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

THE ROLE OF EXPERIENCE IN LEARNING TO DRIVE

A THEORETICAL DISCUSSION AND AN INVESTIGATION OF THE EXPERIENCES OF LEARNER DRIVERS OVER A TWO-YEAR PERIOD

A C C I D E N T R E S E A R C H C E N T R E

MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE
REPORT DOCUMENTATION PAGE

Report No.	Report Date	ISBN	Pages
156	May 1999	0 7326 1455 4	42

Title and sub-title

The Role of Experience in Learning to Drive: A Theoretical Discussion and an Investigation of the Experiences of Learner Drivers Over a Two-Year Period

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Type of Report & Period Covered

General Report, 1997-1998

Sponsoring Organisation

This project was supported by a research grant from the National Roads and Motorists Association (Australia) as part of that organisation's Driver Education Research Project.

Abstract

This report presents a discussion of the theoretical basis for considering driving experience to be an important factor in the development of safe driving skills amongst novice drivers. It is concluded that the cognitive processes underlying the development of driving skills most likely place an upper limit on the potential for driver training to impact substantially on driver safety amongst novice drivers, and that these processes are primarily influenced by driving experience. Data resulting from a longitudinal study of 110 learner drivers are also presented. The analysis of these data suggests that learner drivers accrue relatively little driving experience and that they tend to obtain this experience in daytime, fair weather driving. The implications of these results are discussed.

Key Words

Driving Experience, Young Drivers, Exposure, Learner Drivers, Anxiety, Confidence

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INTRODUCTION

Victoria is a State of Australia with a population of about 4.5 million. About 80% of its population lives in the metropolitan area surrounding its capital city, Melbourne and nearby Geelong. The remaining 20% lives in rural areas or regional urban centres serving the economic and social needs of the surrounding rural areas.

Victoria has a graduated licensing scheme for drivers of motor vehicles which allows accompanied driving by learner drivers from a minimum age of 16 years, a probationary driving licence with some restrictions from a minimum age of 18 years, and a full, unrestricted driving licence after three further years of driving experience. Applicants for a learner permit are required to undertake a road-law knowledge test. The learner permit must be held for a minimum of six months before applying for a licence. Many young people take some professional lessons during this time. Applicants for a probationary licence are required to undertake a practical driving test, a computer-based knowledge test, and a computer-based, multimedia hazard perception test. There are no requirements for graduation from the probationary licence to a full driving licence.

It is possible, therefore, for a learner driver to accrue at least two years of driving experience before being permitted to drive unaccompanied on the State's road network. Langley, Wagenaar, & Begg (1996) noted that the basis for the introduction of a similar scheme in New Zealand was the desire to give novice drivers the opportunity to accrue practice and therefore develop driving skills in relatively safe contexts. In Victoria, the (potential) two years of driving with an older licensed driver, followed by some restrictions on novice licensed drivers are believed to meet the same goals (Fildes, 1986; Haworth, 1994).

The purpose of this report is twofold. It was considered important to present a discussion of the likely importance of experience in the development of safe driving skills, particularly in the context of general interest in educational remedies to the crash problems associated with inexperience and the ambivalent evidence concerning the outcomes of training programs. Thus, the remainder of the Introduction to the paper provides a discussion of some of the issues relevant to the importance of driving experience. This paper also reports some results of a logbook-based study of the amount and type of driving experience accrued by a small sample of learner drivers in Victoria over 24 months of their learner period. There is little published evidence concerning the amount or type of driving undertaken by learners. It was hoped that the results of this study would provide information useful for the development of programs to encourage increased driving by learner drivers.

Driving Experience And Safety

Young and/or inexperienced drivers continue to represent a high risk of crash involvement in spite of road safety measures introduced in Victoria in the last decade. Drivers in the first year of driving in Victoria still have a five-fold greater risk of casualty crash involvement (Cavallo & Triggs, 1998). The high level of crash

involvement amongst novice and young drivers in many jurisdictions has been widely reported and discussed (e.g. Brown, 1982; Brown & Groeger, 1988; Jonah, 1986; Karpf & Williams, 1983; Laberge-Nadeau, Maag, & Bourbeau, 1992; Mayhew & Simpson, 1995; Pelz & Schuman, 1971; Williams, 1985).

The relative contribution of inexperience and young age in the crash involvement of younger or novice drivers is an important issue, with the evidence favoring a stronger emphasis on inexperience. Maycock, Lockwood, and Jester (1991) showed that experience as a driver results in declining crash rates regardless of the age at which driving is commenced, and that initial (but not final) crash rates are higher for drivers who commence driving at an earlier age. Gregersen and Bjurulf (1996) presented a summary of relevant research and concluded that age and experience are important factors in crash involvement, but that experience in particular reduces crash risk amongst new drivers. Gregersen and Bjurulf concluded that age-related effects are most likely relevant only at very young ages (under 17 years of age) and otherwise that experience is the most important of these factors in crash involvement.

There is considerable emphasis in the literature concerning the role of driving experience in the development of a number of cognitive and behavioral skills (e.g. Benda & Hoyos, 1983; Brown, 1982; Brown & Groeger, 1988; Duncan, Williams, & Brown, 1991; Forsyth, 1992; Lewin, 1982), the general conclusion being that driving experience is a key factor in the development both of relatively simple, vehicle control skills and more complex, cognitive skills. The latter include information-processing skills (e.g. van der Colk, 1988; Goodenough, 1976; Milech, Glencross, & Hartley, 1989), self-calibration (e.g. Brown & Groeger, 1988; DeJoy, 1992; Job, 1990; Matthews & Moran, 1986), hazard and risk perception (e.g. Benda & Hoyos, 1983; Brown & Groeger, 1988; Finn & Bragg, 1986; Jonah, 1986b; Summala, 1988), and safety-related motivation or attitudes (e.g. Arnett, 1990; Gregersen & Berg, 1994; Mayer & Treat, 1977; Schuman, Pelz, Ehrlich, & Selzer, 1967).

Experience, Skill Development, and Psychological Processes

The importance of experience in the development of driving skills, therefore, is well accepted. The processes by which experience may impact on driving safety are, however, less well understood. It is argued here, as elsewhere (e.g. Drummond, 1989; Sivak, 1981), that the key to understanding the impact of experience on driving skill relates to the development of cognitive or information-processing skills relevant to the driving task.

The application of a cognitive or information-processing understanding of behaviour and skill development has only occurred at a relatively broad level in the novice driver area, in spite of the likely benefits of a more-detailed application of this approach. One of the underlying issues taken up here is the potential value of applying a number of information-processing models to the novice driver problem to form a base for understanding the processes underlying the development of safe driving skills and for developing new programs to reduce the crash problem associated with this group of road users. There are some remarkable intersections between a number of models of cognitive processes and the development of driving skills, and these intersections are discussed here as they related to the likely importance of experience for novice drivers.

Models of information processing are plentiful (e.g. Atkinson and Shiffrin, 1968; Broadbent, 1958; Cowan, 1988, 1995; Deutsch & Deutsch, 1963; Triesman, 1960), but

it is not appropriate in this paper to discuss how each of these might contribute to our understanding of the relationship between experience and crash involvement. One model, the information processing model developed by Cowan (1988, 1995), provides a useful heuristic for understanding the cognitive processes underlying the driving task, and is taken here as a starting point for discussion.

Cowan's Model

Cowan's model is a model of memory and attention with three major components - a Brief Sensory Store that holds sensory information for very short periods of time; a Long-Term Store that includes internal representations of all encoded stimuli, behaviors, and associations; and a Central Executive which controls voluntary information processing and direction of attention. Cowan's model departs significantly from earlier models of memory and information processing in its suggestion that all stimuli and events activate representations in long term memory and that short-term memory is composed of these activated internal representations of events[1]. Cowan therefore views short-term storage or activated memory as an activated subset of long-term storage rather than as a separate component or structure. Attention, for Cowan, consists of those internal representations in activated memory that are either consciously attended to (through the action of the Central Executive) or attended to because they are novel or of immediate relevance to the goals of the person.

Activation of internal representations of events, stimuli, or perceived relationships in long term store is automatic and, consistent with Logan's (1988) view about the increasing automation of information processing with experience, results in strengthening of the representation in memory. Attended stimuli are encoded into long term storage more elaborately. The control of behavior under Cowan's model is partly due to the action of the central executive, but in many circumstances may be uncontrolled or automatic, resulting directly from the activation of internal representations that are linked directly to behavioral responses.

The driving task for an experienced driver, in the context of Cowan's model, involves the generation of behaviors that meet the multiple goals of vehicle use (e.g. short travel times, safety, enjoyment, stress-minimization) using sensory input which is encoded into internal representations of the driving environment in activated memory. Some encoded representations (e.g. approaching a curve) may be linked directly to behavioral responses (e.g. turning the steering wheel) while some (e.g. a flock of sheep crossing the road for a city resident) may be sufficiently novel or relevant to be activated to a level that results in attention or conscious awareness being directed towards the internal representation or event. Such an event would require processing under the direction of the Central Executive before a response could be generated, so utilizing some of the limited available processing capacity.

[1] It is not possible to avoid the use of psychological terms in a discussion of the importance of experience in the development of safe driving skills. Driving is a task that involves perception, recognition of familiar situations, processing of information about the environment and the driver's place in it, decision-making, and the generation of behaviors that meet a number of goals. These are all cognitive or psychological tasks that are best understood within the context of psychological research and theory. Psychological ideas about memory and information processing generally talk about internal (or mental) representations of things in the real world, short and long term memory, attentional processes, central control of information processing, and mental models of the real world. The reader is referred to introductory texts on cognitive psychology for a background to some of the ideas presented here.

The inexperienced driver faces a more difficult task under the Cowan (1988, 1995) model as more internal representations or events are likely to attract attentional involvement due to their novelty or the lack of automatic links between internal representations of common driving situations and behavioral responses.

Intersections with Other Models

Learning to drive may be understood in terms of Cowan's (1988, 1995) memory/attention model in combination with Logan's (1988) instance theory of automation and Lewin's (1982) three-stage approach to learning a complex perceptual-motor skill. The potential combination of these models with an additional model of error-related processes is discussed later in the report.

Under Lewin's approach there are three stages in learning to perform a complex skill such as driving - the cognitive, the associative, and the autonomous. The cognitive stage involves the development of understanding about the nature of the skill to be learned. The second or associative stage involves the coordination and refinement of motor skills through practice and experience, with declining importance given to understanding the task as action and psychomotor coordination become more important. It is during this stage that automatic behaviors start to develop through experience and practice. The final stage (autonomous) sees the skills become increasingly automatic with increased experience, allowing the concurrent performance of other tasks.

Thus in terms of Cowan's model, the driver moves from conscious processing of information and generation of behavioral responses to road-environment conditions in the first of Lewin's stages to increasing generation of responses without the stimulus event necessarily entering attentional awareness in the third stage. With increasing experience with a range of conditions and the generation of successful behavioral responses to those situations, linkages between event representations and behaviors become stronger and the behavioral response becomes increasingly automatic. This is consistent with Logan's (1988) view that automation of responses results from repeated instances of linkage between environmental events and behavioral responses that strengthen the learned relationship to the point where the behavior follows automatically from the event.

The second and third stages of learning (Lewin, 1982), therefore, involve the storage and strengthening of increasing numbers of links between event conditions and driving responses. The increasing reliance on automatic responses while still gaining experience as a driver may account for the increase in crash risk associated with drivers over the first three years of their driving reported by some authors (Brown, 1982; Pelz & Schuman, 1971), and the increase in pedestrian-crash risk over the first few years of driving reported by Harrison (1998). As drivers develop some automatic responses and rely on them increasingly, there may be occasions when an automatic response is not available for a particular set of circumstances. The generation of a response more appropriate for another, similar set of circumstances via some form of stimulus generalization may result in an incorrect, risky response. Until the novice driver has sufficient instances of a wide range of experiences to provide a wide range of automatic behavioral responses, crash rates may increase with driving experience.

The Training/Experience Debate

There is considerable debate about the potential of driver-training programs to impact positively on driving safety amongst novice drivers.

