal car. Moreover, there is no rear-view afforded by mirrors. Although the ADS provides a view of the road equivalent to about three-quarters of the width of a real windscreen, in order to achieve this, the size of the whole picture is reduced. By using a projection monitor, the size of the image could be corrected, although at a cost of deterioration in screen resolution. To cope with the lack of a rear view when operating the ADS, the program does not allow another vehicle to overtake the participant driving the ADS.

Screen resolution also causes limitations on the maximum range at which an object is visible, given that the smallest representation of an object is one pixel. A single pixel represents a vehicle about 500m away. All other vehicles are red, as the contrast against the sky and road were thought to make them more visible to the 'driver'. This problem is likely to affect 'overtaking' behaviour more than other types of simulated driving behaviour.

The position of the visual image is such that the monitor presents the scene at about one metre from participants' eyes. Either a culminating lens in front of the screen or a projection monitor would present a more realistic view. A doubling of processing power would allow disparate binocular images to be presented, but the distances at which drivers focus are probably too great for binocular disparity to be a significant distance cue. However, all the methodological limitations related to field of view and visual image are consistant across groups of drivers so that any observed group differences in driving performance in the simulator can be fairly reliably ascertained.

One of the major criticisms of the simulator methodology is that participants do not approach the simulator as seriously as they might the driving task, given that the consequences of poor judgement in simulated driving is not as serious as in the real-life task. However, all participants were informed about the seriousness of the study, and it is likely that participants would prefer not to drive as they might in an amusement arcade, given that their driving performance was being measured for research purposes. Indeed, recent work in the Aston Simulator laboratory revealed that a factor analysis of how people appraise the threats of driving showed that people were concerned that driving badly may cause a physical threat to their vehicle, to the driver and passengers and finally a damage their self-esteem. Bad driving is regarded negatively by peers and other road-users. It is proposed that to be seen to be a careless driver in a serious academic study would threaten participants' self-esteem. Alternatively, the participants may have perceived the exercise as a skill-based challenge, again adopting a different approach to the simulated task than they might when driving on the road.

The implications for these studies suggest that older drivers adopt a slower more cautious driving style, but appear worse at controlling the distance from the car in front. In view of the fact that various cognitive faculties decline with age, older drivers may be compensating by driving more slowly. With respect to sex differences in driving performance, it would appear from the data presented here, that there are no differences in the efficiency of their vehicle control abilities. However, several studies designed to investigate this issue more closely have yet to be analysed. But the data are consistent with other experimental and observation studies which show that men take more risks when driving than do women.

Personality and Driving Behaviour

The complete lack of association between the EPQ scales and accident involvement and convictions is surprising given the results of studies of personality and driver behaviour described previously. One possible explanation is that the EPQ does not provide a good measure of impulsivity, which Loo (1979) suggests is responsible for the driver behaviour correlates of EPI extraversion. Alternatively, the self-report measure of accident involvement may have been too unreliable to pick up EPQ correlates of this measure. Apart from problems of memory for accident occurrence, under-reporting and even deliberate falsification are common in reports of accidents (Hale and Glendon, in press). There are also differences between individuals in perceptions of what constitutes an accident (Powell *et al*, 1971). Thus, only a proportion of individuals might regard as an accident an incident which causes minor damage but no personal injury. Another problem encountered in relating individual differences in driver behaviour to accident involvement is that a driver involved in an accident need not necessarily have caused the accident. Accident data collected by insurance companies is strongly oriented towards non-apportionment of blame, so it is difficult to obtain reliable causal attributions of blame from this source (Hale and Glendon, in press).

Practical Implications: Driver Education Programmes

Identifying the individual and group differences which contribute to unsafe driving behaviour allows for more specialised and efficient techniques for designing safety training programmes and mounting publicity campaigns. Some researchers argue that safety interventions such as driver education programmes are ineffective and are often offset by other factors such as traffic density (Stanislow, 1987). Such findings tend to support proponents of Risk Homeostasis Theory. Olsen (1981) asserts that research has constantly shown that driver education programs has no real effect on accident rates, whilst Stuckman-Johnson *et al* (1989) find that whilst accident rates are not affected, violation rates are. Others believe that driver education programs are difficult to implement. The controversy surrounding the benefits of driver education, shows that some researchers remain unconvinced of their ineffectiveness. Perhaps researchers have yet to find the most effective method of influencing driver behaviour in such programs. Moreover, it is clear that such programs need to be tailored to the particular problems of each driver, so that a blanket approach may well prove to be ineffective.

