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CHILD PEDESTRIANS: FACTORS ASSOCIATED WITH ABILITY TO CROSS ROADS SAFELY AND DEVELOPMENT OF A TRAINING PACKAGE

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Child Pedestrians: Factors associated with ability to cross roads safely and development of a training package

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Abstract:

Pedestrian trauma represents a significant proportion of all road trauma. In particular, the safety of child pedestrians is of concern, given that a sizeable proportion of pedestrians killed and seriously injured involve children and the special value society places on its youth. At ages 6-10 years, children are at highest risk of pedestrian collision, most likely due to the beginning of independent unsupervised travel at a time when their road strategies, skills and understanding are not yet fully developed. Road safety education is considered an essential component of teaching children the skills to interact with traffic safely. While many programs are available in Australia and internationally, many do not consider the separate component skills of the road-crossing task and the functional and behavioural factors that may put some children at increased risk. Moreover, some concern has been raised regarding the ability of some education programs to foster the transfer of knowledge to improved behaviour in real-world environments.

This report presents the findings of a two-phased study: i) an experimental study addressing the impacts of functional performance, behaviour, traffic patterns and exposure to traffic on road-crossing skill amongst primary school children using a simulated road-crossing environment and parent survey; and ii) a training study aimed to firstly use this information to develop a targeted and practical training program aimed to teach good road-crossing skills, particularly amongst those who are at highest risk of crash involvement, and secondly, to evaluate the effectiveness of the training program in developing the appropriate functional and behavioural skills required to make safe road-crossing decisions.

In the experimental phase, children viewed video scenes of traffic and made choices about crossing the road by responding 'yes' when they thought it was safe to cross and rated the safety of that crossing. The results of the first phase of the study suggest that children predominantly made decisions based on the distance gap of vehicles and that younger children (6-7 year olds) were 12 times more likely than older children (8-10 year olds) to make critically incorrect crossing decisions (where a 'yes' response was made but walking time was less than the time gap and may have resulted in a collision in a real life scenario). In addition, poor performance on all tests of functional skills was associated with a higher likelihood of critically incorrect crossing decisions. Some differences in travel patterns and traffic exposure were noted, however, no gender differences were found. Based on logistic regression modelling, 'at-risk' children were identified as younger children, those with poorer perceptual, attentional and cognitive/executive skills and those with lower traffic exposure.

Using this information, a targeted and practical training program was developed using a simulated road-crossing environment. Group-based feedback was provided on road-crossing responses. Responses were compared at pre-training, one-week post-training and one-month post-training. Significant overall redutions in proportion of critically incorrect responses were found immediately after training (56%) and one-month post-training (47%) by the case group compared with pre-training responses, and relative to any changes in the control group. The beneficial effects were greater for younger children, females, children with less well developed perceptual, attentional and cogntive skills, and those with little traffic exposure. The effects of the training program on other outcome measures (e.g., proportion of missed opportunity responses, decision time and safety rating responses) were less clear but showed some beneficial effects.

This study has identified 'at-risk' groups of child pedestrians and highlighted key functional and behavioural factors associated with poor road-crossing skill. The evaluation of the training program clearly shows a beneficial effect in improving road-crossing skills amongst 'at-risk' children. This training effect was sustained over a one-month period. The use of a simulated training program that targets the component skills of road-crossing decisions is a novel and safe way to improve essential skills and strategies to cross roads safely and has major implications for improvements to education and training programs for child pedestrian safety.

Key Words:

Safety, pedestrian, child, behaviour, education, training, functional performance

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Preface

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EXECUTIVE SUMMARY

While there is a clear and continuing tendency for Australians and other western populations to rely on motor vehicles as a primary mode of transport, walking still forms a significant component of daily travel routines for most trips. Furthermore, walking has obvious health benefits for children and people of all ages as well as environmental, social and economic benefits and there are many policies and strategies worldwide supported by governments and health professionals that aim to encourage increased walking. While the main emphasis is on enhancing health and mobility of particular groups, their safety should also be taken into account. It is paramount that safe and comfortable walking environments are provided in conjunction with these promotions.

Pedestrians are an extremely vulnerable road user group, largely due to their lack of protection and limited biomechanical tolerance to violent forces when impacted by a vehicle. Crashes involving pedestrians are, therefore, severe in nature and pedestrian safety is a serious community concern. Pedestrian trauma makes up approximately 12 percent of all road fatalities and 9 percent of all serious injuries in Australia. Two hundred and one pedestrians were killed in 2007 and over 3,770 were seriously injured on Australia's roads in 2005-06. Children under the age of 16 years constituted a substantial proportion of these deaths (9%) and a larger proportion of serious injuries (22%). Moreover, research suggests that younger children (between the ages of 6 and 10) are at highest risk of death and injury, with an estimated minimum four times the risk of collision compared with adult pedestrians.

Promotion and education of safe walking practices have long been advocated as a means of promoting a healthy lifestyle and teaching children the skills to interact with traffic safely. However, while common sense dictates that when young children are exposed to traffic, supervision is essential, there is little agreement on developmental milestones that allow independent travel, and very little information given to parents regarding the development of skills. Moreover, there are some concerns that road safety education of children may not be optimal. Traditionally, education programs have focussed on knowledge and attitudes derived from rote learning, rather than skills required to function in traffic environments and lack good ability to foster the transfer of knowledge to safer performance or improved behaviour. They also generally treat each child the same, and are rarely based on understanding of the developmental and behavioural characteristics that may put young children at increased risk for pedestrian injuries. While there are a number of road design solutions which provide barriers to separate pedestrians from traffic and signalised or safe crossing zones, the reality is that there are many more roads where pedestrians remain vulnerable.

The current study aimed to identify some of the factors that may be associated with increased crash risk for young child pedestrians and to develop and evaluate a training package to teach children road safety skills, particularly selecting safe gaps in traffic in which to cross the road. The project was conducted in two phases:

1. To examine the functional and behavioural factors that may be associated with poor gap selection amongst primary school children to identify those who may be at higher risk of crash involvement; and

2. To develop a practical training program aimed to teach good road-crossing skills, particularly amongst those who are at highest risk of crash involvement. The training program was evaluated in terms of its effectiveness in improving skills, especially the appropriate functional and behavioural skills required to make safe gap selections of oncoming traffic.

Phase 1: Identification of 'at-risk' children

Seventy-one children aged between 6 and 10 years of age were randomly selected from five primary schools in the Melbourne metropolitan area to take part in the study. Schools were also randomly selected from the Department of Education list of primary schools.

Three sources of data were used in this phase:

1. Road-crossing responses: responses were elicited in a simulated road-crossing environment in which approaching vehicles were presented. Time gap and speed of the vehicles were systematically manipulated with five levels of time gap (3, 4, 5, 6, and 7 secs) and three levels of vehicle speed (40, 60 and 80kph). These were chosen based on safe and unsafe gaps taking average walking speeds of children into account and speeds of vehicles chosen because they represent common speed zones. Participants were asked to indicate, by pressing appropriate keys on a board, whether or not they would 'cross' in front of the approaching vehicle and decision time was recorded. Participants were also asked to rate the safety of the road crossing.

2. Functional skills: using a battery of neuropsychological tests designed to assess cognitive, perceptual, attentional and executive functioning. Children's walking speed was also measured under two conditions, normal and fast walking pace.

3. Parent survey: designed to gather information about the child's general activity and exposure to traffic, amount of physical activity out of school, amount of supervised and unsupervised walking, parent safety practice, presence of home education on road safety, and parent attitudes to road safety.

The results suggest that children primarily use distance rather than the speed of approaching vehicles when making judgement about safe crossing gaps. This suggests an immediacy effect where a vehicle far away, irrespective of its travelling speed, is judged to be less threatening than one close up.

Of particular interest in this study were the analyses of critically incorrect responses. The finding that more than half of all children made at least one critically incorrect decision, based on their fast walking time and time gap of the approaching vehicle was of particular concern. These children were generally younger. Indeed, age was a strong predictor of critically incorrect decision, with six year olds almost 12 times more likely than 10 year olds to make a critically incorrect decision. Moreover, children who performed poorly on tests of functional performance displayed poor road-crossing skills. The current findings also suggest that exposure to traffic, particularly the amount of independent travel is associated with road-crossing skill. Children who walked independently more frequently were less likely to make incorrect crossing decisions compared with children who walked independently less frequently. This suggests that age-appropriate traffic exposure is beneficial for acquiring road skills.

Phase 2: Development and evaluation of training package

Based on the findings from Phase 1 and previous research and educational literature the training package was developed. The main objectives of the training package were to i) teach children how to identify traffic gaps that are sufficiently large to permit safe crossing, ii) differentiate these from gaps that are too small, iii) incorporate their walking speed into the decision, iv) teach children to focus on time rather than distance or speed per se when making judgements about the safety of traffic gaps, and v) minimise the effects of distractors in the environment.

The training package was conducted over two training sessions. The first session focussed on time gap estimations using model cars travelling at selected speeds, children clapping to time, and incorporating walking speed into time gap decisions. Children also crossed 'pretend roads'. The major component of the first training session utilised simulated road environments with feedback from the simulator and the researchers. Crossing decisions were elicited and children were encouraged to take into consideration the factors affecting gap size (i.e. the speed and distance of approaching vehicles).

The second training session utilised another series of simulated road environments containing distractors, such as a ball bouncing across the road in front of an oncoming car. The presence of a distractor was discussed, and children were questioned over its relevance on their road-crossing decisions. Again, feedback was provided on road-crossing decisions with particular focus on paying attention to important vehicle cues.

A randomised controlled trial was undertaken to evaluate the effectiveness of the training program on improving road safety skills amongst children aged between six and ten years of age (the same children who participated in Phase 1 participated in the evaluation). The same simulated road-crossing environment used in Phase 1 was used here to elicit crossing responses in two post-training sessions (one-week and one-month post-training). Case group children undertook training sessions while control group children undertook a safety-related program not related to road safety.

The current findings suggest that tailored and practical programs have a beneficial effect on children's road-crossing decisions. Programs that are aimed at improving essential skills and strategies to cross roads safely through intensive training and feedback, focussing on known risk factors (gap selection, awareness of one's physical attributes, and attending to the most important factors and not being distracted) are beneficial.

The findings from this evaluation suggested that the training program was successful in reducing the number of critically incorrect responses immediately after training overall, but particularly amongst younger children, females, children who had less well developed perceptual, attentional and cognitive/executive skills, and less traffic exposure. Further, the training effects were sustained over a period up to one-month post-training. Pre-training, one-week post-training and one-month post training road-crossing responses were compared. Significant reductions in proportion of critically incorrect responses were found immediately after training (56%) and one-month post-training (47%) by the case group compared with pre-training responses, and relative to any changes in the control group. Other outcome measures were also examined (i.e., proportion of missed opportunity responses, i.e. failure to accept a 'safe' gap, decision time and safety rating responses). The findings for these outcome measures, however, were not as conclusive as those of critically incorrect responses. Notwithstanding, there were some interesting findings and an overall beneficial effect of the package was demonstrated.

There was a tendency towards an increase of missed opportunity responses overall, and particularly amongst younger female participants and children with less well-developed functional performance. This was an unexpected result, but may be explained by a tendency to make more conservative responses following training.

There was an overall decrease in safety rating responses, supporting the argument that more conservative or appropriate perceptions of risk were achieved after training. This is an encouraging result and, while risk perception was not a focus of the current training program, could be an important factor to include in subsequent training programs.

There was little effect of training on decision times amongst children who underwent training sessions, but was apparent amongst control group children. While this was an unexpected result, the lack of effect on decision time amongst case group children may be explained by the fact that this was not a focus of the training program. While children were encouraged to make quick decisions throughout the study, there was no decision time component in the training whatsoever.

Importantly, however, this study provides good evidence that there are ways to improve road-crossing skills in a safe environment. Simulated traffic environments provide safe ways to examine behaviour and provide training in 'hazardous situations' without putting people at risk as in real traffic environments. While it is acknowledged that there are direct benefits of learning road skills associated with exposure to real traffic, it is also desirable to understand children's behaviour and teach the appropriate skills in a safe environment.

Conclusions and Recommendations

The findings of the current study suggest that there are, indeed, specific behaviours, functional limitations, travel patterns and behaviour in traffic environments that may put some children at increased risk of a pedestrian collision. This information has provided a better understanding of the component skills that comprise the road-crossing task and has identified 'at-risk' children. It has been instrumental in the development of a targeted, practical training program which is aimed at improving essential skills and strategies to cross roads safely amongst 'at-risk' children through the provision of extensive feedback regarding road-crossing decisions in critical time gaps and with a range of distracting factors. The evaluation has clearly shown a beneficial effect in improving road-crossing responses, particularly amongst those children most at risk.

There are several recommendations that are proposed as a result of this research.

Identification of 'at-risk' children

Three important recommendations here are:

- A key safety message to promote to families and schools/teachers is that children under the age of 10 years should not walk unsupervised without appropriate education and training.
- Children as young as six years should receive road safety training targeting those component functional abilities shown to underpin safe road crossing.
- The information from this report should be disseminated to road safety educators, as the results could guide current road safety programs to assist in targeting children for more intensive road safety training.

Further development and promotion of training package

There is scope to make some improvements to the package. Five recommendations here are:

- The package should include more focus on providing feedback to improve missed opportunity responses and decision times.
- The package should be further refined for use by teachers and road safety professionals in schools.
- A comprehensive manual should be prepared, as well as further developing the software to make it more accessible and user friendly.
- This program should be promoted to road safety organisations and the education department, in conjunction with other initiatives such as road design and operation improvements to improve the safety of child pedestrians.
- Parents of young children should be educated on the risks for young children and awareness raised on the dangers of young children walking unsupervised before they gain the appropriate skills to interact safely with traffic.

Recommendations for future research

The following recommendations for future research are:

- **Develop and evaluate other road safety training packages that aim to train children in other areas of child pedestrian safety**. While the ability to select safe gaps in traffic is a critical and difficult skill to master, future programs may benefit from incorporating other aspects of the road-crossing task, such as choosing a safe location to cross, selecting safe gaps in traffic with traffic coming from both directions, and identifying potential hazards in the road environment. A program that incorporated more aspects of the road crossing task will better equip young children to be safer road users.
- **Conduct a larger-scale field trial with a refined training program. Examine the relationship between road crossing decisions in a simulator and real world environment.** It is essential to understand whether the skills gained in simulated environments are transferred to participation in real traffic environments. A field trial examining the effect of the training program on behaviour while interacting with real-world traffic is a necessary step in advancing optimal use and community benefit of the program.
- **Explore the potential for use of a similar training program for novice, teenage drivers**. Although teenagers will have had more traffic exposure, and will have better developed perceptual and attentional skills, there is strong evidence that their executive functions are not fully developed. Moreover, the task of selecting a safe gap in traffic is a complex one, particularly as a new driver. Exposing young adults to this task in a safe and controlled environment may assist young drivers in becoming safer drivers.

1 INTRODUCTION

Crashes involving pedestrians are severe in nature and pedestrian safety is a serious community concern. Research suggests that children, the elderly and the intoxicated are at highest risk of death and injury as pedestrians. Among the child pedestrian group, young children between the ages of 6 to 10 years are at highest risk of death and injury, with an estimated minimum four times the risk of collision compared to adult pedestrians (Struik, Alexander, Cave, Fleming, Lyttle & Stone, 1988; Thomson, 1996). This is most likely due to the beginning of independent unsupervised travel to and from school, and increases in exposure at a time when their road strategies, skills and understanding are not yet fully developed.

Making the decision about when it is safe to cross the road in relation to available gaps in the traffic is a complex task, one that requires competence in a range of functional skills and much of the literature suggests that young children are less competent in traffic than adults because of poorly developed perceptual, attentional, and cognitive abilities (Connelly, Conaglen, Parsonson & Isler, 1998; Dunbar, Hill & Lewis, 2001; Whitebread & Neilson, 2000). Furthermore, it has been shown that young children are generally inconsistent in their road safety behaviours, are easily distracted, have difficulty estimating the speed and distance of oncoming cars appropriately, and are poor at recognising dangerous places to cross (Ampofo-Boateng et al., 1993; Connelly et al., 1998).

Given that behavioural factors play a large role in traffic safety, education and training has long been advocated as a means of teaching children the critical road safety skills and behaviour to be able to interact with traffic safely. There are a number of road safety educational programs available in Australian States and Territories – however, there may be scope for some improvement, particularly in terms of providing more information than road safety knowledge only, and improving the design of training programs. It is suggested that training programs should be more practical and specifically tailored for those who are most in need of training. For example, 'at-risk' groups may include younger children, those who have poor risk perception and likely to take high risks leading to involvement in crashes, or hyperactive, impulsive, inattentive and easily distracted children. The NMRA-ACT Road Safety Trust acknowledges the importance of developing such training packages for child pedestrian safety and kindly provided financial support for this research.

1.1 AIMS OF THE CURRENT STUDY

This project aims to identify some of the factors that may be associated with increased crash and injury risk for young child pedestrians under the age of 10 years, to raise awareness of the issues amongst parents, and to develop and evaluate a training package to teach children road safety skills, particularly selecting safe gaps in traffic in which to cross the road.

The research is divided into two components:

1. The first component will examine the functional and behavioural factors that may be associated with poor gap selection amongst primary school children to identify those who may be at higher risk of crash involvement.

2. The second component will develop a practical training program aimed to teach good road-crossing skills, particularly amongst those who are at highest risk of crash involvement. The program will be evaluated in terms of its effectiveness in

developing the appropriate functional and behavioural skills required to make safe and appropriate gap selection of oncoming traffic.

This information will provide a better understanding of the separate component skills that comprise the road-crossing task and recommendations will be made for educational and training programs that can effectively teach ‘at-risk’ young children the essential skills and strategies to cross roads safely. The findings will also be used as a resource for parents and teachers on child pedestrian safety and appropriate supervision.

1.2 STRUCTURE OF REPORT

This report is structured in five parts. Chapter 2 provides a review of the previous literature on child pedestrian crash risk, discusses factors that influences children road crossing skills and looks at strategies to manage child pedestrian safety. It also reviews different child pedestrian training and education programs and discusses their effectiveness where appropriate. Chapters 3 and 4 present the findings of the first component of the study. In Chapter 3, the findings of the baseline road-crossing skills are presented. Chapter 4 focuses on identification of ‘at-risk’ children, based on functional performance skills. Chapter 5 present the findings of the second component of the study, that is, the development and evaluation of the training program. Finally, Chapter 6 draws together the findings from both phases of the project. Implications of the findings are discussed, and recommendations for future education and training packages and future research are provided.

2 LITERATURE REVIEW

2.1 PEDESTRIANS AND SAFE MOBILITY

Crashes involving vulnerable road users represent a major road safety problem world-wide and there is growing awareness within the road safety community that vulnerable road users may have their own particular needs and difficulties in using the road transport system and that this should be considered when designing and operating the system.

Pedestrians are considered extremely vulnerable road users largely due to their lack of protection and limited biomechanical tolerance to violent forces when impacted by a vehicle. In a collision with a vehicle, pedestrians are always the weakest party and at more risk of injury or death. Furthermore, because of their physical stature, children are especially vulnerable to injuries and children are considered one of the most vulnerable road user groups.

2.1.1 The importance of walking

Non-motorised modes of transport are increasingly becoming more popular, especially for short trips and, in many ways, walking is beneficial to the community. Walking is a major mode of transport, is a component of most trips and has obvious benefits for health and well-being of individuals and the environment. Walking is one of the main ways of increasing physical activity (Catford, 2003) and is strongly recommended by the public health sector because it has been shown to assist with weight control, and reduce the risks of cardiovascular diseases, diabetes and arthritis. Walking can also increase fitness, health and longevity, exercise and enjoyment, a sense of freedom, well-being and relaxation (Forward, 1998; Hydén, Nilsson & Risser, 1998; van der Heiden & Rooijers, 1994; Wigan, 1995). It is also associated with a range of other psychological health benefits including enhanced mental performance and concentration levels, improvements in mood, sleep and energy levels, and tension and stress levels, decreased feelings of anxiety, hostility and depression, with accompanying major public health implications (Forward, 1998; Hydén et al., 1998; van der Heiden & Rooijers, 1994). Recent interventions aiming to increase physical activity among children have demonstrated improvements in children's academic performance, self-concept, mood and mental health, as well as physical health gains (Salmon, Breman, Fotheringham, Ball & Finch, 2000).

In her survey of behavioural factors affecting modal choice in Europe, Forward (1998) found that people of all ages saw walking as a relaxing mode of transport, which increased their sense of freedom and helped them to become healthy and fit. Physical exercise can also decrease societal costs associated with illness and disease and environmental problems such as pollution and congestion. Programs that promote and endorse walking among children may help to alleviate vehicular congestion, especially in the vicinity of schools, enable children to accrue health benefits, teach children the skills to interact with traffic safely and offer a safe and reliable alternative to car travel (Dellinger, 1999; Collins & Kearns, 2005).

In recent years, many concerns over the negative side effects of car usage have been raised along with the recognition of the benefits of alternative modes of transport such as walking and cycling and desire to maintain healthy lifestyle choices. In response, there has been a major push to promote safe walking and cycling in urban areas, particularly in Europe and in Australia (Dijkstra et al., 1998; Victorian Government 2006) in order to meet important goals in urban traffic policy (i.e., accessibility for all, safety and a 'good' environment).

Pedestrian safety concerns are, however, likely to grow if initiatives that promote walking and public transport use (such as Victoria's Walking Action Plan (VICFIT, 2001) and Melbourne 2030 (Department of Sustainability and Environment, 2002) are successful in increasing the amount of walking without concurrent improvements in safety initiatives.

2.1.2 Fatalities and injuries

Encouragingly, there has been a downward trend in pedestrian deaths world-wide. For example, a reduction of 30 percent in pedestrian deaths between 1980 and 1995 on European Union (EU) roads was reported (European Transport Safety Council [ETSC], 1999). Australians, too, have seen substantial reductions in pedestrian deaths and serious injuries over the last few decades (see Figure 1).

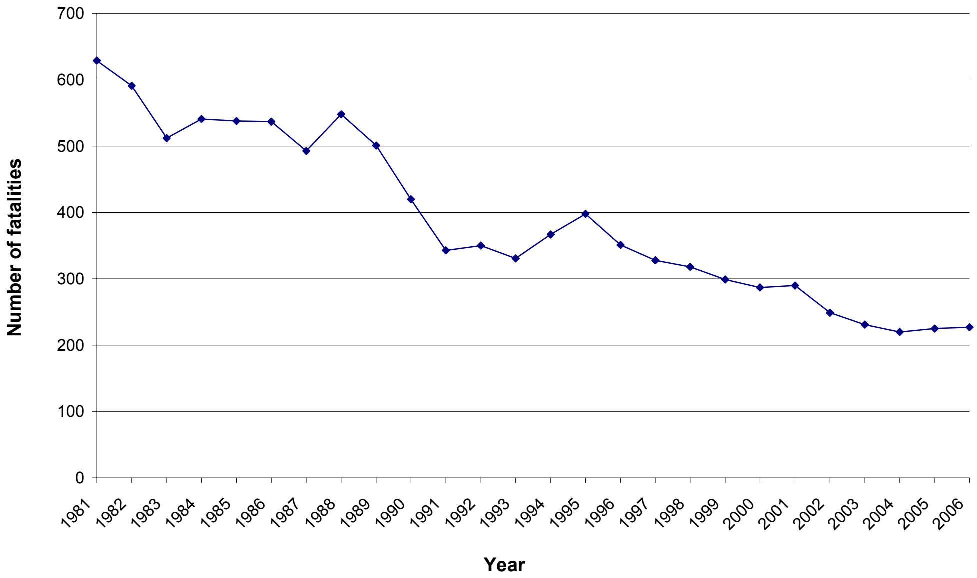


Figure 1: Number of pedestrian deaths in Australia, 1980-2006

Nevertheless, a substantial number of pedestrians die and many more are seriously injured each year throughout the world (Commission of the European Communities [CEC], 2000; Ekman et al., 2001). Indeed, the World Health Organisation (WHO, 2004) provided an important global perspective on the safety of vulnerable road users, reporting that:

- the risk of death in a road crash is far higher for pedestrians, cyclists and motorcyclists, than for car occupants;
- common driving errors and common pedestrian behaviour should not lead to death and serious injury – the traffic system should help users to cope with increasingly demanding conditions; and,
- the global focus on road investment for economic development and personal mobility has meant that the most vulnerable groups – pedestrians and bicyclists – have been largely overlooked, with a resultant heavy cost to the public health sector.

Pedestrian crashes alone constitute a substantial proportion of all road deaths world-wide. In Sweden, pedestrian fatalities constituted between 12 and 20 percent of all road fatalities between 1977 and 1995 (Öström & Eriksson, 2001). Similarly, in Britain and Israel pedestrians composed about a third of road fatalities (Davies, 1999; Hakkert, Gitelman and Ben-Shabat, 2002). In the USA, pedestrian fatalities accounted for approximately 13 percent of all road deaths (National Highway Traffic Safety Administration [NHTSA], 2001). Pedestrian crashes are an even more significant problem in many developing countries. In Karachi, Pakistan, for example, of the reported road fatalities, almost two-thirds (63%) were pedestrians (Khan, Jawaid, Chotani & Luby, 1999). Mohan (1992) reported that, in New Delhi, India, 42 percent of road traffic fatalities were pedestrians in 1985.

In Australia there were 201 pedestrian deaths in 2007 and over 3,770 people sustained serious injuries as a pedestrian in 2005-06. This represented approximately 12 percent of all road deaths (Department of Infrastructure, Transport, regional Development and Local Government, 2008) and approximately 9 percent of all serious injuries (Berry & Harrison, 2008).

Figure 2 shows the rate of pedestrian fatalities per 100,000 population in individual age groups in 2006. While older adults constituted the largest proportion of pedestrian deaths, children under the age of 16 years also constituted a substantial proportion of pedestrian deaths (approximately 9%).

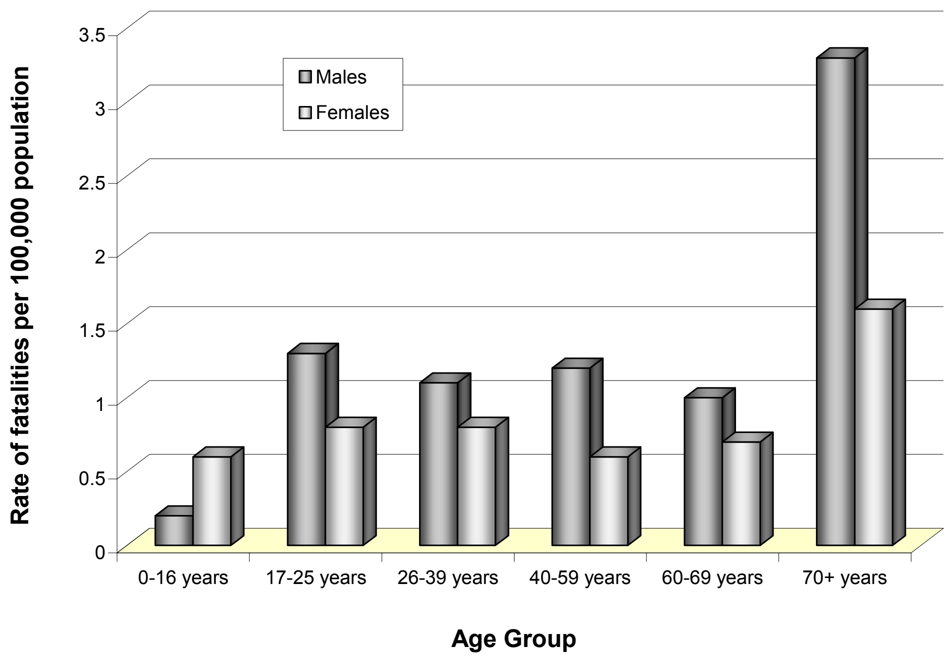


Figure 2: Rate of pedestrian deaths per 100,000 population in individual age groups, Australia, 2007 (Source: Dept. Infrastructure, Transport, Regional Development & Local Government, 2007)

Interestingly, Figure 2 shows that, amongst child pedestrian deaths last year, females were over-represented compared with males. In all other age groups, the reverse was true. Generally, however, in past years, male fatality and casualty rates are significantly higher than for females (Jones & Nguyen, 1988, as cited in Connelly et al. 1998; LTSA, 2000). Other research supports these figures and further report that children between the ages of 6 to 10 are at high risk of death and injury, with an estimated minimum four times the risk of collision compared to adult pedestrians (Struik, Alexander, Cave, Fleming, Lyttle & Stone, 1988; Thomson, 1996).