The argument supporting the potential for training can take a number of forms, but the most relevant in the context of the present paper is that driver training can reduce the need for experience by facilitating the effect of smaller amounts of driving experience or by replacing the need for some driving experience with the product or outcome of the driver-training process. According to this argument, driver training of some sort would assist the development of safe road use skills in the context of reduced or limited driving experience.

Training, under this viewpoint, is not seen as a complete replacement for driving experience but rather as a means of reducing the amount of driving experience needed to reduce crash risk to the levels of more experienced drivers. It is clear, however, that the potential success of driver training in general rests on a number of assumptions, including

- that there are some characteristics of novice drivers which lead to increased crash risks;
- that these characteristics differentiate them from more-experienced drivers; and
- that these characteristics are able to be influenced by some form of driver training with cognitive and behavioral outcomes consistent with those resulting from the usual accrual of driving experience.

Driver training arguments assume that the increased crash risk of novice drivers relates to some characteristics (either of individuals or of behavior) that are prevalent in this group. Training for increased driving skill must have training goals or targets that would lead to increased skill and safety, underscoring the assumption that there are personal or behavioral characteristics that lead to increased crash risk. If there are no characteristics of either the drivers or their behavior that relate to crash risk in novice drivers it is difficult to envision a training program that could impact on their safety.

The evidence relating to this assumption is consistently supportive. There are indeed a number of characteristics of novice drivers and their driving behavior that would be expected to increase their risk of crashing, and a number of such characteristics which have been shown to do so. A number of reviews of the road safety and novice-driver literature (Mayhew and Simpson (1995) being the most recent) detail the consistency of results in this area. Some of the characteristics of novice drivers that are thought likely to increase crash risk include peculiarities in the weighting given to various potential hazards in the road environment, the foci of visual scanning, and poor levels of attentional control and situational awareness. These could all conceivably be the appropriate targets for training efforts for novice drivers.

Arguments in favor of using training as either a substitute for experience or a facilitator of experience also assume that the characteristics outlined above and targeted for training differentiate novice and experienced drivers. If it were the case that some characteristic of novice drivers which was associated with crash risk was found to be as prevalent in the experienced driver population as it is in the novice driver population, then it would be inappropriate to target this characteristic in a training program seeking to use training in place of experience as it would be clear that experience does not

reduce its prevalence. It is possible that crash-related characteristics common to experienced and inexperienced drivers may serve as potential targets for training programs, but the specific focus of this paper is on the crash risk of inexperienced drivers in particular. Using training to substitute for experience or as a facilitator would aim to reproduce the safe driving outcomes associated with experience and so assumes that inexperienced drivers differ from experienced drivers in the targeted characteristics.

Again, empirical evidence reviewed in a number of recent papers (such as Mayhew and Simpson, 1995) is consistent in its support for this assumption. The characteristics outlined above that are associated with crash risk in inexperienced drivers are for the most part characteristics that are more prevalent or more characteristic of less-experienced drivers.

The final assumption implicit in arguments supporting the use of training for learner drivers relates to the trainability of the characteristics associated with safe road use. Training is unlikely to be helpful to learner drivers if the characteristics or behaviors of learner drivers identified above are not amenable to training. At a more complex level, it is necessary that the outcomes of any training be consistent with the cognitive or behavioral outcomes of experience.

The second point is important. While a training program in a skill such as hazard perception at intersections may increase the perception of hazardous situations in this context, it may be the case that the training creates cognitive strategies for hazard perception that are inconsistent with the strategies that result from experience. This dissimilarity may become a problem if there is competition between the trained process and the process that continues to develop with experience. It is important, then, that the outcome of the training match the outcome of experience at the level of the processes involved in the generation of the safety-related skill or behavior.

There are some reasons to believe that the higher-order processes needed for safe driving may derive almost entirely from experience in the driving context. That this is likely is clear from the theoretical issues discussed above (Cowan, 1988, 1995; Lewin, 1982; Logan, 1988). If this is the case, the upper limit to what may be achieved through training may be quite low and focused specifically on lower-order skills such as vehicle handling, and the addition of training-based changes in driver skill may act to slow the development of experience-based skills which ultimately will reduce the crash risk of the driver.

The assumption that the high-crash-risk characteristics that differentiate novice drivers from experienced drivers may be influenced by training is less clearly supported in the empirical literature than the other assumptions. It is widely known that driver-training programs routinely fail to have a demonstrable positive impact on either driver behavior or driver crash risk when evaluated in properly-controlled studies. This outcome is often difficult to accept in the context of a widespread attitude discussed briefly by Mayhew and Simpson (1995) who note the assumption that any lack of skill can be remedied by training, but it is becoming increasingly clear that education and training programs are not generally supported by the empirical data.

At a more-specific level however, there is some evidence that some particular characteristics of the driving and cognitive skills of novice drivers may be influenced with appropriately developed and targeted training. At a relatively low level, conditioning approaches have been shown to impact consistently on the activation of internal representations of events and the generation of behavioral responses. While it

may be technically possible to use conditioning approaches to modify some aspects of the driver's behavior and attention, it is unlikely to be practically feasible to construct a training program around this type of approach. It is also unlikely, in the context of the relative impact of a training program and vastly more time spent driving in the real world (with all the conditioning that occurs in this context), that a training program based on conditioning or similar low-level processes would have a significant long-term impact.

There is some evidence that it may be possible to train some skills that are relevant to safe driving. Training effects have been reported in relation to judgement or decision making amongst pilots (Buch and Diehl, 1984), self calibration (Gregersen, 1996), and attentional control in complex tasks (Gopher, 1992). It is clear, however, that the data weigh strongly against the trainability of safe driving skills in general, and while it may be the case that there is some potential for training programs to be developed that target higher-order driving skills in particular it is incumbent on protagonists in this area to provide clear evidence that training programs are likely to be successful before they are used as part of driver training as a way of reducing the need for driving experience.

Assuming that evidence accumulates that it is possible to change some of the crash-associated characteristics of novice drivers using a training program or module, there is still a need to address the assumption that the outcome of the training program is not inconsistent with the behavioral and cognitive outcome of experience as a driver.

This assumption is the most problematic of all for driver training. Drivers continue to accrue experience regardless of the use of training opportunities, and this experience is likely to impact on the development of specific cognitive and behavioral skills critical to safe driving. Training programs that affect these cognitive and behavioral processes may be counterproductive if their effect is inconsistent with the experience-based changes which will occur over time, regardless of training experiences.

Understanding the potentially limited effect of training requires a fuller understanding of the way in which experience may impact on driving skill. Experience with the road system and the behavior of other drivers is likely to impact on the safety of novice drivers in a number of ways.

Driving is a task that requires a substantial degree of cognitive skill. The road environment is perceptually complex and changing rapidly. The information-processing system must meet a constantly high level of demand, and while it may rarely exceed the information processing capacity of experienced drivers, this is most likely due to the development of strategies for processing information and making decisions based on a substantial amount of experience in the driving environment. These strategies act to ensure that the driver can attend to (and respond to) stimuli in the driving environment that are important in terms of trip completion and safety.

Experience may lead to two processes that reduce the information processing workload. In the first instance, experience in the driving environment would be expected to allow the driver to focus less attention on less important cues and more attention on cues that are important to the driving task. This most likely represents an extinction or habituation process.

The novice driver enters the driving environment where all events and relationships, in the short term, are novel. Cowan argues that the novelty of an event is a key determinant of the amount of attention the event controls, so the novice driver is likely to direct attention to a wide range of events or stimuli, many of which are irrelevant to

the safe-driving task. Cowan further argues that as stimuli in the environment lose their novelty and their importance (in survival terms), they also lose their ability to draw attentional focus, except where there are other reasons for attending to them. For the novice driver this means that experience in the road system where some events are not predictive of danger or directly relevant to the driving task will lead to a reduction in the attention given to them and an increased ability to focus attention on other events which are likely to be more important. Thus the increase in appropriate attentional allocation that occurs with experience may actually be the result of an habituation of the attentional response to less important stimuli.

This strategy for coping with the potential for information overload (reducing the likelihood of responding to events that have been experienced without risky consequences) would be successful if the driving context were firmly rule-based or deterministic in nature. This is not the case, however. The driving environment is probabilistic in nature rather than deterministic, and events which have not predicted negative consequences in limited driving experience may, in time, precede risky situations and may, therefore, be worthy of some level of attention by the driver. An example here might be another vehicle waiting at a stop sign on a side street. The new learner driver is likely to notice and attend to this fairly closely while it is novel, but under Cowan's model the level of attention given to this stimulus will decline quickly if the event is not predictive of something important to the driver such as a hazardous situation. In a deterministic world, this strategy would work. In a probabilistic world where another vehicle at a stop sign will sometimes predict a hazardous situation, failing to attend to the vehicle is not helpful. The consequence of this process on crashes with pedestrians is discussed by Harrison (1998).

The second process that occurs with experience is the development of a complete internal model or representation of the driving environment and the behavior of other vehicles in that environment. The habituation process outlined above most likely aids in the development of a deterministic or rule-based internal model of the driving environment where there are clear relationships between events and consequences. Increasing experience in the driving environment and, in particular, experiences that are inconsistent with the earlier model of that environment most likely results in the development of a probabilistic model of the environment and the behavior of other drivers where the relationship between events and consequences is more flexible (Summala, 1988).

The change from a deterministic to a probabilistic model of the driving context is important as driving guided by a probabilistic model is more likely to take into account the possibility that some generally-safe situations may from time to time be unsafe. Under Cowan's model and this point of view, the ability of drivers to perceive and avoid risky situations is likely to decline initially (in the presence of a developing deterministic model) and then improve as the driver's representation of the driving environment becomes more probabilistic.

Thus, the habituation process that leads to an initially-deterministic model of the driving environment will have the effect of reducing the hazard-detection skill of the novice driver as many potentially-important stimuli will be unprocessed due to their lack of novelty and perceived importance. Increasing experience undoes part of this process. The increasingly probabilistic internal model of the driving environment allows a larger range of stimulus events to take on a level of importance that ensures the activation of appropriate internal representations and consequent behavioral responses because the events may precede a risk or hazard to the driver.

The developing probabilistic model or representation of the driving environment discussed here is consistent with recent consideration given to the application of the concept of situational-awareness to driver safety, and represents a higher-order consequence of experience for the novice driver.

The developing accuracy of the driver's internal model of the driving environment and the behavior of other drivers is also likely to facilitate the development of some of the other characteristics of experienced drivers that seem to be implicated in safer driving, such as appropriate visual scanning and attentional control.

The automation of driving behavior is also a product of driving experience and also fits comfortably into the outline provided by Cowan's model of information processing. Under Cowan's model, repeated instances of stimulus events and behavioral responses result in a declining need for attentional processing of the stimulus and response and an increasing automaticity of the generation of the response. Thus, experience in the driving environment will allow the development of automatic responses to stimuli. These in turn will be influenced by the deterministic/probabilistic dimension of the drivers model – with the generated behavioral response likely to be more flexible (but still automated) under the probabilistic internal model as it develops with experience.

It is clear that there is little evidence bearing on the mechanisms by which training in higher order driving skills might influence the development of these skills in place of driving experience. There are, however, two aspects of the experiential changes in higher order processes that may set an upper limit on the potential of driver training to replace or facilitate experience.

Experience has the effect of automating the mechanism by which behavioral responses are consequent on (and appropriate to) events in the driving environment. Under Cowan's model, events in the environment that are novel or important activate an internal representation of the event which in turn activates any behavioral response associated with the stimulus. The association between the event's representation and the behavior, and the automation of the process without attentional involvement both depend on experience with the event and the behavior.

Cowan's model allows for the involvement of a "central executive" process which might be likened to conscious control of the attentional process and behavior. It would clearly be influenced by training, but the involvement of this process precludes automatic processing. So while the model allows for a direct training effect through the input of the central executive, the input of this process requires attentional awareness and so cannot occur outside attention or as an automatic process.

It is difficult to envisage a means of encouraging automaticity of driving behaviors through training. Cowan's model, and views of driver skill development such as those proposed by Lewin (1982) and Logan (1985, 1988), are consistent in their emphasis on the need for experience before aspects of driver behavior become automated. Evidence from non-driver areas (see Logan, 1985) supports this point of view, and this author is unaware of any substantial body of evidence that the development of automaticity in skilled behavior can be made to occur more quickly through training except where the training involves the provision of experience in the task concerned. For these reasons it seems likely that the development of automaticity in driving behavior is beyond the effect of training. If this is the case, then automaticity is a characteristic of driving behavior which sets an upper limit on the potential for driver training.