In research on motorcycling education programs, researchers have suggested that intervention programmes must be applied early in road users' careers before habits have been fully formed (Chesham, Rutter and Quine, 1990). Such a strategy may well be appropriate for car drivers, as young drivers are particularly at risk shortly after passing their driving test. It may well be that formal training, which tends to be skill-based, however, does not improve the accident rate among some road users (Chesham, Rutter and Quine, 1990). Driver training tends to concentrate on developing the operation and execution of various performance skills such as steering, braking etc. Whilst such skills may be important, the data presented here suggest that by encouraging psychological processes such as developing problem-oriented coping strategies, or a more realistic perception of risk, may be more effective. A lack of driving skill is unlikely to be the sole cause of accident involvement. Other factors such as the ability to perceive hazardous situations accurately and the drivers' emotional reaction may be more important (Jonah and Dawson, 1979).

Sabey and Taylor (1980) in their large-scale analysis of accidents show that the most likely cause of accidents take place when the drivers speed, overtake riskily and drive too close to the preceding vehicle. Another interpretation of this finding is that close following may be related to risk avoidance when attempting to overtake. By driving close to the preceding vehicle the time spent in the lane with oncoming traffic is minimised. Nevertheless, it is thought that all three of these accident types are due to the driver trading off the need to minimise the journey time and the safeness with which the driving task is performed. given this, there are only two possible methods of achieving a reduction in accident rates, either by making sure there is an unrestricted traffic flow so that drivers can reach their destination as quickly as possible, or by implementing driver education programs which attempt to moderate behaviour and cognitions so that drivers do not feel a compulsion to terminate their journeys quite so quickly.

It has been widely projected that there will be a massive increase in the volume of traffic, it would seem that unrestricted traffic flow may be a thing of the past. It would therefore seem appropriate to concentrate on driver education programs as a viable method of reducing accident risk. A reduction of 3,000 accidents per year (a 1% reduction) over the next decade, at an average cost of £20,000 per accident, a saving of £60 million could be achieved (Department of Transport, 1990). Safety schemes and driver education programs are an effective way forward. Indeed, the government has set a target of a one third reduction in casualty statistics by the year 2000 (Department of Transport, 1990).

Driver Stress and Driver Education

If human emotions are inappropriately or inadequately expressed, tension occurs, resulting in either emotional or psychosomatic disorders. The implementation of such mechanisms involve general or selective activation of aspects of neurophysiological, neuroendocrine or immune systems. Psychological theories of emotion suggest that behavioural, perceptual and subjective distress are emotional reactions to the individuals desire for, but inability to achieve, a more satisfying way of life and to function in society.

Human error is defined as the mismatch between the demands of the operational system and what the operator does (Rasmussen, 1987). Human failure can occur in a wide range of different situations causing an unreliability. For example, driver stress may be one of the factors causing such a failure. Errors, according to Fuller (1990) arise out of an interaction, a transaction between the demands of the system and what the operator does. Transactionalism is an ergonomic concept about matching the work environment to the human inhabitant. According to Dixon (1987), the operator may make adjustments to the demands of modern technological life such as the tendency to engage in risk-taking to avoid the aversive experience of boredom. Alternatively, delayed avoidance of road traffic hazards may occur when the driver is suffering from stress.

Drivers can learn to identify and monitor stress-promoting cognitions, restructure cognitions into more adaptive thoughts, use self-instructions to contol stress-engendered self-statements, practice and apply these acquired skills. Patel and Marmot (1988) finds that stress reduction therapy is more effective when used in conjunction with not only relaxation techniques and imaging described by Jacobson (1967), but also behavioural and cognitive strategies also.

Recent research in the Aston Driving Simulator laboratory (Matthews *et al*, 1992) also showed effects of individual differences in driver performance. There are at least two different stress syndromes which are apparent in some drivers. Participants who reported higher levels of aggression as a dimension of driver stress, tend to display poor hedonic tone (unhappiness and frustration) and increasing fatigue. These drivers drive fast and overtake more often and in a riskier fashion. Such drivers may be at increased risk of accident involvement and may be usefully targetted for driver education programs.

