FEDERAL GOVERNMENT'S ROAD SAFETY INITIATIVE

# YOUNG DRIVER RESEARCH PROGRAM -

# A REVIEW OF INFORMATION ON YOUNG DRIVER PERFORMANCE CHARACTERISTICS AND CAPACITIES


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Young Driver Research Program - A Review of Information on Young Driver Performance Characteristics and Capacities


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**Abstract**

This report reviews literature on young drivers' behavioural and personal characteristics in relation to their crash risk Information is discussed within the framework of a theoretical model in which the major determinants of risk are: drivers' personal characteristics (skill, motivation) and their exposure to crash risk (both quantitative and qualitative factors). The review found that young drivers' skills are less developed than those of older drivers; research is required to define the types and amounts of experience needed to become a 'fully skilled' driver, that young driver motivation differs in some important ways from that of older drivers; that decisions made prior to driving influence drivers' subsequent exposure to crash risk, independent of their actual driving performance; and that there is insufficient evidence to reach any clear conclusion on the issue of the 'young problem driver'.



**Key Words**

YOUNG DRIVER, DRIVER BEHAVIOUR, SKILL, ATTENTION, RISK, MOTIVATION, EXPOSURE


**Notes**

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  (d) minor reports of research conducted by other organizations on behalf of FORS are published in the MR series.

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## EXECUTIVE SUMMARY

This report reviews literature on young drivers' behavioural and personal characteristics in relation to their crash risk. Information is discussed within the framework of a theoretical model in which the major determinants of risk are the interacting effects of two broad categories of factors: drivers' personal characteristics (skill, motivation), and drivers' exposure to crash risk (both quantitative and qualitative factors).

A previous report (Macdonald, 1994a) reviewed literature on patterns of young drivers' crash involvement; such information is useful in understanding the role of distance driven, of some physical environmental factors, and of two basic driver characteristics: age and gender. However, the effects on crash risk of other driver characteristics, particularly driving skills, driving-related motives and associated social factors, are not able to be investigated by means of "crash" literature. These factors are the focus of the present review; findings are summarised below.

**Skill-related behaviour**

At present there is insufficient evidence to define the types and amounts of experience needed to become a "fully skilled" driver; many recent authors have identified the need for more research on the processes entailed in the development of driving skill.

Young drivers' less developed vehicle control skills are evident in a lower level of control performance; this is reflected in the quality of use of vehicle controls, including the amplitude, duration, velocity and acceleration of control movements. Drivers at earlier stages of development may need to allocate more attention to vehicle control sub-tasks. It appears that vehicle control skills improve rapidly with increasing experience but that their development is incomplete after periods of one to two years, and possibly after considerably longer periods. Evidence on the amount of experience required for the full development of such skills is unclear.

Less-skilled drivers have to devote a greater proportion of their available attentional resources to conscious decision-making and monitoring of their driving, and therefore have a lesser amount of "spare" attentional capacity available. This necessitates different strategies of attention allocation between different aspects of the task, and between task and non-task activities. With increasing driving skill, the development of better cognitive schemata directly reduces the demands on a driver's attentional capacity.

The development of more accurate and detailed schemata of traffic situations means that young drivers' expectancies of "what might happen next" gradually correspond better with reality. Inexperienced drivers show less awareness than older drivers of the actual realities of road system operation in which other road users cannot always be relied upon to follow road laws. Their over-reliance on formal rules or laws appears to reflect the poorer development of their cognitive schemata, on which are based their perceptions and expectations. Consequently, their direction and

prioritisation of attentional resources is less well fitted to the contingencies of the driving task.

There are major, skill-related differences between drivers of different levels of experience in the way in which they perceive hazards and risks. "Risk perception" is based on learned experience from which have developed cognitive schemata representing both the external road-traffic environment and the driver's own perceived capacity to avoid potential hazards.

When young drivers underestimate risk, this can be attributed to their not noticing or underestimating the potential danger, and/or to their overestimating their own coping ability. According to one view, subjectively experienced risk reflects the driver's own perceived coping capacity more than it reflects objective risk levels. The driver's perception of his or her own capacity to cope with the expected nature of the driving task and its associated hazards has been shown to influence "risky" driving behaviour.

There is some evidence from the crash literature that young drivers' crash risk is highest during the intermediate phase of skill development. At this stage their imperfect driving skills tend to be combined, particularly in the case of young males, with over-inflated levels of confidence in their own driving skill relative to that of their peers.

Driving at night increases the crash risk of all drivers, but more so for inexperienced drivers because of their less detailed and less accurate expectancies and cognitive schemata. When visual information is degraded as it is at night, speed-related errors become more likely because drivers may inadequately adapt their information acquisition and attention-switching behaviour from that which is appropriate when a greater amount of visual information is available.

**Motivational influences on young driver performance**

Crash risk is affected by driver motivation as well as by driver skills, and it is clear that young driver motivation differs in some important ways from that of older drivers. The personal goals or motives of young drivers may sometimes conflict with safety-related goals. Young drivers are more likely to speed or drive in similarly "risky" ways, and this tendency has been associated with specifically youthful motives. Some researchers view risky driving by young people as an expression of their "developmental behavioural health syndrome".

Apart from their effects on deliberate risk-taking, some typically youthful motives and values may affect driving performance by altering the ways in which young drivers allocate attention while driving. Thus, young drivers may be less willing than older drivers to modify their driving, for example by driving more slowly, to compensate for other attentional demands.

Motivational factors have a greater influence on the driving performance of young males than females. For example, personal traits such as rebelliousness and "risk taking" have been associated with crash risk among young males but not among

young females. Conversely, there is evidence of greater skill-related deficits in young females' driving performance.

However, it is recognised that behaviour such as excessive speeding or manoeuvres such as following too closely, which are objectively risky, might be due not so much to deliberate risk taking or risk acceptance, as to lack of skill in hazard perception and cognition. The higher crash risk of young, inexperienced drivers is seen to be a product of both motivational and skill-based factors.

**Factors determining young driver exposure to risk**

Decisions made prior to driving influence drivers' subsequent exposure to crash risk, independent of their actual driving performance. In spite of their conceptual independence, there is evidence of correlations between motivation to *drive* in a risky fashion, and motivation which *increases exposure* to risk.

For example, the proportion of a driver's total exposure which occurs at night, when crash risk is higher, is determined by a combination of "lifestyle" and motivational factors which differ according to driver age. Young people drive more at night than older people, they drive less "crashworthy" vehicles, are less likely to be wearing seatbelts (particularly at night), and they carry more passengers.

**The "young problem driver" issue**

There is evidence of some correlation within the population of young drivers between level of exposure to risk (in terms of the above factors), the "riskiness" of driving performance itself, and personal characteristics such as level of academic achievement and socio-economic status. Some researchers have interpreted such correlations as evidence of a "risky behaviour syndrome", but the low magnitude of correlations casts doubt on their practical significance in the context of road safety.

A related issue is that of the so-called "young problem driver". In this case the main question is not primarily one about the *nature* of young drivers' characteristic skill deficits or risky behaviours; rather, it is about the *distribution patterns* of these characteristics *within* the group of young drivers. At the moment there is insufficient evidence to reach any clear conclusion on this matter.

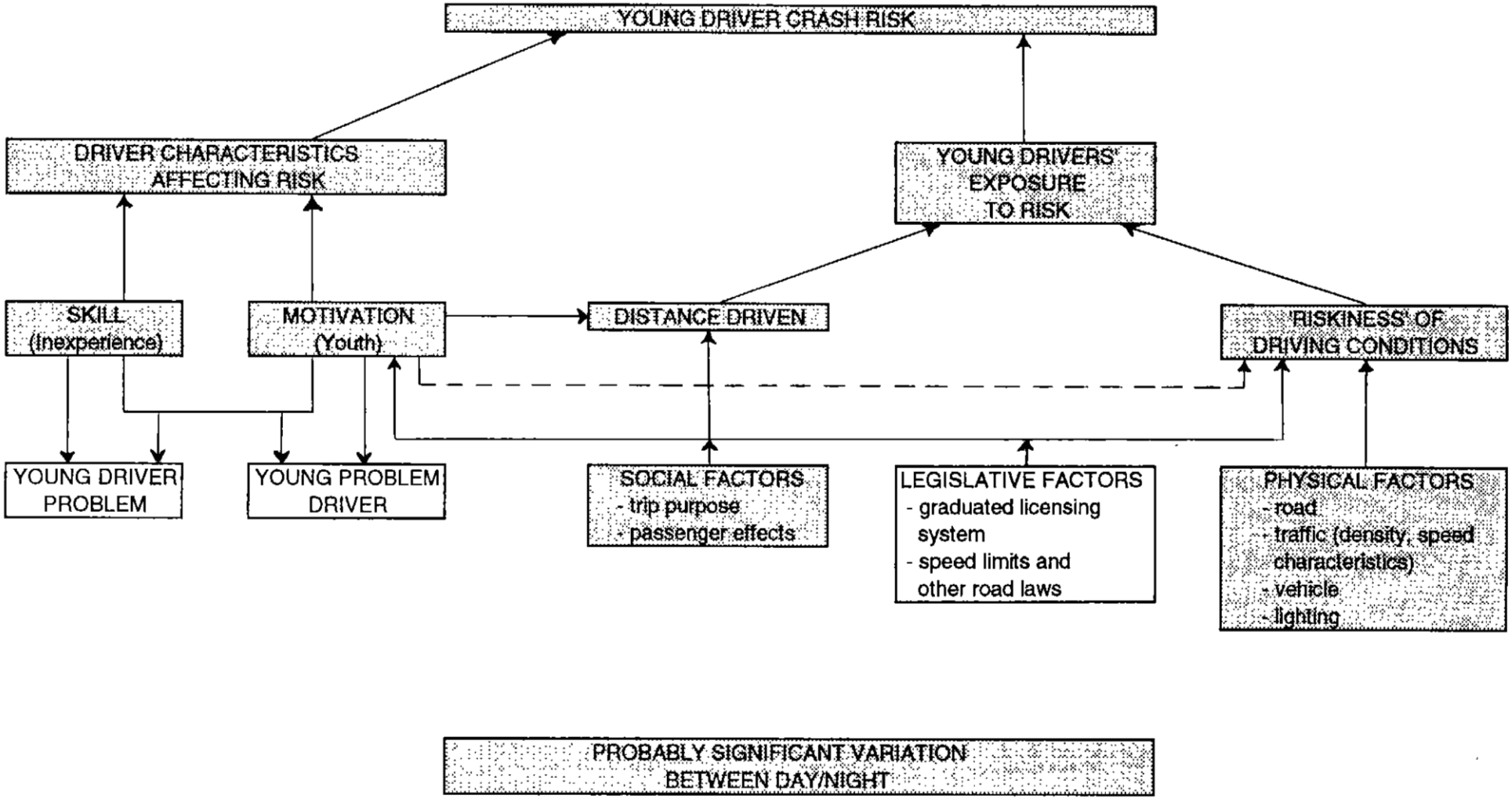
## 1.0 INTRODUCTION

A previous report entitled "A Review of Information on Young Driver Crashes" (Macdonald, 1993) presented:

- an outline of a model of the determinants of young driver crash risk, and
- a description of the magnitude and nature of the young driver crash problem, based on information from studies of crashes.

The present report reviews information on young driver behavioural and personal characteristics, drawn from a wide variety of sources other than the previously reviewed literature which was related more specifically to young driver crashes. Information is discussed within the framework of the model of the determinants of young driver crash risk. Conclusions from the 'young driver' literature reviewed in the present report are related to those from the previously reviewed 'crash' literature.

