M O N A S H U N I V E R S I T Y


# AN OVERVIEW OF NOVICE DRIVER PERFORMANCE ISSUES

# A LITERATURE REVIEW

by

Alan E Drummond

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**Author(s)**
Drummond, A.E.


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**Abstract:**

The over-involvement of young and/or inexperienced drivers in road accidents is a well established international phenomenon. Measures designed to make novice drivers safer per kilometre driven rather than reduce the number of kilometres they drive have failed to achieve positive outcomes. This report presents an applied literature review, designed to suggest future directions for the development of measures to improve novice driver performance.

The report deals with the issues of age versus experience, licensing age, the driving task and models of driving behaviour and correlates of accident involved young drivers to provide important background information. The suggested future directions have been principally drawn from the sections on perceptual skills, hazard/risk perception, the cognitive domain, risk taking and information processing and resource allocation issues. It is suggested that it is only when the differences between concurrently performed skills in capacity allocation (a reflection perhaps of different priorities or differing degrees of validity in the driving schema) and the effects of skill interactions as a function of driving experience are known that valid decisions on skills based countermeasures can be made.



**Key Words:**
Recently qualified driver, skill (road user), driving, driver training, education, accident rate, behaviour





Monash University Accident Research Centre,
Wellington Road, Clayton, Victoria, 3800, Australia.
Telephone: +61 3 9905 4371, Fax: +61 3 9905 4363

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# EXECUTIVE SUMMARY

The over-involvement of young and/or inexperienced drivers in road accidents is a well established international phenomenon. It has also shown itself to be one of the most intractable road safety problems, reflecting perhaps the complexity of the problem relative to other road safety issues. Measures designed to make novice drivers safer per kilometre driven rather than reduce the number of kilometres they drive have invariably failed to achieve positive outcomes. This is due in no small part to the fact that there is little empirical or theoretical indication as to what constitutes safe driving. It is therefore important to view the novice driver problem in a wider context.

An appropriate framework for novice driver safety revolves around the interaction of the following global factors:

- the skilled performance literature indicates that novices perform significantly worse than their more experienced counterparts for a variety of reasons associated with the nature of information processing

- there is mounting evidence that the riskiness of novice driver driving cannot be fully explained by skill decrements and that there is a motivational component contributing to their over-representation in accident statistics.

This report deals firstly with the issues of age versus experience (Section 3.0), licensing age (Section 4.0), the driving task and models of driving behaviour (Section 5.0), driver education and training (Section 6.0) and correlates of accident involved young drivers (Section 7.0) to provide important background information. This was an applied literature review, designed to suggest future directions for the development of measures to improve novice driver safety. It is principally from the remaining sections (perceptual skills, hazard/risk perception, the cognitive domain, risk taking and information processing and resource allocation issues) that this has been achieved.

Low risk on-road behaviour basically requires three things:

- the acquisition of necessary skills

- the ability to apply these skills efficiently and effectively when operating on the road and in traffic

- the willingness or motivation to apply these skills when operating on the road and in traffic.

The first two points relate to a skilled performance focus and represent the suggested future direction for novice driver countermeasures, primarily for pragmatic reasons in that it is considered to be potentially more productive in the short to medium term. Our understanding of general attitudinal components underlying age/experience related factors in driving (the third point) is still at a primitive level; safety measures derived from work in this area are a longer term undertaking.

The literature provides evidence (to varying degrees) of the following; skilled performance differences between novice and experienced drivers;

- novice drivers may have difficulties in judging gap clearance and closure speeds

- novice drivers have a smaller scanning range than experienced drivers and obtain less information from peripheral vision
- novice drivers look closer to the front of the car
- use vehicle mirrors less frequently as a means of obtaining visual information
- young drivers identify distant hazards relatively poorly
- young drivers tend to associate higher levels of hazard with non-moving factors whereas experienced drivers perceive moving objects as more hazardous
- inexperienced drivers have more difficulty in integrating diverse information into an overall assessment of hazardousness
- young drivers underestimate the risk of accident involvement and over estimate their driving ability
- indirect evidence suggests that young drivers may commit performance errors due to a failure to switch attention or because they revert to less efficient ways of processing information
- the novice driver is both less efficient and less effective in attentional distribution
- indirect evidence suggests that inexperienced drivers have fewer responses available to them when deciding what to do; response unavailability may be the most important factor in ineffective decision making.

However, this information is not sufficient by itself to develop novice driver safety measures as there is no guarantee that equipping novice drivers with anyone or more of the above skills means that they will actually be able to apply them when operating on the road. Actual performance is the outcome of an interaction between the absolute level of skill and the ability to perform this skill as one component. The latter aspect relates to the concept of resource (or capacity) allocation and the timesharing characteristics of complex skilled performance.

Thus, this report has strongly emphasised the driving of novice drivers in terms of schemas, plan or strategies. Any particular driving related skill is not performed in isolation (and therefore skills based countermeasures cannot be developed in isolation); rather, it is the outcome of multiple skill performance (i.e. The application of the driving schema) that contributes to safe, or otherwise, on-road behaviour.

The suggested future directions for novice driver safety research reflect these two factors directly by seeking answers to two fundamental questions:

- how do the priorities/models of driving vary, primarily in terms of efficiency and bias, as a function of driving experience and level of demand? That is, is the skilled performance of novice drivers differentially affected by concurrent tasks, and in these circumstances, do they favour different classes of skills (at the expense of others)?

- what are the most relatively important components of safe driving (operationalised as differences between experienced and inexperienced drivers), the acquisition of which should be accelerated to improve novice driver safety?

It is only when the differences between concurrently performed skills in capacity allocation (a reflection perhaps of different priorities or differing degrees of validity in the driving schema) and the effects of skill interactions as a function of driving experience are known that valid decisions on skills based countermeasures can be made.

# 1.0 INTRODUCTION

The over involvement of young and/or inexperienced drivers in road accidents is a well established international phenomenon (Drummond, 1988). It has also shown itself to be one of the most intractable road safety problems, reflecting perhaps the complexity of the problem relative to other road safety issues and the fact therefore that traditional road safety approaches are less applicable. Successful measures in this area have usually involved the reduction of the amount or type of novice driver exposure (e.g. night-time driving restrictions, zero blood alcohol limits); measures designed to make them safer per kilometre driven rather than reduce the number of kilometres they drive have invariably failed to achieve positive outcomes. This is due in no small part to the fact that there is little empirical or theoretical indication as to what constitutes safe driving. It is therefore important to view the novice driver problem in a wider context.

It should also be emphasised that investigation in this area involves the search for relatively subtle effects. With reasonable assumptions on the ratio of casualty to property damage only accidents, Victorian data suggests that drivers in the first twelve months of a probationary licence are involved on average in an accident approximately every 17,000 kilometres. While novice driver accident involvement rates are substantially worse than those of more experienced drivers (refer Figure 1), it is important to note that research in this area is not dealing with gross differences in driving performance as a function of experience.

Driving is a complex perceptual-motor skill, usually taking place in a complex environment. The first years of licensing also usually take place in the late teenage years which bring with them a number of factors which impact on the safety of driving. When trying to place a framework on novice driver safety, the interplay of the following global factors should receive consideration:

- the skilled performance literature indicates that novices perform significantly worse than their more experienced counterparts for a variety of reasons associated with the nature of information processing

- there is mounting evidence that the riskiness of novice driver driving cannot be fully explained by skill decrements and that there is a motivational component contributing to their over-representation in accident statistics.

These two aspects should not be seen as mutually exclusive (as they have been portrayed in the literature) but rather as interdependent; a comprehensive approach to the novice driver area should include elements of both aspects. This review deals with both aspects and while it recommends work in the skills area in the short term, this is primarily a pragmatic decision.

It is pointed out that this has been an applied literature review. That is, it is not a literature review of perceptual skill or decision making in driving (or any other component) as this would have been a massive undertaking. Rather, the various areas were reviewed in order to arrive at suggestions for the future direction of novice driver countermeasure development. This literature review covers the following major areas:

1. scope of the problem
2. the age versus experience issue
3. licensing age

4. the driving task and models of driving behaviour
5. driver education and training
6. correlates of accident involved young drivers
7. perceptual skills & hazard/risk perception
8. the cognitive domain
9. young driver risk taking
10. information processing and resource allocation issues
11. suggestions for further work

The first three serve as background information, the fourth provides a context for subsequent information and sections five through ten review specific major areas relevant to countermeasure development. The section on information processing and resource allocation expands on an aspect of skilled performance which is not usually considered in road safety while the final section presents suggestions for future work, based on the findings of the above.

# 2.0 SCOPE OF THE PROBLEM

## 2.1 THE INTERNATIONAL SITUATION

In all countries comparable to Australia in road safety terms, the novice driver is overrepresented in accidents as the following selection of general results demonstrate:

- U.S. teenagers are responsible for five times as many crash deaths per licence holder as drivers 35-64 years old (IIHS, 1984)

- 16 year old male U.S. drivers have the highest fatal accident rate (per 100 million miles travelled); the overall 16 year old fatal accident rate is some five to six times higher than that for drivers aged 30-59 years (Williams, 1984)

Table 1 presents driver casualty overrepresentation rates (per 100,000 population) of drivers aged 18-20 years relative to drivers aged 25-64 years (e.g. in Austria, drivers aged 18-20 are injured 3.4 times more often when compared to drivers aged 25-64 on a per capita basis)

**Table 1 Relative* Driver Casualty Overrepresentation Rates Per 100,000 Population for Drivers Aged 18- 20 Years By Country, 1982**

| Country | Overrepresentation Rate |
|---|---|
| Austria | 3.40 |
| Belgium | 1.65 |
| Netherlands | 2.04 |
| Norway | 4.56 |
| Spain | 1.35 |
| Sweden | 3.39 |
| Switzerland | 3.20 |
| West Germany | 3.62 |
| United Kingdom | 2.32 |
| United States | 1.98 |

* relative to drivers aged 25-64

- drivers aged 16-19 years in Japan had an accident rate of 251.1 per 10,000 driver licence holders compared to a rate of 83.8 for drivers aged 25-59 years, representing an overinvolvement rate of 3.0 (IATSS, 1983)

- Table 2 presents Canadian data (Warren, 1976) on the effect on fatality risk of two factors, viz, age and alcohol impairment. The product of these two factors results in an estimate of relative risk which reflects the combined effect of both age and alcohol impairment (relative to the fatality risk of the average non-impaired driver which has been set at 1.00)

**Table 2 Fatality Risk Factors by Age Group**

| Age Group | Age * | Alcohol * | Total Risk |
|---|---|---|---|
| 16-17 | 1.99 | 83 | 165 |
| 18-19 | 2.20 | 32 | 70 |
| 20-24 | 0.89 | 35 | 31 |
| 25-29 | 0.61 | 45 | 27 |
| 30-34 | 0.31 | 55 | 17 |
| 35-44 | 0.54 | 40 | 22 |
| 45-49 | 0.74 | 33 | 24 |
| 50+ | 1.69 | 23 | 39 |

* relative to average non-impaired driver
** relative to non-impaired driver of same age

- Thus, a 16/17 year old non-impaired driver is almost twice as likely to die in a road accident than the average driver, a 16/17 year old impaired driver is 83 times more likely to die in a road accident than a non-impaired driver of the same age and a 16/17 year old impaired driver is 165 times more likely than the average non-impaired driver to die in a road accident.

- The accident involvement rate per kilometre driven for 15 and 16 year olds in New Zealand is 4.7 times the rate for drivers over 22 years of age (White, 1979).

## 2.2 THE VICTORIAN SITUATION

In common with other jurisdictions, Victoria accident involvement rates using surrogate measures of driving exposure (e.g. per 10,000 licence holders) also demonstrated the overrepresentation of novice drivers (Deutsch, Healy & Strang, 1981). With the benefit of direct measures of (objectively assigned) distance travelled information collected through on-road exposure surveys (see Drummond and Healy, 1986), it is now possible to calculate the relative safety of novice drivers using a more appropriate exposure measure.

