WHAT INTERACTIONS ARE HAPPENING IN MUNICH'S BICYCLE LANES?

(AND THE ROLE OF FACILITY DESIGN AND HUMAN BEHAVIOR)

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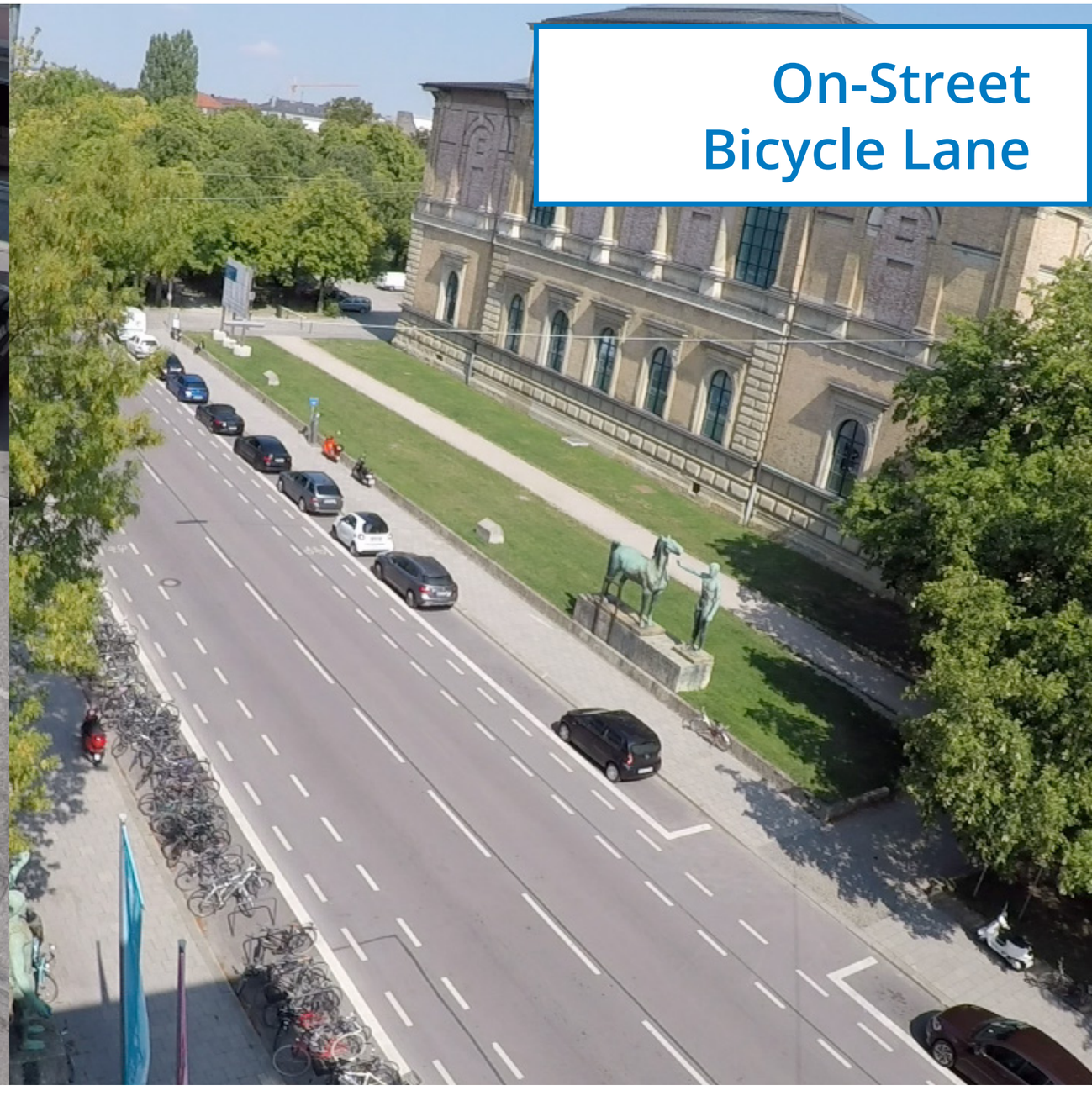
Final Conference of the
mobil.LAB Doctoral Research Group | September 14th, 2020

mobil.LAB Hans Böckler Stiftung TUM Portland State University

BICYCLE LANES

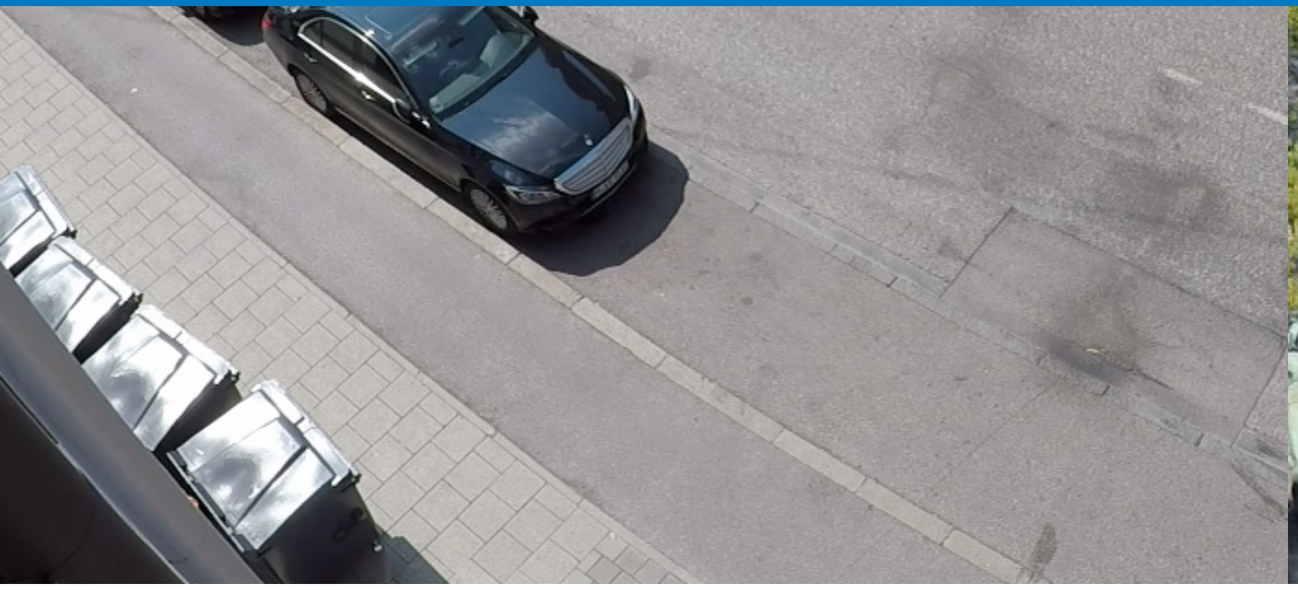
Bicycle Lane Along Sidewalk

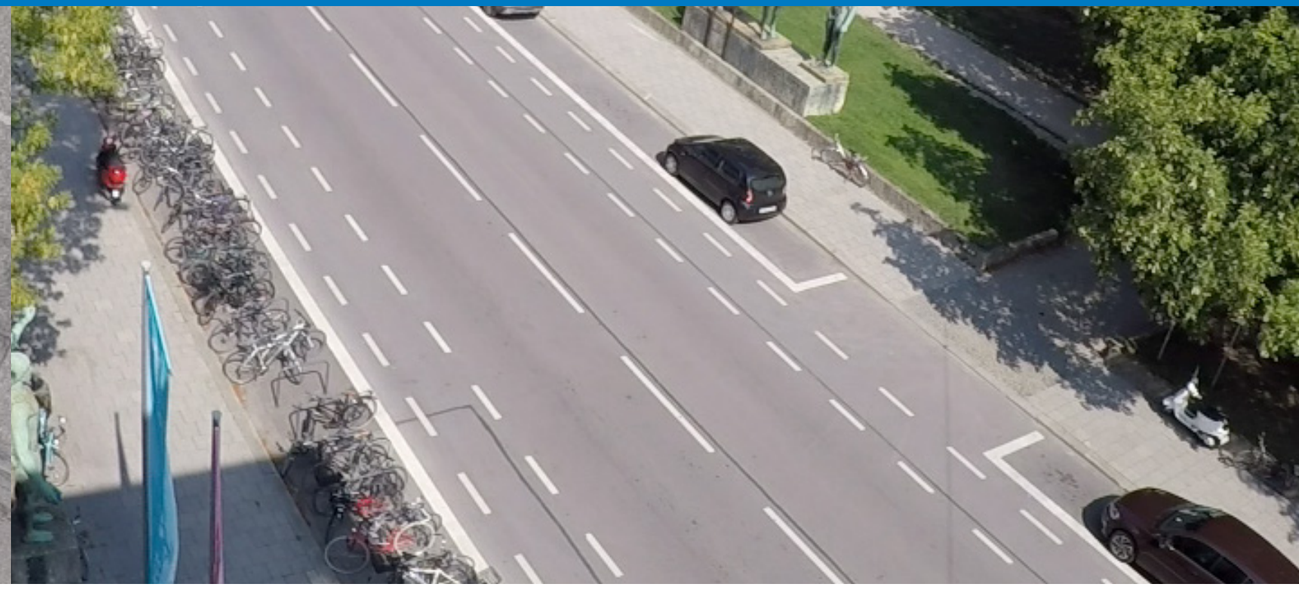
On-Street Bicycle Lane



COMPARING TWO LANE TYPES

Which type of bicycle lane is better?



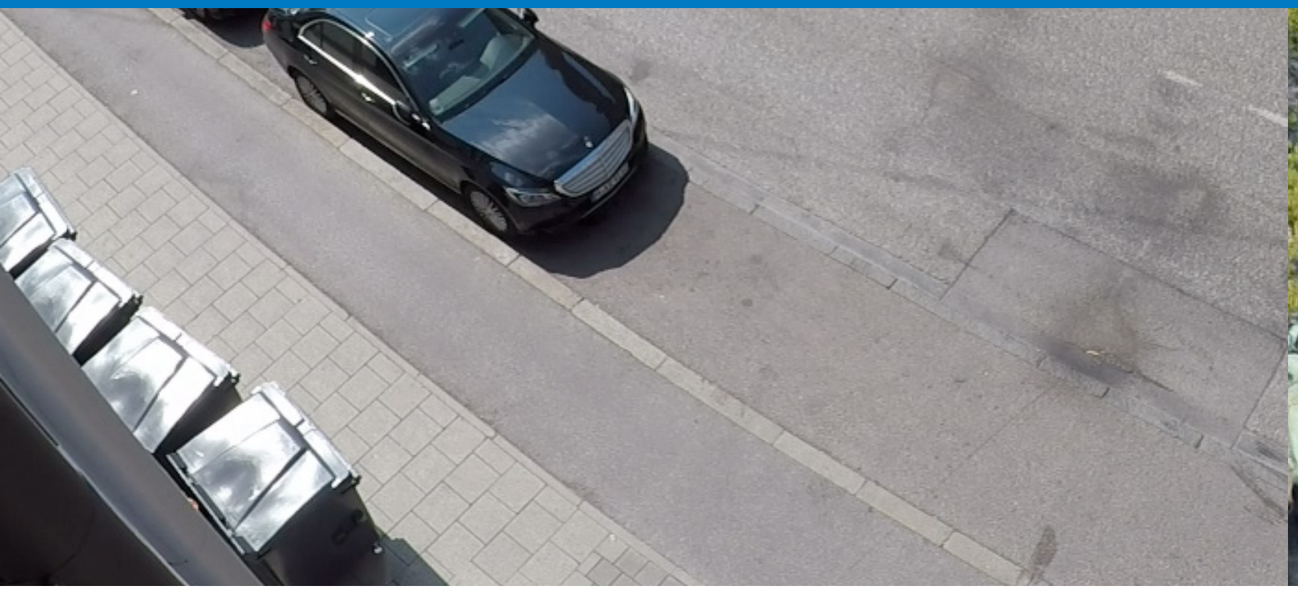


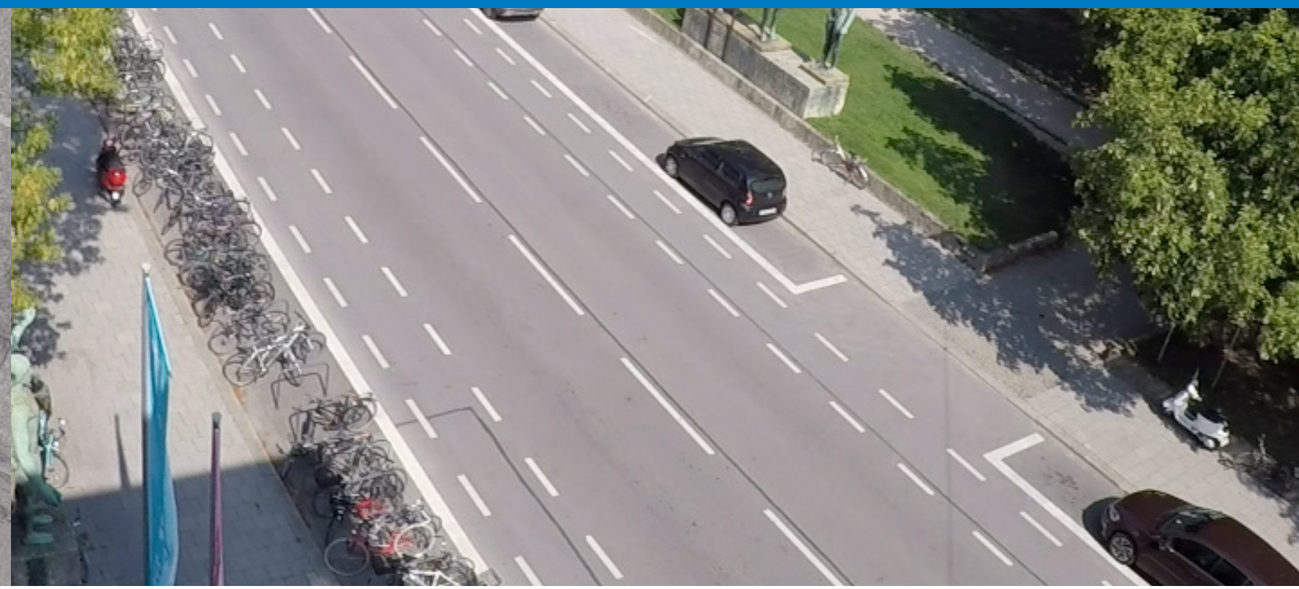
COMPARING TWO LANE TYPES

Bicycle Lane
Along Sidewalk

On-Street
Bicycle Lane

Which type of bicycle lane best meets the **goals** it was designed to achieve?





COMPARING TWO LANE TYPES

Bicycle Lane
Along Sidewalk

On-Street
Bicycle Lane

Which type of bicycle lane best meets the **goals** it was designed to achieve?

Safety

Mobility

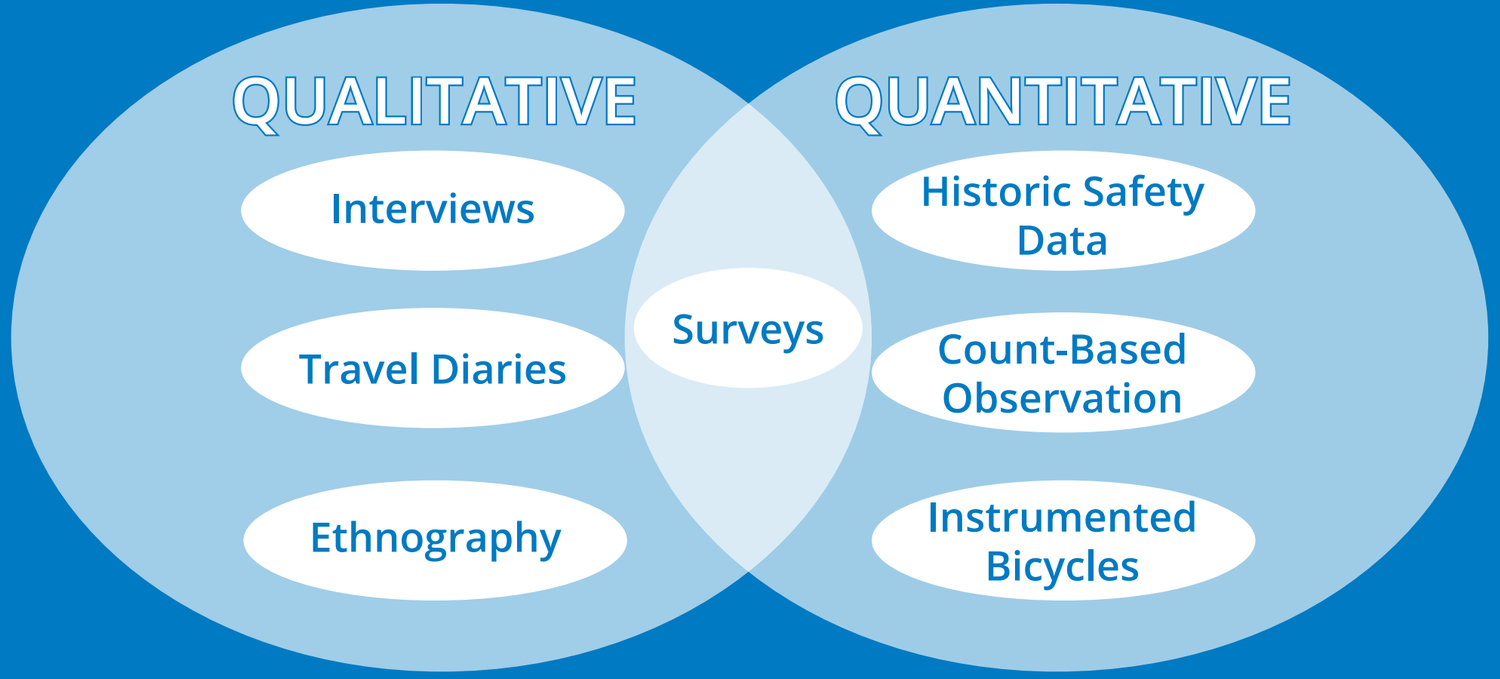
Access

RESEARCH APPROACH

How can we evaluate if these goals are achieved?