**FIGURE 1: CONTRIBUTORY FACTORS TO YOUNG DRIVER CRASH RISK**



## 2.0 DETERMINANTS OF YOUNG DRIVER CRASH RISK

### 2.1 Role and nature of the model

The model and review of factors determining young driver crash risk, as shown in Figure 1, was formulated on the basis of the literature reviewed in both the present and previous reports. Formulation of such a model was necessary because there is no consensus within the literature on any single theoretical framework, and to review the literature without some such common framework would not be very productive.

The model and review should be viewed in the light of the following quotation from a paper entitled "A critical review of driver behaviour models: what do we know, what should we do?" by Michon (1985). Michon commented that to review and integrate the hundreds of relevant studies that have been reported would be "aiming for the impossible. ... A document retrieval scan did readily convince me of the ungainliness of the task". The numbers of abstracts retrieved by Michon under "model", "driver" and "behaviour" were 15129, 12996 and 4489 respectively!

The value of the present model is that it provides a framework within which:

- to summarise major conclusions from the literature;
- to identify areas warranting further basic research, and to formulate the general nature of such research.

The model was outlined by Macdonald (1993). In the present report its validity is substantiated by review of the behavioural literature which forms part of its basis, and it has been slightly modified.

According to the model, crash risk is determined by the interacting effects of two broad categories of factors:

- drivers' personal characteristics (skill, motivation);
- drivers' exposure to crash risk (both quantitative and qualitative factors).

The previously reviewed literature, being focussed on information related to crashes, is useful in understanding the role of distance driven, of some physical environmental factors, and of two basic driver characteristics: age and gender. However, the effects on crash risk of other driver characteristics, particularly driving skills, driving-related motives and associated social factors, are not able to be investigated by means of "crash" literature. These factors are the focus of the present review.

Young driver skills - perceptual and cognitive skills as well as vehicle control skills - are clearly important determinants of driving performance and hence of crash risk, as shown in the model. They are discussed in Section 3 below.

An interesting feature of the model is its depiction of the various ways in which the motivational characteristics of young drivers may affect crash risk. These are discussed in Section 4. Motivation influences:

- driving *performance* on the road (e.g. speeding, following closely);

- driver *exposure* to risk:
  - quantitative (distance driven) and
  - qualitative (riskiness of driving conditions, both physical and social).

The literature does not generally make the above distinctions; however, in the present context they are important because of their implications for crash countermeasure development. For example, if young driver motivational factors affect risk primarily via "exposure" rather than via "performance", the most appropriate means of reducing crash risk would be different from those which should be employed if motivational factors mainly affected on-road driving behaviour.

## 2.2 Structure of the review

Much of the 'young driver' literature is primarily concerned either with skill factors or with motivation factors. Such literature is reviewed in Sections 3 and 4 and constitutes the bulk of the report.

A substantial minority of the literature is equally relevant to both skill and motivation; these reports are referred to in both sections, as appropriate. Also, the complex interactions between skill and motivation in their effects on young driver performance and exposure to crash risk necessitate discussion of some of the basic phenomena of young driver behaviour in more than one section of the report.

Reports dealing specifically with the 'young driver problem' are reviewed in Section 5. Much of the literature reviewed in Section 4 is also relevant to this topic and some is referred to again in this context.

Finally, an overview is presented in Section 6. The literature is summarised and conclusions drawn concerning:

- the effects on driving performance of young driver skill and motivation;

- the effects on exposure to risk of young driver motivation;

- the nature of the 'young problem driver' issue.

## 3.0 SKILL FACTORS

### 3.1 Introduction

The review of Skill Factors is based on two well-established, related theoretical views of driving behaviour. First, the review reflects a view of driving as an information-processing activity involving stages of perception, decision-making and response. Second, throughout the review driving is viewed as a skilled behaviour, based on the theory of skill which was developed by Fitts and Posner (1967) and Rasmussen (1982; 1990), applied to driving and road safety by Michon (1985), and to safety in a broader and more comprehensive framework by Reason (1987), Hale and Glendon (1987) and Hale, Quist and Stoop (1988). The recent report by Milech, Glencross and Hartley (1989) has a similar theoretical basis. It is a view of skill most commonly attributed to Rasmussen, and referred to as the SRK model, standing for "Skills-Rules-Knowledge".

### 3.2 The development of driving skill

Brown, Groeger and Biehl (1987) applied the SRK model of skilled performance to an analysis of the nature of driving skill and its development. In the early stages of skill development, drivers operate for much of their time at the "knowledge" or cognitive level of control, consciously attempting to follow their instructor's directions. They learn the many operating procedures and acquire vehicle control skills. This mode of operation is most typical of drivers at the pre-licence stage.

As control skills develop and acquire some automaticity, drivers concurrently develop greater knowledge of the informal (and formal) "rules" which apply in commonly encountered situations. At this stage their behaviour is heavily rule-based and errors are typically associated with ignorance of rules for particular situations, or misapplication of them (Brown et al, 1987). Good driving demands less conscious attention at this stage than at the earliest "knowledge" stage, but more than at the final "skills" stage.

It appears that the intermediate "rules" stage may last for some years, depending on the rate at which drivers gain experience. Thus, there is evidence that the expectations, perceptions and consequent driving behaviour of drivers during their first few years post-licence may be unduly influenced by their knowledge of road laws; young drivers show less awareness than older drivers of the actual realities of road system operation in which other road users cannot always be relied upon to follow road laws.

For example, relative to experienced drivers, a higher proportion of inexperienced drivers' collisions with other road users occur in situations where they had legal right of way. Consistent with this, they perceive other drivers to be more error-prone than themselves, in spite of their own higher crash rates (e.g. Kuiken and Rothengatter, 1991).

Another manifestation of this tendency to be over-reliant on specific rules may be the general tendency of inexperienced drivers, particularly young males, to be over-involved in collisions with pedestrians, particularly children, and there is evidence that inexperienced drivers are less likely than experienced drivers to be aware of the presence of child pedestrians (Egberink, Oude, Lourens and van-der-Molen, 1986).

Conversely, inexperienced drivers have been found to be *more* aware than experienced drivers of road signs, many of which provide only redundant information or are of little practical significance (Macdonald and Hoffmann, 1991). Together, these findings suggest that less skilled drivers have inadequately developed schemata to direct and prioritise allocation of their attentional resources. Their over-reliance on formal rules or laws may simply reflect the absence of a more effective basis for behaviour.

It may be at this intermediate stage of skill development that young drivers are at most risk of crashing. There is some evidence from the crash literature that this is so (e.g. Pelz and Schuman, 1971; see Brown et al, 1987 for a review).

Forsyth and Kompfner (1991) found from tests of the developing skills of a large and representative sample of young United Kingdom drivers (at licensing and at intervals post-licensing) that in post-licence tests drivers were less likely than in their licence test to have points deducted for poor use of vehicle controls, not using mirrors, being unduly hesitant or too slow, not showing due regard for approaching traffic and passing too close to stationary vehicles; however, they were *more* likely than previously to lose points for driving too fast, approaching intersections too fast, and for not anticipating the actions of other drivers.

These changes in the pattern of recorded driving errors suggest that as drivers gained experience their vehicle control skills improved and became more automatised, they had more attentional capacity available to attend to other aspects of their driving, they were more confident of their own driving ability, but that they still had significant deficiencies in their perceptual/cognitive skills. In fact, from questionnaires given immediately following licence test, 30% of people identified "ability to predict what other drivers were going to do" as an aspect of their driving which still needed improvement; apart from parking (51%), this was the most commonly mentioned skill deficit, suggesting that many people at that very early stage of their driving career had a good awareness of their own deficiencies as drivers.

The results reported above suggest that as skill develops, many drivers gain confidence (as reflected in increased vehicle speed), perhaps at a faster rate than is warranted by improvements in their overall skill. This conclusion is supported by the much earlier observations of United Kingdom drivers by Quenault and Parker (1973), who observed groups of drivers at a range of intervals during the first year post-licence. They found that average speeds tended to increase and vehicle control skills improved during this period, but that whereas speed increased to the same level as a group of more experienced drivers within the first three months post-licence, vehicle control skills were still significantly poorer after one year.

Consistent with this pattern there is some evidence that young male drivers, many of whom are probably at this intermediate stage in their skill development, tend to rate their own skill as a driver as being higher than that of their peers (e.g. Finn and Bragg, 1986). Older drivers and females are more likely to perceive themselves as of similar driving ability to their peers. Spolander (1982; cited in Brown & Groeger, 1988) argued that a major cause of young females' lower crash risk relative to that of their male peers is their lower confidence which more than compensates for their lower levels of driving skill (see Rumar, 1985; Forsyth and Kompfner, 1991).

In the final "skills" stage of skill development, control skills and rule-based behaviours become more integrated and automated at all stages of information processing - perception, decision-making and response. There is less variability within manoeuvres and more consistent organisation of the different operations which comprise a particular manoeuvre (Brown et al, 1987). At present there is little evidence on the types and amounts of experience needed to become a 'fully skilled' driver, and many recent authors have identified the need for more research on the processes entailed in the development of driving skill.

Drivers whose skills are less developed need to devote larger amounts of attentional capacity to their driving, and are more likely to suffer "overload" due to their attentional resources being inadequate to meet driving task demands. This situation is a direct consequence of less-skilled drivers' smaller repertoire of semi-automatic and automatic responses and action routines (see Heinrich, 1990). That is, less-skilled drivers have to devote a greater proportion of their available attentional resources to conscious decision-making and monitoring of their driving.

According to the above view of driving as a skilled, information-processing activity - a view which has general acceptance throughout the research literature - low levels of driving skill may be characterised by:

- poor skill in acquiring and integrating information
- expectancies (based on cognitive "schemata") which are inaccurate and relatively undetailed
- a low level of attentional capacity to process information
- poor skill in attention-switching
- poor vehicle control skills.

Research on driving is concentrated unevenly within this theoretical framework. Milech et al (1989) provided an excellent review of the implications for driving research of findings from research in other areas of skilled performance. There has been relatively little investigation of the manner in which young drivers develop appropriate perceptual/cognitive "schemata", of the ways in which available attentional capacity and patterns of attention allocation vary as skill develops, or of the development of skills in attention-switching.

Several recent reviews already provide, between them, an excellent coverage of literature on the nature and development of driving skill (Macdonald, 1987; Drummond, 1989; Milech et al, 1989). In the rest of Section 3 more recent findings are presented and incorporated with conclusions from previous reviews.

### 3.3 Acquiring information and perceiving "risk"

Rumar (1985) placed considerable emphasis on the physiological limitations of the human sensory and information processing system. He argued that humans are poorly adapted for travel at the high speeds (above 50 km/h) now commonplace in our road traffic system, particularly when visual information is degraded at night. According to Rumar, perceptual filtering of information by drivers is mainly a function of human sensory and perceptual limitations, particularly in their effects on night vision, peripheral detection of vehicles, perception of the velocity of oncoming vehicles, of following distances, and of the speed and speed changes of the driver's own vehicle. Milech et al (1989, p.5) also noted the significance of such limitations.

Trankle, Gelau and Metker (1990), discussing these limitations on driver performance, cited their own research and that of Halpern (1986) in support of the conclusion that young females have poorer spatial perception and orientation skills than young males. In an experiment using computer simulation of driving, Trankle et al (1988) found that young females performed much worse than young males in gap-acceptance tasks at intersections.

Rumar (1985) commented on the role of "cognitive filtering" as a determinant of information acquisition. This refers to the process by which available information is selected on the basis of variables such as its perceived practical significance. It was clearly demonstrated in the case of traffic sign information by Macdonald and Hoffmann (1991), referred to in Section 3.2 above, where the "cognitive filters" of experienced drivers were found to reject significantly more information from traffic signs than was the case for inexperienced drivers.