Serious injuries to pedestrians constituted 11.4 percent of all serious injuries to road users in 2002. Of these, 23 percent comprised children under the age of 16 years (ATSB, 2004) (Figure 3).

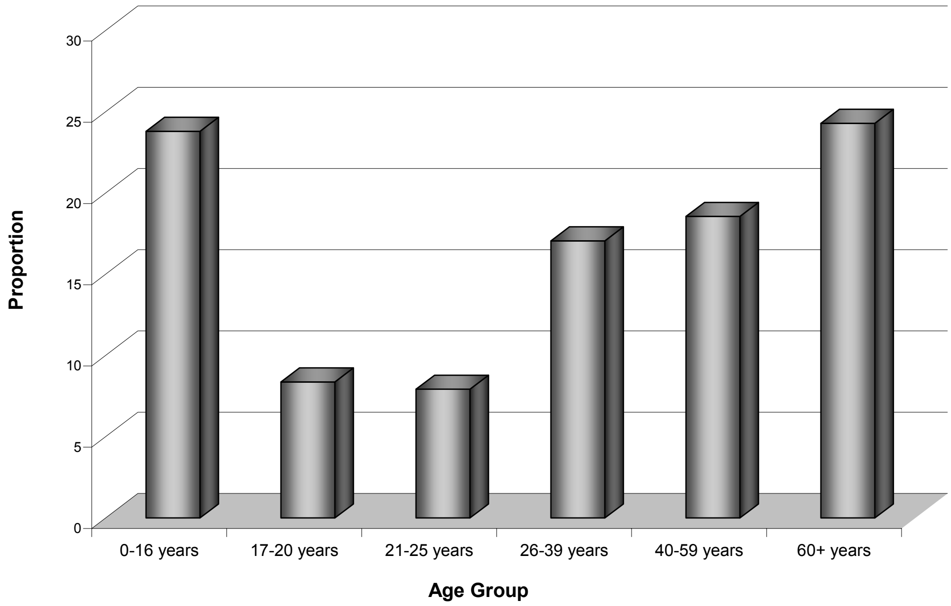


Figure 3: Proportion of serious injuries by age group, Australia 2002 (Source: ATSB, 2004)

While older adults may make up the largest percentage of fatal pedestrian crashes, young children make up a substantial proportion of serious injury crashes. Young children's safety is of particular concern in view of their vulnerability in traffic situations and the special value society places on children (Oxley, 2006).

Once exposure is taken into account, a more meaningful comparison of risk across different age groups is possible. With commencement of their schooling from age five or six, children begin to undertake independent travel and increase their exposure to road injury or death (FORS, 1996). Unfortunately, there have been no recent Australian studies that have used any exposure methods (e.g., distances walked, type of walking, number of roads crossed, time spent walking, etc.) for pedestrians. A New Zealand study utilising a travel survey conducted in 1997/98 found that children experienced a higher risk of death or injury than adults for each hour spent walking (LTSA, 2000). It was also reported that boys, especially those in the 5 to 9 age group, were at higher risk than girls.

There may also be socio-economic differentials in child pedestrian casualty rates. Some argue that, in the UK, children from lower socio-economic status backgrounds are at up to five times increased risk of pedestrian injury compared with children from higher socio-economic status backgrounds (Thomson, Tolmie & Mamoon, 2001; Hewson, 2004). Similar findings are reported in Sweden (Hasselberg & Laflamme, 2004). Whether this is due to behavioural factors on the part of the pedestrian or driver, or other environmental factors, has yet to be determined.

2.1.3 Crash types

Pedestrian crashes are considered by most to be an urban phenomenon. In Australia and New Zealand, as in other motorised countries, the great majority of pedestrian collisions occur on urban roads (over 90%), most often on local streets, close to home and, for children, while the child is unsupervised. Walking is an important means by which children use the road-transport system, particularly for reaching school and social activities and, not surprisingly, child pedestrian crashes occur most often in local streets close to home, and while the child is unsupervised. Many occur while the child is on the way home from school or playing after school (Anderson, Monstein & Adena, 1989; LTSA, 2000; ATSB, 2004; Struik, Alexander, Cave, Flemming, Lyttle, & Stone, 1988). In New Zealand, the majority of pedestrian collisions occur at intersections and at mid-block locations (LTNZ, 2005). International figures show similar patterns (see Oxley, 2006). Moreover, a disproportionate number of young children collide with vehicles whilst attempting to cross a road near parked vehicles (Demetre & Gaffin, 1994).

2.1.4 Crash causation

Despite the fact that young children appear to suffer particular problems interacting with traffic as pedestrians and show relatively high fatality and serious injury risk, compared with older children and adults, there are only a limited number of (in-depth) crash investigations that specifically examine the crash circumstances of this group. Moreover, even though vulnerable child road users are identified as 'high-risk', it is difficult to determine the causal factors related to their crashes from crash statistics alone.

Crashes are complex in nature, often involving several contributing factors and it is a difficult task to determine, first, the major contributing factors and secondly, how and to what extent risk factors contribute to crash risk. Nevertheless, understanding the factors that contribute to crash and injury risk is an important step in the development and implementation of appropriate strategies and countermeasures to ensure safety. Several explanations have been offered to account for the over-representation in serious injury and fatal crashes amongst children. A wide range of studies have examined the safety of vulnerable road users and most attempt to establish relationships between crash frequency and severity, road user characteristics, vehicle factors, road features and other possible contributory factors. The factors that appear to contribute to child pedestrian crashes include: driver behaviour; the road environment; vehicle design and the behaviour of children in traffic (Oxley, 2006). Given that the main focus of this study is the behaviour of children in traffic, other factors will be discussed briefly, with a more in-depth discussion of behavioural factors.

2.1.4.1 Driver behaviour and the road environment

The safety of pedestrians is compromised to a large extent by the design and operation of the road-transport system, which is generally designed for vehicles and, for the most part, seems to be unforgiving for the most vulnerable road users. Dominant attitudes by drivers, failure to acknowledge the rights of pedestrians and fast speeds of drivers in areas of high pedestrian activity greatly increase the potential for crashes and, more importantly, the injury consequences once a collision occurs (Job, Prabhakar, Lee, Haynes & Quach, 1994; Preusser, Wells, Williams, & Weinstein, 2002; Summala, Pasanen, Räsänen & Sievänen, 1996).

There is some evidence that the perception that vehicles have higher status on the road compared with pedestrians and consequent behaviour of drivers may contribute, in part, to increased risk of pedestrian crashes (Baker, Robertson & O'Neill, 1974; Preusser et al., 2002; Snyder & Knoblauch, 1971; Stutts, Hunter & Penn, 1996; Hydén et al., 1998; Summala, Pasanen, Räsänen and Sievänen, 1996).

Hydén et al. (1998) argued that pedestrians and cyclists have a lower status than vehicles and this is primarily because of the fact that pedestrians and cyclists do not pose a threat to car occupants – therefore, drivers are not afraid of pedestrians. The protective behavioural patterns of drivers do not therefore take enough account for unexpected and sudden movements of weaker (vulnerable) road users. Retting, Ulmer and Williams (1999) noted some concern that urban drivers are operating more aggressively, with less regard for traffic law and the vulnerability of other road users.

Recent studies of driver behaviour at Zebra pedestrian crossings show that: drivers are often unwilling to give way to pedestrians; are often unaware of pedestrians in the area; they often disregard the crossing area and continue at high speed; and, do not slow down or maintain a safe speed to be able to handle a possible unexpected situation when pedestrians are at crossings (Várhelyi, 1998; Hakkert, Gitelman and Ben-Shabat, 2002).

Speed and speeding has a great impact on pedestrian safety and there have been many calls for moderating vehicle speeds of drivers in high activity pedestrian (Job, Prabhakar, Lee, Haynes & Quach, 1994; Oxley, Diamantopoulou & Corben, 2001). Clearly, the faster drivers choose to travel, the more likely they are to be involved in a crash, and are more likely to severely injure vulnerable road users. Higher driving speeds reduce predictability and reduce a driver's ability to control the vehicle, negotiate and manoeuvre around obstacles on the roadway. Higher speed also increases the distance a vehicle travels while the driver reacts to a potential collision, reducing the time available to avoid a collision.

More importantly, the probability of injury, and the severity of injuries that occur in a crash, increases, not linearly, but exponentially with vehicle speed – to a power of four for fatalities, three for serious injuries and two for casualties. Even small increases in speed can result in a dramatic increase in the impact forces experienced by crash victims. It is estimated that, for every 1 kph increase in mean speed, the number of injury crashes will rise by around 3 percent (thus an increase of 10 kph would result in a 30 percent increase in injury crashes) (Nilsson, 1984).

Pedestrian and cyclist crashes are highly likely to result in injury to the pedestrian or cyclist even at low vehicle speeds due to the forces exerted by vehicles on them. The critical relationship between vehicle speed and injury severity for pedestrians is demonstrated in a number of reports and illustrated in Figure 4. At collision speeds above 35 kph, the probability that a pedestrian will be fatally injured rises rapidly, with almost certain death at impact speeds of 55 to 60 kph.

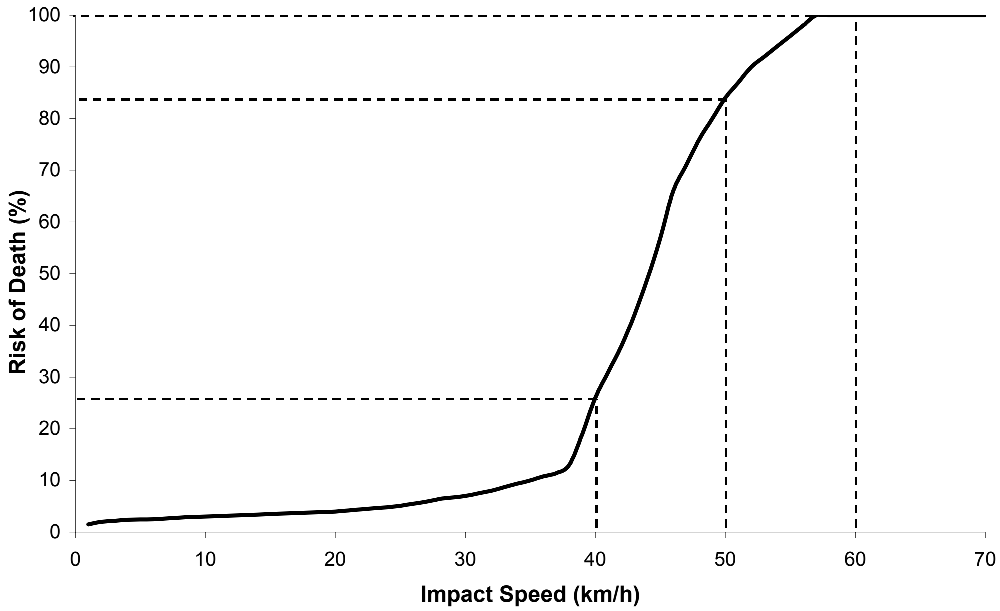


Figure 4: Risk of pedestrian death as a function of vehicle impact speed. (Source: Anderson, McLean, Farmer, Lee & Brooks, 1997)

2.1.4.2 Vehicle Design

Current design of vehicle frontal structures and vehicle mass of both passenger cars and other larger vehicles contributes significantly to the severity of injuries sustained in a collision. Pedestrians struck by a car or four-wheel-drive vehicle with high bumpers and more blunt frontal profiles, are more likely to incur serious head, thoracic, abdominal and spinal injuries than when struck by a bonnet-type passenger car. In contrast, as passenger cars are more aerodynamically streamlined and have lower bumpers than vans, utilities and four-wheel-drives, pedestrians struck by a car are much more likely to incur a leg injury (Ballesteros, Dischinger & Langenberg, 2004; Maki, Kajzer, Mizuno & Sekine, 2003; Lefler & Gabler, 2004).

With the recent rise in popularity of sport utility vehicles (SUVs), minivans and four-wheel-drive vehicles, in many countries, the issue of vehicle design and use of particular vehicle types is becoming more relevant to pedestrian and cyclist safety (McFadden, 1996; Ballesteros, Dischinger & Langenberg, 2004). Furthermore, the fitting of rigid bull-bars to many large vehicles is of great concern to pedestrian safety. The Pedestrian Council of Australia (2003) reported that about 60 percent of four-wheel-drive vehicles and half of the utilities and vans on metropolitan roads in Australia are fitted with bull-bars, and were contributing factors in up to 20 percent of fatal pedestrian crashes on urban roads.

2.1.4.3 The behaviour of children in traffic

It has been suggested that, due to immature and less well-developed cognitive, attentional, perceptual and visual skills, young children are less competent in traffic than older children and adults and this consequently increases their risk as pedestrians (Zeedyk, Wallace & Spry, 2002; Whitebread & Neilson, 2000; Sarkar, Kaschade, and de Faria, 2003; Tabibi & Pfeffer, 2002; Dunbar, Hill & Lewis, 2001).

It stands to reason that younger children experience great difficulty with many aspects of the road-crossing task. Their small stature is one identified source of difficulty. They have greater difficulty seeing over parked cars and other obstacles, and are in turn more easily hidden by them (Demetre & Gaffin, 1994; Leadbetter, 1998). Further, research shows that younger children (under 7 years) experience particular difficulty in choosing a safe location to cross, judging safe gaps in traffic, being distracted by irrelevant information, attending strategically to traffic in complex traffic situations, judging the distance across the road and the speed with which one can propel oneself across that span, and controlling impulsive reactions (Barton & Shwebel, 2007). For children aged 7 years or older, the abilities necessary to interact safely in traffic improve markedly in a number of important aspects but, for many children, these abilities may not be fully developed until at least 11 to 12 years of age. For example, one observational study by Zeedyk, Wallace and Spry (2002) found that very young children (aged 5-6 years) often did not stop at the kerb before stepping on to the road, failed to look for oncoming traffic, and when they did look for oncoming traffic, it was just as likely to be in the incorrect direction as the correct direction.

One crucial element of the road-crossing task that children often have difficulty with is the ability to select a safe gap in traffic.

2.1.4.3.1 Gap selection

Making the decision about when it is safe to cross the road, in relation to available gaps in the traffic, is a vital yet complex task. Judgement of whether a gap in the traffic is sufficient to safely cross requires the determination of the time gap of the nearest vehicle with the planned crossing line and the assessment of whether this time gap exceeds the time required to cross the road, taking into account one's own speed (Simpson, Johnston & Richardson, 2003). There is evidence that children aged below 10 years, have relatively poor skills at reliably setting safe distance gap thresholds, and thus do not consistently make safe crossing decisions (Connelly et al., 1998).

There is some research to suggest that children's poor skills at selecting appropriate gaps in traffic are due to the fact that distance, rather than an approaching vehicles speed, is a primary factor in determining gap acceptance thresholds (Connelly, Isler & Parsonson, 1996, Connelly et al., 1998; Simpson et al,. 2003). In addition, there is also some evidence that adult drivers and older pedestrians also seem to rely on distance rather than the speed of an approaching vehicle (Oxley, Ihsen, Fildes, Charlton, & Day, 2005). It makes sense to cross only when a vehicle is far enough away – many pedestrians do make an initial decision such as 'the further the car is away from me, the safer it is to cross'. This suggests an immediacy effect where a vehicle far away, irrespective of its travelling speed is judged to be less threatening than one close by. While basing a decision primarily on vehicle distance may be a strategy that works reasonably well when a vehicle is far away and for agile pedestrians who can walk fast enough to avoid even relatively close vehicles, it can clearly lead to risky crossing decisions. Clearly, the abilities to perceive and integrate distance information with the speed of the oncoming vehicle accurately and to select a time gap large enough, taking account of physical attributes/limitations, are crucial components for safe road-crossing. It is unclear, however, whether relying on distance for making gap selections is the reason why child pedestrians are at a higher risk of death and injury than adults, or there are other explanations.

There are a handful of studies that have addressed children's road crossing judgements while walking and cycling (Connelly et al., 1998; Demetre, Lee, Grieve, Pitcairn, Thomson & Ampofo-Boateng, 1992; Lee, Young, & McLaughlin, 1984; Pitcairn & Edlmann, 2000; Plumert, Kearney & Cremer, 2004; Simpson et al., 2003). Lee et al. (1984) developed a road-crossing task in which 5-9 year old children crossed a 'pretend road' set up parallel to an actual road. Children were instructed to cross the pretend road as if crossing the adjacent road in the face of oncoming vehicles. The findings indicated that, although children were generally cautious, they sometimes accepted gaps that were too short. In addition, younger children were more likely to make a road-crossing error than older children, suggesting that younger children may overestimate their ability to walk safely through traffic gaps.

Connelly et al. (1998) devised another roadside task where children aged 5-12 years stood at the side of the road in normal traffic conditions and indicated the last possible moment that they would cross. The results showed that across the five speed categories (0-50, 51-55, 56-60, 61-65, 66kph and over) children set similar distance thresholds regardless of the speed of the vehicle. They also reported that one in three of the distance gap judgements made by children under the age of ten was unsafe, and there was some indication of a gender effect, with boys somewhat more likely to make safe decisions compared with girls at age 5-6 years and at 11-12 years.

Both Lee et al. (1984) and Connelly et al. (1998) attempted to measure children's road crossing decisions using roadside tasks. While these studies have high face validity, there are limitations in studies conducted at the roadside. For example, standing at the pretend road places the participant a road's width away from the edge of the real road, and thus may change the perspective of the child (Pitcairn & Edlemann, 2000), and therefore their judgements. Further, typically in on-road settings there is little control over the timing and location of traffic. This was a noted limitation of the Connelly et al. (1998) study. Not all children made judgements of vehicles travelling at each of the five speed groups, making it difficult to draw definitive conclusions about the roles of distance and speed in gap judgements (Plumert et al., 2004).

Three previous studies have assessed children's road crossing decisions using simulated environments (interactive bicycle simulator: Pitcairn & Edleman, 2000; video presentation: Plumert et al. 2004; virtual reality head-mounted display: Simpson et al, 2003). In general, these studies indicated that children are poorer than adolescents and adults in making safe road crossing decisions, and both children and adults tend to base their road crossing decision on distance gap rather than time gap. Importantly, however, each study had some limitations. These include: lack of analyses amongst young children (one of the most vulnerable pedestrian groups), and technical difficulties. For example, the findings of the Plumert et al. (2004) study may have been influenced by the film format used, as it was not a perfect representation of the roadside. The need to fit the road into half a frame of the monitor resulted in the angle of the vision being much wider than normal. The effect of this change on perception is unknown.

2.2 FACTORS INFLUENCING CHILDREN'S ROAD CROSSING SKILLS

Childrens' road-crossing skills and their behaviour in traffic may be influenced by a variety of factors including demographics and individual differences, cognitive ability, and visual, attentional and perceptual skills. While it is suggested that 'at-risk' groups may include younger children, those who also have poor risk perception and therefore likely to take high risks, or hyperactive, impulsive, inattentive and easily distracted children, may also be at increased risk. Little is known, however, about how these factors may affect road crossing decisions.

2.2.1 Demographics and individual differences and the influence on road-crossing skills

Research conducted by Barton and Schwebel (2007) examined the roles of age, gender, ethnicity, family income, and inhibitory control on children's selection of safe pedestrian routes. A sample of 122 children aged between 6 and 10 years were recruited. Children's selection of pedestrian routes were examined in two laboratory tasks, while multiple behavioural and self-report measures were used to measure inhibitory control. The results showed that younger age, ethnic minority status, lower family income, and lower temperamental inhibitory control predicted selection of riskier routes. Neither child gender nor child- or parent-reported temperament was significantly related to route selection. The authors suggested that children from lower economic status and children of minority ethnic background might be targeted for pedestrian training. They also suggested that children with less temperamental control might be supervised more carefully than their temperamental controlled counterparts. The researchers also recommended that younger children between six and eight years old should also be targeted for pedestrian safety intervention.

Further research investigating the demographics and individual differences of children and their road crossing skills was conducted by Underwood, Dillon, Farnsworth and Twiner (2007). They examined whether there were identifiable developmental trends in the perception of road risk assessment, and whether there were gender differences in the reading or understanding of road risk. 119 school children between the ages of 7 and 12 years were asked to sort 20 photographs of road scenes on self-selected criteria (free-sort), and then re-sort the scenes on the basis of the safety of each scene (cued-sort). In the 'free sort' condition, age differences in both the number and types of categories produced were found. However the age variation was not evident for the cued sort condition, indicating that the younger children were strongly influenced by cuing, and that perhaps the older children may have classified the scenes on the basis of safety in the free sort. There were only limited gender differences in assessing safety. Boys tended to focus more on the physical attributes of the scene and females on the actors within the scene.

2.2.2 Cognitive development and effect on acquisition of road-crossing skills

Cognitive development is primarily concerned with the ways in which infants and children acquire and develop internal mental capabilities such as problem solving, memory, and language. These skills are essential in acquiring good road-crossing skills. Jean Piaget charted four stages of cognitive development: the sensorimotor stage (birth to approximately two years), the preoperational stage (approximately two to seven years), the stage of concrete operations (approximately seven to approximately eleven years) and the stage of formal operations (approximately eleven years and above) (Walker, Burnham & Borland, 1994). During each stage, certain critical cognitive abilities are achieved. In the sensorimotor stage, children experience the world through movement and senses. In the preoperational stage, children acquire motor skills and are able to represent objects mentally. However, at this stage they still cannot engage in certain basic mental operations, such as focusing on two dimensions at the same time, or reversing actions mentally. It is around age 7 that children move from the preoperational stage to the concrete operational stage. In this stage, children are able to begin to think logically about concrete events. They form mental representations that adequately reflect possible actions in the physical world. At around age 11, children move into the formal operational stage and develop abstract reasoning. Research suggests that 7 to 11 years of age are the most formative ages for the development of road crossing skills (Foot et al., 2006). This coincides with the concrete operational stage of development.

Briem and Bengtsson (2000) investigated the effects of cognition and character traits on children's behaviour in traffic situations and aimed to investigate how children's understanding of traffic safety influenced their behaviour in traffic situations, and how their behaviour may be affected by character traits. Children's (3-6 years old) traffic behaviour was assessed on a traffic model and on a minor road. Three character traits (activity, distraction and impulsivity) were also assessed on a subgroup of children. The findings suggested that the quality of children's safety knowledge, understanding and behaviour improves markedly with age. The six-year olds were much more capable of understanding the concepts of road traffic safety than the younger children. This age roughly coincides with the developmental transition between cognitive substages noted by Piaget (Piaget & Inhelder, 1969, as cited in Briem and Bengtsson, 2000). The authors also found that impulsivity (lack of impulsive control) was closely related to the children's behaviour in the traffic model.

2.2.3 Behavioural factors and the influence on road-crossing skills

Researchers have investigated the influence of behavioural factors, such as hyperactivity and impulsivity, on injury proneness and road-crossing skills and the findings are contradictory and inconclusive.

For example, one study found that ADHD children had a greater chance than non-ADHD children of being involved in a crash (28% vs. 18%) (Swensen, Birnbaum, Hamadi, Greenberg, Cremieux, & Secnik, 2004). More specific to the road safety context, it has been argued that children with less behavioural control will not stop to think about the risks involved in a crossing, will not pause to search carefully for potential hazards, and will overlook visual obstacles in the process of creating a roadway (Barton & Schwebel, 2007).

A matched case-controlled study that attempted to identify psychosocial factors in childhood pedestrian injury found that hyperactive, impulsive and otherwise behaviour disordered children were not at a higher risk than other children for pedestrian injuries (Christoffel, Donovan, Schofer, Wills, & Lavigne 1996). The study recruited 128 pairs of children aged 5-12 years, matched for age, gender, race and neighbourhood, who either had an injury as a result of a pedestrian collision (cases), or were hospitalized for other reasons (controls). The results showed that children with a pedestrian injury had more stress in the home; had more over-crowded living conditions, performed more poorly in schools and had poorly established family support networks than the controls. However, no child behavioural factors were found to be strong contributors to injury risk for pedestrians.

Wazana (1997) conducted a review of the literature to determine if there are behavioural, emotional, developmental or physical characteristics that may put children at higher risk for injury generally, and pedestrian injury specifically. The paper assesses six child pedestrian injury studies that examined variables of child injury proneness. The review found that the six studies examined showed somewhat different findings: 1) aggression was not associated with injuries, 2) hyperactivity was found to be significant only if looked at in isolation from most other risk factors, 3) internalising and externalising disorders were not significantly related to injuries, 4) lack of caution and preventive behaviour were found to be highly related to injury occurrence, 5) precocious physical development was similarly associated, and 6) a general measure of behaviour problems was found to be a significant risk factor for injuries.

More recently, Hoffrage, Weber, Hertwig, and Chase (2003) proposed that the typical accident-prone child tends to be hyperactive, impulsive, inattentive, easily distractible and has problems controlling actions. In addition, they proposed that accident-prone children tend to be extroverted, attention-seeking and aggressive, and are most often boys. Their study aimed to identify children (aged 5-6 years old) who are particularly prone to making risky and potentially harmful road crossing decisions using two simple games (a gambling game and a computer game where they could send a 'pedestrian' to cross a street in a simulated traffic scenario). Children were then classified as either 'risk-takers' or 'risk-avoiders' based on their behavior in these two tasks. Road-crossing skill was assessed on the pretend road crossing task (as used by Lee et al., 1984). They predicted that i) risk-takers will more frequently arrive at a 'go' decision than risk-avoiders, particularly in medium sized gaps, ii) risk-takers will tolerate shorter leeway times than risk-avoiders, and iii) risk-takers will have shorter decision times than risk-avoiders. The results suggested that risk-taking in the gambling game was predictive of risk-taking in the every-day road-crossing context, particularly in medium sized gaps when uncertainty about the possibility of a safe crossing was highest. During these gaps, risk-takers made a higher proportion of 'go' decisions compared with risk-avoiders, were willing to tolerate shorter leeway times, and reached their crossing decisions more quickly than risk-avoiders. They discussed the implications of these findings for educational programs and suggested that pedestrian training programs might be more effective if they identify those who are prone to risky behaviour.

