Analysis of Walking Speeds and Success Rates on Mid-Block Crossings using Virtual Reality Simulation

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Agenda

- Research Problem
- Virtual Reality Experimental Scenarios
- Analysis of Results
- Conclusions and Recommendations

Mid-Block Crossings

- Mid-block crossings are highly potentially hazardous road situations.
  - Misrepresentation of time needed to cross
  - Misperception of approaching vehicle speeds

- Pedestrians must be able to analyze speeds and gaps in the traffic stream in a safe manner without the assistance of traffic signals or stop signs.

Photo: NY Times

Benefits of Virtual Reality Simulation

- Allow the collection of behavioral data for pedestrians and other road users in controlled and safe conditions.
- Provides interactive simulation, implicit interaction, and sensory immersion (sight and hearing).
- Can be used to study the human brain and its reactions to sensory and cognitive cues (Kearney et al., 2007).
- The fidelity of VR simulation allows obtaining objective measures of pedestrian behavior, such as average walking speeds, that match those measured in real-world situations (Shuchisnigdha et al., 2017).

Study Objectives

- Carry out a roadway crossing experiment using virtual reality (VR) simulation equipment.

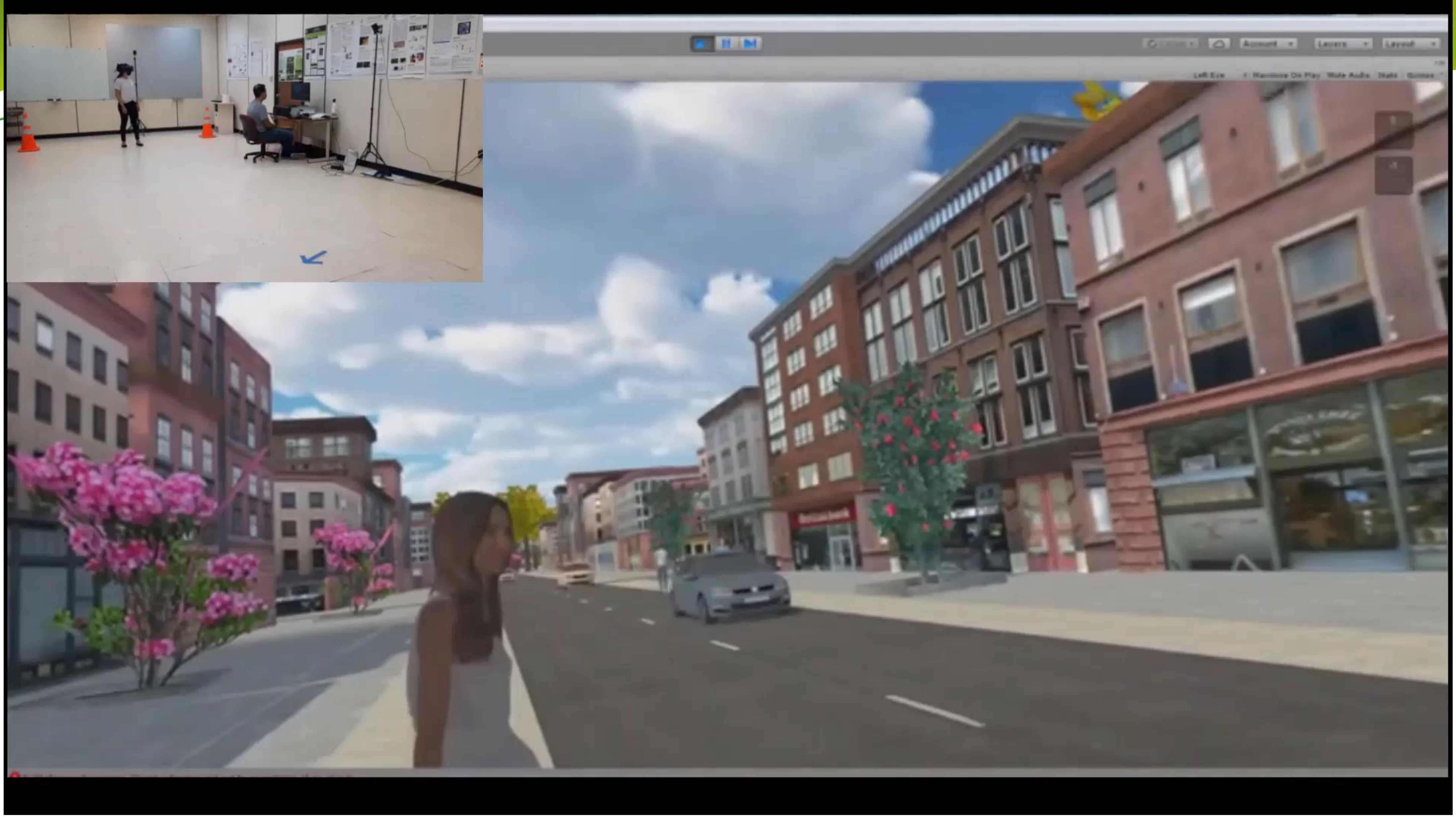
- Analyze pedestrian behavior when making the decision to cross an urban street.
  - Capacity to select a safe gap between vehicles
  - Ability to respond to high-risk situations
  - Choose the proper walking speed