This has profound consequences for arguments about the potential for driver training. Automaticity is a fundamental component of safe driving behavior – partly as it helps drivers to respond more quickly to potential hazards and partly because it frees attentional capacity for other tasks. While Lewin and Logan note that the development of automaticity is the final stage of learning to drive, Cowan's model would have automaticity developing initially from the earliest stages of learning to drive and strengthening throughout the learning process. If automaticity develops gradually throughout the learning time period and is based on experience as a driver, then driver training is unlikely to have significant potential beyond the early stages of learning to drive when the novice driver is learning vehicle control and other low-level driving skills.

This is reinforced by consideration of the importance of attentional processes in the developing automaticity of driving behavior. Automaticity is based on a declining involvement of attentional processes in the behavior. Training processes that activate increased attention on the behavior are likely to reduce the effectiveness of the automatisation processes rather than increase it.

It was noted above that a substantial effect of experience in the driving environment is the development of an internal model of the driving environment that more and more closely represents the environment as experience is accrued. The initial stages of development of this model are based on limited experience and are likely to be deterministic in nature, reflecting the apparent determinism of the driving environment. With increased experience of the probabilistic nature of the environment and the behavior of other drivers, the model is thought to develop a more probabilistic nature.

It is conceivable that a rule-based model of the driving environment could be taught through training techniques. Using these techniques to teach a more-probabilistic model of the driving environment is less easily conceived, however. Internal models develop through experience with the real world, so aiding in the development of a model would require experience-based training focused on the particular aspects of the model that are relevant to safe driving. This might be possible if driving experience could be arranged in a controlled environment.

It might be possible to use a simulation approach to assist in the development of an internal representation of the driving environment that includes some probabilistic components in addition to the more predictable aspects of the environment, but there are a number of problems here that would need to be addressed:

- A simulation approach would need to be based on a high-level simulation which closely resembled the real world. Without this, any internal model developed would be an inadequate reflection of the driving environment and may, therefore, place the novice driver at greater risk of crashing.

- An additional problem with a low-fidelity simulation relates to the novelty of the driving environment compared to the experiences in the simulation. It will be recalled that novel stimuli activate attentional involvement in information processing under Cowan's model. It is not inconceivable that the perception that the simulated environment and the real driving environment are different would lead to the formation of two internal models – one for the simulation and one for the real world. This is likely to be a problem in all but the highest-level simulation systems. There may, therefore, be only minimal, short term transfer from the simulated environment to the driving environment.

There is still a strong need to investigate the usefulness of simulation systems in the training of higher-level driving skills. In the absence of empirical data demonstrating the transfer of this type of training to the real world it is difficult to recommend such an approach.

A controlled environment for experience-based training focused on the particular aspects of the driver's internal model that relate to the probabilistic characteristics of the driving environment may be provided in the context of real-world driver training. It is conceivable, for example, that driving instruction could take place in a real driving context but with events in that context under control of the instructor. Unusual but hazardous events could be programmed to occur early in the driver training process rather than later in the novice driver's experience, potentially leading to the development of a less-deterministic model of the environment. Gregersen (1996) discusses such an approach in some detail.

Apart from the obvious problems relating to the intensiveness of this approach to training and the likely costs involved for each driver, there are some problems relating to the development of the internal model of the driving environment. It is possible that the development of a probabilistic model of the driving environment depends on the existence of a well developed deterministic model. The rule-based model of the driving environment that develops with early driving experience may be the foundation for a more sophisticated model. Certainly Endsley's (1995) discussion of the relationship between situational awareness and human information processing emphasizes the layered development of situational awareness, with higher-order skills and internal representations building on the foundation of lower order skills and representations.

If it is the case that the ultimate probabilistic internal model of the driving environment requires the pre-existence of the earlier deterministic model for its development, then it is again unlikely that driver training techniques will be able to assist in the development of appropriate skills.

A Role for Driver Error

It was argued above that there is a need to understand the cognitive changes which occur as novice drivers become experienced drivers in order to understand the effect of experience on driving skill and safety. The focus thus far has been on cognitive processes which underlie the development of driving skill. It was considered important at this stage to introduce another factor which may play a substantial role in the development of safe driving skills, and which has generally been overlooked in discussions of driver skill development. Consideration of this factor allows another cognitive model to be applied to the novice driver problem.

It is well-accepted that novice drivers are more prone to errors[2] than are more experienced drivers (Harrison et al., 1997; Mayhew and Simpson, 1995). It is proposed here that human error is a critical factor in accidents, and that it is more-so a critical factor in crashes involving younger drivers. It is generally accepted that factors such as excessive speed, alcohol or drug intoxication, fatigue, or lack of concentration have a

[2] Reason's (1990) definition of error is considered appropriate here: An error occurs when "a planned sequence of mental or physical activities fails to achieve its intended outcome … when these failures cannot be attributed to the intervention of some chance agency"

causal role in crashes. On their own, it is unlikely that these factors could cause an accident. It is only through their interaction with the cognitive and behavioral processes which serve driving that they influence the likelihood of an accident occurring. Alcohol, for example, acts to depress a range of cognitive processes and might be argued to increase accident involvement through an increase in the likelihood of error in driving-related tasks. The same could be proposed for the other factors outlined above. Each is better viewed as influencing the likelihood of error on the part of the driver and, through this action, influencing the probability of an accident occurring.

There are two potential benefits likely from taking this view of the action of speed, alcohol and drugs, fatigue, and poor concentration. In the first instance it adds the potential for increased understanding of the way in which these factors might interact with accidents. While it is generally accepted, for example, that fatigue acts to increase crash risk, the mechanisms by which this occurs are not well understood. It is possible that there is a general cognitive deficit associated with fatigue, but the nature of the effects of this deficit on driving skill needs further research.

The second potential benefit likely from an error-based analysis of the effects of these behaviors and inexperience on crash involvement relates to the development of new road-safety measures. Effective road safety programs may ultimately rely on an adequate understanding of the processes underlying crash involvement. Developing an understanding of crash involvement in terms of human error may increase the range of potential countermeasures available for testing.

Reason (1990) and Park (1997), amongst others, have noted that research and theoretical development in the area of human error have increased recently along with developments in cognitive psychology. Indeed, Reason (1990) and Ohlsson (1996) have stressed the importance of considering human error within the context of developments in cognitive psychology, arguing that many of the cognitive mechanisms responsible for skill development are likely to be both sources of human error and results of processes based on human error. It is within this context that this section of the present report was prepared, seeking in part to integrate recent developments in cognitive theory as it relates to human error and driver behavior or accident involvement amongst inexperienced drivers.

In the context of the crash problems associated with inexperience and the development of safer driving skills in the early years of driving, consideration of human error proves beneficial for two reasons. The first relates to the nature of human error as a by-product of the development of safer skills and was discussed briefly in the context of the intermediate development of a deterministic model of the driving environment earlier. The second is more strongly relevant to the role of experience in driving and relates to the possibility that errors resulting from experience in the driving context may serve to help the development of higher-order skills. It is possible that error and the consequent cognitive processes serve to encourage the development of a number of cognitive processes relevant for driving.

Error as a By-Product of Cognitive Shortcuts

Reason (1990) has argued that error is a byproduct of the cognitive heuristics responsible for reducing the cognitive workload required in the production of skilled or complex behaviors. The automaticity of behavior discussed earlier, for example, where

experience with particular linkages between environmental cues and behavioral responses results in the automatic generation of behaviors without the involvement of attentional processes or conscious action, might be expected to result in errors where the behavior generated is inappropriate for the environment but is generated automatically because of some similarities between it and stored representations of environments where the behavior would be appropriate. Thus a cognitive mechanism responsible for safer driving may result in driver errors and crashes. This likelihood was discussed earlier in terms of the intermediate development of deterministic models of the driving environment, but Reason's (1990) treatment of this issue bears some examination in light of the role of experience in the development of driving-related skills.

Reason (1990) developed a model of errors based on models of skilled performance that emphasize different levels of knowledge or performance required to successfully perform a task, with different types of errors in his taxonomy of errors occurring at each level of knowledge or performance. At the skill-based level, where performance is routine and occurs in familiar environments (as might be expected under conditions of automaticity in increasingly experienced drivers), lapses and slips are the dominant error type, with the following characteristics:

- They occur in the context of routine actions or behaviors;
- The focus of attention is not on the particular task or behavior and the behavior is largely under automatic control;
- The dominant influence on the error is likely to be the prior frequency of particular behavioral patterns in that context. Thus, high frequency behaviors in a particular context are likely to be generated under conditions of automatic control even if they are inappropriate for the context;
- These errors are largely predictable given patterns of prior behavior; and
- Error detection is usually rapid and effective.

Under Reason's model, errors under conditions of automated processing are most likely to involve behavioral responses that have occurred in similar contexts with a high frequency. This is a direct outcome of experience and is likely to persist until a wider range of behavioral responses are available for selection.

The involvement of this type of process in crashes has been discussed by Van Eslande and Faucher-Alberton (1997). Van Eslande and Faucher-Alberton reported an analysis of the cognitive processes underlying a number of crashes and concluded that expectations resulting from experience could result in crashes when events occur that do not match the experience-based expectations. They noted that crashes in their sample often involved errors relating to experience in the situation, such as perceptual negligence, reduced attention, and interpretational errors based on prior experience. These authors also reported the results of an investigation into the effect of experience or over-training on an obstacle and hazard avoidance task in a maze, noting that experienced participants were worse than novices in a familiar maze with unexpected (never-before experienced) obstacles.

The characteristics of slips and lapses outlined above lead to some recommendations that might profitably be investigated in the context of countermeasures directed towards novice drivers. A more-detailed analysis of common errors in the driving task (expressed in cognitive rather than behavioral terms) might allow the inclusion of specific training for learners to increase their awareness of the short-term risks as they accrue experience, and material presented in appropriate media might be used to draw attention to the specific crash risk likely to be associated with driving in familiar situations for younger drivers in particular.

Error as a Source of Skill Development

It is unlikely that error will be eliminated amongst novice and inexperienced drivers as it is both a by-product of the accrual of experience and, of course, the development of new skills in an unfamiliar context. It is also possible that errors have an important function in both early training and in the development of higher order driving skills.

In early training when accompanied by an experienced driver, errors may be a source of specific training. The focus groups conducted by Harrison et al. (1997) with parents and learner drivers indicated that mistakes and errors made by the learner driver were widely used as discussion points and training examples by parents and other supervising drivers. While the use of mistakes in this way was believed to contribute substantially to the general level of stress associated with driver training, it was widely recognised that they served a useful purpose in the context of skill development.

In a more general sense, it is also possible that the development of higher order skills amongst licensed, novice drivers may be linked, in part, to the cognitive processing associated with performance errors. The general argument presented here about the importance of experience is strengthened by the extent to which this occurs for learners who are beyond the development of basic skills and for novices early in their driving career.

Ohlsson (1996) views skill acquisition as the successive elimination of errors in performance. He bases his theory on a number of principles, inlcuding:

- Errors result from overly-generalised knowledge structures[3];
- Errors are experienced as a conflict between expectations (what should have happened) and perceptions (what did happen); and
- Error correction occurs through increasing restriction of the contexts in which particular behaviors or knowledge structures are activated.

[3] Knowledge structures in Ohlsson are behavior production rules in which the combination of the person's goal and their context are represented and linked to an appropriate action, selected in a probabilistic fashion from a range of possible actions likely to move the person closer to the goal. The generation of goal-directed behaviors relies on a series of decision-making cycles in which actions are selected based on the combination of goal and context and on the probability of each potential action's success given prior similar contexts, goals, and actions.

In this model, novice drivers are likely to possess relatively general knowledge structures where the limited amount of driving experience leads to rules in which general contextual information and driving-related goals are loosely associated, and where these loosely associated goals and contexts are associated with actions or behaviors which have been successful in the past. When an action occurs in the context of such general rules and it leads to an error, cognitive processing leads to a restriction of the goal-context combination which can activate that behavior such that the behavior is less likely to be activated in that specific context but is still likely to be activated in other contexts where it might still be successful.

