Identifying 'at-risk' child pedestrians and improving their road crossing skills

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Crashes involving pedestrians are severe in nature. The safety of child pedestrians is of particular concern, given that a sizeable proportion of pedestrian trauma involves children. Behaviour is thought to play a major role in crash involvement, however, very little is known about the roles of specific functional and behavioural factors that may affect road-crossing decisions. Moreover, while there are a number of road safety educational programs available in Australian States and Territories, there may be some scope for improvement, e.g., better translation of knowledge to improved performance, and provision of training programs that are practical and specifically tailored fore those most at risk. This paper presents the findings of a two-phased study that examined the factors that may increase pedestrian crash risk amongst 6-10 year old children, identified 'at-risk' children and developed and evaluated a practical and innovative educational and training program using an interactive simulator program. The findings suggest that 'at-risk' groups include younger children, those who have poor perception, attentional and cognitive skills, hyperactive, inattentive and easily distracted children, and those with little traffic exposure. A beneficial effect of the training program on proportion of critically incorrect crossing responses was found, particularly amongst 'at-risk' children. The results show that the training program is a safe and effective way to improve children's road-crossing skills.

Introduction

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. However, crashes involving pedestrians are severe and pedestrian safety is a serious community concern. Pedestrian trauma makes up about 14 percent of all road fatalities in Australia. Two hundred and twenty seven pedestrians were killed in 2006 and over 2,500 were seriously injured on Australia's roads in 2004. Children under the age of 16 constitute a substantial proportion of pedestrian deaths (13%) and a larger proportion of serious injuries (21%) (ATSB, 2007). Research suggests that younger children (between the ages of 6 and 10, and especially males) are at high risk of death and injury (LTSA, 2000), with an estimated minimum four times the risk of collision compared with adult pedestrians (Struik Alexander, Cave, Fleming, Lyttle & Stone, 1988; Thomson, 1996). Moreover, pedestrian crashes are widely regarded as the most serious of all health risks facing children in developed countries (Malek, Guyer & Lescohier, 1990; Thomson, Tolmie, Foot & McLaren, 1996).

Making the decision about when it is safe to cross the road in relation to available gaps in the traffic is a complex task. 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). 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 (Tabibi & Pfeffer, 2003; Zeedyk, Wallace and Spry, 2002; Simpson, Johnston & Richardson, 2003). While it is suggested that 'at-risk' groups may include younger children, those who have poor risk perception and therefore likely to take high risks, or hyperactive, impulsive, inattentive and easily distracted children, little is known about the functional and behavioural factors that may affect road crossing decisions.

Given that behavioural factors play a large role in traffic safety, promotion, education and training of safe walking practices have long been advocated as a means of promoting a healthy lifestyle and teaching children the critical road safety skills and behaviour to be able to interact with traffic safely. In recent years, there has been a major push to promote safe walking and cycling in urban areas, particularly in Europe and in Australia (Dijkstra, Levelt, Thomsen, et al., 1998; Victorian Government 2006) and 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.

There are road safety educational programs for children available in Australia and overseas, 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. Indeed, concerns have been raised regarding their effectiveness. 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. Of particular concern is the argument that young children's ability to apply their knowledge to safer performance or improved behaviour is poor, and that transfer is not automatic (Zeedyk, Wallace, Carcary, Jones & Larter, 2001; Ampofo-Boateng & Thomson, 1991; Rothengatter, 1981). Furthermore, education may produce negative effects in that the increased knowledge that children exhibit can create a false sense of confidence amongst parents and children that their ability to interact with traffic is improving.

It is also suggested that many education and training programs are only moderately successful because these programs generally treat each child the same (Hoffrage, Weber, Hertwig & Chase, 2003). Rather, it is argued that training programs should be specifically tailored for and allocated to those who are most in need of training, i.e., 'high-risk' children. However, there 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.