Urban Street Context

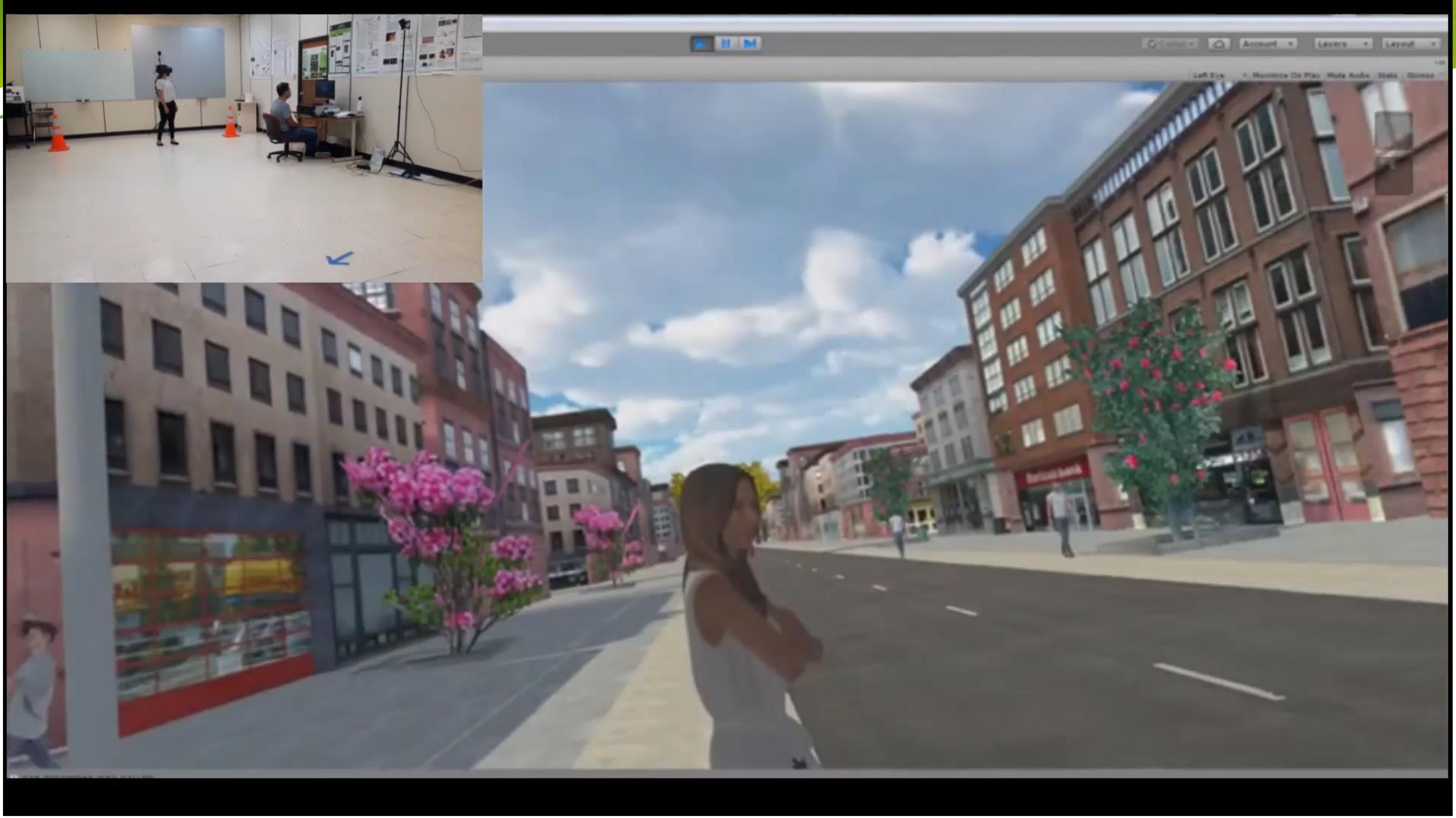
Description of VR Scenarios

One-Lane Street Configuration					
Scenario	Gaps (s)	Traffic Speed	Scenario	Gaps (s)	Traffic Speed
1	2 to 5	15 mph (24 kph)	4	2 to 5	25 mph (40 kph)
2	3		5	3	
3	5		6	5	
Two-Lane Street Configuration					
7	2 to 8	15 mph (24 kph)	8	2 to 8	25 mph (40 kph)

- Three groups of 16 subjects, equally divided in men and women.
- Four age categories (18-25, 26-45, 46-65, > 65)
- Subjects in the one-lane configuration observed each scenario four times.
- Subjects in the two-lane configuration observed each scenario five times.



Video of Simulation Run