2.2.4 Visual, attentional and perceptual skills and impact on road-crossing skills

As indicated previously, much of the literature suggests that young children are less competent in traffic than older children and adults because of poorly developed perceptual and attentional abilities, which consequently increases their risk as pedestrians. (Connelly et al., 1998; Dunbar, Hill & Lewis, 2001; Whitebread & Neilson, 2000). Dunbar et al. (2001) studied switching attention and concentration in a sample of 160 children aged 4-10 years. Attention was examined using a computer game that involved attention switching and concentration was examined using a task that involved children being distracted with a cartoon video while they attempted a difficult task that required matching familiar figures. Their road crossing skills were observed while crossing roads with and without their parents. The results showed that older children were able to switch their attention faster and were less distracted than younger children. Further, children who were able to switch attention more rapidly in the computer game were more likely to appear to look at traffic when they were about to cross the road. In addition, children who were less able to concentrate when challenged by a distracting event tended to be more impulsive, and more impulsive children tended to cross the road in a less controlled manner.

More recently, Tabibi and Pfeffer (2003) investigated the relationship between attention and the ability to identify safe and dangerous road crossing sites among children and adults, by using computer animation displaying a selection of road crossing sites varying in complexity. Attention was measured using the Stroop Test. They found that the number of correctly identified safe and dangerous road crossing sites increased with age and the identification time of sites decreased with age. There was no effect for gender. Due to this lack of gender differences in the ability to identify a safe or dangerous road-crossing site, gender differences in crash rates cannot be explained by differences in identification of road crossing sites. Furthermore, the results indicated that attention is required for identifying road-crossing sites quickly and accurately. The authors suggest that road-safety training programmes for children address these aspects of cognition.

In addition to attentional skills, visual perceptual skills and their influence on road safety skills have been studied. Whitebread and Neilson (2000) attempted to explore the extent to which the improvement of performance as a pedestrian is associated with the development of effective visual search and other related strategies. Sixty children were tested, with 20 children in three age groups; 4-5, 7-8 and 10-11 years. The children were tested on their pedestrian skills using the following tasks: identifying safe places to cross using a set of eight slides; detecting dangerous traffic in a 3-minute video; and coordinating information from different directions in a 3-minute simultaneous video presentation. The results showed that pedestrian skills develop through the primary school age range. At 4 and 5 years, children had little or no understanding of where was a safe place to cross the road. At 7 and 8 years, children were beginning to acquire skills, and could identify some safe places to cross, but not all. By 10 to 11 years, the majority of children had largely acquired all the skills, making more accurate and clearly justified judgements about when it is safe to cross. Further, the results showed that around the age of 7-8 years the frequency of switching direction of visual attention and duration of looking in one direction were related to an emerging understanding of the pedestrian task and ability to sample information from different directions effectively. Among the 7-8 years group, exhaustiveness of visual search was significantly related to pedestrian skills, suggesting a strategic shift of processing visual information at this age.

While common sense dictates that when young children are exposed to traffic supervision is essential, there is little agreement on developmental milestones that allow independent travel, and very little information given to parents regarding the development of skills. Moreover, there are certain disadvantages and risks associated with walking including the danger caused by traffic, personal safety, discomfort if carrying heavy articles, poor facilities, and, walking is time consuming (Forward, 1998; Hydén et al., 1998; Wigan, 1995).

2.3 STRATEGIES TO MANAGE CHILD PEDESTRIAN SAFETY

There are a number of ways to improve child pedestrian safety including training children in skills for interacting safely with traffic, adapting the environment to be more forgiving, and vehicle design improvements. These are discussed below.

2.3.1 Supervision and exposure to traffic

Common sense dictates that when young children are exposed to traffic, supervision is essential. To be safe road users, children's reliance on their own judgement is not enough – they need the support and corrective feedback from others, along with challenge to their own ideas and perspectives that comes from disputing, disagreeing, defending and justifying their own beliefs (Foot et al., 2006).

Parents are generally the first to accompany children on trips and can play an important role in providing a good model of pedestrian behaviour to their young children (Zeedyk & Kelly, 2003). However, few adults treat the crossing event as an opportunity to teach their children explicitly about road safety, do not adapt pedestrian outings to match children's skill level, that children therefore have little opportunity to exercise or develop their own pedestrian skills (Zeedyk & Kelly, 2003), they rarely understand the limitations of young children, have little understanding of the skills required to make safe road-crossing decisions and may not be aware of the important role they can play.

It is generally recommended that child pedestrians should be supervised until they reach the age of nine or ten. It has been argued that the accompanying older person should hold the hand of the child until they reach the age of six, although allowance should be made for the capacities of the individual child. It should be noted, however, that although there is agreement that supervision of young children is necessary, there is little consensus on developmental milestones such as no longer holding hands and allowing independent travel.

Many jurisdictions provide supervision at key crossing points in the form of adult Crossing Supervisors. However, their effectiveness in preventing crashes at school crossings has not been determined.

2.3.2 Training and education

In general, the effectiveness of behaviour training and educative awareness programs in improving overall road safety has been questioned, many believing that they have limited success particularly in terms of getting people to respond to educational campaigns, to learn new strategies and to change habits and attitudes. Recently, however, it has been argued that, as behavioural factors play a large role in traffic safety, more effort should be placed on intervention programs aimed at altering human behaviour and attitudes (Evans, 1991).

For children, however, it is generally argued that they can be effectively taught critical road safety skills and behaviours and this is the justification of providing road safety education programs. Research shows that, even after a single session of education or training, safety knowledge increases amongst children (Morrongiello & Kiriakou, 2006). However, it appears that the transfer from knowledge to safer performance or behaviour is poor and transfer is far from automatic (Zeedyk et al., 2001; Klassen, MacKay, Moher, Walker & Jones, 2000; Ampofo-Boateng & Thomson, 1991; Rothengatter, 1981). Moreover, education may produce negative effects in that children's increased knowledge can create a false sense of confidence amongst parents and children that their ability to face the road environment is improving (Zeedyk & Wallace, 2003).

There have been some attempts to quantify the beneficial effects of education and training on the acquisition of road safety skills, however the results are varied. An early study by Young and Lee (1987) examined the effects of training five-year old children on a 'pretend road' (as in Lee et al. 1984) to safely cross a road. Children were trained individually by the same adult. Training sessions lasted about 15 minutes, and all children received between 9-14 training sessions. Children received two types of feedback about their performance. First, they could see whether they started off too long after a vehicle passed and whether they reached the safety of the railing before a vehicle reached the crossing line. Second, the trainer reprimanded them if they behaved recklessly. In addition, some of the children received a reward when they performed well. The results showed that children's efficiency in crossing through gaps in traffic significantly improved after only an hour or two of training. They started more promptly after the first vehicle had passed and became more consistent in synchronising their crossing with the vehicle. This timing ability reached about adult level in pretend single-lane crossing but fell short of adult performance in two-way road crossing. The standard of performance was also maintained three weeks after training. The authors concluded that the results indicate that young children have the visuo-motor capacity to learn to cross the road safely in traffic, and that a pretend road crossing method is a safe way of enabling children to improve their road-crossing skill.

More recently, Hotz et al. (2004) conducted an evaluation of the WalkSafe program in Florida, USA. The WalkSafe program utilises videos, formal educational curricula, workbooks, and outside simulation activities to promote pedestrian safety among school aged children. The curriculum was hierarchically based to account for the differing stages of children's behaviour and development. Children's knowledge of safety behaviours were tested pre, post and three months after the programs' implementation. In all grades, higher test scores were seen in post-testing conditions, and these results were retained at the three month follow-up sessions. Observations of pedestrian behaviour were also analysed at the same time points. The results showed that the children who participated in the WalkSafe program were more likely to stop and look when crossing the street. However, these results were not sustained at three months follow-up.

Miller, Austin and Rohn (2004) also examined the effects of a training, feedback and reinforcement package on pedestrian safety skills in primary school aged children. The intervention package was a half-hour session in which trainers modelled behaviours to the children and then had children demonstrate the behaviours while crossing a mock intersection. Verbal feedback and reinforcement was provided. Children were observed at two local intersections, and the results showed that the average proportion of safe behaviours increased from 54 percent to 74 percent. However, when the intervention package was withdrawn, the average pedestrian safety behaviour decreased to 57 percent safe behaviours, which is almost the same as the average baseline percentage of safety behaviours.

These findings suggest that training may need to be more practical to be more effective and long-lasting. This has led some researchers to investigate the potential benefits of training children pedestrian skills in a simulator environment (e.g., McComas, McKay & Pivik, 2002; Thomson, Tolmie, Foot, Whelan, Sarvary & Morrison, 2005; Glang, Noell, Ary & Swartz, 2005; Foot, Thomson, Tolmie, Whelan, Morrison & Sarvary, 2006.)

2.3.2.1 Simulator training

Simulator training has long been advocated as a useful tool in many safety areas such as air safety and young driver safety and may also be useful for other road user groups.

Thomson et al. (2005) examined the influence of virtual reality training on roadside crossing judgements of child pedestrians aged 7, 9 and 11 years. Training was conducted using a computer-simulated environment that incorporated realistic 3D scenes, animation routines and interactive features. A character was required to undertake a journey in the virtual neighbourhood and both positive and negative feedback was given to the participants. It consisted of four sessions at the computer, each lasting approximately 30-40 minutes. Children were trained in groups of three, and their road-crossing skills were tested individually at the roadside. They found that the trained children crossed more quickly and that their estimated crossing times became better aligned with actual crossing times. They crossed more promptly, missed fewer safe opportunities to cross, and accepted smaller traffic gaps without increasing the number of risky decisions. However, there was no effect of training for the number of tight fits that trained children accepted.

Similar encouraging results were found by Glang et al. (2005). They evaluated an interactive multimedia program that aimed to teach young children safe pedestrian skills, in particular, the ability to identify potentially dangerous vehicles. Primary school aged children (n=36) participated in the *Walk Smart* program, which is a 40 minute CD-ROM program that places emphasis on breaking down the complex skills of street crossing into its component parts. Road-crossing skills were evaluated by video assessment and a mock traffic environment prior to and after the program. The video assessment showed that the average proportion of dangerous vehicles correctly identified improved about 40 percent from pre-test to post-test, and the behavioural post-test (tested in a mock traffic environment) scores showed similar improvements of about 38 percent. While this improvement is substantial, the authors did not re-test the children at a later date to see if the skills gained would be maintained over time.

A further study examined a different aspect of the road crossing task (Foot et al., 2006). A simulator study was designed to explore children's understanding of drivers' intentions, and explore whether children can be sensitised, through training, to a better understanding of a drivers' likely actions. The study used a pre-test intervention/control post test-design, and involved 191 children between the ages of 7-11 years. Children were tested on the simulator and the roadside one week before and one week after the training program. The training program consisted of four 30-minute training sessions over 4 weeks, and involved use of a simulator and small groups of children with an adult facilitator to guide discussion over decisions made. The results showed that training children of all ages to be more aware of drivers' options when signalling a manoeuvre improved the accuracy in predicting drivers' intentions. However, there was no long term follow-up to see if the changes would be maintained over time. The authors also found a strong link between improvements in judgements and improvements in justifications, suggesting that the gains exhibited by trained children were derived not from exposure to the test material, but from the discussion that promoted explicit reasoning. They suggest that clear benefits appear to have accrued from the impact of adult guidance and peer discussion in encouraging children to explicitly justify their decisions.

2.3.2.2 Evaluations of child pedestrian training and education programs

Behavioural interventions are rarely evaluated, hence it is difficult to gauge their effectiveness overall. Nevertheless, there have been some attempts at assessing the potential benefits of educational programs. For instance, Duperrex, Bunn and Roberts (2002) conducted a review on child road safety education programs. They identified pedestrian safety education programs which randomly allocated individuals to experimental or control treatments. They identified 15 studies, 14 of them dealing with children. They found that the methodological quality of the trials was generally poor and that the trials all used different measures and employed different intervals between the education and the evaluation. None used injury reduction as a criterion, but five of the studies compared the effects of the different treatments on observed behaviour. As the authors point out, linking behaviour to crash reductions depends on untested causal assumptions which, even if true, leave some unanswered questions regarding the relationship between the size of the behavioural effect and the extent of crash reductions.

A further review conducted by Turner, McClure, Nixon and Spinks (2004) examined studies that evaluated community programs to prevent pedestrian injuries in children. A comprehensive search of the literature found three studies that used injury as their outcome measure. Durkin, Laraque, Lubman and Barlow (1999) reported on pedestrian injuries for school aged children pre and post a comprehensive community-based program initiated in northern Manhattan. Strategies as part of the campaign included building and refurbishing playgrounds with fenced perimeters to provide outside play areas other than streets and pavements, safe road crossing instruction to all grade three students, and establishment of supervised recreational programs. A substantial reduction in pedestrian injuries of 45 percent was reported as a result of the program.

Preusser (1988), too, found a reduction of injuries due to mid-block dart and dashes of 21 percent in children under 14 years of age and attributed this reduction to a community education and mass media programme.

The effectiveness of the Harstad Injury Prevention Study (an all injury reduction programme modelled on the Manifesto for safe Communities) was also reported by Ytterstad (1995). Following implementation of the programme, there was an overall decrease of pedestrian injury of 54 percent amongst children ages 0-15 years. Intervention activities included legislative action, construction of separate pedestrian and cyclist roads, enforcement of lowered sped limits, mass media campaigns, targeted education of children and targetted counselling of parents.

This review highlights that multi-faceted programs appear to be more effective in reducing child pedestrian injuries, than interventions that only utilise one strategy. However, all three studies discussed in the Turner et al. (2004) review were conducted overseas. More research needs to be conducted in Australia into the effectiveness of these programs in reducing child pedestrian injuries.

2.3.2.3 Limitations of training programs and recommendations for future training programs

There are concerns that road safety education of children may not be optimal. For example, Bailey (1995) pointed out that, on the rare occasions when road safety education is evaluated, it tends to focus on knowledge and attitudes derived from rote learning, rather than skills required to function in traffic environments. He is particularly critical of one-off and other short- term programs where there is no linking of the lesson to prior knowledge, and no follow-up. Practical programs provide the opportunity to develop skills rather than knowledge alone. Computer simulation programs offer a safe environment to learn road crossing skills. The use of computer simulations has been accepted by the UK Department for Transport for purposes of child pedestrian training (Foot et al, 2006).

It is also suggested that education and training programs are only moderately successful because these programs generally treat each child the same (Hoffrage et al, 2003). Rather, it is argued that training programs should be specifically tailored for and allocated to those who are most in need of training. Barton (2007) suggested that training programs may be more successful if they are adapted to the child’s ability to handle the informational demands in a pedestrian setting. For example, younger children in a training program might receive more intensive instruction on how to attend to distance and speed of vehicles. Underdeveloped selective attention skills in children may be enhanced if training is tailored to their specific developmental needs rather than being delivered in a standardised form. However, there still remains a large amount to be learned about children’s behaviour in traffic environments (Zeedyk & Kelly, 2003) and a better understanding of the developmental and behavioural characteristics that put young children at increased risk for pedestrian injuries. This information will be critical for development of more appropriate and targeted road safety education and training packages.

It has also been recommended that any child pedestrian training program should offer both adult guidance and the opportunity for peer discussion. Adult guidance offers structure, scaffolding and contingent support to steer children, and peer discussion offers dialogue which provokes the generation of concepts and debate, which prompts children to challenge each other, justify their ideas and resolve disagreements (Foote et al., 2006).

2.3.3 Current Australian programs

All Australasian jurisdictions have some form of comprehensive road safety education program that takes students from pedestrian education in pre-school and early primary years, through bicycle education in later primary and secondary years, to pre-driver education in later secondary years. However, very few rigorous evaluations of these types of programs have been attempted and their effectiveness are hence largely unknown. Some examples are described below.

- 'Travel Smart to Schools' programs such as 'RoadSmart', 'Walking School Bus' and 'Kids and Roads' can be found in most Australasian States and Territories. These programs generally aim to promote children walking and cycling to and from school under adult supervision as a safe and active form of transport. Most reports suggest that they are successful and popular programs, particularly in terms of the health, safety, social and environmental benefits (TravelSmart Australia, 2005).

- 'Safe Routes to School' are community-based programs which combine engineering treatments and education (supplemented by enforcement where necessary) to reduce the incidence and severity of road crashes involving primary and secondary school aged children. Programs rely on separating students from traffic as much as is practical, encourage crossing at supervised crossing points and incorporate training activities to ensure students can use the various facilities on the appropriate routes. At least some of these programs stress the need for adult supervision for travel to and from school. Evaluations generally show safety, social and environmental benefits (Rose, 2000; Cairney, 2003). Specifically, an evaluation conducted by Delaney, Newstead and Corben (2004) found that primary school aged children were involved in 12-18 percent fewer casualty crashes after the implementation of the program, depending on the specific time and mode of transport.

- Programs for children at younger ages, such as VicRoads' 'Starting Out Safely' and New Zealand's 'Safe Start / Small Steps' aim to provide information to parents on their role as model, teacher and supervisor to their young children. Information is generally distributed through pre-schools and kindergartens. Although the objective of this earlier training is not to encourage earlier independent road use by children, this may be an outcome if parents and carers believe the children are capable of behaving safely in traffic on their own – in which instance earlier training could be counterproductive. No formal evaluations have been conducted on these programs.

2.3.4 Legislation

Pedestrians are only safe when vehicle speeds are low, in the order of 30 to 40 kph (ETSC, 1999; Wramborg, 2003, Yeates, 2001). At these speeds, most potential collision situations can be recognised and avoided, and, if a collision does occur, damage and injury should be light to severe, but rarely fatal. Research shows unequivocally that crash incidence and crash severity decline whenever speed limits are reduced and increase when speed limits are raised (Anderson, McLean, Farmer, Lee & Brooks, 1997; Haworth, Ungers, Vulcan & Corben, 2001). Most OECD countries have adopted general urban speed limits of 50 kph and some permit zoning at lower speeds in residential areas and school zones. In most Australasian jurisdictions, speed limits in residential streets have been set at 50 kph in order to reduce the severity of injury to pedestrians and cyclists, and many have introduced a time-based variable 40 kph limit at and around school sites.

On 22 January, 2001, a state-wide 50kph default urban speed limit was introduced in Victoria. The primary objective of this initiative was to reduce the incidence and severity of casualty crashes, particularly crashes involving pedestrians. Hoareau, Newstead and Cameron (2006) undertook an evaluation to ascertain its effects following implementation. Five months after implementation, results showed a statistically significant net reduction of 13 percent for all types of casualty crashes and a 22 percent reduction for crashes involving pedestrians. Seventeen months after implementation, results showed an aggregate reduction of 12 percent for all casualty crashes and a reduction between 25 percent and 40 percent of fatal and serious injury crashes involving pedestrians.

2.3.5 Road design and operation

Engineering countermeasures have the potential to quickly and effectively create a safer and more 'crashworthy' travel environment for vulnerable road users. The improvements that appear to provide the most benefit for children include: i) measures to reduce travel speeds where children are present (lower speed zones and traffic-calming measures), and ii) provision of infrastructure that gives higher priority to pedestrians and cyclists in critical locations (through separation of travel modes, e.g., school crossings, supervision, provision of foot and bike paths, signing to warn of children).

Traffic calming measures aim to reduce the number and speed of vehicles in local streets and in areas where there is high pedestrian and cyclist activity. They act to make drivers more attentive to their surroundings and drive more slowly or appropriately for the environment. One such traffic calming measure, the '*woonerf*' concept encourages drivers to drive slowly by physical modifications to the roadway (such as pavement narrowing, refuge islands, alterations to the road surface, speed humps, roundabouts and gateway treatments). These are now common in Europe, with many reports of success, particularly in terms of speed reduction, crash reduction, increased walking and cycling activity, and changes in driver behaviour (Summala et al., 1996; ETSC, 1999).

2.3.6 Vehicle design improvements

The influences of vehicle frontal structures on pedestrian kinematics and injuries have been widely reported. Even though the significance of child pedestrian injuries has been recognised for a number of decades, there is still very limited progress in the injury prevention of child pedestrians. Indeed, due to the absence of experimental data with child dummies, the biomechanical responses and injury tolerance levels of children have not been well understood (ETSC, 1999). There is, however, some progress in developing mathematical models to represent child pedestrians, taking into account differences in anatomical structure and age-dependent properties of biological tissues (Liu & Yang, 2002).

As the fitting of rigid bull-bars is of great concern to pedestrian safety, there are moves world-wide to ban the manufacture and use of aggressive bull-bars. Alternative designs options are low profile, contour-hugging bull-bars that are made of plastic or composite metal/plastic materials (LTSA, 2003; UK Department of Transport, 2003; Hong Kong Department of Transport, 2003).

2.4 POLITICAL, SOCIAL AND OTHER FACTORS ASSOCIATED WITH MANAGING THE SAFETY OF CHILD PEDESTRIANS

Although child pedestrian crashes are a relatively small part of the overall road toll, great emotion attaches to child deaths and injuries, and the community has high expectations for child safety. There is also a pervasive anxiety concerning children's personal safety. One consequence of this is a reluctance to shift funds from adult crossing supervisor programs to other areas of road safety where they might return greater benefits. In the absence of documented benefits, some practitioners question the contribution crossing supervisors make to road safety, but recognise that communities are unlikely to accept a reduction of the programs.

While a great deal of effort has been invested in Safe Routes to (and from) Schools programs, many child pedestrian fatalities happen in the late afternoon or early evening. It seems likely that many of these do not occur on the way directly from school to home. However, these patterns are currently not well understood.

Over the last decade or so, children are increasingly being driven to school or leisure outings even though they could walk or cycle. Child pedestrian crashes would probably be considerably higher were it not for the fact that many children now tend to be driven to and picked up from schools and other destinations. In 1999, 26 percent of primary school-aged children in Perth, Australia, walked to or from school, including only 42 percent of those who lived within a 10 minute walk from school. Further, 81 percent of all trips made by children aged 5-9 years and 62 percent of those made by children aged 10-14 years were by car (Morris, Wang & Lilja, 2001).

Table 1 shows the relationship between travel mode and injury on the journey to and from school in Western Australia confirming the car as the dominant travel mode to and from school, and the mode which generates the most injuries (Cooper & Ryan, 1998).

Table 1: Percentage of injured school children and estimated percentage of school children using each travel mode to and from school, Western Australia 1987-1996.

	Percentage by travel mode:			
	Bus	Car	Cycle/walk	Total
Injured school children	1.6	63.9	34.5	100.0
All children	15.0-31.0*	41.0	28.0	100.0#

* Estimates derived by different methods
\# Assuming 31% bus travel

It is understandable that parents wish to protect their children from perceived risks associated with walking. However widespread transport by car contributes to congestion and traffic complexity, deprives children of the opportunity to undertake regular, incidental physical activity that will lead to long-term better health and most importantly, reduces the opportunity to develop an awareness of traffic and to learn fundamental road safety practice when they can be supervised by a parent/carer (Collins & Kearns, 2005; Timperio, Crawford, Telford & Salmon, 2004).

2.5 SUMMARY

Crashes involving pedestrians are severe in nature and pedestrian safety is a serious community concern. Serious injury data shows that children are much more likely to be involved in a serious injury crash as a pedestrian, compared to adults. Research suggests that children between the ages of 6 to 10 are at highest risk of death and injury, with an estimated minimum four times the risk of collision compared to adult pedestrians.

Three broad strategies are available for managing child pedestrian safety – i) education/ supervision/training, ii) improvements to road design and operation, and iii) improvements in vehicle design. It is important to note that neither education/training programs, environmental modification nor improvements to vehicle design are sufficient solutions by themselves. Gains in children's safety in traffic require innovative combinations of improvements in all three areas.

Vehicle design improvements are underway, however, vehicles are inherently limited in their ability to protect vulnerable road users, and pedestrian safety is unlikely to be markedly improved in the near future through vehicle design changes. In contrast, engineering countermeasures offer quick and effective measures to provide safe environments in which children can walk. Measures to reduce vehicle speeds where there is high pedestrian and cyclist activity along with measures to separate travel modes are highly desirable.

Children face a number of difficulties stemming from their cognitive development, impulsivity and smaller stature. Recent evidence suggests that realistic training in real-life settings can result in success in coping with more complex situations, and recent recommendations are for road safety education to begin at even earlier ages and be tailored to target 'at-risk' children. Notwithstanding, it is not known whether road safety education reduces crashes amongst children. Although there is evidence that pedestrian safety education is effective in increasing knowledge and changing crossing behaviour, there is no clear evidence that this results in fewer child pedestrian crashes.

3 BASELINE ROAD CROSSING SKILLS

3.1 INTRODUCTION

The ability to select safe gaps in the traffic in which to cross is crucial for safe road crossing and there is a need to understand in more detail the behaviour of children on the road, particularly the factors involved in gap selection judgement. Evidence suggests that children aged 6-10 years, particularly males, have a heightened risk of being seriously injured or killed when they cross the road.

This chapter presents the results of the first phase of the study that aims to investigate road-crossing skills amongst primary school aged children. The influence of age and gender on road crossing ability of children in this age group is discussed along with the vehicle factors that may govern gap selection among children.

3.2 METHOD

3.2.1 Recruitment

Letters of invitation were mailed to 50 Principals of government primary schools in the Melbourne metropolitan area (see Appendix A). Schools were selected randomly from the Department of Education list of primary schools but included schools from southern, northern, eastern and western areas of metropolitan Melbourne. Ten expressions of interest were returned and five schools were selected to participate in the study ensuring representativeness of socio-economic areas of Melbourne and included primary schools in Glen Waverley, Bayswater, Sandringham, Mont Albert and Melton.

The research team then liaised with each school Principal to recruit interested parents and children. All children in grades 1 to 5 and their parents were provided the opportunity to participate and letters and consent forms were sent home to all parents (Appendix B). Consent forms were returned to the Principal's office – response rates varied between schools, but were between 22% and 75%. Children of each age (6 to 10 years) including approximately equal numbers of girls and boys were randomly selected for participation. At each school, three children were randomly selected from each year was balanced (a total of 15 children at each school were recruited).

3.2.2 Participants

Seventy-one children and their parents participated in the study, comprising 35 males and 36 females (four children selected were unable to participate on the day of initial testing). Participants were aged between 6-10 years old (13 six year olds, 14 seven year olds, 15 eight year olds, 15 nine year olds and 14 ten year olds).

3.2.3 Simulator Environment

Simulated traffic scenes that were generated from data files from a mid-range driving simulator were used in this study (Figure 5). It showed an undivided, straight two-way residential road (with visual and audio features to make the environment as realistic as possible) from the perspective of a pedestrian waiting at the kerb, with two vehicles travelling from the right-hand side (near-side lane). There was no traffic in the far-side lane.

Time gap and speed of the vehicles were systematically manipulated with five levels of time gap (3, 4, 5, 6, and 7 secs) and three levels of vehicle speed (40, 60 and 80kph) resulting in fifteen different traffic scenarios. Distance co-varied as a function of these two manipulations. Each of the 15 simulated traffic scenes was shown three times (for a total of 45 scenes). The presentations of these scenes were randomised in three sets of 45 scenes. The presentation of each set was also randomised to participants. Simulated traffic scenes were projected onto a large white screen.

