Safety Science 80 (2015) 33–40

Contents lists available at ScienceDirect

Safety Science

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

Are child-pedestrians able to identify hazardous traffic situations? Measuring their abilities in a virtual reality environment

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ARTICLE INFO

Article history:
Received 10 February 2015
Received in revised form 3 May 2015
Accepted 4 July 2015
Available online 18 July 2015

Keywords:
Road crossing
Child pedestrian
Hazard perception
Simulation

ABSTRACT

Background: Child-pedestrians are more prone to fail in identifying hazardous situations. Aiming to better understand the development of hazard-perception abilities in dynamic road situations we examined participants' hazard detection abilities in a virtual environment.
Method: Experienced-adult participants and child-pedestrians observed typical road crossing related scenarios from a pedestrian's point of view and engaged in a hazard detection task.
Results: Consistent with our hypotheses, less instances of obscured field of view by parked vehicles were reported as hazardous by 7–9-year-olds, who were also prone to linger more in identifying situations depicting field of view partially obscured by parked vehicles compared to all other age groups. Reports of obscured field of view by road curvature as hazardous increased with age.
Conclusions: Understanding child-pedestrians' shortcomings in evaluating traffic situations contribute to the effort of producing intervention techniques which may increase their attentiveness toward potential hazards and lead toward reduction in their over-involvement in crashes.

1. Introduction

Research had recognized that pedestrian crashes are among the most common sources to fatality and injury to young children in the industrialized world. Children are vulnerable road users as pedestrians (e.g., Zegeer and Bushell, 2012). Indeed, in 2010 children at the age of fifteen and younger were accounted for 6.8% of the pedestrian fatalities and approximately 22.9% of all pedestrians injured in traffic crashes (NHTSA, 2012). According to the European Road Safety Observatory – ERSO (2011) regarding the EU-24's annual data by country from 2000 to 2009, the proportion of pedestrian mortalities is higher for children (fourteen year olds and below) and the elderly (from the age of 65 on) than for all other age groups. Child-pedestrians are less skilled in coping with traffic compared to adults (e.g., Tabibi and Pfeffer, 2003; Hill et al., 2000). Research has shown that they suffer from poor visual search strategies (Tapiro et al., 2014), are meagre at identifying hazardous situations and their understanding of danger is not robust (Hill et al., 2000). They oftentimes tend to focus on the most salient factor (Whitebread and Neilson, 2000; Foot et al., 1999) while ignoring other critical elements in the traffic environment. These youngsters also tend to demonstrate a more idiosyncratic perspective of traffic situations compared to older children who were able to appreciate situations from a holistic perspective (Underwood et al., 2007). Therefore, assessing their ability to evaluate the hazardousness of road traffic situations (Benda and Hoyos, 1983) or 'read the road' (Horswill and McKenna, 2004; Foot et al., 2006) is extremely important.

A different road-users' novice population whose high traffic crash risk was demonstrated to correlate with its members' deficient hazard perception abilities and lack of driving experience is the young-novice drivers' population (e.g., Horswill and McKenna, 2004) with less than 6 months of driving experience. Strikingly, this population's deficiencies bear remarkable resemblance to those previously described regarding child-pedestrians. Deriving from the domain of hazard perception in driving (e.g., Borowsky et al., 2010; Meir et al., 2014) one can assert that this process requires the capability to detect both actual, materialized hazards (i.e., where failure to engage in an immediate evasive action may cause damage to a road user) and potential hazards that are not physically and momentarily present in the environment (i.e., situations which may or may not develop into an actual hazard and prediction may allow prevention, such as limited field of view caused by road curvature).

The current study aimed to explore child-pedestrians' hazard perception abilities utilizing a conceptual framework taken from

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http://dx.doi.org/10.1016/j.ssci.2015.07.007
0925-7535/

the driving domain (e.g., Borowsky et al., 2010; Meir et al., 2010, 2014). Preceding evidences taken from research conducted in our lab (e.g., Borowsky and Oron-Gilad, 2013) had suggested that engaging in a hazard detection task of observing hazard-perception scenarios and pressing a response button whenever a hazard is detected, is a validated tool for differentiating between young-novice and experienced-adult drivers. As there are resemblances between young-novice drivers' poor ability to identify hazards and child-pedestrians' poor hazard-perception road-crossing abilities, it was attempted to apply the similar set of theoretical and methodological tools which was found to be highly efficient in evaluating and training young-novice drivers' hazard perception skills (e.g., Borowsky et al., 2010; Meir et al., 2010, 2014), in order to create a basis for developing an efficient tool to explore and later on to enhance child-pedestrians' hazard perception skills. Hazard perception skills of pedestrians were evaluated by examination of how static (e.g., parked cars obscuring the field of view) and dynamic features of the traffic environment (e.g., moving vehicles) are perceived by varied age pediatric pedestrians. These participants' abilities are compared to those of experienced-adults in order to better understand the development of the hazard perception skill over time and growth.