Figure 1 shows that the risk of accident involvement decreases steadily with licence experience, with those in the first twelve months of a licence being some 2.7 times more likely to be involved in a casualty accident than standard licence holders (those holding a licence for three years or more).

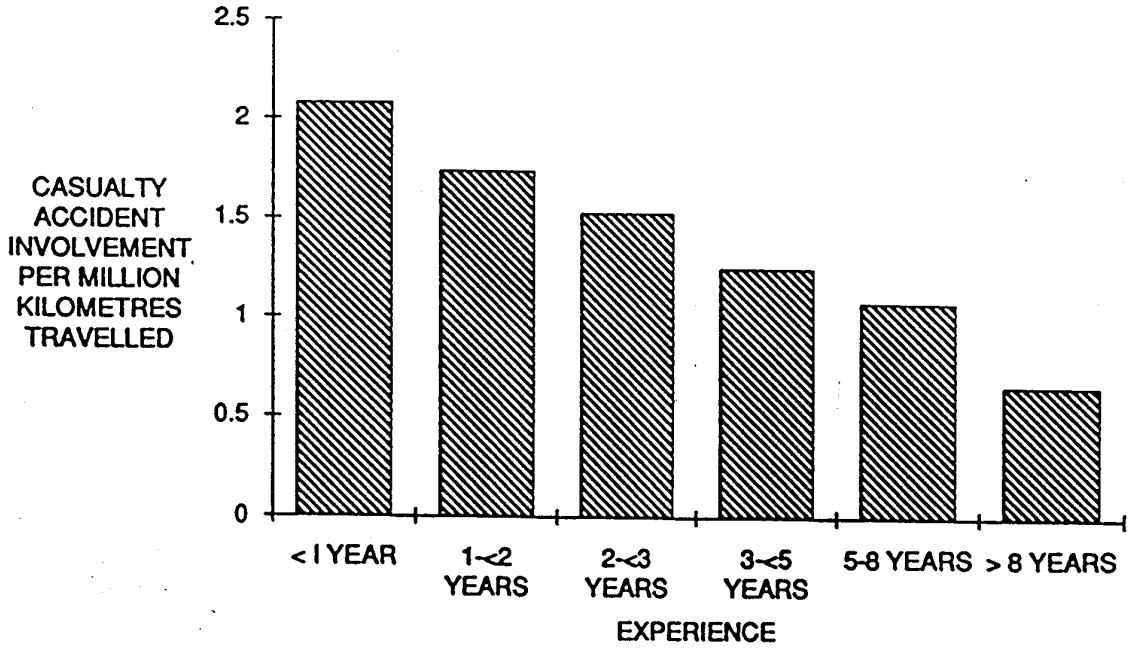



*Figure 1 Risk of Casualty Accident involvement by Time Held Licence, Victoria*

Other general findings of interest from this analysis were:

- the young driver problem has traditionally been thought of as a young male driver problem but Figure 2 shows that when accident involvement is adjusted for exposure, the sex difference is not appreciable in any experience category and virtually non-existent for the least experienced driver group.

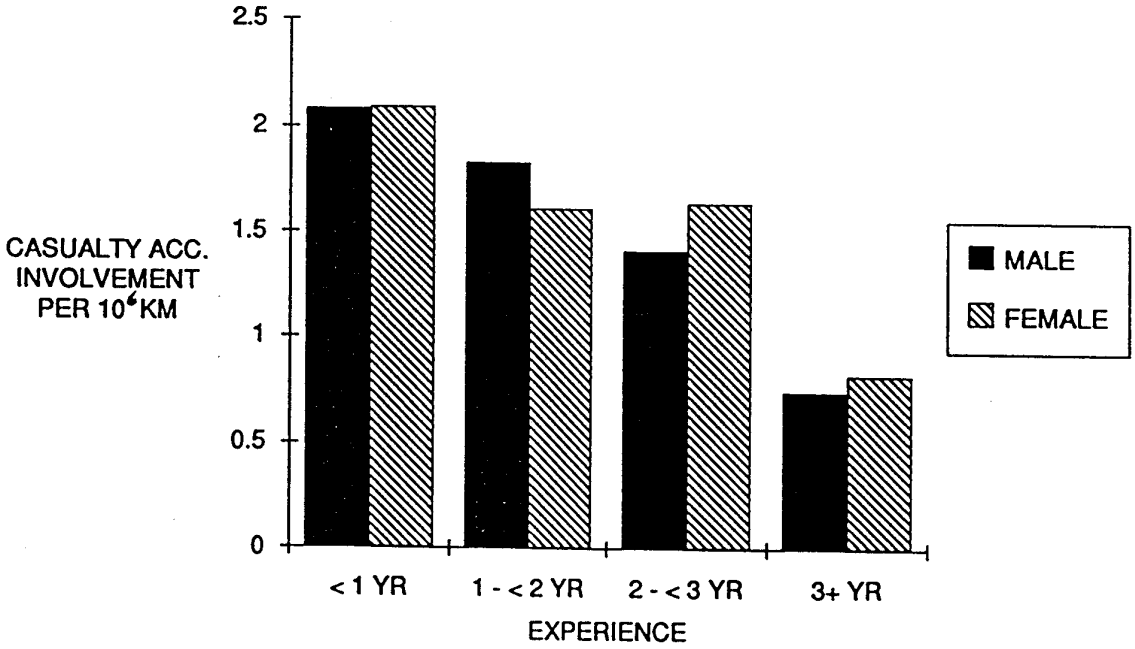



*Figure 2 Risk of Casualty Accident involvement by Driver Experience and Sex, Victoria*

- while night-time driving is associated with a higher risk of casualty accident involvement for all driver groups, drivers with less than one year's experience show:

    - the greatest night-time risk in absolute terms (2.8 accidents per million vehicle kilometres)

    - the largest increase in absolute tenus from day to night driving (1.01 accidents/million kms travelled c.f. 0.34 for standard licence holders)

    - The largest proportional increase in risk from day to night driving (58% compared with 33%, 28% and 49% respectively for the other driver groups)

    - an increasing level of risk relative to standard licence holders through the night, so that for the 1.00am to 5.00am period, they are 7.3 times more likely to be involved in a casualty accident (per unit distance).

- it has been demonstrated that novice drivers had a much higher proportion of their accidents while carrying two or more passengers than did 21-25 year old standard licence holders (Drummond and Torpey, 1984). Figure 3 shows that the carriage of passengers is associated with elevated risk for novice drivers.

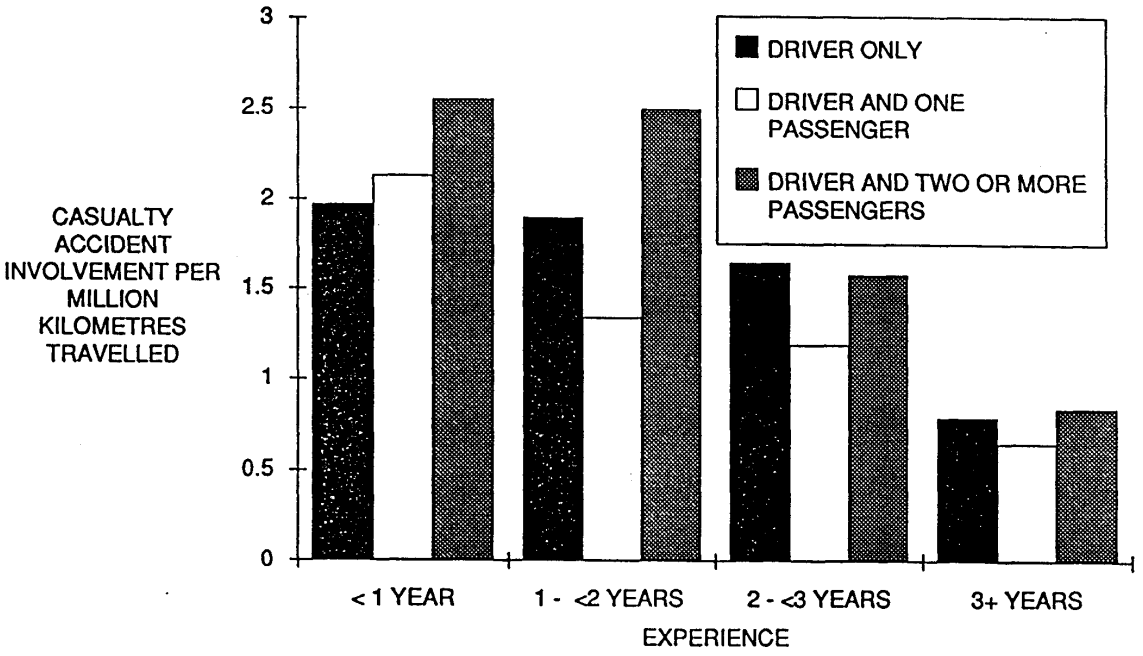



*Figure 3 Risk of Casualty Accident involvement by Vehicle Occupancy and Driver Experience*

## 3.0 AGE VERSUS EXPERIENCE

The debate over whether young age or the lack of experience is the major source of driving problems in the early years of licensing has been both sustained and inconclusive. Pelz and Schumann (1971) suggested age was the stronger predictor as accident involvement peaked one to three years after commencing driving (their finding that those commencing at 15 years of age had a delayed peak is difficult to explain in an age/experience context). A recent US study (State Farm Research 1988) examined accident frequency (without controlling for exposure but controlling for time held licence) and again found that age was by far the strongest indicator (of the variables studied) of accident frequency with 16 year old drivers being involved in 3.5 times as many accidents as drivers aged 17 to 24.

A number of other authors (e.g. Goldstein 1972, Macmillan 1975) have stressed that both age and experience are important and interacting variables with Macmillan (1975) making the point that thinking of the problem in terms of age per se is simplistic. Rather, there is a range of factors correlated with age that contribute to increased accident involvement (otherwise, with an age perspective, road safety practitioners would simply have to wait for young drivers to grow older!). This point has also been made by Warren, Simpson and Chattaway (1980) who distinguish between age and experience related factors on the basis of intention or volition. They see the young driver problem differently to the young problem driver; the former representing those drivers operating at high risk unintentionally as a result of experience/skill decrements while the elevated risk of the latter group tends to reflect intentional choices for certain modes of driving behaviour. At a sociological level, there is some evidence that increased accident involvement may be indicative of what has been called a wider social pathology (Hagger & Dax, 1977, Carlson and Klein, 1970). While this may be true in some instances, such information is not particularly helpful for countermeasure development and is certainly peripheral to the two major thrusts of skills acquisition and risk taking analysis.

Interestingly, the OECD report on driver instruction (OECD, 1976) indicates that European research tends to favour inexperience as the primary factor contributing to the poor safety record of novice drivers. However, the OECD report on young driver accidents (OECD, 1975) indicated that the relative contribution of experience related and age related factors was unclear but indicated that there was an antagonistic relationship between them (i.e. one exacerbates the other). It should also be pointed out that in the same way that age is a generic variable, experience is by no means a unidimensional variable (Jonah, 1986). Experience is obtained through being exposed to the risk of an accident which is known to vary by time of day, occupancy of vehicle, location etc. Despite the qualitative differences in 'experience' that are therefore likely to occur between drivers of the same age and same aggregate distance travelled, understanding of the concept of experience in the young driver arena has been restricted to its quantitative aspects.

As well as being both sustained and inconclusive, it is contended that the age versus experience issue could also be thought of as, to a large extent, irrelevant (certainly in the context of applied research and the search for countermeasures). As noted earlier, driving is a complex task that is performed in a (usually) complex environment. In-depth accident studies (e.g. Sabey and Staughton, 1975, Treat, Tumbas, Mcdonald, Shinar, Hume, Mayer, Stansifer and Castellan, 1979, McLean, Aust, Brewer and Sandow, 1979) show that there is usually a combination of contributory factors in any given accident. When the performance levels of novice drivers are insufficient to meet the demands of the traffic system, it is likely that age related and/or experience related factors will have contributed, to varying degrees. In addition to the relative contribution of these two generic factors to

novice driver accident involvement, it is also important to assess the probability of developing effective countermeasures. It is for this reason that, in the short term, it is recommended that emphasis be given to experience related (i.e. driving skill) factors as they are of direct road safety concern. Our understanding of general attitudinal components underlying age related factors in driving is still at a primitive level (Gardner 1988) and safety improvements in this area require long term, basic research.