Figure 5: Stimulus traffic scenarios presented in the road-crossing simulation

Responses were made on a computer keyboard on the desk in front of participants. Most of the keys were blackened and covered. Two keys ('J' and 'D') labelled 'YES' and 'NO' respectively, were available for participants to indicate whether they would 'cross' the road or not. The keys for numbers 1 to 9 with labels 'very unsafe' below the 1 key and 'very safe' below the 9 key, provided a nominal rating scale on which participants were asked to rate the safety of the road-crossing.

3.2.4 Procedure

Each participant was tested individually. Participants were seated at a desk in a darkened, quite room approximately 2m in front of the projection screen with their right index finger resting on the 'YES' key and their left index finger resting on the 'NO' key. Instructions were given verbally, and the experimenter also demonstrated the simulator task to the child, providing explanation during the demonstration. Practice trials were given until participants indicated that they fully understood the task. Participants were instructed that a buzzer would sound when the first vehicle passed the point of crossing. This 'trigger' vehicle activated a timer. Participants were instructed to look down initially and then at the traffic scene as soon as they heard the buzzer and to decide whether or not they would 'cross' in front of the second vehicle (walking normally across the street), responding as quickly as possible by pressing the 'YES' or the 'NO' key. This deactivated the timer and the time interval was recorded as decision time. After this, participants were asked to rate how safe or unsafe they thought the 'crossing' would have been by pressing the appropriate key (1-9). No time limits were imposed for this response.

Walking time over a distance equivalent to the width of an average road lane (5.6m) at two walking paces was also measured. For normal walking pace, participants were asked to walk as they normally would to a designated object 5.6m away. For fast walking pace, participants were asked to walk as fast as they could, without running, to a designated object 5.6m away.

A battery of neuropsychological and behavioural assessment tools was also administered to participants in the same sessions. In addition, parents completed the Conners' Rating Scale and a traffic and road safety questionnaire. Details and results on these assessments will be reported in Chapter 4. Total testing time took approximately 45 minutes (with a short break between the behavioural assessments and simulator tasks). The simulator task required approximately 15 minutes.

3.3 RESULTS

3.3.1 Road crossing skills

The following results examine the road crossing skills prior to any training or intervention. Five performance measures were analysed. These were walking times, yes/no responses and critically incorrect responses, safety rating responses and decision time.

3.3.1.1 Walking Times

Table 2 shows the means, standard deviations and range (minimum and maximum) of walking times by age.

Table 2: Mean walking times (normal and fast-paced) by age (with standard deviation)

	Normal-paced walking time (s)			Fast-paced walking time (s)		
	Mean *(sd)*	**Minimum**	**Maximum**	**Mean** *(sd)*	**Minimum**	**Maximum**
6 year olds	5.47 *(2.52)*	3.88	13.53	3.92 *(0.81)*	2.90	6.13
7 year olds	5.17 *(1.19)*	3.00	7.19	3.38 *(0.39)*	2.87	4.22
8 year olds	5.32 *(0.84)*	4.53	7.11	3.42 *(0.56)*	2.50	4.72
9 year olds	5.00 *(0.92)*	3.33	7.06	3.07 *(0.49)*	2.30	4.06
10 year olds	4.75 *(1.05)*	3.09	7.34	3.22 *(0.42)*	2.59	4.00

Walking times by age group were analysed by Analysis of Variance (ANOVA) and the effects were explored by post hoc Tukey Tests. Even though younger children tended to take more time to walk 5.6m than older children at a normal walking pace, this difference was not significant, $F(4,66) = .55$, $p>0.05$. However, there was a significant effect of age found for fast walking pace, $F(4,66)$, = 4.58, $p<0.05$. Post-hoc Tukey tests indicated that six year olds walked at a significantly slower pace than nine year olds ($p=0.001$), and ten year olds ($p=0.013$). More variance in responses were also apparent in younger children, compared with older children. There were no other statistically significant differences between the groups.

Table 3 shows the means, standard deviations and range (minimum and maximum) of walking times by gender. These were analysed using t-tests. There was no significant effect of gender found for normal walking time, $t(69)=0.036$, $p>0.05$, or fast walking time $t(69)=-0.275$, $p>0.05$.

Table 3: Mean walking times (normal and fast-paced) by gender (with standard deviation)

	Normal-paced walking time (s)			Fast-paced walking time (s)		
	Mean *(sd)*	**Minimum**	**Maximum**	**Mean *(sd)***	**Minimum**	**Maximum**
Males	5.14 *(1.72)*	3.00	13.53	3.37 *(0.64)*	2.47	6.13
Females	5.13 *(0.98)*	3.09	7.34	3.41 *(0.58)*	2.30	4.72

3.3.1.2 Yes/no responses

Analyses of yes/no responses were undertaken by employing hierarchical logistic regression to examine the impact on the crossing decision of the variables age group, time gap, vehicle speed, and distance gap. Children were grouped into two groups: younger children (6-8 year olds) and older children (9-10 year olds). There is an inter-relationship between the vehicle variables time gap, distance gap and vehicle speed. Because of this co-variance, it was necessary to undertake two separate analyses. Model 1 included age group, gender, vehicle speed and time gap of vehicle as variables and Model 2 included age group, gender and distance gap as variables.

Model 1 revealed that time gap was a strong predictor of crossing decisions, $\chi^2(4) = 522.93$, $p<0.001$. Age group and vehicle speed were also predictors of crossing decisions, $\chi^2(1) = 7.64$, $p<0.05$, $\chi^2(2) = 94.48$, $p<0.001$, respectively. Gender was not a predictor of road crossing decisions, $\chi^2(1) = 1.21$, $p>0.05$.

Model 2 revealed that distance gap was also a strong predictor of road crossing decisions, $\chi^2(1) = 478.09$, $p<0.001$. As in Model 1, age group was also a predictor of road-crossing decisions, $\chi^2(1) = 7.35$, $p<0.05$, and gender was not a predictor of road crossing decisions, $\chi^2(1) = 1.17$, $p>0.05$.

These findings together indicate that participants based their decisions on all vehicle variables (with time gap and distance gap being strong predictors and speed less so) and that the two age groups responded differently to the road-crossing task.

While the modelling results are informative in relation to the individual effects of time, and distance gaps and vehicle speeds, it is also informative to examine and understand the nature in which participants are using these variables to make crossing decisions. Figure 6 shows the proportion of positive crossing responses by vehicle conditions for age group and gender.

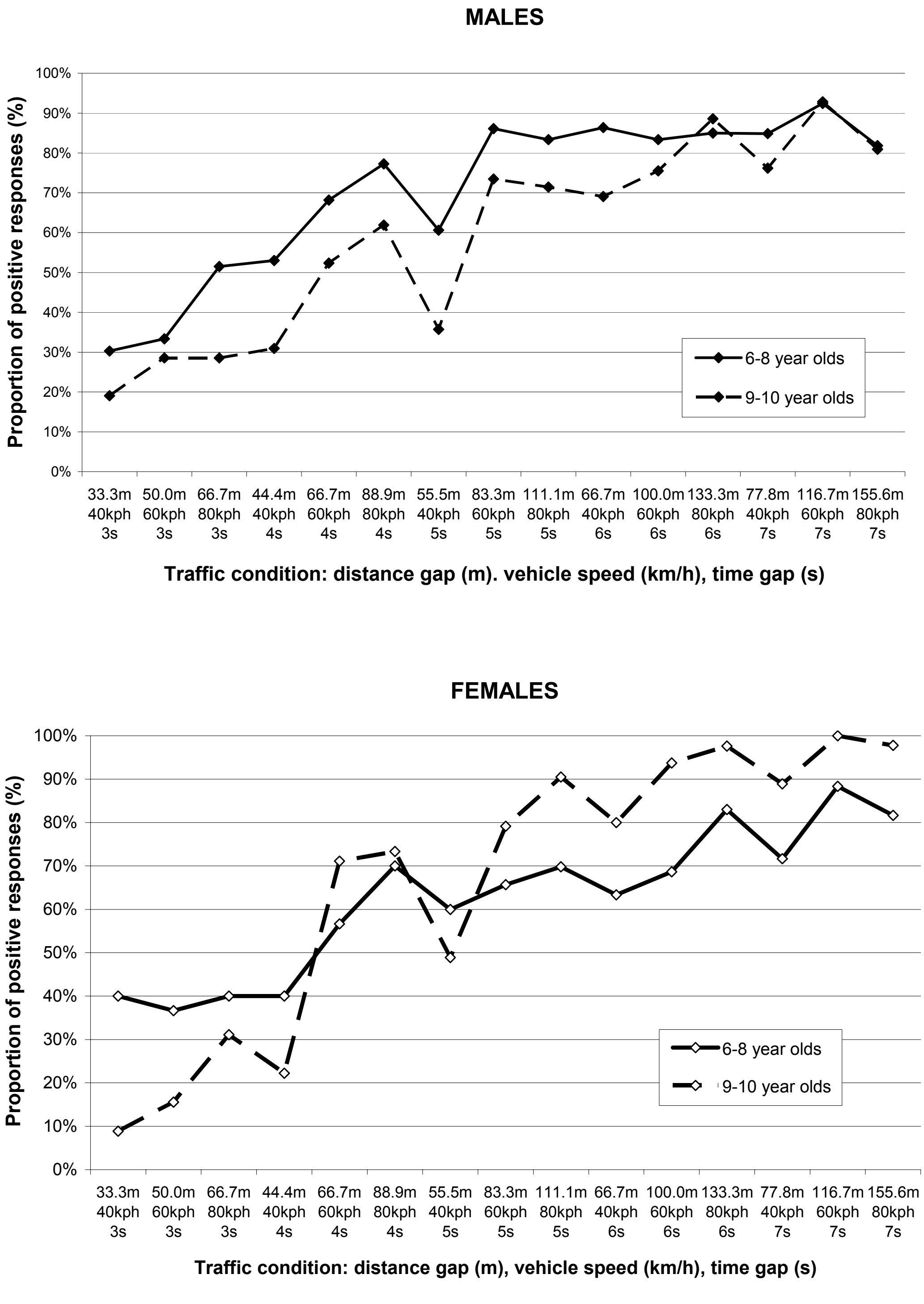


Figure 6: Proportion of yes responses as a function of age group and traffic condition by gender

These data show that all children were less likely to indicate that they would cross when time and distance gaps were small than when they were larger. However, there were significant proportions of children who indicated that they would have crossed in time gaps that were too small for a safe crossing, even at a fast walking pace. This was most apparent for younger children. In time gaps of three seconds (for all vehicle speeds), between 30 and 52 percent of six to eight year old boys and around 40 percent of the same aged girls indicated a 'yes' decision. In the same time gap conditions, between 20 and 30 percent of older boys and between 9 and 30 percent of older girls (9-10 year olds) indicated a 'yes' response.

Figure 6 also indicates that distance, not time gap, was a strong determinant of crossing decisions for all groups. Vehicle speed was also taken into account, but to a lesser extent. For instance, for the three time gap conditions of 4sec the proportion of positive responses increased for all groups as the distance gap increased. Seventy-seven per cent of responses by boys aged 6-8 years in the 80kph x 4sec condition were a 'yes' crossing decision, compared to 53% in the 40kph x 4sec condition. This difference was even more pronounced in the 9-10 year old girls, with only 22% of responses indicating a 'yes' crossing decision in 40kph x 4sec condition, compared to 73% in the 80kph x 4sec condition. In a 4sec time gap, most children would need to increase their walking speed to safely cross the road.

3.3.1.3 Critically incorrect responses

While a 'yes' or 'no' response is an interesting measure in itself, the response needs to be put in context of whether it was a correct (safe) or incorrect (unsafe or missed opportunity) decision, allowing for walking speed. 'Correct' and 'incorrect' responses were scored, taking fast walking times into account. There were four possible responses: correct acceptance (safe), correct rejection (safe), incorrect acceptance (unsafe) and incorrect rejection (missed opportunity). The proportions of responses by age group and gender are shown in Table 4.

Table 4: Proportion of correct and incorrect response by age and gender

	Correct acceptance	**Incorrect acceptance**	**Correct rejection**	**Incorrect rejection**
Males	940 (59.3%)	129 (8.1%)	137 (8.6%)	380 (24%)
Female	902 (58.5%)	107 (6.9%)	167 (10.8%)	365 (23.7%)
Total	***1,842 (58.9%)***	***236 (7.5%)***	***304 (9.7%)***	***745 (23.8%)***
6 year olds	295 (52%)	99 (17.5%)	56 (9.9%)	117 (20.6%)
7 year olds	341 (55.2%)	47 (7.6%)	74 (12%)	156 (25.2%)
8 year olds	434 (66.2%)	42 (6.4%)	67 (10.2%)	113 (17.2%)
9 year olds	395 (59%)	32 (4.8%)	64 (9.6%)	178 (26.6%)
10 year olds	377 (61.1%)	16 (2.6%)	43 (7%)	181 (29.3%)
Total	***1,842 (58.9%)***	***236 (7.5%)***	***304 (9.7%)***	***745 (23.8%)***

The fastest walking speed was chosen over the normal walking speed, because, as in real life situations, a pedestrian is likely to increase their walking speed while on the road if the vehicle is quickly approaching. Of most importance is an incorrect 'yes' response, as these responses would have resulted in a collision, or the driver needing to take aversive action to avoid a collision, in a real-world situation based on the time gap of the vehicle exceeding the child's fastest walking speed. Of the 3,195 scenes shown to the 71 participants (each participant viewed 15 scenes three times, totalling 45 scenes per participant), 540 scenes may have resulted in a collision if the child had chosen to cross the road in a real life situation (based on the fast walking speed of the individual participant). Of these 540 scenes, there were 236 (44%) 'yes' responses made to cross the road. Forty-two participants (59%) made at least one critically incorrect decision.

Table 3 shows that there were few gender differences, approximately 60 percent of each group made a correct 'yes' decision, and only 8 percent of boys and 7 percent of girls made an incorrect 'yes' decision. There were some differences between age groups. Older children were more likely to make a correct 'yes' decision compared with younger children (61% for 10 year olds, 52% for 6 year olds). More importantly, a relatively high proportion of six year old children (18%) made an incorrect 'yes' decision and this reduced as age increased (only 3% of 10 year old children made an incorrect 'yes' decision).

To determine what variables influenced a critically incorrect response, logistical hierarchical multiple regression modelling was employed. Included in the model were age (6, 7, 8, 9 and 10 years), gender, time gap and vehicle speed. The model revealed that age, time gap and vehicle speed were all significant predictors of crossing responses, $\chi^2(4) = 119.62$, $p<0.001$, $\chi^2(1) = 415.43$, $p<0.001$, $\chi^2(1) = 6.67$, $p<0.01$, respectively. As in the analysis of yes/no responses, there was no significant effect for gender. The analysis revealed that:

- Six year olds were 11.96 times more likely to make a critically incorrect decision than ten year olds ($p<0.001$).
- There was an average of 8.25 critical errors per 6 year old participant compared to an average of 1.33 critical errors per 10 year old participant.

3.3.1.4 Safety rating responses

The safety rating responses of children were also analysed. Figure 7 shows the safety rating responses of the children by age group. A score of one indicated that the child thought the scene was very safe to cross, a score of 5 indicated a 'don't know' response, and a score of 9 indicated that the child thought it was very unsafe to cross. The results indicate that younger children were more likely than older children to select an extreme response, by selecting 1 or 9, $\chi^2(9) = 47.37$, $p < 0.001$.

Figure 8 shows mean safety rating response by traffic condition and demonstrates that participants perceived themselves to be safer as time gap increased. In small time gaps, participants indicated that the safety of the 'crossing' was low. Interestingly, as observed for yes/no decisions, perception of safety increased as vehicle distance increased. In conditions where time gap remained constant but vehicle distance increased, so did ratings of safety. For example, in the 4s time gaps, mean safety ratings of younger children increased from 5.3 when vehicle distance was short (44m) to 6.2 when vehicle distance was long (89m). Similarly, mean safety ratings of older children increased from 4.3 to 5.9

in the same conditions. This suggests that participants based their perceived safety more so on distance gap, not time gap.

In addition, while both younger and older children made similar safety rating responses across all traffic conditions, there were some significant differences. In short time gaps, younger children were more likely to make a higher safety rating response, i.e., judged gap to be safer, compared with older children, and this was particularly so in short distance gaps (33.3m/40kph/3s condition: $t(198.55)=3.47$, $p<0.01$, two-tailed; 44.4/40kph/4s condition: $t(192.64)=2.88$, $p<0.01$, two-tailed; 55.5m/40kph/5s condition: $t(201.32)=2.46$, $p<0.05$; 50.0m/60kph/3s condition: t(183.45=1.89, $p=0.06$, two-tailed). In contrast, older children were more likely to make a higher safety rating response compared with younger children in longer time gaps (133.3m/80kph/6s condition: $t(185.03)=-2.22$, $p<0.05$, two-tailed; 116.7m/60kph/7s condition: $t(199.92)=-2.59$, $p<0.05$, two-tailed; 155.6m/80kph/7s condition: $t(192.87)=-2.38$, $p<0.05$, two-tailed).

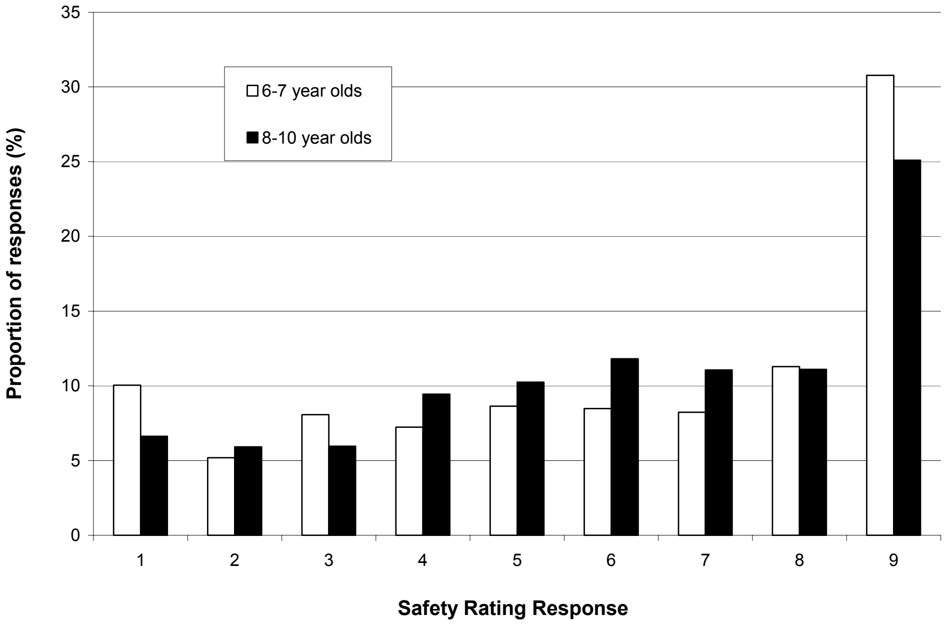


Figure 7: Safety rating responses by age group

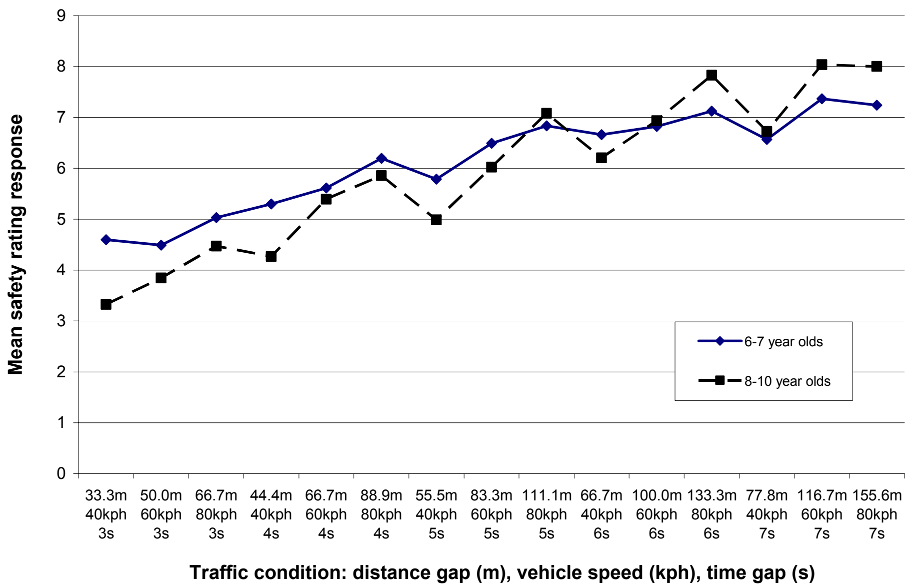


Figure 8: Mean safety rating response by age group and traffic condition

3.3.1.5 Decision Time

The time taken by children to make a decision was also examined. Decision time (s) was recorded as the time the first trigger vehicle passed the crossing point to the time when the child made their 'yes/no' response. Table 5 shows mean decision time and standard deviations by age.

Table 5: Mean decision time (and standard deviation) by age

	Decision Time (s)	
	Mean	***sd***
6 year olds	2.63	1.80
7 year olds	4.05	3.03
8 year olds	3.15	2.07
9 year olds	2.94	2.11
10 year olds	2.23	1.73

An overall effect of age was found for decision time, $F(4,3190)$, = 59.66, $p<0.001$. Post-hoc Tukey tests revealed significant differences across all ages (p's<0.05), except between eight and nine year old participants, who took a similar amount of time to make their decisions. In general, decision time decreased as age increased (excluding decision times of 6 year old participants). When data were broken down into age groups, the analyses revealed that younger children (6-7 year olds) took significantly more time to make their decision than older children (8-10 year olds), 3.34s vs. 2.79s, $F(1,3193)$,=48.99, $p<0.001$).

In previous studies of pedestrian road-crossing decisions amongst adults, decision time has been used in conjunction with walking speed to calculate safety margins. In these cases, it was clear that responses were made immediately a 'yes/no' decision had been made. However, in the current study, it was apparent that many children did not make their response on the keyboard as they made their decision. In many cases, children told the experimenter before entering it on the keyboard and responded after the second vehicle had passed the crossing point. An attempt was made to identify and remove the 'outliers' however, long decision times were frequent and removal of these reduced the dataset substantially. It was therefore decided that decision time would not be added on to the walking speed of a child to determine if they had made a safe or unsafe decision. This was decided as it was observed that many children did not make their selection on the keyboard at the same time that they had made their decision (but had clearly made a decision immediately after the trigger vehicle passes as instructed). The research team decided that using walking speed alone would be a more accurate determinant of a safe or unsafe crossing decision, keeping in mind that all analyses of safety-based responses (i.e., critically incorrect responses) are minimum estimates, which would be greater if decision time were included in the calculation.

3.3.2 Practice effects

Analysis of the data was undertaken to determine if any practice effects occurred during baseline testing as participants inspected and responded to 15 traffic scenes three times. Three data sections were calculated from the video sequence 1-45. These were used to determine if there were any significant differences in performance between each section. Two regression models performed to analyse critically incorrect responses (model 1 with age and gender as factors and model 2 with functional performance measures as factors) were used to compare responses in the three sections of video scenes. The data revealed that there were no significant differences when the section variable was added to the regression models (model 1 section 1 vs section 3: $\chi^2(1)=0.33$, $p= 0.57$; model 1 comparing section 2 vs section 3: $\chi^2(1)=0.61$, $p=0.437$; model 2 section 1 vs section 3: $\chi^2(1)=0.12$, $p=0.730$; model 2 section 2 vs section 3: $\chi^2(1)=0.12$, $p=0.731$). These findings rule out any practice effects over time.

3.4 DISCUSSION

The broad aim of this component of the study was to determine what vehicle factors may govern gap selection among young children and to examine the influence of age and gender on the ability to select safe gaps in the traffic. The findings indicate that young children (6-10 year olds) generally have poor skills at reliably selecting safe gaps in traffic, and that the youngest children are at higher risk of making poor road crossing judgements compared with older children.

The results suggest that children primarily used distance rather than the speed of approaching vehicles in making judgements about safe crossing gaps. This is evidenced by the result that children were more likely to make a 'yes' crossing decision in a larger distance gap, despite the time gap being the same (see Figure 6). This was shown in both the younger and older children, and has also been shown in other studies with child pedestrians (Connelly et al., 1998; Simpson et al., 2003), older adult pedestrians (Oxley et al., 2005), intoxicated pedestrians (Oxley, Lenné & Corben, 2006) and younger drivers (De Lucia, Bleckley, Meyer & Bush, 2003). It is therefore likely that it is not age alone that determines the use of distance, speed or time gap in making a road-crossing decision. One explanation for using distance as the primary factor in determining safe gaps in traffic is that pedestrians make an initial decision such as ' the further away the car is from me, the safer it is to cross.' This suggests an immediacy effect where a vehicle far away, irrespective of its travelling speed, is judged to be less threatening than one close up (Oxley et al., 2005). This may be particularly pertinent to child pedestrians, who are perhaps taught to only cross the road when the oncoming vehicle is far away. In addition, many children may only be exposed to local roads as pedestrians, where speed limits are between 40kph to 60kph. It may be that is not age, per se, that determines the use of distance in gap selection judgements, but the limited exposure of young children to vehicles travelling at higher speeds.

Further, although it appears that distance gap is primarily used in making road-crossing decisions, it does not mean that participants are unable to make use of time gap information. It may be that participants are not paying attention to time-of-arrival information, and using other factors to guide their decision. It is possible that training programs could be designed to teach children to pay attention to speed and time gap information and not to simply rely on distance gap (Simpson et al., 2003).

Of most interest in this phase of the study were the analyses of critically incorrect responses. Of concern is the number of children who made a critically incorrect crossing decision, which may have resulted in a collision in a real life scenario. More than half of all children (59%) made at least one critically incorrect decision, based on their fast walking pace and time gap of the approaching vehicle. It should be noted that, if such high proportions of critically incorrect judgements of gaps, especially amongst younger children, were made in real-world crossings, there would be far more emergency avoidance or braking or child pedestrian crashes than actually occur. This is clearly not the case, therefore the number of incorrect responses reported in this study should not be seen as an estimate of real world outcomes. Notwithstanding, the analyses identified a number of predictors of poor road crossing decision. Age was a strong predictor of a critically incorrect crossing decision, with six year olds almost 12 times more likely than 10 year olds to make a critically incorrect decision. This finding may be associated with slower walking speeds of younger children. Six year old children walked, on average, 0.72 seconds slower than the ten year olds in the normal walking pace trial, and 0.70 seconds slower in the fast pace walking trial. This could influence the higher proportion of critically incorrect responses found in the 6 year old group, as it takes them longer to cross the road, resulting in more 'unsafe' scenarios. Further, younger children may also over-estimate how quickly they can cross the road. This is consistent with other research that shows that children often over-estimate their abilities, and that 6-year olds who over-estimate their physical abilities are more at risk for injury (Plumert, 1995). It may be that, in the current study, the younger children were more likely to over-estimate how quickly they could cross the road compared to the older children, resulting in a higher proportion of 'yes' responses in the 6-8 year old age groups in the shorter time gaps, and higher proportion of critically incorrect decisions in the younger age groups. It may also be that they lack the attentional and cognitive skills to calculate time gap in a short time frame.