As the novice driver gains experience, his or her generation of goal-directed driving behaviors relies more strongly on the existence of many specific knowledge structures that determine automatic responses to a large number of specific context-goal situations. Thus the development of appropriate automatic behaviors for a large number of driving situations depends on experiencing errors and processing those errors in a way that limits the activation of behaviors as experience accrues.

The importance of driving experience in this understanding of the role of errors is clear. Errors are essential for the development of higher-order skills and automaticity, but errors can only occur with experience in a range of driving situations. It follows, therefore, that experience as a driver in a range of driving situations after the development of basic driving skills is most likely important for the development of these skills.

It also follows that driver training that does not focus on broad experiences as a driver is unlikely to have any impact on the development of error-based skills. It is important to note that the cognitive processing discussed by Ohlsson is not available to conscious control, and so is not available to interventions based on conscious processes such as awareness-raising. These processes, assuming that they must occur in some form in the development of appropriate and safe levels of automaticity, clearly suggest some additional limitations on the effect of training approaches to the learner-driver.

Implications

The likelihood that driver training is limited in its potential leads back to a reliance on experience in safe driving contexts as the best choice for improving the safety of novice drivers. Graduated licensing schemes such as that in Victoria therefore take on a heightened level of importance for novice drivers.

The scheme in Victoria allows for at least two years as a learner driver if the learner obtains their learner permit at the minimum age of sixteen years. The potential benefits of a scheme such as this, however, rely on the accrual of substantial driving experience by learner drivers in the safe context of accompanied driving before they are licensed and allowed to drive unaccompanied with few restrictions. There are some doubts that the learner period is utilized as well as it could be by learner drivers and their families.

Focus-group discussions reported by Harrison, Triggs, Wheeler, and Fitzharris (1997) suggested that learner drivers do not generally accrue much experience until relatively late in the learner period, and the results of a survey of, and discussions with the parents of learner drivers reported in the same volume suggested that about 60% of learner drivers with an average of 10 months learner experience had driven less than 10 times with one or other parent.

It is difficult to know why learners may accrue so little experience. It is possible that obtaining a learner permit is a right of passage for teenagers and that it serves as an age-identification card for young people more strongly than as a permit to drive. It is also possible that there is no sense of time pressure until near to the end of the learner period, reducing the perceived importance of practice for the learner driver. It may also be the case that learner drivers commence the learner period with a period of driving practice and then, either through boredom or because they have developed basic skills and a false sense of their own skill, limit their practice. A final alternative relates to the emotional stress or arousal which seems to be a common consequence of parental involvement in driver training. Both learner drivers and parents in the Harrison et al. (1997) study indicated that emotional disturbance was fairly common and that it was an issue that needed to be addressed if increased levels of learner driver practice were to result.

The actual amount of driving practice undertaken by learner drivers in Victoria is still uncertain. In part, the data reported in this paper were collected to investigate the amount of experience accrued by learner drivers. It was also hoped that the data reported here might shed some additional light on the type of driving experience accrued by learners and on the level of emotional distress associated with learning to drive.

METHOD

Participants

Participants were 130 learner drivers recruited as part of a long-term logbook-based study of learner drivers. Fifteen of the drivers failed to provide any driving trip data, suggesting that they either did not drive or, more probably, that they failed to fill in the logbooks as required. An additional five learners only provided logbooks intermittently through the project. Telephone contact with them and their parents by the author suggested that these learners were not taking their involvement in the project seriously. Contact with the remaining learners and their parents suggested that they were using the logbook as requested. The twenty drivers were not included in the study, resulting in a sample of 110 learner drivers who completed the logbooks over two years of their learner period.

The participants were recruited from secondary schools in the metropolitan area surrounding Melbourne (the capital city of Victoria) and rural regional centres of Victoria. After obtaining permission from central authorities, secondary schools in the State, Catholic, and independent school systems were approached for assistance with the recruitment of recent or soon-to-be learner drivers. Three schools refused to participate. The author or another researcher approached potential participants identified by each school to discuss the project and provided an information kit with a mail-back enrolment package to potential students. The larger sample of 130 participants resulted from the provision of information kits to a total of 370 students.

Participants had experienced their first drive on a public road at an average age of 16.1 years, and their first drive off the road system at an average of 12.1 years. The age of first driving experience and the age at obtaining a learner permit were independent of the participants' sex.

Procedure

Participants completed a continuous logbook of their driving experience which they returned to the author at the end of each calendar month in a postage-paid envelope. The logbook required the provision of data for each trip undertaken by the learner. Participants indicated the length of each trip and the time taken to complete it, the nature of the roads on which the trip was undertaken, the weather and light conditions, specific skills practiced while driving, a rating of the confidence level of the driver on a 1 to 9 scale, and the nature of the supervising licensed driver. Participants were asked to complete a trip-entry in the logbook every time they went for a drive, whether it was for practice, a lesson, or for a specific reason. To facilitate this and to improve the reliability of data entry, the logbooks were designed to be scanned by an optical scanner. An example of the content of the logbook is included as an Appendix. Each logbook allowed for twenty driving trips to be recorded and participants were encouraged to use more than one logbook in a month if their driving required it.

Before returning each logbook at the end of the month, some additional items were completed by respondents relating to the number of instances of abusive behavior by

other drivers, emotional reactions by the learner or the supervising driver, and near-misses and crashes experienced during the month.

A newsletter was sent to participants every six to eight weeks to encourage continued involvement, and regular contact by telephone ensured that participants remained interested in the project. Participants were also contacted whenever they were late sending in a logbook or when there were inconsistencies in their logbook entries. Some contact was also made with parents which served to keep them informed of the study and to collect informal feedback about the involvement of participants.

RESULTS

Preliminary Survey

The enrolment package returned by participants at the start of the project included a preliminary survey which sought data concerning some demographic details, the pre-learner experience of the participant, and the intentions of the participant in relation to learning to drive.

Sixty-one participants (55%) were male. The mean age of participants at the time of passing their learner-permit test was 16.2 years (ranging from 16.0 years to 17.8 years). Participants came from families with an average of 2.8 offspring, and 49 participants (45%) had older siblings. Participants' households had an average of 2.5 motor vehicles.

All the participants were in school at the time of their recruitment. Fifty-seven percent of respondents lived in the metropolitan area surrounding Melbourne. About 70% of Victoria's population live in the Melbourne metropolitan area.

The age distribution of participants at the time they obtained their driving permit is shown in Figure 1.

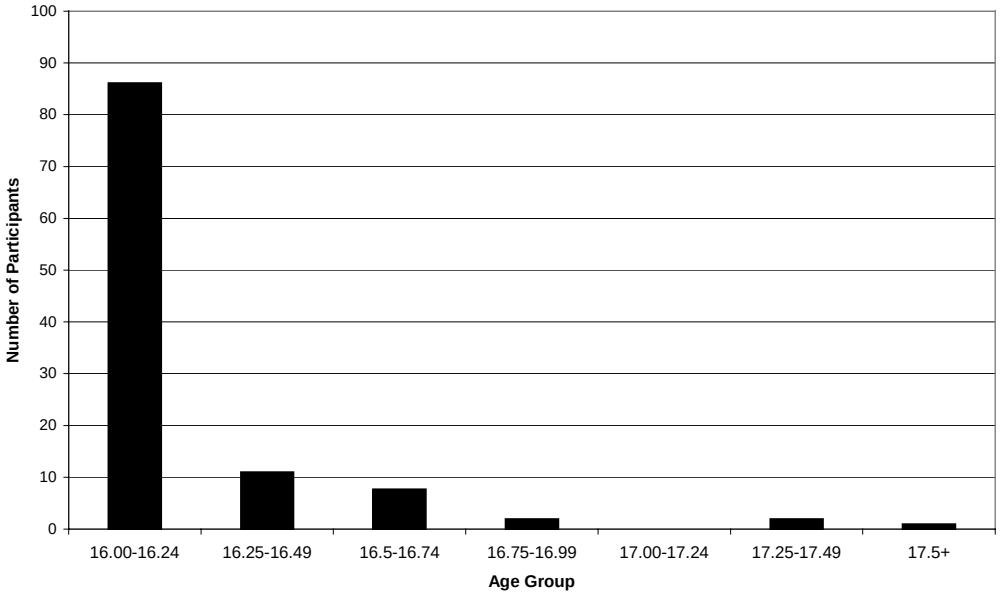

Figure 1: Age of Learner Drivers at Start of Learner Period

Participants were asked to indicate their intentions in relation to some aspects of learning to drive. One hundred and one (92%) participants indicated that they intended to obtain driving lessons from a professional instructor in addition to practicing with

and learning from their parents or other older licensed drivers. These respondents were asked to indicate when they intended to undertake professional lessons and what characteristics they would use to select an appropriate instructor. Multiple responses were allowed on both these items. The data resulting from these items is shown in Table 1.

Table 1: Learner Driver Expectations Concerning the Use of Professional Driving Instructors

ITEM	NUMBER OF RESPONSES	PERCENTAGE OF LEARNERS SELECTING EACH RESPONSE
Timing of Professional Lessons		
Before anything else	13	12%
Early in the learner period	28	25%
About half way through the learner period	35	32%
Near the end of the learner period	71	70%
Just before the licence test	54	49%
Factors Relevant to Choice of Instructor		
Price	44	40%
Reputation for teaching ability	67	61%
Reputation for having learners pass the test	22	20%
Guarantee of licence	13	12%
Recommendations from others	46	42%

The data presented in Table 1 indicate that the participants generally believed they would take professional lessons towards the end of the learner period rather than at the beginning, and that the strongest factors in selecting a professional driving instructor were considered to be the instructor's teaching ability, recommendations from other people, and price.

Participants provided some data concerning their immediate family. Figure 2 shows the age distributions of the parents of participants.

Participants were asked to specify who would take the main role in supervising their driving practice as a learner. Forty-six (42%) participants indicated that one or other of their parents would take this role, 31 (28%) indicated that their father would do so, 24 (22%) their mother.

Eighty (73%) participants had driven a motor vehicle prior to obtaining their learners permit. The average age at which they reported having driven (but not on a public road) was 12.9 years, and the average age at which they first drove on a public road was 16.1 years. Figure 3 shows the distribution of prior driving experience.