It is acknowledged that there is some influential opposition to such an approach. For example, two widely known models of driving (Naatanen and Summala, 1976; Wilde 1982) would both contend in different ways that improving actual driver performance may not necessarily improve their level of operating safety. These models assign great importance to motivational aspects of driving and propose that the additional motives which drivers satisfy through driving are either independent of, or more potent than, safety related motives.

The very strong conclusion from this discussion is that a better understanding of the driving task, in all of its dimensions, is required for the future development of safety measures; this approach applies even more so in the area of novice driver safety where traditional, descriptive approaches to countermeasure development have not been productive. An alternative view has been put forward by Sivak (1981) who suggested that the most productive approach may lie in rigorous research on the effects of transient states (fatigue, alcohol impairment, etc) on a variety of skills with good face validity to driving, thus obviating the need for fundamental research on the nature and demands of the driving task. Further discussion of these issues is dealt with in the section on driving models.

## 4.0 LICENSING AGE

A decision as to the minimum age at which people can obtain a driver's licence allowing solo driving is only partly based or reviewed on road safety grounds. Although there is a wide variation in licensing age between motorised jurisdictions, ranging from 15 years of age in New Zealand to 18 in the State of Victoria, Australia, there have apparently been few reasons advanced for the choice of any particular age. Cameron and MacDonald (1973) suggest that the minimum age is based on the assessment of two implicit criteria:

- the skills required for on-road driving are too difficult for a juvenile
- drivers should have the capacity to bear the potential financial responsibilities that may flow from participation in the traffic system.

While the initial choice of licensing age may be an historical artefact, it is clear that this age plays a central role in novice driver safety, in terms of both absolute safety outcomes and potential strategies for improving novice driver safety. Given its centrality, there have been relatively few studies which have addressed the issue directly. Cameron (1972) analysed data from two Australian States in an attempt to determine the optimum age for driver licensing. His data showed that the accident rate (per driver) was no worse for drivers aged 16 to 18 years than for those aged 18 to 20 years. Similar to the findings of Pelz and Schuman (1971), rates tended to peak between the ages of 18 and 20 although there was an indication that those who commenced driving at 16 or 17 tended to have a lower peak, due perhaps to the benefits of accumulated experience. Further support for a lower licensing age was derived from the principle of separating legal drinking and legal driving ages.

The approach adopted by Cameron is an example of adopting a mobility model, i.e. assessing the impact of variations in licensing age on an (individual) rate basis and implicitly assigning a nett positive value to the driving mobility of very young drivers. In this vein, a report presented to and subsequently endorsed by the Australian Transport Advisory Council (ACRUPTC, 1980) stated that "It is therefore desirable for the licensing age to be as low as is practicable, to extend the benefits of car usage to as wide a group as possible". Henderson (1972) on the other hand adopted a public health model which uses the absolute impact of greater exposure (i.e. more accidents) as its evaluation criterion and argued for the continued development of traffic safety programs as the prime means of influencing young driver safety. He accurately anticipated problems in Victoria more than a decade later by suggesting that the demand for mobility would be greater than the demand for safety.

In an evaluation of the effect of the withdrawal of driver education in Connecticut, Robertson (1980) noted that 20% of licensed 16 year olds would be involved in a casualty accident (or an accident involving $400 or more property damage) before their eighteenth birthday. In the driver education debate, the issue of the value of this mobility relative to this level of crash involvement has not been the subject of rational debate.

Toomath and White (1982) analysed New Zealand accident and exposure data and concluded that a lower licensing age leads to nett benefit in terms of absolute accidents, thus refuting the thrust of the public health model. As far as the author knows, this is the only occasion on which findings of this type have been reported. Karpf and Williams (1983) reviewed overinvolvement rates of young American drivers and suggested that

consideration be given to raising the licensing age to 17 or 18 years, a move which would produce a nett road safety benefit.

Drummond (1986) evaluated the effect of the different licensing ages in the various Australian States, controlling for differences in levels of safety and accident reporting rates by standardising the accident involvement rates for 26 to 59 year old drivers and adjusting young driver involvement rates accordingly. It was found that in other States (with lower licensing ages) the additional accidents resulting from allowing persons to drive below age 18 were not offset by their lower accident rates at ages 18-20. Furthermore, the proportion of 18-21 year olds who hold a licence in Victoria was lower than that in most other States. It was concluded that the higher licensing age results in a nett road safety benefit (in public health terms) even though the accident involvement rate of 18 and 19 year old drivers in Victoria is generally higher than that of first and second year drivers in other States.

As noted above, the need to separate the legal drinking and driving ages is often advanced as an argument for lowering the licensing age. Drummond (1987) examined the validity of this argument and concluded that a positive effect (if any) due to the separation of legal drinking and driving ages is diluted by under-age exposure to alcohol and swamped by the safety disadvantages of increased exposure. Hurst and Badger (1987) investigated the same question using a different method of analysis and concluded that from a public health perspective, a higher licensing age should probably be chosen. However, they also pointed out the need for a systems approach to be adopted in order to determine the actual effect of exposure denial to young drivers, including the extent to which this potential exposure is replaced by other drivers.

In summary, the choice of licensing age is a crucial determinant of the public health outcomes of young driver driving. However, licensing age is often viewed as a given in any jurisdiction rather than a variable which can be manipulated to achieve optimal safety outcomes. It is an issue which transcends the road safety perspective but, while the benefits in terms of accident reduction can be reasonably estimated, there is little information on the value of novice driver mobility to be used for comparative purposes.

# 5.0 THE DRIVING TASK AND MODELS OF DRIVING BEHAVIOUR

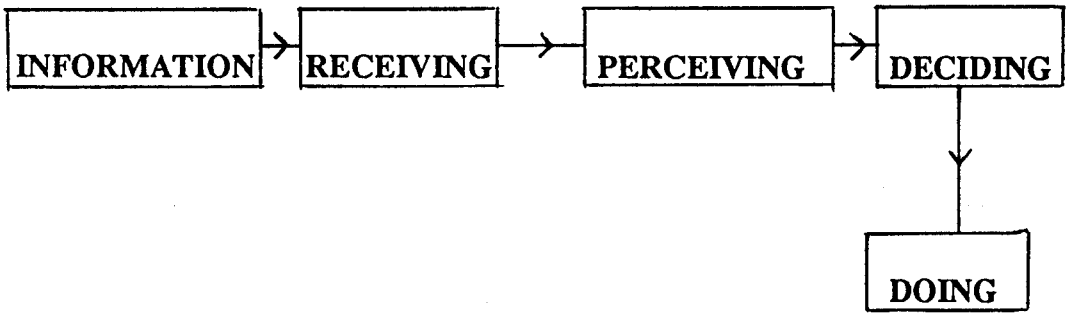
## 5.1 INTRODUCTION

Two major paradigms have emerged within which the novice driver safety problem is being addressed. Although proponents of these paradigms, especially of the motivational approach, would disagree it is contended that they should more appropriately be regarded as complementary rather than mutually exclusive. In many ways, this divergence parallels the age and/or experience discussion over the most valid way of tackling the problem. The two approaches are discussed below.

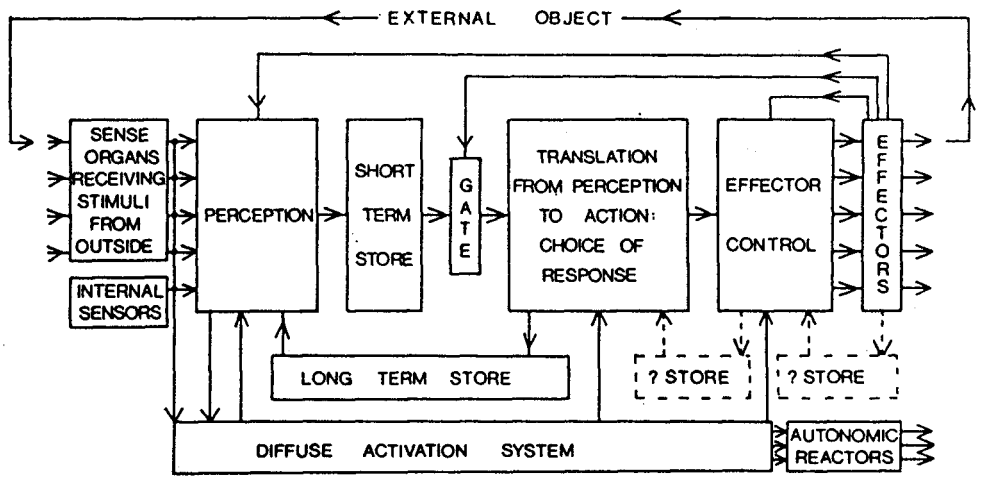
It is certainly not intended that this section provide comprehensive coverage and/or a critical review of current driver behaviour models. There are several excellent reviews (see for example Johnston and Perry, 1980; Michon, 1985) and extended coverage of motivational models in two recent publications (Ergonomics, Vol 31(4) 1988; Rothengatter and De Bruin (Eds), 1988). Rather, this section has been included to expand on the two interrelated approaches to improving novice driver safety, namely by improving the various psychological processes associated with the driving task in principle and by addressing the motivational which both directly and indirectly affect the application of such skills in real world performance.

## 5.2 INFORMATION PROCESSING MODELS

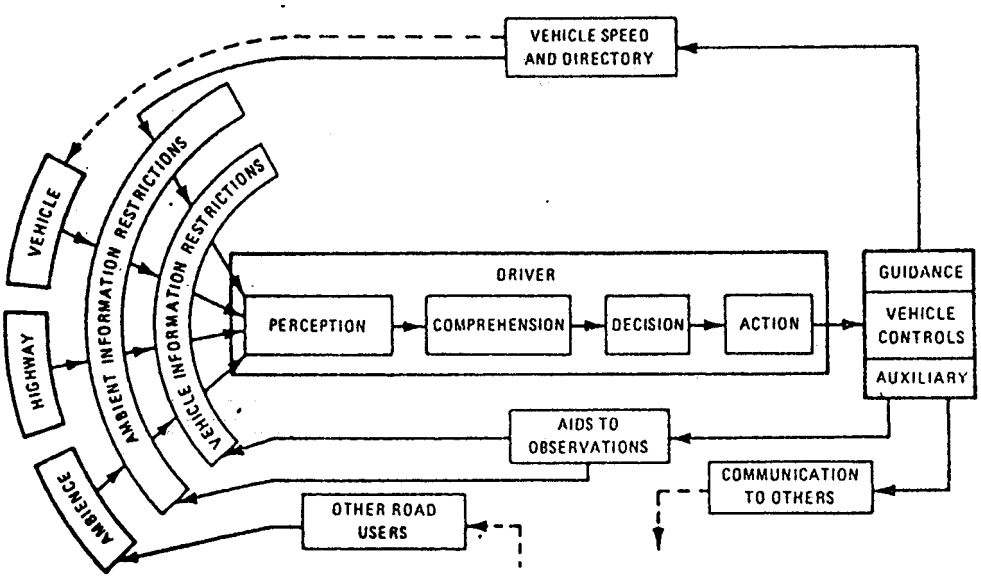
The driving task can be described in traditional information processing terms, requiring as it does the extraction of relevant information from the environment, processing of these data and the making of decisions and the continuous monitoring of performance. There have been a variety of models proposed in the literature, all based on the same theoretical concepts but differing in complexity. They generally portray the four generic components of sensation, perception, decision making and incorporation of feedback in slightly different ways (Marteniuk, 1976). While the human performance model can be simply represented as:




with various feedback loops, the model provided by Welford (1976) and shown below serves as an excellent framework.