The safety rating responses indicated that risk perception also may differ across age groups. It was not surprising to find that children overall felt safer with longer time gaps than with shorter time gaps, however, it was concerning that in short time gaps of 3 and 4 seconds (gaps that are clearly too short for most children to cross safely), safety ratings were moderate (between 3 and 6). Lower safety ratings in these traffic conditions would have been expected. Interestingly, there were some age group differences here – younger children felt safer than older children in short time gaps but less so in longer time gaps. These findings suggest that, in general, children are poor at perceiving risky traffic conditions, but it is the youngest children who demonstrate poorer risk perception, and particularly so in unsafe conditions.

Surprisingly, gender was not a predictor of road crossing decisions, critically incorrect responses or safety rating responses. This is an unexpected result, particularly as a number of studies suggest that boys make a higher proportion of unsafe decisions (Connelly et al., 1998) and crash statistics suggesting higher rates of death and injury amongst young boys, compared with young girls (ATSB, 2006; LTSA, 2000). Based on a their New Zealand travel survey, the LTSA (2000) found that 5-9 year old boys had almost double the risk of death or injury than girls in the same age group for each hour spent walking.

The current finding may, in part, be explained by the nature of the simulator environment. Research with children of varying ages has demonstrated that there is greater risk taking behaviour among boys than girls (e.g. Morrongiello & Rennie, 1998). It may be that boys and girls make similar judgements in a controlled simulator environment, but that boys are more likely to take risks when in an actual roadside setting. In addition, child pedestrian safety is more likely to be at stake when children are impulsive, distracted or delay decision making to the last moment (Connelly et al., 1998). It is possible that boys are more impulsive and more easily distracted in a roadside environment than girls, yet when these distractions are removed, they make similar gap selection decisions to girls. More importantly, this may be of serious concern considering the current findings show that a relatively high proportion of decisions were unsafe amongst all aged children, even in such a controlled environment, without any distracting environmental factors. It is possible that children would make even more unsafe decisions in an environment that contains distracting information.

In light of this, the present study may have produced gap selection judgements that may be different from those of children in normal traffic, particularly among boys. As the participants did not need to cross an actual road there was no risk in making an erroneous decision. It has been suggested by Ebbesen et al. (1977, as cited in Connelly et al, 1998) that perceived risk affects decision making, so removal of risk may have affected the outcome in this study. Further, the results may be an artefact of the impoverished two-dimensional viewing conditions of the simulator. However, these effects are likely to be minimal, as a validation study by Oxley, Fildes, Ihsen and Charlton (1997) showed that crossing decisions and perceptions of safety by younger and older adults in real world and filmed versions of traffic scenes were highly correlated. This has yet to be validated in children, and is an area for future research.

3.5 SUMMARY

The findings presented in this chapter indicate that young children (6-10 years) have generally poor skills of selecting safe gaps in traffic. The results suggest that children primarily used distance rather than speed when making their road-crossing decisions. Age was a strong predictor of making a critically incorrect response, while gender was not a predictor. The youngest children were at highest risk of making critically incorrect decisions and were more inconsistent than older children.

4 IDENTIFICATION OF 'AT-RISK' CHILD PEDESTRIANS

4.1 INTRODUCTION

This phase of the project aimed to identify some of the behavioural factors that may be associated with increased crash and injury risk for young child pedestrians under the age of 10 years. This Chapter presents the findings of the examination of functional and behavioural factors that may be associated with poor gap selection amongst primary school children.

4.2 METHOD

4.2.1 Participants

See section 3.2.1 for a description of the participants.

4.2.2 Behavioural assessments

A battery of behavioural assessments were used to examine functional performance and the impact on road-crossing decisions. Children completed three tests: the Motor-free Visual Perception Test, the Tower of London, and the Children's Colour Trail Test. Parents completed the Connor's Parents Rating Scale and a questionnaire on their child's general activity and traffic exposure. Detailed descriptions of each test follow.

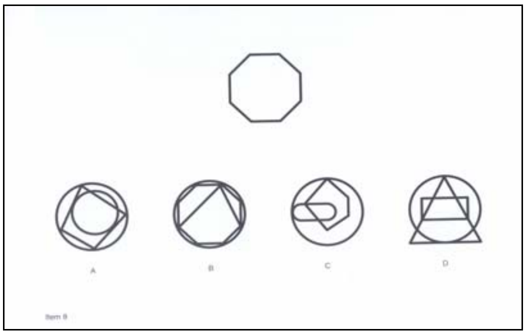
4.2.2.1 Motor free visual perception test-3 (MVPT-3) (Colarusso & Hammill, 2003)

The MVPT-3 assesses an individual's visual-perceptual processing ability with no motor involvement needed to make a response. Participants are shown a series of items that include line drawings, with the following five areas of visual perception represented in the test:

- Spatial Relationship – the abilities to orient one's body in space and to perceive the positions of objects in relation to oneself and to other objects;
- Visual Discrimination – the ability to discriminate dominant features in different objects;
- Figure-Ground – the ability to distinguish an object from its background;
- Visual Closure – the ability to identify incomplete figures when only fragments are presented; and
- Visual Memory – the ability to recall dominant features of one stimulus item or to remember the sequence of several items.

Examples of items are presented in Figure 9. Children are asked to choose one figure at the bottom of the page that matches the example figure at the top of the page. In some cases, the figure should be finished without moving any lines, in other cases, children are asked to identify a shape within others.

Scores are calculated for total number of items correctly identified. A higher score on the MVPT-3 indicates higher performance.



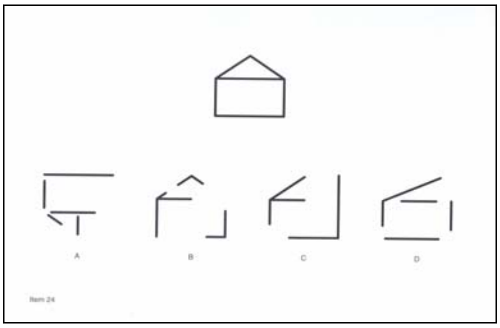


Figure 9: Examples of MVPT-3 Items

4.2.2.2 Tower of London (TOL) (Shallice, 1982)

The TOL assesses higher-order problem solving ability, particularly evaluating attention disorders and executive functioning difficulties amongst 6-80 year olds. Participants are asked to arrange beads on a tower-structure board to match a configuration in a diagram presented to them. Scores are calculated for total correct, total moves, total initiation time, total execution time, total time violations and total rule violations. A higher score indicate higher performance. Figure 10 shows a child completing the TOL assessment.

Figure 10: Example of child completing TOL assessment

4.2.2.3 Colour Trails (Llorente, Williams, Satz & D'Elia, 2003)

The Children's Colour Trail Test is a two-part paper and pen test that is designed to measure visual search, sustained attention, sequencing and other executive skills. Figure 11 shows Parts 1 and II.

In Part I, participants are asked to connect, sequentially and as fast as possible, numbered circles that are randomly scattered over a page. All odd numbers are printed in a pink circle; all even numbers are printed in a blue circle.

In Part II, each number is printed twice, once in a pink circle and once in a blue circle. Participants are asked to connect circles in consecutive order from 1 to 15, by alternating between pink and blue circles.

Scores are calculated for total execution time and total number of errors for both parts one and two. A lower score indicates higher performance.

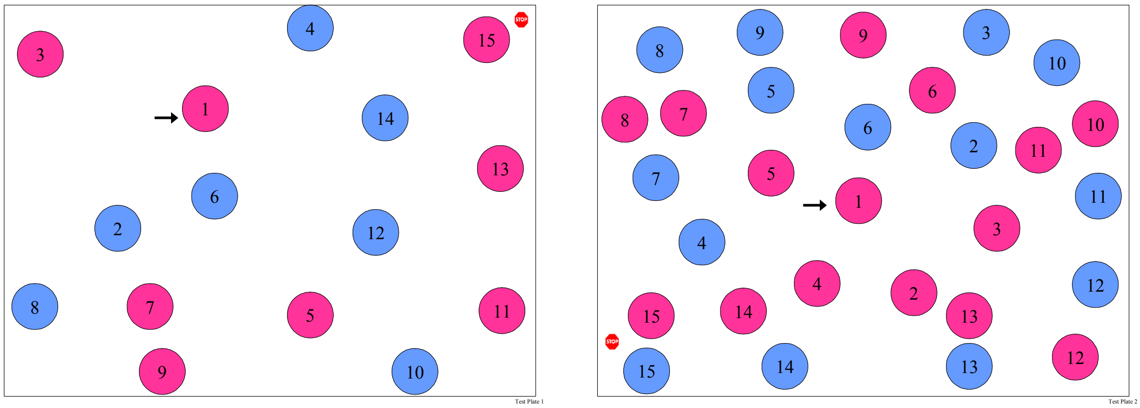


Figure 11: Colour Trails Test Parts 1 and 2

4.2.2.4 The Conners' Parent Rating Scale (Revised) (Conners, 1997)

In addition to the MVPT-3, The TOL and The Children's Colour Trails Test completed by the children, parents of participants were asked to complete the Conners' Parent Rating Scale. This scale assesses for the following in children and adolescents:

- conduct problems,
- cognitive problems,
- anxiety problems,
- social problems, and
- attention-deficit/hyperactivity disorder.

Parents are given a list of 27 common problems that children have, e.g., 'inattentive, easily distracted', 'fails to complete assignments', 'has trouble concentrating in class'. They are asked to rate each item according to their child's behaviour in the last month on a scale of 0 (not true at all) to 3 (very much true). Items are grouped into four components: Oppositional; Cognitive problems/inattention; Hyperactivity, and ADHD and four separate scores are calculated. Higher scores indicate possible behavioural problems.

4.2.2.5 Traffic and Road Safety Questionnaire

A Traffic and Road Safety Questionnaire was designed specifically for the study for parents to complete (See Appendix C). It gathers information about the child's general activity and exposure to traffic, particularly the amount of walking undertaken to and from school, amount of physical activity out of school, amount of supervised and unsupervised walking, parent safety practice, presence of home education on road safety, and parent attitudes to road safety.

4.2.3 Procedure

Section 3.2.4 provides a description of the procedure for the simulator testing.

All children were tested on the behavioural assessments individually. The battery of assessments was conducted either immediately before or immediately after the simulator testing and the order of undertaking tests was counterbalanced. Participants were seated at a desk in a quiet room and told that they were going to complete some interesting tasks.

The Tower of London beads were presented to the child and they were instructed that they were going to be shown pictures of the beads arranged differently, and they would be required to move the beads to match the pictures in a certain number of moves. The rules of the Tower of London were explained and a sample diagram was presented to the child to ensure they understood the task. The researcher did not begin the Tower of London tasks until it was clear that the child understood what was required. The researcher timed the child's planning time (the time from when they were presented the card to when the moved the first bead) and solution time (the time from when they were presented the card to when the completed the task) and recorded the number of errors.

For the MVPT-3, participants were shown a series of line drawings, with five areas of visual perception represented in the test. An example was provided before testing of each area of visual perception, and participant understanding of the task was ensured before answering the questions in that section.

In the Colour Trails, all children were given a practice task prior to the test. The child was asked to work as quickly as possible and to try and not lift the pencil from the paper. If an error was made, the child was immediately directed to correct the error and start at the point where the mistake was made.

Children were handed the Traffic and Road Safety questionnaire and the Conners' Rating Scale to give to their parents to complete. Parents were provided with a reply-paid envelope to return the questionnaires to the researchers.

4.3 RESULTS

The results of this phase are presented in three sections: functional performance and age group differences; traffic exposure and age group differences; and impact of functional performance on road-crossing decisions.

4.3.1 Functional Performance

Mean scores on tests of functional performance by age group are presented in Table 6. Preliminary analyses comparing the performance of younger children (6-8 years old) with the performance of older children (9-10 years old) on assessments were conducted using t-tests. In general, the older children performed significantly better than the younger children, particularly on the Tower of London test and both the Trails tests. Older children were also less likely to have rated highly on two of the Connors Rating Scale components (the oppositional and hyperactivity scores). Significant correlations were found between the MVPT-3 and the Trails tests, and all Connors Rating Scale components.

Table 6: Mean score on functional assessment by age group.

Assessment	Young children (6-8 years) (n=42)	Older Children (9-10 years) (n=29)	p-value
	Mean Score *(sd)*	**Mean Score** *(sd)*	
Tower of London	71.36 *(14.36)*	78.14 *(12.90)*	< 0.05
Colour Trails: I	36.90 *(15.60)*	22.95 *(11.03)*	< 0.001
Colour Trails: II	83.52 *(32.88)*	51.99 *(22.78)*	< 0.001
MVPT-3	102.67 *(18.58)*	106.61 *(15.54)*	= 0.37
Connors Rating Scale (Oppositional)	55.28 *(10.33)*	50.42 *(6.88)*	< 0.05
Connors Rating Scale (Cognitive problems/inattention)	52.45 *(9.57)*	49.19 *(7.05)*	= 0.12
Connors Rating Scale (Hyperactivity)	55.58 *(7.13)*	51.89 *(6.84)*	< 0.05
Connors Rating Scale (ADHD)	54.53 *(7.87)*	51.62 *(7.24)*	= 0.13

4.3.2 Traffic exposure and traffic education

Parents provided information on traffic exposure and behaviour, particularly in terms of frequency and quality of supervised walking undertaken by their child (who they were supervised by and whether they held their hand while crossing the road), and frequency of playing in the street.

Figure 12 shows the frequency of walking unsupervised by age group. Overall, the majority of children never walked unsupervised, but this was more common amongst younger children (90%), compared with older children (72%), $\chi^2(4) = 8.10$, $p = 0.08$. Parents of older children were more likely to report that their children occasionally or sometimes walking unsupervised compared with parents of younger children.

Not surprisingly, parents of younger children were more likely to report that they held their child's hand while crossing the road compared with parents of older children (62.5% vs. 26.9%), $\chi^2(1) = 7.99$, $p < 0.01$.

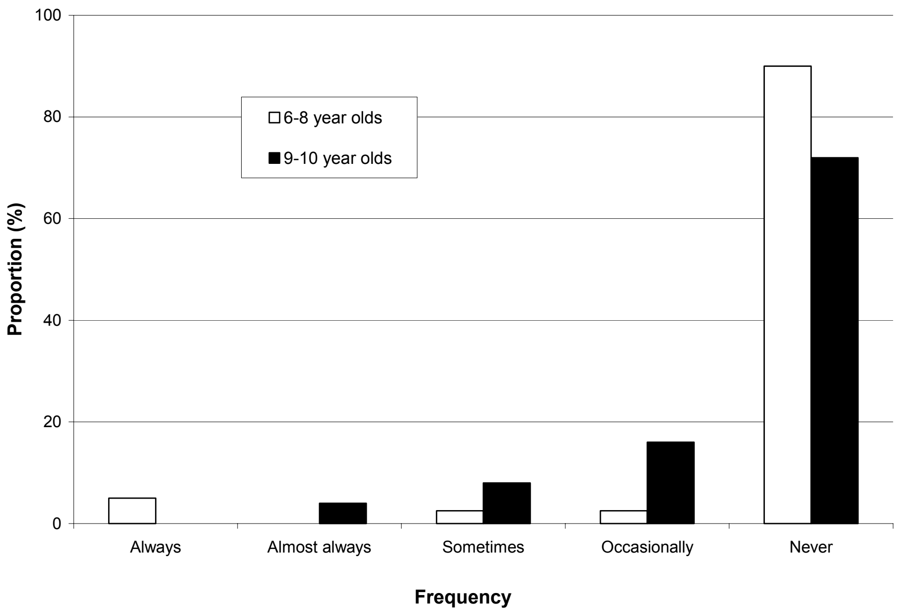


Figure 12: Frequency of walking unsupervised by age group

Parents were asked to indicate different modes of transport used to get to school and how frequently these transport modes were used. The majority of parents indicated that they drove their children to school. Over 90 percent of parents reported that their children never used a school bus or public bus to get to and from school. In addition, children rarely rode a bicycle to school. Figure 13 shows the frequency of children being driven to school by parents by age group. Approximately half of children in both age groups were driven by their parents to school always or almost always. While there were no statistically significant age group differences, a greater proportion of parents of younger children indicated that they always drove their children to school (22.5%), while parents of older children were more likely to indicate that they almost always drove their children to school (34.6%). A substantial proportion of parents of older children (19.2%) reported that they only occasionally drove their child to school.

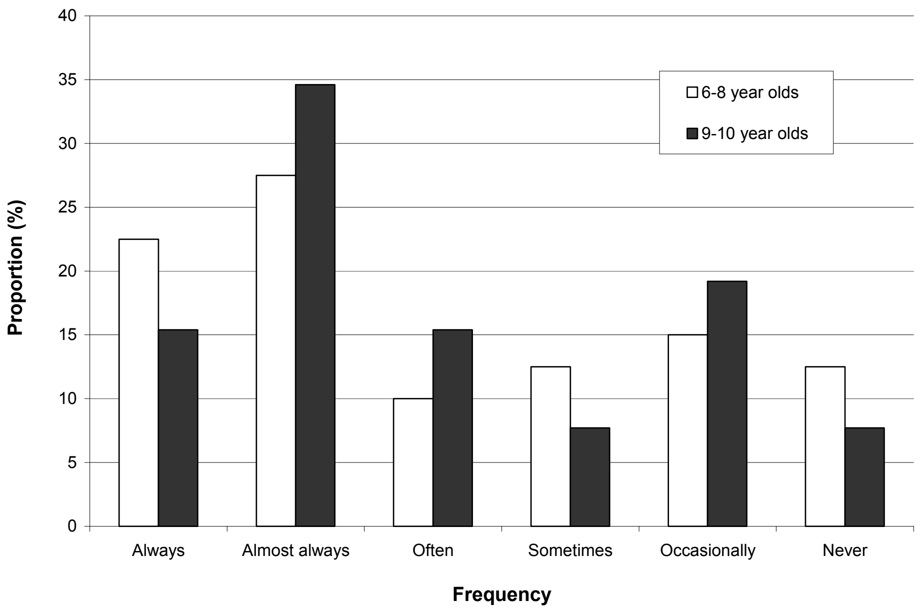


Figure 13: Frequency of children being driven to school by parents

Parents were also asked to record how often their child played on the street (see Figure 14). The majority of parents indicated that their children never played in the street and this was particularly so amongst younger children (68%), compared with older children (35%), $\chi^2(4) = 9.85$, $p = 0.08$. Substantial proportions of parents also reported that their children played in the street three to four times a week (15% of younger children and 19% of older children).

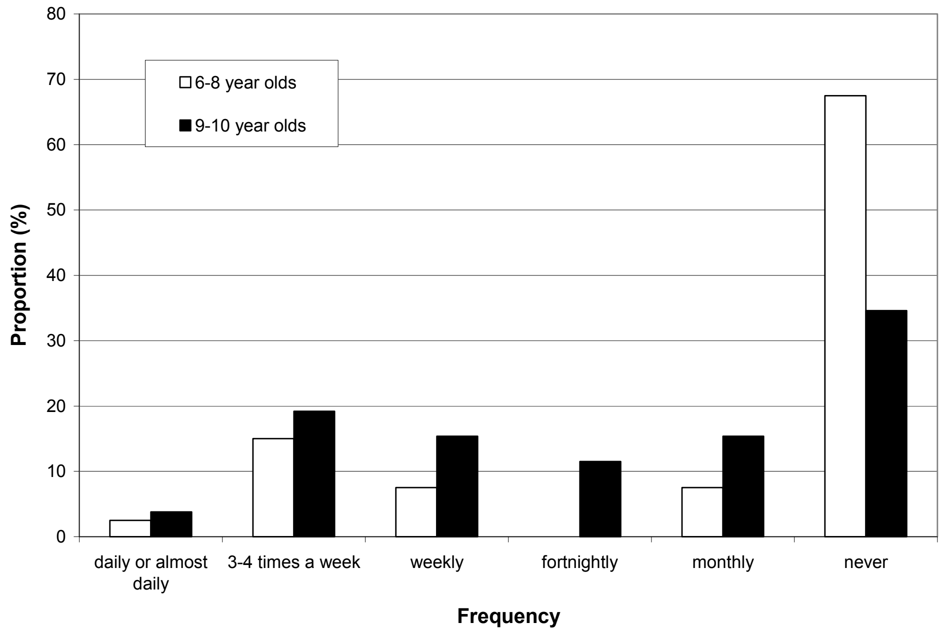


Figure 14: Frequency of playing in the street by age group

Amount of traffic on residential streets was also reported. Amongst parents of younger children, the amount of traffic was equally distributed between 'a lot of traffic, 'some' traffic' a little traffic' and 'hardly any traffic'. For older children, fewer parents reported living on streets with a 'lot of traffic' (11.5%). The amount of traffic did not seem to affect the frequency of playing in the street for older children, however, there was some suggestion that it played at least some part in the likelihood of playing in the street by younger children, $\chi^2(12) = 18.82$, $p = 0.08$. There also seemed to be some suggestion that, for older children, the amount of traffic on their street affected the likelihood of walking unsupervised. Those with hardly any traffic were more likely to walk unsupervised more often, $\chi^2(9) = 17.40$, $p < 0.05$.

Parents also provided information on level of traffic education, their attitude to traffic education and a rating of their child's ability to cross the road safely and some group differences were found. Almost all parents indicated that it is important to teach their children to cross the road. The majority also reported that they had taught their children to cross where there are lights. Not surprisingly, this was more common amongst older children compared with younger children (100% vs. 85%), $\chi^2(1) = 4.29$, $p < 0.05$. However, no other group differences were noted for other road safety education – teaching to cross where crossing guards are present (younger children: 85%; older children: 85%), crossing at zebra crossings (younger children: 74%; older children: 85%), and looking both ways before crossing (younger children: 100%; older children: 96%).

No significant group differences were found for ratings of a child's ability to cross the road safely, however, parents of older children were more likely to rate their child's ability as better than average, compared with parents of younger children (46% vs. 20%). In comparison, parents of younger children were more likely to rate their child's ability as about average, compared with parents of older children (65% vs 39%).

4.3.3 Predictors of critically incorrect responses

Logistic regression modelling was used to examine the impacts of functional performance, traffic exposure factors and vehicle factors on the likelihood of making critically incorrect responses. Potential variables included: Tower of London raw score; Colour Trails I & II time (s); MVPT-3 raw score; Connors Rating raw scores (all four components); independent travel exposure (high or low); and parent ratings of child's ability to cross the road safely (significantly better than average, better than average, average, and worse than average). Continuous test scores were dichotomised, using the median as a division between the two groups of values for each variable and were classified as being high or low, for scores above or below the median, respectively. The model resulting from these analyses is summarised in Table 7.

Table 7: Multivariate model for predicting critically incorrect responses.

Variable	Wald Statistic	p-value	Rel. Odds Ratio *(95% CI)*
Time gap	172.85	< 0.001	0.25 *(0.20, 0.31)*
Vehicle speed	5.08	< 0.05	1.01 *(1.00, 1.02)*
Tower of London score	14.24	< 0.001	0.98 *(0.96, 0.99)*
Colour Trails II score	26.41	< 0.001	1.01 *(1.01, 1.02)*
Connors Rating Scale (Hyperactivity)	2.64	= 0.10	1.06 *(0.99, 1.14)*
Independent travel	4.65	< 0.05	2.36 *(1.08, 5.16)*
Supervised travel	2.65	= 0.10	0.76 *(0.56, 1.06)*
Ability to cross roads (significantly better than average)	3.80	= 0.05	3.82 *(0.99, 14.72)*

Poor performance on tests of attentional, cognitive and executive functional performance was associated with a higher likelihood of critically incorrect responses. Two traffic exposure factors were also associated with the likelihood of critically incorrect responses. In sum, the analysis revealed that:

- Children who seldom walked independently were 2.4 times more likely than those who frequently walked independently to have made critically incorrect responses.

- Children whose road-crossing ability was rated by their parents as worse than average were 3.8 times more likely than those whose road crossing ability was rated as significantly higher than average to have made critically incorrect responses.

4.4 DISCUSSION

The broad aim of this phase of the study was to examine road-crossing decisions amongst young children with a view to identify ‘at risk’ children. There is a large body of literature suggesting that young children are less competent in traffic, are generally inconsistent in their road safety behaviours and are easily distracted. The current findings generally support these contentions and have highlighted some additional factors that may be associated with poor road-crossing skill, including less well-developed attentional, cognitive and executive skills, and little unsupervised traffic exposure.

Safe walking and making decisions about when it is safe to cross roads in relation to available traffic gaps is a complex task requiring adequate functioning of a range of sensory, perceptual, cognitive, executive and physical abilities, particularly attention, perception of speed and distance, processing of sensory input, judgement, decision-making and memory. In order to cross a road safely without engineering assistance, pedestrians must, while approaching or stopping at the edge of the road, inspect the roadway in both directions and look for approaching vehicles. This part of the task involves detecting objects and motion, ascertaining the direction and velocity of moving objects, the identity of the object and estimating when the vehicle will arrive at the crossing point, and judging one’s own walking speed. This may involve judgements about vehicle distance, velocity, acceleration and deceleration. These operations rely on reasonably intact perceptual, attentional and cognitive skills. Furthermore, in many situations pedestrians must integrate and remember information about traffic in both directions and in multiple lanes as well as combine vehicle arrival times with own walking speed in order to reach a decision to cross safely. This requires focussing and re-focussing attention on the traffic in both directions, switching attention from one source of information to another, and selecting and integrating the relevant information to arrive at a safe decision. Once a crossing has been initiated, near- and far-sides of the road have to be re-scanned to verify (or update) earlier estimates of arrival time of vehicles and adjustments to walking speed may have to be initiated. These operations require ability to process complex information rapidly. Clearly, walking, crossing roads and negotiating traffic are complex processes requiring good functioning and performance and it is likely that limited or under-developed capability in any cognitive or executive function has the potential to compromise pedestrian performance because of poor detection of oncoming vehicles poor choice of a safe place to cross and difficulty in crossing the road quickly enough to evade oncoming vehicles. These factors can lead to increased crash risk.

While previous research has examined children’s behaviour in traffic and discussed behaviour in terms of performance limitations (often using the Piagetian models of children’s cognitive development and the capacities of the ‘pre-operational stage’ around 5-7 years of age, and of the ‘concrete operational stage around 7-11 years of age) (e.g., Whitebread & Neilson, 2000; Sarkar, Kaschade & de Faria, 2003; Dunbar, Hill & Lewis, 2001; Tabibi & Pfeffer, 2003; Zeedyk et al., 2002), few have examined the specific functional skills that may impact on road-crossing decisions. Moreover, it should be noted that Piagetian models of children’s cognitive processes have been critically assessed in recent times and need to be viewed with some caution. Furthermore, alternative explanations, such as lack of critical experience or competencies, may be equally valid. Notwithstanding, the major limitations identified that may affect road skills amongst young children include:

- Generally lower cognitive ability compared with adults such as lower memory capacity (e.g., Sandels, 1975), lack of ability to integrate two or more variables such as object distance and speed into a single judgement such as time-of-arrival (e.g., Cross, 1988);

- Lack of domain-specific knowledge such as traffic-related knowledge and choosing a safe place to cross (e.g., Bongard & Winterfield, 1977; Demetre & Gaffin, 1994; Zeedyk et al., 2001; Tabibi & Pfeffer, 2002);

- Limited perceptual and attentional skills such as limited peripheral vision, selective and divided attention, both of which are required to judge safe traffic gaps;

- Immature visual search strategies (e.g., Whitbread & Neilson, 2000);

- Distractability such as showing awareness to the most important source of information when challenged by a distracting event (e.g., Dunbar et al., 2001); and

- Inferior physical and motor skills such as controlling impulsive reactions (e..g, Briem & Bengtsson, 2000; Pitcairn & Edlmann, 2000).

