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IMPROVED SAFETY AND EFFICIENCY OF PROTECTED/PERMITTED RIGHT TURNS IN OREGON

ITE WESTERN DISTRICT MEETING
KEYSTONE, COLORADO
JUNE 25, 2018

Research Team:

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Objectives

- Understand and assess driver comprehension and response to the FYA for right turns
- Develop an understanding of the safety and operational implications of using the FYA for permitted right-turns

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Research Methods

Oregon Driver Survey

- Determine driver comprehension for PPRT phasing alternatives.
- Identify potential factors for microsimulation and driving simulator study.

Simulation of PPRT in Oregon

- Software in the loop
- Evaluate the operational performance of PPRT phasing.
- Identify potential factors for driving simulator study.

Oregon Driving Simulator Study

- Evaluate PPRT phasing alternatives for potential conflicts with active transportation through surrogate safety measures.

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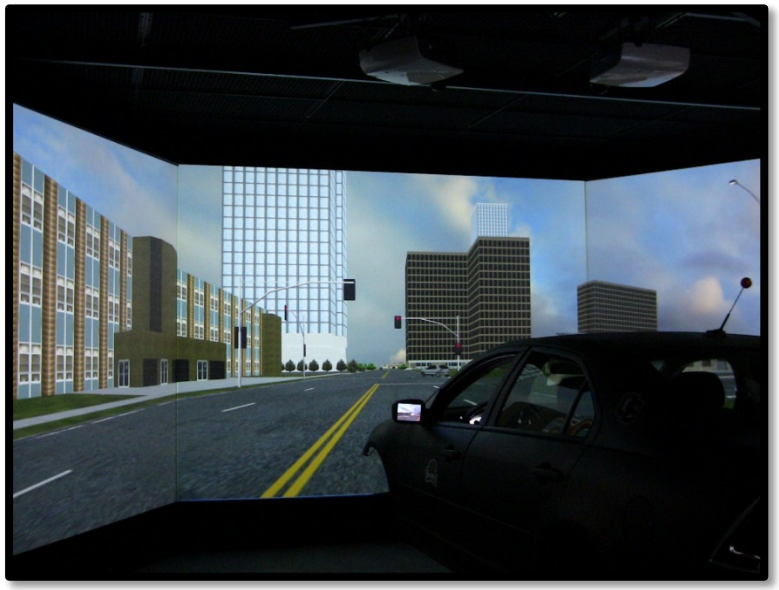
OSU Driving Simulator

View from outside the car



View from inside car w/ ped crossing

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Independent Variables & Levels

VARIABLE	ACRONYM	CATEGORY	LEVEL	LEVEL DESCRIPTION	
Signal Head	SHA	Nominal (categorical)	1	CR: Circular Red	
			2	CG: Circular Green	
	SHB		1	SRA: Solid Red Arrow	
			2	SGA: Solid Green Arrow	
			3	FYA: Flashing Yellow Arrow	W: Walk interval
					C: Clearance walk interval
Geometry	G	Discrete	1	TB1: Right-turn bay length 1: 50 ft	
			2	TB2: Right-turn bay length 2: 100 ft	
Pedestrians	P	Discrete	1	No pedestrians crossing	
			2	Pedestrians crossing	

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Experimental Scenarios

T #	RT #	SIGNAL HEAD	BAY LENGTH (ft)	PEDESTRIAN
Grid 1				
6	1	FYAC	50	None
22	2	SGA	100	Pedestrian crossing
9	3	SRA	100	None
14	4	CG	50	Pedestrian crossing
Grid 2				
23	1	FYAW	100	Pedestrian crossing
8	2	CG	100	None
2	3	CG	50	None
18	4	FYAC	50	Pedestrian crossing
Grid 3				
19	1	CR	100	Pedestrian crossing
5	2	FYAW	50	None
7	3	CR	100	None
4	4	SGA	50	None
Grid 4				
20	1	CG	100	Pedestrian crossing
12	2	FYAC	100	None
10	3	SGA	100	None
21	4	SRA	100	Pedestrian crossing
Grid 5				
16	1	SGA	50	Pedestrian crossing
1	2	CR	50	None
11	3	FYAW	100	None
17	4	FYA	50	Pedestrian crossing
Grid 6				
3	1	SRA	50	None
13	2	CR	50	Pedestrian crossing
15	3	SRA	50	Pedestrian crossing
24	4	FYAC	100	Pedestrian crossing