Such an information processing system has been placed in a driving context by Fell (1976); this is presented below.




Thus, the essence of skilled driving could be considered. To involve the timely integration of relevant information into the decision making process, with monitoring/regulation of performance through awareness of feedback. Given this, there are three central dimensions which deserve further consideration when dealing with driving performance as a function of experience. These are:

- Anticipation

  Given the lags in information processing due to its serial nature and the fact that, with regard to the often complex nature of the driving environment, information is available from a large number of sources, the extent to which drivers can operate in advance of real time is a hallmark of experience.

- Expectancies/Priorities

  Given the potential complexity of driving performance, it is not possible (nor perhaps desirable) for drivers to avail themselves of all possible information. The

perceptual opportunity costs from restricted information gathering are overcome in two ways as experience increases;

1. information gaps are filled in on the basis of more valid expectancies of events, as likelihood estimates of any range of possible scenarios are refined through direct experience

2. information gathering is optimised through experience so that crucial, situation-specific information is recognised and processed.

- Capacity/Resource Allocation

  The efficiency of processing improves as it shifts from controlled to automatic processing (Schneider and Shiffrin, 1977). This reflects improvements in a number of areas including the automaticity of basic driving skills, the recoiling of task information into larger, though more complex, bits and the refinement of the model or schema which guides the overall driving task.

The concept of model driven driving is of central importance to the proposed future directions of novice driver safety research (as is the area of resource allocation - see the section on suggested future work). While a task analysis of driving has listed some 1500 elements (McKnight and Hundt, 1970), it is totally unrealistic to expect drivers to operate at such a rudimentary level. Rather, drivers implement skilled performance in accordance with a plan/schema/model which both dictates driving and, in situation-specific terms, is dictated to by driving. As Neisser (1976) states, a schema is "...a pattern of action as well as a pattern for action". It is not reasonable to conceive of all the elements of driving to be subsequently described in this report, the perceptual components of driving, attention, decision making, information processing, in short the elements involved in complex psychomotor performance, cannot be applied afresh and continuously during every driving episode. Thus, driving experience could be seen as facilitating the progression from "...a kind of stimulus response mode to a pre-programmed mode which makes performance relatively stable..." (Riemersma, 1979).

The concept of a strategic level to human performance gained acceptance some time ago (see for example, Miller, Galanter and Pribram, 1960; Neisser, 1976). Whether it is called a schema, an image, a plan, a model, an algorithm or a strategy, the concept remains the same, viz, the purposeful co-ordination of capacities (both skills and resources) to meet the perceived demands of the task at hand effectively and efficiently. Thus, experienced driving could perhaps be seen just as validly in terms of what is decided as being unnecessary to do as in the usual way of what is done. The cognitive structure, therefore, to support safe driving is developed and validated through experience and has two major advantages:

i) it facilitates normal performance through the valid and efficient application of skills and resources, having apparently developed in an ad hoc, individual manner through experience, given the absence of formal input.

ii) when events not catered for by the model are encountered, it increases the probability of the driver responding appropriately.

Thus, it is important to view skill related aspects of driving in their proper context and that is as components of the driver's schema. This emphasises again that differences in

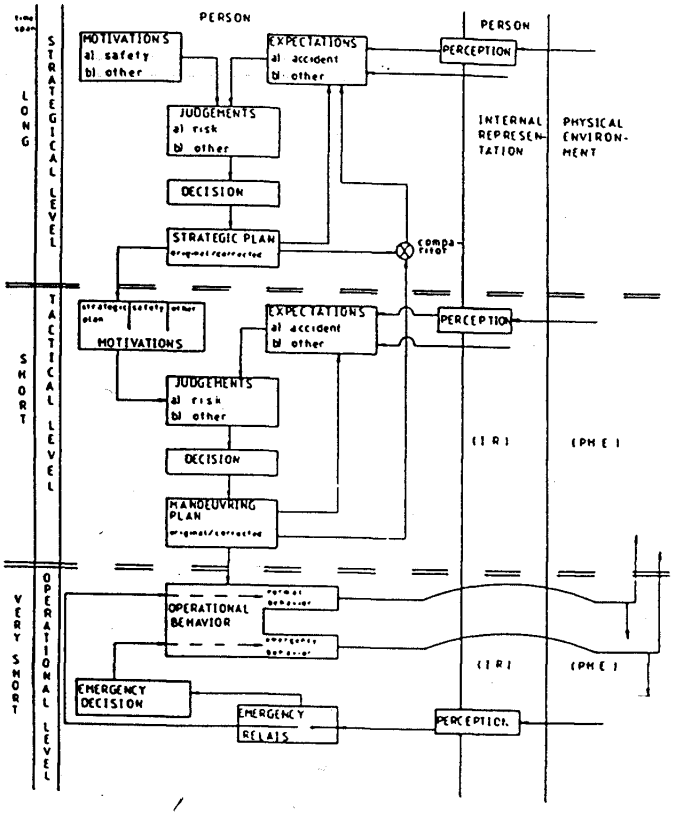
performance of isolated skills may reflect either varying skill levels or strategies (and hence the level of "service" to the particular skill). It is a central contention of this report that it is only when the relative importance of skills and resources (and their interaction via schemata) are understood that potentially effective novice driver risk reduction measures can be developed.

## 5.3 MOTIVATIONAL MODELS

In its most summary form, this perspective states that the most enduring approach to increasing the level of safety on the road is to alter the value of behaving in a range of ways which are seen as antagonistic to safety but which satisfy other motives for driving.

While very different in approach, the two best known approaches in this area are probably the zero risk theory of driver behaviour (Naatanen and Summala, 1976; Summala, 1988) and the Risk Homeostasis theory (see for example, Wilde, 1982; Wilde, 1988). These have been dominant of the field at the conceptual/descriptive level since their formulation. However, for the present purposes, the model proposed by van der Molen and Botticher (1987) is most appropriate in describing the motivational perspective. The model, presented below, takes a more detailed approach and supports more direct application to real world traffic situations. The model is hierarchically structured, incorporating both long term, short term and immediate concerns, and safety issues "compete" with other issues in order to arrive at decisions on driving behaviour.

Thus, the contribution of motivational models is to place driving in its personal and social context by illustrating that safety is not the only motive that drivers are attempting to satisfy during each trip. The modification of driver motives towards those more consistent with a safety objective can potentially make a very great contribution to road safety; it will require a sustained research effort to realise this goal.



# 6.0 DRIVER EDUCATION AND TRAINING

## 6.1 INTRODUCTION

There can be no doubt that by far the greatest level of activity in the novice driver safety area has been directed to the area of novice driver preparation methods. This has taken a wide variety of forms but whether it is called pre-driver education, (advanced) driver training or, post-licence, defensive driving or driver improvement, the general aim remains the same. This aim is in general terms to ensure that the beginning driver is 'equipped' to undertake the driving task safely when a licence is first obtained or through remedial treatment in the subsequent stages of driving. It is apparent that the major flaw in this approach is that nobody has defined precisely what this aim actually means.

It is perhaps too easy to dismiss this strategy in the light of the available literature, giving as it does a pessimistic view on the efficacy of education and training. However, despite the early warning by Goldstein (1971) that 'this is not an area where good common sense can suffice', the lack of appropriate content in such courses stands out as the single greatest contributor to this overall outcome. Thus, the process of education and training has been unfairly dealt with due to major content problems. At a conceptual level, there is no reason why the strategy of skill acquisition through a structured educational approach should not apply effectively to driving in the same way as it successfully applies to many other areas of skilled performance.

## 6.2 CONCEPTUAL ISSUES

Before proceeding to a relatively brief review of outcome studies (as this is to a large extent incidental to the main thrust of this report), it is appropriate to deal with education and training strategies at a conceptual level first (primarily because it is felt that the greatest single contribution to the failure of this general strategy of driver preparation comes from conceptual inadequacies).

An overview of this field would suggest that there has been a very large imbalance between process and content issues. While it is logical to determine what the important dimensions of driving to be taught/trained are (i.e. content issues) before developing methods for transmitting this information (i.e. process issues), there can be little doubt that process issues have received by far the greatest attention. While this point was made some 15 years ago (Cameron and MacDonald, 1973), this trend has unfortunately been maintained and has led to some evaluation studies confining themselves to comparisons of different focus of driver education (e.g. Ohlson & Stoke; 1986; Dreyer & Janke, 1979). This approach accepts the current forms of education and training as a given and works within the defined educative framework rather than addressing the more fundamental questions which may ultimately lead to the development of safety enhancing programs. This may be because driver education is a well entrenched program (see for example Butler 1982) which is now expected to be widely available, presumably for reasons other than safety (this point is expanded below).

It is difficult to understand why there is so little sophistication in course content. While the courses often cover a wide range of areas, they are often areas with high face validity. Rothengatter (1987) stresses that the formulation of educational objectives must be based on empirical evidence to ensure that the approach is both relevant and valid. It is precisely this type of information which has failed to be incorporated (not that we know all that we

need to know!); this deficiency is compounded by the fact that the information which is incorporated into the educative approach is relatively unsophisticated (compared to what is known about other elements of the traffic system) and it should therefore not be considered surprising that little of benefit has been demonstrated (Raymond, Risk & Shaoul, 1973).

Thus, the fact that there is no substantive theoretical foundation to the education/training approach (Saffron, 1981) presents the major problem. Given this lack of real understanding of the driving task, driver education often reverts to a series of global rules (Shaoul, 1975). While Shaoul terms this a "persuasive model", the gap between what is taught and what the driving task requires, taking into account the dynamic demands of traffic, the environment and the vehicle, almost guarantees that such education and training strategies will fail to meet their safety objective.

In the OECD report on driver instruction (OECD, 1976), the following summary is given,

> "...essential finding is that, in most countries, driver education is based on vague foundations, intuitive concepts of the driver task and objectives not specific enough to contribute to effective program development and evaluation."

It is unfortunately the case that this criticism applies equally well towards the end of the 1980s, as it did when it was written in the mid 1970s.

## 6.3 RATIONALE

The perspective outlined above is of course only valid if driver education/training is viewed as a safety measure. It is reasonable to contend that such courses, driver licensing manuals, driving lessons and so on do convey the basic information and skills that are a necessary (but not sufficient) pre-requisite to safe driving. It is unrealistic to expect totally naive applicants to undertake licence tests, having had no behind the wheel training, no exposure to road law or no experience of basic vehicle operation. This suggests that the educative approach may be fulfilling non-safety objectives; in this vein, Campbell (1980) has explicitly stated a hierarchy of aims for driver training and the consequent criteria for program success. Briefly, the hierarchy embraces:

1. making vehicle operators out of those who are not

2. ensuring knowledge of rules and road law in those that don't possess it

3. producing drivers safer than those who have not been so trained.

It is only on the last point that all current/previous driver preparation strategies can be taken to task and one which has been stated by Lund, Williams & Zador (1986) who undertook further analysis of data from the De Kalb County driver education evaluation. The very last sentence in the article states,

> "...high school driver education should be viewed only as a method for teaching basic driving skills and not as a strategy for reducing teenagers' involvement in crashes."

The demonstrated failures on the safety component of this hierarchy has provided the motivation for the development of graduated licensing schemes (Waller, 1975; Budd, Boughton & Quayle, 1982). This shifts the onus of responsibility for the learning of safe

driving skills onto novice drivers and is in effect saying that discovery learning is the best method by which the requisite skills can be acquired (in order to overcome experience related factors). This learning by trial and error, where the potential for error is reduced through the structuring of exposure, may be complemented by maturational effects (decreasing the effects of age related factors) so that the most difficult driving period in both experience and age tenus (the first few years/late teenage years) can be negotiated as safely as possible. However, this approach is a passive one and, at least in Victoria (if it involves lowering the age at which unaccompanied driving begins), is in contradiction with the public health model of road safety (Drummond, 1986).