The findings of this component of the study demonstrated that children who performed poorly on tests of functional performance displayed poor road-crossing skills. In particular, it has highlighted that poor road-crossing skill may lie within poorly or under developed higher order functions such as attentional, cognitive and executive skills. In the road-crossing context, these kinds of skills are likely to be important in tasks such as understanding and remembering traffic rules and signs, following directions, planning where and when to cross roads, allocating attention, processing information quickly and accurately, and minimizing the effects of distraction.

In addition, much of the research on child pedestrian safety discusses the importance of exposure to traffic and acquiring skills in real-traffic environments (e.g., Zeedyk & Kelly, 2003), particularly developing an awareness of traffic and learning fundamental road safety practices, initially under adult supervision and leading to independent travel. The current findings suggest that exposure to traffic, particularly the amount of independent travel is associated with road-crossing skill. Children who walked independently more frequently were less likely to make incorrect crossing decisions compared with children who walked independently less frequently. This suggests that age-appropriate traffic exposure is beneficial for acquiring road skills.

4.5 SUMMARY

The findings of this phase of the study suggest that there are, indeed, specific behaviours, functional limitations, travel patterns and behaviour in traffic environments that may put some children at increased risk of a pedestrian collision. This information has provided a better understanding of the separate component skills that comprise the road-crossing task and has identified ‘at risk’ children. This information was instrumental in the development of a targeted, practical training program for Phase 2 of the project.

5 DEVELOPMENT AND EVALUATION OF THE TRAINING PROGRAM

5.1 INTRODUCTION

Education and training has long been advocated as a means of teaching children the critical road safety skills and behaviour to be able to interact with traffic safely. There are a number of road safety educational programs available in Australian States and Territories; however there may be scope for some improvement, particularly in terms of providing more information than road safety knowledge only, and improving the design of training programs. It is suggested that training programs should be more practical and specifically tailored for those who are most in need of training. The findings from Phase 1 of the study suggest that there are, indeed, specific behaviours, functional limitations, travel patterns and behaviour in traffic environments that may put some children at increased risk of a pedestrian collision. These results were instrumental in the development of a targeted, practical training program which aimed at improving the essential skills and strategies to cross roads safely amongst 'at risk' children.

This chapter describes the development and evaluation of a training package and discusses the uses for such a package, limitations and areas of further improvement and research.

5.2 DEVELOPMENT OF THE TRAINING PACKAGE

The results of Phase 1 of the project, along with previous research, strongly influenced the development of the training package. It was decided that the training program should be held in small groups, rather than on an individual basis and guided by two adult researchers. This decision was based on previous research by Tolmie, Thomson, Foot, Whelan, Morrison, and McLaren (2005) who investigated the effects of adult guidance and peer discussion on training in roadside search skills. They found that progress and learning was greatest when adult 'scaffolding' was supplemented by peer discussion.

Further research by Cross and Hall (2005) suggests that programs that aim to teach children pedestrian safety need to be interactive and involve problem-solving with consistent and prompt feedback from an adult. They also suggest that programs structured on the use of didactic knowledge-only strategies (such as rote learning of rules) are inappropriate, as younger children are not able to generalise this learning to real roads. These factors were taken into consideration when designing the program, with the aim to make it as interactive, interesting and informative as possible.

The results of Phase 1 of the project suggest that 'at-risk' children include those who performed more poorly on the functional measures assessed. These results suggested that the program needed to target those with poor perceptual, attentional, cognitive and executive functional performance, and those who walked more slowly. The trainers attempted to address the needs of these 'at-risk' children by constantly reminding children to focus on the task and to avoid distractions. Prompt feedback on their decisions was provided to help keep the children interested in the training program. The program was also multi-modal to help maintain interest levels and to appeal to all the children in the program. Furthermore, as the results of Phase 1 also revealed that distance was a strong determinant of road-crossing decisions, the training package also attempted to encourage children to consider both the distance and vehicle speed when making their road-crossing decisions.

5.2.1 Aims of the training program

The main objectives of the training package were to:

- Teach children how to identify traffic gaps that are sufficiently large to permit safe crossing;
- Differentiate these from gaps that are too small;
- Incorporate their walking speed into their decision and walk as fast as possible when crossing roads;
- Teach children to focus on time rather than distance or speed per se when making judgements about the safety of traffic gaps; and,
- Minimize the effects of distractors in the environment.

5.2.2 Description of training program

The main component of the program incorporated the use of the simulator where children were required to make road-crossing decisions in critical time gaps and with a range of distracting factors. Extensive feedback regarding gap selection skills and ability to disregard distracting factors was provided throughout the program. Additional components of the program included discussions of road safety and crossing roads, and demonstrations of the relationships between distance, speed and time gap. The training was conducted in small groups (6-8 children per group) and was run over two sessions.

5.2.2.1 Training session 1

The first component of the training session initially involved a brief discussion with the children on what factors they consider are important in crossing the road. This served two purposes; firstly, it acted as an icebreaker and helped the children feel comfortable in the group environment, and secondly it provided an opportunity for the researchers to gain an understanding of the road safety knowledge of the children. Examples of some of the questions asked to promote discussion were "Where should you look when you cross the street?" "What does a person need to think about and how does a person need to behave when they are about to cross the road?" and "If there are lots of cars how do you decide when it is safe to cross the road?"

The second component of the training session used matchbox cars to illustrate differences in distance and time of approaching traffic. The aim of this component was to demonstrate to children how speed and distance interact to create different time gaps. Using two matchbox cars on a play mat with a two-lane road and a pedestrian crossing at the end, researchers demonstrated that cars can be travelling at different speeds which will affect time gap. Children were instructed to clap in time with a metronome or clock whilst the cars were 'driving' on the road. Several different scenarios were depicted:

- One car with a six second time gap (measured in claps) between the starting position and the pedestrian crossing.
- One car with a three second time gap between the starting position and the pedestrian crossing.

- Two cars, both starting from the same starting position. One car reaches the pedestrian crossing in three seconds; the second car requires six seconds.

- Two cars, one starting at a midpoint between the starting position and the pedestrian crossing. The car starting at the midpoint position reaches the pedestrian crossing in three seconds; the car starting at the starting position reaches the pedestrian crossing in 6 seconds.

- Two cars, one starting at a midpoint between the starting position and the pedestrian crossing. Both cars have a six second time gap from their respective starting positions and the pedestrian crossing

Discussion was promoted after each scenario among the children as to why they thought the matchbox cars reached the pedestrian crossing at different times.

The third component of the first training session aimed to assist children to make simple estimates of time and distance in relation to crossing the road, while incorporating their own walking speed, to increase their awareness of their own walking speed, and demonstrate the importance of walking quickly when crossing the road. Researchers marked out a 5.6 metre ‘pretend road’. The participants then had turns in ‘crossing the road’ while other members of the group timed the crossing by counting claps.

The fourth and major component of the first training session involved using the simulator to practice the road crossing task with feedback from the simulator and the researchers. All the children in the group had a record sheet to record whether or not they would cross the road for each simulator scene shown. The simulator was paused after every scene and the children then discussed their responses and why they made the decision they did. The scene was then played again to show the outcome of the crossing decision. If the scene depicted a safe crossing gap (based on a six second time gap), the simulator showed a cartoon character safely crossing the road and jumping for joy once reaching the other side of the road (see Figure 15).

Figure 15 Positive response for safe time gap

If the scene depicted an unsafe crossing gap, the scene froze and a 'splat' symbol was shown on the screen (Figure 16). In addition, positive and negative feedback was provided from the instructors after each outcome was shown.

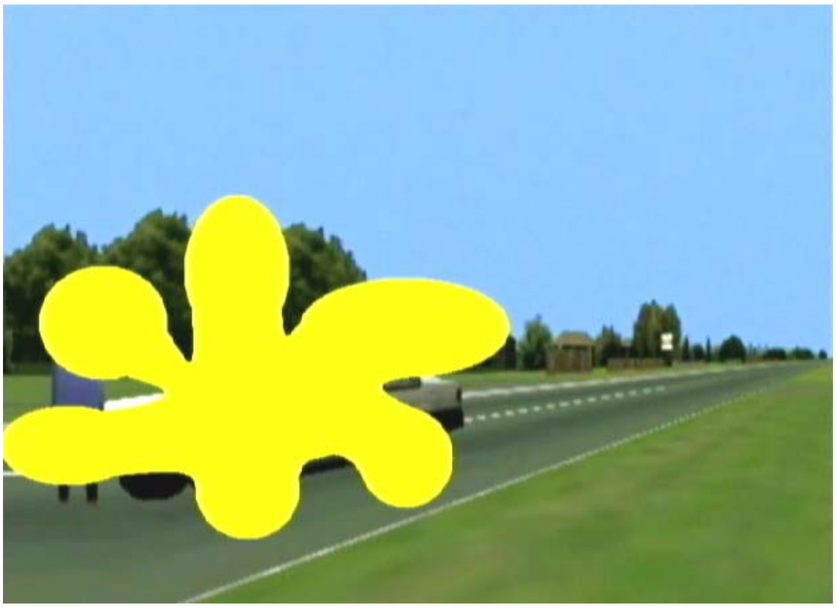


Figure 16 Negative response for unsafe time gap

The simulator was then paused once again to allow for further discussion about the outcome of the crossing decision. Children were encouraged to take into consideration the factors affecting gap size (i.e. the speed and distance of approaching vehicles). Trainers explicitly prompted children to use such information when formulating decisions about when to cross, and encouraged the children to discuss amongst themselves the reasons behind their decisions.

5.2.2.2 Training session 2

The second training session began with a revision of the key points from the first training session. Children were encouraged to discuss what they had learned from the previous day.

The simulator was then used to provide further training for the children. In this set of simulator scenes, three distractors were incorporated in the scenes: a ball bouncing across the road, a person waving from the other side of the road, and a car horn beeping (see Figure 17).

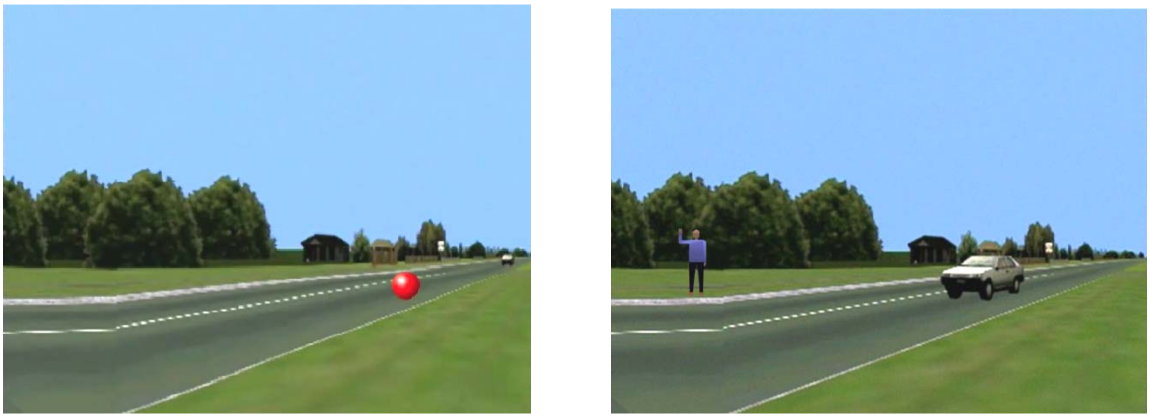


Figure 17: Examples of distractor scenes

As in the first training session, all the children had a record sheet to record whether or not they would cross the road for each simulator scene shown. The children were instructed that they should to make their decisions like they did the previous day, but that this time it was different from the day before, and they may need to concentrate more when they are making the decision about crossing the road. No specific mention was made of any possible distractors. The simulator was paused after every scene and the children were asked to discuss their responses. After the first scene, discussion of the distractor was raised, and children were questioned over the relevance of the distractor on their road-crossing decisions. The aim of this was to have the children focus solely on the cars, and not any other information that may be distracting them in the environment. As in the first training session, the simulator was played to show the outcome of the crossing decision after each scene (if it was a safe crossing, the simulator showed a cartoon character safely crossing the road and jumping for joy once reaching the other side of the road, if the scene depicted an unsafe crossing, the scene froze and a 'splat' symbol was shown on the screen). The simulator was paused once again to allow for discussion about the outcome of the crossing decision. The training session was concluded with a warning of the danger of attempting to cross the road in the real world. At the end of each training session, a warning message was displayed that read "Remember doing these exercises on the computer does not mean that you can cross real roads by yourself." One of the children was asked to read the message out to the group, and the warning was reinforced by the researchers.

5.3 EVALUATION OF THE TRAINING PROGRAM

The effectiveness of the training program in teaching 'at-risk' children appropriate road-crossing and road safety skills was assessed using a case-control study design.

5.3.1 Participants

The participants in this evaluation were the same children who participated in Phase 1 of the study (see Section 3.2.1). These children were randomly selected for inclusion in the case group (n=36) or the control group (n=35) within each school. This was to allow for roughly equal group sizes within each school for training purposes. The two groups were compared on age, gender and functional measures and it was found that both groups were roughly equal. Due to absences or illness, nine children (case group, n=2; control group, n=7) were not retested after the training program (either immediately after the training or 1 month after the training program) and these children's data were excluded from the analysis.

5.3.2 Procedure

Approximately 6 months after the pre-training testing, researchers returned to the participating primary schools to conduct the training sessions. Training session one and two for the case group were conducted on separate days, usually one day after the other.

Children in the control group participated in a separate session that delivered a safety message not related to road safety. This was a fire safety package developed utilising resources from the Country Fire Authority (CFA). A manual that is designed to assist teachers in preparing a fire safety program for primary school students was obtained from the CFA, and colouring activities, find-a-word and crossword puzzles were downloaded from their website (www.cfa.vic.gov.au).

The researchers led a discussion on fire safety in the home. Points that were raised for discussion included identifying hot objects in the home, how to behave around hot objects, and what to do if someone gets a burn or a fire starts. A poster was shown that displayed a picture of a home with 24 hazardous situations. This CFA poster is designed to stimulate structured discussion about fire and burn hazards around the home. Children were asked to spot the hazards and to explain why it was a hazard. They were then asked what could be done to make the house safer. At the conclusion of this discussion, children selected one of the colouring or puzzle activities to complete independently. The control program session lasted approximately 30 minutes.

5.3.2.1 Post-training testing

There were two post-training testing sessions, in which children's road crossing skills were tested using the same simulated road environment as previously used (described in Section 3.2.4). The first post-training testing occurred within a week of the training program, and the second post-training session was conducted approximately 1-2 months after the training program. Participants in both the case and control groups were tested at the same time points.

5.3.2.2 Training of the control group

After all testing was completed, the researchers returned to each participating primary school and offered the training program to all the children who were in the control group. This was a condensed version of the training program administered to the case group and was completed in a single one hour session.

5.4 RESULTS

The findings are presented in terms of effect of training on four outcome measures: critically incorrect responses, missed opportunities, decision time and safety rating responses. Within these factors, the overall effect of training is presented along with more in-depth analyses of the effectiveness of training for 'at-risk' children. Here, age group, gender, functional performance and traffic exposure were examined.

5.4.1 Effects of training on critically incorrect responses

Logistic regression analysis was used to examine the impact of training on road crossing skills using critically incorrect responses (where a child decided to cross but the time gap was too small for a safe crossing) as an outcome measure.

Comparison of critically incorrect responses of case and control participants revealed significant differences between pre-training and post-training responses. Figure 18 shows the proportions of critically incorrect responses between pre-training, one-week post-training and one-month post-training by case and control group. The analysis showed statistically significant reductions in critically incorrect responses by case group children one-week post-training (56.4% reduction; $\chi^2(1)=13.33$, $p<0.001$, CI=0.28-0.68) and one-month post-training (46.9% reduction; $\chi^2(1)=8.43$, $p<0.01$, CI=0.35-0.81), compared to responses prior to training, and relative to any changes in the control group, suggesting there is a good level of maintenance of the training effect.

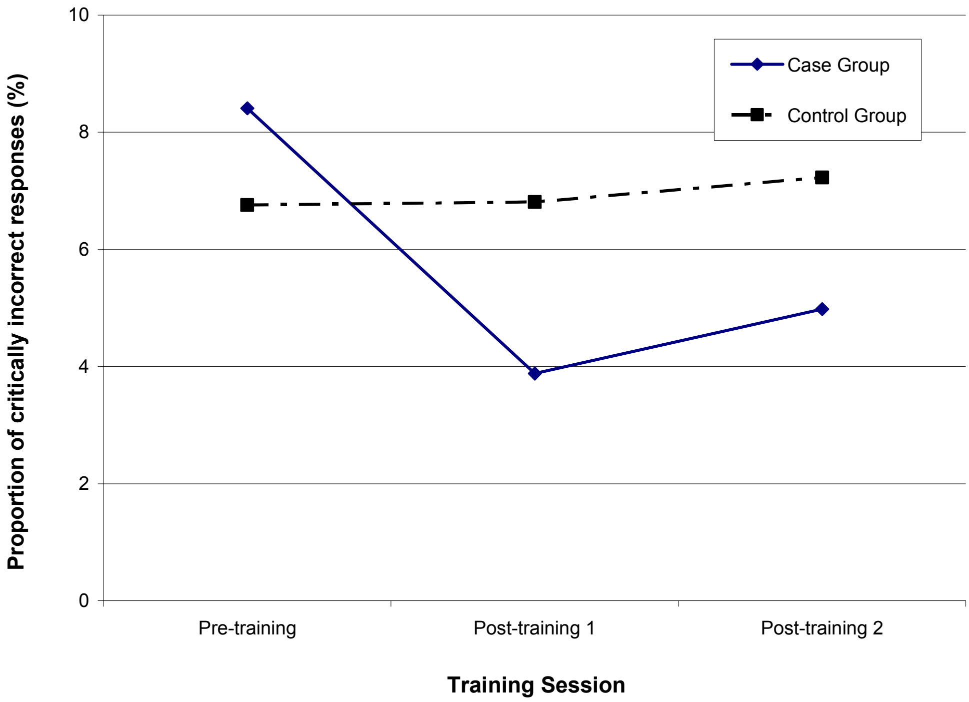


Figure 18: Proportions of critically incorrect responses by training session and training group

5.4.1.1 Effects of training on critically incorrect responses by age group

The proportion of critically incorrect responses by training session, age group and training group are shown in Figure 19. The results showed that the training program had a more beneficial effect for younger children compared with older children. Younger case group children (6-8 years) had a significant reduction in proportion of critically incorrect responses one-week post-training (57.7% reduction: $\chi^2(1)=11.23$, $p<0.001$, CI=0.26-0.70) and one-month post-training (49.9% reduction: $\chi^2(1)=7.82$, $p<0.01$, CI=0.31-0.81), compared to the responses prior to training and relative to any changes in the control group.

While there was a reduction in proportion of critically incorrect responses amongst the older case group children (9-10 years) compared to these responses prior to training and relative to any changes in the control group, this reduction was not statistically significant (56.2% reduction one-week post-training, $\chi^2(1)=2.53$, $p=0.11$, CI=0.16-1.21; 38.6% reduction one-month post-training, $\chi^2(1)=1.02$, $p=0.31$, CI=0.24-1.58).

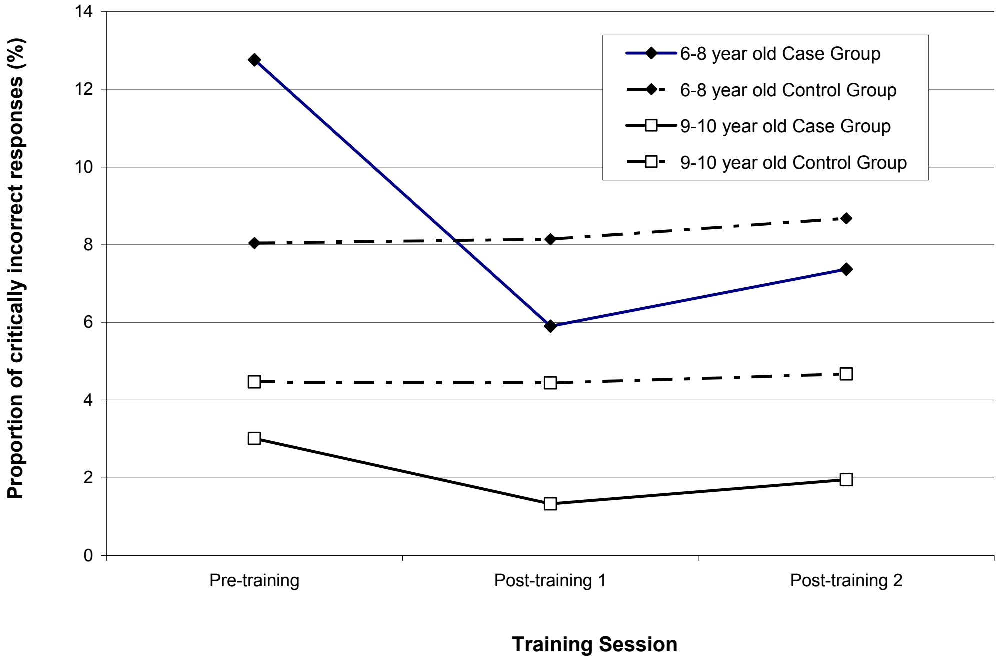


Figure 19: Proportion of critically incorrect responses by training session, age group and training group

5.4.1.2 Effects of training on critically incorrect responses by gender

The results were then examined regarding the influence of gender and the effectiveness of training (Figure 20).

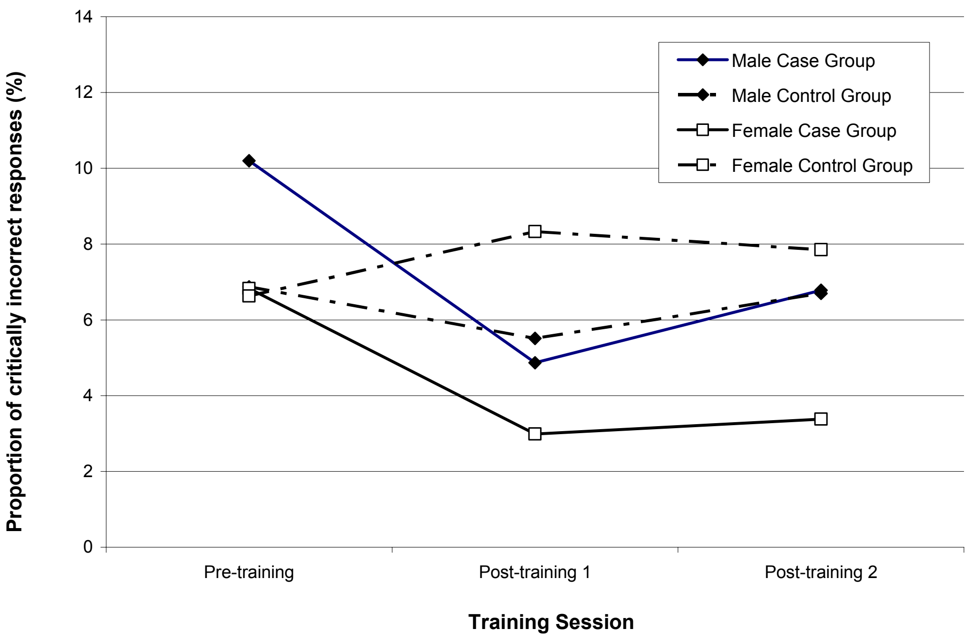


Figure 20: Proportion of critically incorrect responses by training session, gender and training group

Statistically significant reductions in proportion of critically incorrect responses amongst female case group children were found compared to responses prior to training and relative to any changes in females in the control group (67.1% reduction one-week post-training: $\chi^2(1)=10.89$, $p<0.01$; CI=0.17-0.64; 60.2% reduction one-month post-training: $\chi^2(1)=7.67$, $p<0.01$, CI=0.21-0.76). While responses of male case group children showed reductions as a result of training session (43.0% reduction one-week post-training, $\chi^2(1)=3.24$, $p=0.07$, CI=0.31-1.05; and 34.2% reduction one-month post-training, $\chi^2(1)=2.06$, $p=0.15$, CI=0.371-1.17), these were not statistically significant.

5.4.1.3 Effects of training on critically incorrect responses by functional performance measures

There were some mixed results associated with the effect of training by functional performance measures. Children who scored more poorly on the Colour Trails Parts I and II, the MVPT-3 and the Connors Hyperactivity test appeared to benefit more from training than children who performed better on these tests. Statistically significant reductions in proportion of critically incorrect responses were found amongst those with higher scores (higher score = poorer performance) on these tests one-week post-training and one-month post-training, compared with pre-training responses.

Colour Trails Part I:

- 13.2 percent reduction per 10-unit score increase one-week post-training, $\chi^2(1)=7.77$, $p<0.005$; CI=0.79-0.96;
- 8.8 percent reduction per 10-unit score increase one-month post-training, $\chi^2(1)=3.43$, $p=0.06$, CI=0.83-1.01.

Colour Trails Part II:

- 8.1 percent reduction per 10-unit score increase one-week post-training, $\chi^2(1)=12.84$, $p<0.001$; CI=0.88-0.96;
- 5.7 percent reduction per 10-unit score increase one-month post-training, $\chi^2(1)=6.49$, $p<0.05$, CI=0.90-0.99

MVPT-3:

- 13.2 percent reduction per unit score increase one-week post-training, $\chi^2(1)=14.40$, $p<0.001$; CI=0.81-0.93;
- 10.7 percent reduction per unit score increase one-month post-training, $\chi^2(1)=10.18$, $p<0.001$, CI=0.83-0.96

Connors Hyperactivity test:

- 14.4 percent reduction per unit score increase one-week post-training, $\chi^2(1)=9.28$, $p<0.002$; CI=0.78-0.95;
- 10.4 percent reduction per unit score increase one-month post-training, $\chi^2(1)=5.45$, $p<0.02$, CI=0.82-0.98

In contrast, children who performed better on the Tower of London test (lower score = poorer performance) appeared to benefit more from training than children who performed more poorly on this test. A reduction of 11.3 percent in proportion of critically incorrect responses per 10-unit score increase one-week post-training was found, $\chi^2(1)=14.94$, $p<0.001$; CI=0.83-0.94. A reduction of 8.7 percent in critically incorrect responses per 10-unit score increase one-month post-training was also found, $\chi^2(1)=9.64$, $p<0.001$, CI=0.86-0.97.

5.4.2 Effects of training on missed opportunity responses

The main focus of this evaluation has been on reducing the number of critically incorrect responses in children. While it is hardly a disadvantage to miss a crossing opportunity or two when crossing lightly trafficked two-lane residential streets, particularly when compared with the alternative of increasing the probability of making a critically incorrect response, it is also important that we are teaching children when it is safe to cross as well as when it is unsafe to cross (i.e., reducing the unpredictability of child pedestrian road crossing behaviour). Analyses of the missed opportunity responses (when a 'no' response was made and the time gap was safe) were undertaken to determine if training has a beneficial effect on teaching children to know when it is safe to cross.

