Research Report Summary

SAFER-SIM University Transportation Center, 69A3551747131
Alberto M. Figueroa-Medina, PhD, https://orcid.org/0000-0002-2635-4988;
Didier M. Valdés-Díaz, PhD, https://orcid.org/0000-0003-1915-3464;
Benjamín Colucci-Ríos, PhD, https://orcid.org/0000-0002-8857-8442;
University of Puerto Rico Mayaguez
[December 2020]

Study of gap acceptance and walking speeds of pedestrians using virtual reality simulation

The recent focus placed on pedestrian safety is based primarily on the alarming increasing amount of fatalities in the U.S. The 6,283 pedestrian fatalities observed in 2018 was the largest number on record from the previous 28 years [1]. The study of roadway contexts and the related behavioral factors that cause these fatalities is needed to identify road modifications, new or improved safety treatments, and education strategies that can effectively modify road user behavior and performance.

Factors of Pedestrian Fatalities

Around 75% of pedestrian fatalities occur in urban areas, during dark conditions, and at locations outside of intersections [2]. A mid-block crossing is one of the most dangerous scenarios for a pedestrian. Conflicts and crashes at an uncontrolled crossing can be influenced by excessive vehicle speeds, inadequate conspicuity, drivers not yielding to pedestrians, and insufficient separation from traffic. Older pedestrians tend to have decreased risk perception, larger minimum gap acceptance, and longer waiting times when crossing a road [3-4]. In contrast, males and middle-aged pedestrians have been found to accept the smallest gap in traffic [5].

Study Objective

The objective of this study was to carry out a virtual reality (VR) simulation experiment to analyze the behavior of pedestrians when making the decision to cross at an uncontrolled location on a one-lane and a two-lane urban street. VR scenarios (see box at right for details) with different vehicle speeds and gaps between vehicles were shown. The ability to detect safe vehicle gap times in traffic, the walking speeds, and the crossing

Virtual Reality Scenarios

One-lane Urban Road Crossing

Vehicle gaps

- Fixed 3-seconds
- Fixed 5 seconds
- Variable from 2-5 seconds, in ½-s increments.

Vehicle speeds

- 15 mph
- 25 mph

Two-lane Urban Road Crossing

Vehicle gaps from 2-8 seconds, in ½-s increments.

Vehicle speeds

- 15 mph
- 25 mph

Three groups of 16 subjects, each performing from 10 to 12 trials for a total of 928 observations.

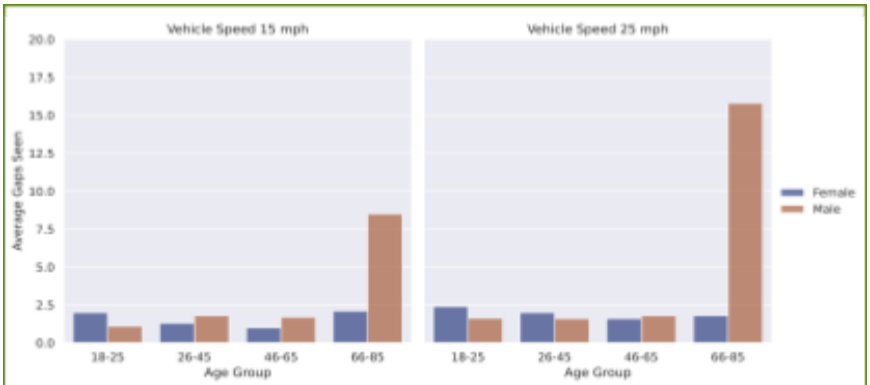
success rate for 48 subjects were measured in the VR experiment.

Selected Results and Conclusions

The average time of the gaps taken by pedestrians varied from 4.5 to 4.7 seconds for males and from 4.4 to 4.8 seconds for females in the one-lane crossing. For the two-lane crossing setting, the average time of the gaps taken increased from 6.6 to 7 seconds for males and from 6.4 to 6.7 seconds for females.

The average walking speed varied from 4.11 to 4.75 ft/s, depending on the vehicle gap and speed combinations. Although no major differences in speeds were observed between the male and female distributions, it was observed that 7% of females addressed the crossing at a faster pace than males.