A considerable body of research on drivers' perceptual characteristics has been concerned with the topic of 'perceptual style', particularly field dependence versus independence (see McKenna; Duncan and Brown, 1986; Macdonald, 1987; and Drummond, 1989, for reviews). It is no doubt true that some differences in perceptual capacities and characteristics between individual drivers, and possibly between groups of drivers such as males and females, are partly due to differences in genetic characteristics, some of them related to differences in personality and/or intelligence. However, the implications of such research for the development of practicable road crash countermeasures have not been identified.

Most research related to drivers' acquisition and integration of information has been concerned with behaviour which is to a large degree learned, in particular, the way in which drivers identify hazards and perceive risk.

Clearly, there are major, skill-related differences between drivers of different levels of experience in the way in which they perceive hazards and risks. Lack of driving experience has been shown to be associated with less effective strategies of visual information acquisition and a lesser ability to integrate perceived information into a holistic view of the driving situation and its attendant risks. As a consequence, inexperienced drivers have poorer hazard perception abilities than drivers whose skills are better developed (see Macdonald, 1987; Hoyos, 1988; Brown and Groeger, 1988; Drummond, 1989; Milech et al, 1989).

The psychological and cognitive processes which underlie hazard perception were well described almost 30 years ago by Australia's first professional researcher into the "human factors" aspects of road traffic system design.

> "The ability to construct and use effectively a continuously changing predictive appreciation of a complex system is a mark of developed driving skill. Since drivers in general are given little or no instruction on what cues to attend to in these circumstances, the fact that so many drivers travel so many miles without accident bears witness to the remarkable human capacity for heuristic solution of complex dynamic problems."
>
> (Cumming, 1964, p.5)

Brown and Groeger (1988) argued that it is important to separate the process of hazard identification from that of hazard evaluation or risk perception. This is certainly true in an experimental context, because different sorts of performance measures will produce different sorts of response, and care must be taken in interpreting the results of experiments in this area.

In some experiments drivers have been asked to make assessments or ratings of risk levels. Trankle, Gelau and Metker (1990) reviewed some recent European research in the area of risk assessment. They conducted an experimental study using a wide variety of slide-presented traffic situations, in half of which the subjects were given information on presumed driving speed. Subjects were of different gender and age groups (18-21, 35-45, 65-75 years). It was found that young males generally rated risk lower than older males, especially in the following situations: darkness, curved or inclining/declining roadways, and rural environments. There was no comparable age effect for females. Trankle et al (1990) concluded that young male drivers seem to perceive risk as relatively low in "situations that do not display explicit danger signals".

Brown and Groeger (1988) found that young drivers underestimated the risk of certain traffic situations. They noted that low risk ratings could result from drivers not noticing or giving a low rating to the potential danger and/or from them giving a high rating to their own coping ability. Young males seem more prone than older drivers or young females to perceive their own driving capacity as greater than that of their peers (e.g. Finn and Bragg, 1986)

In support of the central role of drivers' self-perception of skill on their perception of risk, Peck (1985) cited the finding of Bragg and Finn (1982) that young drivers did not rate the risk levels of various driving tasks any differently from the ratings of older drivers, *unless* the task was presented in terms of the subject's own risk. Under this condition the young drivers rated risk as lower, presumably because of a relatively higher rating on their own capacity to cope with the difficulties presented by the hazard.

It is important to distinguish between drivers' assessments of risk levels for the benefit of researchers, and their 'risk perceptions' when going about their normal activities as drivers. In fact Summala (1988) stated that drivers' capacity to estimate 'risk' under experimental conditions, which he termed subjective risk, develops quite early and does not change with driving experience. He used the term "ostensive risk" for the feeling of fear or uncertainty which is sometimes experienced by drivers, and which they normally try to avoid.

Summala (1988) suggested that most novice drivers begin by experiencing considerable uncertainty or fear in many traffic situations: that is, their level of ostensive risk is high. However, these feelings are gradually extinguished as they gain experience and a greater sense of control, their skills become more automatised and they become more self-confident. According to this view, subjectively experienced risk is more a reflection of the driver's own perceived coping capacity than of objective risk levels.

The nature of 'risk perception' and its importance as a determinant of driving behaviour varies significantly between different theories of driver behaviour. For example, Taylor (1964) equated perceived risk simply with the driver's level of emotional tension or anxiety; later (1976) he defined subjective risk as "the perception of loss of control". Brown (1980) suggested that error-correction probability determines drivers' subjective risk (cited by Brown & Groeger, 1988). Hoyos (1988), reviewing literature on the relationship between "mental load and risk in traffic behaviour", concluded that perceived overload of attentional capacity is the major determinant of high levels of perceived risk; that is, perceived judgements of risk are largely based on information load.

Wilde's (1982) risk homeostasis theory was based on the assumption that drivers are generally aware of variations in level of risk. However, this assumption has been widely criticised (e.g. Evans, 1985; McKenna, 1985). Naatanen and Summala (1976) and Summala (1988) argued that drivers are not generally aware of risk as such; rather, they tend to drive so as to avoid the discomfort associated with the subjective experience of risk. This issue is pursued further in Section 4 below.

Brown and Groeger (1988) described how the nature of risk perception varies according to task demands and available attentional capacity. Under relatively stable traffic conditions 'risk perception' may be related to perception of a "safe space" around the vehicle, represented and perceived in terms of appropriate memorised stopping or avoidance characteristics of the driver's own vehicle. Under unstable traffic conditions, risk perception may be related to "safe space" maintenance plus a

variety of comparisons between the perceived likely manoeuvres of nearby road users and a repertoire of learned hazard-avoidance possibilities.

The above account emphasises the complex nature of what is often termed, with deceptive simplicity, 'risk perception'. In reality it is based on a complex range of experiences from which have developed cognitive schemata which represent the spatio-temporal characteristics of vehicles and road traffic along with the perceived capacities of self and vehicle to avoid potential hazards.

Inherent in Brown and Groeger's description of the factors underlying risk perception is the significance of maintaining a safe space around the vehicle. This concept dates from Gibson and Crooks' (1938) "field of safe travel". Closely related to such concepts is the driver's capacity to estimate 'time to collision' in any given situation. Cavallo, Laya and Laurent (1986) found in a field experiment that experienced drivers were better able to estimate "time to collision".

However, there is evidence that under normal circumstances drivers may rely on even simpler heuristics when maintaining safe distances from other vehicles. For example, Summala (1985) suggested that such decisions are based simply on absolute distances which may vary a little in different situations. Describing the basis upon which a driver decides to overtake a cyclist, he wrote:

> "Hence on a narrow road the 'narrow road' passing model is typically chosen. Problems arise only when there is an oncoming vehicle in the situation. The driver may anticipate that there is not enough space, i.e. that his minimum safety margins will be threatened if he has to meet another car and pass the cyclist simultaneously and he consequently may either go on and feel himself anxious or slow down and wait for an opportunity. Here again he does not use probabilistic information but only a simple subjective safety margin measure."
>
> (Summala, 1985, p.55)

The ability to predict the trajectories of road users, including the trajectory of the driver's own vehicle, appears to be intrinsic to the identification and assessment of most hazards. It follows that the development of vehicle control skill is likely to be closely associated with this aspect of hazard perception skill. "Adaptive control" models of driver behaviour (reviewed by Reid, 1983) are relevant in this area. There is evidence from research in this area, for example from McLean and Hoffmann (1971), that with increasing experience drivers learn to use higher-order steering cues, and hence direct their gaze further ahead down the road. This is consistent with research on the development of drivers' perceptual skills which shows that with increasing experience drivers become better at identifying distant traffic hazards (e.g. Brown, 1982).

It is known that experienced drivers tend to fixate further ahead of the vehicle, make more use of peripheral vision, and have shorter fixation times (e.g. Mourant and Rockwell, 1972; Miltenburg and Kuiken, 1991). There is considerable evidence that

such a pattern of information acquisition is primarily a reflection of a high information-processing load (e.g. Miura, 1986).

The process by which hazards are identified and evaluated is a joint function of both the general acquisition of vehicle control skills, and of the acquisition of more specifically perceptual/cognitive skills based on the development of accurate internal representations, or cognitive schemata of the nature of the road traffic system and of hazards.

Macdonald (1987) and Brown et al (1987) both pointed out that to the extent that the visual scanning pattern of novice drivers is a product of their relatively undeveloped cognitive schemata and related information processing characteristics, it is likely to be ineffective or counterproductive to simply train them in better strategies of visual information acquisition. On the other hand, it can also be argued (Brown et al, 1987) that training such patterns, as component sub-skills, may facilitate development of other components of driving skill. Such an argument is based on a considerable body of theoretical work on the development and training of complex skills (e.g. Schneider, 1985).

To be able to predict the probable effectiveness of such training strategies, and to optimise their design, more information is needed on the nature of driving skill development. In particular, information is needed on the ways in which the attentional demands of different aspects of the driving task, and drivers' attention allocation strategies, change with increasing driving experience of various sorts. The extent and rate of such changes need to be established, and their effects on the development of higher-order aspects of driving skill. In view of the potentially significant implications for driver training, such research appears well warranted.

### 3.4 Expectancies and cognitive schemata

A schema can be defined as being an organised structure of knowledge which represents, in a generic form, concepts, procedures, events or sequences of events (Thorndike, 1984; cited by van Elslande & Luber, 1991).

The significance of drivers' mental models or cognitive schemata of their task and environment have received considerable attention in the recent research literature. Moray (1990) pointed out that drivers' perceptions rely heavily on learned redundancies, which are basic in the development of the mental models which control information sampling locations and rates.

Much of the earlier research on hazard perception can be interpreted in these terms. For example, Quimby and Watts (1981) found that young drivers took longer to respond to traffic hazards (presented on film) than older drivers. The authors interpreted this result as due to the young drivers' lesser ability to recognise the situations presented as being potentially hazardous, which is consistent with their "internal representations" or schemata of hazards being less well developed than those of the older drivers.

Cognitive schemata are important determinants of drivers' expectancies, of the perceived significance of objects and events both current and potential, and hence of attention allocation. With increasing experience drivers develop more accurate and detailed schemata of traffic situations, so that their expectancies of 'what might happen next' correspond better with reality. Since a driver's expectancies are an important determinant of the perceived significance of different components of the traffic situation, it would be expected that the more accurate expectancies of experienced drivers in terms of where to look, what to look for, and the relative significance of different events, would produce a more effective pattern of attention allocation than that of inexperienced drivers.

According to Summala (1985), the basis of driving skill must be:

> "the memory representation of the traffic system, hierarchically organized as schemata, programs or internal models which govern both the perceptual and motor sides of behaviour (Head, 1920; Bartlett, 1932; Kelley, 1968; Neisser, 1976; Johannsen and Rouse, 1979). This internal representation of the statics and dynamics of the system to be controlled is the basis of automatized control."
>
> (Summala, 1985, p.50)

Van Elslande and Luber (1991) discussed the nature of such schemata which they saw as critical determinants of drivers' expectancies and hence much of their behaviour. They wrote in terms of "the representational context" (or schemata) which are compared and contrasted with "the situational context" (the observed environment) in order to interpret the driving situation. According to these authors, various "interpretative schemata" are used to select and process data.

The complex nature of cognitive schemata can be seen from the results of a laboratory simulation experiment by Hancock, Caird and Johnson (1991), demonstrating the influence on decision-making of some situation-specific factors. They found that subjects' gap acceptance behaviour was significantly influenced by the type and velocity of the approaching vehicle and the size (in seconds) of the gap. That is, these factors are components within cognitive schemata which determine gap acceptance behaviour.