A final relevant point in this discussion has been raised by McKnight (1985) who has suggested that safety related aspects of driver education be delayed until basic driving skills have been satisfactorily acquired. Such follow-up driver education could be implemented in a graduated licensing framework to gain benefits from (structured) real world experience and a more relevant educational program, given perhaps at a time when the student is more able to learn.

## 6.4 OUTCOME STUDIES

The evaluation of driver preparation strategies has had a chequered history, with the validity of both experimental design and evaluation criteria contributing to varying outcomes over time.

The issue of evaluation criteria is not specific to this particular field of road safety research and encompasses two issues. The first relates to the nature of the criteria; Shaoul (1975) makes the point that driver education programs aim to change behaviour but are subsequently evaluated on other terms, i.e. accidents, to which the specific behavioural changes can make varying contributions. Engel, Paskaruk & Green (1978) report on a program whose purpose was to produce four tests to be used as evaluation criteria in the areas of knowledge, driving performance in normal traffic, attitudes and driving related skills aptitude. While such an approach avoids the narrow (usual) use of knowledge and attitudes, the rationale for selecting these tests and the relationship(s) between the factors measured by the tests and accident involvement is unclear. Brown, Groeger and Biehl (1987) have pointed out both the need for establishing causal links between driver behaviours and accidents and the logical difficulties that flow from using a single, gross criterion measure (accident involvement) as a measure of success in operating in a very complex area.

The second, and more important in public health terms, issue is how the level of safety achieved (number of accidents) should be assessed, i.e. whether it should be in terms of accidents per licence holder or accidents per capita. This is a crucial distinction, especially in jurisdictions with lower licensing ages, as completion of driver education is associated with higher licensing rates (and therefore greater exposure to risk) without a sufficiently high, (if any) compensatory reduction in risk to offset this expanded exposure.

The first evidence of a public health disbenefit from education and training appears to have come from Raymond, Risk and Shaoul (1973) and expanded upon by Shaoul (1975). The results of the Salford driver training study indicated fewer crashes per driver but similar crashes per unit exposure (the study used a non-random control group). More importantly, the study provided some evidence that participation in the training program increased the number of licensed drivers (relative to the control group) for a period of up to five years. This point was subsequently explored in a number of U.S. studies (Robertson & Zador,

1978; Seaver, Nichols, Carlson & Voas, 1978; Robertson, 1980,). The consensus from this work is that participation in formal driver education/training schemes increases the rate of licensing and therefore the involvement of teenage drivers in crashes. In the final report on the Safe Performance Curriculum Demonstration Project (Stock, Weaver, Ray, Brink & Sadof, 1983), the public health disbenefit (i.e. The increased rate of accident involvement per capita) was not established. However, Lund, Williams & Zador (1986) re-examined the data and noted a number of factors which may have served to attenuate the licensing rate differences between treatment and control groups. These factors comprised the incorporation of only those students who stated they intended to obtain a licence as soon as possible into the evaluation, insurance discounts for around 10% of the control group and peer group pressures. The results of the re-analysis established the presence of a public health disbenefit due to participation in driver education.

## 6.5 REVIEW OF STUDIES

General reviews of driver preparation or remedial education strategies have all noted that any benefits apparently derived from participation were attributable to the type of person receiving the 'treatment' rather than the nature of the 'treatment' (see, for example, Budd, Boughton & Quayle, 1982; Butler, 1982; Campbell, 1980; Goldstein, 1971; Lund & Williams, 1984; Saffron, 1981). The Safe Performance Curriculum (De Kalb County) Evaluation is usually held up as the preferred model due to its random allocation strategy - the element most notable by its absence in other evaluations. Self selection or volunteer bias as a major contaminating factor had been noted as early as the late 1960s (Asher, 1968) who noted that people taking driver education were different in important respects to those not participating. Lund & Williams (1984) in a review of defensive driving course evaluations (which concluded that the best scientific evidence indicates that DDC does not decrease the likelihood of motor vehicle crashes) point out that positive evaluation outcomes have invariably been associated with poorer experimental designs.

Raymond, Risk & Shaoul (1973) assessed the impact of a driver education course in Salford, U .K. The reported results indicate the importance of the rate criterion adopted as the accident rate per driver favoured the trained group while the accident rate per unit distance favoured the control group. However, if the latter analysis was restricted to injury accidents, there was no significant difference between the groups. Their conclusion that, given continued development of the program, "the future for driver education looks fairly good", could be interpreted as damning the program with faint praise.

A couple of studies located have started from the position that it is more appropriate to evaluate different forms of treatment rather than make treatment-control comparisons (as driver education is so deeply ingrained). Dreyer & Janke (1979) assessed the relative effects of range and non-range driver training. While the design and analysis aspects were superior to the normal evaluation, the study was apparently beset with operational difficulties which makes the pattern of results very difficult to interpret. Students who underwent range (i.e. off-road) training reported fewer subsequent accidents but there was no difference when the analysis was restricted to police reported accidents. At the same time, performance on intermediate criteria (skill and knowledge) was higher among non-range trained students. Ohlson & Stoke (1986) examined the crash and conviction records of novice drivers over the first three years of driving as a function of the driver training program attended. Students receiving the simpler form of training demonstrated a lower conviction rate (per 100 students) than did those receiving more comprehensive training programs.

The U.S. Highway Safety Standard for Driver Education explicitly mentions that students should receive practice driving and instruction in basic and advanced driving techniques, including techniques for handling emergencies. Both Council, Sadof, Roper & Desper (1975) and Bathhurst (1980) have investigated emergency manoeuvre training. While Bathurst noted that initial differences between novice and experienced drivers had disappeared (and both groups had improved) following the training program, the review by Council et al indicated a lack of positive outcomes (although none of the studies addressed novice drivers directly. The potentially negative interaction between this specific set of skills, the motivational component of novice driving and levels of risk taking was also noted. This has some parallels with the "immunization" concept proposed by Pelz (1976) who observed initially more dangerous, but subsequently safer, driving by young participants in traffic workshops.

As mentioned above, the De Kalb County study is regarded as the most scientific attempt to evaluate driver education (again, it should be emphasised that the Safe Performance Curriculum was the object of the evaluation and not the principle of driver education). Subjects were randomly assigned to one of three groups, namely:

- a comprehensive program based on the Safe Performance Curriculum (SPC), involving classroom, simulator and on- and off-road training
- a standard pre driver licence training (PDL) program
- a control group.

The final report (Stock et al, 1983) arrived at the following conclusions:

- as mentioned above, per capita accident and violation rates of SPC, PDL and control drivers were not statistically significant (i.e. There was no public health disbenefit observed from higher licensing rates amongst treated drivers)
- accident and violation rates per licensed driver (who completed the course[s]) were significantly lower in the SPC and PDL groups, compared to the control group, in the first six months of licensed driving but were no different in the second and subsequent six monthly periods.

As pointed out above, Lund et al (1986) re-examined the data and findings and noted that the difference in per licensed driver rates were very similar to differences in reported exposure (both distance and duration of travel) and so may have been no more than an artefact of (lower) exposure. While the differences in average daily time or distance of travel are not large in absolute terms (4 miles/day, around 7 minutes/day) and the original evaluators considered them not to be of sufficient magnitude to account for the accident and violation effects found, there is a strong similarity in proportional terms between crash and exposure variations by group (refer Table 1, Lund et al, 1986). However, no analysis was reported by the evaluators, or subsequently by Lund et al, as to whether the measured differences in exposure reflect real differences between the groups. As noted in the previous section, this re-examination also indicated a number of factors which had the potential to mask public health disbenefits. Re-analysis using more powerful statistical techniques produced evidence of higher per capita accident and violation rates amongst treated drivers, thus supporting earlier research (e.g. Robertson and Zador, 1978; Seaver et al, 1978; Robertson, 1980).

## 7.0 CORRELATES OF ACCIDENT INVOLVED YOUNG DRIVERS

Young driver safety research reflects the typical evolutionary pattern of most facets of safety research in that there was an early emphasis on the role of individual differences in accident involvement. Accident proneness, defined very broadly, was the dominant paradigm and research was directed at determining the psychological and sociological correlates of accident involved drivers.

A selection of those qualities which have been identified as being more commonly associated with accident involved or violation incurring young drivers compared to either older, more experienced drivers or non accident involved young drivers is given below:

- low intelligence, youthfulness and a personality makeup in which social responsibility is lacking are broad characteristics which seem most closely related to accidents (McFarland, Moore & Warren, 1955). Consistent with the introductory points above, it was suggested that biographical data on the extent of adjustment (either personal, social or economic) are the most useful in distinguishing safe from unsafe drivers.

- the deviant behaviour of 16-19 year old drivers convicted of two or more traffic violations can be partially explained by:

    - a lack of thought about the implications of their behaviour

    - perceptions of repression

    - rebelliousness and selfishness

    - hypersensitiveness, lack of self confidence and feelings of 'personal unworthiness'

    - a reduced sense of civic responsibility (Beamish & Malfetti, 1962).

- education (failure or participation in vocational courses) factors, being a regular cigarette smoker before the age of 16 years:, commencing full time employment at/before age 17 (and before licensure) or having been charged with non-traffic offences were all significantly more frequent in an accident group (Kraus, Steel, Ghent & Thompson, 1970).

- drivers aged 16-20 years and involved in accidents or offences scored highest on 'impulse expression' compared to 21 to 24 year old drivers, as manifested by:

    - anger in frustrating traffic situations

    - driving as a relief from problems

    - daredevil driving (Schuman, Pelz, Ehrlich & Selzer, 1967)

- accident involved drivers aged 16-20 years were more likely to have fathers in higher level occupations, compared to new licensees (Waller, 1970)

- Asher and Dodson (1971) correlated 377 social and psychological measures against accident involvement and found a number of significant, but very low, correlations.

The general pattern was a negative relationship between social /economic /educational dimensions and accident involvement.

- characteristics of accident involved drivers, many of which are age-related, include being emotionally less mature, less responsible and relatively less well adjusted (McGuire, 1976)

- Mayer and Treat (1977) administered a 24 page questionnaire to a young 'accidents' group and a young 'no accidents' group. The 22 scales related to personal and social maladjustment, impulse/risk taking expression and clerical ability. A number of scales correlated with one another so discriminant analysis was used to reduce the 22 scales to seven, comprising citizenship, antisocial tendencies, general psychopathology, number comparison, negativism, external control and school socialisation. The discriminant function subsequently assigned 14 students (7 in each group) to their correct group with 86% accuracy. While the questionnaire was a potpourri of items, the authors speculated that one explanation for findings such as these may be the influence that 'maladjustment' has on information processing performance.

While correlational relationships such as those listed above are not particularly useful in practical terms, and should never be seen as ends in themselves, it does provide general evidence that a proportion of young driver accidents are likely to be due to young 'problem' drivers. Indeed, Klein (1972) went so far as to suggest that deviant driving was to be expected as young drivers were members of a deviant population.

Despite absolute claims such as this, evidence in the area serves to further reinforce the view that novice driver safety has two, complementary aspects - the skills-based and the motivational - and that safety improvements can potentially be derived from both. However, there are no data available which would allow the relative contribution of each aspect (and the relative effectiveness of potential countermeasures in each area). To this end, further work on correlates of accident involved drivers cannot be supported; rather, more detailed work is required on each of the above two aspects.

## 8.0 PERCEPTUAL SKILLS

information required for the driving task is primarily obtained through visual functioning (Riemersma, Moraal & Godthelp, 1985). While relationships between visual ability and accident involvement are generally weak and applicable to older age groups (Davison, 1986), the driving task relies more on the application of perceptual skills than the absolute level of visual ability. This issue is consistently brought to the fore in in-depth studies which consistently report perceptual error as a significant contributing factor to accident occurrence (see, for example, Sabey and Staughton, 1975). It is thus not unrealistic to expect that differences in perceptual driving skill levels as a function of driving experience may contribute to the overinvolvement of novice drivers in crashes. This section reviews the evidence on perceptual skill differences.