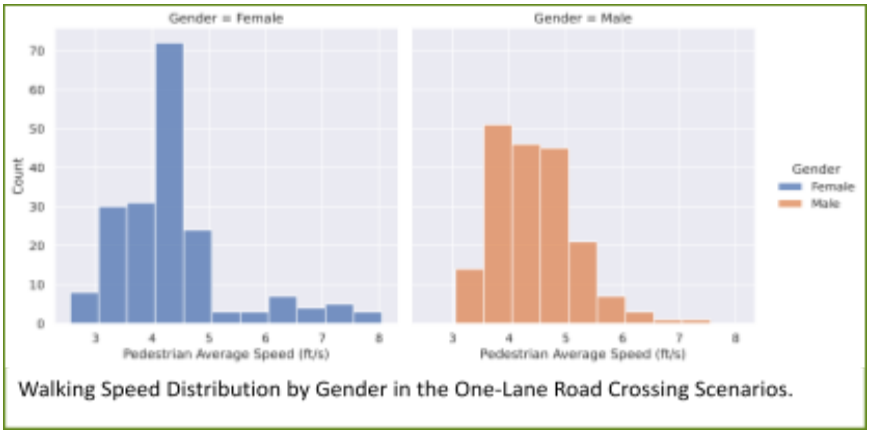
In terms of age, the 66-85 years old group had the lowest crossing success rate of 89.6% in the one-lane road setting. The worst success rate of 79.7% was for the group that observed the 25-mph scenario with constant gaps of 3 seconds in the one-lane context.



Average Gaps Seen by Gender and Vehicle Speeds in the Two-lane Crossing Scenarios.

Recommendations

This study can be replicated with special interest groups, such as diverse mobility and senior persons, to detect differences in behavior and performance. The ethnic group used in this study was predominantly Hispanic or Latino, thus the study methods using VR can be adapted to similar urban scenarios and gap acceptance where other cultures or a combination of them prevails (i.e., African-American, American Indian, Asian, etc.).



Walking Speed Distribution by Gender in the One-Lane Road Crossing Scenarios.

"Older pedestrians are most exposed to crashes when crossing at an uncontrolled location, especially when facing higher vehicle speeds."

Outcomes

- As vehicle speed increased from 15 to 25 mph, senior pedestrians had a 15.5% increase in getting hit by traffic when making a mid-block crossing. Road crossing awareness with educational campaigns targeting senior persons is essential.
- Observed 15th percentile walking speeds of 3.5 ft/s confirm suggested typical values for the timing design of traffic signal controls.
- Advances in current VR technology can measure human behavior for road safety experiments in controlled environments. Attention must be used with senior persons to allow them to be comfortable with the VR headset and the simulation environment.

Impacts

- Based on observed crossing success rates, reducing vehicle speeds from 25 to 15 mph has the potential of reducing 1,425 deaths per 100k road crossings of senior pedestrians.

References

1. 1. NCSA. 2018 fatal motor vehicle crashes: Overview. Traffic Safety Facts Research Note. Report No. DOT HS 812 826. Washington, DC: NHTSA. (2019).
2. 2. NCSA. Preview of motor vehicle traffic fatalities in 2019 (Research Note. Report No. DOT HS 813 021). NHTSA. (2020).
3. 3. Hamed, M. M. Analysis of pedestrians' behavior at pedestrian crossings. Safety Science, 38(1), 63–82. (2001).
4. 4. Holland, C., & Hill, R. The effect of age, gender and driver status on pedestrians' intentions to cross the road in risky situations. Accident Analysis and Prevention, 39(2), 224–237. (2007).
5. 5. Ravishankar, K., & Nair, P. Pedestrian risk analysis at uncontrolled midblock and unsignalised intersections. Journal of Traffic and Transportation Engineering, 5(2), 137–147. (2018).

Alberto M. Figueroa-Medina, PhD, https://orcid.org/0000-0002-2635-4988; Didier M. Valdés-Díaz, PhD, https://orcid.org/0000-0003-1915-3464; Benjamín Colucci-Ríos, PhD, https://orcid.org/0000-0002-8857-8442; University of Puerto Rico Mayaguez