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Intersection Layout

With 50 ft exclusive right turning bay

With 100 ft exclusive right turning bay

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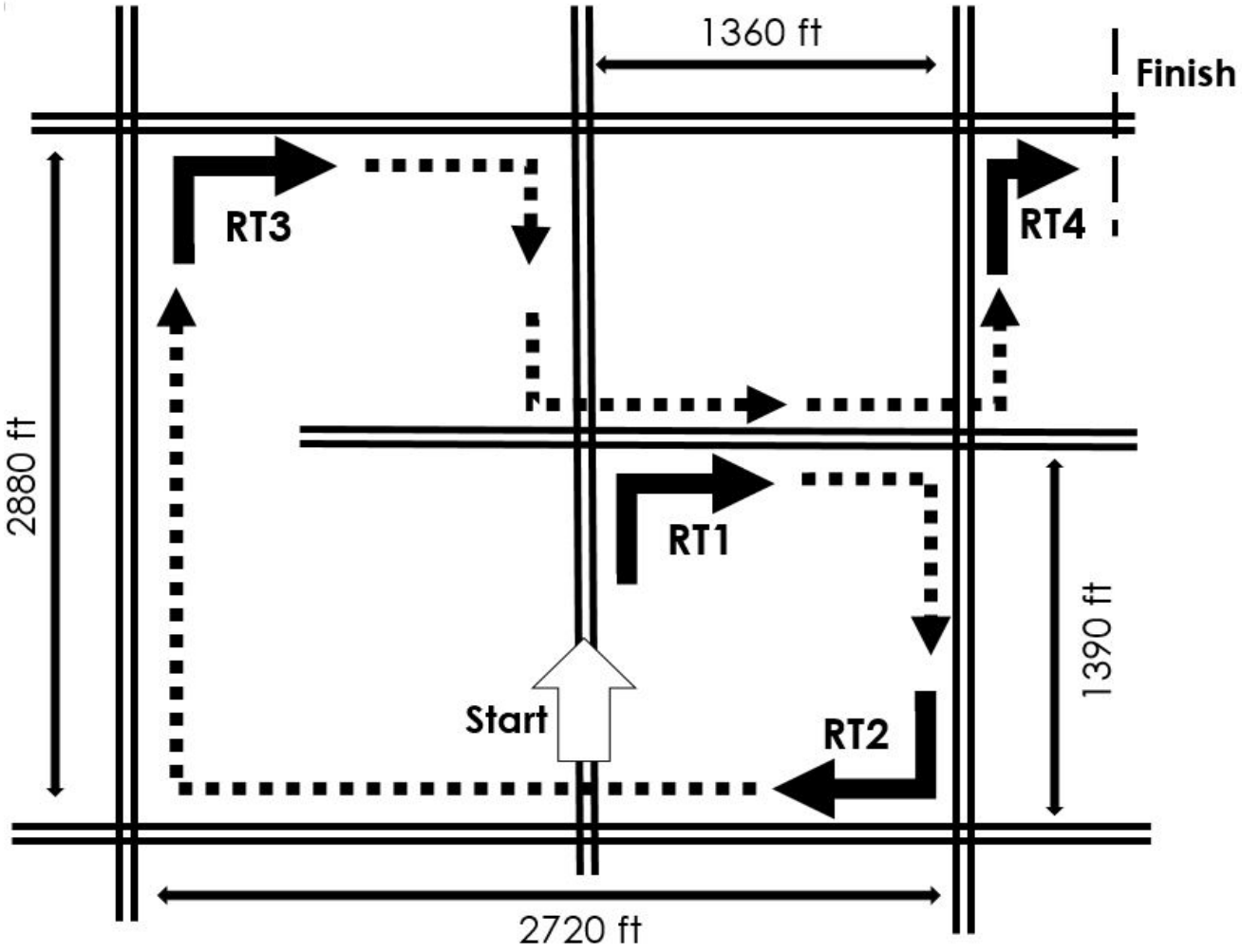
Example Experimental Trial w/ 4 Scenarios