Brown and Groeger (1988) argued that there is a need for research to elucidate the process by which drivers develop internal representations of hazards. They wrote that it is important for researchers to understand the changes which occur in drivers' internal representations of traffic hazards during skill development. The identification of a hazard may be seen as a process based on an internal representation of events in spatio-temporal form. Such internal representations, or schemata, are based on learned associations of hazardous objects and events with specific parts of the road traffic system, particularly the dynamic characteristics of other road users. They allow predictions of trajectories, and identification and assessment of the nature of associated hazards.

Milech et al (1989) pointed out that the development of expertise in driving is similar in some important ways to the development of expertise in other areas of complex human performance. Most importantly, the knowledge of skilled drivers is organised differently from the knowledge of less skilled drivers: their cognitive schemata are different. Based on this different form of knowledge organisation, experts are able to perceive their environment more holistically.

In spite of the high level of interest in the concept, there is a paucity of evidence concerning the characteristics of skilled versus unskilled forms of driver schemata. Noy and Zaidel (1991) noted a growing interest in the use of verbal protocols and related analysis techniques as a technique for eliciting and organizing information on the content of cognitive tasks or processes. However, they have not yet been systematically applied to the investigation of drivers' schemata. Noy and Zaidel commented that:

> "Qualitative measures of driving, subjective and underdeveloped as they may be at present, hold considerable potential for improving our understanding of drivers' internal representations of the traffic environment and strategic behaviour."
>
> (Noy and Zaidel, 1991, p.1485)

Riemersma (1988) used a repertory grid technique to address the questions: how do drivers internally represent different categories of road, and how are those representations mapped on to "official" road categories? Multidimensional scaling and clustering analyses showed that drivers' subjective categorisations of roads were closely related to the roads' objective physical characteristics, but less well-determined by their official category.

Saad, Delhomme and van Elslande (1990) observed the on-road behaviour of groups of drivers of varying levels of experience, and subsequently interviewed them concerning their perceptions during the drives. They found that experienced drivers on a country road approaching a rather inconspicuous intersection where they had right-of-way slowed down significantly more than novices did. The authors said that experienced drivers

> "appear to detect the intersection better or more quickly. They take account of the impediments to visibility and carry out some anticipatory adjustment to make allowance for the possible arrival of another user."
>
> (Saad et al, 1990, p.204)

The fact that novices slowed down less than experienced drivers even when vehicles were visible at the intersection lead the authors to wonder about

> "how the two groups of drivers view the status of the road along which they are driving. They seem to have a different representation of the danger of conflict with another user arriving at the junction from another direction. The

> experienced drivers seem to consider that, although they have priority, the risk is not zero and they adjust their speed in consequence. The novices, on the other hand, seem to have a greater sense of their priority on this road in view of the characteristics of the approach route and the small amount of traffic."
>
> (Saad et al, 1990, p.205)

This finding is clearly supportive of the results from crash literature mentioned in Section 3.2 above which show that young drivers are more likely to be "in the right" in collisions with other road users. It may also be related to young drivers' over-confidence, discussed in Section 3.2. Van Elslande and Contri (1991) identified drivers' confidence in their initial perception of the situation as a factor likely to impede their taking appropriate action in some circumstances. They said that:

> "Expecting the other driver to adjust to the situation results in users not reacting when faced with a critical situation, as they assume they clearly have right of way, or adopt a strategy aimed at forcing their way through. The feeling of being in control of the situation is related to the confidence that drivers have in their initial analysis of the problem."
>
> (van Elslande and Contri, 1991, p.214)

However, it is interesting that the difference in intersection approach speed between experienced and novice drivers observed by Saad et al (1990) occurred only on the lightly trafficked country road, not on a much busier urban road. The nature of drivers' cognitive schemata, which were suggested by Saad et al (1990) as a factor underlying the observed differences, warrants further research.

It is logically predictable that the poorer quality of inexperienced drivers' schemata and associated expectancies would present particular dangers at night, when information from the driving environment is impoverished due to the lower light levels. In these circumstances the importance of detailed and accurate expectancies would be maximised, since drivers use them to 'fill in the gaps' in directly observed information, and at night such gaps are presumably larger. That is, drivers would be expected to place greater reliance on their expectancies when visual information is degraded (as at night) than otherwise. This would place inexperienced drivers at a relative disadvantage.

Exacerbating the problems of night time driving is a tendency to ignore or underestimate the potential significance of information when it is inconspicuous or absent compared to information which is easily visible (e.g. Wickens, 1984; Michon, Smiley and Aasman, 1990). This general characteristic of human decision-making behaviour means that *all* drivers at night, or in other conditions where hazards are not immediately or easily visible, would tend to ignore invisible or inconspicuous hazards, or to underestimate their significance. However, the more detailed mental models and more accurate expectancies of experienced drivers would provide better protection against this tendency than would be the case for inexperienced drivers.

Thus, driving at night increases exposure to risk for all drivers, but more so for inexperienced drivers because of their less detailed and accurate expectancies and cognitive schemata. Any increase in speed at night, either of the individual young driver or of other vehicles, would further increase the young driver's crash risk, since available perception and decision time decreases as speed increases.

### 3.5 Attentional capacity: Allocation to avoid overload

Lack of driving experience is associated with a lesser amount of 'attentional capacity' to cope with sudden difficulties. This necessitates different strategies of attention allocation between different aspects of the task, and between task and non-task activities.

The relatively low level of attentional capacity at the disposal of young drivers can be understood in terms of the process by which skill develops. As described in the SRK model the development of skill is accompanied by increasing 'automatization' of components of the activity, with concomitant decreases in their demands for conscious attention during performance, which releases attentional capacity for application to other aspects of behaviour.

Thus, an inexperienced driver's patterns of attention allocation can be seen as to some extent a function of the degree of automatization of different components of the overall task and hence of the total amount of available attention. For example, when driving skill is in its early stages of development, drivers typically devote little attention to distant events, concentrating their limited capacity on the more immediate aspects of their task.

Based on this model, Heinrich (1990) identified the major problem of novice drivers as their greater dependence on conscious control of their driving behaviour, due to their smaller repertoire of automatised behaviour routines. This results in novice drivers having less 'spare' attentional capacity for use in emergencies. He pointed out that, due to "the special real time dynamics of road traffic", control of danger (i.e. crash avoidance) must operate largely at more automated levels of performance - levels at which inexperienced drivers are likely to be performing to a lesser extent, and less adequately.

The more developed cognitive schemata of more skilled drivers permit what Milech et al (1989) referred to as more 'holistic' perceptual and cognitive processes. In contrast, they said that:

> "novices are able to process less information about an environment than experts, for novices must search for critical features of the environment and integrate the resultant featural description into a perception. Experts, on the other hand, do not have to search and integrate, for their perception is holistic. Even if the only difference between expert and novice drivers is that experts

have a holistic perception, this gives experts a very considerable advantage, particularly in environments which are complex, stressful or ambiguous."

(Milech et al, 1989, p.9)

That is, the development of better cognitive schemata with increasing driving skill directly reduces the demands on a driver's attentional capacity. The implications of the varying attentional demands of performance at different levels of skill were pointed out by McKnight (1985). McKnight found that whereas experienced drivers were easily able to learn and demonstrate more fuel-efficient driving techniques, groups of inexperienced drivers given the same training were quite unable to do so. McKnight attributed this result to the inexperienced drivers' lack of spare attentional capacity to attend to such higher-order, and from their point of view lower-priority, aspects of driving performance.

Evidence that drivers allocate their limited attentional capacity in accordance with the perceived priorities of the situation was reported by Evans and Wasielewski (1983). They found that drivers adopt longer following headways when passengers are present than when they are alone. This was the most clear-cut of many factors which were found to be associated with different average following distances. They interpreted this as a reflection of attention-sharing between the driving task and interactions with passengers: following at a greater distance demands less attention, leaving more attention available for passengers.

Similarly, Von Pupka (1977; cited by Hoyos, 1988) reported clear evidence of compensatory changes in speed on a driving simulator when subjects were allowed to light a cigarette, eat an apple, or use a cassette recorder. There was a significant decrease in driving speed while subjects paid attention to these non-driving activities. Another example is the commonly experienced phenomenon in which a driver stops conversation with a passenger in mid-sentence in order to allocate 'full attention' to the driving task. The possible influence of social factors and motives of young drivers on such attention allocation practices is discussed in Section 4.

Harms (1986) reported a study in which drivers' attentional capacity was found (by secondary task performance measurement) to be lowest in environments with high information load. It was concluded that 'load stress' rather than 'speed stress' tended to produce attentional overload. This result is consistent with those of previous similar studies (e.g. Macdonald and Cameron, 1973; Macdonald, 1976; Macdonald and Hoffmann, 1977). It follows that young drivers, who are more susceptible to attentional overload, would tend to cope by attending to fewer information sources rather than by reducing speed. Such a conclusion is consistent with the empirical evidence.

Also, the greater probability of inexperienced drivers suffering attentional overload, or near-overload, means that they are more subject to high levels of physiological arousal and the associated effects on attention allocation which have been reported in the psychological literature (Kahneman, 1973; Welford, 1976; Wickens, 1984). Attention tends to become focussed on a narrower range of information sources, producing a

sort of 'tunnel vision' effect in the sense that information perceived as less relevant is less likely to be attended to. Also, there is increased difficulty in discriminating relevant from irrelevant stimuli, and lability of attention is increased.

An example of drivers' changed attention allocation under conditions of high attentional demand was reported by Miura (1986), who observed a lower use of information from peripheral vision. This was found both when the high demand was due to increased information load (complex environment, more events, higher speed) and when it was due to reduced processing capacity (fatigue). It was noted that under the higher demand conditions drivers acquired information more actively, focussing directly on information sources perceived as important, which is inconsistent with a high level of use of information from peripheral vision. Thus, as discussed in Section 3.3 above, evidence that inexperienced drivers make less use of peripheral vision than more experienced drivers (e.g. Mourant and Rockwell, 1972) can be viewed as a consequence, or at least as an expected correlate, of attentional overload or near-overload.

### 3.6 Attention switching

Attention allocation is also affected by skill in the actual process of switching attention between different components of the activity. Attention switching is itself a skill which requires practice on that specific task to develop (see Schneider, 1985); inexperienced drivers may simply lack skill in this process.

Reason (1985) and Hale and Glendon (1987), applying the SRK model of skilled performance to the investigation of "human behaviour in the control of danger", identified errors in switching between different levels of attentional control as a common factor in accident occurrence. Typically, people continue to operate at one of the two lower, more automatised levels of control and, failing to identify the appropriate cues, do not allocate the extra attention needed to 'switch up' when appropriate to the rule-based or knowledge-based levels of operation.

Rumar (1985) highlighted the basic sensory problems associated with night driving which underlie higher-order problems such as failure to direct and allocate attention appropriately. He argued that crash rate is significantly higher at night compared with the daytime because drivers do not fully realise the intrinsic limitations of their own sensory and perceptual system, particularly the degree of their degradation at night, and therefore do not attempt to compensate sufficiently for them.

Relating Rumar's comments to the SRK model and the common type of error in which people fail to switch to a higher level of attentional control, it seems that such errors may be particularly a problem for inexperienced drivers at night. Since the information needed to 'trigger' such a change in attention is likely to be degraded at night, drivers (particularly inexperienced ones) may need to modify their information seeking and attention allocation strategies at night to avoid crashes due to errors of this type.

Rumar (1988) discussed the nature of the cues which might cause drivers to switch between different levels of attention allocation, and suggested that a 'feeling of risk' might be a significant cue. It seems likely that for more experienced drivers the cues to 'switch out of automatic' are more appropriate, better learned and more likely to be responded to automatically. Unfortunately there appears to be no research on drivers to directly substantiate these hypotheses.

