Accident Analysis and Prevention 86 (2016) 9–15

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Community-based pedestrian safety training in virtual reality: A pragmatic trial

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ARTICLE INFO

Article history:
Received 13 March 2015
Received in revised form
29 September 2015
Accepted 1 October 2015

Keywords:
Pedestrian safety
Virtual reality
Children
Pragmatic trial
Injury prevention

ABSTRACT

Child pedestrian injuries are a leading cause of mortality and morbidity across the United States and the world. Repeated practice at the cognitive-perceptual task of crossing a street may lead to safer pedestrian behavior. Virtual reality offers a unique opportunity for repeated practice without the risk of actual injury. This study conducted a pre-post within-subjects trial of training children in pedestrian safety using a semi-mobile, semi-immersive virtual pedestrian environment placed at schools and community centers. Pedestrian safety skills among a group of 44 seven- and eight-year-old children were assessed in a laboratory, and then children completed six 15-minute training sessions in the virtual pedestrian environment at their school or community center following pragmatic trial strategies over the course of three weeks. Following training, pedestrian safety skills were re-assessed. Results indicate improvement in delay entering traffic following training. Safe crossings did not demonstrate change. Attention to traffic and time to contact with oncoming vehicles both decreased somewhat, perhaps an indication that training was incomplete and children were in the process of actively learning to be safer pedestrians. The findings suggest virtual reality environments placed in community centers hold promise for teaching children to be safer pedestrians, but future research is needed to determine the optimal training dosage.

1. Background

Almost 5000 American pedestrians are killed annually, and 207,000 others injured. About one-fifth of injured pedestrians are children (NCIPC, 2015). One major reason children have increased pedestrian injury risk compared to adults is because crossing a street requires sophisticated cognitive and perceptual processing, skills that develop during childhood. Previous risk assessment work suggests that most 5- to 6-year-olds and some 8-year-olds fail in judging the speed of traffic and choosing safe traffic gaps accurately and consistently when crossing a road (Lee et al., 1984; Pitcairn and Edlmann, 2000).

Multiple strategies can be used to reduce child pedestrian injury risk (Schwebel et al., 2014a; World Health Organization, 2013). Environmental changes such as traffic calming and pedestrian management (e.g., diverting to pedestrian bridges/tunnels) are highly effective but complicated and costly to implement (Jones et al., 2005; Rothman et al., 2014). Increased supervision of children by parents, school officials, or crossing guards also appear to be effective (Barton and Schwebel, 2007; Gutierrez et al., 2014; Yeaton and Bailey, 1983), but research suggests parents rarely instruct their own children in pedestrian settings (Zeedyk and Kelly, 2003) and hiring school officials or law enforcement officials to protect child pedestrians is costly.

A third alternative is to train children themselves to cross streets more safely. Research in North America finds that children frequently walk alone or with same-age peers on streets (Macpherson et al., 1998; Martin et al., 2007; McDonald et al., 2011), and children in middle childhood (ages 5–9) experience pedestrian injuries especially frequently when crossing roads at or between intersections close to home or school (Agran et al., 1994; DiMaggio and Durkin, 2002; Lightstone et al., 2001; Warsh et al., 2009). Thus, efforts to teach children to be safer pedestrians are needed, with mid-block neighborhood crossings as a priority in middle childhood. Such efforts must supplement environmental

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http://dx.doi.org/10.1016/j.aap.2015.10.002
0001-4575/

and supervisory efforts to improve child pedestrian safety through multi-faceted prevention programs.

Previous work indicates that 7- and 8-year-old children can learn to be safer pedestrians with appropriate training (Schwebel et al., 2014a). Of particular relevance to the present work, behavioral interventions that offer individualized repeated practice at crossing a street hold promise toward teaching children the complex cognitive-perceptual skills required to cross safely at mid-block locations with bidirectional traffic. Traditionally, this sort of repeated practice was offered live, at streetside locations, with training closely monitored by competent adult pedestrians (Barton et al., 2007; Demetre et al., 1993; Rothengatter, 1984; Young and Lee, 1987). More recently, scholars have explored the use of virtual reality to provide children with repeated practice crossing a street (Bart et al., 2008; Schwebel et al., 2014b; Thomson et al., 2005).