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Experiment – Data Acquisition

Participants:

- 52 Participated
- 5 Simulator Sickness
- 1 calibration issue
- 46 Usable
- 1,104 total-right turn scenarios

Data:

- Visual attention
- Observed driver behavior
- Position and speed of vehicles, and pedestrians
- Pre-post survey

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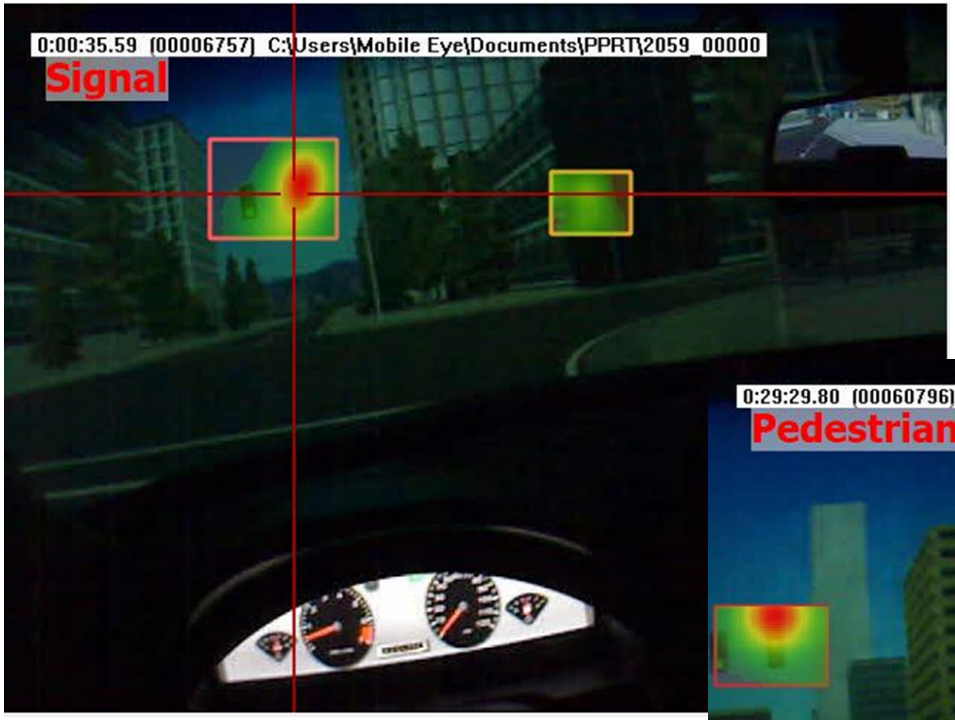
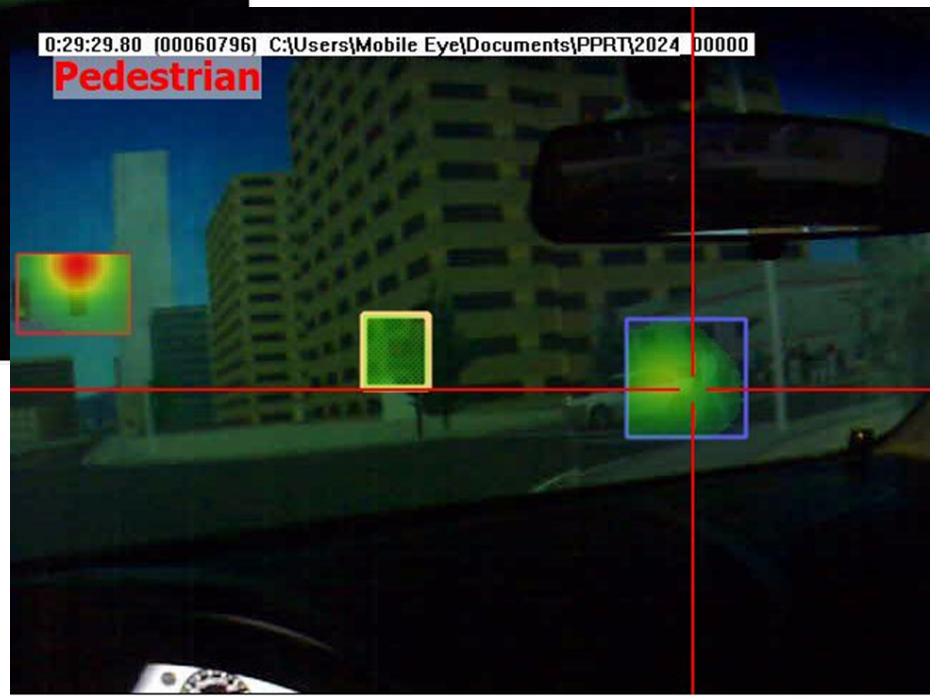
Visual Attention – Areas of Interest (AOIs)