TYPICAL RESEARCH APPROACHES

How can we evaluate if these goals are achieved?

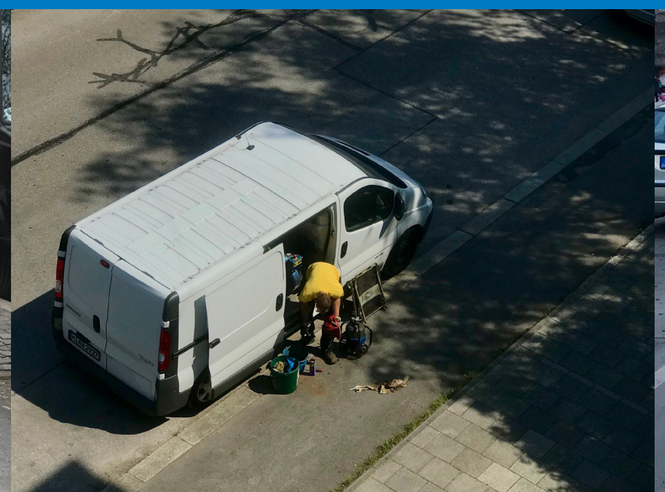




"...it is **not possible to pre-program the interaction** between public life and space in detail, but targeted studies can provide a basic understanding of what works and what does not, and thus suggest qualified solutions."

Gehl J and B Svarre. How To Study Public Life. *Island Press: Washington, DC*. 2020.






INTERACTIONS & REACTIONS ARE KEY

Assumptions:

Interactions are a natural and unavoidable. BUT, the aim is that interactions do not require the impacted person to adjust their behavior to negotiate the interaction.

INTERACTIONS & REACTIONS ARE KEY

Assumptions:

Interactions resulting in some form of lateral reaction or yielding action are indicators that something isn't working well with the design of the facilities or how they are being used.

INTERACTIONS & REACTIONS ARE KEY

Assumptions:

No negative intent is assumed on the part of the person or object who instigates the interaction. The infrastructure or other conditions may be responsible for incorrect behavior.

NEW MIXED-METHOD APPROACH

Methods Applied:

-Direct, Unobtrusive Observation

- Grounded Theory-Driven Coding

- Binary Logistic Regression

Unit of Analysis:

Interactions

(Involving at least 1 bicyclist and 1 other person or stationary object)

Design Review:

- Interaction Frequency
- Interaction Characteristics
- Interaction Severity

NEW MIXED-METHOD APPROACH

Avoids Reliance on Reported Behavior:

"...it is not unusual for persons to say they are doing one thing but in reality they are doing something else." (Corbin & Strauss 2015)

Focuses on Observed Behavior:

"...direct observation provides much more accurate results about behavior than do reports of behavior." (Bernard 2018)

Applies Grounded Theory:

Data is gathered using both inductive and deductive logic, with an openness to document and analyze both expected and unexpected interactions.

METHODOLOGY: Understand the Scene

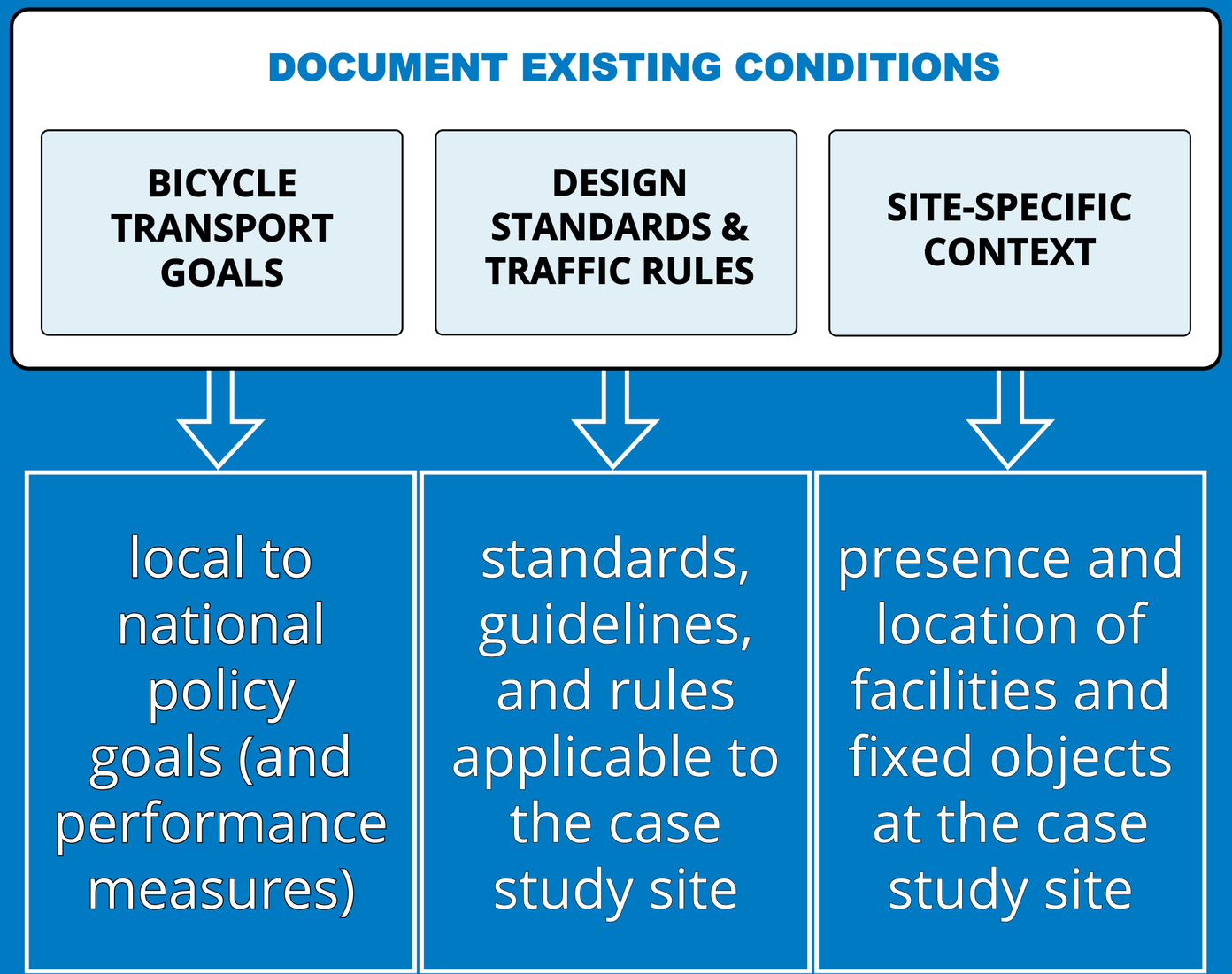
DOCUMENT EXISTING CONDITIONS

BICYCLE TRANSPORT GOALS

DESIGN STANDARDS & TRAFFIC RULES

SITE-SPECIFIC CONTEXT

METHODOLOGY: Understand the Scene



METHODOLOGY: Observe Behavior & Use

DOCUMENT EXISTING CONDITIONS

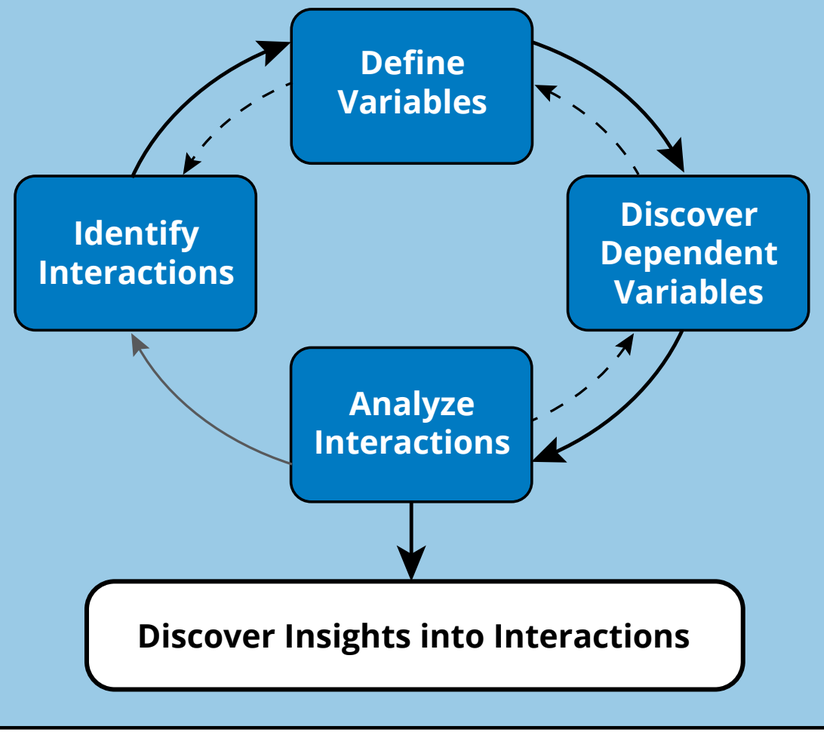
BICYCLE TRANSPORT GOALS

DESIGN STANDARDS & TRAFFIC RULES

SITE-SPECIFIC CONTEXT

OBSERVE INTERACTIONS

ITERATIVE CODING PROCESS



METHODOLOGY: Observe Behavior & Use

DOCUMENT EXISTING CONDITIONS

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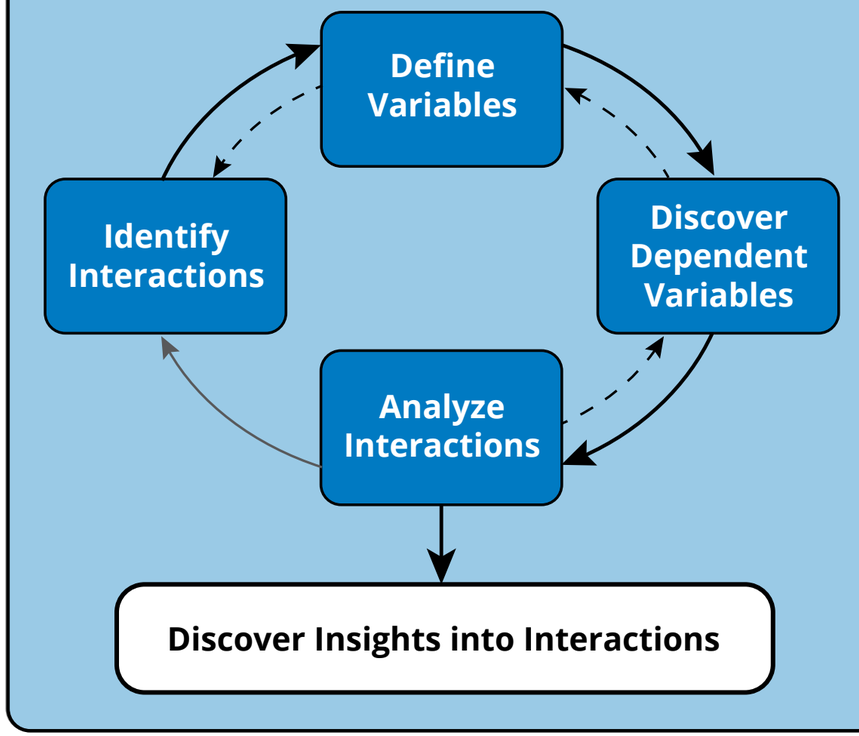


What types of **interactions** are bicyclists involved in while using streets with different types of bicycle facilities?

METHODOLOGY: Observe Behavior & Use

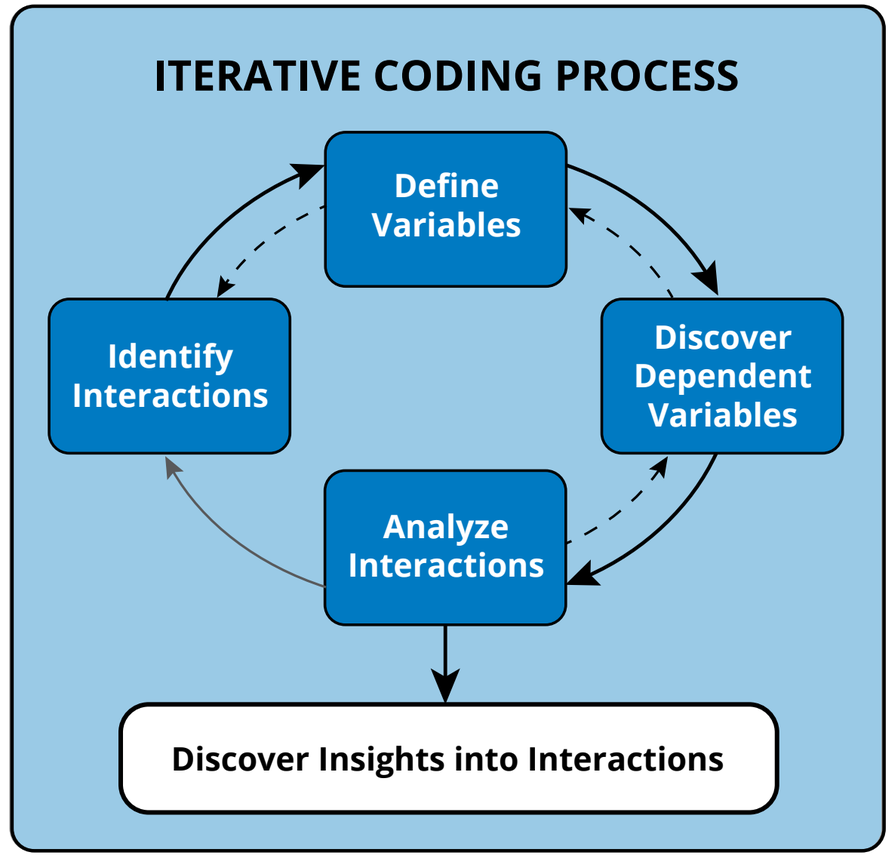
DOCUMENT EXISTING CONDITIONS

BICYCLE TRANSPORT GOALS

DESIGN STANDARDS & TRAFFIC RULES

SITE-SPECIFIC CONTEXT

OBSERVE INTERACTIONS



...what instigated it?
...where did it occur?
...who and what was involved?
...what were participants doing?