Video of Simulation Run

Video of Simulation Run

Gap Accepted and Gaps Observed Results

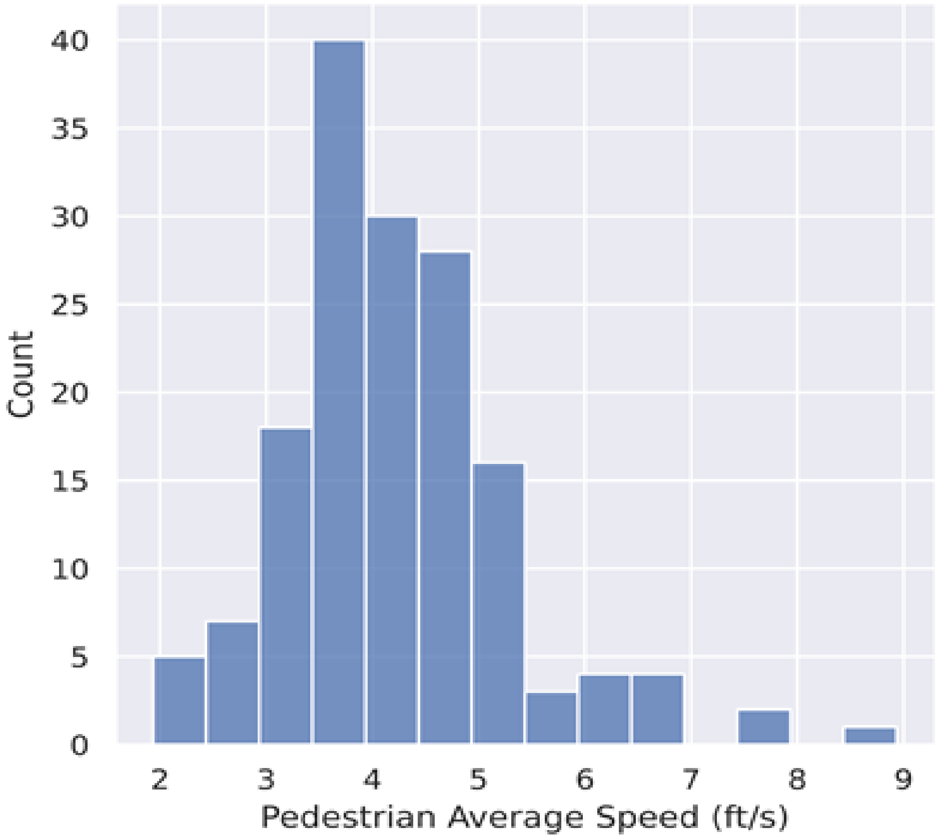
	Gap Accepted (s)		Frequency of Gaps Observed	
Factor	Average Value	Standard Deviation	Average Value	Standard Deviation
Overall	4.48	1.45	4.8	11.3
Age				
18-25 years old	4.40	1.43	3.8	5.7
26-45 years old	4.48	1.31	3.0	3.5
46-65 years old	4.51	1.65	3.8	6.7
66-85 years old	4.54	1.40	8.7	20.5
Gender				
Female	4.50	1.38	4.2	9.3
Male	4.47	1.52	5.4	13.0
Vehicle Speed				
15-mph	4.64	1.50	4.5	9.5
25-mph	4.32	1.38	5.0	13.0
Number of lanes				
1-lane	4.00	1.03	5.6	12.7
2-lane	5.60	1.66	3.0	6.8