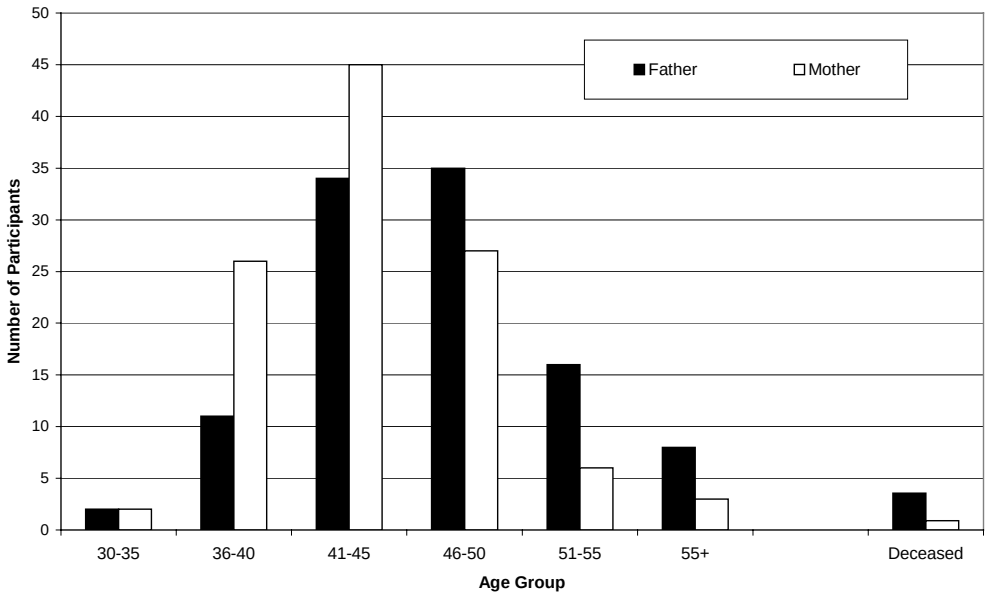

Figure 2: Age Distributions of the Parents of Learner Drivers

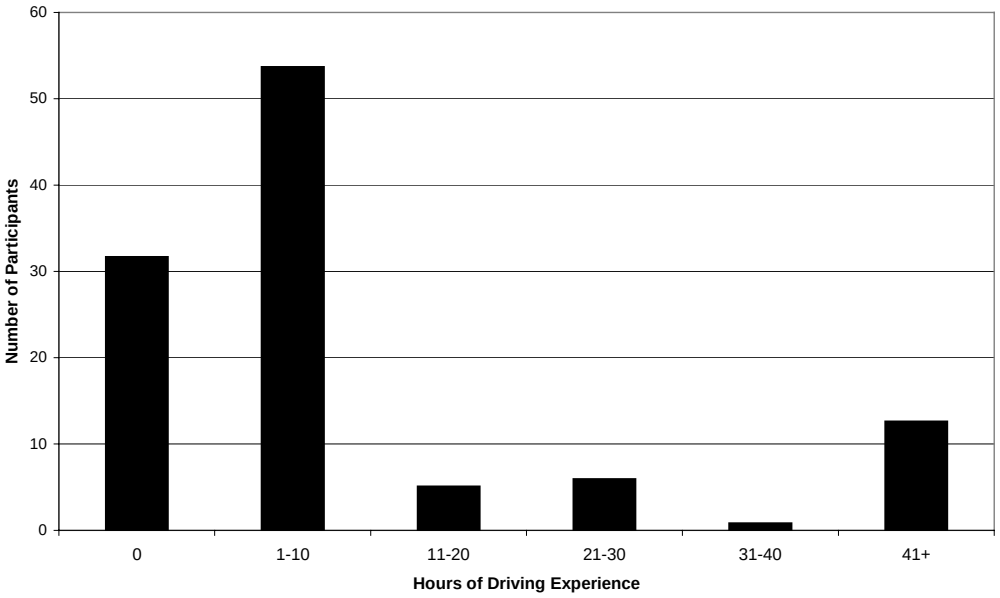

Figure 3: Prelearner Driving Experience

Driving Experience as a Learner

The experience as a learner driver was analysed by calendar month. Learner drivers in this study drove an average of 49.5 km each month, requiring an average of 51.9 minutes in the car. This equates to an average of 1,188 km or 20.8 hours of driving per person in the two years of the learner period sampled here. This driving involved an average of 1.6 driving trips per month, or an average of 40.2 trips per person over the

two-year period. Figure 4 shows the distribution of driving trips over the two years, Figure 5 shows the mean distance driven each month over the same period, and Figure 6 shows the average trip length each month.

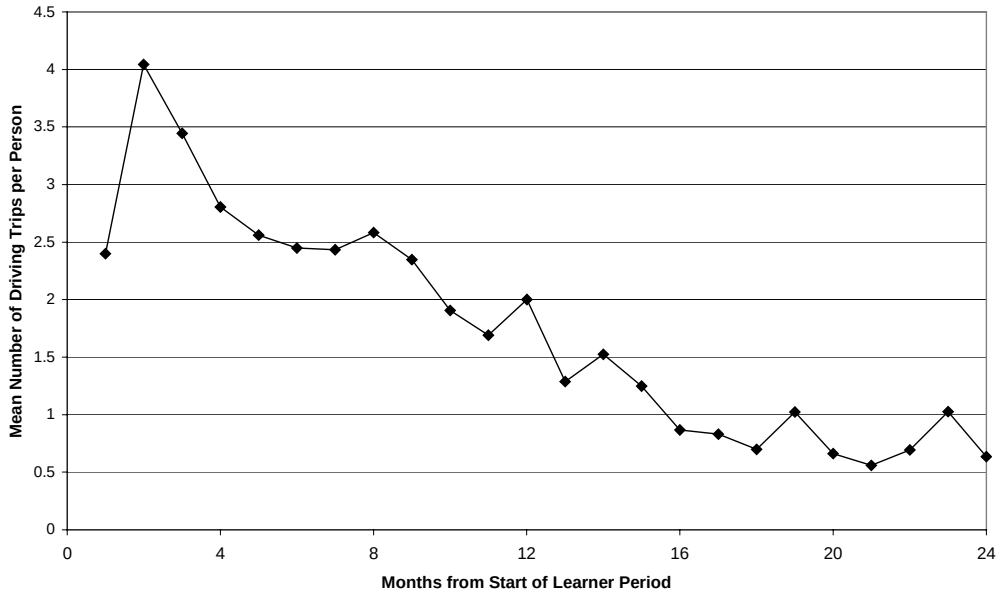

Figure 4: Mean Number of Driving Trips Each Month per Participant

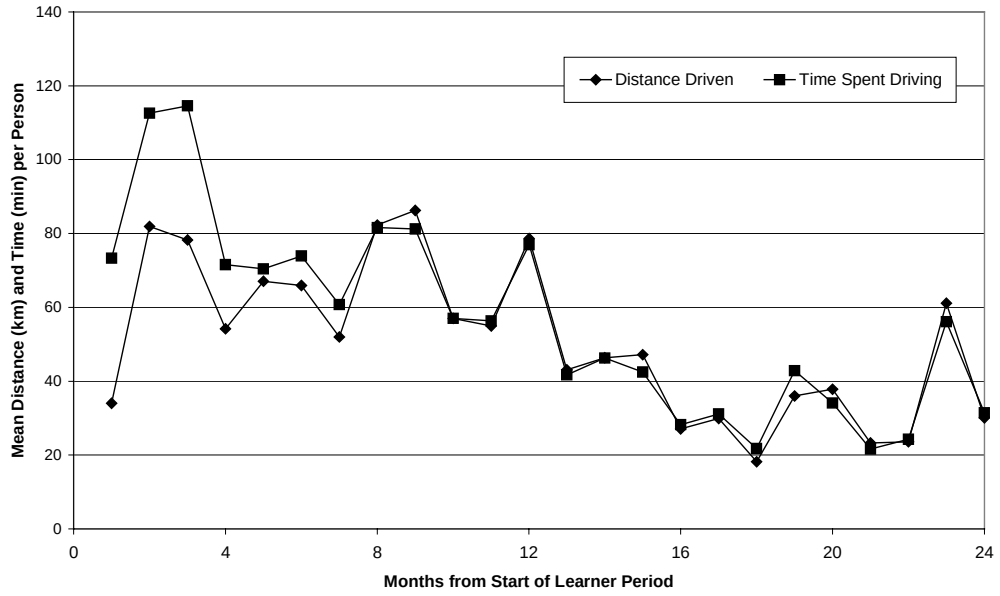

Figure 5: Mean Distance Driven And Time Driving Each Month per Participant

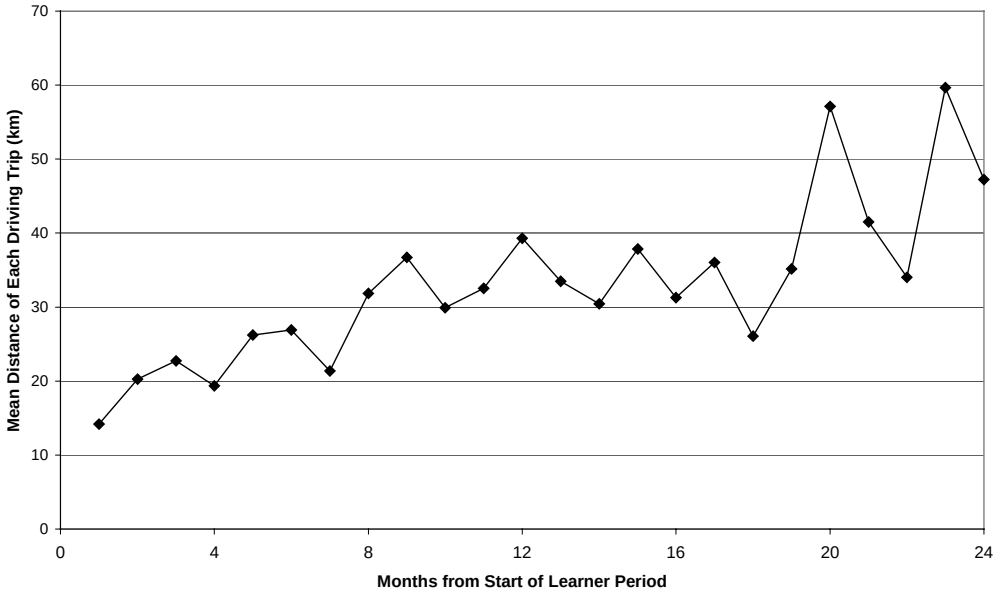

Figure 6: Mean Distance per Driving Trip for Each Month

Figures 4 and 5 show that the amount of driving undertaken by learner drivers in the sample peaked in the first two months of the learner period and then declined for the remainder of the two-year period. At the peak, learners were driving for between 3.5 and 4 trips per month, driving between 100 and 120 kilometres, and spending about 80 minutes in the car.

Figure 5 also suggests that learner drivers average about 60 km/h after about 8 months driving experience and that prior to this their average driving speed is somewhat less.

Figure 6 suggests that the distance driven on each driving trip increases over the whole of the learner period, starting at an average of 15 km per trip and increasing to between 40 and 60 km per trip towards the end of the two-year period measured here.

For each driving trip, the learners were asked to estimate their confidence level while driving. Figure 7 shows the mean confidence rating for each participant by sex and month. The ratings were provided on a 9-point scale (1-9). The data presented in Figure 7 suggest that confidence levels amongst young drivers increase quickly to their maximum level. Male confidence ratings were consistently higher than female confidence ratings, and male ratings appear to be more stable over the two-year period than female ratings.

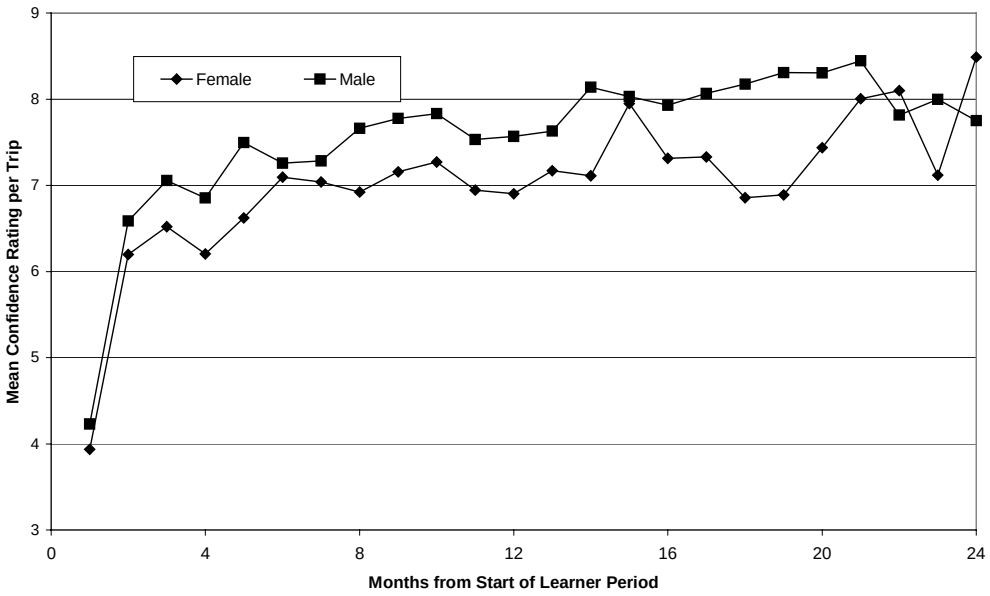

Figure 7: Mean Confidence Ratings for Each Driving Trip by Sex and Month

The effects of place of residence (rural or metropolitan), sex (male or female), pre learner experience (none, 1-10 hours, or more than 11 hours), and time as a learner (months since receiving permit) on the distance and time driving each month, the number of driving trips, and the mean confidence ratings each month were investigated using a multivariate analysis of variance. The use of a single analysis ensured that the usual problems associated with repeated analyses were minimised.

The results of the tests of between-subjects effects are shown in Table 2. Concerns about the sample size necessitated a restriction in the analysis to two-way interaction effects and main effects.