This paper provides an overview of a study that aimed to investigate the impacts of functional performance, behaviour, age and gender, and travel patterns and exposure to traffic on road-crossing skill amongst primary school children and to use this information to develop and evaluate a targeted educational and training package to teach young children appropriate road-crossing skills.

Method

A two-phase study was undertaken. The first component examined the functional and behavioural factors that are associated with poor gap selection amongst primary school children to identify those at higher risk of crash involvement. The second component aimed to develop a practical training program and evaluate it in terms of its effectiveness in developing relevant functional and behavioural skills required to make safe and appropriate gap selection of oncoming traffic.

Phase 1: Identifying contributing factors to poor gap selection

Participants: Seventy-one children (35 males and 36 females) and their parents participated in the study. Children were aged between 6 and 10 years (13 six year olds, 14 seven year olds, 15 eight year olds, 15 nine year olds and 14 ten year olds) and were recruited through five randomly selected government primary schools in the Melbourne metropolitan area. Parents provided informed consent for their participation and their child's participation.

Simulated road-crossing environment: Simulated traffic scenes generated from a mid-range driving simulator were used to elicit road-crossing responses. All scenes 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 approaching vehicles travelling from the right-hand side (near-side lane in Australia). No approaching traffic was visible 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 traffic scenes was shown three times, therefore each participant viewed a total of 45 scenes presented in random order. Traffic scenes were projected onto a large white screen.

Participants were seated at a desk in a darkened quiet room approximately 2m in front of a projection screen and with a computer keyboard placed in front of them. Practice trials were provided where the experimenter demonstrated the simulator task verbally and trials were given until participants indicated that they fully understood the task. Each participant was instructed to look at the traffic scene and, as soon as they heard a buzzer (sounded when the first approaching vehicle passed the point of crossing and which activated a timer), to indicate whether or not they would 'cross' in front of the second vehicle, responding as quickly as possible using the 'J' or 'D' keys labelled 'YES' and 'NO' respectively. 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.

Functional performance measures: Participants also completed a battery of neuropsychological tests designed to assess cognitive, perceptual, attentional and executive functioning. In addition, parents completed a rating scale of their child's attentional behaviour. The assessments are outlined below:

Tower **o**f **L**ondon [TOL] (Culbertson & Zillmer, 1998): measures higher order problem-solving ability, evaluates attention disorders and executive functioning difficulties.

Children's Colour Trails Tests, Parts I & II (Llorente, Williams, Satz & D'Elia, 2003): measures visual search, sustained attention, sequencing, and other executive functions.

Motor-**F**ree **V**isual **P**erception **T**est, Version 3 [MVPT-3] (Colarusso & Hammill, 2003): assesses an individual's visual-perceptual ability with no motor involvement needed to make a response.

Connors' Parent Rating Scale (Connors, 1997): completed by a parent about their child and assesses conduct, cognitive, anxiety and social problems and attention-deficit/hyperactivity disorders.

Walking time over a distance equivalent to the width of an average road lane (5.6m) at two walking paces (normal and fast) was also measured.

Parent survey: Parents of children in the study completed a questionnaire is designed to gather 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.

Analysis of the data was undertaken using preliminary bi-variate tests and employing hierarchical logistic regression modelling to examine the impacts of age and gender, functional performance and traffic exposure on road-crossing responses.

Phase 2: Development and evaluation of training program

Participants: Children who took part in the first phase of the study took part in the training sessions, approximately 4-6 months later. Training was conducted using a case-control study design. Children were randomly selected for the training group (cases, n=36) or non-training group (controls, n=35). Participants were selected in order to allow roughly equal numbers of children at each age and within each school for training purposes. The two groups were matched on age, gender and analyses revealed there were no significant differences between groups on age, gender and functional measures.