Moray (1990) identified failure to "schedule attentional sampling of the environment" appropriately as a likely cause of road crashes. Consistent with other authors, Moray said that attention sampling locations and rates are determined by drivers' mental models or schemata. Moray also noted that high speed crashes in fog are due to degradation of the visual information upon which speed perception depends. Speed monitoring normally occurs automatically, and Moray argued that unless drivers deliberately schedule attentional sampling of the environment, their perception of speed in such circumstances is likely to be in error.

It follows, then, that when visual information is degraded as in fog or at night, speed-related errors become more likely, due to drivers failing to adapt their information acquisition behaviour from that which is appropriate when a greater amount of visual information is available. This point in relation to speed monitoring at night may be seen as a special case of the more general phenomenon suggested above whereby attention-switching errors are more likely under conditions of degraded visual information.

### 3.7 Vehicle control skill

Evidence on changes in vehicle control skills with driving experience was reviewed by Macdonald (1987). She concluded that:

> "there is clear evidence of differences between drivers associated with different levels of driving experience. They may be differentiated by their different patterns of control activity and, more clearly, by the more accurate and faster performance by experienced drivers of slow-speed vehicle manoeuvres such as reversing and parking.
>
> Experienced drivers with good accident records are generally smoother in their manoeuvring, with lower maximum values of longitudinal or lateral acceleration forces. They are able to track along a line with smaller and less variable lateral error, and can bring their vehicle to rest at a designated line, or negotiate a path through narrow gaps, more accurately. In contrast, less experienced drivers or those with a poorer accident record have a fast and abrupt response style. They apparently reach decisions on the basis of less information and respond quickly and inaccurately."
>
> (Macdonald, 1987, pp.64-65)

There has been less research in this area of driving skill during the time since the above review, than is the case for the perceptual/cognitive aspects of skill. The findings from recent research are consistent with these earlier conclusions.

Two recent studies have reported the use of an instrumented vehicle to investigate changes in performance with increasing experience. Mikkonen (1989) recorded the driving performance of over 100 subjects grouped into six categories of experience ranging from newly licensed to highly experienced professionals. The most sensitive indicators of driving experience were scores describing the quality of use of vehicle controls, based on the amplitude, duration, velocity and acceleration of each control movement. For example, variability of *the accelerations of clutch control movements* was useful: it decreased with increasing experience, and was independent of traffic conditions, and of familiarity with the car or the road. The author concluded that:

> "Development of traffic skills can be measured from the refinement of drivers' psychomotorics. The development consists of several components like improvements in handling the car and mastering traffic events ..."
>
> (Mikkonen, 1989, p.96)

Miltenburg and Kuiken (1991) measured parameters of vehicle movement rather than drivers' vehicle control movements. They observed relatively low within-subjects variability, indicating that individual drivers had their own styles of driving. However, they found that on a straight road the standard deviation of lateral speed, representing swerving frequency, was higher for inexperienced drivers (licensed less than 5 years and driven less than 100,000 km over the last 5 years, *or* licensed more than 5 years but driven less than 10,000 km per annum) than for either novices (less than one year of experience) or very experienced drivers (licensed more than 5 years and driven more than 100,000 km in last 5 years). Furthermore, on a rural road the inexperienced drivers were found to have a higher standard deviation of lateral position, indicating that they swerved over a greater lateral distance.

There is inadequate information from which to deduce the causes underlying the differences between very inexperienced (novice) and inexperienced groups of drivers, but it seems most likely to reflect a decrease in the attention allocated to vehicle control by the slightly more experienced group. This interpretation is consistent with the much earlier results of Safren, Cohen and Schlesinger (1970) who found changes in the relationship between steering wheel control movements and speed changes for groups of different experience, interpreted by the authors in terms of experience-related differences in the way in which separate aspects of the driving task were "fused". Macdonald and Hoffmann (1980) also interpreted changes in steering wheel reversal rate associated with varying task demands in terms of variation in attention allocation strategy according to level of attentional demands.

Kuiken and Rothengatter (1991) reported the results of a questionnaire study of three large groups of drivers differing in experience. Respondents were asked to report their own crashes, 'incidents' and errors, from lists provided. The two less experienced groups (defined as for Miltenburg and Kuiken (1991; see above) reported

more incidents related to reversing, parking and negotiating bends. Errors mentioned most often by these groups were vehicle control errors (e.g. use of clutch, mirrors), and errors related to cognitive actions and skills (e.g. misjudgment of speed, reacting inappropriately to the situation). Experienced and very experienced drivers more often reported rear-end collisions and incidents due to sudden obstacles on the road, and to a lesser degree, incidents whilst crossing or turning at intersections.

Forsyth and Kompfner (1991) found from questionnaires given immediately after drivers had passed their licence tests that the aspect of their driving most commonly identified as still requiring improvement was parking (51%). There was also some evidence that young female drivers had poorer vehicle control skills than those of young males: in their licence tests, significantly more vehicle control errors were made by females, who had a 10% lower pass rate. The reason for this difference is unclear. Females reported having had more professional lessons prior to their licence test, but a little less practice with friends or relations, and less practice in the dark, in bad weather conditions, in busy town centres, on fast dual carriageways and on narrow roads.

Overall, young drivers' less developed vehicle control skill appears evident both in a lower level of control performance, and in less attention being available for other components of the driving task. They may have a smaller repertoire of responses available to handle critical situations than would be available to more experienced drivers. It appears that vehicle control skills improve rapidly with increasing experience but that their development is incomplete after periods of one to two years, and possibly after considerably longer periods (see Section 3.2, p. 5 above). There no direct evidence on the amount of experience required for the full development of such skills.

The Monash University Accident Research Centre research program on the nature of basic driving skill is exploring the nature of differences between drivers of different levels of experience, including differences in vehicle control skills. Results from this program can be expected to elucidate some of the issues raised above.

## 4.0 MOTIVATION FACTORS

### 4.1 Introduction

There appears to have been less empirical research on the relationship between driver motivation and performance than is the case for skill. A considerable amount of theoretical work has been published over the last decade, often with some associated laboratory experimentation, but there has been relatively little evaluation of such theories in terms of experimental data on drivers' on-road behaviour.

As noted in Section 2, the motivational characteristics of young drivers may affect crash risk in two separate ways: in their driving performance on the road, and in the extent and nature of their driving 'exposure' to risk. Thus, young drivers differ to some extent from older drivers in their needs and motives, which possibly may lead them to:

- exhibit a greater readiness to 'take risks' in the process of driving (e.g. speeding, following closely, reckless manoeuvres of various sorts)

- drive further, and/or make a greater proportion of their trips under conditions which increase exposure to risk of crashing (e.g. at night, with passengers, 'recreational' trips, without wearing a seatbelt).

The literature in this field does not generally make the above distinction between motivational effects on driver performance and on exposure to risk. In the present context the distinction is important because of the different implications for crash countermeasure development. If young driver motivational factors affect risk primarily via 'exposure' rather than via 'performance', the most appropriate means of reducing crash risk would be different from those which should be employed if motivational factors mainly affect on-road driving behaviour.

Reports on motivational factors are reviewed within three main sections: 4.2, related to the influence of motivation (interacting with skill factors) on driving performance, 4.3, related to the influence of motivation on exposure to crash risk, and 4.4, related to social, motivational and other personal correlates of young driver crash risk.

Literature on the influence of motivation on driving performance is discussed first at the general level (4.2.1), and then specifically in terms of young driver motives and driving performance (4.2.2). Interactions between the effects on crash risk of young driver skill and motives are also considered (4.2.2).

### 4.2 Motivation and driving performance

#### 4.2.1 Background: Theoretical and empirical research

Errors in driving performance, a few of which result in crashes, may be caused by inadequacies in the driver's skill and by the nature of the driver's motives; in the vast majority of cases it is likely that errors result from the interacting effects of both skill

and motivational factors. The processes by which driver skill and motivational factors interact has been the topic of much theoretical model development.

Fuller (1984; 1990) has developed a theoretical model of the driving task in which driving is conceptualised as a continuous sequence of hazard avoidance responses. The roles of driver motivation and of skill are both central to this model. Interest is focussed on the timing of avoidance responses in relation to the hazards: the later the responses, the less likely they are to be effective, and the less opportunity there is to recover from error.

In the context of Fuller's model, behaviour is determined by two main factors: the driver's knowledge of the actual probability and nature of the hazard, and motives in relation to hazard avoidance. Knowledge of probability is based on "the contingencies of the road environment", i.e. the relationships between hazard precursors and the actual occurrence of hazards. Fuller noted evidence that acquiring such knowledge is particularly difficult when it is probabilistic; learning is slow and performance is error prone.

Experiments within this theoretical context have shown that risk taking behaviour varies as a function of the probability of encountering a hazard. This factor was varied in a laboratory computer-simulation of the driving task (Fuller, 1990). When probability was relatively low and there was something to be gained by gambling that it would not occur, subjects adopted a riskier strategy rather than make an anticipatory avoidance response. Under such conditions, response latencies to actual hazard occurrence were longer. Fuller argued that such conditions are representative of actual road conditions. For example, when sight distance is restricted drivers have to decide whether or not to slow down in case there is an obstacle on the road ahead.

In such circumstances delayed avoidance responding is often rewarded and hence made more likely in spite of its higher risk because, compared with the safer anticipatory avoidance response, a delayed response commonly achieves rewards such as time saving, the possibility of matching the response more appropriately to the actual situational demands, an increase in self esteem through demonstration of a skilful avoidance response, a boost to arousal level (if boredom is a problem), or saving of energy (if no avoidance response is actually required). Fuller commented that presumably the probability and value of such rewards are weighed against possible aversive consequences such as loss of self esteem, loss of vehicle control, and accident, property damage, injury or even death. Loss of time and increased control effort would appear to be additional relevant factors.

Naatanen and Summala (1976) and Summala (1985; 1988) have proposed a somewhat different theoretical model from that of Fuller. According to their model driving behaviour is affected, like other forms of behaviour, by people's need to achieve certain goals, or satisfy particular motives. The basic ones are said to be minimising time and effort. In the case of most ordinary driving, behaviour proceeds in largely habitual fashion, thus minimising effort by minimising the need for much conscious attention. If people are in a hurry they are likely to drive faster and accept shorter

gaps. Or if monotony or boredom are problems, as is likely on long trips, people may drive faster.

The above theories are probably the two major ones in the current research literature in this area, and in neither of them is 'perceived risk' a central factor determining behaviour. The observation of 'risk-taking' behaviours such as speeding or acceptance of very small gaps does not necessarily imply that the drivers concerned are motivated to seek or experience "risk".

Duncan (1990) pointed out that human behaviour is intrinsically goal-directed, and discussed the possible role of drivers' competing personal goals as determinants of driving behaviour such as speeding or a decision to overtake. It was suggested that differences in drivers' goals and values may partly explain differences in the driving behaviour of young versus older drivers.

Rothengatter (1988) described work by himself and Vogel to investigate motivational factors associated with speed choice. They identified four factors: pleasure in driving, traffic risks, driving time, and expenses. The factor 'pleasure in driving' was the largest contributor to drivers' attitudes towards speeding. 'Speeders' believed more strongly than 'non-speeders' that it is more enjoyable to drive fast, whereas non-speeders believed that it is riskier to drive fast. Both groups evaluated risk and pleasure similarly. That is, speeders reported no less concern about risk, but they apparently did not perceive speeding as risky. Various correlations were found between reported speed and travel purpose, annual mileage and vehicle characteristics.

Michon (1985) discussed the role of possible motivational determinants of a driving speed. He stated that most drivers who normally exceed speed limits do not consider that their speeding endangers safety; speed choice is determined not by level of perceived risk or safety, but by factors such as 'pleasure in driving' and minimising travel time, with the balance between such goals varying according to the driver's trip purpose.

