6-9-2022

Assessing the Impact of Three Intersection Treatments in a Bicycling Simulator

Logan Scott-Deeter
Oregon State University

David Hurwitz
Oregon State University

Brendan Russo
Northern Arizona University

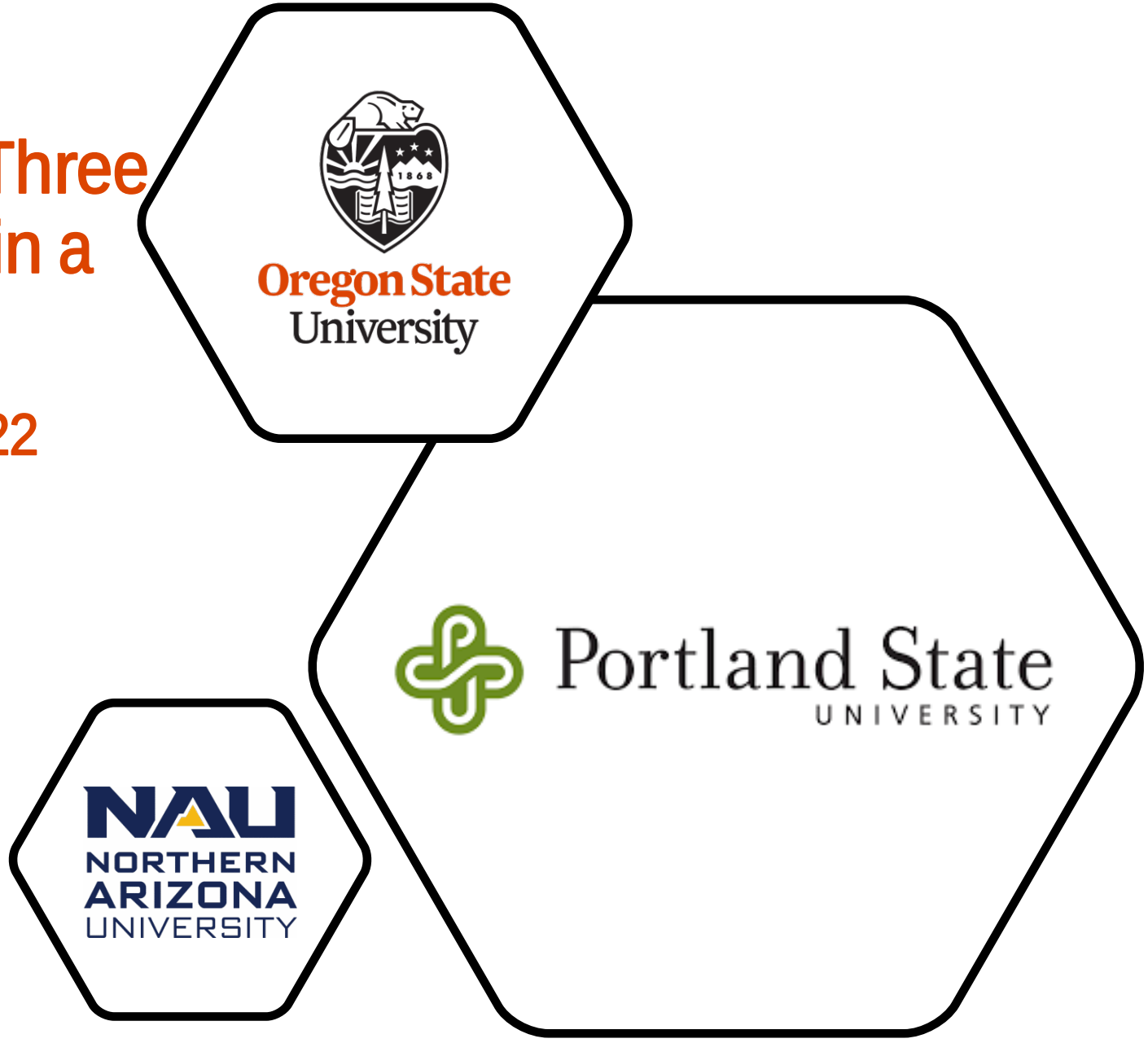
Edward Smaglik
Northern Arizona University