Training sessions: The training group underwent two training sessions on two consecutive days. Training was designed to i) teach children how to identify traffic gaps that are sufficiently large to permit safe crossing, ii) to differentiate these from gaps that are too small, iii) to incorporate their walking speed into their 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) to minimize the effects of distractors in the environment. Extensive practice, familiarity and feedback was provided throughout the training sessions and training was conducted in small groups (6-8 children per group).

All participants in the control group undertook a separate activity on fire safety that did not have a road safety message. At the end of the study all control group participants were offered the training sessions.

Post-training testing was undertaken in two sessions. Nine children (cases, n=2; controls, n=7) were not available to be re-tested after training. All remaining participants (cases, n=34; controls, n=29) viewed traffic scenarios using the simulated road-crossing task as in phase 1 and asked to make the same road-crossing responses as before (i.e., indicate whether or not they would have crossed in front of the second approaching vehicle). The first post-training session was conducted approximately one week after training and the second approximately one-month after training.

Analysis of the data was undertaken using preliminary bi-variate tests and employing nominal logistic regression modelling to examine the effect of training on road-crossing responses.

Results: Phase 1

Road-crossing decisions: Road-crossing decisions were analysed in terms of simple yes/no responses and in the context of whether the response was a correct (safe) or incorrect (unsafe or missed opportunity) decision, based on average walking speed and characteristic of the scene (i.e. time gap and vehicle speed). Safety rating responses closely resembled the yes/no crossing decision and are therefore not reported here.

Figure 1 shows the proportion of positive crossing responses by vehicle condition for age group (gender is not shown as there were no significant differences).

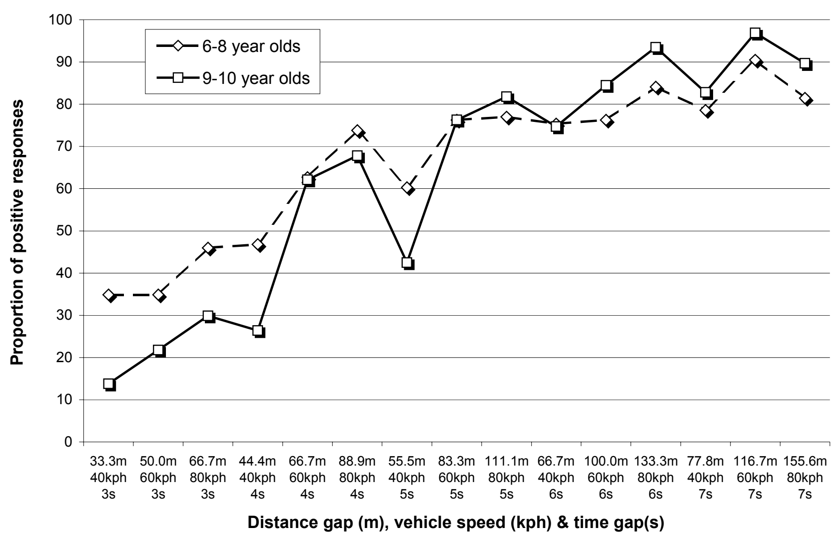


Figure 1 – Proportion of ‘yes’ responses as a function of age group, vehicle speed, time gap and distance gap.

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, some group differences were apparent. For example, the younger group as more likely than the older group to indicate that they would cross the road in short time gaps. Indeed, a large proportion of younger children (52%) indicated that they would have crossed the road in a three second time gap (for all vehicle speeds), even though most of the children required longer than three seconds to walk the distance of the carriageway even at their fastest pace. On average, 6-7 year olds took 5.3 secs to walk the distance of an average lane width at a normal walking pace and 3.65 secs at a fast walking pace. In comparison, only 9 percent of older children indicated that they would have crossed in these traffic conditions. On average 8-10 year olds took 5.0 secs to walk the same distance at a normal walking pace and 3.2 secs at a fast walking pace.