The second 'type' tend to report disliking driving, are more tense but drive more slowly and cautiously. Whilst such drivers may not be displaying risky behaviour necessarily likely to lead to an accident, driver education programs may be specifically targetted in order to improve the health and well-being of such drivers. Perhaps this second 'type' of driver may be attempting to reduce the demands of the task.

Jacobson (1967) developed a relaxation technique which has proved effective in stress reduction shown below. The client is able to detect and become aware of tension by a process of comparison whilst vigorously tensing a muscle group and then relaxing the muscles.

Jacobson's Anxiety-Relaxation Thesis

Major assumptions:

1. Anxiety and relaxation are mutually exclusive;
2. Comparing tension to relaxation;
3. Anxiety is not caused by a problem 'out there', but results from unproductive energy expenditure in trying to solve the problem;
4. Imagery during the problem solving evokes physiological activity and expends energy.

Anxiety-reducing Procedure:

1. Identify the tension producing situations;
2. Identify the reactions, the tension-image patterns;
3. Use images during relaxation techniques;
4. Eliminate the images while maintaining relaxation.

Such methods have been widely used in several areas to reduce stress (Culbertson and Hatch, 1990), which can last for some months after the intervention (Goodspeed and DeLucia, 1990) and may be appropriate for the reduction of driver stress.

Gramstead (1990) showed how reality therapy can be used to reduce driver stress to shape the behaviour of problem drivers. In this study, the instructor addressed issues such as feelings, attitudes and perceived fairness of receiving a traffic citation. After putting together a profile of effective behaviour, participants identify alternative effective behaviour and develop ways in which they can carry out those behaviours. Such a strategy can be used in the reduction of driver stress. Drivers who report high levels of aggressive reactions to driving situations might outline alternative ways of dealing with driving situations which tend to elicit aggressive responses such as becoming hostile towards other drivers. Once these scenarios have been identified, the driver may be helped to develop alternative modes of behaviour which would be more beneficial for health and well-being.

Another strategy to helps drivers cope with stress if emotional or attitudinal responses cannot be changed using traditional methods is to change the situation which causes the stress. For example, drivers may avoid the rush hour, take a less congested route, travel by public transport etc.

With respect to the findings for sex and age groups, given the findings presented here, it would seem that younger drivers, in particular females would benefit most from advice on adjustments which could be made to reduce the stress of driving. Recognition of those driving situations that result in personal stress, and then planning to avoid them, is an important skill for these drivers to acquire.

Risk Perception Studies and Driver Education

The data support Matthews and Moran's (1986) conclusion that studies of risk perception have implications for countermeasures intended to reduce accident risks. Gregory, Boroughs and Ainslie (1985) showed that participants changed their attitudes towards traffic safety legislation by imagining self-relevant scenarios of automobile accidents in which the participant themselves is involved in the accident Such a strategy may be usefully employed in an intervention programme in order to create a more realistic perception of risk to self.

Svenson (1981) believed that one of the reasons why drivers considered themselves to be safer than the average driver might be that drivers believe safety information is directed at their fellow drivers rather than at themselves. Hendrickx and Vlek (1990) found that by presenting participants with risk information about blind curves prior to scenario information resulted in a 6km/h speed reduction. This reduction could reduce the accident rate by as much as 25% concluded the authors. Hendrickx and Vlek (1990) do suggest, however, that educational campaigns aimed at reducing risk-taking by presenting drivers with accurate information about which types of roads carry risks of accidents may not always produce such promising results. It cannot be guaranteed that the information has reached the individual drivers in the same way as it does during controlled experimental investigations. Moreover, it is difficult to ascertain to what extent such information may be prone to extinction over time.

Driver education programmes should aim to reduce over-optimistic assessments of personal capabilities and risk. McKenna *et al* (1991) interpreted this phenomena as being due to either a 'positive-self' or 'negative-other' judgement. Findings were consistent with a 'positive-self' bias, so that there appears to be a self-enhancement process operating, particularly within younger male drivers. Women show less self-enhancement generally in judgements of four scenarios; reversing, parking, judging the width of vehicles and navigating whilst driving in unfamiliar areas. Here, women considered themselves to be no better than the average driver. Therefore, driver education programmes should be directed not just towards young males as Matthews and Moran (1986) imply, but towards younger and older women drivers also.