METHODOLOGY: Define "Interaction"

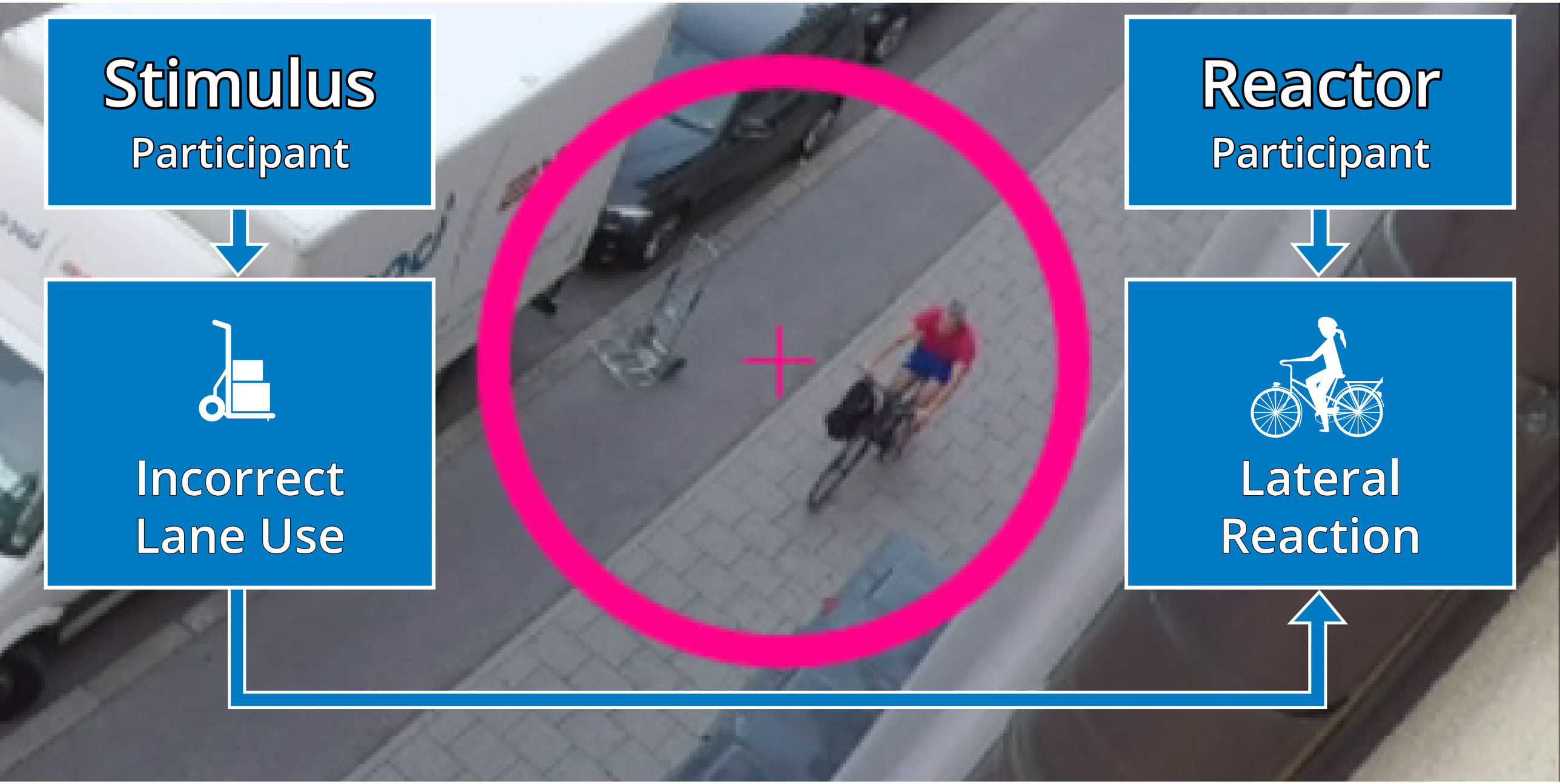
Interaction Definition: "a negotiation of movement between a Stimulus and Reactor, involving a bicyclist and another person using any mode of transportation or a stationary object." (Silva et al. 2020)

Stimulus + **Reactor**

The **person** or **object** whose action or presence instigates the interaction.

The **person** who reacts (or not) to the action or presence of the stimulus.

METHODOLOGY: Define “Interaction”



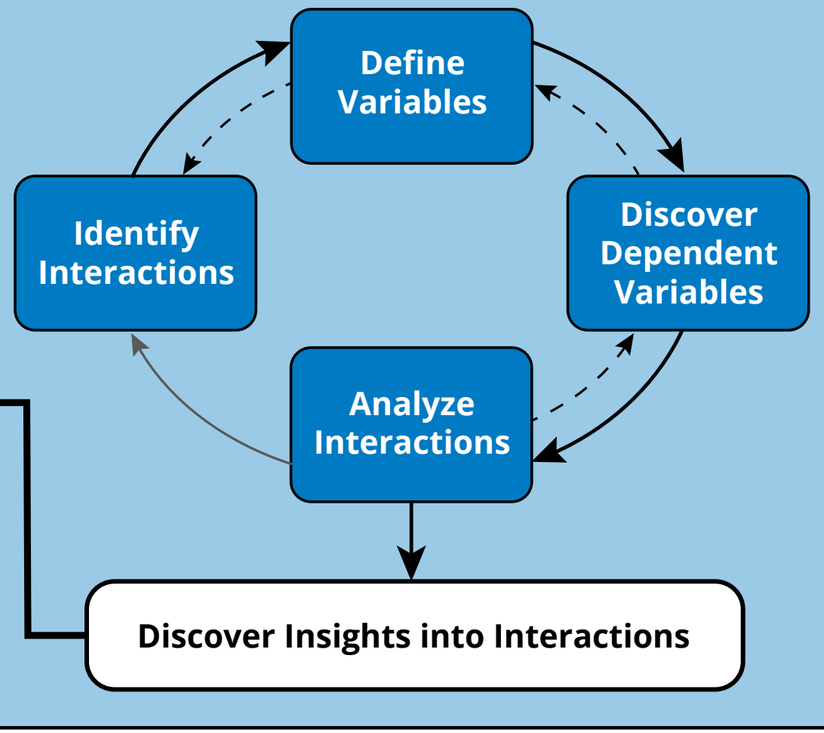
METHODOLOGY: Evaluate Functionality

DOCUMENT EXISTING CONDITIONS

- BICYCLE TRANSPORT GOALS
- DESIGN STANDARDS & TRAFFIC RULES
- SITE-SPECIFIC CONTEXT

OBSERVE INTERACTIONS

ITERATIVE CODING PROCESS



EVALUATE IMPACT OF INTERACTIONS

PERFORMANCE MEASURE REVIEW

- Safety
- Mobility
- Access

METHODOLOGY: Evaluate Functionality

Bicycle Lane Along Sidewalk

Based on the Analysis

On-Street Bicycle Lane

Which type of bicycle lane best meets the **goals** it was designed to achieve?

Safety

Mobility

Access

METHODOLOGY: Analyze Interactions

Stimulus

Reactor

Stimulus Action

Reaction to Stimulus

=

IMPACT OF INTERACTION

METHODOLOGY: Analyze Interactions

Dependent Variable =

"Reaction to Stimulus"

0 = No Reaction ☺

1= Lateral Reaction or Yielding ☹

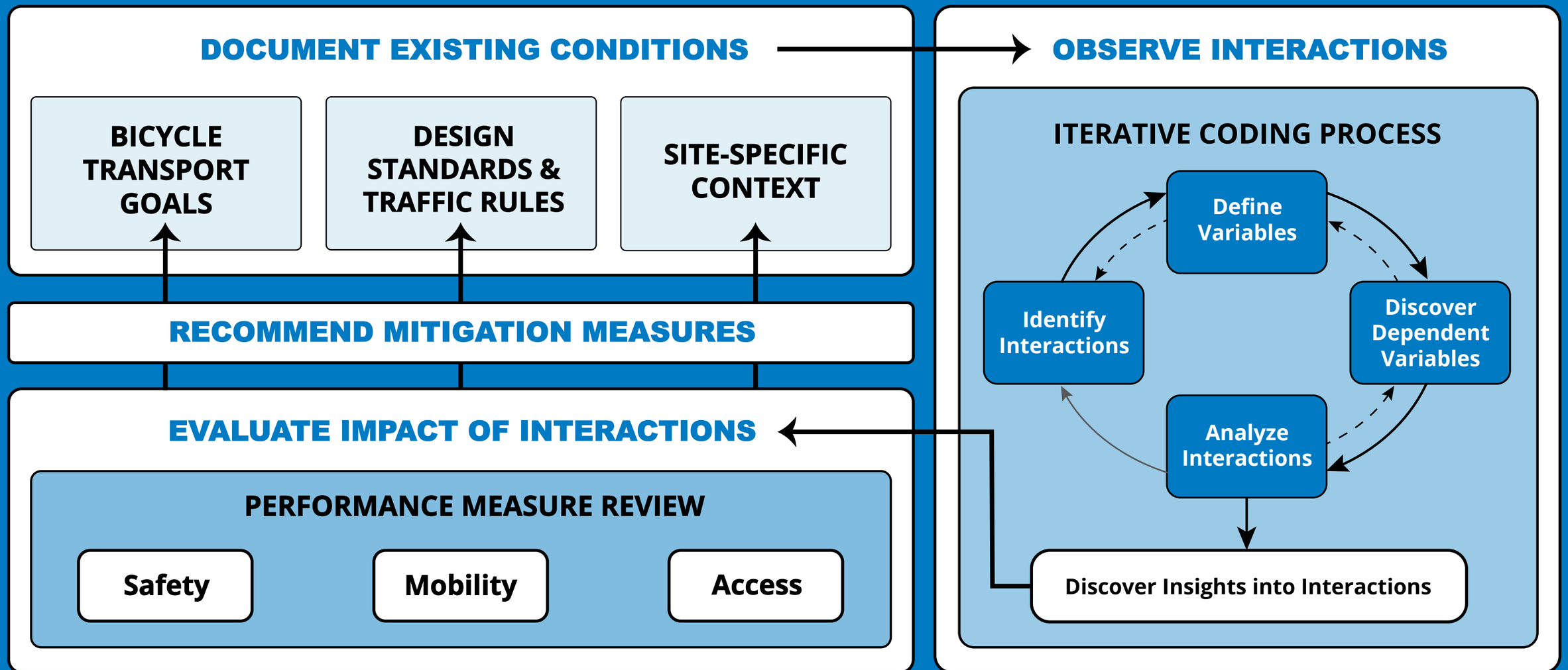
METHODOLOGY: Analyze Interactions

Reaction to Stimulus =

constant x

Spatial Variables *x*
Temporal Variables *x*
Behavioral Variables *x*
Participant Characteristic Variables

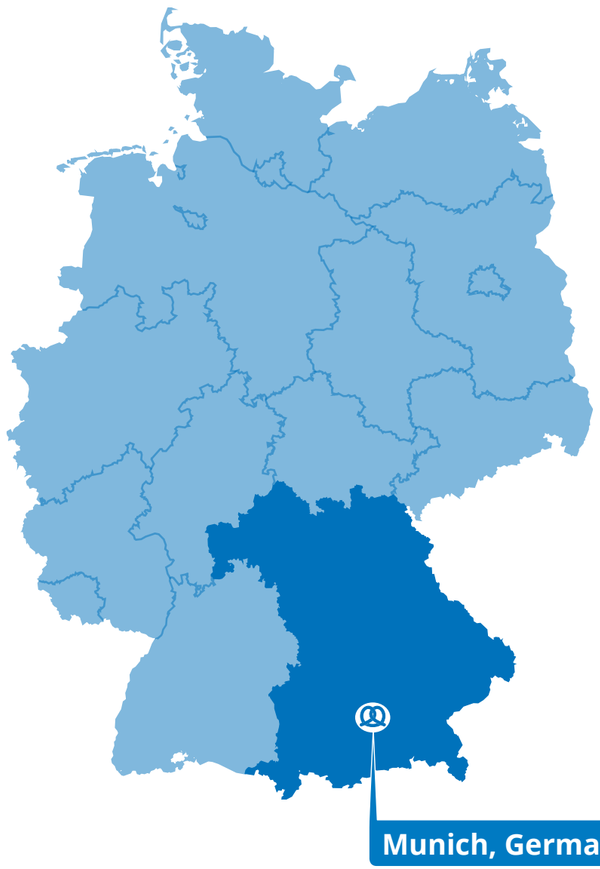
METHODOLOGY: Discover Problem-Areas



COMPARATIVE CASE STUDY

Bicycle Lane Along Sidewalk

One-Day Study of Two Streets Segments



On-Street Bicycle Lane

COMPARATIVE CASE STUDY

One-Day Study of
Two Streets Segments

Bicycle Lane Along Sidewalk

Site: Augustenstraße

1208 Interactions Observed

From 07:48 to 20:16
(Duration: 12hrs 28min)

1.6 Interactions per Minute

On-Street Bicycle Lane

Site: Arcisstraße

280 Interactions Observed

From 08:15 to 20:01
(Duration: 11hrs 46min)

0.4 Interactions per Minute

COMPARATIVE CASE STUDY

Bicycle Lane Along Sidewalk

Findings for: 1-on-1 Interactions

On-Street Bicycle Lane

Site: Augustenstraße

582 1-on-1 Interactions Observed

(48% of Interactions at Site)

0.8 Interactions per Minute

Site: Arcisstraße

210 1-on-1 Interactions Observed

(75% of Interactions at Site)

0.3 Interactions per Minute

COMPARATIVE CASE STUDY

Reaction to Stimulus =

constant x

Spatial Variables *X*
Temporal Variables *X*
Behavioral Variables *X*
Participant Characteristic Variables

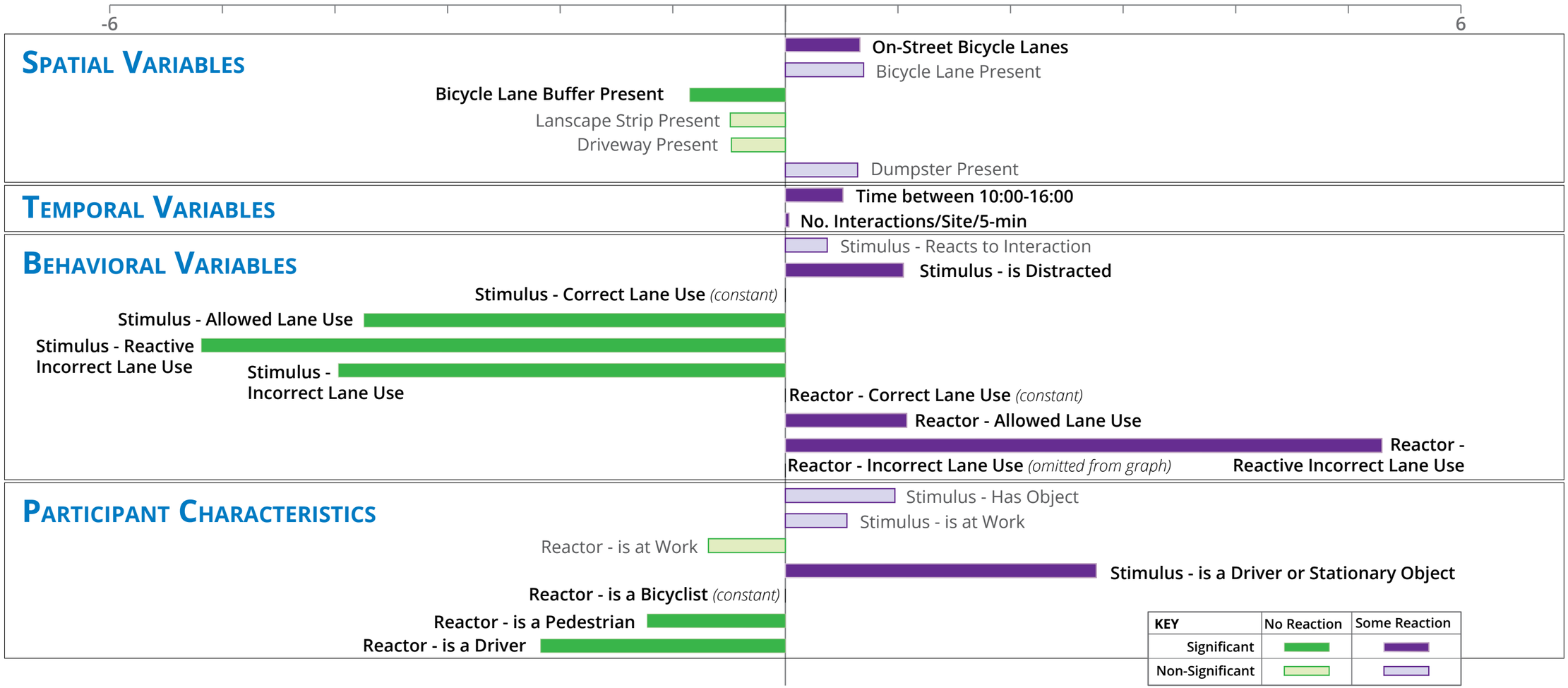
COMPARATIVE CASE STUDY: Results

Group	Variable	Values	β	Significance
Spatial Variables	**Case Study Bicycle Lane**	(0=Along Sidewalk; 1=On-Street)	.662	**.078**
	Bicycle Lane Present	(0=No; 1=Yes)	.695	.231
	Bicycle Lane Buffer Present	(0=No; 1=Yes)	-.849	**.067**
	Driveway Present	(0=No; 1=Yes)	-.479	.237
	Landscape Strip Present	(0=No; 1=Yes)	-.489	.177
	Dumpster Present	(0=No; 1=Yes)	.642	.486
Temporal Variables	**Time of Day**	(0=AM or PM Peak; 1=10:00-16:00)	.511	**.033**
	No. Interactions/Study Lane/5-min (continuous)		.032	**.081**
Behavioral Variables	Stimulus' Reaction to Reactor	(0=No Reaction; 1=Lateral Reaction or Yielding)	.372	.174
	Stimulus Distracted	(0=No; 1=Yes)	1.048	**.032**
	Stimulus' Lane Use	**(1=Correct Lane Use)**		**.000**
		(2=Allowed Use of the Roadway)	-3.743	**.000**
		(3=Reactive Incorrect Lane Use)	-5.187	**.000**
		(4=Incorrect Lane Use)	-3.970	**.000**
	Reactor's Lane Use	**(1=Correct Lane Use)**		**.000**
		(2=Allowed Use of the Roadway)	1.078	**.019**
		(3=Reactive Incorrect Lane Use)	5.298	**.000**
		(4=Incorrect Lane Use)	18.683	.998
Participant Variables	Stimulus Has Object	(0=No; 1=Yes)	.973	.272
	Stimulus is At Work	(0=No; 1=Yes)	.547	.237
	Reactor is At Work	(0=No; 1=Yes)	-.683	.428
	Stimulus' Mode	**(0=Bicyclist or Pedestrian; 1=Driver or Stationary Object)**	2.761	**.000**
	Reactor's Mode	**(1=Bicyclist)**		**.000**
		(2=Pedestrian)	-1.228	**.000**
		(3=Vehicle Driver)	-2.174	**.001**

