Transportation Research Part F 31 (2015) 124–132

Contents lists available at ScienceDirect

Transportation Research Part F

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

Illegal crossing behavior of pedestrians at signalized intersections: Factors affecting the gap acceptance

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ARTICLE INFO

Article history:
Received 11 April 2014
Received in revised form 17 March 2015
Accepted 20 April 2015
Available online 16 May 2015

Keywords:
Illegal crossing
Distance gap
Safety margin
Crossing time
Signalized intersection

ABSTRACT

Purpose of designing crosswalks is to allow pedestrians to cross the roads safely avoiding conflicts between pedestrians and motorized vehicles. However, pedestrians do not always comply with the crossing rules, whether it is timing (signalization) and/or location (crossing facility). An observation survey of illegal crossings was conducted at six intersections in Izmir, Turkey to determine the distance and time gap perception of the pedestrians for safe road-crossing within the 25 m of the crosswalk. Each intersection was observed on weekdays during afternoon (12.30–13.30) and evening peak hours (17.00–18.00). Totally, 444 illegal crossings were observed at all intersections. Data were analyzed playing the video recordings in office. All roads were consisted of two lanes. In this study pedestrians' illegal crossing behavior at signalized intersections depending on the position of the oncoming vehicle is of interest. Safety margins and crossing times of the pedestrians were also reported. Position of the vehicle was determined for the first lane at the instant the pedestrian stepped the lane. Pedestrians' distance gap perception was categorized into five groups depending on the position of the oncoming vehicle which are; vehicle is within the 25 m of the crosswalk, vehicle is within the 25–50 m of the crosswalk, vehicle is within the 50–75 m of the crosswalk, vehicle is just beyond 75 m, and vehicle is out of field of view. Factors affecting the distance gaps, safety margins and crossing times were analyzed by ANOVA. The most significant effect was the vehicle speed in all analysis. Pedestrians based their decision of crossing on distance rather than time gap.

1. Introduction

Pedestrians constitute the vulnerable part of the road users worldwide. About 1.24 million road traffic deaths occur each year around the world which makes road traffic injuries the eighth leading cause of death globally. More than 270,000 pedestrians die annually in road traffic crashes, that is, 22% of all road deaths (World Health Organization, 2013). The death rate of pedestrians is by itself shows the importance of pedestrian safety. However, especially in developing countries pedestrians have long been treated as a second degree component of traffic. What is pleasing is this understanding has started to change.

Pedestrians experience several processes when crossing a road. However the fundamental point is their ability of determining the available time and relating it to the time needed to cross (Lobjois & Cavallo, 2007). Each pedestrian has his/her own critical gap to accept or reject crossing. Crossing starts when the pedestrian chooses the most appropriate gap s/he perceives. This choice can be affected from several factors such as age, size of pedestrian group, vehicle speed, and vehicle type.

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http://dx.doi.org/10.1016/j.trf.2015.04.007
1369-8478/

Intersections are dangerous due to the high risk of pedestrian–vehicle interactions. Though signalized intersections reduce the risk of pedestrian–vehicle conflicts yet the risk still exists. Unfortunately, assuming all pedestrians comply with traffic rules would only be in an imaginary world. Observation surveys showed that pedestrians prefer making illegal crossings instead of waiting for the green light (Keegan & O'Mahony, 2003) or they prefer crossing outside the crossing facility in order to minimize their walking distance (Eliou & Galanis, 2012). Pedestrians making illegal crossings either cross against the lights or away from the lights (Lange, Haiduk, Schwarze, & Eggert, 2011).

The present study was conducted to examine the effects of age, gender, crossing individually or as a group of pedestrians, carrying stuff and the speed of oncoming vehicle on gap selection. Gap can be defined in terms of distance and time. This study aimed to find the time and distance gap perception of pedestrians using real-world observations at six signalized intersections in Izmir, Turkey. Each intersection was observed on weekdays during afternoon (12.30–13.30) and evening peak hours (17.00–18.00) using six video cameras. Safe distance gap perception was determined for each lane at crossing facility belonged one of the five groups; vehicle is within the 25 m of the crosswalk, vehicle is within the 25–50 m of the crosswalk, vehicle is within the 50–75 m of the crosswalk, vehicle is just beyond 75 m, and vehicle is out of field of view. In a study by Räsänen, Lajunen, Alticafarbay, and Aydin (2007) illegal crossings within the 25 m of the pedestrian bridge were observed. During a preliminary study it was observed that the major part of the illegal crossings were within the 25 m of the crosswalk which supports the study of Räsänen et al.