It is important to note that different interventions may be necessary for male and female drivers. Driver training should not only teach the novice the mechanics of vehicle-handling but also emphasise the riskiness of driving, and the difficulty of judging personal safety accurately. All drivers would benefit from such interventions, but particularly the young male driver.

Young male drivers are dangerous partly because they are over-confident about their driving abilities, particularly in their driving judgements, according to the data presented here. Interventions need to stress their limitations, perhaps during initial driver training, particularly as men are prone to over-estimate their competence following the driving test (Spolander, 1983a). However, it must be borne in mind that Summala (1987) reported that hazard control skills are difficult to teach to male novice drivers, especially when other motives such as showing off and sensation seeking appear to be more influential in their driving behaviours. Intervention for women may depend on the reasons why they believe themselves to be less at risk that their peers, in spite of their relatively low estimates of their ability. Future investigations may reveal these reasons.

Driver Performance Studies and Driver Education

On the basis of the research presented here, training programs could be developed using driving simulators to train drivers to correct errors under a simulated environment and thereby minimising the potential for real-life errors to occur which may lead to road traffic accidents. Duncan (1990) suggests that the timing of component driving skills such as gear-changing, braking etc. comprises an activity and that these components are independent. Performance might adapt with repeated performance of the same activities leading to the establishment of errors within the sequence. Because systems are error-tolerant to a certain extent, the relationship between actions and consequences may become weak or change in some way. The novice driver then, may go from a situation in which continual feedback is provided by the driving instructor, to one in which he or she is performing only a partly established series of activities within a traffic system which is largely error-tolerant.

If a driver carries out an act despite the probability of that action resulting in a negative outcome, then this would be an example of risk-taking. Alternatively, the driver may perform activities incompentently due to a number of factors, without intending to take risks. By braking down the components of the driving task, such as braking, steering, speeding etc. it is possible to identify the types of errors drivers are making, for whatever reason, ie whether such errors are the result of lack of experience, risk-taking, emotional responses to the driving situation etc. It is not practical to measure such components in real driving, as this would be an uncontrolled environment. Driving simulators may prove to be the more cost-efficient method of measuring driving components and identifying the relationship between individual and group differences in driving performance.

The ultimate value of simulation is the transfer effectiveness to real driving. Research has shown that participants in driving simulator studies are better prepared for taking a driving test after simulator training compared with a control group who received no training (Bishop, 1967; Baron and Williges, 1975).

Simulation can be used to improve hazard perception skills. A computer-based simulation of the driving task can explore separate and interactive effects of hazard perceptual abilities. Such a program may help to train drivers to accurately identify the conditions which may lead to accident involvement. For example, Sojourner and Antin (1990) compared the effects of simulated head-up displays and dashboard-mounted digital speedometer on perceptual driving tasks in a simulated driving environment. While viewing the video-taped test scene, 20 participants performed navigation, speed monitoring and salient cue detection tasks. The head-up display produced superior performance on the experimental tasks and enabled participants to respond quicker to salient cues.

Fuller (1990) demonstrates the applications of driving simulators in training drivers to detect hazards more quickly. Participants were presented with a simulated driving task in which 15 hazards were displayed along with their probability of occurring. During the display, participants may anticipate the hazard or use an avoidance response if the hazard turns into an imminent occurrence. The driver then has 2 seconds in which to make an avoidance response to avoid a simulated collision.

Maximum points were awarded for anticipatory responses (50 points) and no points were awarded for avoidance responses. There was a penalty of minus 200 points if the participant crashes. Another major feature of this study was that drivers had to reach their destination in the shortest time possible, anticipatory responses such as slowing down obviously detracted from the main aim of the task. The study revealed that when hazard probability levels were low, subjects tended to opt for a riskier strategy. This tendency translates into real-life driving. The main objective for the risky driver may be to reach their destination in the shortest time possible and gambling that it is highly unlikely that they will encounter a negative consequence associated with not heeding warning signs or 'reading the road' based on their previous experiences. Perhaps driver simulators can be used to demonstrate that this strategy does not always pay, and be the basis for the realisation that for the sake of a few more minutes on the journey, they can decrease their likelihood of being involved in an accident.