Figure 1 also indicates that distance, not time gap was a strong determinant of crossing decision for both groups of children. Vehicle speed was also taken into account, but to a lesser extent. For instance, for the three 4 sec time gap conditions the proportion of positive responses increased for both groups as the distance gap increased. For the younger group, 74 percent indicated that they would have crossed in the higher vehicle speed condition (80kph), compared with 47 percent in the lower vehicle speed condition (40kph). This was even more pronounced in the older group, with 68 percent responding positively in the higher vehicle speed condition and only 26 percent in the lower vehicle speed condition.

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. Responses were scored in one of four possible categories, taking into account fast walking speeds: correct acceptance (safe), correct rejection (safe), incorrect acceptance (unsafe), incorrect rejection (missed opportunity). The fastest walking speed was chosen over normal walking speed because, as in real life situations, any pedestrian is likely to increase their walking speed if a vehicle is quickly approaching. The proportions of responses by age group are shown in Table 2.

Table 2 – Proportion of correct and incorrect responses by age

	Correct acceptance	**Incorrect acceptance**	**Correct rejection**	**Incorrect rejection**
6 year olds	295 (52.0%)	99 (17.5%)	56 (9.9%)	117 (20.6%)
7 year olds	341 (55.2%)	47 (7.6%)	74 (12.0%)	156 (25.2%)
8 year olds	434 (66.2%)	42 (6.4%)	67 (10.2%)	113 (17.2%)
9 year olds	395 (59.0%)	32 (4.8%)	64 (9.6%)	178 (26.6%)
10 year olds	377 (61.1%)	16 (2.6%)	43 (7.0%)	181 (29.3%)
Total	**1842 (58.9%)**	**236 (7.5%)**	**304 (9.7%)**	**745 (23.8%)**

Approximately 60 percent of participants indicated that they would have crossed when it was safe to do so. However, the most important response to examine here is an incorrect acceptance, as this response would have resulted in a collision, or the driver needing to take aversive action to avoid a collision in a real-world situation, had a child decided to cross the road with a time gap shorter than their fastest walking speed. Younger children were more likely than older children to have indicated that they would have crossed in these risky conditions. A regression model revealed that age, time gap, and vehicle speed were significant predictors of crossing responses: age, $\chi^2(4) = 119.62$, $p<0.001$; time gap, $\chi^2(1) = 415.43$, $p<0.001$; vehicle speed, $\chi^2(1) = 6.67$, $p<0.01$. Six year old children were 11.96 times more likely to make a critically incorrect decision than 10 year old children, $p<0.001$, with an average of 8.25 critical errors per 6 year old participant compared with an average of 1.33 critical errors per 10 year old participant. Gender was not a significant predictor.

Functional performance: Mean scores on tests of functional performance by age group were calculated and compared between young children (6-8 years) and older children (9-10 years). In general, the older children performed significantly better than the younger children, particularly on the Tower of London test ($p<0.05$) and both the Trails tests (p's<0.001). Older children were also less likely to have rated highly on two of the Connors Rating Scale components (the oppositional and hyperactivity scores) (p's<0.05). Significant correlations were found between the MVPT and the Trails tests, and all Connors Rating Scale components.

Traffic exposure: Parents provided information on traffic exposure and behaviour, particularly in terms of frequency and quality of supervised walking undertaken by their child (who supervised and whether they held their hand while crossing the road), and frequency of playing in the street. The majority of younger children never walked unsupervised, compared with older children (88% vs. 72%). Older children were more likely than younger children to report occasionally or sometimes walking unsupervised, $\chi^2(4) = 8.10$, $p = 0.08$.

Some other group differences with regard to amount of road crossing education were also noted. Older children were more likely to have been taught to cross at signalised crossings compared with younger children (100% vs 85%), $\chi^2(1) = 4.29$, $p < 0.05$. Older children were also more likely to not hold their parent's hand while crossing, compared with younger children, $\chi^2(1) = 7.99$, $p < 0.01$.

