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The effect of environmental distractions on child pedestrian's crossing behavior

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ABSTRACT

Pedestrians are subject to an increasing number of stimuli and distractions derived from the roadside environment. Although the effect of distractions on child road crossing ability was recognized, there has been no systematic exploration of the effects of roadside distractions on child road crossing behavior. This work was aimed at studying the effect of roadside distractions on pedestrian road crossing behavior, focusing on elementary school-aged children, who are less capable of making a safe road crossing decision and are more vulnerable to the effect of distractions. Three types of audio distractions (a. sudden, momentary, and prominent noise, b. multiplicity of auditory elements, and c. continuous loud noise) and similar three types of visual distractions were pre-defined. Fifty-two children (aged 7–13) and adults arrived at the dome virtual reality laboratory and viewed 20 simulated crossing scenarios, embedded with visual and auditory distractions, and decided on the appropriate time to start crossing the virtual road. The results demonstrate that when exposed to environmental distractions, participants chose smaller crossing gaps, took more time to make crossing decisions, were slower to respond to the crossing opportunity, and allocated less visual attention to the peripheral regions of the road. Those effects were age related, and affected younger participants more significantly. Furthermore, visual distractions affected pedestrian behavior more than auditory type distractions. This study highlights an issue not yet adequately addressed, and the results should be considered by transportation professionals, and road safety educators, so better road safety programs to educate children can be created.

1. Introduction

Pedestrian casualties constitute almost a third of all road fatalities in Europe and in the Americas (WHO, 2013a). Among pedestrians, middle and elementary school children are considered to be an age group that deserves special attention. The World Health Organization (WHO) reports that road traffic injuries ranks among the four main causes of death for children above five years-old and is the number one killer for children aged 15–17 (WHO, 2013a). Another reason that children deserve special attention, is related to their high fatality rate as pedestrians out of all child-involved road fatalities (e.g. car occupants). For example, the annual report of the IRTAD group from 2015, approximates that half of all road fatalities of those aged 5–14 in the OECD countries were pedestrians (IRTAD, 2015). Part of the reason why children are involved in road crashes as pedestrian in such high proportion can be attribute to lower level of motorization for these ages. Yet, controlled studies have shown that children are less skilled in crossing the road compared to adults, as expressed in their poorer ability to evaluate the dangers in the road environment (e.g., Hill et al., 2000; Tabibi & Pfeffer, 2003). They oftentimes tend to focus on the most salient factor (Foot et al., 1999; Meir et al., 2013) while ignoring other critical elements in the traffic environment. They suffer from poor visual search strategies (Tapiro et al., 2014; Whitebread and Neilson, 2000) and are meagre at identifying hazardous situations (Hill et al., 2000; Meir et al., 2015).

To make a good crossing decision, pedestrians are required to shut out distractions (e.g., commercial billboards, noisy sirens, etc.) and avoid distracting activities (e.g., cell phone use) that may lead them to miss critical information from the road crossing environment (Bungum et al., 2005; Nasar et al., 2008; Schwebel et al., 2012; Tapiro et al., 2016). Children hold limited attentional skills that are still being developed in ages 9–10, which puts them at higher risk in comparison to adults when attempting to cross the road while been distracted (Doyle, 1973; Huang-Pollock et al., 2002; Lavie, 2005; Pearson and Lane, 1991). Due to their lower attentional capacities, when distracted, children 6–11 years-old are less capable of identifying safe places to cross the road and it take them longer to do so in compare to adults (Tabibi and Pfeffer, 2007). Although the effect of distractions on

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children had been recognized in the aforementioned studies, a limited number of studies has systematically investigated the effect of cell phone distraction on children's road crossing (e.g., Tapiro et al., 2016) and no such study investigated the effect of distractions posed from the road environment on children road crossing behavior.

About 70% of all pedestrian fatalities in the European Union and 76% in the United States occurred in urban areas (WHO, 2013b). However, urban areas vary in their characteristics as reflected in the road geometry and road elements (e.g., turns and intersections), traffic density and speed, auditory and visual noise exposure, pedestrian movements, land use (e.g., residential, business, commercial/retail, and mixed), etc. The effect of land use on the number of adult and child pedestrian casualties was reported in several studies. Commercial/retail sites, as well as high-density residential areas, were found to be positively associated with higher number of pedestrian-vehicles collisions (Loukaitou-Sideris et al., 2007). Secondary retail (where stores are located along the road) is the main land use type associated with child pedestrian casualties; low density residential, educational sites (includes schools, colleges and universities and libraries) and primary retail sites are also positively associated with child pedestrian casualties (Dissanayake et al., 2009). Other factors related to the road environment, like traffic volume and pedestrian activity, were found to contribute to the risk of pedestrian collisions and the total number of pedestrian injuries (Leden, 2002; Lyon and Persaud, 2002; Miranda-Moreno et al., 2011; Roberts et al., 1995; Yiannakoulias and Scott, 2013). It was also suggested that the built environment can indirectly increase the total number of injured pedestrians; as built environments with mixed land uses, greater density, and higher transit supply are positively associated with pedestrian activity, which is then positively associated with the number of injured pedestrians (Miranda-Moreno et al., 2011). However, the aforementioned studies that utilized existing collision data do not state whether pedestrian involved collisions were a result of changes in the behavior of pedestrians in reaction to factors in the road environment (e.g., distractions), or rather, a matter of other factors that are related to the level of exposure. Yet, a controlled experimental study (that are less common) was able to demonstrate that pedestrian's behavior is affected when exposed to different environmental condition. When exposed to higher level of traffic, children tend to choose smaller crossing gaps, react faster, and adopt shorter safety margins (Barton and Morrongiello, 2011). Essentially, Barton and Morrongiello (2011) demonstrated that child pedestrian-vehicle collisions are not only the outcome of greater exposure in certain environments, but rather, and more importantly, it is the environment itself that affects pedestrians' behavior in a way that exposes them to higher risk. A study focusing on the effect of ambient street noise on pedestrian behavior was able to demonstrate that when exposed to higher levels of ambient street noise the pedestrian becomes less aware of his surroundings. It was expressed in remembering fewer visual objects that were present along their path, narrower peripheral vision, expedited walking speed and changes in social behavior (Korte and Grant, 1980). Although not directly related to road crossing behavior, the study does support the notion that environmental noise affects pedestrian behavior in general. Which may indicate that under similar circumstances the same phenomena can happen when crossing the road.