Barry, Roper and Pitts (1974) analysed accident data in an attempt to provide information on critical manoeuvres for inclusion in the North Carolina driver education program. The guiding hypothesis however, that crashes of 16-18 year old drivers are more likely to involve emergency situations such as brake failure, tyre blowouts or skidding, seems to be slanted more toward vehicle related than driver related factors. While the emergency situations analysis did not prove fruitful, additional coding and analysis of multi-vehicle accidents suggested that young drivers were overrepresented in pulling out into the path of oncoming traffic and rear end collisions. The authors speculated that this may be indicative of inexperience in judging gap clearance and closure speeds.

This approach was greatly expanded in the work of Lohmann, Leggett, Stewart and Campbell (1976) who combined accident and exposure (frequency of occurrence) data to estimate the relative risk of various unsafe driving actions (UDAs). Comparisons of the age category distributions (youth, adult, elderly) of UDA and non-UDA drivers indicated that youths were overrepresented in the following too closely, speeding and travelling left of the centre line UDAs. This could be interpreted as providing indirect evidence for the contribution of perceptual skill differences (although they could also be explained fully by motivational differences). in contrast to Barry, Roper and Pitts (1974), young drivers accounted for only a very small proportion of the pulling out in front of oncoming traffic UDA (3.6%) relative to the frequency of this behaviour (17.8%).

The work done by Mourant and Rockwell (1972) is often cited in the area of perceptual skilled performance as a function of driving experience. They had 10 subjects (6 novice, 4 experienced) undertake a variety of driving tasks while their level of visual functioning was monitored. Equating wide horizontal scanning with good visual performance, it was found that novice drivers had a smaller scanning range than experienced drivers and interestingly, the horizontal fixation range deteriorated through the novice driver training phase. Thus, inexperienced drivers obtain less information from parafoveal (peripheral) vision. When the median horizontal fixation location was plotted (by first and second half of the particular task), experienced drivers showed a general shift to the right (left in the Australian context) by up to six degrees, except on the freeway driving task. The same procedure was applied to median vertical fixation locations and the trend was for more novice drivers to look closer to the front of the car than experienced drivers (in neighbourhood driving), by a couple of degrees. There were indications in this and later work (Mourant & Donohue, 1974) that inexperienced drivers had less frequent mirror usage as a means of obtaining information.

The acquisition of scanning skills in the early stages of licensing was suggested to be a move from a process of initially seeking important cues to a process of concentrating only

on important cues. There are several parallels between the visual functioning of inexperienced drivers and that of alcohol impaired drivers in that intoxicated drivers are more likely to miss objects to the left or right of the road, more likely to miss non-moving objects and distribute their attention less (Buikhuisen and Jongman, 1972).

The majority of work in the area of perceptual skill has revolved around the relationship between measures of perceptual style and accident involvement with subjects rated as being field dependent (i.e. less able to find target figures embedded in the environment) associated with greater accident involvement. Although very popular in the past, this approach would appear to have at least two major problems which may prevent it from making any son of useful contribution to the development of road safety countermeasures, viz;

- there is conceptual confusion over what field (in) dependence actually is and what tests of it (embedded figures test [EFT], rod and frame test [RFT]) are actually measuring. Although the initial work on perception of the upright (see for example, the review by Witkin, 1959) was explicit in referring to these differences as reflecting personality differences, the tone of more recent work appears to suggest a perceptual skill difference (which may be amenable to training). Given this, this approach seems more allied to the search for personality based predictors which has little pragmatic utility than the identification of specific skill decrements.

- in view of the complexity of the driving task, the process of establishing simple correlational relationships between an independent variable and a multidimensional criterion (i.e. accidents) is unlikely to be a productive approach in terms of increasing understanding of on-road performance or assisting in the development of safety initiatives.

Nevertheless, there have been a number of studies looking at this relationship. Barrett and Thornton (1968) investigated the relationship between perceptual style and driver response to an emergency situation on the basis that one of the main determinants of effective (i.e. quick) response is the ability to detect and identify the onset of an emergency situation (in their case, the emergence of a pedestrian). Despite losing 52% of subjects due to simulator sickness, the results showed that only the RFT with no body tilt correlated significantly with reaction time and deceleration rate. It was concluded that this form of RFT accounted for 25-56% of individual differences in measures of the ability to react to an emergency situation.

Using the same logic as above, Barrett, Alexander and Forbes (1973) reviewed the available procedures for assessing driver decision making performance within an information processing framework and identified four intrinsic predictors which had the potential to substantially improve safety levels if valid training programs were to be implemented. The four predictors were perceptual style, reaction pattern (whether a response was initiated early or late in the processing chain), frustration tolerance and attention. This report also reviewed a number of studies on perceptual style and accident involvement, all of which found results in the predicted direction.

Mihal and Barrett (1976) explored three predictors which they stated were consistent with an information processing approach, viz, perceptual style, selective attention and perceptual motor reaction time. The results supported the hypotheses that both perceptual style and selective attention were related to reported accident involvement. Exploratory

analysis demonstrated stronger relationships for the older subsample of drivers (45 to 64 years) than for those drivers aged 25-43 years.

Goodenough (1976) reviewed the evidence on field dependence and individual differences as a factor in road safety. While noting a number of studies that showed a correlational relationship between field dependence and accidents or violations, a much more important outcome of the review was an explicit statement to the effect that the behaviours of field dependent drivers that contribute to accidents and/or the behaviours of field independent that may contribute to avoiding accidents remain to be specified. Given the correlational and conceptually unclear nature of the relationship, the inclusion of perceptual style in the above statement may be irrelevant. However, the review concluded that there is evidence to suggest that field dependent drivers do not quickly recognise developing hazards, are slower in responding to embedded road signs, have difficulty in learning to control a skidding vehicle and fail to drive defensively in high speed traffic.

The last two findings were derived from the work of Olson (1974) who hypothesised that there may be differences in skid control and platooning behaviour as a function of perceptual style. Especially where the former measure is concerned, it is not at all clear why there should be a relationship {and no supporting evidence is provided). There was no difference in skid control between field dependent and field independent drivers, although Olson noted that the latter group improved over time, suggesting that such drivers are able to alter their behaviour in changed conditions. Avolio, Kroeck and Panek (1985) picked up the theme of three primary information processing factors and included the group embedded figures test in a small test battery. While the effect was in the predicted direction, the result was not statistically significant.

More recent work (McKenna, Duncan and Brown, 1986) has shown a less important role for perceptual style. The authors noted that although a positive correlation may exist with both subsequent accident involvement and success in the bus driver training course and EFT score, it is probably very weak. Only when the EFT score was very poor did there appear to be an effect on the percentage of drivers passing the training course. The authors recommended detailed investigations of specific skills rather than simply correlating a range of single measures with a complex criterion measure, i.e. accident involvement. in summary, there are some parallels in the area of perceptual style with other areas of road safety in that a reasonably straightforward approach showed some promise in a number of early studies but the optimism has been tempered in recent years as the effects have been shown to be much less than those demonstrated earlier. The existence of any relationship at all should also not be interpreted as grounds for countermeasure development; in the context of increasing sophistication of road safety initiatives and the need to understand the mechanism of action of countermeasures, a simple, correlational relationship, regardless of magnitude, is unlikely to be a productive area for continued research and development. Given the proximity of perceptual style to the personality-based approaches, it lies outside the information processing and/or motivational approaches which are suggested here as being the areas of greatest potential payoff.

# 9.0 HAZARD/RISK PERCEPTION

## 9.1 INTRODUCTION

The next area to review follows logically from the above information in that it involves the major application of pure perceptual skills, viz, the detection of (potential) hazards while driving and the assessment of risk (both objective and subjective) in order to 'regulate' driving behaviour. Studies in this area will be outlined and then a synthesis presented.

An excellent overview of issues in this area can be found in Brown and Groeger (1988). The core issue in their approach is the mismatch between the perception of actual hazards and the driver's perceived ability to handle them, an approach which could form a useful basis for driver training. It has been noted that these two factors have sometimes been confounded in research (Benda & Hoyos, 1983); they will be discussed separately below.

## 9.2 HAZARD PERCEPTION

Currie (1969) attempted to simulate three hazardous situations realistically by using scale model cars and the threat of electric shock if the "driver" behaved inappropriately. The non-accident group perceived the hazard more quickly in all three situations, only one of which however was statistically significant. Given the visual scanning evidence of Mourant and Rockwell (1972) that young drivers tend to fixate closer to the front of their own vehicle and the finding of Brown (1982) that young drivers identify distant hazards relatively poorly, both delays and failures in hazard perception are not surprising.

Oude Egberink, Lourens and Van Der Molen (1986) administered a questionnaire designed to rate the relative frequency of a range of behaviours manifested in the presence of child road users and videotaped actual driving performance in circumstances with substantial interaction with child pedestrians and cyclists. The analysis techniques rated driver performance relative to normative behavioural criteria, as defined by a panel of experts and accident data analysis. Both self reported and actual behaviour demonstrated that young drivers drove more dangerously in the presence of children. This greater level of danger could not be explained by differential travel speeds as the actual passing speeds were virtually identical (29.9 km/h for young drivers compared to 30.5 km/h for the older group). However, when asked to recall whether the presence of children had been noticed during the trip, older drivers reported having detected children significantly more often than did the young driver group (63% compared to 51 %). This outcome is interesting in both relative and absolute terms; while young drivers detected (assuming perfect recall) less children while driving, even the experienced driver group only detected two children out of every three encountered. This may be partially explained by earlier research (Soliday and Allen, 1972; Soliday, 1974) which indicated that younger drivers tended to associate higher levels of hazard with non-moving (i.e. environmental) factors whereas more experienced drivers perceived moving objects as more hazardous. This highlights the systemic nature of the driving task and the central importance of model driven behaviour, i.e. operating on the road in accordance with schemata or dynamic predictive models (Cumming, 1964; Neisser, 1976). The above findings can only be explained by an understanding of the complex interaction of perception, attention, decision-making and the relative resources allocated to each of these functions as they are reflected in the schemata which drivers of differing levels of experience apply. This point is expanded later.

The above work has been confined to a unitary assessment of hazard. Such an approach limits the understanding of hazard perception primarily to the perceptual domain. Hazardousness is a multidimensional concept involving the weighted aggregation of a continuously changing number of specific hazards. An indication that poorer hazard perception is an outcome reflecting more than straight perceptual skills has been provided by Benda and Hoyos (1983). in two experiments, subjects were asked to assess the similarity in hazard of pairs of pictures of the same scene separated briefly in time. The previous confounding of hazard and risk was acknowledged and an attempt to control this was made: through experimental instructions and the use of a control group who were asked to simply rate the similarity of the pictures.

It was found that hazard assessment (as opposed to hazard perception) differed as a function of driving experience with more experienced drivers making more global or holistic assessments of hazardousness. Less experienced drivers operated at a more detail driven level, apparently less able to integrate diverse stimuli into an overall assessment. This is consistent with information processing in the initial stages of skill acquisition in that informational bits contain less information and processing of the same amount of information requires greater resources. A major determinant of hazard assessment was the level of information load, with more hazardous situations associated with demanding traffic circumstances in which driving is often undertaken on the basis of limited information because of time constraints. in these circumstances, hazardousness may be equated with insufficient information for the task at hand, in which the probability of driver error is increased (Hoyos, 1988).

Thus, hazard perception can be seen as one component of the driving task which has both a specific, skill related dimension and a more general, capacity related dimension which is a function of skill levels in other driving task components as well as improvements in information processing efficiency. Improvement in both of these dimensions is a hallmark of the experienced driver. The processes involved in this development are not clear (Hoyos, 1988; Brown and Groeger, 1988), but it is clear that the efficient and valid incorporation of hazard perception into the schemata by which drivers actually drive is an essential stage in the development of safer on-road performance. As Brown and Groeger (1988) conclude, the acceleration of this process has the potential to substantially improve novice driver safety.