Some evidence supporting the subjective value of the driving experience as a motivator (its level of pleasure or comfort) was provided by Macdonald (1990). A large questionnaire study of a group of Melbourne drivers reported placing most value on 'driving at a comfortable speed' (perhaps implying the minimising of effort), relative to other goals of minimising travel time (the second most highly valued), minimising the number of stops (also related to minimising effort), and minimising fuel costs. It appeared that the reported values of these drivers affected their behaviour in that few of them used a system of 'dynamic' advisory speed signs which would have resulted in slightly lower fuel costs and numbers of stops - goals on which they reported placing relatively little value. Risk avoidance as a possible driver goal was not included in this study.

Summala (1988) stated that in the matter of speed choice the main determinant is the speed limit, with people driving quite routinely for most of the time, according to learned habits, and using simple cues in the traffic environment. As outlined in Section 3.3 there is normally no sense of risk, this being an unpleasant condition

which drivers are motivated to avoid. He noted, however, that "light uncertainty" may be experienced as pleasurable, perhaps particularly so by young people.

Summala suggested that perceived 'risk', which drivers normally try to avoid, is an unpleasant experience associated with a sense of inadequate control and caused by perceived discrepancies between drivers' cognitive schemata and their current perceptions. Thus, when driving an unfamiliar vehicle people tend to travel at a slower speed because their schemata governing vehicle handling do not fit properly with feedback information from the strange car, which necessitates an increase in conscious attention to the task until the relevant schemata become adapted to the characteristics of the new car. Only when performance is sufficiently automatised and expectations based on the schemata are sufficiently in accordance with feedback do people feel safe or comfortable enough to resume driving at normal speed. Alternatively, some people may drive at normal speed throughout, choosing instead to tolerate a raised level of uncertainty or anxiety.

Another theory related to driver motivation and risk taking, which enjoyed some popularity during the 1980s, is the risk homeostasis model of Wilde (1982). It has been widely criticised because of the central role it attributes to perceived risk and its premise that drivers are generally able to perceive changes in objective levels of risk. According to this theory, people adjust their driving behaviour so as to maintain risk at a constant, personally acceptable level. Wilde and his co-workers have shown that people differ in their preferred risk level and that such differences may be reflected in behaviour. For example, Wilde, Claxton-Oldfield and Platenius (1985) identified two groups, risk-seekers and risk-avoiders, on the basis of responses to three questionnaire measures of individual differences in risk taking. In subsequent laboratory experiments on risk taking, some significant behavioural differences between the groups provided support for the validity of their classification.

Recently, a UK research project to study drivers' attitudes and behavioural intentions has been based on Fishbein and Azjen's (1975) theory of reasoned action and its successor, the theory of planned behaviour (TPB) (Parker, Manstead, Stradling and Reason, 1992). Measures were taken of a large, stratified sample of UK drivers' beliefs, evaluations and behavioural tendencies related to four types of violation: drink-driving, speeding, following too closely, and dangerous overtaking. It was found that drivers' scores based on the TPB model accounted for 47% of behavioural intentions related to 'speeding' behaviour. Of particular interest in the present context were the results concerning age-related differences; these are reported in Section 4.2.2.3 below.

### 4.2.2 Young driver motivation and driving performance

In the above section, literature on motivation and driving performance in general was discussed. The present section deals with literature pertaining specifically to the motives of young drivers and their effects on driving performance.

***Deliberate risk taking and risk perception***

In the context of Fuller's model, the higher crash risk of novice drivers is seen as a product of a greater preference for risk (e.g. as found by Jonah and Dawson, 1987), together with incomplete or inaccurate knowledge of the 'actual contingencies' of the road environment. That is, perceptual/cognitive skill factors are hypothesized to interact closely with motivational factors.

In reviewing literature on causal factors in young driver crashes, Peck (1985) observed that "risk-taking has been advanced by numerous authorities as an explanatory construct. It has been posited that young persons either have problems judging hazards, enjoy taking risks, or both." Romanowicz and Gebers (1990) concluded that most of the evidence suggests that "risk-taking is a (if not *the*) major factor underlying the high accident rate among teens". However, they appeared to include failure to perceive hazards as part of 'risk-taking'.

Speeding is commonly regarded as 'risk-taking' behaviour. Knapper (1985) cited evidence that young male drivers are more likely to exhibit risky behaviour such as speeding or driving close to the vehicle ahead (Evans and Wasielewski, 1983; Konecni, Ebbeson and Konecni, 1976). Consistent with this, Williams, Lund and Preusser (1985) found from a large questionnaire survey of USA high school students that many young licensed drivers, especially males, reported frequently driving at more than 70 mph.

However, it needs to be recognised that behaviour such as excessive speeding or manoeuvres such as following too closely, which are objectively risky, might be due at least in part to a failure to identify all the potential hazards and associated risks of such behaviour. From this point of view, the behaviour might be due not so much to deliberate risk taking or risk acceptance, as to lack of skill in hazard perception and cognition. Deviating from the views of Peck (1985) and Romanowicz and Gebers (1990) cited above, Schlag (1987; cited in Trankle et al, 1990) concluded from a study which entailed behavioural observations and the measurement of attitudes towards risky events that in many cases poor skill in hazard perception rather than high risk tolerance was the main determinant of objectively risky behaviour.

As discussed in Section 3, the driver's perception of his or her own capacity to cope with the expected nature of the driving task and its associated hazards has been shown to influence 'risky' driving behaviour. Drivers who perceive themselves to be particularly good drivers might be more likely to "take risks", since they might perceive the expected hazards and associated driving task demands as not particularly risky for highly skilled drivers such as themselves. There is evidence that males are more likely than females to over-rate their own level of driving skill, which in this context is consistent with their observed riskier driving. This phenomenon might be categorised more as a lack of perceptual skill (in this case inaccurate perception of self - a lack of insight) than as a motivational factor. However, the literature in this area is not clear-cut; driver performance is influenced by complex interactions between a range of different factors: perceptions of own driving skill, perception of the environmental demands, and a range of probably conflicting motives.

***Young driver motivation***

Lewis (1985) related findings from the general psychological literature on cognitive development during adolescence to the possible values, motives and behaviour of young drivers. Compared to older adolescents, young ones have more difficulty imagining circumstances which are outside of or contradictory to personal experience. Lewis suggested that "... perhaps cognitive growth makes it easier to imagine the consequences of an unexpected stop by the driver one is tailgating or to reflect on one's own motives for driving fast."

An experimental study of adolescents' decision-making processes (Lewis, 1985) revealed that their awareness of possible future consequences of their decisions increased from 11% to 42% over the age range 12-18 years. Parallel to this, there was evidence of an increasing ability over this age range to imagine risks associated with health-related decisions: there was an increase from 50% at age 12 years to 83% at age 18 years in those spontaneously mentioning such risks during discussions of the decisions.

Lewis identified the "socio-emotional 'developmental tasks' of adolescence" as being to achieve autonomy and identity (and possibly, increased 'sensitivity to outside control'). It was suggested that motives associated with these processes may tend to encourage higher risk-taking behaviour.

Jessor and Jessor (1977; cited by Jonah, 1990) presented evidence that adolescent 'problem behaviour, including drinking, are determined by the interaction of personality with socio-cultural factors such as behavioural norms, opportunities to learn and perform deviant behaviours, and access to culturally valued goals. The development by these researchers of 'Problem Behaviour Theory' provides a conceptual basis for investigations of questions concerning the existence and practical significance of "Young Problem Drivers" (see Section 5 below).

Knapper (1985) noted the importance of recognising that young drivers are affected by many goals, not simply that of avoiding crashes: they may have significant psychological or interpersonal goals which may sometimes conflict with safety-related goals. He concluded that there is a need for research to determine the role of such factors which may underlie young drivers' higher crash risk, particularly studies of young drivers' behaviour, attitudes and motivations when 'at the wheel'.

Peck (1985) suggested that a sense of personal vulnerability, or lack of such a sense, may be a basic factor underlying deliberate risk-taking behaviour among young drivers. According to this view, a sense of personal vulnerability is a characteristic which increases with age up to some time in the early twenties.

> "Unless one has a sufficient sense, cognitively and affectively, of being vulnerable to catastrophic events, there is little motivation to drive cautiously and defensively. If this conjecture has any validity, it leads to the pessimistic conclusion that not much can be done to short-circuit the process. In other

words, it may not be possible for any feasible countermeasure to make most 18-year-olds respond to the driving tasks like most 30-year-olds other than the passage of 12 years."

(Peck, 1985, p.60)

Much more optimistically, the research based on planned behaviour theory by Parker et al (1992), described in Section 4.2.1 above, suggests that young people are not unconcerned with outcomes, but perhaps that potential positive outcomes are more influential than potential negative outcomes. They found that:

> "the younger drivers are less aware of or concerned with the negative outcomes (for themselves or others) of violations; are more attuned to the potentially positive outcomes, as compared to older drivers; see their friends and intimates as less likely to expect them not to commit violations; and find it difficult to resist committing the violations." (p.129)

The general pattern of results for males overall was "a weaker echo" of that for young drivers. Males showed:

> "... less awareness of or concern with the negative outcomes of violations, especially speeding, and greater difficulty in resisting commission of the violations." (p.129)

In the context of the present research project, the most interesting results from this study concern the relationships between time of day, presence/absence of a passenger (always specified as a person of the same age and sex as the respondent) and drivers' responses.

> "For speeding, responses indicated a consistently more 'permissive' orientation to speeding at night than during the day, but for the other three violations, time of day affected responses only in conjunction with the passenger factor. Across a variety of measures, the presence of a passenger was found to result in a less permissive orientation to the violations during the day, but a more permissive orientation at night.
> ... these interaction effects have to be accounted for in terms of factors such as the 'social' nature of nighttime driving with a passenger, which might be seen as encouraging a more carefree and less responsible approach to driving than the more 'business' nature of daytime driving." (p.129)

Furthermore, Parker et al (1992) reported that drivers' self-reported "propensity to commit driving violations" (drink-driving, close following, speeding and dangerous overtaking) was significantly related to crash rate; there was no systematic relationship between error and crash rates.

*Young driver motives and skill*

The way in which young drivers allocate attention between the driving task and other elements in their environment is undoubtedly influenced by the interacting effects of their various goals and motives. For example, youthful drivers more often than older drivers may be motivated to avoid giving passengers the impression that they are unable to carry on a conversation while driving or that they are excessively cautious. This may lead young drivers to allocate more attention to interactions with passengers and less to their driving task, particularly in situations where the hazards are potential rather than clearly apparent.

Evidence was presented in Section 3 above which clearly demonstrated a general tendency to modify driving behaviour so that it demands less attention, when more attention is being paid to non-driving activities. It may be that at least in some circumstances, young drivers may be less willing than older drivers to modify their driving, for example by driving more slowly, to compensate for other attentional demands. That is, some typically youthful motives and values may affect driving performance at a very basic level by altering the ways in which young drivers allocate attention while driving. Thus, motivation may interact with skill in determining the content of information on which drivers base their decisions.

In this vein, Brown and Groeger (1988) pointed out that motivational factors interact with skill-related factors in ways which are currently unclear. They argued that there is a need to investigate the extent of the role of motivational factors such as time pressure, and of motives which may be typical of sub-categories of driver such as male adolescents. They suggested that young drivers may be more likely to initiate risky manoeuvres because of "youthfulness and sensation-seeking" (Zuckerman, 1979; cited by Brown & Groeger, 1988) and "autonomy development" (Douvan, 1974; cited by Brown & Groeger, 1988). The significance of such motives have been the focus of research by Jessor (1984) and Lewis (1985), who view risky driving by young people as an expression of their "developmental behavioural health syndrome".