Learner driving behavior was related to the place of residence of the participant. Learner drivers living in rural areas reported driving a greater distance each month (mean = 92.8 km) than learners in the metropolitan area (33.2 km). Similarly, drivers in rural areas spent an average of 109.9 minutes driving each month (1.8 hours) compared to those in metropolitan areas who spent 29.7 minutes each month (0.5 hours). Rural residents also drove more often (3.6 driving trips per month) than metropolitan residents (0.8 trips per month).

Male and female learner drivers only differed in terms of their confidence levels, with males consistently more confident on average (mean rating of 7.6) than females (7.0).

The amount of time as a learner driver was related to the distance driven, time spent driving, and confidence level. These relationships are shown in Figures 5, 6, and 7.

There was one significant two-way interaction. The confidence level of drivers was influenced by the interaction between sex and place of residence. This is shown in Figure 8, where it is clear that female learner drivers in metropolitan areas had lower average confidence ratings than male drivers in either area and female drivers in rural areas.

Table 2: ANOVA Results for Distance Travelled, Time Driving, Trips per Month, and Mean Confidence Rating (non-significant F ratios suppressed, p<.05 where F ratio stated)

EFFECT	DISTANCE DRIVEN PER MONTH	TIME DRIVEN PER MONTH	No. OF TRIPS PER MONTH	MEAN CONFIDENCE RATING EACH MONTH
Residence	$F_{(1,612)} = 17.2$	$F_{(1,612)} = 2.8$	$F_{(1,612)} = 12.8$	ns
Sex	ns	ns	ns	$F_{(1,612)} = 8.5$
Time as a Learner	$F_{(23,612)} = 2.8$	$F_{(23,612)} = 2.8$		$F_{(23,612)} = 3.4$
Pre-learner Experience	ns	ns	ns	ns
Residence × Sex	ns	ns	ns	$F_{(1,612)} = 17.0$
Residence × Time as a Learner	ns	ns	ns	ns
Residence × Pre-learner Exp.	ns	ns	ns	ns
Sex × Time as a Learner	ns	ns	ns	ns
Sex × Pre-learner Exp.	ns	ns	ns	ns
Time as a Learner × Pre-learner Exp.	ns	ns	ns	ns

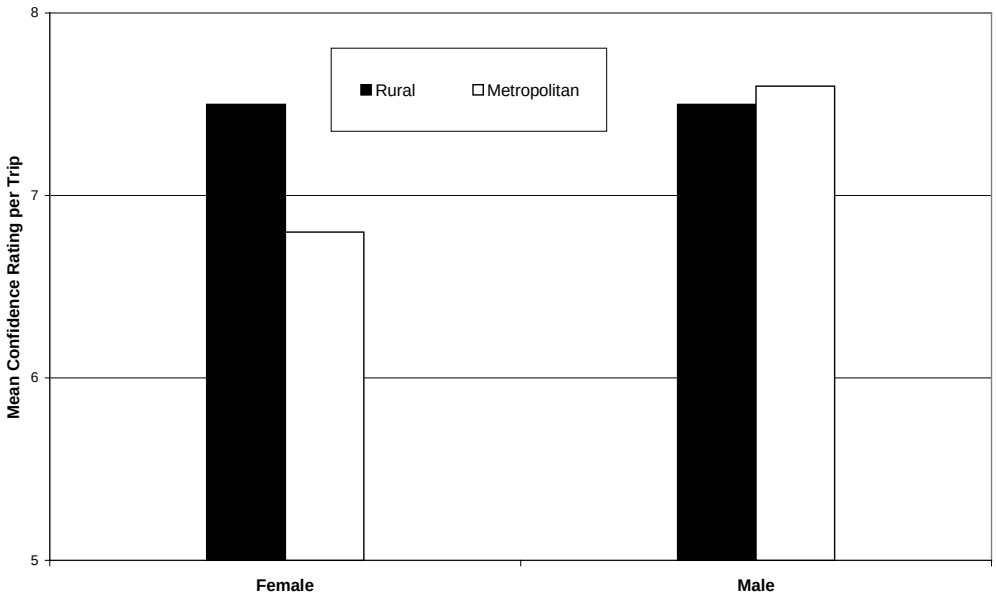

Figure 8: Confidence per Trip be Sex and Residence

Participants were also asked to indicate on each trip the particular driving skills they specifically practiced while driving. Figures 9 and 10 show the proportion of driving trips involving practicing a particular skill over the 24 months of the learner period. Figure 9 presents data relating to skills which might be regarded as vehicle control skills, while Figure 10 presents data relating to skills that involve a level of hazard perception or immersion in traffic.

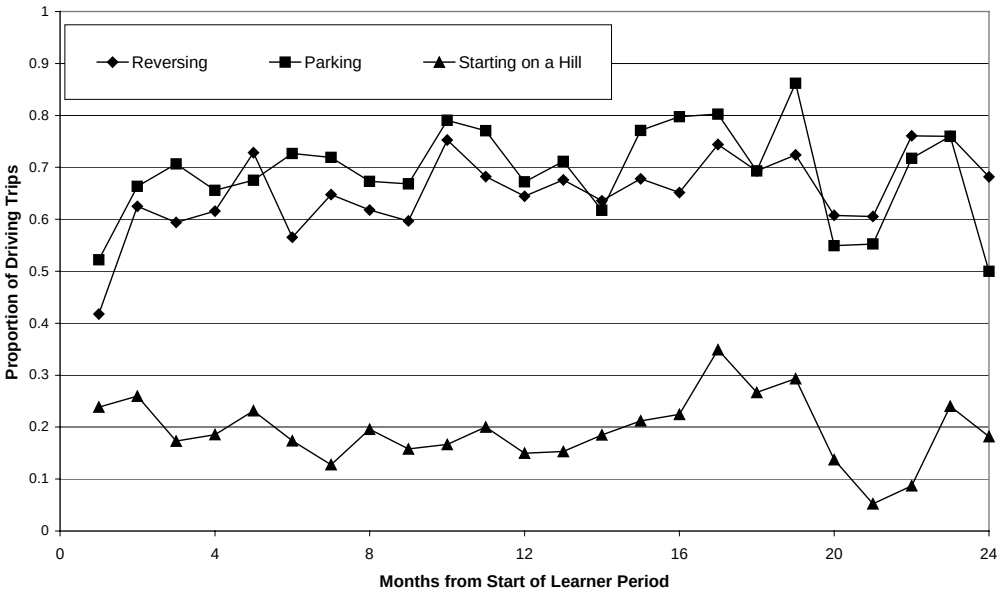

Figure 9: Proportion of Trips Involving Practicing Specific Vehicle Control Skills

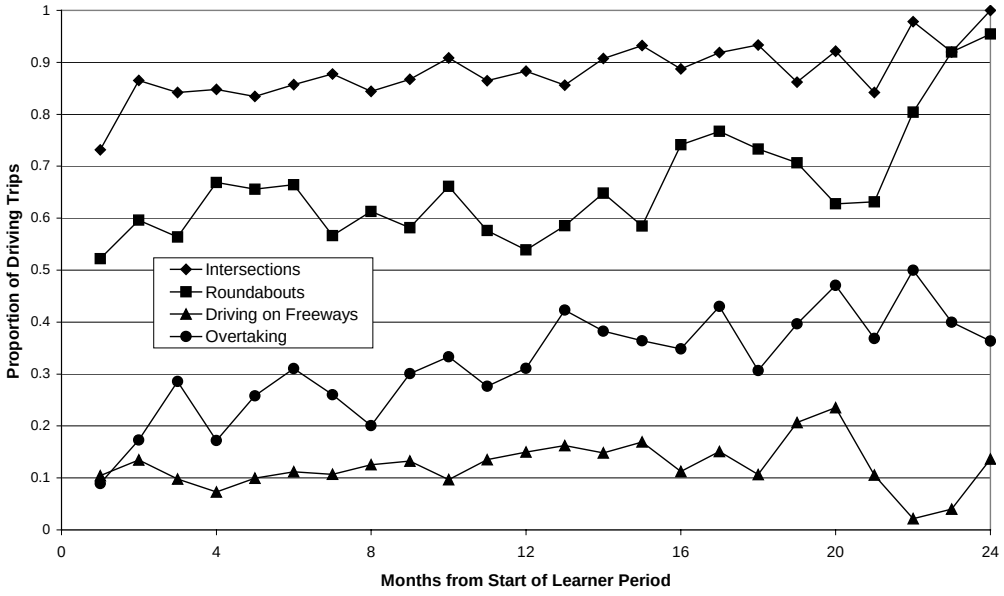

Figure 10: Proportion of Trips Involving Practicing Specific Driving Skills Involving Coping with Traffic

Figure 9 suggests that there is a substantial focus on practicing basic vehicle control skills throughout the learner period, and that there is no reduction in the amount of effort invested in the development of these skills.

Figure 10 suggests that skills relating to handling intersections and roundabouts are also practiced throughout the learner period, with both showing slight upward trends. Practicing overtaking also shows a general upward trend throughout the learner period, although starting from a lower level. Driving on freeways is less often practiced than the other skills and does not show an upward trend.

The percentage of driving trips undertaken in different weather conditions and at different times of the day are shown in Figure 11. On average, 91.9% of driving trips occurred in dry conditions, 7.4% in rain, and 0.7% in fog. Eighty-three percent of trips occurred in daylight, 11% at night, and 6% around dusk or (probably less likely) dawn. It is clear in Figure 11 that the majority of driving trips undertaken by learners occur in dry conditions during the daytime (78.7%). Very few driving trips occurred in more-hazardous situations.

Figures 12 and 13 show the percentage of driving trips in each month disaggregated by time of day and weather conditions respectively. It is clear that there is very little change in the distribution of driving trips over the learner period.