COMPARATIVE CASE STUDY: Results

More Associated w/ No Reaction

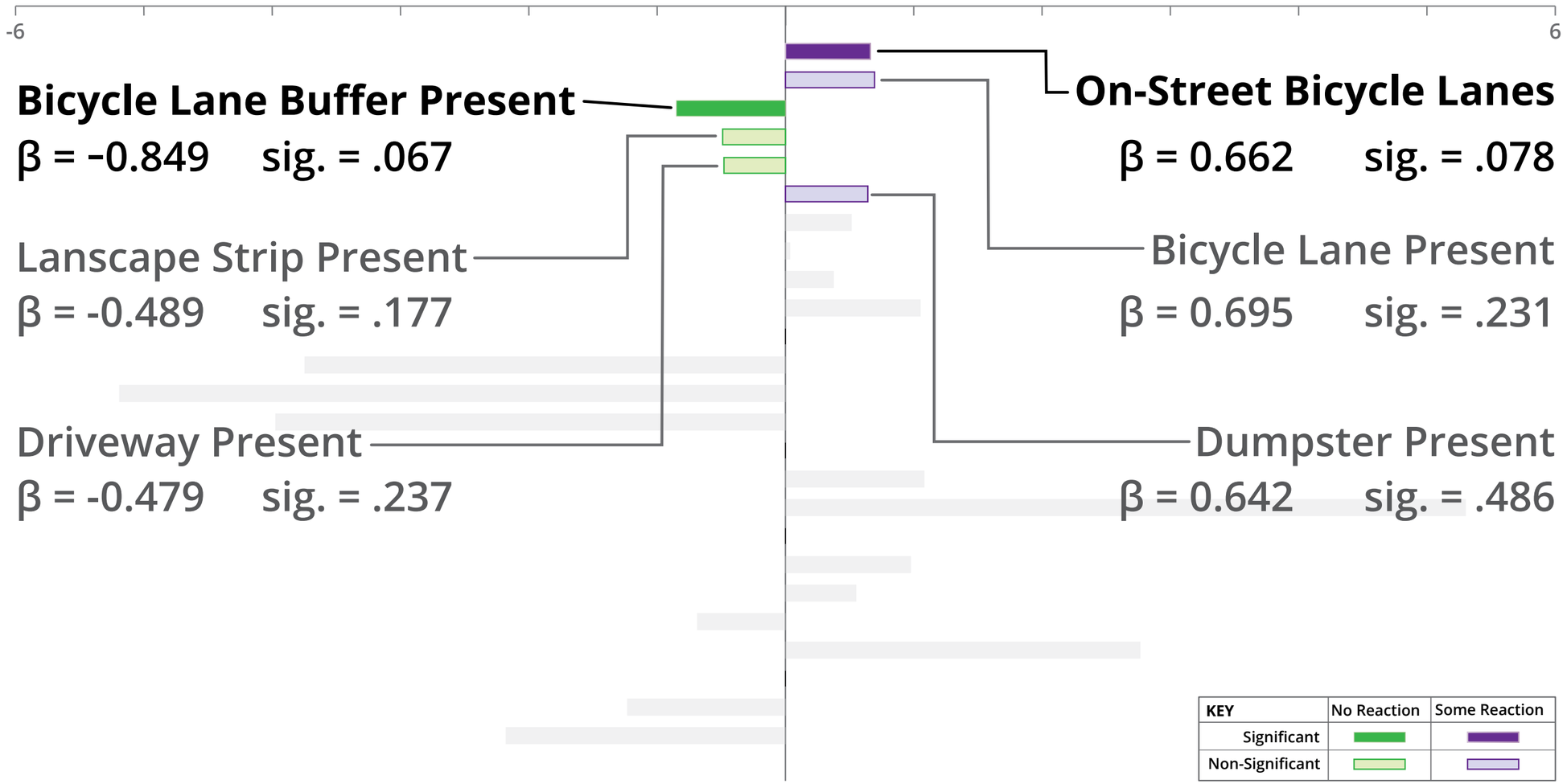
More Associated w/ Lateral Reactions & Yielding



RESULTS: Spatial Variables

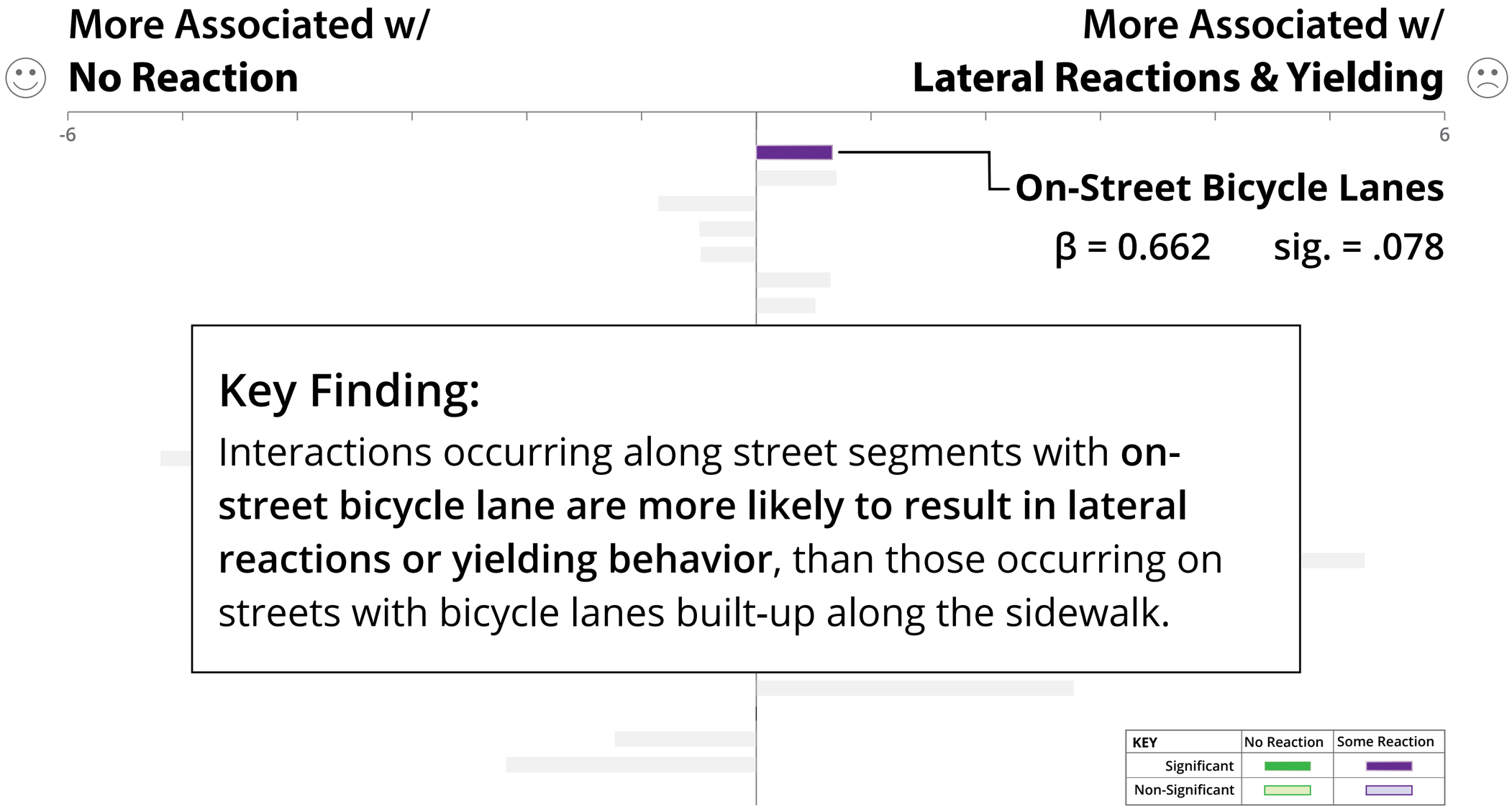
More Associated w/ No Reaction

More Associated w/ Lateral Reactions & Yielding



KEY	No Reaction	Some Reaction
Significant		
Non-Significant		

RESULTS: Spatial Variables



Key Finding:

Interactions occurring along street segments with **on-street bicycle lane are more likely to result in lateral reactions or yielding behavior**, than those occurring on streets with bicycle lanes built-up along the sidewalk.

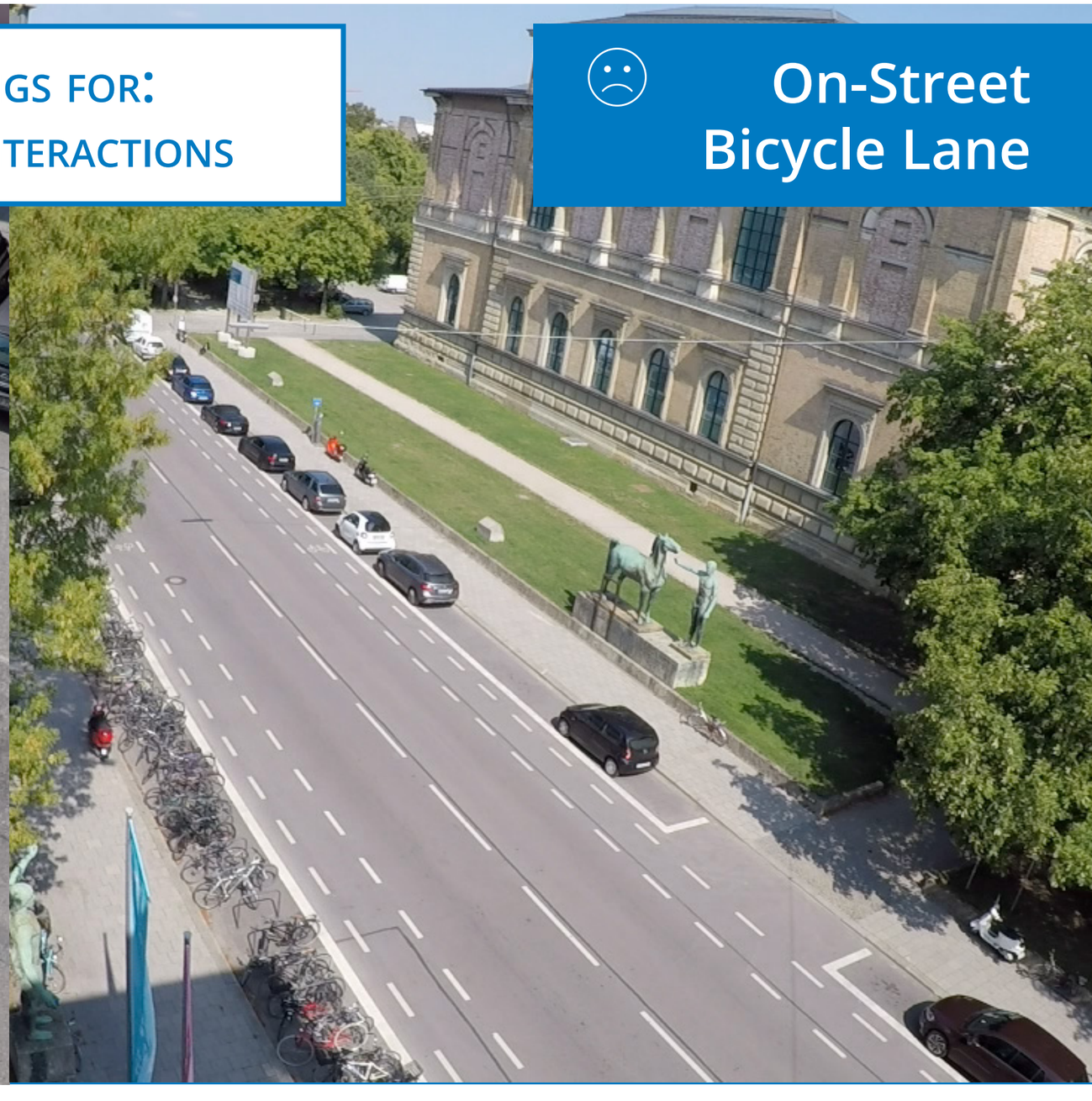
KEY	No Reaction	Some Reaction
Significant		
Non-Significant		