## 9.3 RISK PERCEPTION

The perception of risk takes the information obtained through the above process (i.e. information on hazards and hazardousness) and interprets it as a pre-condition for action according to an assessment of the actual risk to the driver presented by the individual hazard or the overall driving circumstances. This interpretation procedure has two main elements:

- an assessment of the level of relevant capabilities as a means of determining what form of coping strategy, if any, is required to be implemented
- inaccurate assessment of the level of hazard posed by a particular set of circumstances
- The level of risk which the individual driver chooses to operate at.

The first two factors are discussed below; the third is dealt with in the section on risk taking.

There are a number of studies which indicate that the perception of risk is heavily influenced by, in the case of young and/or inexperienced drivers, an overestimation of their ability to deal with driving problems as they are encountered. It is not yet clear what the relative contributions are of this self appraisal of ability and the assessment of hazard levels, although they can be reasonably seen as interdependent.

Disregarding motivational factors for the present, it is clear that hazard perception interacts with the first two factors above to produce the basis for driving performance. The fact that risk perception appears to be a particular problem for young drivers can be derived from the findings of the studies outlined below.

There have been two major North American studies in recent: years which have used the same technique of contrasting self, peer and different group comparisons of the likelihood of accident involvement in various scenarios (Finn and Bragg, 1986; Mathews and Moran, 1986). The main points from these two studies can be summarised as follows:

- young drivers see themselves as less likely to be accident involved than their peers, but with similar chances to those of older drivers

- older drivers see their chances of being accident involved as similar to their peers, but much less than those of young drivers

The same general pattern was maintained over a number of different driving situations. Thus, the evidence indicates that young drivers do perceive the risk of accident involvement to be significantly lower when compared to older drivers. As self assessment of risk by young drivers was lower than that for their peer group, the role of driving ability is certainly implicated as an explanatory factor (this also indicates that risk assessments, rather than hazard assessments, were being made). Although the data from these studies could potentially be explained by factors other than ability, evidence from other studies supports the interpretation that there is a negative relationship between perceived driving ability and the perceived risk of accident involvement where young drivers are concerned. This has been proposed as a possible explanation for the peak in accident rates that have~ sometimes been found to occur two to three years after licensing (e.g. Pelz and Schuman, 1971).

Swenson (1981) and McCormick, Walkey and Green (1986) have both investigated the role of perceived driving ability directly. Svenson asked American and Swedish students (median ages 22 and 33 years respectively) to rate themselves on safety and skill criteria relative to other respondents. Although it is not possible to separate out age-related effects from cultural effects, the results show that both U.S. and Swedish subjects rated themselves as both safer and more skilful than their peers (on the safety criterion, 82.5% and 51.4% in the top thirty per cent of drivers respectively; on the skill criterion, the percentages with the same rating level were 58.5% and 39.9%). McCormick et al (1986) extended the research and controlled for cultural effects by having drivers rate themselves relative to the 'average driver' and a 'very good driver' on eight semantic differential scales covering wisdom, predictability, reliability , consideration, safety, relaxation, value and responsibility . There was no differential effect by age, sex or socio-economic status group; 80% of respondents rated themselves over the eight scales as above average. The difference on every scale relative to the average driver was statistically significant. A

degree of realism was present, however, as there was also consistent, significant differences in favour of the 'very good driver' relative to the respondents.

In summary, there is evidence that inexperienced drivers assess the presence of hazards both less effectively (i.e. fail to detect) and less efficiently (i.e. greater resources are required to process the same amount of hazard related information as this is done at the molecular rather than the molar level). The former is attributable to sub-optimal perceptual strategies, reflecting different priority allocation rather than specific perceptual skill decrements. This assessment deficit is exacerbated by the fact that hazardousness appears to be associated with driving conditions of information (over) load.

Hazard perception provides the requisite information for the process of risk perception, the outcome of which is the maintenance or charging of current driving behaviour. It is apparent that another source of error is introduced at this stage as the above errors are compounded by the fact that young drivers also underestimate the risk of accident involvement and overestimate their driving ability.

# 10.0 THE COGNITIVE DOMAIN

## 10.1 INTRODUCTION

The previous section noted that there are identifiable differences in both hazard and risk perception as a function of driving experience. Again, however, a systemic approach to the driving task should emphasise the contribution of cognitive skills to these and other aspects of overall performance. Defined broadly, these cognitive skills fall into two categories, namely attentional skills and decision making skills. These two areas are reviewed in turn below.

## 10.2 ATTENTIONAL SKILLS

In many respects, attentional skill can be viewed as the fulcrum on which effective driving performance rests. There is both a direct cost of degraded attentional performance (in-depth studies consistently show a significant proportion of accidents attributable to lapses in attending) and an opportunity cost associated with inefficient distribution of attention (i.e. while looking in one direction, other parts of the visual field are not being attended to). While attentional distribution would appear to be the primary determinant of schemata validity, it is overly simplistic to regard attentional skills as unidimensional. Zaidel, Paarlberg and Shinar (1979) listed four basic attributes (dimensions) to attentional performance:

- intensity, as measured by the total effort invested
- distribution, as reflected in the allocation strategy
- regularity, as shown by the persistence and consistency of attentional behaviour
- mode of control, as indicated by the extent to which attentional behaviour is self controlled and active.

Attentional skill is acquired through experience, with improvements in all of the above dimensions as driving experience increases. However, there is a certain degree of circularity in this process. The application of schemata in a driver's repertoire requires information sampled from many sources and attention is distributed in accordance with schemata priority to obtain it. in many driving situations, and especially those associated with hazardousness (Benda and Hoyos, 1983), the number of sources and thus the amount of information to be ideally integrated are too great for the attentional capacity available and, in these circumstances, the driver fills in the gaps in his dynamic predictive model (schema) from expectancies derived from his experience (Cumming, 1964).

Once again, attentional skill is influenced by, and influences, other components of the driving task. As with hazard perception, the cues to which drivers respond in regulating their attentional behaviour are not known (Zaidel et al, 1979). However, this interdependence emphasises the utility of driver schemata as the appropriate context for the investigation of driving skill differences as a function of driving experience.

For the centrality of its role, there has not been much work directed to the area of attentional skill (this applies equally to the centrality of driving to road safety where there has been a much greater concentration on accident characteristics to the detriment of direct

human factors research). There have been a number of studies involving dichotic listening tasks, the results of which have indicated correlational relationships between selective attention (in the auditory modality) and subsequent performance or accident involvement (Gopher and Kahneman, 1971; Kahneman, Ben-Ishai and Lotan, 1973; Mihal and Barrett, 1976). In the last study, tests of three predictors derived from the information processing model were given to drivers working for a utility company. The results showed a significant correlational relationship between selective attention (in the auditory modality) and accident involvement. The significant intercorrelations between the measure of selective attention and perceptual style, choice and complex reaction time, could be interpreted as supporting a more holistic measurement method rather than the test battery approach.

Avolio, Kroeck and Panek (1985) followed a similar model but included a visual as well as an auditory selective attention test Scoring was based on three measures, namely:

- omission errors - failure to report the valid stimulus
- intrusion errors - reporting an incorrect, competing stimulus
- switching errors - errors following a cue to switch attention.

Volunteer drivers were divided into two groups, a 'no accidents' group and a 'one or more accidents' group. Analysis showed a significant effect for all three measures on the auditory selective attention test in the predicted direction (i.e. The accident group made significantly more errors). Omission and switching errors were more common in the accident group when operating in the visual modality and switching errors in both modalities demonstrated the strongest correlational relationship with accident involvement the authors speculated that attentional switching may represent a necessary, but not sufficient, information processing capability for safe on-road performance. While this study did not address experience related effects directly, they can perhaps be inferred from the information processing explanation offered by the authors. It was suggested that performance errors in complex tasks may result from either a failure to switch attention (younger drivers fixate visually for longer periods) or a regression into controlled processing (in order to incorporate the new information derived from the switching of attention), a processing mode which is much less efficient than automatic processing in which the benefits of experience are reflected in greater efficiency (Schneider and Shiffrin, 1977). The latter aspect may also be relevant to the novice driver as it relates directly to the information processing costs of less developed schemata.

Further indirect support for such an explanation comes from the work undertaken by Nissen and Corkin (1985) who investigated the role of both spatial and temporal expectancy on performance on a (visual) simple reaction time task as a function of age. While younger subjects demonstrated quicker reaction times averaged over all trials, the effect of both spatial and temporal expectancy (having information as to the location and timing of the stimulus) served to comparably reduce reaction time in both younger and older subjects. One role of attentional skill can be deduced from these results in that one outcome of experience (reflected in the developed schemata) is a knowledge of stimuli expectancy. Thus, attentional distribution could be thought of as knowledge driven and purposeful in experienced drivers; without this base, the novice driver is both less efficient and less effective in attentional distribution.

Additional indirect evidence can be obtained from an elegant study by Robinson (1975). In a simulated car following task, the visual display was only made available on request. Variable closure speeds and the relative costs of visual sampling and "collisions", together with the assessed level of subject risk preference were the independent variables used. Results showed that the low risk preference group (perhaps could be equated with experienced drivers for our current purposes) had higher attention levels at all closure speeds and cost ratios. This could be interpreted as suggesting, albeit very tentatively, that attentional "skill" may have a motivational component.

Finally, in a very interesting, systemic approach to understanding the driving task, Lourens (1988) estimated the incidence of generic perceptual, cognitive and motoric errors in relation to six basic driving parameters. in the analysis, attentional errors were defined in vigilance, selectivity and information overload tenus; analysis demonstrated attentional errors to be a substantial contributor to total performance errors.

## 10.3 DECISION MAKING

As with computer based applications where the output can only be as "good" as the input will allow, decision making in the driving task will reflect both the quality and quantity of prior information processing activities as well as motivational factors. Thus, it is difficult to deal with decision making in isolation from other components; less effective decision making can perhaps be better treated as a symptom rather than a cause of less effective driving performance by inexperienced drivers.

Decision making has been conceptualised in a number of ways, with the number of processes involved indicating differing levels of analysis rather than theoretical issues (Triggs, 1981). At a general level, decision making can be thought of as the manipulation of outcome probabilities and the value or utility of each outcome in order to select and subsequently implement a response. It is apparent, therefore, that decision making comprises both skills-based and motivational-based factors. In addition, the (potential) complexity of the driving task and the characteristics of skilled driving suggest that decision making in driving will not be normative or optimal in nature but, rather, much simplified with driven) actually operating in bounded rationality terms (van der Colk, 1988). This again highlights the importance of the schemata or models which drivers adopt as a means of coping with driving task demands, the validity of which could be expected to correlate positively with driving experience.

There have been few studies which have addressed decision making as a function of experience so indirect evidence must primarily be relied upon. The preceding sections have shown that the informational input to an inexperienced driver decision making processes is likely to be significantly degraded relative to more experienced drivers and they are thus in a much poorer position to make appropriate decisions. However, where decision making itself is concerned, this has mainly been viewed in the context of driver performance in emergency situations. Both Bathurst (1980) and Malaterre, Ferrandez, Fleury and Lechner (1988) have speculated that the unavailability of an appropriate response may be the most important factor in ineffective decision making. Malaterre et al (1988) asked subjects to report what action they would take in response to an approaching collision. The majority of responses included braking, often as an initial reaction, and it was tentatively suggested that such a response may be heuristically based (i.e. derived from the driver's schema) rather than an outcome of normative decision making based on the available physical information. It seems reasonable to contend that response availability would be a more acute problem in drivers with less experience.

In the study by Lourens (1988) mentioned above, decision errors were coded on the basis of insufficient or incorrect knowledge, anticipation or decision making ability as well as level of riskiness of decisions. While decision errors 'were also found to make a substantial contribution to total errors (and consequently cognitive errors being generally more frequent than perceptual and motoric errors), the coding classification indicates the difficulty of dealing with decision making skill in isolation from other aspects of the driving task.