Studies that examined the effect of environmental distractions on driving behavior can provide insights into the potential effects of environmental distractions on pedestrians. A comprehensive literature review highlighted two main conclusions from the reviewed studies on the impact of environmental distraction on safe driving: 1) there is clear evidence that under certain circumstances, external stimuli (e.g., signs, and billboards), can be a threat to safe driving (e.g., causing slower response time, missing of signs), and 2) that "too much" 'visual clutter' overloads drivers at or near intersections and junctions and can interfere with drivers' visual search strategies and lead to accidents (Wallace, 2003). Studies that utilized eye movement trackers had deepened the knowledge on the effect of visual clutter on drivers' visual attention. For example, it was shown that high levels of clutter caused more peripheral glances and longer fixations at the stimuli (Perez and Bertola, 2010). The location of the stimuli also alters drivers' eye-movements; street level advertisement (in comparison to raised advertisements) caused longer fixation duration when looked at, they drew more fixations, were overall more observed, and partially faster to draw attention toward (Crundall et al., 2006).

Many of the aforementioned studies had examined the circumstantial links between environmental characteristics (e.g., the type of land use, traffic volume) and pedestrian-vehicle collision's risk. Others have shown an effect of traffic volume on pedestrians behaviors (e.g., Barton & Morrongiello, 2011). Yet, and although the impact of distractions on the child pedestrians road crossing ability was recognized (Tabibi and Pfeffer, 2007; Tapiro et al., 2016), no such effort was done to investigate the effect of distracting elements from the road environment on children and adults road crossing behavior. Similar to what Barton and Morrongiello (2011) have done, it is necessary to better understand which elements in the road environment, beside traffic volume, might affect pedestrians' behavior, and how these elements impact pedestrians crossing performance, especially children, the more vulnerable group of pedestrians.

Based on this need, the present study aimed to examine, in a controlled simulator study, how typical distracting elements from a typical urban environment affect child pedestrians' road crossing behavior. The main hypothesis was that distracting elements could cause a behavioral change in participants crossing decision and visual attention in a simulated environment. Accordingly, research hypotheses stated that (1) environmental distractions would have a detrimental effect on participants crossing decision, as expressed in previews studies with cell phone distraction (Schwebel et al., 2012; Tapiro et al., 2016); (2) adult pedestrians would be more consistent in their crossing behavior regardless of the environmental elements compared to child-pedestrians; (3) visual distractions will be more detrimental than auditory distractions and (4) as previously demonstrated (Barton and Schwebel, 2007; Tapiro et al., 2016; Whitebread and Neilson, 2000) road crossing performance would be age related; each children age group will be better than its younger counterparts and adults will demonstrate the best crossing performance.

2. Method

2.1. Participants

Fifty-two participants, 14 adults aged 22–29 year-olds (mean = 25.4, SD = 1.8), 11 children aged 7–8 year-old (mean = 7.8, SD = 0.7), 18 children aged 9–10 year-old (mean = 9.7, SD = 0.7) and 9 children aged 10–13 year-old (mean = 12.02, SD = 0.97) were included in the study. Child participants received an educational gift equivalent of eight USD; adult pedestrians were students compensated by bonus credit in an engineering introductory course. All participants had "normal vision", with corrected static acuity of 6/9 (20/30) or better. Recruitment of children was made via mass mail that was sent to all university employees, and fliers distributed in local elementary schools in the area.

2.2. Apparatus

2.2.1. The dome simulator

The Dome simulator consists of 180 degrees spherical screen (radius of 3.25 m) aligned with a very accurate projection system of three projectors. This setting allows measurement of the participants when watching pre-designed simulated scenarios of real-life situations from the roadside perspective, without the risk of harm (Fig. 1). The dome facility is equipped with an advanced 5.1 channels sound surround system that enables an immersive experience. Prior, validation of the dome simulator for pedestrians' perception of distance and speed was