Mayhew and Simpson (1990) reported that increased experience post-licence was a stronger determinant of crash risk for people obtaining their licence at a relatively old age than for young people. For the youngest licensed drivers, age was found to be a better predictor of crash rate than experience, suggesting that the negative effects of presumed youthful motives such as aggressiveness and competitiveness counterbalanced the positive effects of improved skill.

An investigation of self-reported driving errors by Reason, Manstead, Stradling, Baxter and Campbell (1990) has interesting implications concerning the relative effects of skill and motivational factors on young driver behaviour. It was based on Reason's categorisation of errors based on the SRK model of skilled performance, into unintentional violations (unintentional, illegal errors), violations (intentional, illegal errors), mistakes (legal, decision errors) and slips (legal, errors in automatised behaviour). Each error was categorised in this way and rated on a 3-point risk scale. Factor analysis identified three main factors, on the basis of which three scores were

derived for each driver: a 'violation' score, a 'dangerous error' score and a 'silly lapse' score. The relationships between driver age, sex and these scores were calculated.

Drivers (males and females) were divided into nine age groups (from under 20 years to 56 years and over). It was found that:

- for both sexes but especially for males, numbers of 'safe' drivers increased with age
- males, especially young males, were over-represented in the low error/high violation group
- males were greatly over-represented in the group scoring high on both errors and violations, for all but the youngest age group
- females of all ages were low on both dangerous errors and violations
- females, especially older females, were over-represented in the high error/low violation group
- those reporting high numbers of violations tended to rate themselves as particularly skilful.

These results are consistent with a variety of other findings. The greater reported improvement with age in males over this wide age range is supportive of age-related motivational factors being more significant among young males than young females. Conversely, the high ratio of reported errors to violations among females, particularly older females, is supportive of greater skill-related deficits in these groups.

The relatively greater importance of motivational factors among males is also apparent in their higher rates of reported violations across all age levels. It is possible that the lower incidence of reported dangerous errors among females may be reflective of generally lower speeds, which would be consistent with other evidence. An effect of high levels of self-perceived driving skill (largely a male phenomenon) on risk-taking is suggested by the positive correlation between such self-perceptions and reported violation rates.

Overall, these results suggest that motivational factors are a greater factor in male driver errors, and skill factors are a greater factor in female driver errors. In view of the generally higher level of male than female crash rates, at least until very recently, this may be interpreted as supportive of a greater role of motivational factors than skill factors in reported crashes.

Perhaps the current upward trend in female crash rates (Macdonald, 1993) is evidence of a change in the motivational characteristics of young female drivers such that they are becoming more similar to those of young males. Another more definite factor is the increased female rate of drink driving (Popkin, 1989).

The above suggestions that skill deficits are a more significant crash risk among young females and that motivational characteristics are more significant among young males, receive some support from other studies. Williams and Karpf (1984) reported data from Sobel and Underhill (1976) that personal traits such as rebelliousness and 'risk taking' were associated with crash risk among young males but not among young females, for whom the only significant predictor of crash risk was distance driven.

A report by Harrington (1972) showed that. whereas driver training (mainly directed at development of vehicle control skill) is generally ineffective in reducing the crash risk of young males, there is evidence of a slight benefit in terms of crash risk for young females. This finding may be interpreted as evidence that females have poorer starting levels of vehicle control skill, that the crash risk of young males is more affected by motivational than skill factors, and/or that the motivations of females lead them to respond more positively to skills training.

## 4.3 Young driver motivation and exposure to crash risk

Graduated licensing systems are becoming an increasingly common means of attempting to reduce young drivers' exposure to crash risk, particularly by the inclusion of features such as a night curfew or passenger restrictions. The literature and issues related to the effectiveness of graduated licensing systems are reviewed and discussed separately (Haworth, 1992a; Drummond, 1992).

### 4.3.1 Determinants of exposure 'quality'

According to the present model of the determinants of young driver crash risk, 'exposure' is a multidimensional concept in which distance driven is the major quantitative component, and in which the qualitative aspects of the distance driven also affect exposure. The quality of exposure is determined by a wide range of factors: road, traffic, vehicle and environmental factors together influence the nature and level of driving task demands, or the driver's capacity to cope with demands, or the driver's capacity to avoid injury in the event of a crash: regardless of the mechanisms, they all change the risk of a reported crash.

It is clear that young, inexperienced drivers are over-represented in crashes relative to older drivers, but such information must be interpreted in terms of the varying exposure to risk of different categories of drivers.

Hoyos wrote that:

> "I believe that one of the most important tasks of traffic research is to learn more about the qualitative exposure of drivers to risks or hazards. Specific traffic measures ... cannot be planned until these essential observations have been made."
>
> (Hoyos, 1988, p.579)

The complexity of the issues involved in any investigation of the 'quality' of exposure is illustrated by a brief consideration of the nature of night driving.

People driving a set distance at night are exposed to greater risk, based on crash statistics, than if they drive the same distance during the day. Possible reasons for this were discussed in Section 3. It was pointed out that night driving is not associated with an excessive information load in terms of the number and complexity of information sources. However, the lesser amount and poorer quality of visual information at night increases the demands of visual sampling and information seeking. In addition, the unpredictability of information may be greater at night, due to ambiguities in visual cues from the roadway, or perhaps to an increase in speed variance among other road users. More speculatively, a possible increase in unexpected manoeuvres on the part of other drivers may also play a role in increasing the demands of night driving. Such phenomena would increase the information processing load on drivers, thus increasing task difficulty.

The degraded quality of stimulus information at night combined with young drivers' less developed cognitive schemata (see Section 3.4), puts them at a particular disadvantage. It follows that, to the extent that young drivers spend relatively more of their total driving time at night than other groups of drivers, their less well-developed driving skill exposes them to higher levels of risk which will to some extent explain their over-involvement in crashes.

The proportion of a driver's total exposure which occurs at night is determined by a combination of 'lifestyle' and motivational factors which differ according to driver age. Young drivers tend, for various reasons, to drive more at night than older drivers. There may be sub-groups of young drivers for whom this is significantly more so, and it is possible that some of these have higher levels than average of motivational characteristics which further increase their risk. Evidence related to the latter possibility is discussed in the following sections.

Similar arguments apply in relation to other behaviours more likely to be exhibited by young people, and which are associated with a higher probability of reported crashes, such as driving less 'crashworthy' vehicles (e.g. Williams, Preusser, Lund and Rasmussen, 1987; Haworth, 1992b), and not wearing seatbelts (e.g. Boughton, Milne and Cameron, 1980), particularly at night (e.g. Cooper, 1987; Noordij, Meester and Verschuur, 1988).

### 4.3.2 Risk exposure and risk taking

It is clear that, statistically speaking, there are risks associated with a decision to drive at a particular time and place, in a particular vehicle, with or without certain passengers, wearing a seatbelt or not, and so on. That is, decisions made prior to driving influence subsequent exposure to crash risk, independent of actual driving performance. These pre-driving decisions can therefore be seen (e.g. Hoyos, 1988) as entailing "risk taking", although they do not directly influence driving performance itself.

There is evidence that older drivers whose skills are deteriorating modify their exposure to risk as a means of avoiding too much of an increase in their personal risk level (e.g. Waller, 1991). However, evidence of similar adjustment in the case of young drivers appears to be lacking. The youngest and most inexperienced drivers might be less able or willing to limit their exposure; they might be less concerned than old drivers by the risks they face; and/or young people might be more willing than old people to "take risks".

It cannot be assumed that level of "risk taking" in decisions controlling exposure to risk will be similar to that in driving performance: the factors affecting these two types of decision are significantly different. Decisions affecting exposure are made under little if any time pressure, often in non-driving situations; decisions while driving are typically made under time pressure, and are strongly influenced by the immediate demands of the driving task; personal motives influencing decisions in these different types of situation are also likely to differ somewhat. However, the effects of the two different kinds of motives (those influencing exposure and those influencing driving performance) may interact in their effects on crash risk.

For example it appears likely, although there is no direct evidence, that the role of a possible young driver motive such as the need to develop or express independence from authority, which might influence driving performance itself, would vary in its influence according to the nature of the particular trip. Thus, this motive seems more likely to affect behaviour during recreational driving with peer-group passengers present than during a solo trip to work. On this basis, weekends would tend to be times of increased risk for drivers influenced by such a motive because of the greater probability of recreational driving of this sort.

Although they are conceptually independent, there is empirical evidence of correlations between motivation which *increases exposure* to risk, and motivation to *drive* in a risky fashion. For example, there is some suggestive evidence (Williams, Lund and Preusser, 1985; 1986) that at least in the USA, young drivers with the greatest quantitative exposure are more likely than others to drive for recreational purposes, and to drive in a risky fashion. Such findings are discussed below, together with evidence on relationships between these motivation-related factors and other correlates of crash risk such as personal and social characteristics.

## 4.4 Personal and socio-cultural correlates of risky behaviours and young driver crash risk

A large survey of high school students in seven states of the USA during 1983 produced several conclusions concerning the behavioural and other correlates of young driver crash risk and exposure to risk:

- students with lower grades were more likely to own cars, to drive more, and to be involved in 'deviant driving practices' (Williams, Lund and Preusser, 1985);

- car ownership was associated with more driving, more crashes, and poor academic performance among males (Williams, Preusser, Lund and Rasmussen (1987);

- a higher reported frequency of driving after drinking was associated with less time spent on homework and poorer academic performance, working part-time, greater participation in social activities, less perceived parental influence on travel, owning a car, higher mileage driven, speeding, and having crashes and/or violations (Williams, Lund and Preusser, 1986);

- there were significant relationships between licensing age and gender (males were younger than females) school grade (those with higher grades were older) and parental education (those with more highly educated parents were older) (Lund, Preusser and Williams, 1987).

It follows from the last result that drivers in the youngest age range have, on average, lower school grades and less well-educated parents than the 'older' young drivers, which might be interpreted as indicating that the youngest age group of drivers in this large USA sample included a larger proportion from lower socio-economic levels. It is interesting to note that drivers of low socioeconomic level have been identified as having an increased crash risk (NHTSA, 1990).

The above results supported and expanded earlier results such as those reviewed by Peck (1985) on the role of youth in traffic accidents. In particular, Harrington (1972) found that easily the best predictor of young drivers' crash rate was their citizenship grade in high school. High accident subjects reported more socially deviant past activities, poorer school and parental relationships, more traffic convictions, higher mileage, more involvement with cars during high school, and being more emotionally involved with driving.

Lewis (1985) found that driving-related aggression was more prevalent among males aged 17-35 years than among older drivers. She cited evidence that both driving-related aggression and driving-related anxiety in males declined over ages 16-66 years and that self-reports of emotional impulse expression in driving decrease over ages 16-24 years.

In Canada, Jonah (1990) reported information from a large telephone survey of 10,000 Canadians aged 16-69 years on age differences in:

- "risky driving": drinking and driving, non-use of belts and aggressive driving such as frequent speeding and overtaking (combining exposure and performance related risks),

- 'risky' behaviour unrelated to driving (heavy alcohol use, illicit drugs), and

- traffic accidents/violations.

Young drivers (aged 16-24) were more likely to report risky driving, higher crash and violation rates (corrected for distance), and other risky behaviour; the age effect was stronger for males. Risky driving, the other risky behaviours and accident/violations rates were all positively and significantly correlated, and correlations were highest for drivers under 25 years, especially for those aged 20-24; however, the magnitude of the correlations was low.

For example, the correlation over all drivers between score on a driving aggression scale and non-wearing of a seatbelt was only 0.16; between aggressive driving and driving after 2+ drinks it was 0.09. The overall correlation between 'risky behaviours' for drivers aged 16-19 years was 0.18; it was 0.21 for those aged 20-24; however, these latter values are perhaps deceptively high because of their inclusion of several different measures of drinking-related and drug-related behaviour for which reasonable correlations could be expected. Jonah interpreted the existence of statistically significant correlations as evidence for the existence of a 'risky behaviour syndrome', but their low magnitude casts doubt on its practical significance.