Sirisha Kothuri
Portland State University, skothuri@pdx.edu

Assessing the Impact of Three Intersection Treatments in a Bicycling Simulator

Road Safety and Simulation 2022
Presented on June 9th, 2022

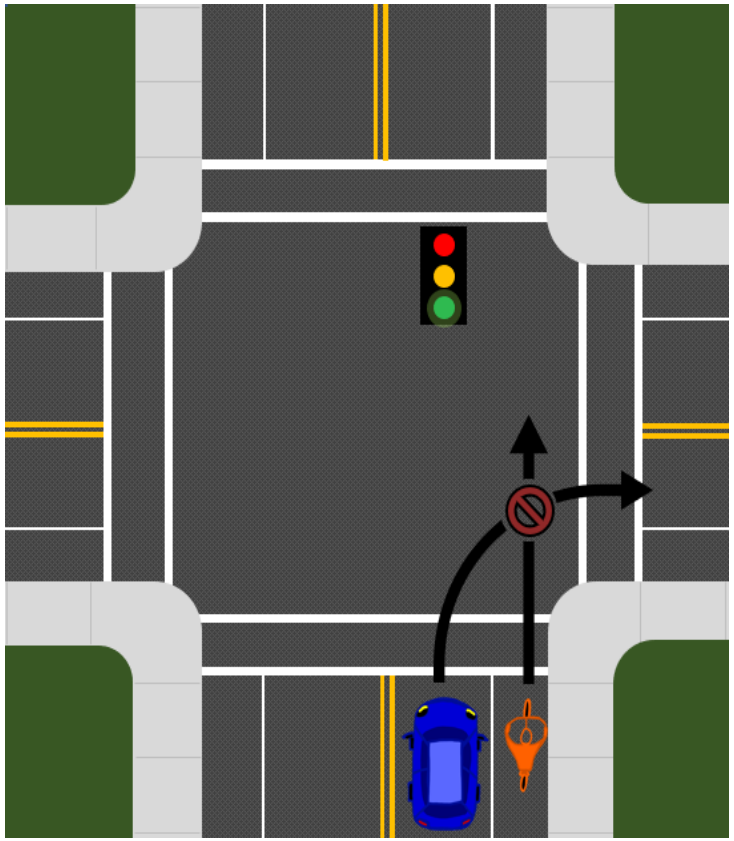
Logan Scott-Deeter, MSCE
Oregon State University
David Hurwitz, PhD
Oregon State University
Brendan Russo, PhD
Northern Arizona University
Edward Smaglik, PhD
Northern Arizona University
Sirisha Kothuri, PhD
Portland State University