While there was a slight increase in missed opportunity responses by case group children one-week post-training (6.4% increase; $\chi^2(1)=0.15$, $p=0.70$, CI=0.78-1.45) and one-month post-training (6.1% increase; $\chi^2(1)=0.14$, $p=0.71$, CI=0.78-1.45), compared to responses prior to training, and relative to any changes in the control group, these changes were not significant.

5.4.2.1 Effects of training on missed opportunity responses by age group

No statistically significant changes were apparent for missed opportunity responses by age group, however, it is worth noting that the proportion of missed opportunity responses increased amongst younger case group children (6-8 years) in both post-training sessions, compared to responses prior to training (26.0% increase one-week post-training: $\chi^2(1)=1.23$, $p=0.27$, CI=0.83-1.90; 11.4% increase one-month post-training: $\chi^2(1)=0.27$, $p=0.60$, CI=0.74-1.67), compared to the responses prior to training and relative to any changes in the control group. However, amongst older case group children (9-10 year olds), reductions in proportion of missed opportunity responses were found, compared to these responses prior to training (30.9% reduction one-week post-training: $\chi^2(1)=2.00$, $p=0.16$, CI=0.42-1.15; 19.4% reduction one-month post-training: $\chi^2(1)=0.68$, $p=0.41$, CI=0.48-1.35). These findings may suggest that the responses of younger children were somewhat more conservative following training compared with older children.

5.4.2.2 Effects of training on missed opportunity responses by gender

Likewise, no statistically significant changes were apparent for missed opportunity responses by gender. Increases in proportion of missed opportunity responses amongst female case group children were found compared to responses prior to training and relative to any changes in females in the control group (26.0% increase one-week post-training: $\chi^2(1)=1.09$, $p=0.30$, CI=0.82-1.95; 20.6% increase one-month post-training: $\chi^2(1)=0.72$, $p=0.40$, CI=0.78-1.86). Decreases in proportion of missed opportunity responses amongst male case group children were found compared to responses prior to training and relative to any changes in males in the control group (13.3% reduction one-week post-training: $\chi^2(1)=0.38$, $p=0.54$, CI=0.55-1.36; 10.1% reduction one-month post-training: $\chi^2(1)=0.21$, $p=0.65$, CI=0.57-1.41. Again, these finding may suggest that responses of females were somewhat more conservative following training compared with males.

5.4.2.3 *Effects of training on missed opportunity responses by functional performance measures*

In general, no significant changes in proportion of missed opportunity responses by functional performance measures were found, but there was a trend of an increase in these responses overall. A summary of the findings each functional performance measure follows:

Tower of London:

- 1.9 percent increase per 10-unit score increase one-week post-training, $\chi^2(1)=0.83$, $p=0.36$; CI=0.78-1.06;
- 1.6 percent increase per 10-unit score increase one-month post-training, $\chi^2(1)=0.60$, $p=0.44$, CI=0.98-1.06.

Colour Trails Part I:

- 3.2 percent increase per 10-unit score increase one-week post-training, $\chi^2(1)=0.45$, $p=0.50$ CI=0.9-1.13;
- 1.3 percent increase per 10-unit score increase one-month post-training, $\chi^2(1)=0.07$, $p=0.79$ CI=0.92-1.11.

Colour Trails Part II:

- 4.5 percent increase per 10-unit score increase one-week post-training, $\chi^2(1)=5.07$, $p<0.05$; CI=1.01-1.09;
- 3.6 percent increase per 10-unit score increase one-month post-training, $\chi^2(1)=3.17$, $p=0.08$, CI=0.99-1.08

MVPT-3:

- 0.1 percent reduction per unit score increase one-week post-training, $\chi^2(1)=0.001$, $p=0.97$; CI=0.95-1.05;
- 0.4 percent increase per unit score increase one-month post-training, $\chi^2(1)=0.02$, $p=0.88$, CI=0.96-1.05

Connors Hyperactivity test:

- 10.0 percent increase per unit score increase one-week post-training, $\chi^2(1)=5.96$, $p<0.02$; CI=1.02-1.19;
- 8.7 percent increase per unit score increase one-month post-training, $\chi^2(1)=4.52$, $p<0.05$, CI=1.01-1.17

5.4.3 Traffic exposure and effectiveness of training

Interestingly, children who engaged in independent travel less frequently were more likely to benefit from training compared with children who engaged in independent travel more frequently. Statistically significant reductions in proportion of critically incorrect responses were found amongst infrequent independent travellers one-week post-training (59.5% reduction: $\chi^2(1)=13.62$, $p<0.001$, CI=0.25-0.65) and one-month post-training (50.1% reduction: $\chi^2(1)=8.85$, $p<0.01$, CI=0.32-0.79), compared to pre-training responses, and relative to the control group. Reductions in proportion of critically incorrect responses amongst frequent independent travellers one-week and one-month post-training compared with pre-training were not significant (52.2% reduction one-week post-training, $\chi^2(1)=0.53$, $p=0.47$, CI=0.07-3.53; 29.2% reduction one-month post-training, $\chi^2(1)=0.13$, $p=0.72$, CI=0.10-4.82.

With regard to missed opportunity responses, there were no statistically significant changes as a result of training.

5.4.4 Effects of training on decision time

Arguably, a short decision time may be beneficial for crossing roads safely but only if it is associated with improved crossing responses and it was hypothesised that training would result in shorter decision times. Decision times were first analysed using regression modelling with decision time as a continuous variable. Overall, significant interaction effects were found between training group and training session, one-week post-training, $\chi^2(1)=62.89$, $p<0.001$, CI=0.53-0.87 and one-month post-training, $\chi^2(1)=68.79$, $p<0.001$, CI=0.0.55-0.89. However, the analysis also revealed that decision times amongst case group children did not change as a result of training and remained at around 3.2 s at each training session. In contrast, decision times of control group children decreased from 3.07s to 2.54s and 2.39s across training sessions. These results suggest that overall, training had little effect on decision time. Given this non-significant effect, it was considered unnecessary to explore further any relationship between decision time and crossing decision, however, it is interesting to note that, while the control group made shorter decision times in post-training sessions, their crossing decisions did not change over time. It may be that the case group children were taught to be more cautious as a result of training. This issue is worth further research.

Figure 21 shows the mean decision time by training session by age and training group and shows that decision times of younger and older case group children remained stable across training sessions.

Younger case group children took longer to make a decision to cross than older case group children and control group children in all training sessions. Significant interaction effects were found for age group, training group and training session, (young group: $\chi^2(1)=59.61$, $p<0.001$, CI=0.68-1.14 one-week post-training, $\chi^2(1)=50.34$, $p<0.001$, CI=0.62-1.09 one-month post-training; older group: $\chi^2(1)=9.02$, $p<0.01$, CI=0.13-0.63 one-week post-training, $\chi^2(1)=12.33$, $p<0.001$, CI=0.20-0.70). Training had little effect on decision times amongst case group children in both age groups, however, decision times amongst control group children decreased over training sessions.

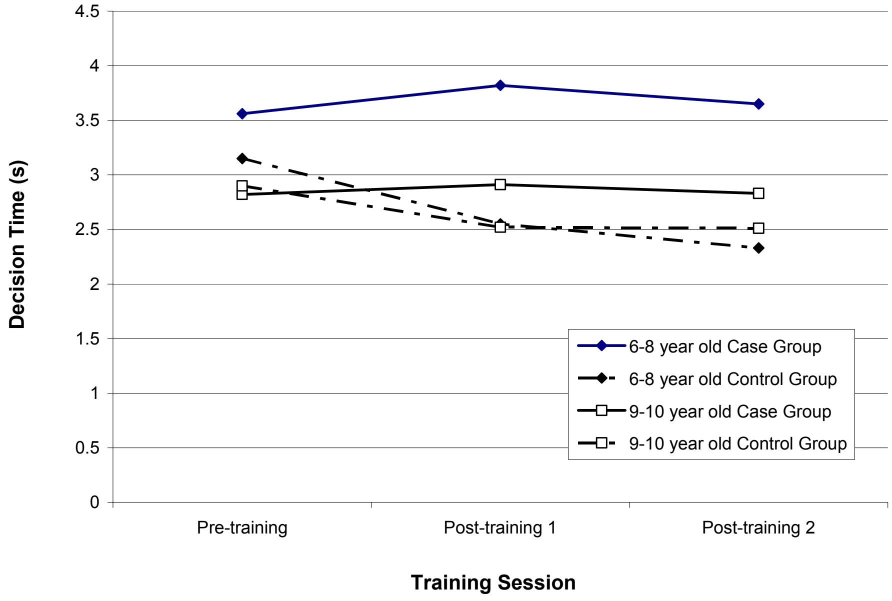


Figure 21: Mean decision time (s) by training session, training group and age group.

Figure 22 shows the mean decision time by training session and by gender and training group. As for age group, decision times remained stable across training sessions for both female and male case group children, but decreased amongst control group children, suggesting that training had little effect on case group males and females. Like for age group comparisons, significant interaction effects for gender, training group and training session were found (females: $\chi^2(1)=64.70$, $p<0.001$, CI=0.80-1.31 one-week post-training, $\chi^2(1)=65.52$, $p<0.001$, CI=0.82-1.34 one-month post-training; males: $\chi^2(1)=13.00$, $p<0.001$, CI=0.13-0.59 one-week post-training, $\chi^2(1)=9.33$, $p<0.01$, CI=0.13-0.59.

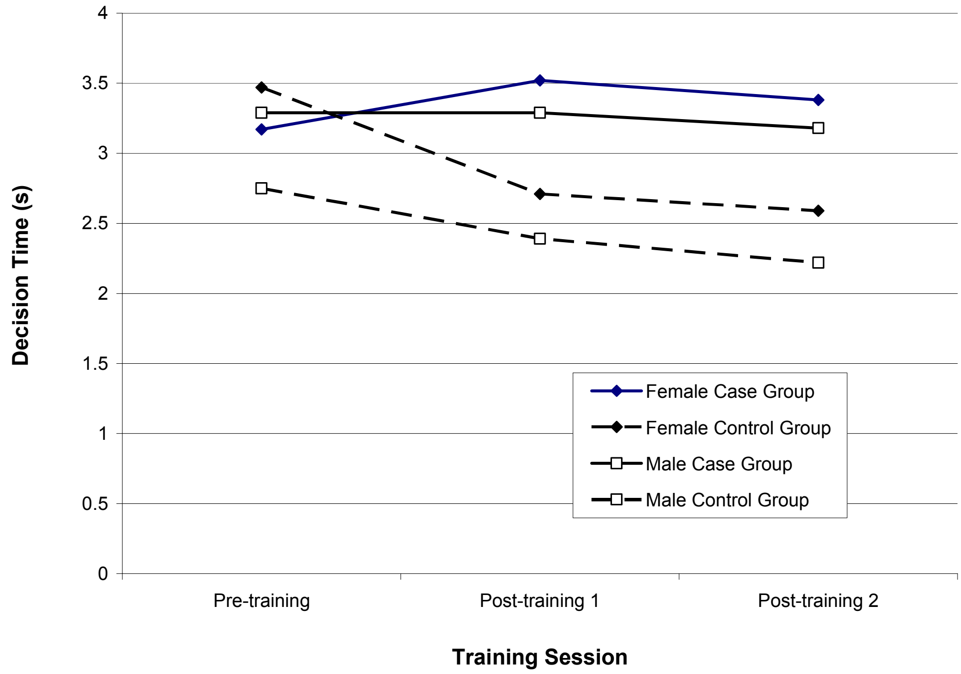


Figure 22: Mean decision time (s) by training session, training group and gender

5.4.5 Effects of training on safety rating responses

Finally, the effectiveness of training was examined by comparing safety rating responses prior to and following training to gain an appreciation of the effect of training on risk perception. An overall reduction in mean safety rating response was found amongst training group from 6.06 prior to training to 5.73 one-week post-training and 5.76 one-month post-training. In contrast, mean safety rating responses amongst control group children increased from 5.60 prior to training to 6.09 and 6.29 in subsequent sessions. Tests of statistical significance were not performed here given the nature of the data and difficulty in grouping/defining 'safe/unsafe responses. Notwithstanding, analysis of the data suggests some effect of training on perceptions of safety.

The effect of training on safety rating responses by age group is shown in Figure 23 and shows some age differences. Responses of younger case group children decreased one-week post-training and one-month post-training compared with responses prior to training. Similarly, responses of older case group children decreased one-week post training and one-month post-training compared with responses prior to training.

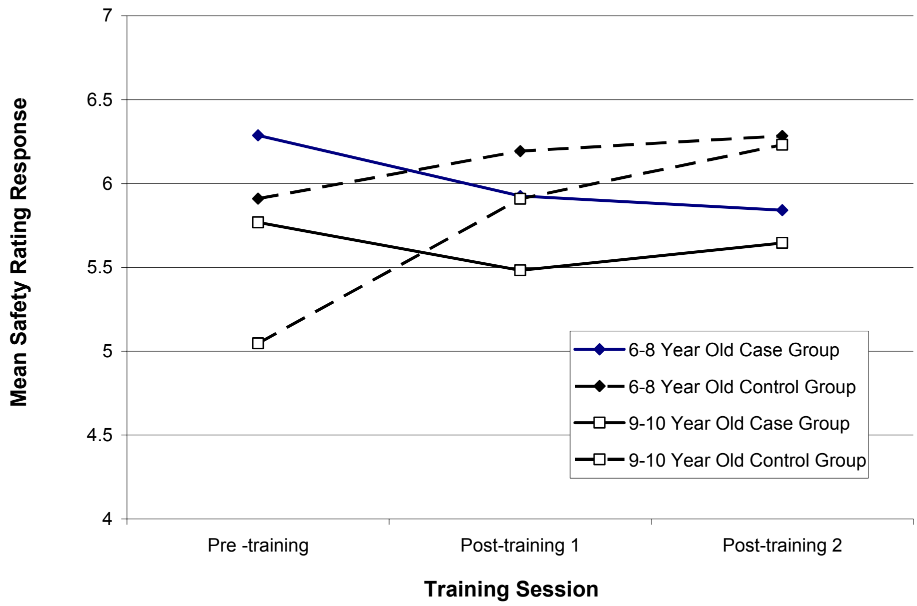


Figure 23: Mean safety rating responses by training session, age group and training group

The effect of training on safety rating responses by gender is shown in Figure 24. While post-training responses amongst male case children did not change compared with pre-training responses, those of female case children did. Safety rating responses by case group females decreased from 6.14 prior to training to 5.56 one-week post-training and 5.47 one-month post-training.

These findings together, suggest an overall beneficial effect of training on improving the perception of riskiness of crossing decisions, but particularly amongst females.

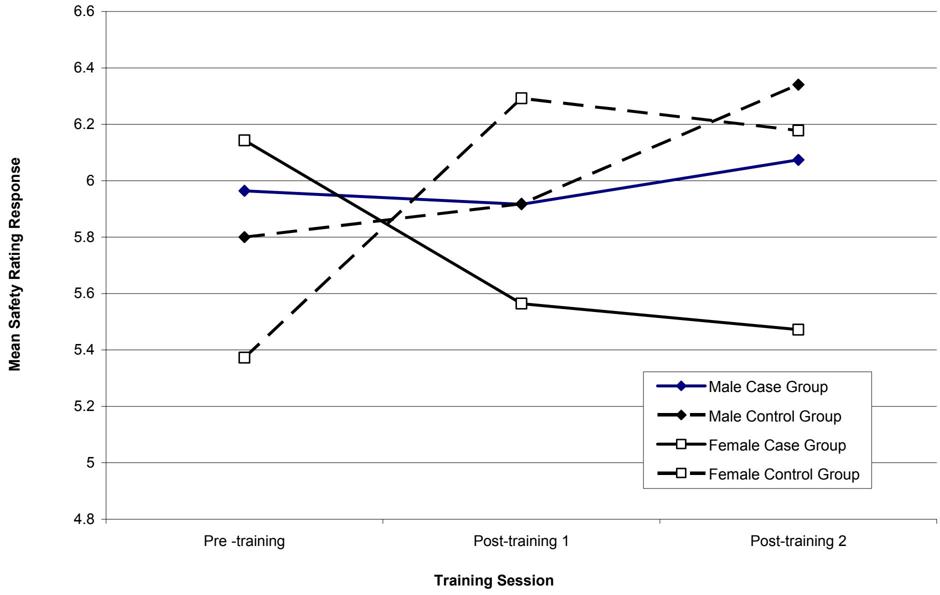


Figure 24: Mean safety rating responses by training session, gender and training group

5.4.6 Case Studies

As indicated previously, the training sessions were designed to have maximum benefit for 'at-risk' children (as defined in the first phase of the study). It, therefore, is useful to examine the effectiveness of training on individual children. Case studies were undertaken on selected children, particularly younger children, those with poorer performance on functional performance measures and those with little unsupervised travel. The following two cases demonstrate the effectiveness of training amongst 'at-risk' children.

Case 1

Case 1 is a 7 year old female. Her performance on the Tower of London was average for the 6-8 year old age group, (72, mean=71.36), while her scores on the Colour Trails 1 and 2 were slightly better than average for her age group (Trails 1 = 26, mean = 36.9; Trails 2 = 65, mean = 83.52). Her score on the MVPT was also slightly better than average (109, mean=102.67). This indicates that her higher order executive functioning and problem solving abilities are average, while her visual search and visual perceptual skills are above average. However, her scores on the Conners' Rating scale are higher than the average for her age group, and indicate that there are possible problems in the areas of cognition and attention, oppositional behaviour, and hyperactivity. From the parent/guardian questionnaire, it was evident that Case 1 had a fairly low level of supervised traffic exposure – more importantly, she had a higher than average level of unsupervised traffic exposure, as she walked unsupervised daily or almost daily to a location other than school. Her parents rated her ability to safely cross the road compared to other children as better than average.

Case 1 made 8 critical errors when tested prior to any training. After the training program, she made no critical errors when tested immediately post-training and one-month post training. The training program was extremely effective in reducing the number of critical errors made by Case 1.

Case 2

Case 2 is a 6 year old male. His performance on the Tower of London task was slightly below average for the 6-8 year age group (61, mean 71.36), and his scores on the Colour Trails 1 and 2 were also worse than average (Trails 1 = 59, mean = 36.9; Trails 2 = 103, mean = 83.52), however his MVPT score was better than average (115, mean= 102.67). This indicates that his higher order executive functioning, problem solving abilities and visual search strategies are below average, while his visual perceptual skills are above average. His scores on the Conners' rating scale are average, indicating that there are no problems in the areas of cognition and attention, oppositional behaviour and hyperactivity. His level of supervised traffic exposure was high, as his parent always walked to school with him, and he always held his parent's hand when crossing the road.

Prior to any training, he made 35 critical errors. After the training program, he made 26 critical errors at both testing time-points; immediately after and one month after training. Case 2 had a very slow walking speed. His fastest walking pace was 6.13 seconds. This was almost twice as slow as the average for the group, and would contribute to the high number of critical errors. It appears that the training was slightly effective for Case 2, however his extremely slow walking pace places him at a higher risk for making a critical error, and would contribute to the high number of critical errors still evident post-training.

5.5 DISCUSSION

The broad aim of this phase of the project was to develop and evaluate a practical training program aimed to teach good road-crossing skills. A practical program involving use of a computer simulator and intensive feedback was developed. The results were encouraging and showed that this program was effective in improving children's road crossing skills.

As indicated previously, education is recognised as a key strategy to teach young children to interact appropriately and safely with traffic as pedestrians and cyclists. Road safety education programs are common in pre-school and early primary years and most of these programs and interventions aim to teach critical road safety skills, encouraging walking and cycling and awareness of risks amongst parents and often utilise a combination of educational curricula with engineering countermeasures. Unfortunately, few have been evaluated and some concerns have been raised as to their effectiveness in improving skills and ultimately reducing crash and injury risk. The major problems seem to lie with the assumption that, if children were provided with information, their knowledge about road safety would translate into improved behaviour on the road, however this may not be the case, especially for younger children (Ampofo-Boateng & Thomson, 1991; Zeedyk, et al., 2001). Indeed, there have been calls to improve such programs and interventions by increasing training and practical components of programs to ensure the transfer from knowledge to safer performance or behaviour (Zeedyk et al., 2001; Klassen et a., 2000), providing the opportunity to gain practical skills rather than knowledge alone (Bailey, 1995) and targeting programs to those who are most in need of training (Barton, 2007).

Moreover, effective teaching strategies need to be considered when designing road safety training and education programs. The educational and psychological literature clearly acknowledges that children learn best when i) the learning environment is supportive and productive; ii) the learning environment promotes independence, interdependence and self motivation; iii) childrens' needs, backgrounds, perspectives and interests are reflected in the learning process; iv) children are challenged and supported to develop deep levels of thinking and application; and v) learning connects strongly with communities and practice beyond the classroom.

The design of the current training program considered the above factors and aimed to provide an optimal learning environment, one that provided practical information with intensive feedback to improve the separate component skills of crossing roads safely, particularly with regard to making appropriate gap selection decision based on distance, speed and time gap information, knowledge of one's own walking speed and the importance of walking quickly when crossing roads. In addition, the focus of the training was on teaching those most at risk, i.e., young children, those with poorer perceptual, visual search, attentional and cognitive/executive functional skills, and those who had little unsupervised traffic exposure.

The current findings support the above contentions, suggesting that tailored and practical programs have a beneficial effect on children's road-crossing decisions. Programs that are aimed at improving essential skills and strategies to cross roads safely through intensive training and feedback, focussing on known risk factors (gap selection, awareness on one's physical attributes, and attending to the most important factors and not being distracted) are beneficial. The findings from this evaluation suggested that the training program was successful in reducing the number of critically incorrect responses immediately after training overall, but particularly amongst younger children, females, children who had less well developed perceptual, attentional and cognitive/executive skills, and less traffic exposure. Further, these results were maintained at one month follow-up.

The effects of the training were greater for younger children (6-8 year olds) and females. There may be several reasons for this. Firstly, in Phase 1 of the larger study, younger children were shown to be significantly more likely to make a critically incorrect response than older children. Younger children may have received more benefit from the program due to the fact that there was more scope for improvement. However, there were no differences in the number of critically incorrect responses between females and males, and this cannot be the explanation for the differences in the effectiveness of training between the genders. Moreover, children around this age are developing skills rapidly, they take an interest in learning, develop technical, co-ordination and computational skills, begin to organise ideas and share thoughts, develop physical capabilities and become more confident physically, and become more aware of their community and their health needs. Older children, having developed these skills, broaden their knowledge, apply many of the practical skills they have mastered previously with independent thinking and strategies, and apply logical reasoning to both ideas and concrete objects. Given that the focus of the training program was on developing computational skills regarding the approach of vehicles (distance, speed and time information), it is not surprising that younger children who are at the stage of rapid development of these skills benefited more from the training compared with older children.

While the evaluation of the training program focussed on reducing poor road crossing decisions (i.e., reducing the number of critically incorrect responses), it was important to evaluate it in terms of other behaviours as well, particularly a change in number of missed opportunities, faster decision times and potentially improved risk perception. It was hypothesised that training may reduce the number of missed opportunity responses due to it's focus on reducing inconsistent crossing behaviours (a noted risk factor for younger children) and as found by Thomson et al. (2005). It was also noted that faster decision times may have a safety benefit (Thomson et al., 2005), and hypothesised that training would reduce the time required to make a decision. Furthermore, baseline data suggested that many children did not perceive risk appropriately prior to training, particularly in small time gaps and especially amongst younger children. It was hypothesised that training may decrease the mean safety rating responses. The findings for these outcome measures, however, were not as conclusive as those of critically incorrect responses. Notwithstanding, there were some interesting findings that are worth further discussion.

There was no significant effect of training on proportion of missed opportunity responses. Indeed, there was a tendency towards an increase of missed opportunity responses overall, and particularly amongst younger female participants and children with less well-developed functional performance. This was an unexpected result, but may be explained by a tendency to make more conservative responses following training. Given that the training program focussed on improving safe crossing responses, particularly selecting larger time gaps in oncoming traffic, it is not surprising that children were less likely to respond positively (i.e., decide to cross) in time gaps that may have been considered 'marginally safe'. It may be that childrens' perception of risk changed as a result of training. Indeed, the safety rating results support this argument. There was an overall decrease in safety rating responses, suggesting that more conservative or appropriate perceptions of risk were achieved after training. This is an encouraging result and, while risk perception was not a focus of the current training program, could be an important factor to include in subsequent training programs.

Likewise, there was little effect of training on decision times amongst children who underwent training sessions, but was apparent amongst control group children. While this was an unexpected result, particularly the decrease in decision time amongst control group children, the lack of effect on decision time amongst case group children may be explained by the fact that this was not a major component of the training program. While children were encouraged to make quick decisions throughout the study, there was no explicit focus on decision time in training sessions.

Importantly, however, this study provides good evidence that there are ways to improve road-crossing skills in a safe environment. Simulated traffic environments provide safe ways to examine behaviour and provide training in 'hazardous situations' without putting people at risk as in real traffic environments. While it is acknowledged that there are direct benefits of learning road skills associated with exposure to real traffic, it is also desirable to understand children's behaviour and teach the appropriate skills in a safe environment.

5.5.1 Summary

In sum, the findings of the evaluation were encouraging. The training program was successful in improving road-crossing skills, particularly selecting safe and appropriate gaps in the traffic in which to cross and perceptions of risk. While some unexpected results were found, particularly in terms of missed opportunity responses and decision times, an overall beneficial effect of the program was demonstrated.

6 CONCLUSIONS AND RECOMMENDATIONS

The broad aims of this study were to i) examine road-crossing decisions amongst young children with a view to better understand the separate component skills that comprise the road-crossing task and to identify 'at-risk' children, and to ii) develop and evaluate the effectiveness of a practical and targeted educational and training program aimed to improve gap selection decisions amongst 'at-risk' young children.

Seventy-one children between 6-10 years old and their parents participated in the study. Children's road crossing-skills were tested in a simulated road traffic environment and functional performance was measured using a battery of neuropsychological and behavioural assessment tools to help identify 'at-risk' children. A training package was then developed and evaluated based on these results.

6.1 ROAD CROSSING SKILLS

Children's ability to select safe gaps in traffic was tested in a simulated road-traffic environment. The findings show that young children (6-10 years) have generally poor skills of selecting safe gaps in traffic. The finding that substantial proportions of children made critically incorrect responses, based on their fast walking time and time gap of the approaching vehicle was of particular concern. The results suggest that children primarily used distance rather than the speed of approaching vehicles in making judgements about safe crossing gaps. This was evidenced by the result that children were more likely to make a 'yes' crossing decision in a larger distance gap, despite the time gap being the same. Age was a strong predictor of a critically incorrect crossing decision, with six year olds almost 12 times more likely than 10 year olds to make a critically incorrect decision. Surprisingly, gender was not a predictor of road crossing decisions, or critically incorrect responses.

6.2 IDENTIFYING 'AT-RISK' CHILDREN

There is a large body of literature suggesting that young children are less competent in traffic, are generally inconsistent in their road safety behaviours and are easily distracted. The current findings generally support these contentions and have highlighted some additional factors that may be associated with poor road-crossing skill, including vehicle factors, young age, less well-developed attentional, cognitive and executive skills, and little unsupervised traffic exposure.

Children who performed poorly on tests of functional performance displayed poorer road crossing skills than those who performed well. Making decisions about when it is safe to cross in relation to available gaps in the traffic and judging one's own walking speed are complex tasks. However, very few studies have examined the specific functional skills that may impact on road-crossing decisions. The current study has highlighted that poor road-crossing skill may lie with poorly developed perceptual attentional, cognitive and executive skills, as well as hyperactivity and inattentiveness.