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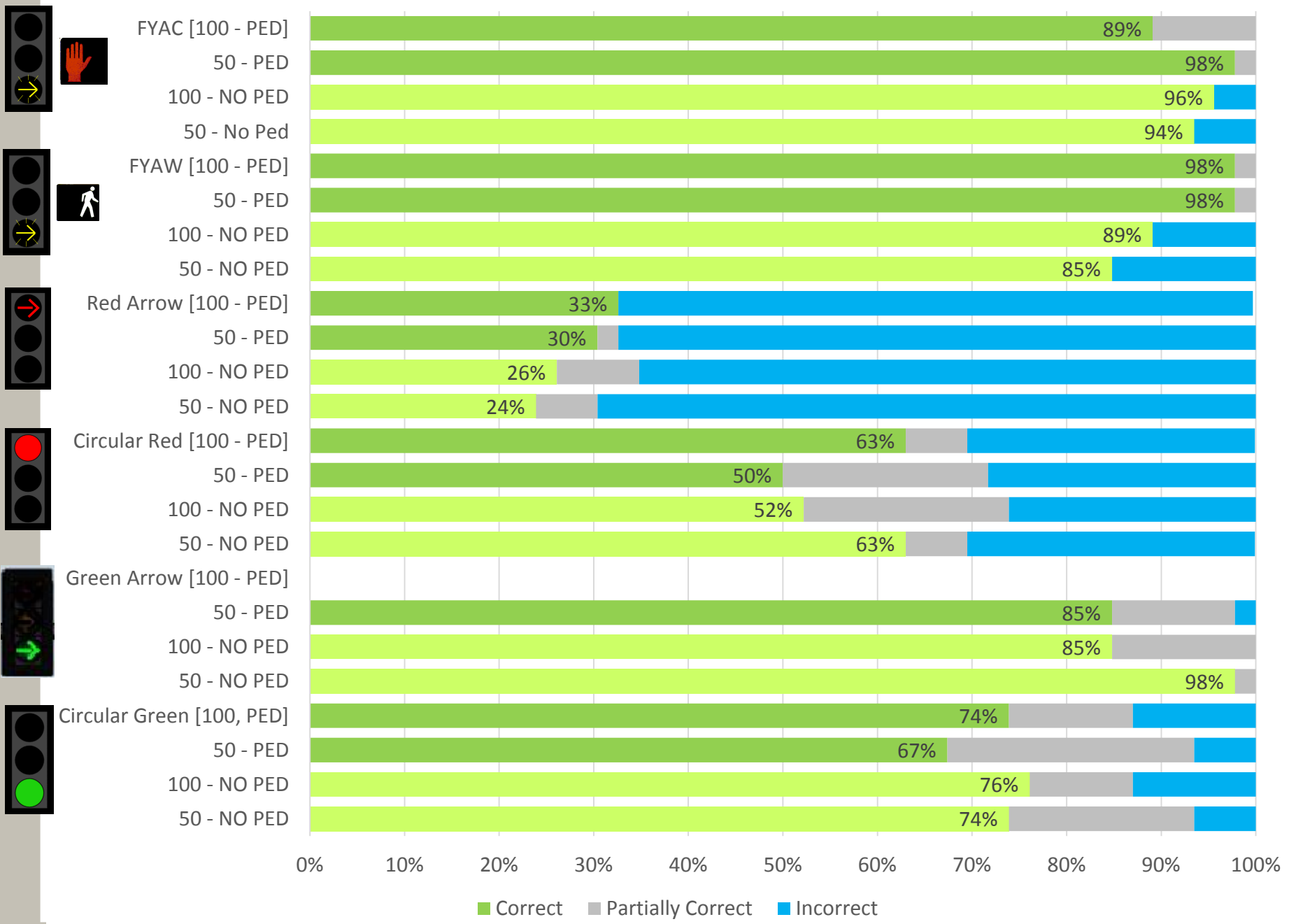