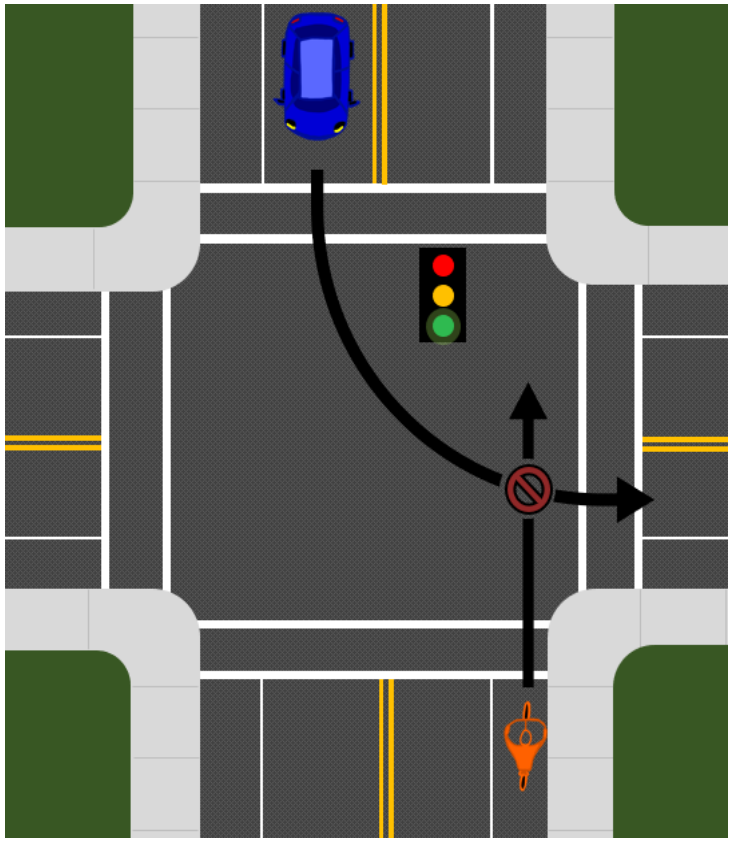


Motivation

- There have been proven economic, health, and environmental benefits associated with biking (Simmons et al., 2015)
- 857 bicyclist fatalities in the US 2018 (NHTSA, 2020)
  - o Due to crashes with vehicles
  - o 79% occurred in urban environments
- Improved safety can promote more bicyclists
- Assess three treatments and their effectiveness at reducing right and left hook crashes

Right and Left Hook Crashes





Bike Box

- Adopted from the advanced stop bar
  - o Common in European countries
- Provides bicyclist with a “waiting area”
  - o Helps assist turning or through bicyclists
  - o Makes cyclist more visible to motorists
- Unique pavement markings and geometry

Bike box in Portland, OR

R10-6a Sign

Bicycle Signal

- Dictates movement of bicyclists
  - o Separate phase from vehicular signals
- Distinguishable by bicycle icon or housing unit color
- MUTCD guidelines require:
  - o 8- or 12- inch diameter
  - o Accompanied by R10-10B sign

Bicycle signal in Portland, OR

R10-10b Sign

Mixing Zone

- Mixing zone with yield entry markings
- Brings the right-hook crash potential back from the intersection
  - o Reduces mental load at intersection
- Allows bicyclists to claim the lane
  - o Requires vehicles to yield to bicyclists
  - o Provides opportunity to move away from turning side of the vehicle

Mixing zone in Portland, OR

OSU Bicycling Simulator

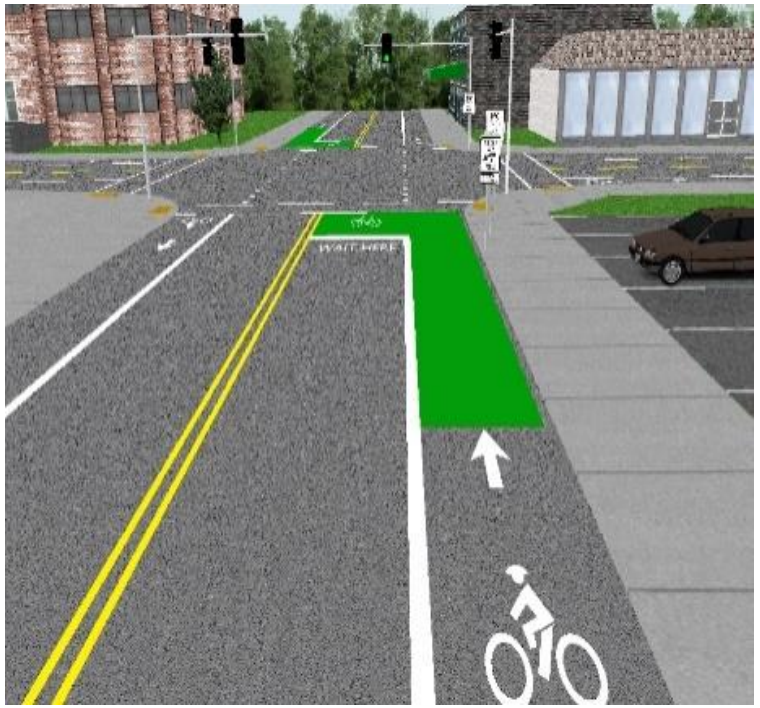
Experimental Equipment

- OSU Bicycling Simulator
  - o Outputs instantaneous time-space data about rider
- ASL Mobile Eye XG
  - o Provides fixation and saccade data
- Shimmer3 GSR Device
  - o Measures skin conductance

GSR (top) and eye tracking (bottom) equipment

Field to Simulator – Bike box

Bike box in real-world



Modeled for simulator

Field to Simulator – Bicycle Signal

Bicycle Signal in real-world

Modeled for Simulator

Field to Simulator – Mixing Zone

Mixing zone in real-world

Modeled for Simulator

Experimental Design

- Variables of Interest
  - Conflict type
  - Treatment
  - Stopping requirement
- Performance Measures
  - Survey
  - Lateral position
  - Conflict recognition
  - Level of stress