The gap perception studies usually were carried out in virtual environment (Liu & Tung, 2014; Lobjois & Cavallo, 2007; Oxley, Ihsen, Fildes, Charlton, & Day, 2005). Some studies used real-world data only for calculating safety margins (Koh & Wong, 2014; Zhuang & Wu, 2012).

The aim of this study is to find whether the pedestrian gap acceptance is governed by distance or time gap, and to reveal the factors (age, gender, vehicle speed, etc.) underlying the pedestrian's safe gap choice. The illegal crossings (crossing away from the lights) within 25 m of the crosswalk were examined, and safety margins, distance gaps, speed of the oncoming vehicle and vehicle type were extracted from the recordings. The data obtained were then used as variables in analyses of variance (ANOVA) to understand which factors affect pedestrians' gap acceptance and crossing times.

2. Literature review

The question when to cross leads to a term known as critical gap. The Highway Capacity Manual 2010 (HCM, 2010) defines the critical gap as "*the time in seconds below which a pedestrian will not attempt to begin crossing the street. If the available gap is greater than the critical gap, it is assumed that the pedestrian will cross, but if the available gap is less than the critical gap, it is assumed that the pedestrian will not cross.*" Chu and Baltes (2001) define the critical gap as the sum of crossing time and safety margin. The crossing time is the time that a pedestrian needs to cross a particular street. Safety margin is given as the difference between the time a pedestrian crosses the traffic and the time the next vehicle arrives at the crossing point. Three components namely, the supply of gaps, crossing time, and safety margin rule the pedestrian crossing behavior.

Brewer, Fitzpatrick, Whitacre, and Lord (2006) conducted a study at 42 sites in seven states to observe the pedestrian behavior and they tried to evaluate pedestrian gap acceptance. The selection of appropriate gaps depends on the pedestrians' judgments on the speed of oncoming vehicles and the available time to complete the crossing. A remarkable finding was that pedestrians focused on only one lane at a time, taking advantage of an adequate gap in each individual lane unlike the usual assumption that pedestrians wait for all lanes to clear before crossing. In contrast to Brewer et al. (2006), Yannis et al. (2013) found that distance from the oncoming vehicle was a better determinant for gap acceptance, rather than the vehicle's speed. Other effects associated with the accepted gaps were found as presence of illegally parked vehicles, presence of other pedestrians, and oncoming vehicle's size.

The limited number of previous studies about the gap perception mainly focused on the effect of age (Connelly, Conaglen, Parsonson, & Isler, 1998; Dommes, Cavallo, Vienne, & Aillerie, 2012; Liu & Tung, 2014; Lobjois, Benguigui, & Cavallo, 2013; Lobjois & Cavallo, 2007, 2009; Oxley, Fildes, Ihsen, Charlton, & Day, 1997; Oxley et al., 2005). Oxley et al. (1997) investigated the age related differences in crossing actions on two-way undivided and on one-way divided roads. They made video recordings and analyzed individual road crossings of 80 young and 80 old pedestrians. Results showed that young pedestrians' gap acceptance (51.3 m) was lower than elderly pedestrians' gap acceptance (69.1 m) on the two-way undivided road. Old pedestrians made less safe choices compared to the young pedestrians despite they left longer gaps because the old pedestrians underestimated their crossing times. On one-way roads the crossing behavior of young and old pedestrians was similar. Old pedestrians' average gap acceptance was 134.1 m and young pedestrians' gap acceptance was 119.2 m on one-way roads. The authors did the first study which investigated the relation between the road complexity and gap acceptance in real-world. The study of Connelly et al. (1998) only investigated the gap thresholds of 48 school children whose ages ranged from five to twelve. Children indicated that their motive to say "No" to crossing was distance although about one third of the children took into account both distance and the speed of the oncoming vehicle. Liu and Tung (2014) did a simulation based study to investigate the effects of age, time gap, time of day, and speed of approaching vehicle on the decision of pedestrians to cross a road. They used pre-recorded videos and showed them to sixteen young (24–29 years old) and sixteen elderly participants (61–79 years old) in which a vehicle was approaching from the left and they asked the participants to indicate the last moment at which they thought they would safely cross. The main determinant for the participants to make a crossing decision was distance gap. The authors adopted the definition of Oxley et al. (2005) for safety