Virtual reality offers several advantages over individualized streetside pedestrian safety training. It provides a safe computer-generated environment with realistic images and sounds that offer a feeling of immersion without the risk of actual injury. It can provide systematic delivery and control of stimuli, customized training to individual skill levels, and an engaging and fun learning environment. Further, virtual reality training can be administered with minimal adult supervision and monitoring. In the most extensive published evaluation of virtual reality pedestrian safety training, Schwebel and colleagues implemented a randomized controlled trial to 240 seven- and eight-year-olds who were randomly assigned to receive pedestrian safety training in a series of six 30-minute sessions within a virtual pedestrian environment, through individualized streetside training, through a series of computer-based games and videos, or to be in a no-contact control group (Schwebel et al., 2014b). Results suggested that children trained individually by an adult at streetside locations or through the virtual reality environment demonstrated greater learning than those trained through games/videos or those in the no-contact control group.

Previous work suffered from two significant limitations, both of which the present study overcomes. First, previously-tested virtual reality environments were not mobile. A system that is fixed to a given location curtails broad dissemination of the intervention across communities. Opportunity for broad dissemination and implementation is a key aspect of public health translation into practice (Glasgow et al., 1999, 2003). With a mobile system that can be transferred to different schools, community centers, or other institutions, interventionists can offer children intense training over the course of a few weeks and then move the system to another location where a new group of children can receive similar training. One gains the potential to disseminate an intervention widely. We therefore refined a previously-developed and validated system to a more mobile environment that could be readily transported. Second, previous work was conducted in sterile controlled laboratory environments, thus limiting generalizability to the actual locations where child pedestrian safety training is more likely to occur such as schools and community centers. In this study, we implemented pragmatic trial methods by testing virtual reality training in field environments under the typical circumstances of its potential implementation (Schwartz and Lellouch, 1967; Thorpe et al., 2009; Ware and Hamel, 2011). Rather than training children in a somewhat artificial laboratory environment, we trained children in their schools and community centers.

We hypothesized that training in the mobile virtual environment located in schools/community centers would improve children's pedestrian safety across four performance measures: attention to traffic, delay in entering safe traffic gaps, time to contact with oncoming traffic while crossing, and unsafe simulated crossings. We evaluated these hypotheses using a within subjects pre-post research design, with children's pedestrian safety assessed at baseline, and again after exposure to six 15-minute training sessions.

2. Methods

2.1. Participants

Forty-four 7- and 8-year-old children (mean age = 8.01 years; SD = 0.56; range = 6.8–9.0) were recruited in 2014 from three sites in the Birmingham, Alabama area: Hemphill Elementary School ($n = 11$), Bluff Park Elementary School ($n = 28$), and the YMCA Downtown Youth Center ($n = 5$). The sample was 52% African-American, 48% Caucasian, and 51% female. About one-quarter (26%) of children came from a household with parent-reported annual income of less than $20,000, 21% with household income between $20,000 and $39,999, 23% with household income between $40,000 and $99,999 and 31% with household income greater than $100,000. Based on parent reports, 30% of the sample walked to school regularly (at least once/week and usually considerably more often) and 95% walked on streets regularly (at least once/week and usually considerably more often) for transportation, commuting, or recreation.

The study protocol was approved by the IRBs at University of Alabama at Birmingham and University of North Carolina Chapel Hill. All parents of study participants provided informed consent and children provided developmentally-appropriate informed assent.

2.2. Specifications of the virtual environment

The virtual reality environment was based on a previous semi-immersive virtual environment that was validated to represent real-world behavior among samples of both children and adults (Schwebel et al., 2008). It used identical scenery, sound, and responding as the previous system. The software was ported to the Unity gaming platform and runs on a single Windows 7 PC with an Intel Core i5-3330 3.0 GHz Quad-Core desktop processor and GeForce GT 640 video card. The three screen displays are comprised of 3 vertically mounted Samsung MD55C 55″ Direct-lit LED displays (see Fig. 1 for photo of system).

To ease transportability and security, the casing that houses the virtual environment was constructed of museum-quality materials. It is durable enough to handle heavy use by intermittently supervised children and frequent movement to different sites, but light enough to be transported. It breaks into 5 parts to fit onto a small truck. The CPU and monitors are situated inside locked

Fig. 1. Photograph of virtual reality environment placed at a school for use in training.