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. No group differences were noted here – almost all parents indicated that they had taught their children to cross where there are lights (younger children: 85%; older children: 100%), where crossing guards are present (younger children: 85%; older children, 85%), cross at zebra crossings (younger children: 74%; older children, 85%), and to look 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%).

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 raw score; Connors Rating raw scores (all four components); independent travel exposure (high or low); and 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 resulted from these analyses is summarised in Table 5. This model indicates that vehicle factors, predicted responses, particularly time gap. Not surprisingly, as time gap increased, the likelihood of a critically incorrect response decreased.

Table 5 – 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. Children who seldomly walked independently were 2.4 times more likely than those who frequently walked independently to have made critically incorrect responses. Furthermore, 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.

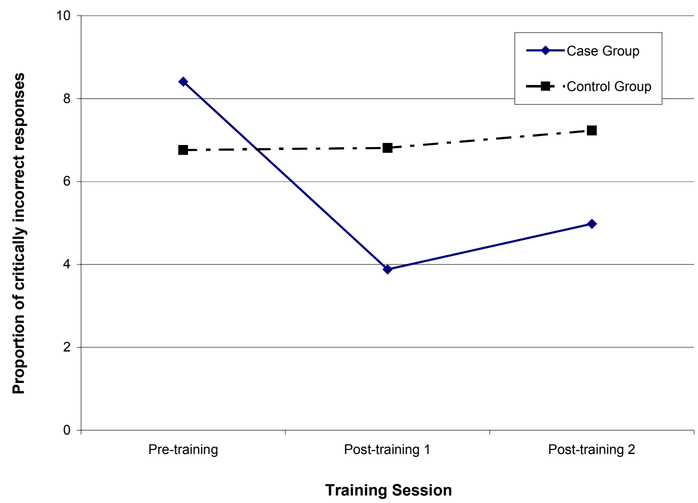
Results: Phase 2

Multiple regression analysis was used to examine the impact of training on road crossing skills using critically incorrect responses as the outcome measure.

An initial overall comparison of critically incorrect responses of case and control participants revealed significant differences between pre-training and post-training responses. Figure 2 shows the proportions of critically incorrect responses in pre-training, one-week post-training and one-month post-training by training group. The analysis showed statistically significant reductions in critically incorrect responses one-week post-training (56%; $\chi^2(1)=13.33$, $p< 0.001$, CI=0.28-0.68) and one-month post-training (47%;

$\chi^2(1)=8.43$, $p< 0.01$, CI=0.35-0.81), compared to responses prior to training, and relative to any changes in the control group.

Figure 2: Proportions of critically incorrect responses by training



session and training group

In order to examine the effectiveness of training amongst 'at-risk' groups, a series of subsequent regression analyses were undertaken on variables identified as 'risk' factors, i.e., age group, gender, functional performance and traffic exposure. For the majority of variables, there were significant beneficial effects of training. Figure 3 shows the proportions of critically incorrect responses by training session and age group.

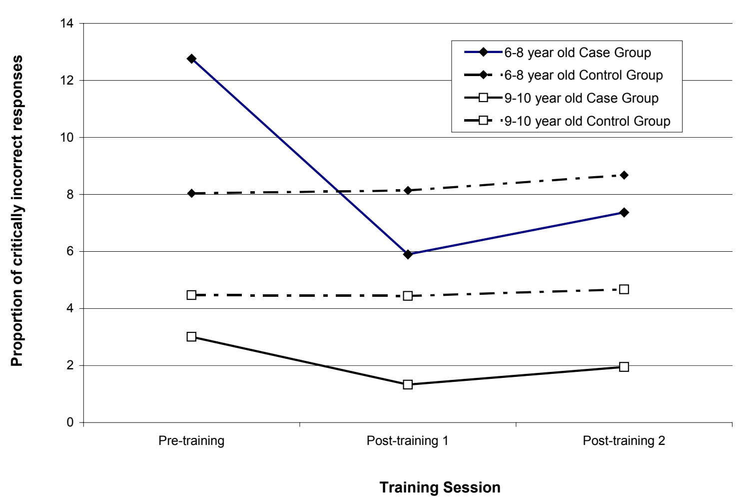


Figure 3: Proportions of critically incorrect responses by training session and training group