To explore the hazard perception abilities and deficiencies of child-pedestrians in the context of road-crossing, and in order to try and gain better understanding regarding the implications of lack of experience as pedestrians on children's road safety behavior, it was tried to create a research-based taxonomy of factors (i.e., Presence of zebra-crossing, Presence of moving vehicles and Field of view) which will be able to differentiate among pedestrians at different age and experience levels. It was hoped that the creation of this taxonomy will lay the ground toward a better understanding of child-pedestrians' hazard perception ability and would provide an initial step toward the process of producing proper guidelines for future hazard perception training program regarding this population. Since the majority of children are injured on non-arterial roads, particularly in residential areas (e.g., Roberts et al., 1994; Lawson, 1990; Rao et al., 1997), factors in the current study were all examined in a residential settings.

Moreover, no consistent difference in the level of pedestrians' crash rate between one and two-way roads with similar cross-section was found (e.g., Summersgill and Layfield, 1996; Wazana et al., 2000). Zebra-crossing present a high risk for road crashes (Ekman, 1996; Pfortmueller et al., 2014), where crossing without any noticeable pedestrian protection may increase pedestrians' vigilance. Indeed, it was reported that marked crossings without other facilities provide pedestrians with a false sense of security (e.g., Koepsel et al., 2002; Ekman, 1996) as they are less detectable to vehicles. Furthermore, level of hazardousness tends to correlate with the presence of vehicles (Ampofo-Boateng and Thomson, 1991). The younger child-pedestrians are, the more likely to base the evaluation of safety of crossing site on a single factor such as the presence or absence of vehicles. For 5 and 7 year olds the safety-level of a site based exclusively on their ability to detect vehicles on the road, conversely, locations presenting no vehicles were judged by them as safe. Furthermore, crashes tend to take place in locations where the visibility is restricted, e.g., at curvatures, near stationary vehicles (Ampofo-Boateng and Thomson, 1990; Petch and Henson, 2000).

Aiming to understand children's ability to detect hazards in natural, ecological environment depicting (as is the case in real-life) both static and dynamic factors the experimentation was situated in a Dome projection facility. Although one could suggest that extensive practice of road-crossing skills occur in real life settings, such methodology may pose serious ethical and practical risks and require extensive resources (e.g., Schwebel et al., 2008; Albert and Dolgin, 2010). Indeed, outdoor traffic environments are unpredictable and pose difficulties in controlling all relevant variables (e.g., Novak, 2009; Barton and Morrongiello, 2011), thus it was decided to examine these skills in a standardized, regulated simulation environment without jeopardizing the participants. This was achieved, as in several earlier studies (e.g., Schwebel et al., 2008; Novak, 2009; Meir et al., 2013), by creating a systematic manipulation of factors in a virtual environment. Virtual reality may be described as a computer or video generated environment, designed to mimic real world situations by providing a user with a sense of being immersed in a displayed virtual world through realistic graphics, high-quality sound and the ability to interact with the virtual world (e.g., Reid, 2002; Schwebel et al., 2008; Novak, 2009). The utilization of virtual environment for training and assessment can aid in reproducing identical situations for each of the participants and controlling confounding variables (e.g., Schwebel et al., 2008; Novak, 2009; Stavrinos et al., 2009). Evidence suggests that virtual reality environment might be utilized as an appropriate methodology, both for etiological research on the sources for child-pedestrians' injuries and for intervention research (e.g., Schwebel et al., 2008; Simpson et al., 2003). To conclude, it was decided to use a Dome projection environment technique, which enables accurate, controllable and immersive simulation of diverse crossing environments. Meir et al. (2013) showed that while engaging in a road-crossing decision task in a dynamic environment, 7–13-year-olds' ability to determine if and when to cross was unsatisfactory compared to that of experienced-adults'. Its novelty stemmed from the examination of dynamic environmental features (e.g., presence of moving vehicles) on the development of the hazard detection skill. Lastly, as the current experiment is meant as a first step toward establishing an intervention for enhancing child-pedestrians hazard perception's abilities, it is important to note that the virtual reality environment "adds the ability to practice uncommon, expensive and dangerous tasks. Additionally, the operator has more control over what scenarios can be presented to the participant, and can change the scenario in response to performance. The other significant benefit is that performance can be recorded and analyzed" (Tzanavari et al., 2014, pp 2).

The present study aimed to examine the development of the hazard perception abilities among pedestrians and to serve as an initial mapping tool for appreciating the skill of perceiving hazards from different aspects. It was hypothesized that the ability to identify hazard instigators prior to their materialization develops with age until maturation. Accordingly, research hypotheses stated that (1) Experienced-adult pedestrians would be more sensitive to potential hazards compared to child-pedestrians and would be more inclined to refer to situations where field of view is restricted as hazardous; and that (2) The older a child-pedestrian, the more they would pay attention to potential hazards such as restricted field of view.

2. Method

2.1. Participants

Age for pediatric pedestrians was defined as 7–13. Around the age of 7, children progress to the concrete operational stage, and begin to think logically about concrete events (e.g., Flavell, 2004). Also, 7-to-11 years of age are the most formative stage for the development of road crossing skills among children (e.g., Thomson et al., 1996; Foot et al., 2006). Forty-seven participants, 20 experienced-adult participants (20–27-year-olds; mean age = 25.2, SD = 1.88) and 27 child-pedestrians (nine 7-to-9-year-olds with mean age = 8.12, SD = 0.65; seven 9-to-10-year-olds with