RESULTS: Spatial Variables

Bicycle Lane Along Sidewalk

Findings for: 1-on-1 Interactions

On-Street Bicycle Lane



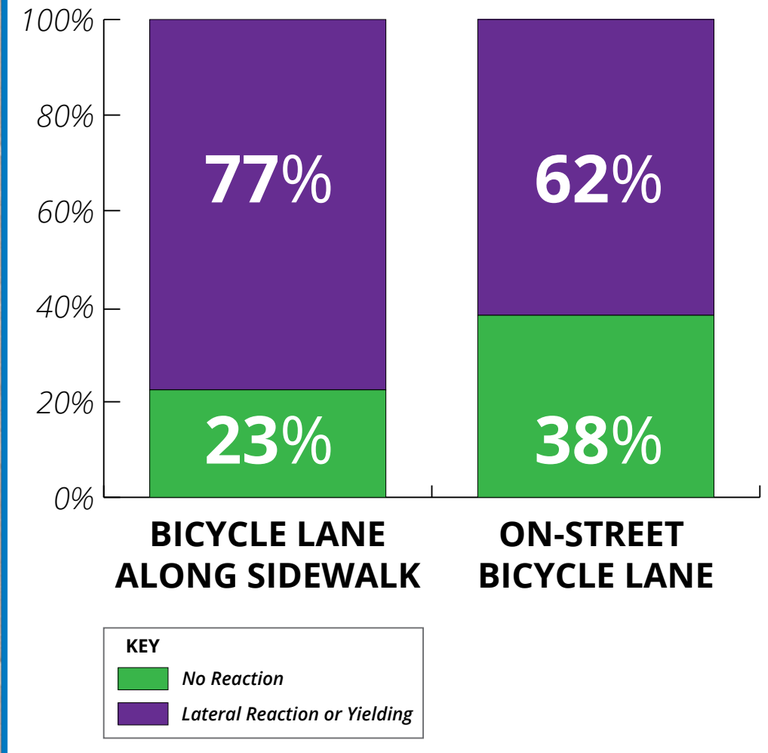
RESULTS: Spatial Variables

Bicycle Lane Along Sidewalk

Findings for: 1-on-1 Interactions

On-Street Bicycle Lane

Bicycle Lane Type x Reaction Type
% within Bicycle Lane Type

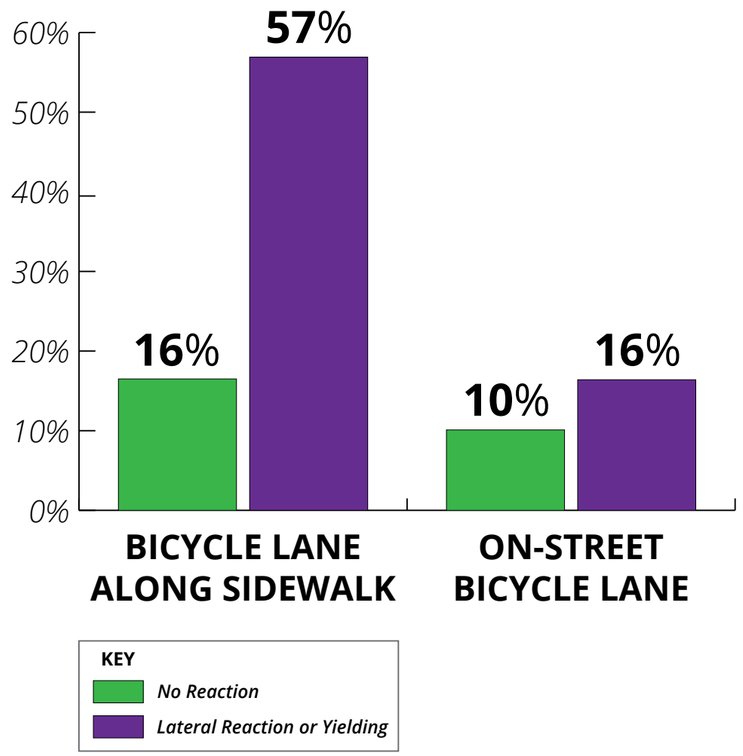


RESULTS: Spatial Variables

Bicycle Lane Along Sidewalk

Findings for: 1-on-1 Interactions

Bicycle Lane Type x Reaction Type
% of Total Interactions



On-Street Bicycle Lane

RESULTS: Spatial Variables

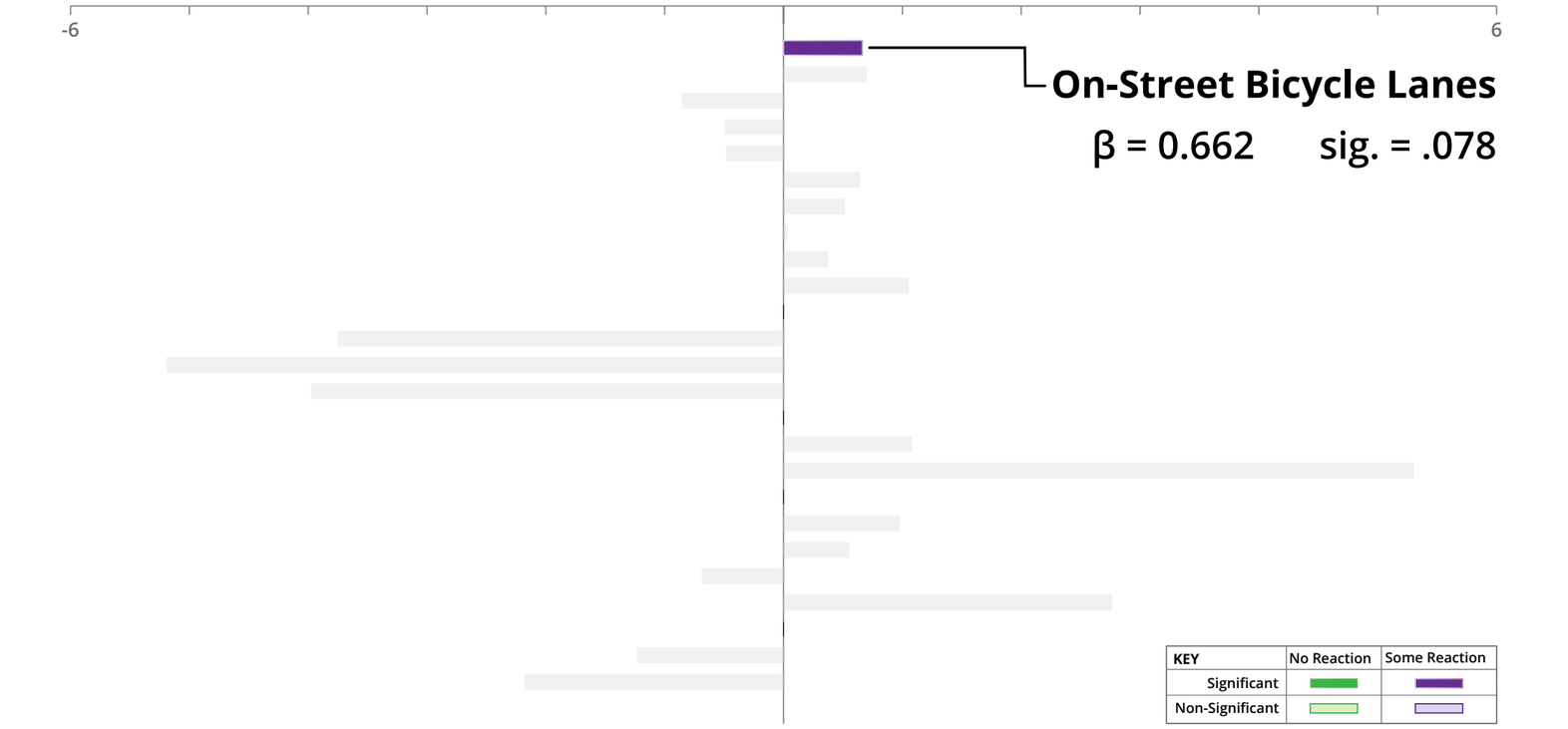
Bicycle Lane Along Sidewalk

Findings for: 1-on-1 Interactions

On-Street Bicycle Lane

More Associated w/ No Reaction

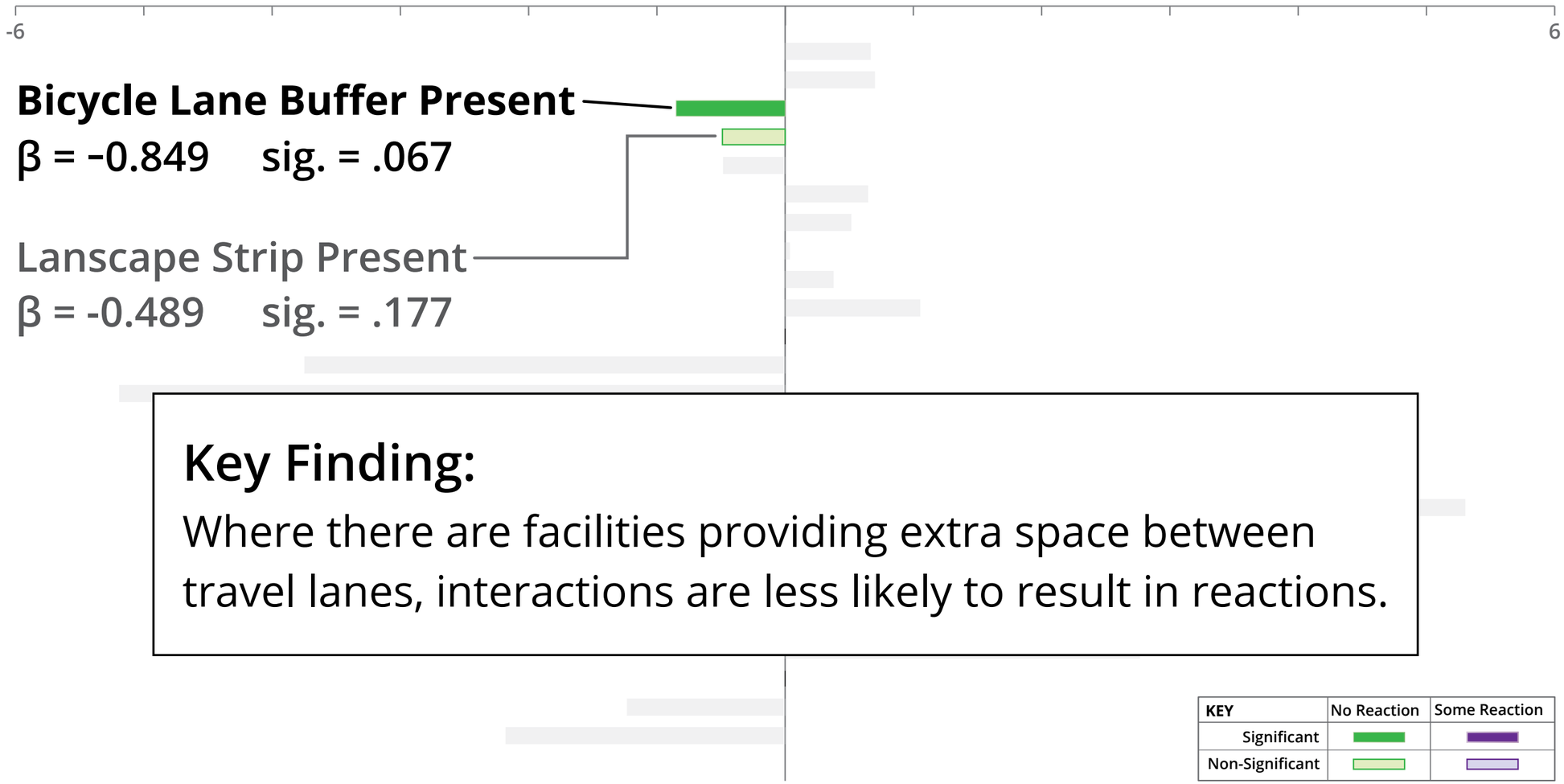
More Associated w/ Lateral Reactions & Yielding



RESULTS: Spatial Variables

More Associated w/
No Reaction

More Associated w/
Lateral Reactions & Yielding



Key Finding:

Where there are facilities providing extra space between travel lanes, interactions are less likely to result in reactions.

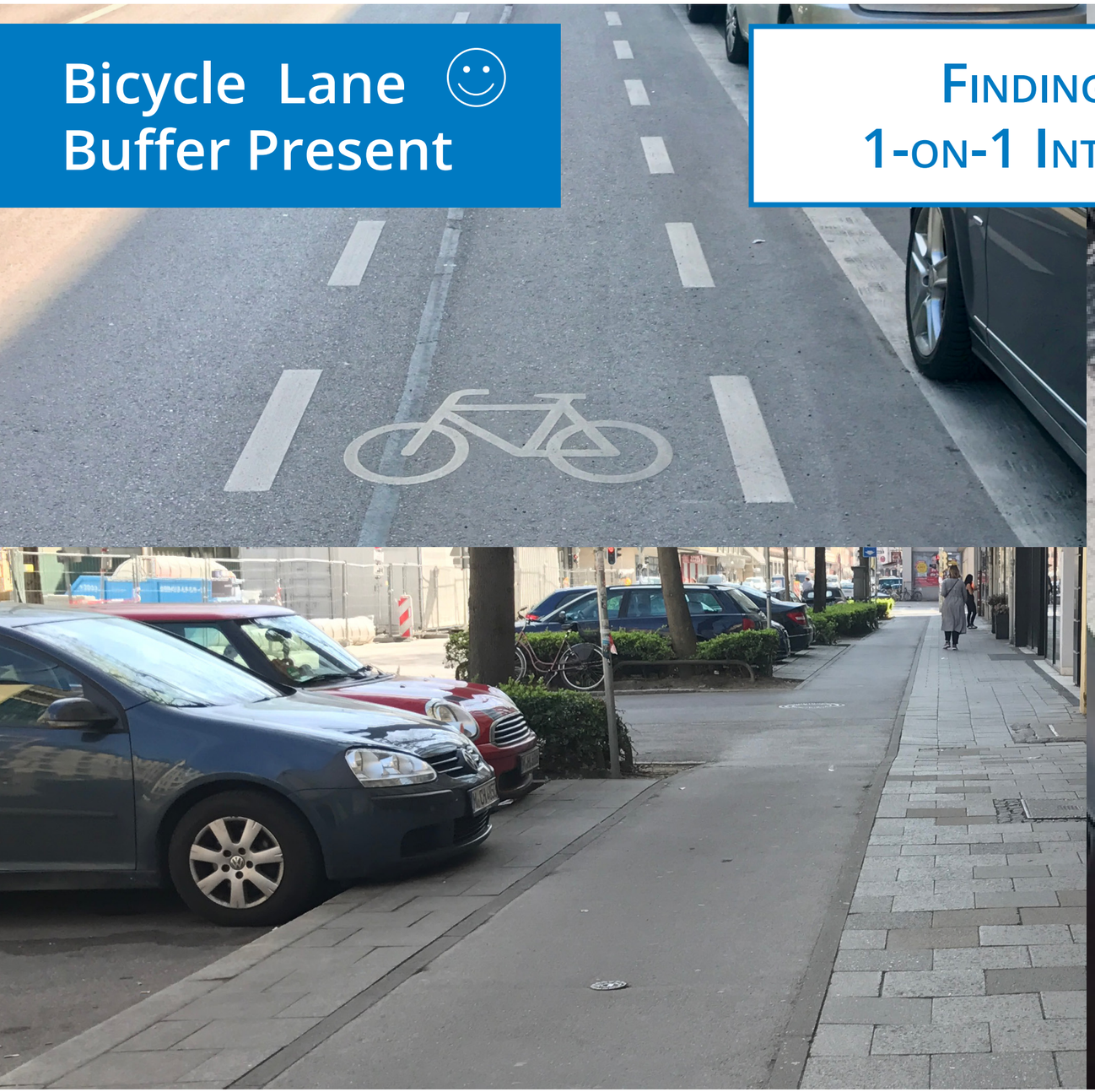
KEY	No Reaction	Some Reaction
Significant		
Non-Significant		

