Crossing roads safely: The effects of training on improving children's road crossing decisions

Melinda Congiu, Michelle Whelan, Jennifer Oxley, Angelo D'Elia, Judith Charlton & Brian Fildes.

Abstract

Pedestrian crashes are among the most common causes of death and serious injury to young children in the developed world. An initial phase of our research showed that younger children (6-7 year olds) and those with poor or under-developed functional skills may be at higher risk of crash involvement, compared with older children with well developed skills. While education is considered an essential tool to teach children road safety skills, current programs may be limited because they may not target specific skills and are not tailored for those who are most in need of training. A practical education and training program using a simulated road environment was developed that aimed at improving road-crossing skills amongst children most at risk. The training provided intensive positive and negative feedback on road-crossing choices and focussed on identification of safe traffic gaps, and assessing time gap rather than distance or speed alone when making crossing judgements. The effectiveness of the training package was assessed using a case-control study design, and compared road-crossing responses prior to, immediately after, and approximately one month after training. The findings showed significant reductions in critically incorrect responses (where a child decided to cross but the time gap was too small for a safe crossing) immediately after training (56%) and one month after training (47%) by the case group (n=34), compared to responses prior to training, and relative to any changes in the control group (n=28). The results show that the training program is a safe and effective way to improve children's road-crossing skills.

Crashes involving pedestrians are severe in nature and pedestrian safety is a serious community concern. Two hundred and twenty seven pedestrians were killed Australia-wide between January 2006 and December 2006 and over 2,500 sustained serious injuries as pedestrians in 2002. Children under the age of 16 years constituted a substantial proportion of pedestrian deaths (9%) and a larger proportion of serious injuries (21%) (Australian Transport Safety Bureau, 2007). 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 (Struik, Alexander, Cave, Fleming, Lyttle & Stone, 1988; Thomson, 1996). This is most likely due to the beginning of independent unsupervised travel 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. This task 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). Further, 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.

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. Researchers have examined the effectiveness of training children in a variety of road safety skills such as the ability to identify safe and dangerous places to cross, road-crossing safety behaviours (e.g. looking both ways before crossing), and the ability to detect relevant road-crossing features in order to make safe road crossing decisions (Young & Lee, 1987; Zeedyk, Wallace, Carcary, Jones, & Larter, 2001; Miller, Austin, & Rohn, 2004; Tolmie, Thomson, Foot, Whelan, Morrison, & McLaren, 2005). The effectiveness of these training programs are varied, with some showing significant and long lasting improvements, while others have only shown minimal effectiveness.

Some researchers have investigated the potential benefits of training road-crossing skills amongst children 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). Thomson et al (2005) examined the influence of virtual reality training on the roadside crossing judgements of child pedestrians. They found that the trained children crossed more quickly, 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. Other studies have found that simulator training packages have improved children's ability to identify dangerous vehicles (Glang et al, 2005), and improved their ability to predict drivers' intentions (Foot et al, 2006). However, post-testing in these two studies occurred immediately after training (Glang et al, 2005) or one-week after training (Foot et al, 2006) with no longer term follow-up to see if the results would be maintained.

There are a number of road safety educational programs currently available in Australian States and Territories (e.g. 'RoadSmart', and 'Safe Routes to School'), 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. 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, et al, 2001; Ampofo-Boateng & Thomson, 1991; Rothengatter, 1981). It has also been suggested that the design of training programs could be improved by developing more practical programs that provide the opportunity to develop skills

rather than knowledge alone. Computer simulation programs offer a safe environment to learn practical road crossing skills (Foot et al, 2006).

The aim of this study was to develop and evaluate a training package which incorporated a computer simulator to teach children road safety skills, particularly selecting safe gaps in traffic in which to cross the road. It was part of a larger study that also examined the behavioural and functional factors associated with the ability to select safe gaps in traffic.

Method

Participants

Seventy-one children participated in the study, comprising 35 males and 36 females. 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) and were recruited through five randomly selected government primary schools in the Melbourne Metropolitan area. Children were randomly assigned to 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. Nine children (case group, n=2; control group, n=7) were unavailable for re-testing after the training program and these children were excluded from the analysis.

Simulated Road Environment

Simulated traffic scenes that were generated from data files from a mid-range driving simulator were used in this study (Figure 1). 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 vehicles travelling from the right-hand side (near-side lane). There was no traffic in the far-side lane.