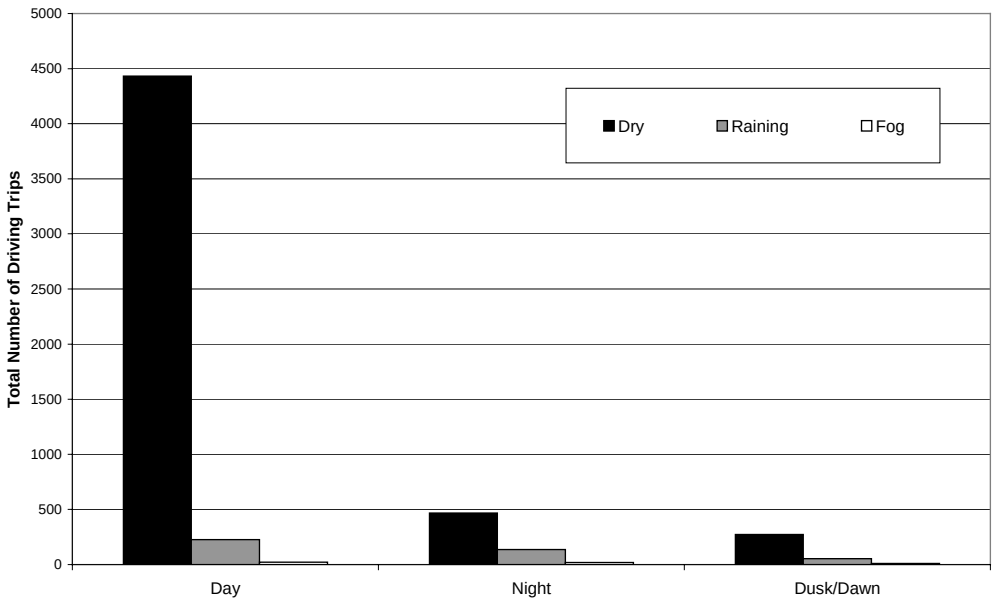

Figure 11: Total Number of Driving Trips by Time of Day and Weather Conditions

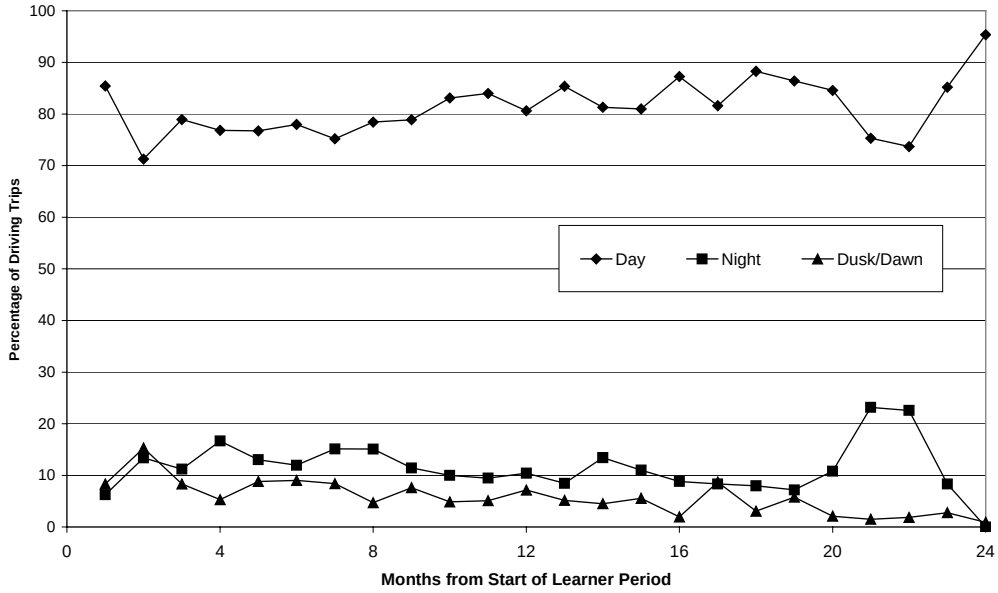

Figure 12: Percentage of Driving Trips at Different Times of Day

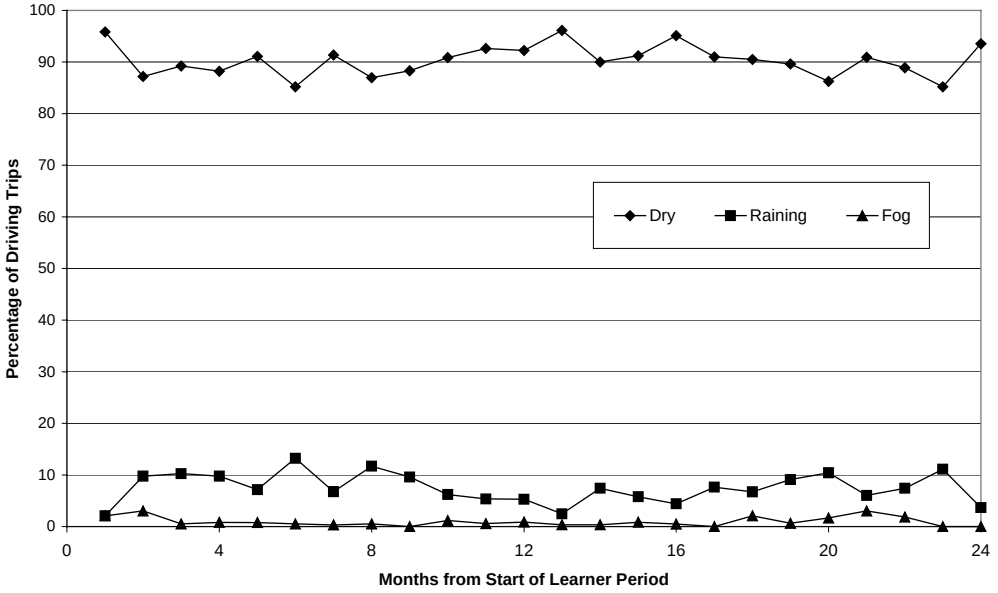

Figure 13: Percentage of Driving Trips in Different Weather Conditions

Negative Experiences of Learner Drivers

Participants provided information about a number of negative experiences as part of the logbook data returned each month. The average percentage of driving trips resulting in these negative experiences is presented in Table 3.

The learner driver participants reported that on 12.4% of their driving trips they felt anxious, that on 12.0% of their trips they became upset and on 13.3% their supervising driver became upset, and that they failed to detect a hazard on 6.8% of their driving trips. Crashes occurred on 0.4% of driving trips.

Table 3: Percentage of Driving Trips Involving Negative Experiences

EVENT	MEAN PERCENTAGE OF TRIPS INVOLVING THE EVENT
Abused by another driver	2.3%
A near miss or almost having a collision	4.3%
Failing to detect a hazard	6.8%
Becoming upset	12.0%
Having the supervising driver become upset	13.3%
Feeling anxious while driving	12.4%
Being stopped by a Police officer	0.9%
Saw Police conducting speed enforcement	13.0%
Saw Police conducting drink-drive enforcement	5.2%
Crashed	0.4%

Figure 14 shows the average number of instances of becoming upset, the supervisor becoming upset, and feeling anxious reported by participants per hour of driving for each month of experience as a learner. It is clear that emotional disturbance was more prevalent earlier in the learner period than later.

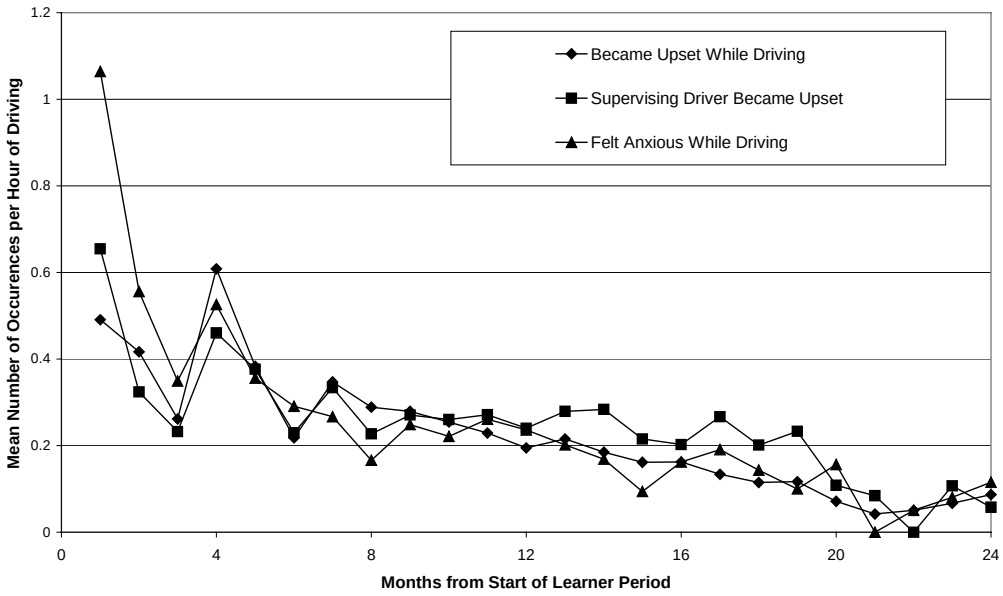

Figure 14: Instances of Emotional Disturbance per Hour of Driving

Figure 15 shows the average number of instances of seeing Police enforcement activity per hour by month. Participants reported no instances of seeing speed enforcement until 2 months into the learner period, and no instances of seeing drink-driving enforcement until 3 months into the learner period. Awareness of speed enforcement activity (in particular) increased markedly through the first five months.

Figure 15: Instances of Seeing Enforcement Activity per Hour of Driving

Figure 16 shows the number of times (per hour) the participants reported having had a near miss, and having failed to detect a hazard disaggregated by month. Near misses and failing to detect hazards declined quickly to a relatively stable level after two-three months experience.

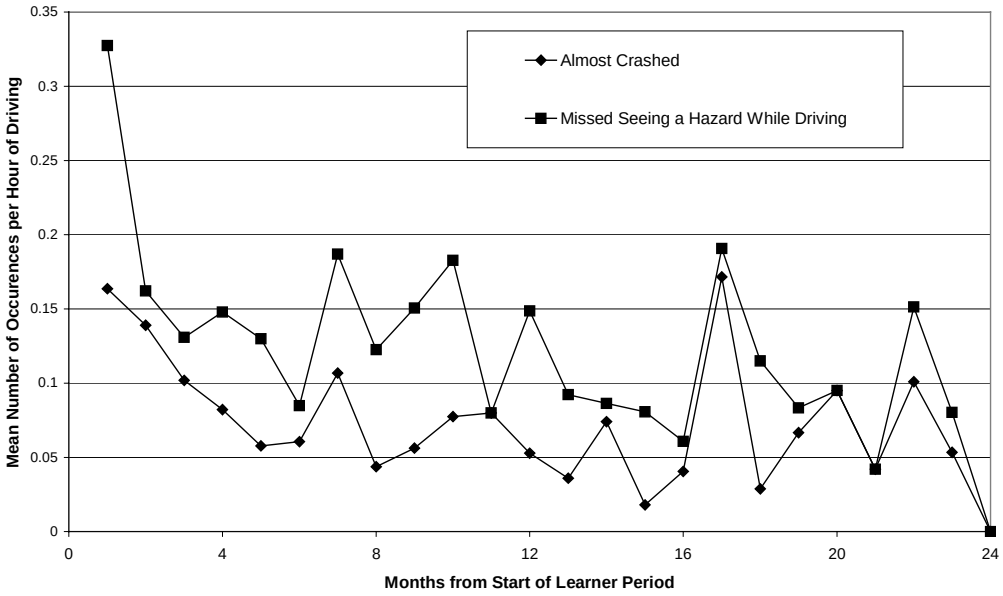

Figure 16: Instances of Near Misses and Failure to Detect Hazards per Hour of Driving

Relationships Between Some Variables

It was considered worthwhile to investigate the overall relationship between some of the measures to assess the extent to which driving experience was related to the experiences of the learner drivers. To accomplish this, an exploratory factor analysis was conducted using the monthly data for each participant. Sixteen variables were entered into the analysis which was based on a Spearman correlation matrix given the inclusion of categorical data. The analysis resulted in the extraction of four factors which were then subjected to oblique rotation. The four factors accounted for 60.6% of the variance in the included items.

The loadings of variables on each of the four factors are shown in Table 4. The first factor appears to represent the amount of driving each month. The distance driven, time taken, and number of driving trips all load on this factor, as do the amount of time as a learner and the place of residence of the learner. The relationships between driving behavior and place of residence and time as a learner are not surprising as they are consistent with results discussed earlier. The number of times the learner felt anxious while driving also loaded on this factor, but in a way that suggests that the number of anxious reactions most likely reflected the driving exposure of the participant – months in which there was more driving were associated with more experiences of anxiety.

Table 4: Factor Loadings (Loadings less than 0.3 suppressed)

	I	II	III	IV
Number of Driving Trips	.81			
Time Spent Driving	.80			
Distance Driven	.79			
Residence in Metropolitan Area	.75			
Months of Learner Experience	-.69	.42		
Mean Confidence Rating		.87		
Sex		.39		
No. of Times Saw Drink-Drive Enforcement			.83	
No. of Times Stopped by Police			.73	
No. of Times Saw Speed Enforcement			.55	
No. of Times Supervisor Became Upset				.70
Number of Times Learner Became Upset				.66
Number of Times Failed to Detect Hazard				.61
Number of Near Misses				.59
Number of Times Abused by Other Drivers				.56
Number of Times Learner Felt Anxious	.31	-.42		.47

The second factor appears to represent the confidence of the learner. In addition to the confidence ratings, the sex of the learner and their time as a learner also loaded on this factor. This is also not surprising as it also confirms results discussed earlier. The number of experiences of anxiety each month also loaded on this factor such that confidence was inversely related to anxiety.

The third factor appears to represent contact with the Police engaged in traffic enforcement. The three enforcement measures (seeing speed enforcement, seeing drink-driving enforcement, and being stopped by the Police) loaded on this factor.

The fourth factor appears to represent the negative emotional events reported while driving. The number of times the learner or their supervisor became upset loaded on this factor, as did the number of times the learner nearly crashed or missed seeing a hazard and the number of times they were abused or felt anxious while driving. The close relationship between the measures of anxiety and upset feelings and the measures of poor hazard detection and near misses suggests that there may be a causal link between these events.

The correlations between the factors are shown in Table 5. In general they are not high, but the driving factor (I) and the emotional factor (IV) were correlated (r=.39) suggesting that more instances of negative emotional reactions and errors occurred with greater driving exposure.