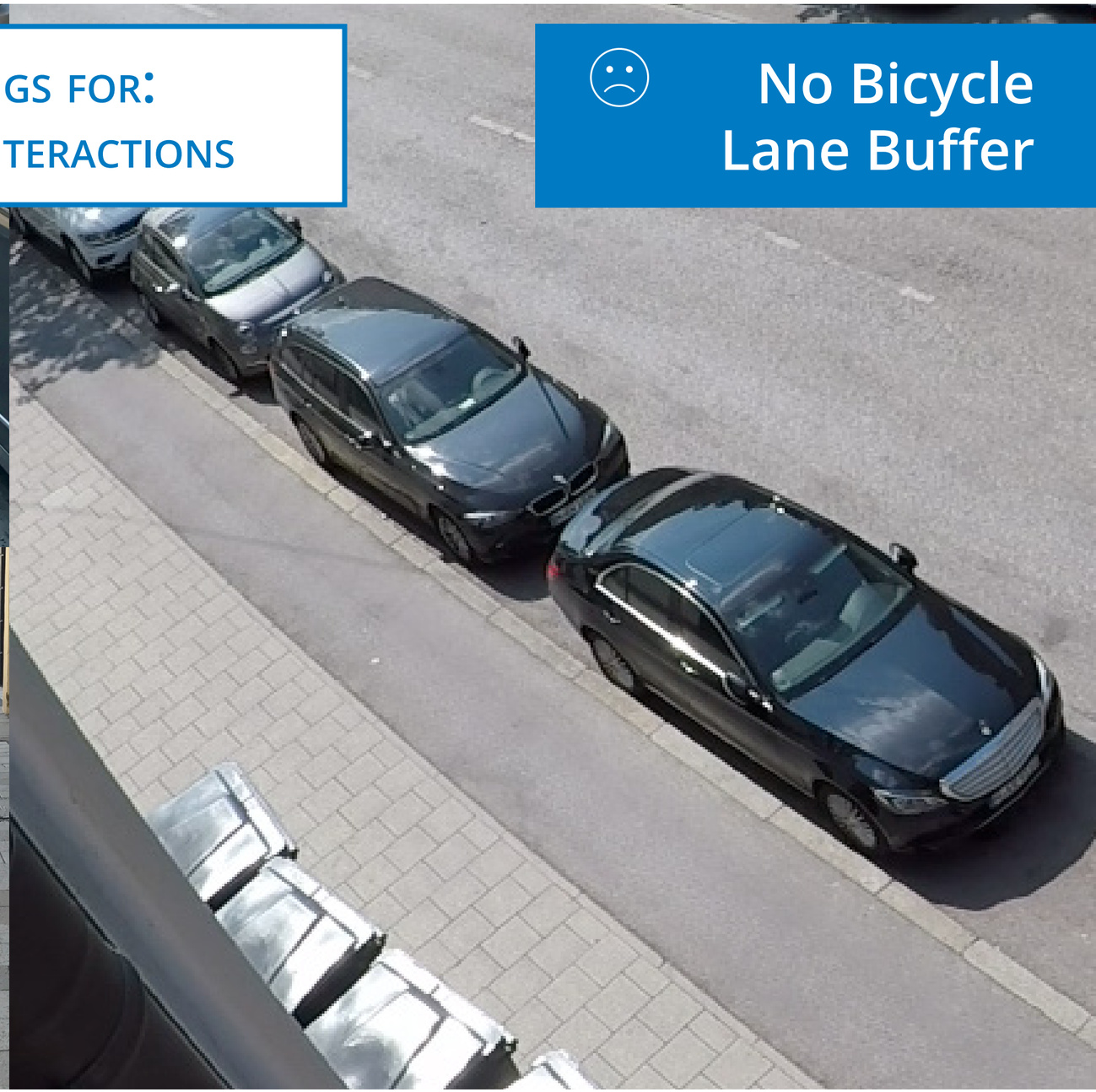
RESULTS: Spatial Variables

Bicycle Lane Buffer Present

Findings for: 1-on-1 Interactions

No Bicycle Lane Buffer





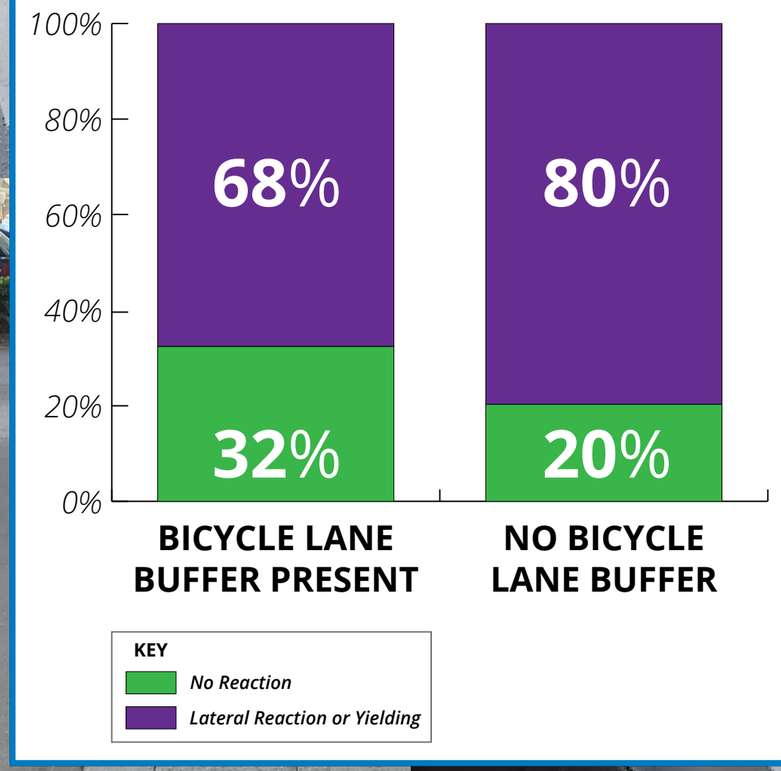
RESULTS: Spatial Variables

Bicycle Lane Buffer Present

Findings for: 1-on-1 Interactions

No Bicycle Lane Buffer

Bicycle Lane Buffer x Reaction
% within Bicycle Lane Buffer



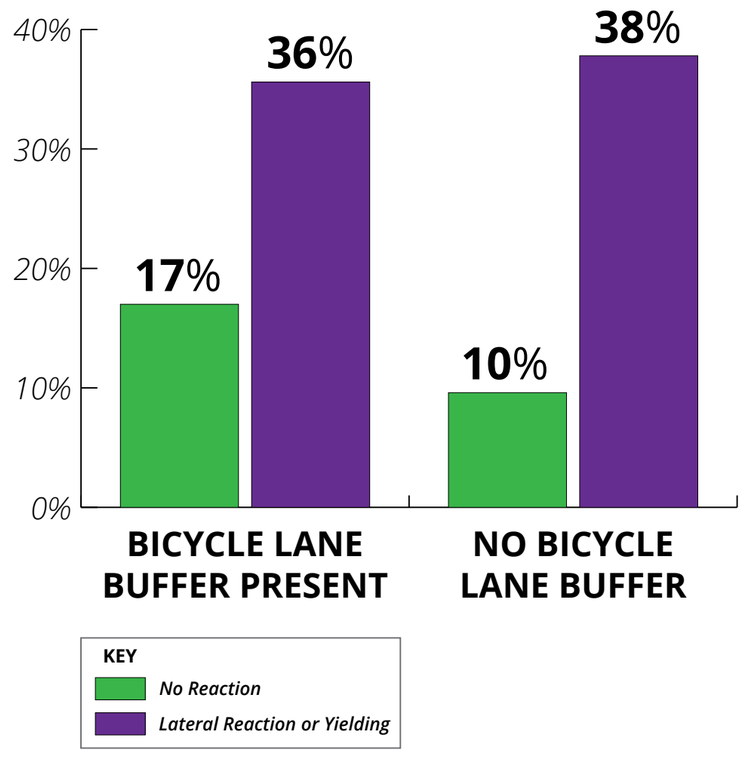
RESULTS: Spatial Variables

Bicycle Lane Buffer Present

Findings for: 1-on-1 Interactions

No Bicycle Lane Buffer

Bicycle Lane Buffer x Reaction
% of Total Interactions

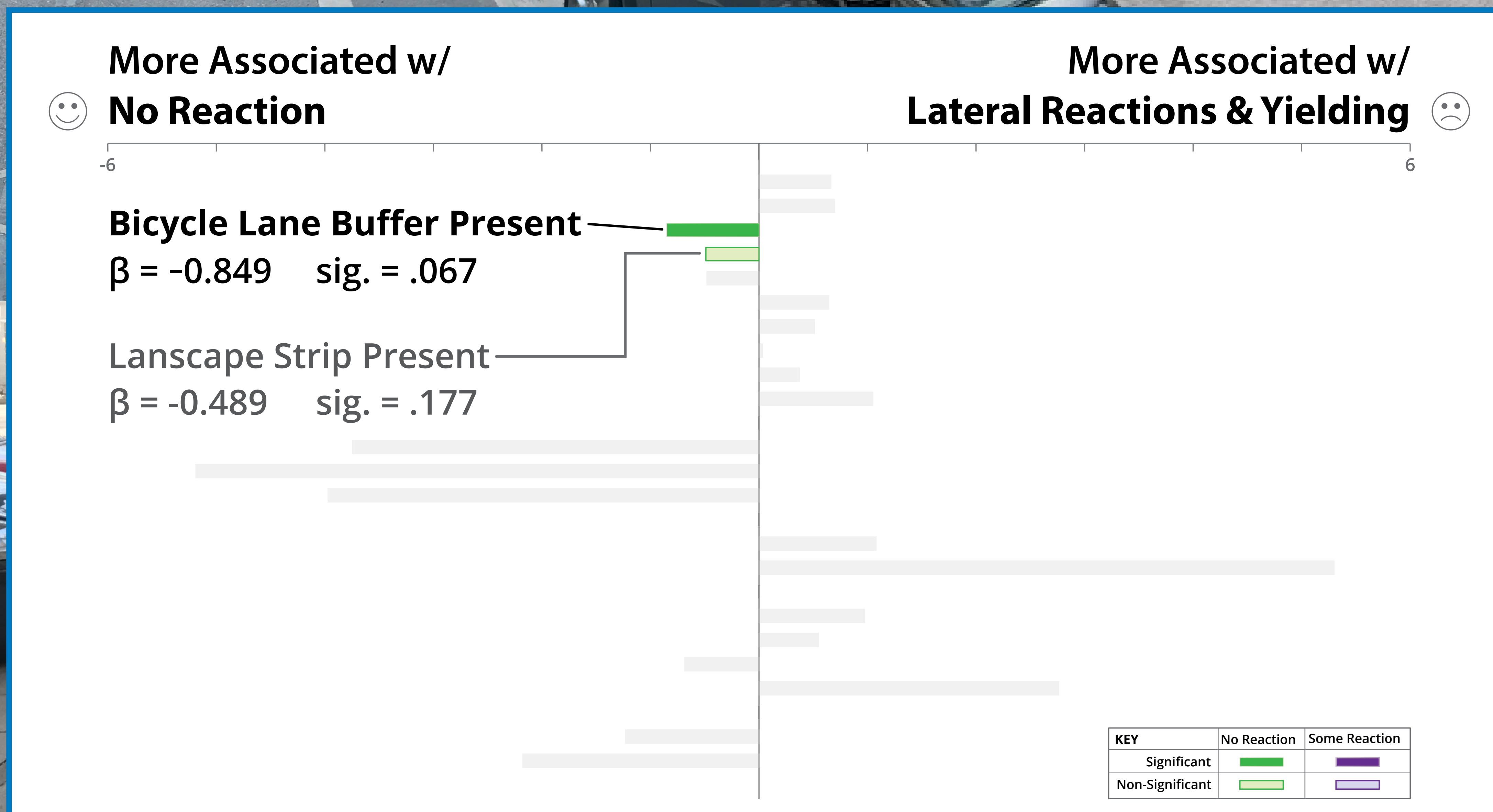


RESULTS: Spatial Variables

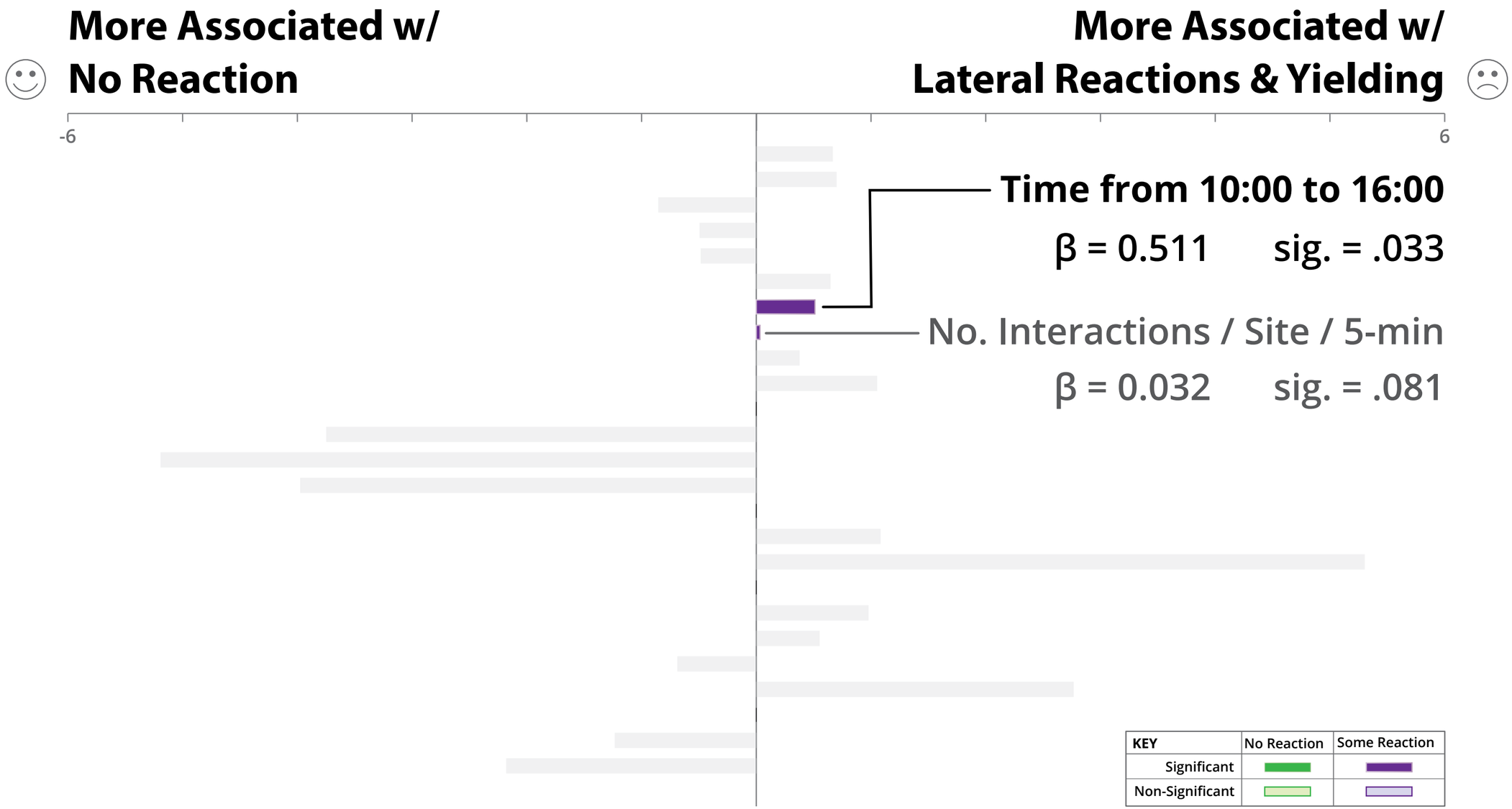
Bicycle Lane Buffer Present ☺

FINDINGS FOR: 1-ON-1 INTERACTIONS

☹ **No Bicycle Lane Buffer**



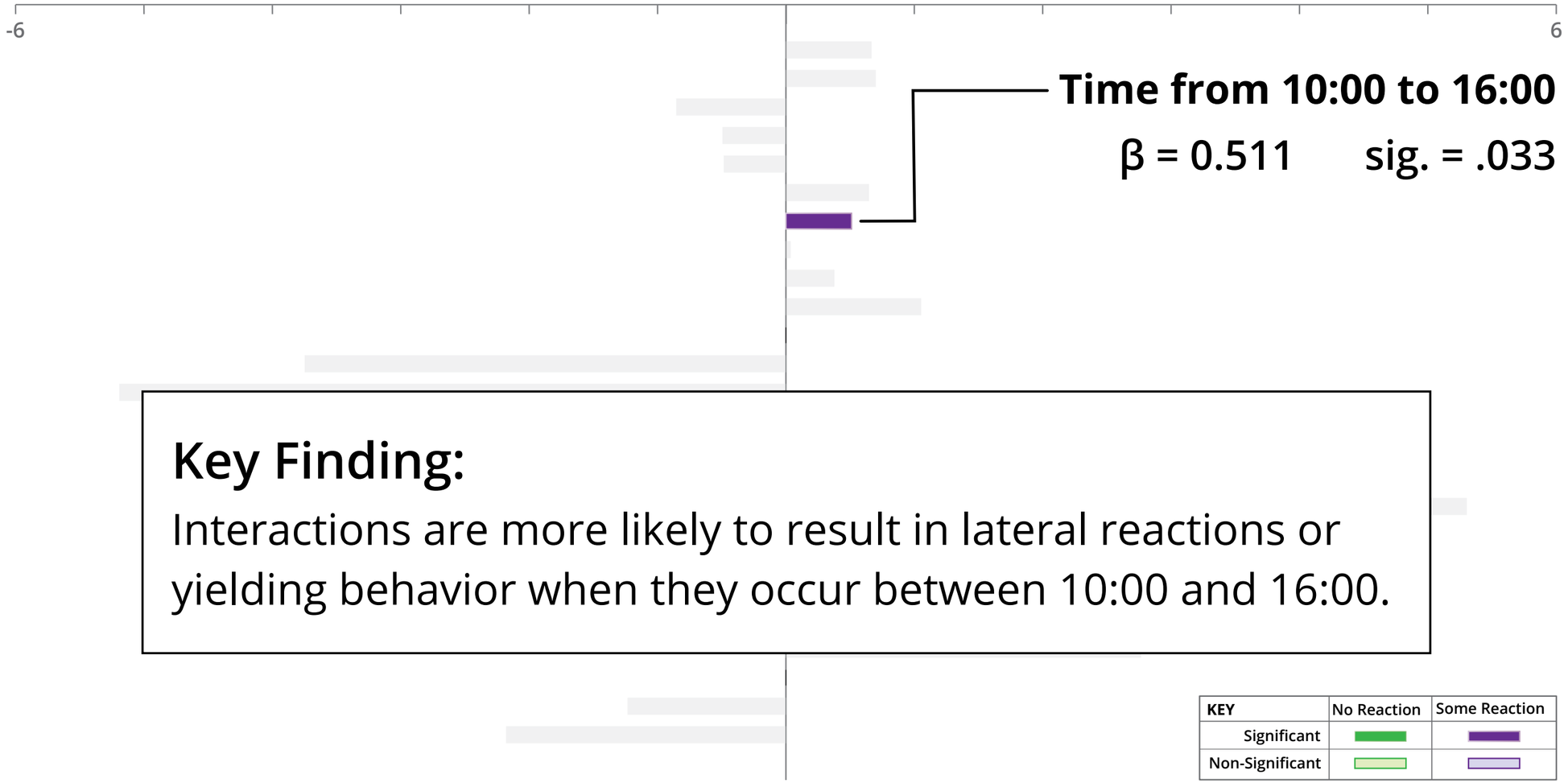
RESULTS: Temporal Variables



RESULTS: Temporal Variables

More Associated w/ No Reaction

More Associated w/ Lateral Reactions & Yielding



Key Finding:

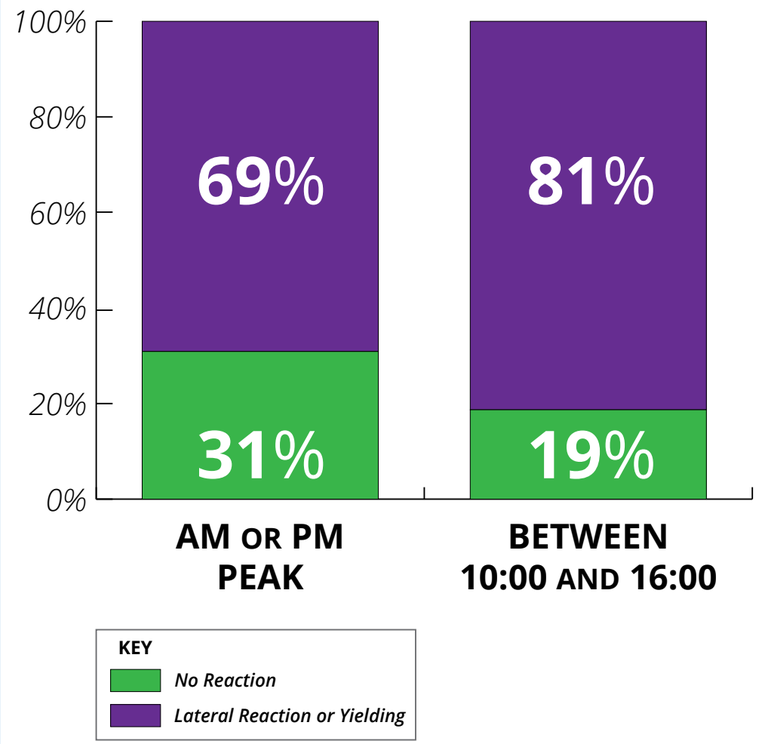
Interactions are more likely to result in lateral reactions or yielding behavior when they occur between 10:00 and 16:00.