OLS Model of the Gap Accepted to Cross

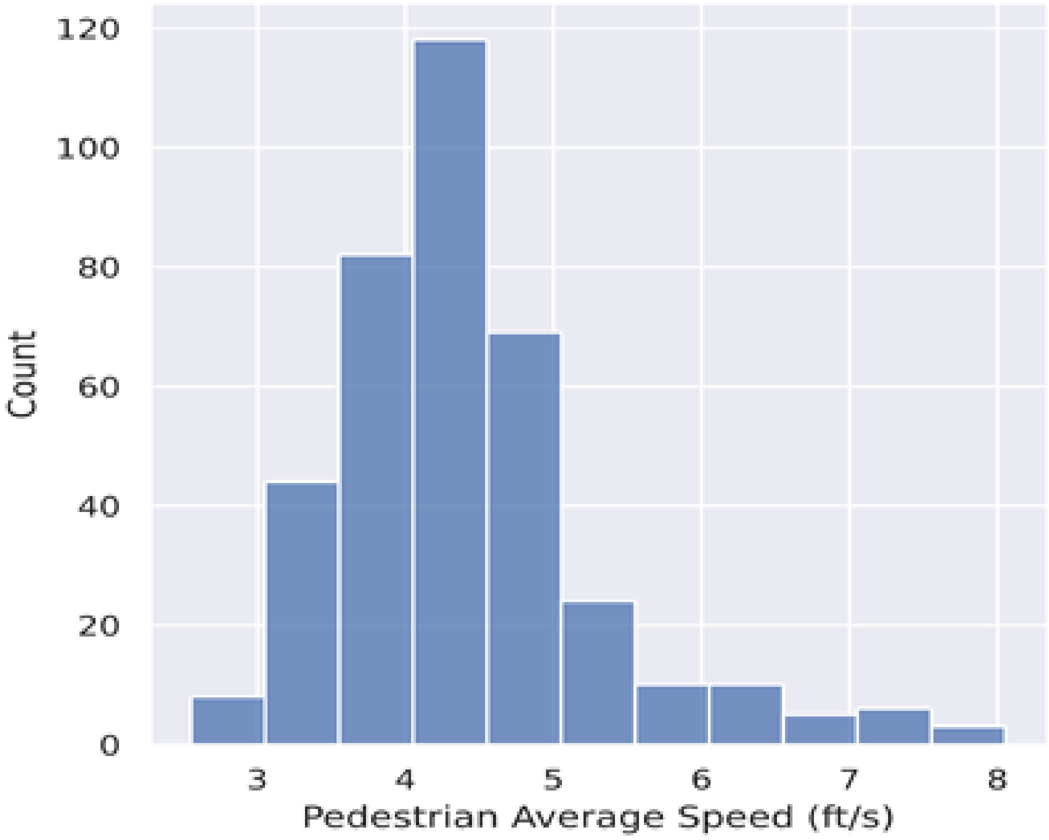
Parameter	Level	Base Model	Model w/Interactions
Constant		3.78 (<0.001)	3.89 (<0.001)
Age	26-45 years old	0.04 (0.77)	0.04 (0.77)
	46-65 years old	0.09 (0.54)	0.08 (0.55)
	66-85 years old	0.19 (0.21)	0.19 (0.21)
Gender	Male	0.002 (0.93)	-0.15 (0.21)
Vehicle Speed	25-mph	-0.30 (<0.001)	-0.30 (<0.001)
Number of lanes	2-lane	1.92 (<0.001)	1.66 (<0.001)
Gap fixed	3-s and 5-s gaps	0.59 (<0.001)	0.59 (<0.001)
Gaps observed	Continuous	-0.19 (<0.001)	-0.01 (<0.001)
Gender-# of lanes	Male + 2-lane	----	0.53 (0.02)
Adjusted R^2		29.7%	33.1%