Table 5: Correlations Between Factors

	I	II	III	IV
I		-.03	.15	.39
II			-.03	-.04
III				.24

DISCUSSION

The data reported above were collected primarily to investigate the nature of driving experience in twenty-four months of learning to drive for a sample of self-selected learner drivers. The nature of the sample of learners in this study is important in the context of interpretation of the results.

The participants in this study were recruited from secondary school in metropolitan and rural areas of Victoria. The use of schools as a source of participants means that the sample of participants used here may be younger than the wider population of learners. Given that the mean age of beginning learner drivers in the present study was 16.2 years, and that the mean minimum period required before participants would be allowed to obtain a licence was therefore 1.8 years, it is possible that this group of learner drivers may have been less likely to be interested in accruing driving experience than older learner drivers who are closer to the minimum licensing age.

This concern is countered in part by the likely bias of the sample towards learner drivers who may be more motivated than learner drivers in general. Involvement in the project was undertaken on a voluntary basis. This suggests that the learner drivers who did volunteer to take part are likely to be relatively motivated about learning to drive, and therefore that they would be more motivated about accruing driving experience (other things being equal).

It is probable, therefore, that these learner drivers represent relatively motivated, younger learner drivers. The general effect of this bias in recruitment on the pattern of driving experience is uncertain, although it is considered most likely that the driving experience data reported here represent an over-estimation of the amount of driving experience accrued by learner drivers in general.

In this light, the apparently low level of driving experience reported by participants is of some concern. On average, learners in this sample accrued only 20.8 hours of driving experience over the twenty-four month period, equating to an average of about 12 minutes of driving per person each week. This driving experience accrued in an average of 40.2 driving trips per person over the twenty-four months, or in about 0.4 driving trips per week for each person. About 65% of weeks involved no driving practice. The informal, ongoing contact between the research team and each participant suggested that the low level of reported driving reflected the reality of driving practice for this group.

The amount of driving undertaken by participants declined over the twenty-four months, both in terms of the distance and time involved and the number of driving trips. The only upward trend was in the distance driven on each trip which slowly increased across the twenty-four months. A peak in driving experience around the third month of the learner period coincided with the confidence asymptote discussed below, suggesting that learners may have limited their driving at first as they developed basic skills and some level of confidence in the vehicle. Once confidence levels stabilized, it appears that the participants increased their level of driving experience before gradually returning to lower levels.

The results suggest that the nature of driving practice changes slightly over the twenty-four months of the learner period. There is a suggestion that driving practice involves an increasing concentration on traffic-related skills but no real decline in the concentration on vehicle control skills. It is also clear from the data relating to the awareness of Police enforcement activity that learner drivers do not venture onto higher-volume roads (where Police activity is substantially more likely) until at least one month into the learner period. It is possible that the first few "trips" involve practice in low-risk environments such as car parks.

The results relating to the amount of driving undertaken by learners suggest that lifestyle and interests may play an important role in the amount of driving experience accrued. Rural residents drove significantly more than metropolitan residents, reflecting the greater opportunity to drive further in rural areas. They also took more driving trips than their metropolitan peers, suggesting that parents or other licensed drivers are more able (or willing) than those in the metropolitan area to provide practice opportunities. The role of lifestyle and interests in the accrual of driving experience could profitably be investigated in further research.

Learner drivers accrued very little driving experience in potentially hazardous conditions such as at night and in wet conditions. This is of some concern given the likely importance of a broad range of driving experiences for the development of safe driving skills. The average learner in this sample only had three experiences of driving in the rain, and 4.4 driving trips at night. It is also of some concern that the learners here did not report any noticeable changes in this driving pattern over the duration of their learner period. It might be hoped, for example, that learners would increase their practice in potentially hazardous situations such as at night and in the rain, but there was no evidence that this had occurred. The results here lead to a suggestion that increased attention should be given to encouraging practice in increasingly complex driving situations prior to obtaining a probationary licence.

While accruing a relatively small amount of driving experience, the participants achieved an asymptotic level of confidence within two-three months of commencing the learner period. (equating to about 100-200 km of driving experience or 7-10 driving trips). Similarly, instances of anxiety while driving were relatively stable from about 5-6 months weeks. The fast increase in driving confidence noted above underscores the widely-reported over-confidence of younger drivers (Brown and Groeger, 1988; Job, 1990). It is most unlikely that learner drivers will possess more than a minimum level of driving skills after 200 km of driving experience and a small amount of pre-learner driving, but in spite of this it appears that there is no substantial change in confidence levels after this amount of driving experience.

The results of the data analyses suggest that confidence levels were related to a number of variables. Male participants were significantly more confident on average than were female participants, those in rural areas were more confident than those in metropolitan areas, and those with larger amounts of driving experience were more confident than those without. The effects of sex and experience on confidence levels are consistent with the results of other research.

Female learners in the metropolitan area were less confident (on average) compared to those in rural areas and compared to males in both areas.

The involvement of parents in the learner driver period is critical for the accrual of sufficient driving experience. In considering possible reasons for the low levels of driving reported by participants in this study and elsewhere (e.g. Harrison et al., 1997),

it is important to note the possibility that aspects of the driver-training experience may act to reduce the attractiveness of driver training to both the learner and the learner's parents.

The results of the present study suggest that learning to drive is an emotionally stressful activity, for both the learner and the supervising driver. While mean confidence levels increased in the first two months of the learner period, this time period was also characterized by high levels of emotional stress. The incidence of anxious feelings on the part of the learner and upset feelings for either the learner or the supervisor were highest in the early months of the twenty-four months, and in spite of declining levels of emotional disturbance it was still the case that an average of 13.3% of driving trips across the twenty-four months involved the supervisor becoming upset, and 12.4% of trips involved feelings of anxiety for the learner driver.

It would not be surprising if the decline in driving practice after the initial level of activity and the generally-low level of driving practice across the twenty-four months reflects, in part, the stressfulness of driver training for both the parents and the learner. It may be the case that the stress discourages both parents and learners from using opportunities for practice. This would be consistent with Harrison et al.'s (1997) focus-group findings from parents and learners which resulted in recommendations that measures be instituted to help parents and learners cope more successfully with the stress involved in driver training and practice. There is a clear need here for further research with a view to implementing programs which focus on the emotional issues associated with the learner period.

The results of the factor analysis were consistent with earlier results but also suggested that there was a relationship between negative emotional responses and driving exposure. This supports the general stressfulness of learning to drive and adds emphasis to the need to target this problem in the longer term.

In general, the results of the logbook study raise some serious concerns about learner-driver practice. This study involved the collection of prospective data from a small sample of relatively motivated learner drivers. In spite of this, they accrued very little driving experience over the two-year period. Over that period, their driving activity reduced rather than increased, and there was no increase in driving activity in complex situations such as those which might occur at night or in inclement weather. In the context of the strong emphasis given to the need for experience in the first section of this report, the apparent failure of learners to gain much experience needs to be addressed.

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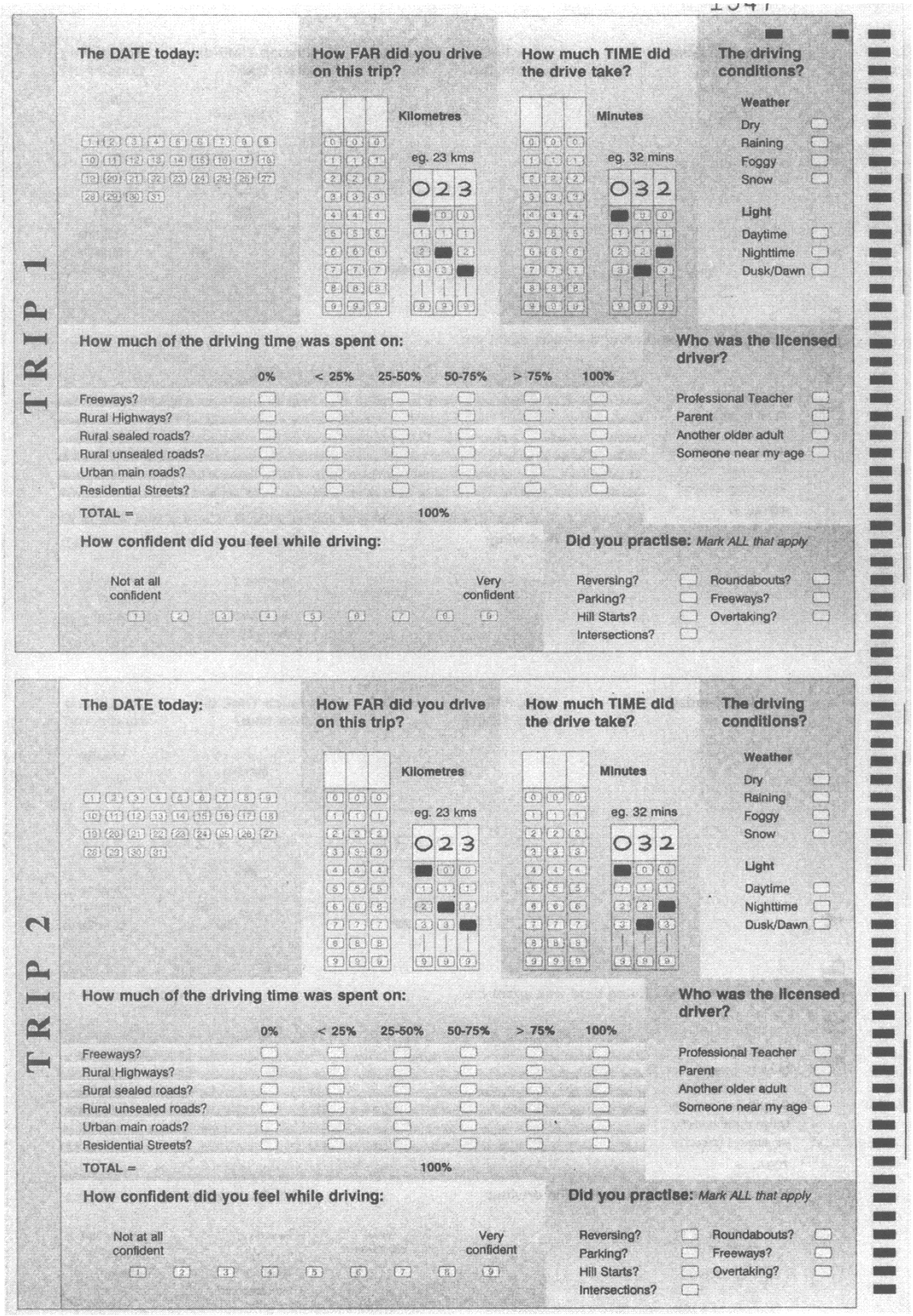
APPENDIX


TRIP 1
The DATE today:
How FAR did you drive on this trip?
Kilometres
eg. 23 kms
How much TIME did the drive take?
Minutes
eg. 32 mins
The driving conditions?
Weather
Dry
Raining
Foggy
Snow
Light
Daytime
Nighttime
Dusk/Dawn
How much of the driving time was spent on:
0%
< 25%
25-50%
50-75%
> 75%
100%
Freeways?
Rural Highways?
Rural sealed roads?
Rural unsealed roads?
Urban main roads?
Residential Streets?
TOTAL =
100%
Who was the licensed driver?
Professional Teacher
Parent
Another older adult
Someone near my age
How confident did you feel while driving:
Not at all confident
Very confident
Did you practise: Mark ALL that apply
Reversing?
Parking?
Hill Starts?
Intersections?
Roundabouts?
Freeways?
Overtaking?
TRIP 2
The DATE today:
How FAR did you drive on this trip?
Kilometres
eg. 23 kms
How much TIME did the drive take?
Minutes
eg. 32 mins
The driving conditions?
Weather
Dry
Raining
Foggy
Snow
Light
Daytime
Nighttime
Dusk/Dawn
How much of the driving time was spent on:
0%
< 25%
25-50%
50-75%
> 75%
100%
Freeways?
Rural Highways?
Rural sealed roads?
Rural unsealed roads?
Urban main roads?
Residential Streets?
TOTAL =
100%
Who was the licensed driver?
Professional Teacher
Parent
Another older adult
Someone near my age
How confident did you feel while driving:
Not at all confident
Very confident
Did you practise: Mark ALL that apply
Reversing?
Parking?
Hill Starts?
Intersections?
Roundabouts?
Freeways?
Overtaking?