KEY	No Reaction	Some Reaction
Significant		
Non-Significant		

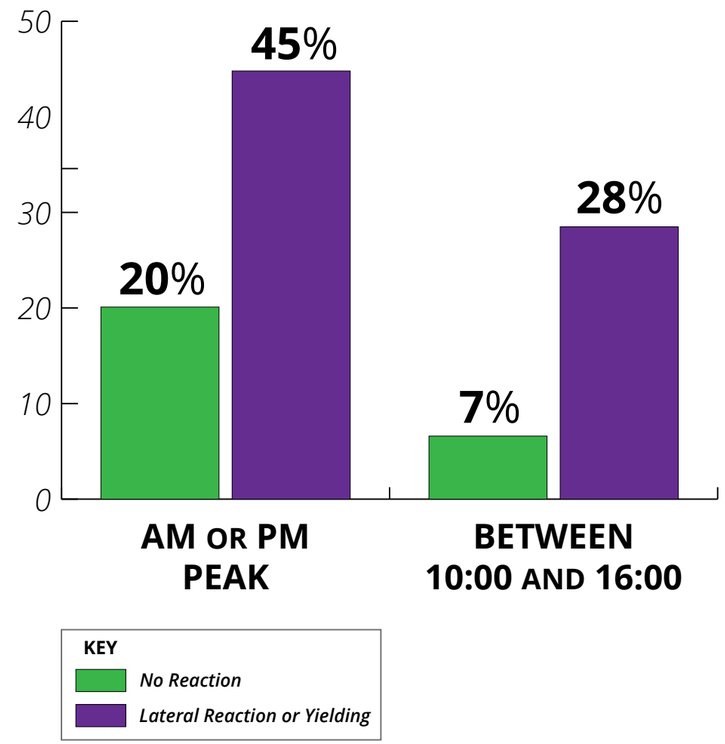
RESULTS: Temporal Variables

Findings for: 1-on-1 Interactions

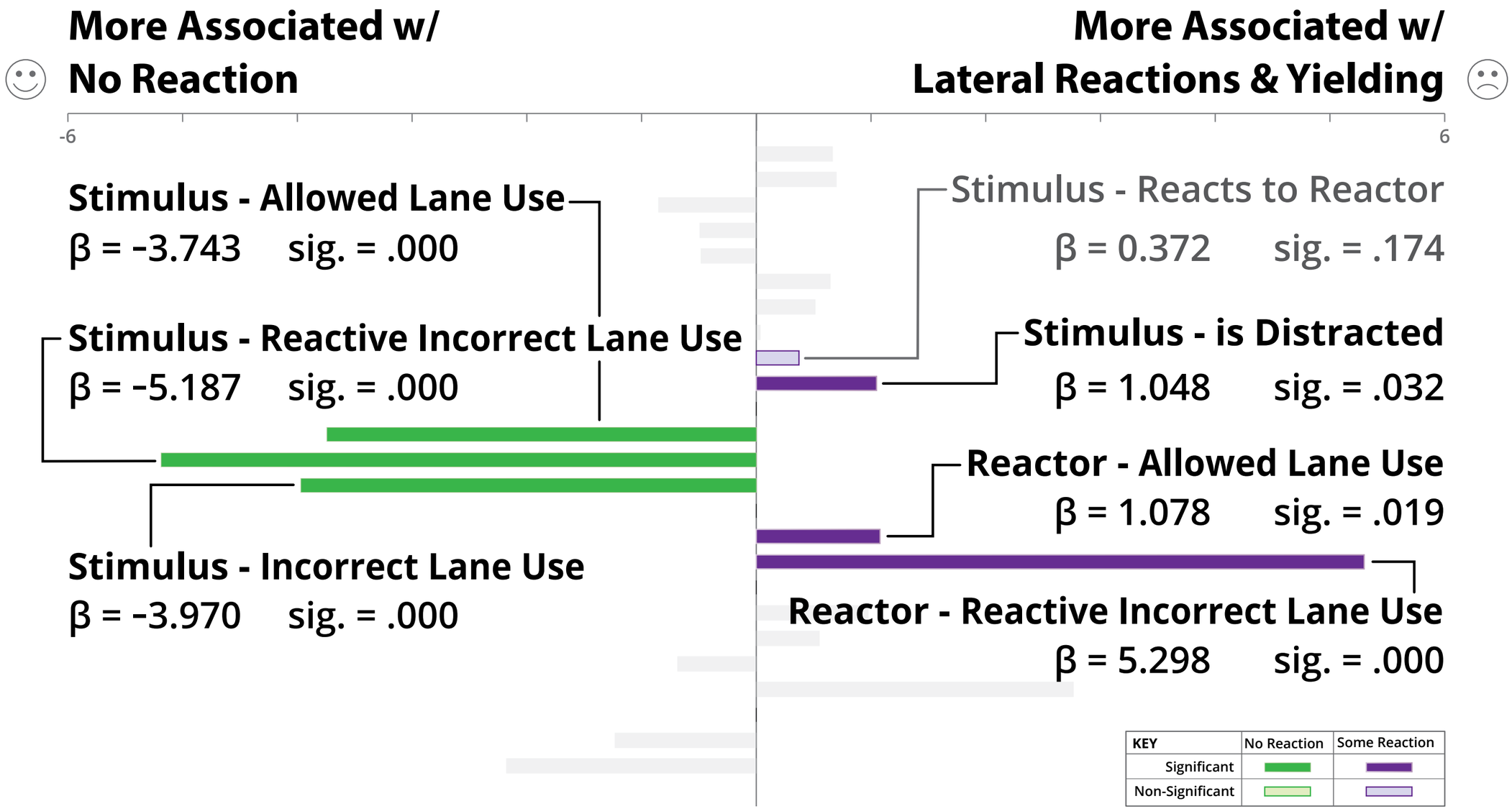
Time of Day x Reaction Type
% within Time of Day



Time of Day x Reaction Type
% of Total Interactions



RESULTS: Behavioral Variables



RESULTS: Behavioral Variables

More Associated w/ No Reaction

More Associated w/ Lateral Reactions & Yielding

-6 ... 6

Stimulus - Allowed Lane Use
β = -3.743 sig. = .000

Stimulus - Reactive Incorrect Lane Use
β = -5.187 sig. = .000

Stimulus - Incorrect Lane Use
β = -3.970 sig. = .000

Stimulus - Correct Lane Use
β = *reference* sig. = .000

Key Findings:

The Reactor Participant is **most likely** to react when the Stimulus Participant is legally using their designated travel lane.

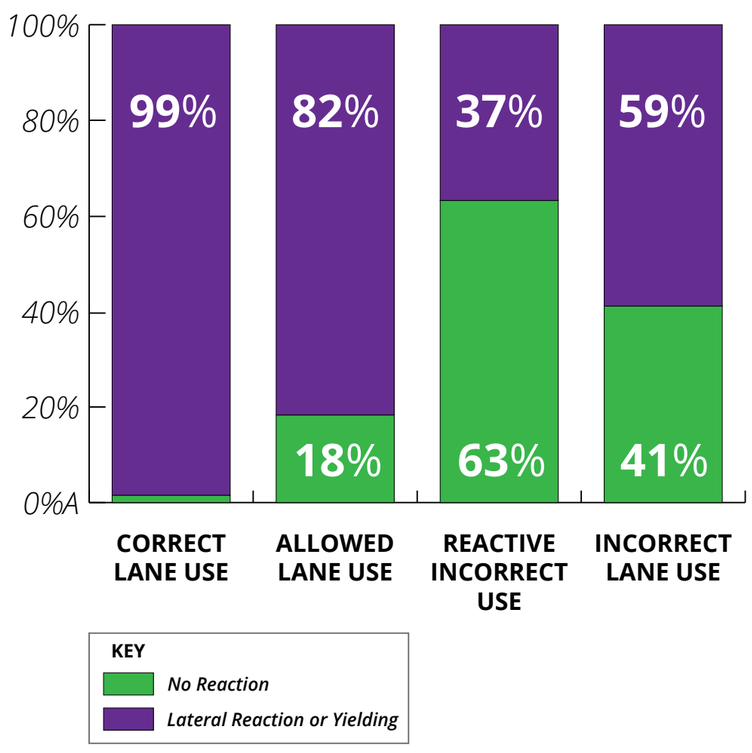
The Reactor Participant is **least likely** to react when the Stimulus Participant reactively moves to a travel lane they are not designated to use.

KEY	No Reaction	Some Reaction
Significant		
Non-Significant		

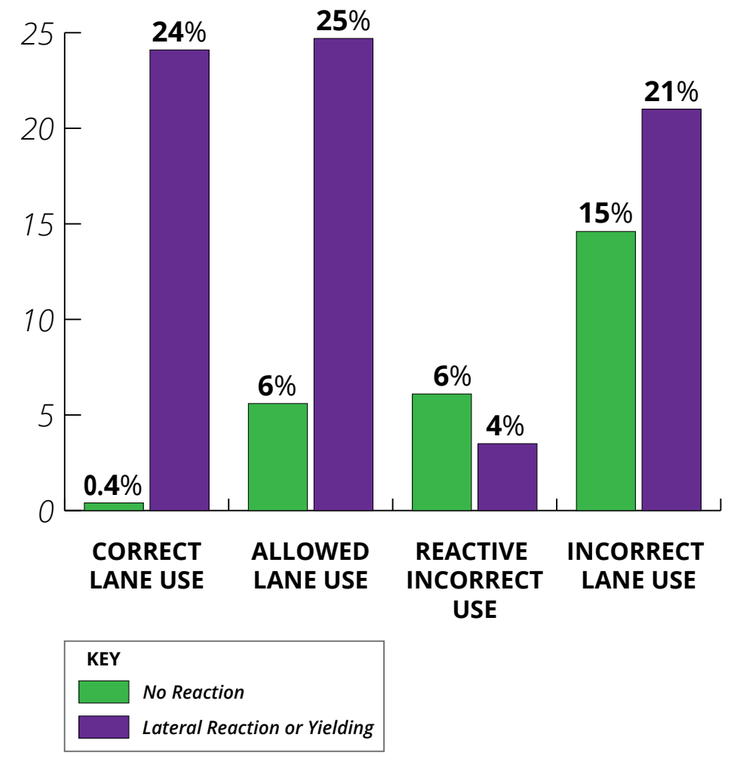
RESULTS: Behavioral Variables

Findings for: 1-on-1 Interactions

Stimulus Lane Use x Reaction Type
% within Stimulus Lane Use



Stimulus Lane Use x Reaction Type
% of Total Interactions



RESULTS: Participant Variables

More Associated w/ No Reaction

More Associated w/ Lateral Reactions & Yielding

-6 6

Reactor - is at Work
β = -0.683 sig. = .428

Reactor - is a Pedestrian
β = -0.489 sig. = .177

Reactor - is a Driver
β = -0.479 sig. = .237

Stimulus - Has an Object
β = 0.662 sig. = .078

Stimulus - is at Work
β = 1.048 sig. = .032

Stimulus - is a Vehicle Driver or Stationary Object
β = 0.642 sig. = .486

KEY	No Reaction	Some Reaction
Significant		
Non-Significant		

RESULTS: Participant Variables

More Associated w/ No Reaction

More Associated w/ Lateral Reactions & Yielding

-6 6

Key Findings:

Bicyclists are the **most likely** to react to interactions.

Vehicle Drivers are the **least likely** to react to interactions.

Vehicle Drivers and Stationary Objects are the **most likely** to instigate a reaction.

Reactor - is a Pedestrian
β = -0.489 sig. = .177

Reactor - is a Driver
β = -0.479 sig. = .237

Stimulus - is a Vehicle Driver or Stationary Object
β = 0.642 sig. = .486

Stimulus - is a Bicyclist or Pedestrian
β = *reference* sig. = .000

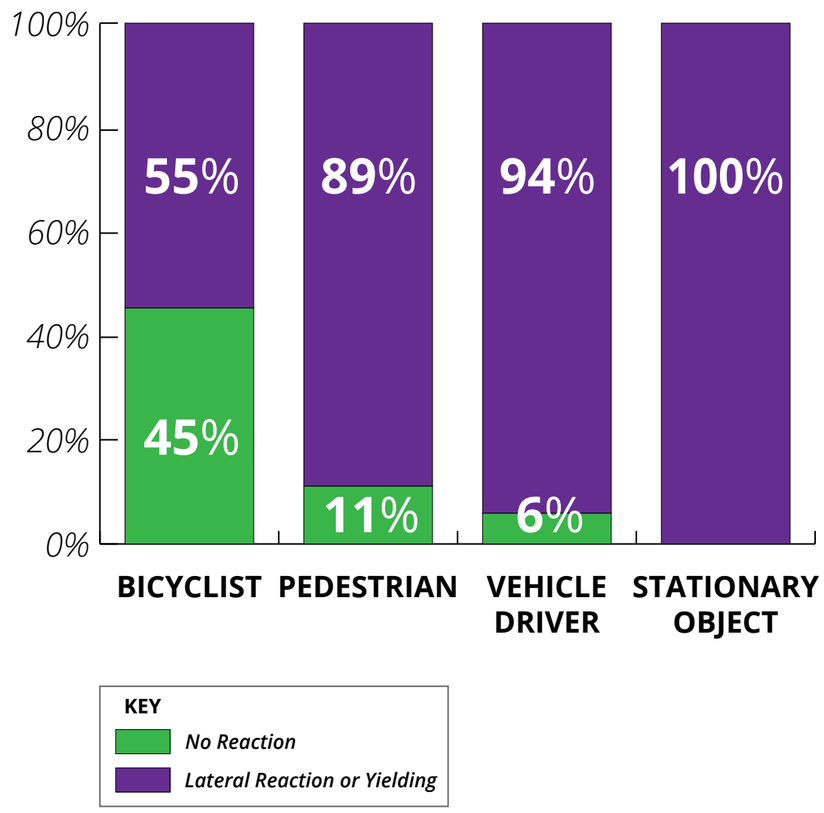
Reactor - is a Bicyclist
β = *reference* sig. = .000