It would appear that older drivers may suffer from a slow deterioration in their cognitive abilities leading to poorer vehicle control. The elderly driver would benefit from periodic refresher courses which would identify declining skills. Ways of compensating for age-related deficits could be taught, for example, avoiding high-risk situations such as driving at night-time or in rush-hour traffic. A driving simulator can help to establish that driving performance may have deteriorated over the years, as there appears to be a certain reluctance to accept that cognitive, perceptual and motor changes have taken place (AA, 1988). According to Harrington and McBride (1970), older drivers tend to have problems with traffic signs and signals and are most likely to be cited for this type of violation. Research with driving simulators could be directed towards the characteristics of traffic signs which may make them less visible and confusing. Improvements in the use of traffic signs could lead to fewer violations and accidents. A driving simulator could also be used to train older drivers to drive at a greater temporal distance from the car in front, or used to inform such drivers about what characterises an accident blackspot, such as a junction.

The applied utility of using a driving simulator to measure information processing whilst performing a simulated driving task was demonstrated by Stern, Barrett and Alexander (1980). Their results indicated that perceptual information processing skills of older adults can be improved through training. Performance on critical driving tasks after training significantly improved. The encouraging finding is therefore that not only does information processing skills such as selective attention predict accident involvement but that such skills are trainable. However, there are limitations to the use of simulators for training drivers in certain types of road environments, for example driving behaviour at junctions. Perhaps the use of virtual reality may prove useful for the training of manoeuvres such as turning.

Conclusion

Individuals differ in their driving behaviour. The studies presented here suggest that a large proportion of the variance is attributable to sex and age differences. However, there appears to be several other factors which might predispose individuals to drive in ways which are likely to lead to an accident. Greater self-report levels of stress, less effective coping strategies, unrealistic perception of risk, personality and poor driving performance skills are also likely to contribute to accident risk. In particular, simulated driving tasks have revealed differences in information-processing capacities for certain groups of drivers. Moreover, findings revealed that certain biographical groups are more likely to show such characteristics in their driving behaviour.

One of the major problems in investigations of individual differences and accident involvement is not only the inconsistency of research findings but also, several researchers question the utility of such an approach (McKenna, 1983; McKenna *et al*, 1986) as it may not be ethical to attempt to change personality in order to improve road safety. However, whilst little can be done to change personality, such information may prove useful when recruiting professional drivers. Moreover, much can be done to change perceptions and affective reactions to driving, as shown above.

McKenna *et al* (1986) suggests that examining the relationship between accident involvement and component skills which are more directly relevant to the driving task may be worthwhile. It is not the aim of the research presented here to predict accident involvement from individual or group differences, rather to attempt to identify driving behaviour as a function of individual and group differences. If such differences in driving behaviour may ultimately point the way to predictors of accident involvement then such an approach may prove fruitful. Future research should attempt to identify component skills, perhaps by using simulation. With the technological advancements that have been witnessed in the past twenty years or so, it seems credible that simulation may progress to 'virtual reality'. Future investigations are unlikely to suffer from the same methodological limitations evident in the driver simulator studies presented here, and may prove to be highly informative about the nature of individual and group differences in driver behaviour.

With increases in traffic volume and road congestion expected to become a major feature of life in Westernised countries, researchers from several related disciplines are becoming increasingly interested in driving behaviour. More and more resources are being devoted to the study of driving behaviour and ways of reducing accident-related losses. Future research on the relative contributions of risk perception is likely to adopt a more applied perspective, by attempting to de-bias illusory perceptions (Mckenna *et al*, 1991). Future research into driver stress should focus on the links between emotional reactions to the driving task and accident liability, risk-taking, errors and violations etc. Computer-based driving simulation environments are still in the early stages of development. However, it is likely that within a decade or so, such methods will be firmly established given the advances in computer-aided design at low-cost. Future research in this area can fully investigate the nature of individual and group differences in driving behaviour from several perspectives.