It was clear, however, that young drivers in this study, particularly males, reported behaving in 'riskier' fashion than older drivers both in terms of their decisions affecting exposure to risk (drinking, drug use, seatbelt use) and in their actual driving performance.

The USA Department of Transportation National Highway Traffic Safety Administration (NHTSA, 1990) reported several new research projects to identify, among other things, young people's values and their possible causal relationships with high-risk driving behaviour. For example, one project is concerned particularly with identifying possible means of increasing safety belt use among several groups identified as 'high risk', including young people and those in lower socioeconomic levels.

## 5.0 'YOUNG PROBLEM DRIVERS'

Evidence has been presented above and in the previous review of 'crash' literature (Macdonald, 1993) that crash risk varies with driver age and gender as well as with driving experience. Literature in the present review suggests that these differences are due to motivational characteristics as well as to skill. It is not unreasonable, then, to question whether there might be major sub-groups among young drivers, other than males and females, which differ significantly in their crash risk.

In particular, it has been suggested that there is a sub-set of young drivers, mainly male, with a common set of personal and sociocultural characteristics, who exhibit various risky types of behaviour to a much greater degree than other young drivers. Such drivers have been termed 'young problem drivers'. The question can be put as follows:

> Do *most* young drivers exhibit 'risky' characteristics such as those discussed above, or is the problem *largely confined to a relatively small subset of young drivers*, so-called 'young problem drivers', who are largely responsible for the elevated crash risk of young drivers overall?

It is important to note that the question is not primarily one about the *nature* of young drivers' characteristic skill deficits or risky behaviours: it is a question of the *distribution patterns* of these characteristics *within* the group of young drivers. At the moment there is insufficient evidence to reach any clear conclusion on this matter.

Donovan and Jessor (1985) concluded that alcohol intoxication, drug use, delinquency and precocious sexual behaviour constitute a problem behaviour 'syndrome' among youth, and suggested that it reflects a general underlying dimension of 'conventionality' including psycho-social attributes such as lower academic achievement orientation, lower religiosity, higher value on independence and greater orientation to friends than to parents.

Jonah (1986) attributed young drivers' high crash rate to a 'risk behaviour syndrome', based on that of Jessor and Jessor (1977; cited by Jonah, 1990). Johnson and White (1989) suggested that a 'problem behaviour syndrome' may be based on an underlying risk-taking orientation and other personality and social environmental attributes of unconventionality as measured by the Jessors and their colleagues. They investigated factors related to young drivers' drinking and driving using self-report data, and found that the factors predicting impaired driving among youth may be the same as those predicting drug use and other forms of deviant behaviour. They interpreted this evidence as supportive of a 'problem driver' perspective such as that proposed by Jessor and Jessor (1977; cited by Jonah, 1990).

Jessor, Donovan and Costa (1989) discussed 'Problem Behaviour Theory' and risky driving. They presented evidence of correlations between drink-driving, other forms of risky driving, other measures of problem drinking, and other problem behaviours. Positive correlations were found between drink-driving, some other forms of risky driving and a variety of other 'problem behaviours', and negative correlations were

found with health-enhancing and conventional behaviours. The authors concluded that "These findings make clear that DUI and risky driving are elements of a more general lifestyle that implicates many other areas of activity, not just those related to motor vehicles."

They pointed out that, in agreement with theoretical expectations based on Problem Behaviour Theory, variation in drink-driving and risky driving "could be accounted for to a significant degree by psycho-social characteristics, especially personal controls against and perceived models for problem behaviour among friends." They also noted that Wilson and Jonah (1989) have shown the predictiveness of their Problem Behaviour Theory for traffic accidents and violations.

The same limitations apply to the above data in terms of their implications for the validity and utility of the 'young problem driver' concept, as in the case of the data from Williams and his co-workers, and from Jonah, discussed in Section 4.

However, to establish the validity of the 'young problem driver' as a separate sub-species of young driver, it appears necessary to demonstrate intercorrelations between risk-related personal motives, sociocultural characteristics, exposure to crash risk and driver performance characteristics. It might be predicted that personal characteristics such as aggressiveness would vary throughout the young driver population according to an approximately normal distribution. The analysis would need to focus on questions such as: do young male drivers who fall close to the high end of the distribution on 'aggressiveness' also fall at this end of the distributions of several other 'risky' characteristics such as 'drives a lot at night', 'often fails to wear a seat belt', 'often drives at excessive speed', 'frequently weaves and overtakes'? The various reports of Williams, Lund and Preusser in the USA and Jonah in Canada, cited in Section 4, and the work of the Jessors and their co-workers described above, provide evidence that some such relationships may exist; however, reported correlation levels are low.

For the concept of 'young problem driver' to have practical utility, it is necessary to demonstrate that there are sub-groups of young drivers who each score at high levels on the same set of personal and risky driving characteristics. If such groups are shown to exist, and if they are large enough for potential countermeasures to be cost-effective, it would be appropriate to develop measures which focus on these groups. In the absence of such evidence, countermeasures should more logically be focussed on specific risky behaviours rather than on specific groups of individuals. Targeting of countermeasures could be improved by use of information on the personal and psycho-cultural characteristics of the drivers most likely to exhibit these behaviours.

As mentioned in Section 4, the USA Department of Transportation NHTSA (1990) has identified various groups of drivers as 'high risk'. The Department aims in a new research project "to examine the broad spectrum of risk taking behaviour" among those "similar groups of problem-involved individuals" who have been identified in relation to occupant protection, alcohol, drugs, and speed-related behaviour. These people are said to "have a different belief structure regarding risk and injury than those who are not problem-involved." Information on the statistical characteristics of

these groups' risk levels in relation to each other and to those of the general driver population was not presented, so their status as significantly different 'problem driver' groups is impossible to assess.

It must be concluded, then, that there is currently insufficient evidence from which to determine the validity or potential utility of the young problem driver concept.

# 6.0 OVERVIEW OF YOUNG DRIVER BEHAVIOUR

## 6.1 Effects of skill deficits on young driver performance

At present there is little evidence on the types and amounts of experience needed to become a 'fully skilled' driver, and many recent authors have identified the need for more research on the processes entailed in the development of driving skill.

Young drivers' less developed vehicle control skills are evident in a lower level of control performance; this is reflected in the quality of use of vehicle controls, including the amplitude, duration, velocity and acceleration of control movements. There may also be differences between drivers at different levels of skill development in the attention allocated to vehicle control sub-tasks. It appears that vehicle control skills improve rapidly with increasing experience but that their development is incomplete after periods of one to two years, and possibly after considerably longer periods. The evidence on the amount of experience required for the full development of such skills is unclear.

Less-skilled drivers have to devote a greater proportion of their available attentional resources to conscious decision-making and monitoring of their driving, and therefore have a lesser amount of 'spare' attentional capacity available. This necessitates different strategies of attention allocation between different aspects of the task, and between task and non-task activities. The development of better cognitive schemata with increasing driving skill directly reduces the demands on a driver's attentional capacity.

The development of more accurate and detailed schemata of traffic situations means that young drivers' expectancies of 'what might happen next' gradually correspond better with reality. Inexperienced drivers show less awareness than older drivers of the actual realities of road system operation in which other road users cannot always be relied upon to follow road laws. Their over-reliance on formal rules or laws appears to reflect the poorer development of their cognitive schemata, on which are based their perceptions and expectations. Consequently, their direction and prioritisation of attentional resources is less well fitted to the contingencies of the driving task.

There are major, skill-related differences between drivers of different levels of experience in the way in which they perceive hazards and risks. 'Risk perception' is based on learned experience from which have developed cognitive schemata which represent the spatio-temporal characteristics of vehicles and road traffic along with the perceived capacities of self and vehicle to avoid potential hazards. Lack of driving experience has been shown to be associated with less effective strategies of visual information acquisition and a lesser ability to integrate perceived information into a holistic view of the driving situation and its attendant risks. As a consequence, inexperienced drivers have poorer hazard perception abilities than drivers whose skills are better developed.

There is some evidence from the crash literature that young driver crash risk is highest at this intermediate, 'rule-based' stage of skill development. At this stage their imperfect driving skills tend to be combined, particularly in the case of young males, with over-inflated levels of confidence in their own driving skill relative to that of their peers.

Low risk ratings can result from young drivers not noticing or giving a low rating to the potential danger and/or from them giving a high rating to their own coping ability. According to one view, subjectively experienced risk reflects the driver's own perceived coping capacity more than it reflects objective risk levels. The driver's perception of his or her own capacity to cope with the expected nature of the driving task and its associated hazards has been shown to influence 'risky' driving behaviour.

Driving at night increases the crash risk of all drivers, but more so for inexperienced drivers because of their less detailed and accurate expectancies and cognitive schemata. When visual information is degraded as it is at night, speed-related errors become more likely, due to drivers failing to adapt their information acquisition and attention-switching behaviour from that which is appropriate when a greater amount of visual information is available.

### 6.2 Motivational effects on young driver performance

Crash risk is affected by driver motivation as well as by driver skills, and it is clear that young driver motivation differs in some important ways from that of older drivers. The personal goals or motives of young drivers may sometimes conflict with safety-related goals; the risky driving by young people is viewed by some researchers as an expression of their 'developmental behavioural health syndrome'. Young drivers are more likely to drive in a 'risky' fashion, such as speeding, and this tendency has been associated with specifically youthful motives. Importantly, there is evidence of some day/night differences in young driver motives related to risky behaviour such as speeding and non-wearing of seatbelts - differences which may be influenced by the presence/absence of a passenger.

Apart from their effects on deliberate risk-taking, some typically youthful motives and values may affect driving performance by altering the ways in which young drivers allocate attention while driving. Thus, young drivers may be less willing than older ones to modify their driving, for example, by driving more slowly to compensate for other attentional demands.

Motivational factors have a greater influence on the driving performance of young males than on that of females. Conversely, there is evidence of greater skill-related deficits in young females' driving performance. For example, personal traits such as rebelliousness and 'risk taking' have been associated with crash risk among young males but not among young females.

However, it is recognised that behaviour such as excessive speeding or manoeuvres such as following too closely, which are objectively risky, might be due not so much to deliberate risk taking or risk acceptance, as to lack of skill in hazard perception and

cognition. The higher crash risk of young, inexperienced drivers is seen to be a product of both motivational and skill-based factors.

## 6.3 Factors determining young driver exposure to risk

Decisions made prior to driving influence drivers' subsequent exposure to crash risk, independent of their actual driving performance. In spite of their conceptual independence, there is evidence of correlations between motivation which *increases exposure* to risk, and motivation to *drive* in a risky fashion.

For example, the proportion of a driver's total exposure which occurs at night, when crash risk is higher, is determined by a combination of 'lifestyle' and motivational factors which differ according to driver age. Young people drive more at night than older people, they drive less 'crashworthy' vehicles, and at least in some countries, they are less likely to wear seatbelts, particularly at night.

## 6.4 The 'young problem driver' issue

There is evidence of some correlation within the population of young drivers between level of exposure to risk (in terms of the above factors), the 'riskiness' of driving performance itself, and personal characteristics such as level of academic achievement and socio-economic status. Some researchers have interpreted such correlations as evidence of a 'risky behaviour syndrome', but the low magnitude of correlations casts doubt on its practical significance in the context of road safety.

A related issue is that of the so-called 'young problem driver'. In this case the main question is not primarily one about the *nature* of young drivers' characteristic skill deficits or risky behaviours; rather, it is about the *distribution patterns* of these characteristics *within* the group of young drivers. At the moment there is insufficient evidence to reach any clear conclusion on this matter.

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