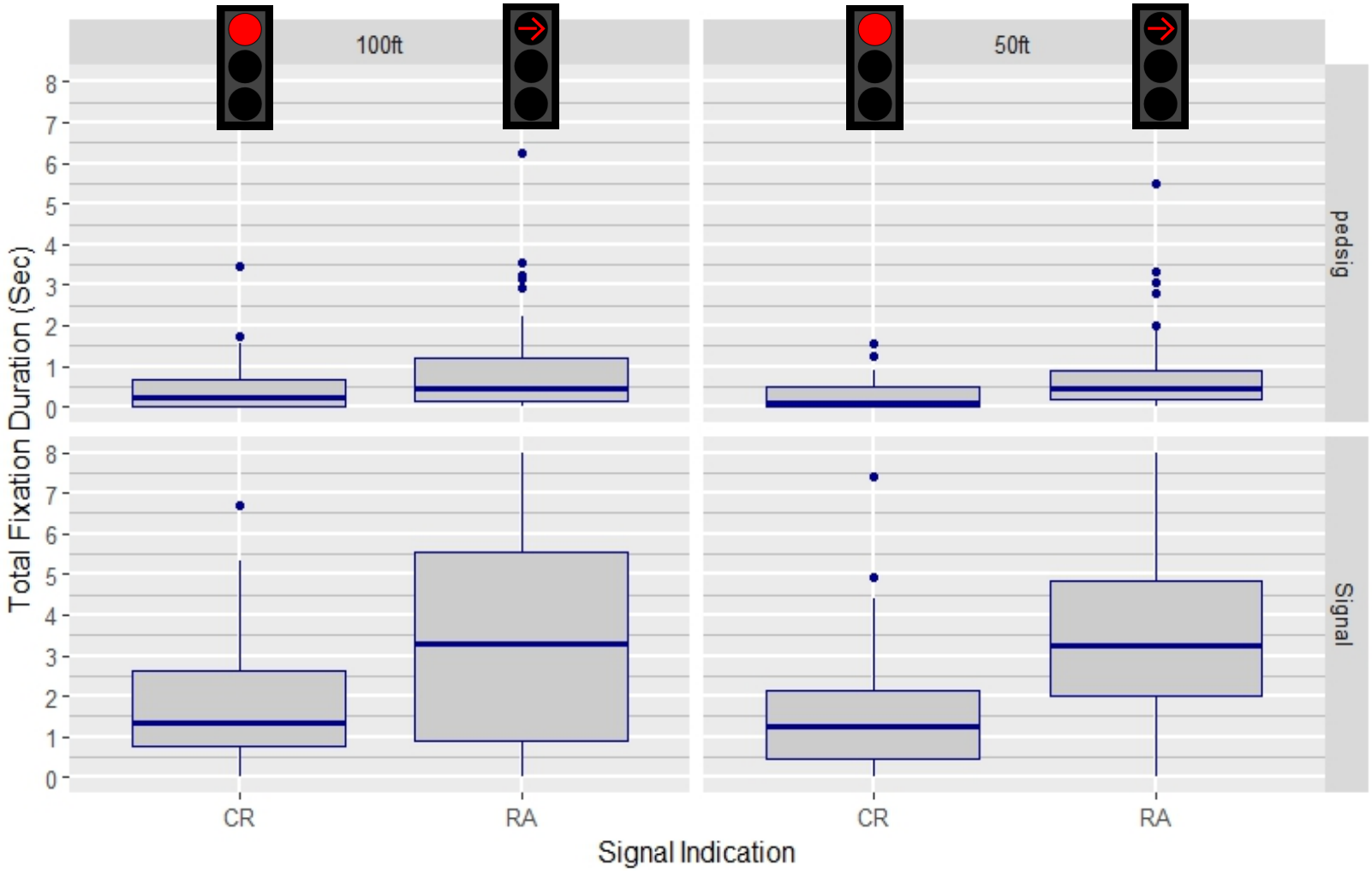
Error Coding of Observed Behavior