The nature of the required processing in order to "make" the decision provides further indirect evidence of ways in which driving experience contributes to more effective decision making. To this end, the diagram presented below provides a concise summary (the diagram has been taken from Hale and Glendon, 1987 [p 37] and depicts a model developed by I. Rasmussen).

| LEVEL OF FUNCTIONING | COGNITIVE FUNCTION | BEHAVIOUR RESPONSE |
|---|---|---|
| KNOWLEDGE | INTERPRETATION | EVALUATION /TASK DEFINITION |
| RULES | IDENTIFICATION | PROCEDURE |
| SKILLS | OBSERVATION /ACTIVATION | EXECUTION |

This three level approach has some parallels with the automatic/controlled processing distinction (Schneider and Shiffrin, 1977) with the skills level equating to automatic processing (with minimal, if any, decision making involved). The rules based level necessitates the selection and retrieval of stored procedures or responses to standard events, with consequently greater decision making input. The final level, the knowledge based level, is required when the operator does not want to use or does not possess appropriate rule based procedures and must therefore actively solve the presenting problem prior to implementing a response. Again, it is reasonable to conceive of novice drivers operating at the more resource intensive end of the spectrum, with a greater need to actively make decisions in the absence of a fully developed driving schema.

The final component influencing decision making is the utility assigned to the range of potential responses. If risk taking behaviour(s) is viewed as having greater utility by younger, less experienced drivers, the probability of performance failure (due to hazard /risk misperception, attentional errors or inappropriate decision making) is consequently higher; evidence for this aspect is briefly reviewed in the next section.

# 11.0 RISK TAKING

## 11.1 INTRODUCTION

As noted in previous sections on models of driving behaviour and decision making, an analysis of the young driver problem which is restricted to skilled performance issues is likely to be incomplete. There is sufficient evidence to suggest that part of the young driver problem can be attributed to motivational factors relating directly or indirectly to risk taking. However, there is no evidence available to estimate the relative importance of this aspect, especially considering that risk taking behaviour comprises an unintentional component (Jonah, 1986). That is, risk taking behaviour may sometimes be a manifestation of skilled performance decrements in the areas of hazard/risk perception and/or attention. The approach adopted as a result of this review, i.e. to focus on skill related issues in the short to medium term, is primarily a pragmatic one.

In keeping with the tone of this report, the interested reader is referred to excellent recent reviews by Hodgdon, Bragg and Finn (1981) and Jonah (1986). The literature in this area indicates that there are several behaviours which are both indicative of higher levels of accident risk and are more frequently manifested by younger drivers. Thus, risk taking behaviour has been mostly inferred from the differential willingness of driver groups to exhibit smaller gap acceptances, higher travel speeds, lower restraint use or shorter headways. Each of these areas is dealt with in turn.

## 11.2 GAP ACCEPTANCE

While not assessing the effect of driver age directly, Jackson and Gray (1976) operationalised risk taking behaviour as the time spent waiting and the time interval before the next oncoming car or cars turning off a busy road into a shopping centre. Results showed that male drivers with male passengers had the shortest wait times. Given the findings of Victorian analysis that carriage of two or more passengers is associated with elevated risk of accident involvement for novice drivers (which is almost entirely explained by late night driving), such results could be interpreted as indicating greater risk taking by young and/or male drivers.

The study by Barry et al (1974) indicated that young drivers were overrepresented in pulling out into the path of oncoming traffic and rear end accidents. As previously noted, the authors speculated that this may have been the result of skill decrements in making judgements about gap clearance and closure speeds. An alternative interpretation could suggest that the finding was a reflection of greater willingness to take shorter gaps because of higher levels of risk taking.

## 11.2 HIGHER TRAVEL SPEEDS

Wasielewski (1984) measured free travel speeds and obtained driver/vehicle details through the use of still photographs. While the correlation between successive observations of the same driver/vehicle combination was relatively weak (0.26), the plot suggested that the bulk of this relationship was derived from more consistency at higher travel speeds (reflecting the fact that higher operating speed is a more stable behaviour and perhaps therefore indicative of risk taking rather than a variety of other determining, but transient, factors). Given that a highly significant, negative relationship was found between

estimated driver age and free travel speed, this provides some supporting evidence for higher risk taking by young drivers.

Cowley (1983) examined accident, offence and travel speed data in an attempt to identify the characteristics of the "speeding" driver. He found that probationary licence holders (i.e. those drivers in the first three years of licensing) were overrepresented in serious speeding offences (25 km/h or more above the posted speed limit), having over twice as many offences as would be expected on the basis of licences held.

Quimby and Watts (1981) demonstrated that young drivers had smaller safety margins in the negotiation of real world hazards due to their higher travel speeds. The consensus from these and other studies is that young drivers operate at relatively higher travel speeds and that it is reasonable to conclude that greater risk taking contributes to these behavioural choices.

## 11.4 LOWER RESTRAINT USE

Jonah (1986) noted a number of restraint studies in North America which seem to indicate that young drivers tend to have lower than average restraint use rates, although the relationship does not appear to be a linear one. Lund (1986) indicates that, in the United States, drivers under the age of 25 years display lower usage rates than do older drivers.

Recent Victorian data (Cave, 1986) on driver restraint use by age are not particularly helpful in this respect, mainly because of the uniformly high usage rates achieved in Victoria (usage rates vary between 92% and 95%). There are differential rates in the rear seat by age, however, with the 18-25 year age group having the lowest usage rate as the table below shows:

**Table 3 Rear Seat Passenger Restraint Use Rates By Age Group**

| Age Group (yrs) | Restraint Use (%) |
|---|---|
| 0-7 | 68.4 |
| 8-13 | 57.2 |
| 14-17 | 50.1 |
| 18-25 | 36.8 |
| 26-39 | 45.7 |
| 40-59 | 55.6 |
| 60+ | 63.8 |

## 12.0 INFORMATION PROCESSING AND RESOURCE ALLOCATION ISSUES

The above sections have described a number of studies which have pointed to differences in aspects of driving performance as a function of driving experience. However, actual performance is the outcome of an interaction between the absolute level of skill and the ability to perform this skill as one component of overall performance. The latter aspect relates to the concept of resource allocation and the time-sharing characteristics of complex skilled performance. It is obvious that the influence of these two factors (skill and resources) need to be disentangled before remedial strategies can be entertained. Thus, the process of novice driver countermeasure development requires answers to two fundamental questions:

i) how does (central) resource allocation to the basic components of complex skilled performance vary (primarily in terms of efficiency and bias) as a function of driving experience and level of demand?

ii) what are the most relatively important components of safe driving (operationalised as differences between experienced and inexperienced drivers), the acquisition of which should be accelerated to improve young driver safety?

It cannot be emphasised strongly enough that these two issues; need to be addressed in parallel. A concentration on the second question would result in decisions like, "there is a significant difference between novice and experienced drivers in Skill X; therefore, we will train novice drivers in this skill to increase safety". However, a particular driving-relevant skill is not performed in isolation; rather, it is the outcome of multiple skill performance (i.e. The application of the: driving schema) that contributes to safe, or otherwise, on-road behaviour.

Illustrating these points, Ellingstad, Hagen and Kimball (1970) pointed out that the physical response aspect of the driving task "apparently requires the integration of multiple psychomotor processes, and cannot be fully understood when individual performance measures are examined in isolation". Damos (1978) demonstrated that performance on multiple task measures could predict pilot performance better than comparable single task measures. Damos, Smist and Bittner (1983) suggested that there are individual differences in multiple task response strategies, with certain strategies leading to poorer performance in multiple task situations, although there may be no difference in single task performance. Wickens and Kessel (1980) found that mode of operation (controlling versus monitoring) in a dynamic system (flying) was differentially affected by the nature of concurrently performed tasks.

Thus, an iterative, single skill approach alone would fail to take into account the possibility that the real problem may lie in another capacity and/or skill interaction, perhaps in a different psychological domain. It is only when the differences between concurrently performed skills in capacity allocation and the effects of skill interactions as a function of driving experience are known that valid decisions on target skills can be made. Thus, a possible outcome of such investigation is that the decrement in the performance of a specific skill is of minor importance relative to the decrements in the performance of the same skill in a time-sharing context (i.e. performing the skill in conjunction with a number of other skills and trying to match task demands with finite capacity). This again emphasises the importance of viewing driving skills in their schematic context rather than in isolation.

It should also be noted that an integrated approach to the investigation of skilled performance provides some overlap with motivational aspects as, for want of a better word, attitudes can have a direct influence on performance. The topics of utility, risk taking and performance criteria are closely related. For example, attitudinal factors do exert an influence on decision making behaviour through the determination of utilities of the various outcomes (and hence the probabilities of response options). In the signal detection aspect of perceptual functioning, attitudinal factors play a role in the placement of the criterion cutoff, i.e. The level above which an operator will always respond as though a signal has occurred (for example, it: could be hypothesised that an experienced driver places this criterion closer to the origin because 'false positives' or driving with a greater safety margin is considered to be behaviour with higher utility.

## 13.0 SUGGESTED FUTURE DIRECTIONS

This literature review has identified two major areas for novice driver countermeasure development, viz;

- skilled performance improvements
- motivational improvements, notably in the area of novice driver risk taking

As mentioned several times in the report, it is suggested that preference be given to the former area, primarily for pragmatic reasons, as it is considered to be potentially more productive in the short to medium term.

However, it has also been pointed out that restricting the investigation just to the investigation of single skills in isolation has a lower probability of generating successful countermeasures than investigating skilled performance in its schematic context through the analysis of the interaction between driving related skills and resource allocation (capacity). Thus, the skills analysis program will have two major components;

- assessing the relative differences (and their characteristics) in specific skill performance as a function of driving experience
- assessing the relative differences in specific skill performance when performed in conjunction with other skills which comprise the complex, overall skill of driving.

The second component of the skills analysis program will probably adopt a dual task paradigm and establish the performance operating characteristic (POC) graphs (see Wickens, 1984) and/or capacity equivalence curves (Colle, Amell, Ewry & Jenkins, 1988) for drivers of varying age/experience undertaking two competing motor, perceptual or cognitive driving related tasks. The 'simultaneous' performance of two or more tasks (skills) is made possible by the allocation of (finite) central capacity to each activity. Factors influencing this process include the automaticity of the skill, attention level, experience and the allocation strategy. There are competing theoretical explanations for the way in which capacity can be distributed. Single resource theory states that the total capacity pool is available to be spread across the range of task types while multiple resource theory (a more recent development in the skilled performance literature) holds that allocation flexibility is more restricted with resources being dedicated to certain types of task demand (and not transferable to service other demand types).

Thus, the planned approach supplements the single skill approach with information absolutely essential for valid decision making on strategies for accelerating skill acquisition in novice drivers. It will allow the assessment of the absolute and relative degree of efficiency (the extent to which performance on a particular task decreases when it must be performed in conjunction with another task) and the pattern of bias (the favouring of a particular task, or class of tasks, to the detriment of other, concurrent tasks).

The results of such work will allow an understanding of the more fundamental issues of skilled performance in driving and provide the necessary guidance for the assessment of specific skill decrements (with a much higher probability that the improvement of a particular skill will actually translate into safer on-road driving performance).

## 14.0 CONCLUSION

This report was undertaken with the aim of identifying the suggested future direction of novice driver accident countermeasure development through an applied literature review. While providing background information on related areas such as licensing age and driver education and training, the primary focus of this report has been on skills based measures to improve on-road performance.

However, it is not sufficient to identify single skill decrements in isolation; performance is the outcome of the interaction between the absolute level of skill and the ability to perform this skill as one component of overall performance. Thus, the process of novice driver countermeasure development requires answers to two fundamental questions:

- how does (central) resource allocation to the basic components of complex skilled performance vary (primarily in terms of efficiency and bias) as a function of driving experience and level of demand?

- what are the most relatively important components of safe driving (operationalised as differences between inexperienced and experienced drivers), the acquisition of which should be accelerated to improve novice driver safety?

Subsequent work in the young driver area will be addressing these two questions.

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