In addition, much of the research on child pedestrian safety discusses the importance of acquiring skills in real-traffic environments (e.g., Zeedyk & Kelly, 2003), particularly developing an awareness of traffic and learning fundamental road safety practices, initially under adult supervision and leading to independent travel. However, the research is also clear that children do not acquire the necessary skills for independent travel until at least 10-11 years of age (Whitebread & Neilson, 2000; Connelly et al., 1998), and that acquisition of skills in real-traffic environments can be dangerous. The current findings suggest that exposure to traffic, particularly walking independently, is associated with road-crossing skill. Children who walked independently more frequently were less likely to make incorrect crossing decision compared with children who walked independently less frequently. This suggests that age-appropriate (supervised and unsupervised) traffic exposure is beneficial for acquiring road skills.

6.3 DEVELOPMENT AND EVALUATION OF A CHILD PEDESTRIAN SAFETY TRAINING PACKAGE

Most importantly, this study provides evidence that there are ways to improve road-crossing skills without exposure to traffic. Education has long been advocated as a means of teaching children the skills to be able to interact with traffic safely. Road safety education programs are common in pre-school and early primary years; however, there are some concerns as to their effectiveness. The major problems seem to lie with the assumption that, if children were provided with information, their knowledge about road safety would translate into improved behaviour on the road; however this may not be the case, especially for younger children (Ampofo-Boateng & Thomson, 1991; Zeedyk, Wallace, Carcary et al., 2001). Indeed, it is argued that improved programs should include targeted and practical training in order to be effective.

The current findings support this contention. The training program aims at improving essential skills and strategies to cross roads safely through intensive training and feedback, focusing on known risk factors such as identifying safe gaps in which to cross by assessing time gap rather than distance or speed alone, knowing one's walking speed, and attending to the most important factors and not being distracted. The evaluation of the training program clearly showed a beneficial effect in reducing the number of critically incorrect responses, particularly amongst those most at risk, i.e., young children, those with less well developed perceptual, attentional and cognitive skills, and inattentive and easily distracted children. While the findings were less clear with regard to other outcome measures (missed opportunity responses, decision time and safety rating responses), it appears that the training program resulted in more conservative crossing responses and a greater appreciation of risk perception.

6.4 LIMITATIONS

There are some limitations of this study that warrant discussion. First, this study may have produced gap selection judgements that may be different from those of children in normal traffic, particularly among boys. There are two reasons why this may occur. One reason may be that as the participants did not need to cross an actual road there was no risk in making an erroneous decision. It has been suggested by Ebbesen et al. (1977, as cited in Connelly et al, 1998) that perceived risk affects decision making, so removal of risk may have affected the outcome in this study. Further, research with children of varying ages has demonstrated that there is greater risk-taking behaviour among boys than girls (e.g. Morrongiello & Rennie, 1998). This may explain the lack of gender difference in making road-crossing decisions. It may be that boys and girls make similar judgements in a controlled simulator environment, but that boys are more likely to take risks when in an actual roadside setting. This may be of some concern considering the findings of Phase 1 of this study show that children often made unsafe decisions in a controlled environment, without any distracting environmental factors. It is possible that children would make more unsafe decisions in an environment that contains distracting information. A second reason for the possible difference between simulator road-crossing decisions and the decisions of children in normal traffic may be that the results are an artefact of the impoverished two-dimensional viewing conditions of the simulator. However, these effects are likely to be minimal, as a validation study by Oxley, Fildes, Ihsen and Charlton (1997) showed that crossing decisions and perceptions of safety by younger and older adults in real world and filmed versions of traffic scenes were highly correlated.

A second limitation of the study is that children's selections of gaps in the traffic were not tested in the real roadside environment. It is therefore unknown how well the skills gained in the training environment transfer to the real environment. However, it is likely that skill transfer would be high, as this has been found by other researchers using similar simulator training programs (e.g. Glang et al, 2005; Thomson et al, 2005; McComas, et al, 2002).

A third limitation is that it is unknown if this training program would be effective in reducing child pedestrian crashes and injuries. As discussed in the literature, there have been very few evaluations of child pedestrian safety training programs, and even fewer that have used injury as an outcome measure. Further, it appears that the transfer from knowledge to safer performance or behaviour is poor and transfer is not automatic (Zeedyk et al, 2001; Klassen et al, 2000; Ampofo-Boateng & Thomson, 1991; Rothengatter, 1981). Nevertheless, it is still important to prepare children for the road traffic environment and the use of simulator training appears to be a safe and effective way of teaching initial road-crossing skill. Further, an advantage of the program developed in this study is that it teaches separate component skills of the road-crossing task, which is a step beyond imparting information or knowledge only. It is probable that trained skills are more likely to have an effect on child pedestrian crash risk than knowledge alone.

6.5 RECOMMENDATIONS

Education and training packages are important and effective means to improve child pedestrian safety, but children need to be taught the appropriate skills. This package offers a safe and unique way to train young children to cross roads safely. There are several recommendations that are proposed as a result of this research.

6.5.1 Identification of 'at-risk' children

Previous research suggests that children under the age of 10 years lack the skills to interact safely with traffic when unsupervised. While the current findings support this, additional factors that may put young children at increased risk of collision were identified. These included young age, little traffic exposure and less well developed functional skills. Three important recommendations here are:

- A key safety message to promote to families and schools/teachers is that children under the age of 10 years should not walk unsupervised without appropriate education and training.

- Children as young as six years old should receive road safety training that specifically targets those component functional abilities shown to underpin safe road crossing.

- The information gained from this research should be disseminated to road safety educators, as the results could guide current road safety programs to assist in targeting children for more intensive road safety training.

6.5.2 Further development and promotion of training package

The training program developed for this study appeared to have a beneficial effect on road-crossing decisions amongst young children. There is scope, however, to make some improvements to the package, particularly in reducing proportions of missed opportunities and reducing decision time. Four recommendations here are:

- The package should include more focus on providing feedback to improve missed opportunity responses and decision times.
- The package should be further refined for use by teachers and road safety professionals in schools.
- A comprehensive manual should be prepared, as well as further developing the software to make it more accessible and user friendly.
- This program should be promoted to road safety organisations and the education department, in conjunction with other initiatives such as road design and operation improvements to improve the safety of child pedestrians.
- Parents of young children should be educated on the risks for young children and awareness raised on the dangers of young children walking unsupervised before they gain the appropriate skills to interact safely with traffic.

6.5.3 Recommendations for future research

There are a number of areas where more research is required to. The following recommendations for future research are:

- Develop and evaluate other road safety training packages:

  Future research could attempt to develop and evaluate other road safety training programs that aim to train children in other areas of child pedestrian safety. This study only examined one aspect of the road-crossing task, the ability to select safe gaps in traffic. While this is a critical and difficult skill to master, future programs may benefit from incorporating other aspects of the road-crossing task, such as choosing a safe location to cross, selecting safe gaps in traffic with traffic coming from both directions, and identifying potential hazards in the road environment. A program that incorporated more aspects of the road crossing task will better equip young children to be safer road users.

- Conduct a larger-scale field trial with a refined training program:

  Further research should also examine the correlation between road crossing decisions in the simulator environment and in normal traffic. While a validation study by Oxley, et al, (1997) showed that crossing decisions and perceptions of safety by younger and older adults in real world and filmed versions of traffic scenes were highly correlated, this has yet to be validated in children. It is essential to understand whether the skills gained in simulated environments are transferred to participation in real traffic environments. A field trial examining the effect of the training program on behaviour while interacting with real-world traffic is a necessary step in advancing optimal use and community benefit of the program.

- Develop a similar training program for novice drivers:

  The results of this study could be used to develop a similar simulator driving training program for young adults prior to any driving experience. Although young adults will have had more traffic exposure as pedestrians and as passengers than young children, and will have better developed perceptual and attentional skills, the task of selecting a safe gap in traffic is a complex one, particularly as a new driver. Exposing young adults to this task in a safe and controlled environment may assist young adults in becoming safer drivers and lower their risk of making dangerous and risky decisions when on the road.

6.6 CONCLUSION

Walking is a major mode of transport, it can increase fitness, health and longevity, and decrease environmental problems such as pollution and congestion. However, pedestrians are an extremely vulnerable road user group, largely due to their lack of protection and limited biomechanical tolerance to violent forces when impacted by a vehicle. Due to this, crashes involving pedestrians are severe in nature and pedestrian safety is a serious community concern.

Research suggests that children between the ages of 6 to 10 years are at highest risk of death and injury. Further, young children's safety is of particular concern in view of their vulnerability in traffic situations and the special value society places on children. Three broad strategies are available for managing child pedestrian safety – behavioural programs, improvements to road design and operation (including speed reduction in areas of high pedestrian activity), and improvements in vehicle design. It is important to note that neither education/training programs, environmental modification nor improvements to vehicle design are sufficient solutions by themselves. Gains in children's safety in traffic require innovative combinations of improvements in all three areas.

The results of this study have enhanced our understanding of which children are at increased risk of a pedestrian collision. This information is a valuable resource on which a range of safety initiatives can be based, including environmental improvements, but particularly educational and training programs. This has resulted in the development of a safe, practical and effective educational and training program that targets risk factors and appears to improve children's road-crossing skills.

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Appendix A

Principal Name,
Primary School Name,
Street,
Suburb, postcode.

Letter of Invitation/Explanatory Statement – School Principal

Child pedestrians: Factors associated with ability to cross roads safely and development of a training package.

Dear School Principal,

Crashes involving pedestrians are severe in nature and pedestrian safety is a serious community concern. Child pedestrians aged 6-10 years have been identified as those at increased risk of fatal and serious injury, possibly because they are gaining a certain level of independence at an age when their road skills and strategies are not fully developed. Young children are generally inconsistent in their road safety behaviours, are easily distracted, have difficulty estimating the speed and distance of oncoming cars appropriately, and are poor at recognising dangerous places to cross.

The Monash University Accident Research Centre is undertaking a project for the NRMA-ACT Road Safety Trust to identify some of the functional and behaviour factors that may be associated with poor road crossing decisions and to develop and evaluate a practical training program to improve road-crossing behaviour, particularly for those children who may be at higher risk of crash involvement.

The outcomes of this project are hoped to have a positive long-term impact on child pedestrian safety, as we will gain a better understanding of the factors that contribute to increased risk for young pedestrians. The training package we aim to develop will help to improve road-crossing skills amongst young children and will also help change parental attitudes towards pedestrian safety. We are also hopeful that children involved in the study will directly benefit from involvement in this project and that their road safety awareness and skills will be increased.

We would like to invite your school to take part in this important study. We are hoping to include 50 children from 6-10 years of age and their parents from a number of primary schools in the Melbourne Metropolitan area and therefore are looking for approximately 10 children and their parents from each school.

Details of the research:

The project is divided into two parts, the first to identify some functional and behavioural factors that may contribute to increased crash risk, and the second to assess the effectiveness of a training program to improve road-crossing skills. Details of the research components are:

Part I: Children will be asked to undertake a battery of tests to identify functional and behavioural performance that may be related to poor pedestrian performance. These tests include the Children's Colour Trails Test, the Tower of London test, and the Motor-Free Visual Perception Test. In addition, parents will be asked to complete a traffic and road safety questionnaire and the Conners' Rating Scale. All children will also be asked to make road-crossing decisions in a simulated pedestrian road-crossing task. This will involve children using a computer and pressing buttons to make choices such as those s/he would make when crossing the road.

Children will complete these tasks over two sessions, approximately one week apart, each requiring approximately 30-45 minutes each. All tasks can be conducted during school hours on any day that suits the school curriculum. Parents will be given consent forms for their child's involvement and asked to complete the questionnaire at home and at a time convenient to them. It is expected that the questionnaire will take approximately 20 minutes to complete.

Part II: This component aims to examine the effectiveness of training and feedback on pedestrian performance. Children will be randomly selected to receive practice, training and feedback or not. For those selected to receive training, they will view the simulated road-crossing environment again (requiring approximately 45 minutes). Those not selected for training will view a video or other appropriate activity that does not contain a road safety message (taking approximately 30 minutes). Both groups will make road-crossing decisions in the simulated road-crossing environment twice again at two separate time points (approximately one month apart). These sessions will require an additional 30 minutes at each time point. Children in the group who did not receive the training as part of this study will be offered the training at the end of the study. Again, all tasks can be conducted during school hours on any day that suits the school curriculum.

Confidentiality

The information we will collect from students and parents is for research purposes only and will be treated in the strictest confidence. All data will be coded and participants will be identified only by number, and not name, on the database. Student's names will only appear on the informed consent form, and contact details will be stored separately from other details. Only the researchers will have access to the data, which will be stored in locked filing cabinets in secure offices at MUARC. In accordance with University regulations, data must be stored for a minimum of five years. After this period, all data will be permanently destroyed. Only group findings will be reported and these will be made available to the sponsors of the project in the form of a report and conference papers and journal articles may also arise from this research project. No findings which could identify any individual participant will be published.

There is no financial reward offered for participation in this project. Students and parents are free to decide whether or not to participate in this study, and can withdraw their consent at any time by filling in the Revocation of Consent Form. Neither students nor parents will be disadvantaged as a result of withdrawing.

Your school's participation

If you agree for your school to take part in the study, please sign and return the Consent Form, providing your school's contact details, in the self-addressed envelope. One of our researchers will contact you shortly to discuss the study further and arrange for letters of invitation and consent forms to be sent to students and their parents. Please keep this explanatory statement for your reference.

Should you have any complaint concerning the manner in which this research ***<Project number 2005/941>*** *is conducted, please do not hesitate to contact the Monash University Standing Committee on Ethics in Research Involving Humans at the following address:*

The Secretary
The Standing Committee on Ethics in Research Involving Humans (SCERH)
Building 3D
Research Grants & Ethics Branch
Monash University VIC 3800
Tel: +61 3 9905 2052 Fax: +61 3 9905 1420 Email: scerh@adm.monash.edu.au

If you have any questions regarding this study please contact me on (03) 9905 4374 or Jennie.Oxley@muarc.monash.edu.au.

Yours Sincerely,

Dr Jennifer Oxley
Senior Research Fellow
Monash University Accident Research Centre

CONSENT FORM – SCHOOL PRINCIPAL

Child pedestrians: Factors associated with ability to cross roads safely and development of a training package.

I agree for researchers at Monash University Accident Research Centre to undertake a research project on child pedestrian safety at (*name of school*). The project has been explained to me in the Letter of Invitation/Explanatory Statement, which I will keep for my records.

I understand that agreeing for the school to take part in the project means that students aged 6 to 10 years and their parents will be invited to take part in the project to undertake the following tasks:

- Children will complete a number of assessments designed to measure functional performance and behaviour
- Children will undertake simulated road-crossing tasks
- Parents will complete a questionnaire providing details on their child's pedestrian activity, travel patterns, and behaviour.

I understand that any information students and their parents provide is confidential, and that no information that could lead to the identification of any participant will be disclosed in any reports on the project, or to any other party. I also understand that the school's, students and parent's participation is voluntary, that the school can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way.

Name of Principal (please print): ....…..…………

Name of School: ………………………………………………………………………

Address: ....…………………………………………………………………..

…………………………………………………………………………………………

Telephone: ....….. Fax: ……………………………………..

E-mail: ………………………………………………………………..

Signature.………………………………………………………..Date: ...……../…………

Please return the completed <u>Consent Form</u> in the envelope provided to Monash University Accident Research Centre

Appendix B

Letter of Invitation/Explanatory Statement – Parents

Child pedestrians: Factors associated with ability to cross roads safely and development of a training package.

Dear Parent/Guardian,

Crashes involving pedestrians are severe in nature and pedestrian safety is a serious community concern. Child pedestrians aged 6-10 years have been identified as those at increased risk of fatal and serious injury, possibly because they are gaining a certain level of independence at an age when their road skills and strategies are not fully developed. Young children are generally inconsistent in their road safety behaviours, are easily distracted, have difficulty estimating the speed and distance of oncoming cars appropriately, and are poor at recognising dangerous places to cross.

The Monash University Accident Research Centre is undertaking a project for the NRMA-ACT Road Safety Trust to identify some of the functional and behaviour factors that may be associated with poor road crossing decisions and to develop and evaluate a practical training program to improve road-crossing behaviour, particularly for those children who may be at higher risk of crash involvement.

The outcomes of this project are hoped to have a positive long-term impact on child pedestrian safety, as we will gain a better understanding of the factors that contribute to increased risk for young pedestrians. The training package we aim to develop will help to improve road-crossing skills amongst young children and will also help change parental attitudes towards pedestrian safety. We are also hopeful that children involved in the study will directly benefit from involvement in this project and that their road safety awareness and skills will be increased.

The Department of Education and Training and the Principal, (*name of Principal*), have agreed for us to conduct the project at (*name of school*). We wish to include both students and their parents in the research and this letter describes what each participant will be invited to do. Students aged between 6 and 10 years were given these forms by their teachers, as we do not have any contact details of students or their parents. We are sending you this statement to explain the study to you and to seek your permission for your and your child's involvement in the study.

Details of the research:

The project is divided into two parts, the first to identify some functional and behavioural factors that may contribute to increased crash risk, and the second to assess the effectiveness of a training program to improve road-crossing skills. Details of the research components are:

Part I: Children will be asked to undertake a battery of tests to identify functional and behavioural performance that may be related to poor pedestrian performance. These tests include the Children's Colour Trails Test, the Tower of London test, and the Motor-Free

Visual Perception Test. In addition, parents will be asked to complete a traffic and road safety questionnaire and the Conners' Rating Scale. All children will also be asked to make road-crossing decisions in a simulated pedestrian road-crossing task. This will involve children using a computer and pressing buttons to make choices such as those s/he would make when crossing the road.

Children will complete these tasks over two sessions, approximately one week apart, each requiring approximately 30-45 minutes each. All tasks can be conducted during school hours on any day that suits the school curriculum. Parents will be given consent forms for their child's involvement and asked to complete the questionnaire at home and at a time convenient to them. It is expected that the questionnaire will take approximately 20 minutes to complete.

Part II: This component aims to examine the effectiveness of training and feedback on pedestrian performance. Children will be randomly selected to receive practice, training and feedback or not. For those selected to receive training, they will view the simulated road-crossing environment again (requiring approximately 45 minutes). Those not selected for training will view a video or other appropriate activity that does not contain a road safety message (taking approximately 30 minutes). Both groups will make road-crossing decisions in the simulated road-crossing environment twice again at two separate time points (approximately one month apart). These sessions will require an additional 30 minutes at each time point. Children in the group who did not receive the training as part of this study will be offered the training at the end of the study. Again, all tasks can be conducted during school hours on any day that suits the school curriculum.

Confidentiality

The information we will collect from you and your child is for research purposes only and will be treated with the utmost confidentiality. All data will be coded and participants will be identified only by number, and not name, on the database. Your name and your child's name will only appear on the informed consent form, and contact details will be stored separately from other details. Only the researchers will have access to your data, which will be stored in locked filing cabinets in secure offices at MUARC. In accordance with University regulations, data must be stored for a minimum of five years. After this period, all data will be permanently destroyed. No findings which could identify any individual participant will be published.

There is no financial reward offered for participation in this project. You and you child are free to decide whether or not to participate in this study, and you can withdraw your consent at any time by filling in the Revocation of Consent Form, which is attached, and sending to me. Neither your child nor you will be disadvantaged as a result of withdrawing.

Findings of the study

Only group findings will be reported and these will be made available to the sponsors of the project in the form of a report and conference papers and journal articles may also arise from this research project.

Due to the nature of some of these tests, it MAY be discovered that your child displays certain behaviours which you and your child's teachers may not have already identified. You may wish to be informed of your child's test outcome and can indicate on the consent for whether or not you prefer to be informed of the outcome of your child's assessment. In any event, the general implications of performance for safe road-crossing will be discussed with all children and parents. We can also provide you with further testing options for your child and relevant services which may be able to assist.

If both you and your child agree to participate in the study, please sign and return the Consent Form to your child's teacher in the sealed envelope provided. Please keep this explanatory statement for your reference.

Should you have any complaint concerning the manner in which this research ***<insert your project number>*** *is conducted, please do not hesitate to contact the Monash University Standing Committee on Ethics in Research Involving Humans at the following address:*

The Secretary
The Standing Committee on Ethics in Research Involving Humans (SCERH)
Building 3D
Research Grants & Ethics Branch
Monash University VIC 3800
Tel: +61 3 9905 2052 Fax: +61 3 9905 1420 Email: scerh@adm.monash.edu.au

If you have any questions regarding this study please contact Dr Jennie Oxley on (03) 9905-4374 or Jennie.Oxley@muarc.monash.edu.au.

Yours Sincerely,

Dr Jennifer Oxley
Senior Research Fellow
Monash University Accident Research Centre

Consent Form – Parent

Child pedestrians: Factors associated with ability to cross roads safely and development of a training package.

I agree that that I, and my child, for whom I am parent/guardian, may take part in the above Monash University research project. The project has been explained to me in the Letter of Invitation/Explanatory Statement, which I will keep for my records.

I understand that agreeing to take part in the project means that I am willing to allow my child to undertake the following tasks:

- Complete assessments designed to measure functional performance and behaviour, and
- Complete simulated road-crossing tasks.

I understand that my child's participation in this study also requires my completion of a short questionnaire, which I have completed and returned with this consent form.

I understand that any information my child and I provide is confidential, and that no information that could lead to the identification of my child will be disclosed in any reports on the project, or to any other party. I also understand that our participation is voluntary, that my child and/or I can choose not to participate in part or all of the project, and that my child and/or I can withdraw at any stage of the project without being penalised or disadvantaged in any way.

I understand that I can indicate whether I prefer to be informed of my child's test performance. I, therefore,

❒ DO ❒ DO NOT

wish to be informed of the outcome of my child's assessment.

I have been informed that only group results will be reported in all publications and will be available from the Monash University Accident Research Centre upon request, once the study has been completed.

I have also been informed that the information collected will be stored in a secure location at the Monash University Accident Research Centre for a minimum of seven years, as required by Monash University regulations.

Participant's Name (please print): ....………

Participant's Age:......................years………………months

Parent's/Guardian's Name (please print): ....

Your relationship to participant (parent or legal guardian):...

Signature..…………………………………………..Date: ...……../…………

Please return the completed Consent Form and background questionnaire in the envelope provided to your child's teacher

REVOCATION OF CONSENT – PARENT

Child pedestrians: Factors associated with ability to cross roads safely and development of a training package.

I hereby wish to withdraw my consent for myself and my child to participate in the research project named above and understand that such withdrawal will not have any consequences for me or my child.

Participant's Name (please print): ....…..…………

Parent's/Guardian's Name (please print): ....

Signature..……………………………………………………..Date: ...……../…………

Appendix C

Child pedestrians: Factors associated with ability to cross roads safely and development of a training package.

Thank you for participating in this research.
Please return this form to your child's teacher.

Please read each question carefully and place a tick in the appropriate box. If you make a mistake, just cross it out and place a tick in the correct box.

Section A: Demographics

1. *How old is your child? ____years _____months*
2. *What gender is your child? __________*
3. *Does your child have any siblings?*

   ❑ *Yes*

   ❑ *No*

   If yes, could you please indicate the gender and age of each child.

Sibling 1:	*Age______*	*Gender________*
Sibling 2:	*Age______*	*Gender________*
Sibling 3:	*Age______*	*Gender________*
Sibling 4:	*Age______*	*Gender________*

Section B: Exposure to traffic

4. *Listed below are some common forms of transport that your child may use to get to school. Please indicate how often your child uses each form of transport to get to and from school?*

❑ *Car driven by parent/guardian*

❑ *Always*	❑ *Sometimes*
❑ *Almost always*	❑ *Occasionally*
❑ *Often*	❑ *Never*

b. *Car driven by other person*

❑ *Always*	❑ *Sometimes*
❑ *Almost always*	❑ *Occasionally*
❑ *Often*	❑ *Never*

c. School bus

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

d. Public bus

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

e. Train

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

f. Bicycle

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

g. Walks supervised by parent/guardian

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

h. Walks supervised by other adult

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

i. Walks unsupervised by adult, but with friend or sibling

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

j. Walks unsupervised

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

k. Other, pleases specify …………………………………

- ❑ *Always*
- ❑ *Almost always*
- ❑ *Often*
- ❑ *Sometimes*
- ❑ *Occasionally*
- ❑ *Never*

5. *Does your child regularly walk supervised by an adult to a destination other than school (e.g. milk bar, sporting activity, friends house)?*

- ❑ *Yes*
- ❑ *No*

If yes how often?

- ❑ *Daily or almost daily*
- ❑ *3-4 times a week*
- ❑ *Weekly*
- ❑ *Fortnightly*
- ❑ *Monthly*
- ❑ *Less than monthly*

6. *Does your child regularly walk unsupervised by an adult to a destination other than school (e.g. milk bar, sporting activity, friends house)?*

- ❑ *Yes*
- ❑ *No*

If yes how often?

- ❑ *Daily or almost daily*
- ❑ *3-4 times a week*
- ❑ *Weekly*
- ❑ *Fortnightly*
- ❑ *Monthly*
- ❑ *Less than monthly*

7. *How often in the last month has your child played in your front yard, or a neighbour's front yard?*

- ❑ *Daily or almost daily*
- ❑ *3-4 times a week*
- ❑ *Weekly*
- ❑ *Fortnightly*
- ❑ *Monthly*
- ❑ *Never*

8. *How often in the last month has your child played in your street?*

- ❑ *Daily or almost daily*
- ❑ *3-4 times a week*
- ❑ *Weekly*
- ❑ *Fortnightly*
- ❑ *Monthly*
- ❑ *Never*

9. *How much traffic is there on your street?*

- ❑ *A lot of traffic*
- ❑ *Some traffic*
- ❑ *A little traffic*
- ❑ *Hardly any traffic*

Section C: Road safety practices

10. *Have you taught your child to cross the road at a zebra crossing?*

- ❑ *Yes,* if yes please explain how you taught your child
- ❑ *No,* if no please give reasons

____

____

____

____

____

____

11. *Have you taught your child to cross the road where there are lights?*

- ❑ *Yes,* if yes please explain how you taught your child
- ❑ *No,* if no please give reasons

____

____

____

____

____

____

12. *Have you taught your child to cross the road where there are crossing guards present?*

- ❑ *Yes*
- ❑ *No*

13. *Have you taught your child to look both ways before crossing the road?*

- ❑ *Yes*
- ❑ *No*

14. *Does your child always hold your hand, or another adult's hand, when crossing the road?*

- ❑ *Yes*
- ❑ *No*

15. *How important do you think it is to teach your child how to safely cross the road at his/her current age?*

- ❑ *Very important*
- ❑ *Somewhat important*
- ❑ *Somewhat unimportant*
- ❑ *Very unimportant*

16. *How would you rate your child's ability to safely cross the road compared to other children the same age?*

- ❑ *Significantly better than average*
- ❑ *Better than average*
- ❑ *About average*
- ❑ *Worse than average*
- ❑ *Significantly worse than average*

THANK YOU AGAIN FOR PARTICIPATING
IN THIS RESEARCH.

This questionnaire will provide valuable information on travel patterns, activities and behaviours of child pedestrians and will assist us in developing programs for child pedestrian safety.