Average Walking Speed Distributions

One-lane Street



Two-lane Street



OLS Models of the Logarithmic Transformation of Walking Speed

Parameter	Level	Base Model	Model w/Interactions
Constant		1.50 (<0.001)	1.48 (<0.001)
Age	26-45 years old	-0.09 (<0.001)	-0.07 (0.08)
	46-65 years old	0.04 (0.06)	0.06 (0.13)
	66-85 years old	-0.11 (<0.001)	-0.11 (<0.001)
Gender	Male	0.02 (0.16)	0.10 (<0.001)
Vehicle speed	25-mph	0.003 (0.84)	0.03 (0.35)
Number of lanes	2-lane	-0.02 (0.54)	-0.07 (0.06)
Gap accepted	Continuous	-0.01 (0.20)	-0.01 (0.19)
Gap fixed	3-s and 5-s gaps	0.03 (0.13)	0.03 (0.10)
Age-Gender	26-45 yrs. old-male	--	0.09 (0.04)
	46-65 yrs. old-male	--	-0.25 (<0.001)
	66-85 yrs. old-male	--	-0.03(0.45)
Age- Number of lanes	26-45 yrs. old-2lanes	--	-0.01 (0.74)
	46-65 yrs. old-2lanes	--	0.10 (0.02)
	66-85 yrs. old-2lanes	--	0.13 (<0.001)
Age-Vehicle speed	26-45 yrs. old-25mph	--	-0.13 (<0.001)
	46-65 yrs. old-25mph	--	0.15 (<0.001)
	66-85 yrs. old-25mph	--	-0.04 (0.30)
Gender-Vehicle Speed	Male-25 mph	--	-0.06 (0.05)
Adjusted R^2		10.9%	27.9%

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Street Crossing Success Rates

Scenario	Vehicle Speed (mph)	One-Lane Road	Two-Lane Road
1 2-5s gaps	15	0.983	1.000
	25	0.984	0.987
2 3-s gap	15	0.984	
	25	0.812	
3 5-s gap	15	1.000	
	25	0.984	

- Three age groups exhibited a better success crossing rate in the two-lane street than in the one-lane street.
- When comparing age groups in the one-lane street, the worst crossing success rate was observed for the 66-85 age group with 88.5%.

Logit Model for the Probability of a Subject Being Hit by a Vehicle

Parameter	Coefficient	Standard Error	P-value
Age	0.467	0.273	0.08
Gender	-0.793	0.614	0.196
Vehicle speed	0.123	0.052	0.018
Gap Accepted	-0.615	0.337	0.068
Gap seen	0.009	0.007	0.175
Gap fixed-3s	2.186	0.748	0.003
Walking speed	-1.352	0.355	<0.001
Log-likelihood	-49.246	Pseudo r-square	0.35
P-value	<0.0001		

Conclusions and Recommendations

- Older subjects had the greatest problem to cross the street.
- Gap accepted increased with the number of lanes and decreased with the vehicle speed and the number of gaps watched before crossing.
- Age and gender, the number of lanes, and the fixed gap were significant factors of walking speed.
- The probability of being hit by a vehicle when crossing increases with age, higher vehicle speeds, and shorter gaps between vehicles. In contrast, it decreases with larger gaps accepted to cross and the walking speed.
- The application of innovative safety countermeasures, such as new traffic control devices, and the impacts on road user behavior can potentially be studied using VR technology as part of experimental procedures considered for future traffic control devices.
- It is recommended to expand the VR experiment to study crossings on curves, unsignalized intersections and roundabouts.

Thanks for your attention!

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