KEY	No Reaction	Some Reaction
Significant		
Non-Significant		

RESULTS: Participant Variables

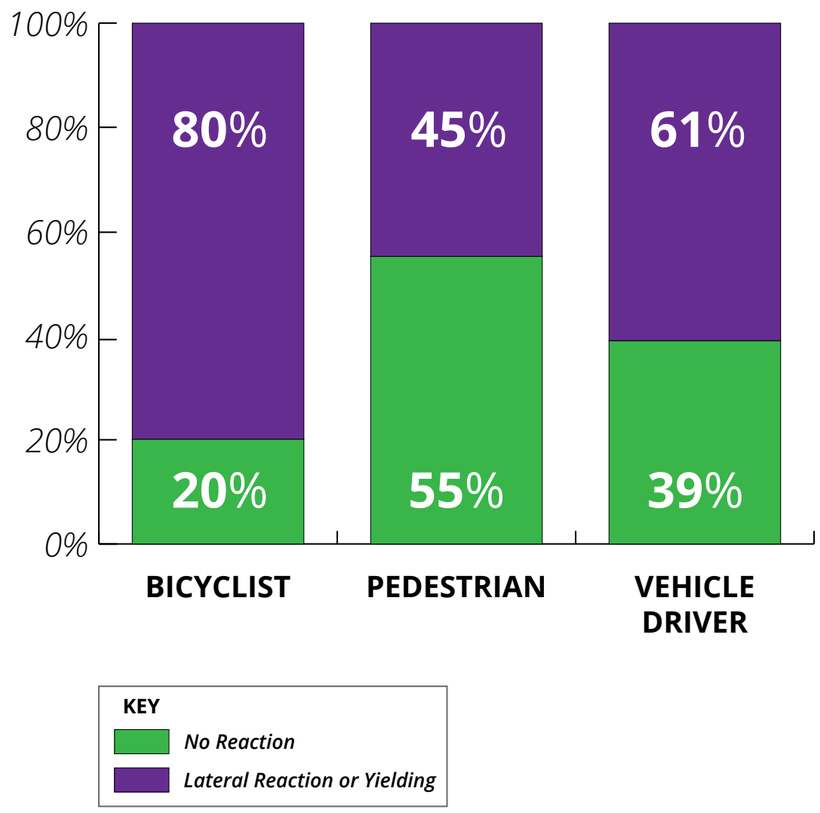
Stimulus Participant

Stimulus Mode x Reaction Type
% within Stimulus Mode



Reactor Participant

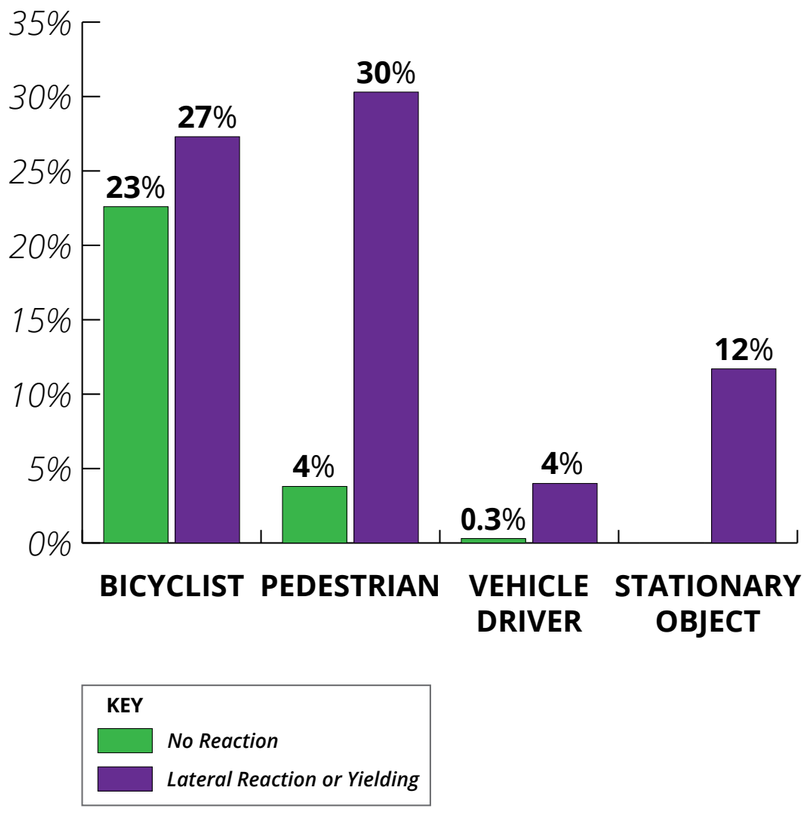
Reactor Mode x Reaction Type
% within Reactor Mode



RESULTS: Participant Variables

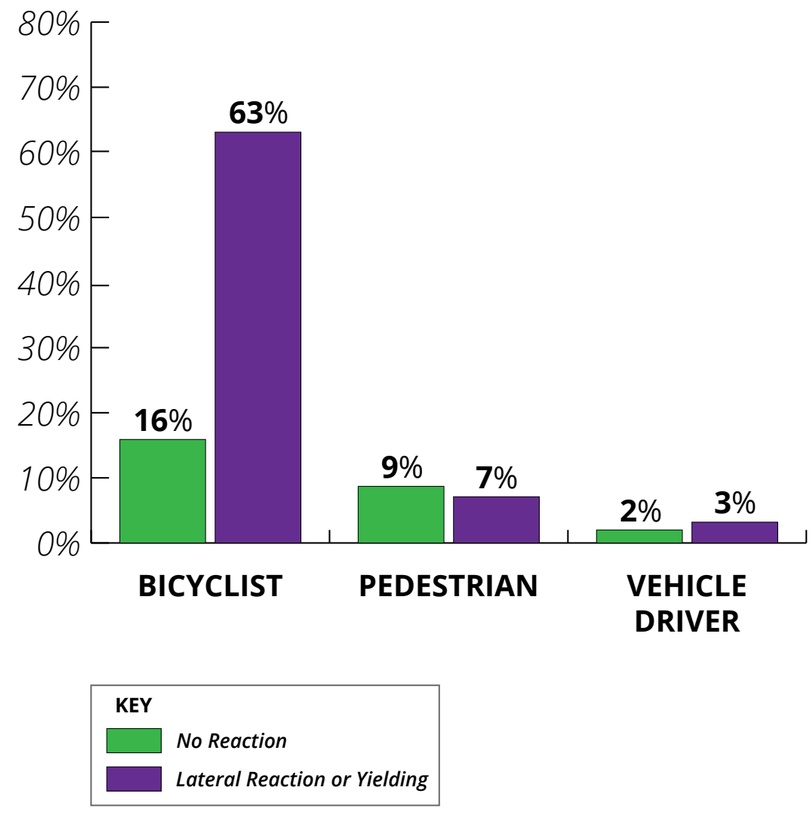
Stimulus Participant

Stimulus Mode x Reaction Type
% of Total Interactions



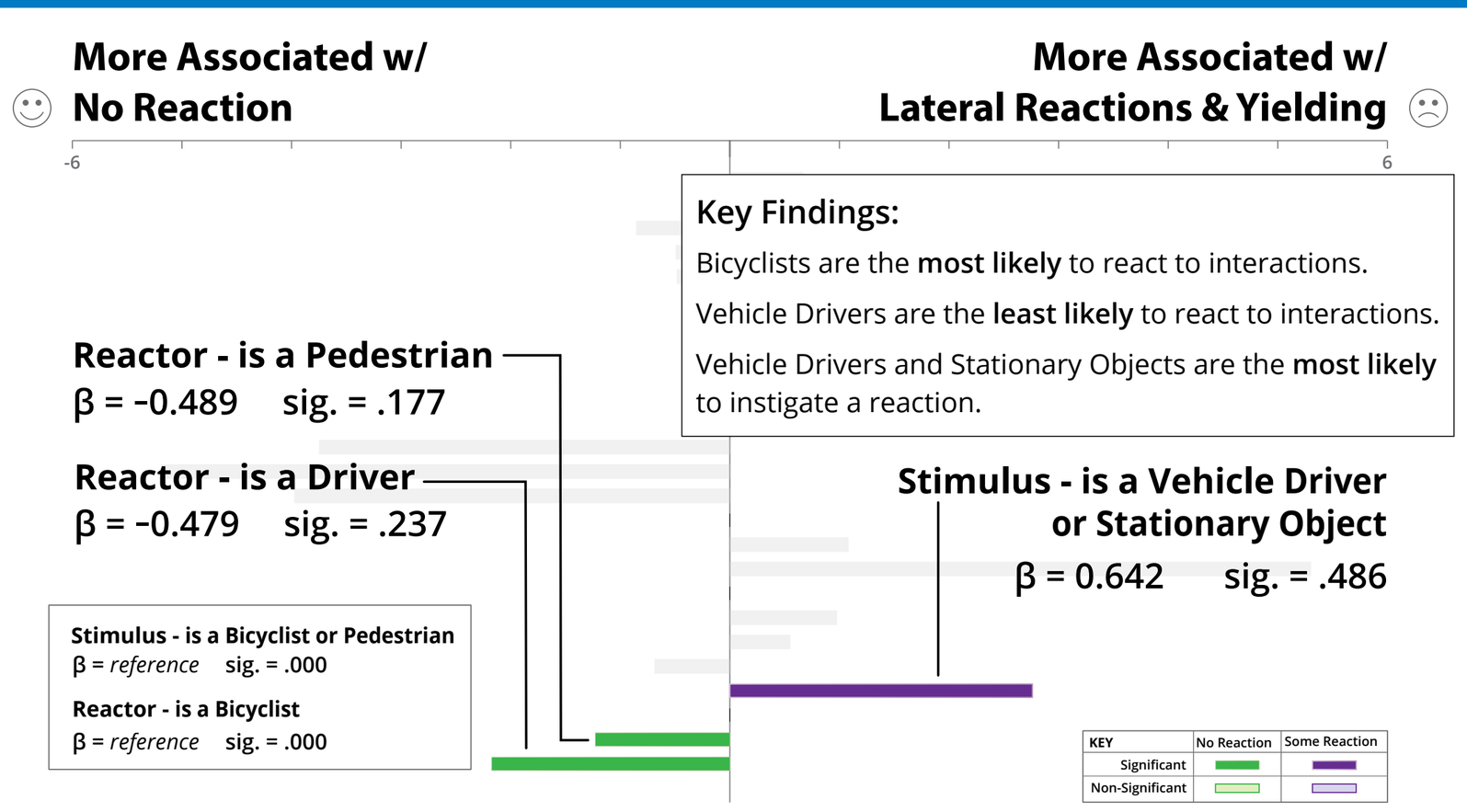
Reactor Participant

Reactor Mode x Reaction Type
% of Total Interactions

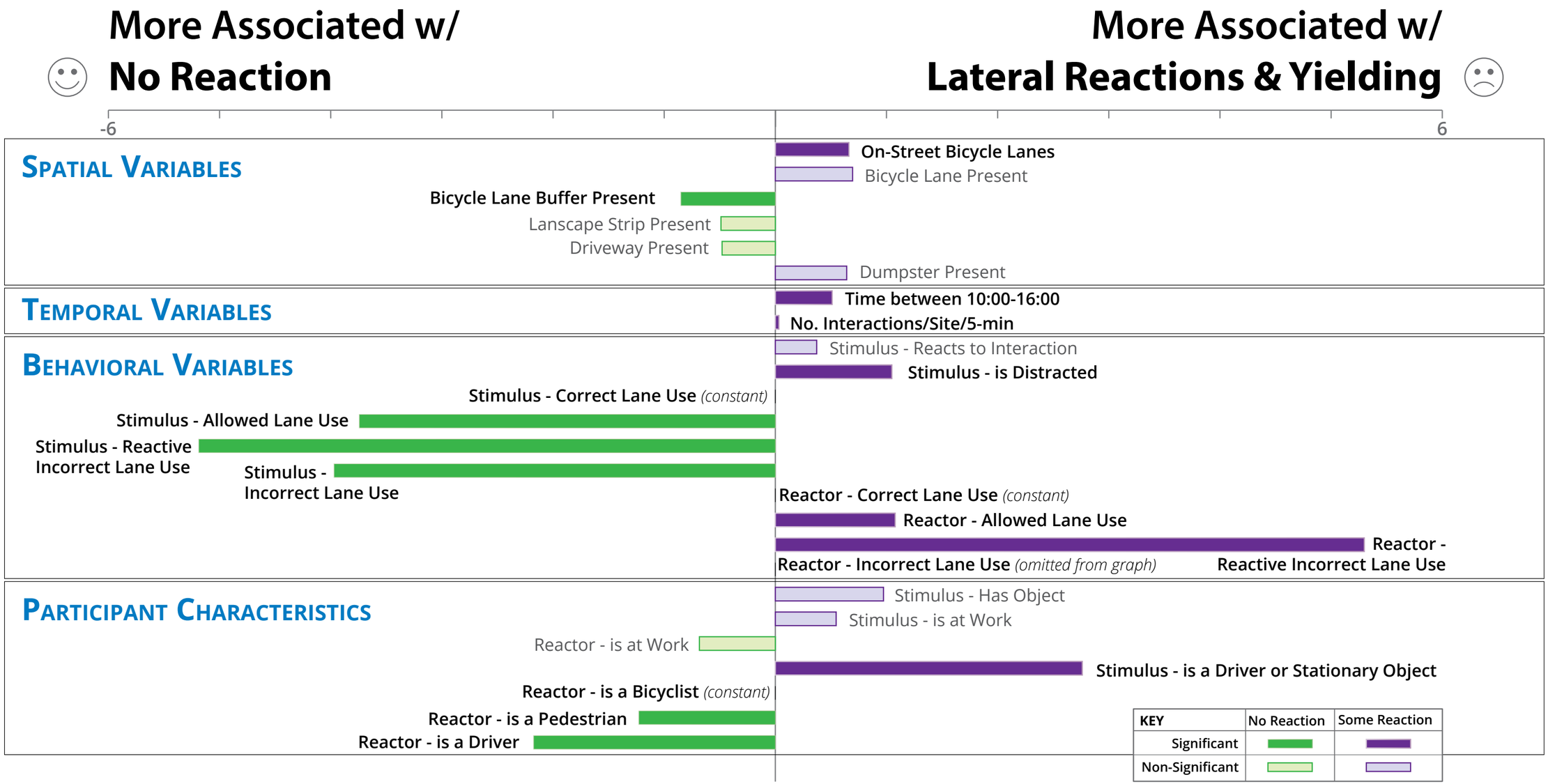


RESULTS: Behavioral Variables

Findings for: 1-on-1 Interactions



COMPARATIVE CASE STUDY: Results



RESEARCH APPROACH

With all this new data, do we know if we are achieving goals?

EVALUATION: Spatial Variables

	Safety	Mobility	Access
On-Street Bicycle Lane	–		
Bicycle Lane Present	(–)		
BL Buffer Present	+	+	+
Landscape Strip Present	(+)	(+)	(+)
Driveway Present	(–)		(+)
Dumpster Present	(–)	(–)	

EVALUATION: Design, Use and Users

- **On-Street Bicycle Lanes:**
  Fewer interactions, mostly 1-on-1 interactions, but higher statistical likelihood for interactions resulting in reactions.

- **Bicycle Lane Buffers and Landscape Strips:**
  Extra space is good for safety, mobility, and access!

- **Time of Day:**
  Street designs perhaps better accommodate “no reaction” interactions during commute times, but functionality reduces during the day when the street use is more diverse.

- **Legal Lane Use:**
  A person who is simply using their travel lane can be a stimulus of a lateral reaction in another person legally using their lane. This should not be happening so much…

- **Transport Mode:**
  Bicyclists are reacting the most, indicating an issue with objective/subjective safety and/or that the roadway design is not providing enough capacity for different mode users.



"The main challenge to investigating the functionality of bicycle facilities along street segments is that **urban street are not only transportation facilities, they are public spaces.."**

Silva C, **Moeckel** R, **Clifton** K. Proof of Concept for a Grounded Theory Approach to Understanding Interactions Occurring on Bicycle Facilities. *Transportation Research Record*. August 2020. doi:10.1177/0361198120943588




RESEARCH OUTLOOK

- **Evaluation of Case Study Sites:**
  This method and findings can be used to evaluate the existing bicycle lanes and generate design standards and traffic regulations to avoid undesirable/unsafe interactions.

- **Inform Existing and Future Research on Bicyclists' Interactions:**
  Future research can investigate how road users perceive the discovered interactions to identify those with the greatest impact on subjective safety.

- **Inform Understanding of User Behavior in Other Contexts:**
  The grounded theory-driven observational method can be used to investigate interactions/behaviors on other types of infrastructures and public spaces.

- **Provide Insights into Impacts of Emerging Micro-mobility:**
  Exploratory studies using this method can be used to help us understand how e-scooter user behaviors; how they use the roadway and how they interact with other mode users.

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Thanks!

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All photographics and graphics contained in this document were taken or made by Cat Silva.

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