if respondents indicated that they would…	Correct	Partially Incorrect	Incorrect
Steady Circular Green	Turn right with caution after yielding to pedestrians (if present) in the crosswalk	Turn without checking for pedestrians even though the walk indication was displayed (or) not checking before turning but stopping once they saw a pedestrian	Stop before turning (vehicle speed < 1 mph) to check for pedestrians (or) A crash with a pedestrian
Steady Green Arrow	Turn right without stopping, recognizing that the SGA indicates a protected right-turn movement	Check for pedestrians and turn right (or) Slow down and check for pedestrians and other cross traffic but did not recognize the protected movement in either case	Stop before turning (some noted remain stopped until the signal display became green)
Steady Circular Red *&* *Steady Red Arrow*	Come to a complete stop (vehicle speed < 1 mph) and complete the turn when they find a safe gap	Turn right without coming to a complete stop (Vehicle speed > 1 mph)	Stop and remain stopped until the green indication
Flashing Yellow Arrow	Turn right with caution after yielding to pedestrians (if present) in crosswalk	Turn right without caution (vehicle speed >15 mph) (or) Not yielding when necessary	Stop before turning (vehicle speed < 1 mph) to check for pedestrians, (or) Remain stopped until the green indication


FYAC [100 - PED]
89%
50 - PED
98%
100 - NO PED
96%
50 - No Ped
94%
FYAW [100 - PED]
98%
50 - PED
98%
100 - NO PED
89%
50 - NO PED
85%
Red Arrow [100 - PED]
33%
50 - PED
30%
100 - NO PED
26%
50 - NO PED
24%
Circular Red [100 - PED]
63%
50 - PED
50%
100 - NO PED
52%
50 - NO PED
63%
Green Arrow [100 - PED]
50 - PED
85%
100 - NO PED
85%
50 - NO PED
98%
Circular Green [100, PED]
74%
50 - PED
67%
100 - NO PED
76%
50 - NO PED
74%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Correct
Partially Correct
Incorrect

Visual Attention – Total Fixation Duration (TFD)



