Accident Analysis and Prevention 98 (2017) 287–294

Contents lists available at ScienceDirect

Accident Analysis and Prevention

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

Effects of secondary tasks on auditory detection and crossing thresholds in relation to approaching vehicle noises

Shane J. Davis, Benjamin K. Barton*

University of Idaho, United States

ARTICLE INFO

Article history:
Received 13 May 2016
Received in revised form 17 October 2016
Accepted 18 October 2016
Available online 27 October 2016

Keywords:
Pedestrian safety
Secondary tasks
Distraction
Auditory cues
Vehicle detection

ABSTRACT

Research suggests an association between distracting environmental sound stimuli and poorer performance in detecting and localizing approaching vehicles using auditory cues. However, no studies have investigated the distractive potential posed by intrapersonal distractors in the context of pedestrian auditory perception. We examined the effects of holding naturalistic vocal and texting cell phone conversations on participants' auditory detection of approaching vehicles and crossing thresholds in a non-visual simulated setting. Ninety-nine adults were randomly assigned to conditions of vocal conversation, texting conversation, or a control group and completed an auditory vehicle detection task. Participants in the vocal cell phone conversation group detected vehicles at significantly shorter distances than participants in the control group. The concurrence of a secondary task did not affect the distances at which participants deemed vehicles noise too close for them to safely cross (i.e., crossing thresholds). Implications for future research and injury prevention are discussed.

1. Introduction

Approximately 3700 pedestrians aged 18–65 died and more than 144,000 sustained medically attended injuries in the United States in 2013 (National Center for Injury Prevention and Control, 2016). Research has identified several intrapersonal risk factors for adult pedestrian safety including aspects of personality, risk perception, attitudes, and perceived behavioral control (Barton et al., 2016b; Herrero-Fernández et al., 2016; Schwebel et al., 2009). Environmental factors such as high traffic volume and obstructed visibility also are related to pedestrian injury risk (La Scala et al., 2000; Roberts et al., 1995). The role of auditory information in pedestrian safety is another emerging area of empirical inquiry (Barton et al., 2012). One factor yet to receive attention is the effect of auditory distraction on pedestrians' perception and use of approaching vehicle noises. We examined the distances at which participants detect approaching vehicles and deem said vehicles too close for safe crossing in the context of visual silence and a secondary task, specifically communication by texting and vocal cell phone conversation.

1.1. Auditory cues in the pedestrian task

Both visual and auditory perceptual skills are necessary for safe pedestrian navigation. Visual perception plays an important role in orienting towards potential threats to safety the external environment and has received much attention in literature concerning pedestrian safety (e.g. Barton, 2006). However, many pedestrian injuries occur in locations where visibility is obstructed such as bends in the roadway, crossroads, crests of hills, streets with large volumes of parked cars, and streets with higher traffic volume (Ampofo-Boateng and Thompson, 1989; La Scala et al., 2000; Roberts et al., 1995). An estimated 40–70% of children's and 20% of teenagers' accidents when crossing the street involve visual occlusion by a parked vehicle (van der Molen, 1981). In situations with obstructed visibility and/or high environmental demands, auditory perception becomes more important in detecting approaching vehicles and making crossing decisions. However, research suggests pedestrians have significant difficulty making decisions when reliant on auditory perception (Emerson and Sauerburger, 2008; Guth et al., 2005). The results of such studies underscore the need for research examining the auditory perceptual skills necessary for detecting and locating approaching vehicles in the pedestrian traffic environment.

A recent line of research has examined the role of vehicle noise in pedestrian safety. Initial research found vehicle speed was significantly related to pedestrians' performance in detecting and

* Corresponding author at: Department of Psychology & Communication Studies, PO 443043, University of Idaho, Moscow, Idaho, 83844-3043, United States.
E-mail addresses: barton@uidaho.edu, drbbarton@gmail.com (B.K. Barton).

http://dx.doi.org/10.1016/j.aap.2016.10.024

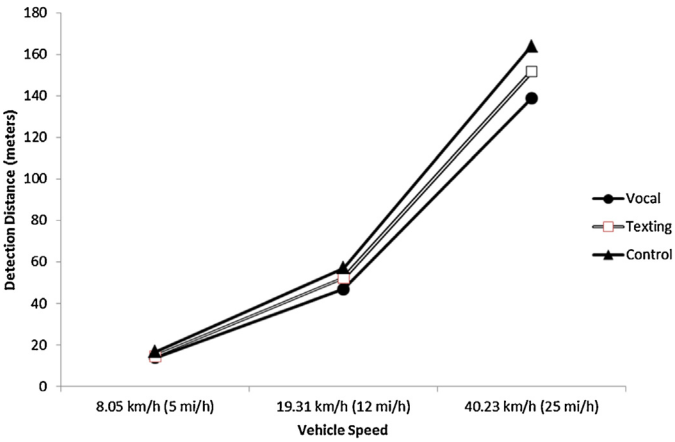

Fig. 1. Plot of speed by secondary task condition for detection distance.

Table 1
Overall means and standard deviations for detection distance and crossing threshold.