While the proportions of critically incorrect responses improved one-week post-training and one-month post-training for both younger and older case groups compared with pre-training responses, the responses of the younger group improved significantly more than that of the older group, suggesting that younger children received more benefits than older children from the training program. The analysis showed statistically significant reductions in critically incorrect responses amongst the young group one-week post-training (58%;$\chi^2(1)=11.23$, $p<0.001$, CI=0.26-0.70) and one-month post-training (50%; $\chi^2(1)=7.82$, $p<0.01$, CI=0.31-0.81), compared to responses prior to training, and relative to any changes in the young control group. For the older group, while there were reductions in critically incorrect responses one-week post-training (56%) and one-month post-training (39%), compared with pre-training responses, these reductions were not significant.

Likewise, statistically significant reductions in critically incorrect responses amongst females were found compared to responses prior to training and relative to any changes in females in the control group (67% one-week post-training, $\chi^2(1)=10.89$, $p<0.01$; CI=0.17-0.64; 60% one-month post-training, $\chi^2(1)=7.67$, $p<0.01$, CI=0.21-0.76). While responses of males showed reductions as a result of training session (43% one-week post-training and 35% one-month post-training), these were not significant.

With regard to functional performance measures, there were some mixed results. Children who scored more poorly on the Colour Trails Parts 1 & 2, the MVPT and the Connors Hyperactivity test appeared to benefit more from training than children who performed better on these tests. Statistically significant reductions in 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 1: 13% reduction per 10-unit score increase one-week post training, $\chi^2(1)=7.77$, $p<0.01$; CI=0.79-0.96; 9% 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 2: 8% reduction per 10-unit score increase one-week post training, $\chi^2(1)=12.84$, $p<0.001$; CI=0.88-0.96; 6% reduction per 10-unit score increase one-month post training, $\chi^2(1)=6.49$, $p<0.05$, CI=0.90-0.99

MVPT: 13% reduction per 5-unit score increase one-week post training, $\chi^2(1)=14.40$, $p<0.001$; CI=0.81-0.93; 11% reduction per 5-unit score increase one-month post training, $\chi^2(1)=10.18$, $p<0.01$, CI=0.83-0.96

Connors Hyperactivity test: 14% reduction per unit score increase one-week post training, $\chi^2(1)=9.28$, $p<0.01$; CI=0.78-0.95; 10% reduction per unit score increase one-month post training, $\chi^2(1)=5.45$, $p<0.05$, CI=0.81-0.98

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 20% in critically incorrect responses per 10-unit score increase one-week post-training was found, $\chi^2(1)=14.94$, $p<0.001$; CI=0.98-0.99. A reduction of 10% 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=0.99-0.99.

Interestingly, children who engaged in independent travel less frequently were more likely to benefit from training than children who engaged in independent travel more frequently. Statistically significant reductions in critically incorrect responses were found amongst infrequent independent travellers one-week post-training (59%; $\chi^2(1)=13.62$, $p<0.001$, CI=0.25-0.65) and one-month post-training (50%; $\chi^2(1)=8.85$, $p<0.01$, CI=0.32-0.79), compared to pre-training responses, and relative to the control group. Reductions in critically incorrect responses amongst frequent independent travellers one-week and one-month post-training compared with pre-training were not significant.

Discussion

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 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.

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.

Of particular interest in this study were the analyses of critically incorrect responses. 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. These children were generally younger – age was a strong predictor of critically incorrect decision, with six year olds almost 12 times more likely than 10 year olds to indicate that they would have crossed when they should have said 'no'.

Moreover, 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.

Most importantly, however, this study also 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 show 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.

Conclusions

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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