Independent Variable Levels

VARIABLE	CATEGORY	LEVEL	LEVEL DESCRIPTION
Type of Conflict	Nominal (categorical)	1	Right turning vehicle is arriving at intersection
		2	Right turning vehicle is waiting at intersection
		3	Left turning vehicle
		4	No conflicting vehicle
Intersection Treatment	Nominal (categorical)	1	Bike Box
		2	Bicycle Signal
		3	Mixing Zone
Stopping Requirement	Discrete	1	Red indication upon arrival
		2	Green indication upon arrival

Results – Pre Ride Survey

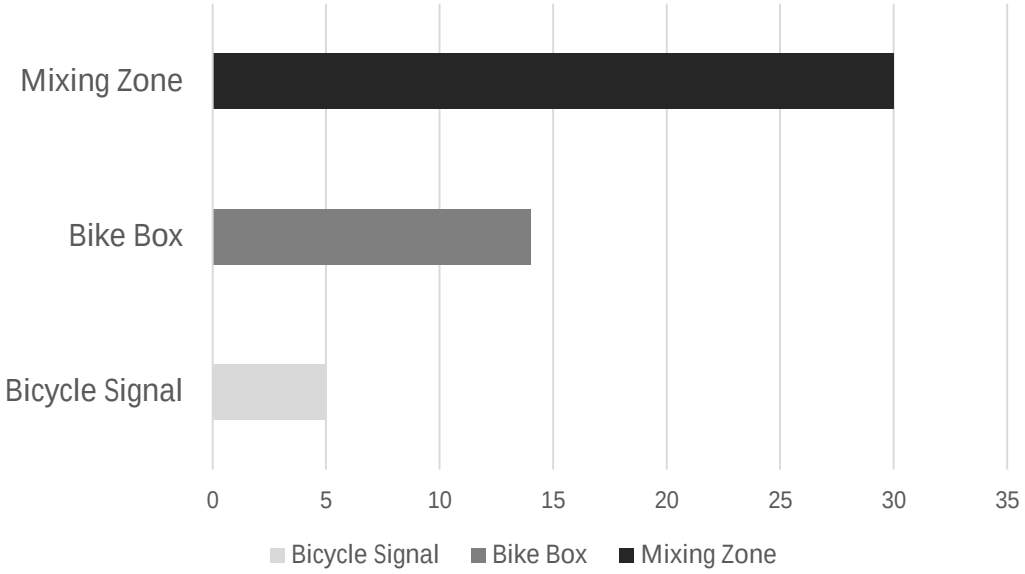
- 23 Female – 17 Male
- Well distributed in bicycling experience and frequency
- Majority of riders selected that they ride local
  - Local refers to riding around Corvallis, OR
  - Urban is a dense city environment
  - Rural is open land-use where majority is not buildings

Pre-ride survey response breakdown

Question	Response Options	# of Participants	% of Participants
How often do you ride a bike per week?	0 times	7	17.5
	1 time	10	25
	2-4 times	9	22.5
	5-10 times	11	27.5
	More than 10	3	7.5
How long do you ride a bike per week?	0-1 hour	18	45
	1-2 hours	7	17.5
	2-3 hours	6	15
	3-4 hours	2	5
	> 4 hours	7	17.5
What type of riding do you do?	Urban	8	20
	Rural	3	7.5
	Local	22	55
	None	7	17.5

Results – Post Ride Survey

- Majority of participants (90%) have not seen at least one treatment
  - o Indicates potential for more promotion of newer treatments
- 69% were uncomfortable approaching an unfamiliar design
- Additional free response question
  - o Asked for participants to indicate which treatment made them feel discomfort
  - o Participants were allowed >1 answer