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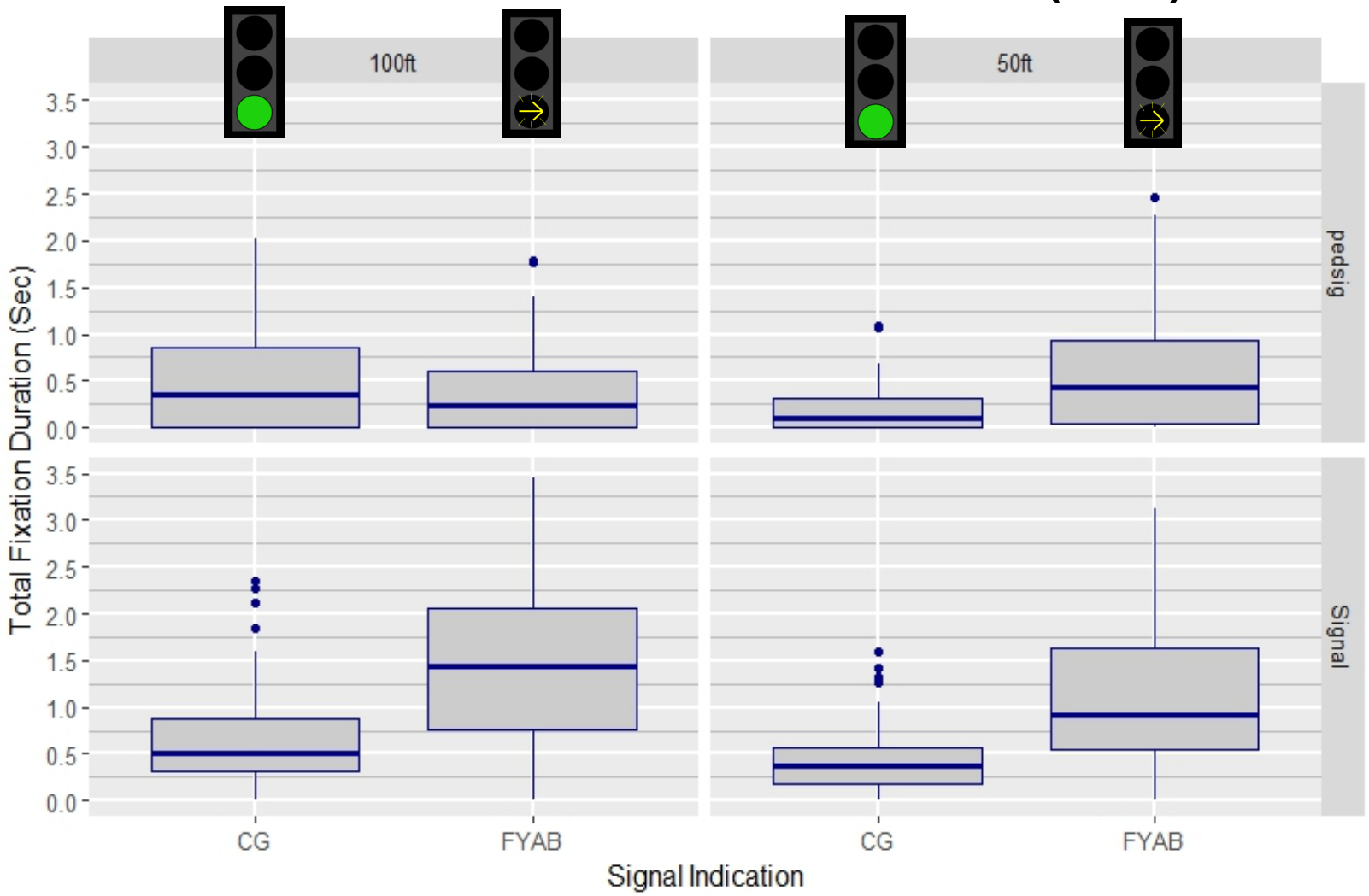
Visual Attention – Total Fixation Duration (TFD)



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Comparison: Indications that require driver yielding

- **Steady Circular Green**
  - Results between survey and driving simulator are consistent.
  - Survey (73%) and simulator (67 – 74%) simulator correct response.
  - Partially correct responses resulted from respondents failing to state in the survey (25% of the sample) or to demonstrate in the simulator (by near misses with pedestrians; 10%-19% of right turns) that they would yield to pedestrians

- **Flashing Yellow Arrow**
  - Results between survey and driving simulator are consistent.
  - Survey (77%) and simulator (84-95%) simulator correct response
  - Incorrect responses (stop) were fail-safe.
  - Evidence of better driver yielding to pedestrians.

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Comparison: Indications that require driver stop

- **Steady Circular Red**
  - Results between survey and driving simulator are not as comparable.
  - Correct survey responses (83%) were higher compared to the simulator experiment (50-63%) primarily dues to high “stop and stay stop” behaviors (could be carryover effect from RA.
  - Incorrect responses generally were a result of fail-safe actions.
- **Steady Red Arrow**
  - Results between survey and driving simulator are consistent.
  - Evidence of significant misunderstanding of the steady red arrow indication from both survey and simulator experiment as correct responses were 52% (survey) and 23-33% (simulator).
  - Only 50% of the survey respondents stated that both displays have the same meaning.

Comparison of Results: Indications that communicate the movement is exclusive

- **Steady Green Arrow**
  - In survey, partially correct responses were coded if drivers indicated that they would check for pedestrians or other users before turning right (32%) but only 13% of drivers in the simulator experiment.
  - This is a fail-safe response.

Limitations of Research

Simulator

- Potential for fatigue effects.
- Limited number and levels of variables were evaluated.

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Recommendations for Practice

- Expand use of FYA in PPRT operation
  - Overall, research evidence suggests that the FYA encourages better driver response preferred over the circular green display for permissive operation, particularly in the presence of pedestrian movements.
- Recommend the use of R10-17a sign at locations using the STEADY RED ARROW

R10-17a

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Questions?

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