There are obvious limitations to drawing firm conclusions from simulator and questionnaire-based research; it is likely that perceptions and behaviours differ in the laboratory. This is, of course, one of the major drawbacks of any laboratory-based psychological research. It is also important to note that only a very limited aspect of driving behaviour has been studied here. (Obviously, there are many factors which may have predisposed drivers to drive the way they do). The research presented here cannot pretend to offer a comprehensive investigation. Rather, the studies undertaken have attempted to isolate and investigate in some depth, the likely contributors to driving behaviour.

From the series of studies described, it is clear that biographical variables play an important role in predicting driver behaviour, although it appears that psychological variables such as driver stress, risk perception and personality play a pivotal role in driver behaviour also, mediating biographical characteristics. Theories of human behaviour contribute significantly to an understanding of driver behaviour among certain groups of drivers by suggesting that certain perceptions, affective responses, coping strategies and personality may lead to unsafe driving behaviour. Future research may prove more effective if studies of driver behaviour attempt to integrate biographical and psychological variables within a meta-theoretical framework. Whilst biographical data says little about the underlying psychological nature for particular driving behaviour, it has proved to be highly predictive in assessing a driver's likelihood of being involved in an accident. By including psychological variables, an eclectic approach may uncover the processes which underpin group differences in driving behaviour

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Appendix

Figure 2.1 Anova Table: Old Age Differences in Driving Aggression

	SS	DF	MS	F	Sig of F
Within Cells	13248.87	67	197.74		
Sex	1278.50	1	197.74	6.47	.013

Figure 2.2 Anova Table: Old Age Differences in Dislike of Driving

	SS	DF	MS	F	Sig of F
Within Cells	14189.19	67	211.78		
Sex	1757.22	1	211.78	8.30	.005

Figure 2.3 Anova Table: Sex and Age Differences in Driving Alertness

	SS	DF	MS	F	Sig of F
Within Cells	12132.48	157	213.42		
Sex	1283.52	3	1283.52	3.72	.032
Age	2332.62	3	2332.62	5.43	.002

Figure 2.4 Anova Table: Sex and Age Differences in Being Overtaken

	SS	DF	MS	F	Sig of F
Within Cells	15642.91	158	212.31		
Sex	15642.91	3	1723.42	3.09	.04
Age	17332.62	3	1672.13	2.13	.09

Figure 2.5 Anova Table: Old Age Differences in Being Overtaken

	SS	DF	MS	F	Sig of F
Within Cells	31723.04	67	473.48		
Age	8003.48	2	4001.74	8.45	.001

Figure 2.4 Anova Table: Sex and Age Differences in General Driver Stress

	SS	DF	MS	F	Sig of F
Within Cells	13572.91	157	192.63		
Sex	3723.52	3	1823.23	9.97	.000
Age	3635.23	3	1914.79	7.05	.000

Figure 2.7 Anova Table: Old Age Differences in General Driver Stress

	SS	DF	MS	F	Sig of F
Within Cells	12573.98	67	187.67		
Age	3632.52	2	1816.26	9.68	.000

Figure 4.1 Anova Table: Group Differences in Mean Speed

	SS	DF	MS	F	Sig of F
Within Cells	126609.45	53	2388.86		
Sex	14693.28	1	14693.25	6.15	.016
Age	57841.19	1	57841.19	24.21	.000

Figure 4.2 Anova Table: Group Differences in Accelerator Mean

	SS	DF	MS	F	Sig of F
Within Cells	371548.45	53	7010.35		
Sex	41470.84	1	41470.84	5.92	.018
Age	18189.09	1	191789.09	7.05	.000

Figure 4.3 Anova Table: Sex Differences in Braking Variability

	SS	DF	MS	F	Sig of F
Within Cells	2013.49	53	37.99		
Sex	174.62	1	174.62	4.60	.037

Figure 4.4 Anova Table: Sex Differences in Accelerator Variability

	SS	DF	MS	F	Sig of F
Within Cells	25309.10	51	496.26		
Sex	3697.28	1	3697.28	7.45	.009

Figure 4.5 Anova Table: Group Differences in Mean Braking

	SS	DF	MS	F	Sig of F
Within Cells	51581.35	51	1011.40		
Sex	3705.26	1	3705.26	3.66	.061
Age	3490.50	1	3490.50	3.45	.069