Detection distances in meters (feet)		
Speed in km/h (mi/h)	*M*	*SD*
8.05 (5)	15.30 (50.20)	2.89 (9.48)
19.31 (12)	52.44 (172.05)	12.28 (40.28)
40.23 (25)	152.20 (499.35)	29.01 (95.19)
Crossing thresholds in meters (feet)		
Speed in km/h (mi/h)	*M*	*SD*
8.05 (5)	5.40 (17.71)	2.62 (8.60)
19.31 (12)	18.84 (61.82)	8.28 (27.17)
40.23 (25)	61.00 (200.14)	24.50 (80.39)

Note. N = 99.

localizing approaching vehicles (Barton et al., 2012). Generally, detection distance was positively correlated with vehicle speed. Slower moving vehicles were detectable only at a short distance from the participant while faster moving vehicles were detectable at significantly greater distances.

Two studies in this line have investigated developmental differences in pedestrians' reactions to noises of approaching vehicles. In one study, adults and older children detected approaching vehicles more quickly and were more accurate in determining direction of approach and arrival of the vehicle at their location (Barton et al., 2013). More recently, the performance of younger adults aged 18–30 and older adults aged 60 and above was compared (Barton et al., 2016a). Researchers examined indices of auditory detection distance, direction of approach, and judgments of threshold for safe crossing. Older adults detected vehicles at greater distances than younger adults and were more conservative with their determination of thresholds for safe crossing.

Other studies have examined the roles of extraneous in the pedestrian environment. Emerson and Sauerburger (2008) examined ambient background noise interfering with pedestrians' ability to detect approaching vehicles at a safe distance. Ambient background noise, compared to factors such as vehicle speed and the presence of hills or bends in the roadway, was found to be the strongest predictor of vehicle detection time. Additionally, background traffic noise has been found to impede pedestrians' ability to determine the travel path of a vehicle (Ashmead et al., 2012). More recently, researchers examined noises from approaching vehicles in the context of competing noise from a second vehicle, a common situation on busy streets (Ulrich et al., 2014). The masking effect noise from a second vehicle indicated heightened risk for pedestrians. Auditory vehicle detection performance in the presence of a secondary vehicle was significantly worse than when no secondary vehicle was present. However, no studies have examined how auditory detection of approaching vehicles, in the absence of visual information, is affected by a competing sound stimulus in the form of a secondary task.

1.2. Distraction from a secondary task

Much research is needed to investigate the primary mechanisms by which secondary tasks interfere with pedestrian navigation and decision making. Cell phones are a common form of secondary task distraction among pedestrians. Wireless subscriber connections in the United States comprise almost 378 million devices (CTIA-The Wireless Association, 2016). Use of a cell phone while crossing may affect safety in various ways. For example, one study assessed the virtual street-crossing behaviors of participants under conditions of no distraction, a hands-free cell phone conversation, and listening to music on a portable player (Neider et al., 2010). Participants holding a vocal cell phone conversation took more time to cross the street and were less likely to successfully do so as compared to the other two conditions, suggesting that cell phone use is a task that impedes a pedestrian's ability to notice and subsequently act on crossing opportunities.

Three experiments have examined the impact of cell phone use on pedestrian behavior in virtual environments. The first experiment (Stavrinos et al., 2011) compared participants' performance under no distraction with performance holding a naturalistic cell phone conversation. Participants performed more poorly when holding a cell phone conversation regardless of conversation type with one exception: Attention to traffic seemed to be inhibited more by cognitively complex conversations than naturalistic conversations. In the second experiment, participants completed a virtual street-crossing task while texting, listening to music, and holding a vocal cell phone conversation (Schwebel et al., 2012). Pedestrians texting or listening to music while crossing a virtual street were significantly more likely to be hit by vehicles than participants either undistracted or holding a vocal cell phone conversation. Most recently, Tapiro et al. (2016) investigated the impact of cell phone conversations on participants' visual attention and ability to make safe crossing decisions. Participant age groups included adults as well as children aged 7–8, 9–10, and 11–13 years. For all age groups, cognitively demanding conversations resulted in slower reaction times, smaller crossing gaps, and less attention to the visual periphery compared to conditions of naturalistic conversation and no distraction. However, to our knowledge no studies have examined the impact of a secondary task (particularly a cell phone conversation) on pedestrian auditory perception when visual information is not available.

1.3. Aims & hypotheses

Our goal was to build on previous work by examining the impact of a concurrent secondary task on vehicle detection and crossing thresholds. Naturalistic cell phone conversations in the auditory and visual modalities served as distracting secondary tasks.

The introduction of a secondary task in either modality (talking or texting) was expected to be associated with differences in vehicle detection distance and the distance at which a participant deems the situation unsafe to cross. Previous studies have suggested cell phone use to be detrimental to pedestrian perception and response (e.g., Neider et al., 2010), and a competing vehicle was found to produce a masking effect on a target vehicle (Ulrich et al., 2014). Therefore the concurrence of a cell phone conversation (both talking and texting) was hypothesized to result in participants A) detecting approaching vehicle noises at shorter distances, B) deeming a vehicle noise too close for them to safely cross the street at shorter distances, and C) more failures to respond to vehicle stim-