For the pre and post-testing, 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 presented in a random order). Simulated traffic scenes were projected onto a large white screen.

For the first training session there were 16 different simulator scenes shown. Feedback was provided via the simulator after every scene with the following images: If the scene depicted a safe crossing gap (based on a six or seven second time gap), the simulator showed a cartoon character safely crossing the road and jumping for joy once reaching the other side; for an unsafe crossing gap (a three or four second time gap), the scene froze and a 'splat' symbol was shown. In the

second training session there were 24 simulator scenes. These simulator scenes contained three different distractors: a ball bouncing across the road, a person waving from the other side of the road, or a car horn beeping. The same feedback was shown for safe and unsafe crossing gaps.

Figure 1:   Stimulus traffic scenarios presented in the road-crossing simulation

Objectives of the training program

The main objectives of the training package were (1) to teach children how to identify traffic gaps that are sufficiently large to permit safe crossing, (2) to differentiate these from gaps that are too small (3) to incorporate their walking speed into the decision, (4) to teach children to focus on time rather than distance or speed per se when making judgements about the safety of traffic gaps and (5) to minimise the effects of distractors in the environment (adapted from Tolmie, Thomson, Foot, Whelan, Sarvary, & Morrison, 2002).

Procedure

Pre and Post-Testing Procedure
Participants were seated at a desk approximately 2m in front of the projection screen with a computer keyboard placed in front of them. Instructions were given verbally, and the experimenter also demonstrated the simulator task to the child. Participants were instructed that a buzzer would sound when the first vehicle passed the point of crossing. Participants were instructed to look 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, responding as quickly as possible by 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.

At the pre-test session, walking time over a distance equivalent to the width of an average road lane (5.6m) at two walking paces (normal and fast) was measured. In addition, a battery of neuropsychological and behavioural assessment tools was also administered as part of a larger study.

Approximately 6-8 months after the pre-training testing, researchers returned to the participating primary schools to conduct the training sessions. The first post-training testing session occurred within a few days of the training program, and the second post-training session was conducted approximately 1 month after the training program.

Training procedure

Two training sessions were conducted on consecutive days. Training session one began with a brief discussion on what factors are important in crossing the road. Next, the researchers demonstrated that cars can be travelling at different speeds which will affect their time of arrival by using two matchbox cars on a play mat. Children were instructed to count claps whilst the cars were 'driving' on the road. Several different scenarios were depicted, for example; two cars, both starting from the same starting position, but one car reached the end point in three claps but the second car required six claps to reach the end point.

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. The participants then had turns in crossing a 'pretend 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. The simulator was paused after every scene for the children to discuss their responses. The scene was then played again to show the outcome of the crossing decision. Once again, the simulator was paused to allow for further discussion and for the trainers to provide feedback. 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 used the simulator scenes containing distractors. The trainers did not advise the children of the distractors before the first scene was shown. After the first scene was shown, the presence of the distractor was raised, and children were questioned over its relevance on their road-crossing decisions. The aim of this was to have the children focus solely on the cars and the road-crossing task, and not any other information that may be a distraction. At the end of both training sessions, 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."

Children in the control group participated in a separate activity on fire safety. This was developed utilising resources from the Country Fire Authority (www.cfa.vic.gov.au). At the end of the study all control group participants were offered the training program.

RESULTS

Children's responses to the road-crossing scenes 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). Of interest to this study is the effect of training on critically incorrect responses, where a child decided to cross but the time gap was too small for a safe crossing. Table 1 shows the proportion of correct and incorrect responses by age group prior to training.

Table 2:   **Proportion of correct and incorrect responses by age prior to training**