Anova Table: Age Differences in Position Variability

	SS	DF	MS	F	Sig of F
Within Cells	40.19	50	.80		
Age	6.73	1	6.73	8.38	.006

Figure 4.6 Anova Table: Group Differences in Distance Variability

	SS	DF	MS	F	Sig of F
Within Cells	20756.22	51	406.98		
Sex	1436.13	1	1436.13	3.53	.066
Age	2493.60	1	2493.60	6.13	.017

Figure 4.7 Anova Table: Old Age Differences in Speeding

	SS	DF	MS	F	Sig of F
Within Cells	87603.43	41	2136.67		
Age	81837.43	2	40918.71	19.15	.000

Figure 4.8 Anova Table: Old Age Differences in Speeding Variability

	SS	DF	MS	F	Sig of F
Within Cells	4265.73	41	104.04		
Age	636.24	2	318.12	3.06	.058

Figure 4.9 Anova Table: Old Age Differences in Acceleration

	SS	DF	MS	F	Sig of F
Within Cells	248247.04	41	6054.81		
Age	233923.21	2	116961.61	19.32	.000

Anova Table: Old Age Differences in Acceleration Variability

	SS	DF	MS	F	Sig of F
Within Cells	22082.85	41	538.61		
Age	3305.13	2	1652.57	3.07	.057

Figure 4.10 Anova Table: Old Age Differences in Braking

	SS	DF	MS	F	Sig of F
Within Cells	40795.94	41	955.02		
Age	5986.81	2	2993.41	3.01	.06

Figure 4.11 Anova Table: Old Age Differences in Acceleration

	SS	DF	MS	F	Sig of F
Within Cells	23550.20	41	584.15		
Age	3013.12	2	1506.56	2.58	.088

Figure 4.12 Anova Table: Old Age Differences in Braking when Following a Lead Vehicle

	SS	DF	MS	F	Sig of F
Within Cells	74562.41	41	1818.60		
Age	13894.45	2	6947.23	3.82	.030

Figure 4.13 Anova Table: Old Age Differences in Braking Variability when Following a Lead Vehicle

	SS	DF	MS	F	Sig of F
Within Cells	41319.91	41	1007.80		
Age	7748.20	2	3874.10	3.84	.030

Anova Table: Old Age Differences in Positioning when Following a Lead Vehicle

	SS	DF	MS	F	Sig of F
Within Cells	170.71	41	4.16		
Age	30.57	2	15.28	3.67	.034

Anova Table: Old Age Differences in Positioning Variability when Following a Lead Vehicle

	SS	DF	MS	F	Sig of F
Within Cells	30.58	41	.75		
Age	6.39	2	3.19	4.28	.020

Figure 4.14 Anova Table: Old Age Differences in Distance Variability when Following a Lead Vehicle

	SS	DF	MS	F	Sig of F
Within Cells	29606.83	40	740.17		
Age	5599.03	2	2799.52	5.78	.031

Figure 4.15 Anova Table: Sex Differences in Speeding

	SS	DF	MS	F	Sig of F
Within Cells	11536.38	89	4.16		
Sex	4629.62	1	4629.62	35.72	.000

Figure 4.16 Anova Table: Sex Differences in Acceleration

	SS	DF	MS	F	Sig of F
Within Cells	58150.08	89	653.37		
Sex	8338.56	1	8338.56	12.76	.001

Figure 4.17 Anova Table: Sex Differences in Mean Position

	SS	DF	MS	F	Sig of F
Within Cells	83.06	89	.93		
Sex	8.46	1	8.46	9.06	.003

Figure 4.18 Anova Table: Sex Differences in Position Variability

	SS	DF	MS	F	Sig of F
Within Cells	50.56	89	.57		
Sex	10.33	1	10.33	18.19	.000

Figure 4.19 Anova Table: Sex Differences in Mean Number of Overtakes

	SS	DF	MS	F	Sig of F
Within Cells	69864.08	89	784.99		
Sex	11376.02	1	11376.02	14.49	.000

Anova Table: Sex Differences in Number of Risky Overtakes

	SS	DF	MS	F	Sig of F
Within Cells	777.92	89	8.74		
Sex	69.90	1	69.90	8.00	.006