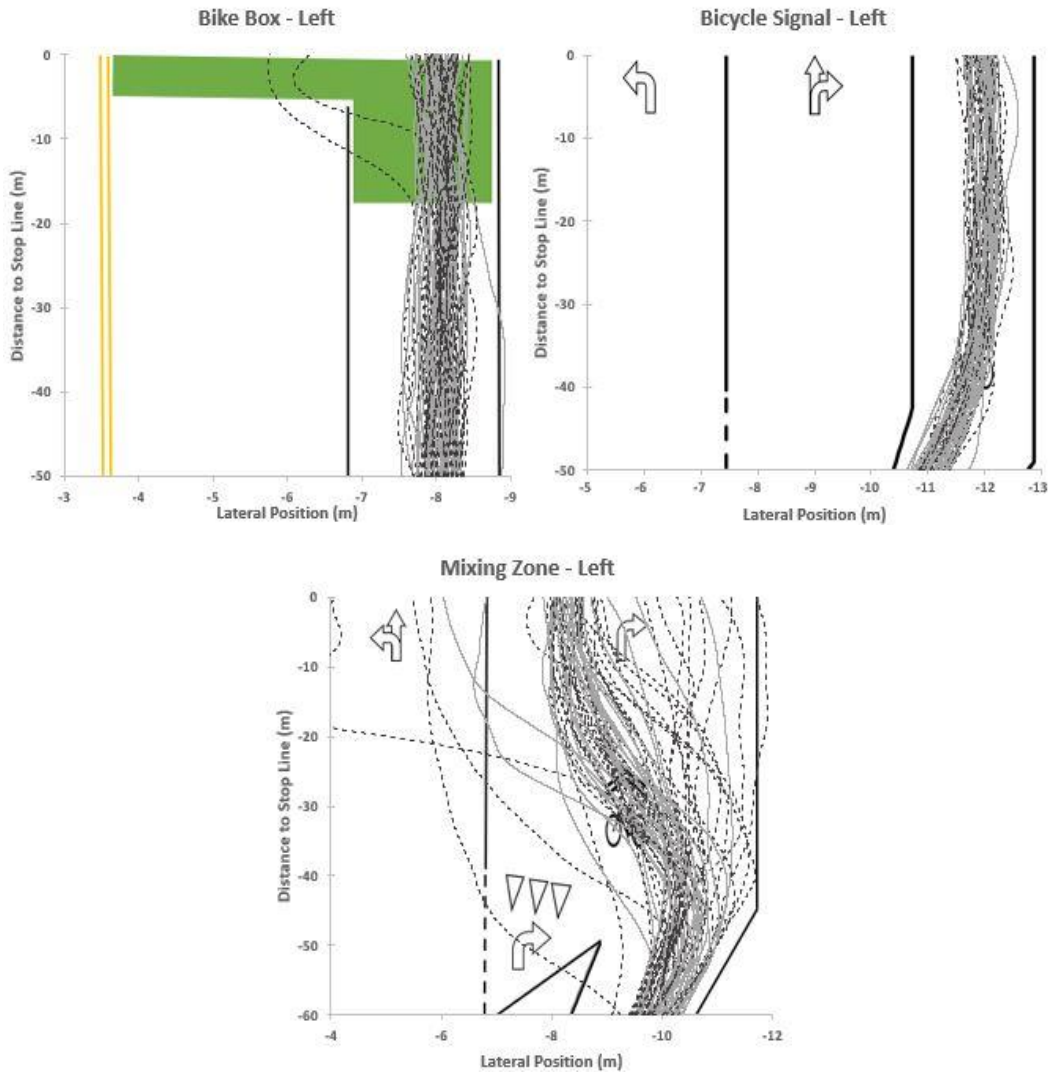


Participant response indicating discomfort traversing certain treatments

Results – Positioning

- Visualizations show participant movements
  - Dark/dotted line indicates red arrival
  - Grey/solid line indicates green arrival

- Assessed positioning using the offset from the center of lane



Statistical Analysis - Positioning

- Assessed positioning as offset from center of lane
  - Recommended by SAE Standards
- Average offset from lane center:
  - Mixing zone = 1.02 m
  - Bike box = 0.24 m
  - Bicycle signal = 0.17 m
- Repeated Measures ANOVA showed statistical significance
- Bonferroni Pairwise Comparison Test
  - Largest offset in Mixing zone