	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%)**

Logistic regression analysis was then used to examine the impact of training on road crossing skills using critically incorrect responses 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 2 shows the proportions of critically incorrect responses between pre-training, immediately post-training and one-month post-training by case and control group. The analysis showed statistically significant reductions in critically incorrect responses immediately after training (56%; $\chi^2(1)=13.33$, $p<0.001$, CI=0.28-0.68) and one month after 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.
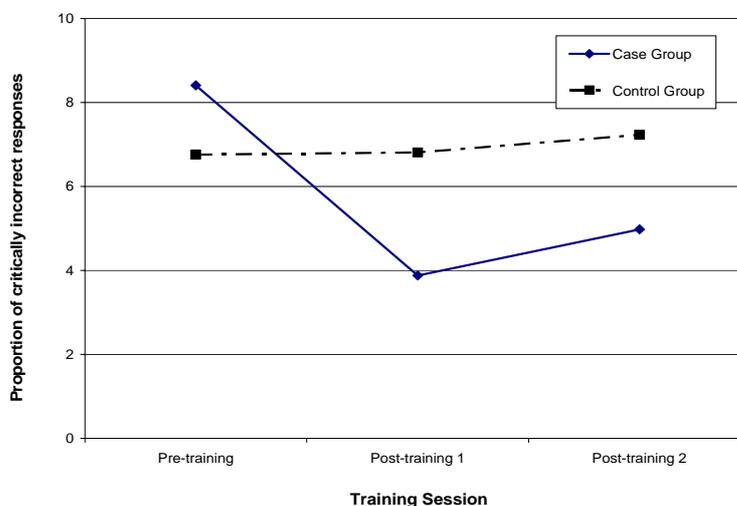
Figure 2: Proportions of critically incorrect responses by training session and training group

In order to examine which children benefited the most from the training, further regression analyses were undertaken. Figure 3 shows the proportion of critically incorrect responses by training session and age group. The results showed that younger children (6-8 years) had a significant reduction in critically incorrect responses immediately after training (58%; $\chi^2(1)=11.23$, $p<0.001$, CI=0.26-0.70) and one month after training (50% $\chi^2(1)=7.82$, $p<0.01$, CI=0.31-0.81). However, while there was a reduction in critically incorrect responses for older children (9-10 years), this was not significant (56% immediately after training; 39% one month after training).
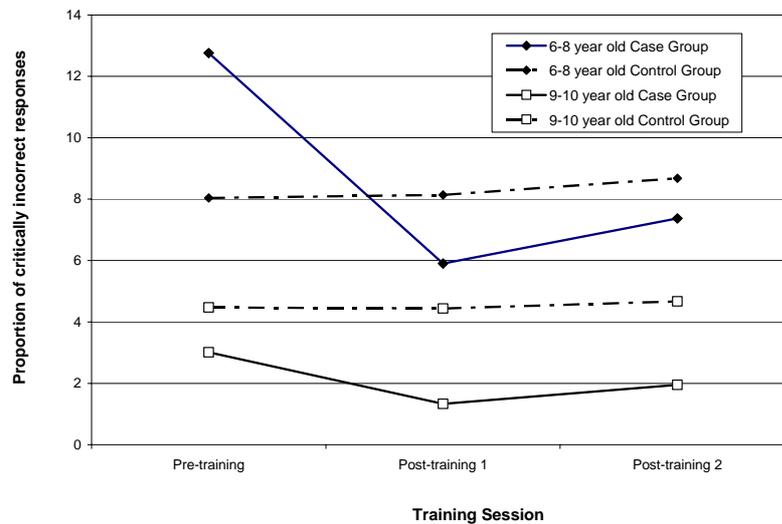
Figure 3: Proportions of critically incorrect responses by training session, age group and training group

In addition, significant reductions in critically incorrect responses amongst females were found compared to responses prior to training and relative to any changes in the control group (67% immediately 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 (43% immediately post-training; 35% one-month post-training), these were not significant.

DISCUSSION

The broad aim of this 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 showed that this program was effective in reducing the number of critically incorrect responses in young children. Further, these results were maintained at one month follow-up.

The effects of the training are 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 pre-training, and this cannot be the explanation for the differences in the effectiveness of training between the genders. It may be that there are other functional and behavioural factors that further influence the effectiveness of training. This will be examined as part of the larger project.

One limitation of the study is that children's gap selections 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 simulator training programs (e.g. Glang et al, 2005; Thomson et al, 2005; McComas, et al, 2002), and 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.

Much of the research on child pedestrian safety discusses the importance of acquiring skills in real-traffic environments (e.g., Zeedyk & Kelly, 2003), 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.

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, 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 shows a beneficial effect in reducing the number of critically incorrect responses.

Conclusion

Three broad strategies are available for managing child pedestrian safety – behavioural programs, improvements to road design and operation, 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 highlight the benefits 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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