Statistical Analysis - Positioning

Bonferroni Comparison on Positioning

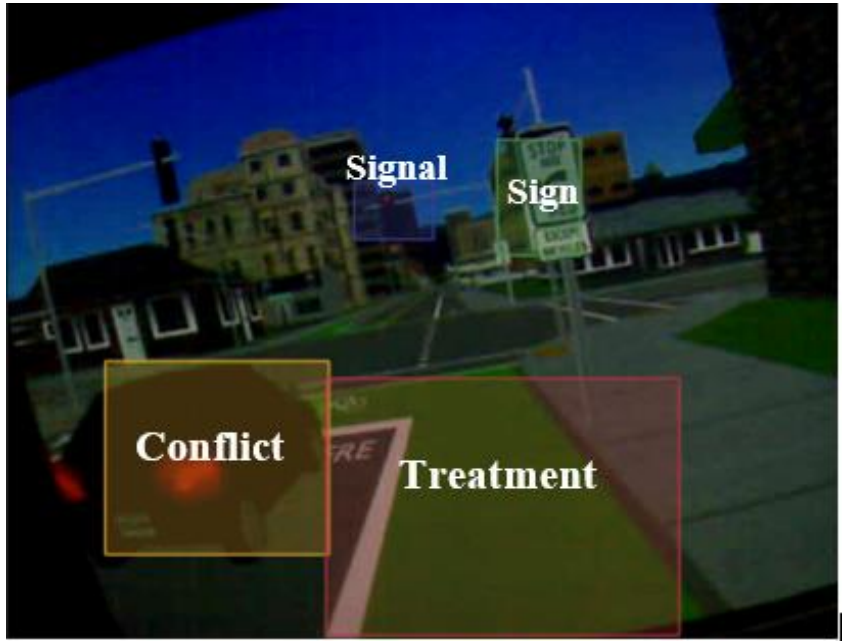
Treatment (i)	Treatment (j)	Estimate	SE	p-value	95% CI	
					Lower	Upper
Bike Box	Mixing Zone	0.782	0.153	<0.01*	0.399	1.166
	Bicycle Signal	-0.067	0.024	0.029*	-0.128	-0.005
Mixing Zone	Bike Box	-0.782	0.153	<0.01*	-1.166	-0.399
	Bicycle Signal	-0.849	0.160	<0.01*	-1.250	-0.448
Bicycle Signal	Bike Box	0.067	0.024	0.029*	0.005	0.128
	Mixing Zone	0.849	0.160	<0.01*	0.448	1.250

*Note: All measurements in meters

Results – Conflict Recognition

Visual attention was used to assess conflict recognition

Total Fixation Duration (TFD) on conflict vehicle



Results – Conflict Recognition

- Mixing zone resulted in largest TFD values
- Statistically significant result found from ANOVA test
  - o P-value<0.01
- Bonferroni Pairwise Comparison Test
  - o Mixing zone had TFD values of 1.9 and 2.8 seconds more
  - o Bicycle signal had lowest TFD values

Bonferroni test on Treatment type

Treatment (i)	Treatment (j)	Est.	SE	p	95% CI	
					Lower	Upper
Bike Box	Mixing Zone	-1.906	0.300	<0.01*	-2.686	-1.126
	Bicycle Signal	0.976	0.210	<0.01*	0.430	1.522
Mixing Zone	Bike Box	1.906	0.300	<0.01*	1.126	2.686
	Bicycle Signal	2.882	0.287	<0.01*	2.135	3.628
Bicycle Signal	Bike Box	-0.976	0.210	<0.01*	-1.522	-0.430
	Mixing Zone	-2.882	0.287	<0.01*	-3.628	-2.135

Recommendations

- All designs had positive and negative attributes
- Bicycle signal may be too safe
  - Did not require riders to perceive the potential conflict danger
- Mixing zone made participant feel uncomfortable
  - Although it promoted safe riding habits – participants did not enjoy
- Bike box provided a good balance of safety and functionality
  - No extreme findings – Improved safety without eliciting unsafe behaviors
- We recommend:
  - Bicycle signal be installed only when a clear need is present
  - Mixing zone be installed where fatal crashes occur
  - Bike box is the most versatile and can be installed most frequently

Acknowledgements

Thank you to the Oregon Department of Transportation for sponsoring this project (SPR 833)

Oregon State University

NAU
NORTHERN ARIZONA UNIVERSITY

Portland State UNIVERSITY