Fachhochschule Nordwestschweiz
Hochschule für Architektur, Bau und Geomatik

Creating immersive virtual environments for travel behaviour research: insights from a cycling experiment

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THANKS TO

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RESEARCH OBJECTIVES

Objectives

To understand what is needed to make cycling a viable mode of transport in Singapore

Explore **Virtual Reality** as a research tool for **traveller behaviour** research?

/ To understand **behaviour**

/ For **public engagement**

Research questions

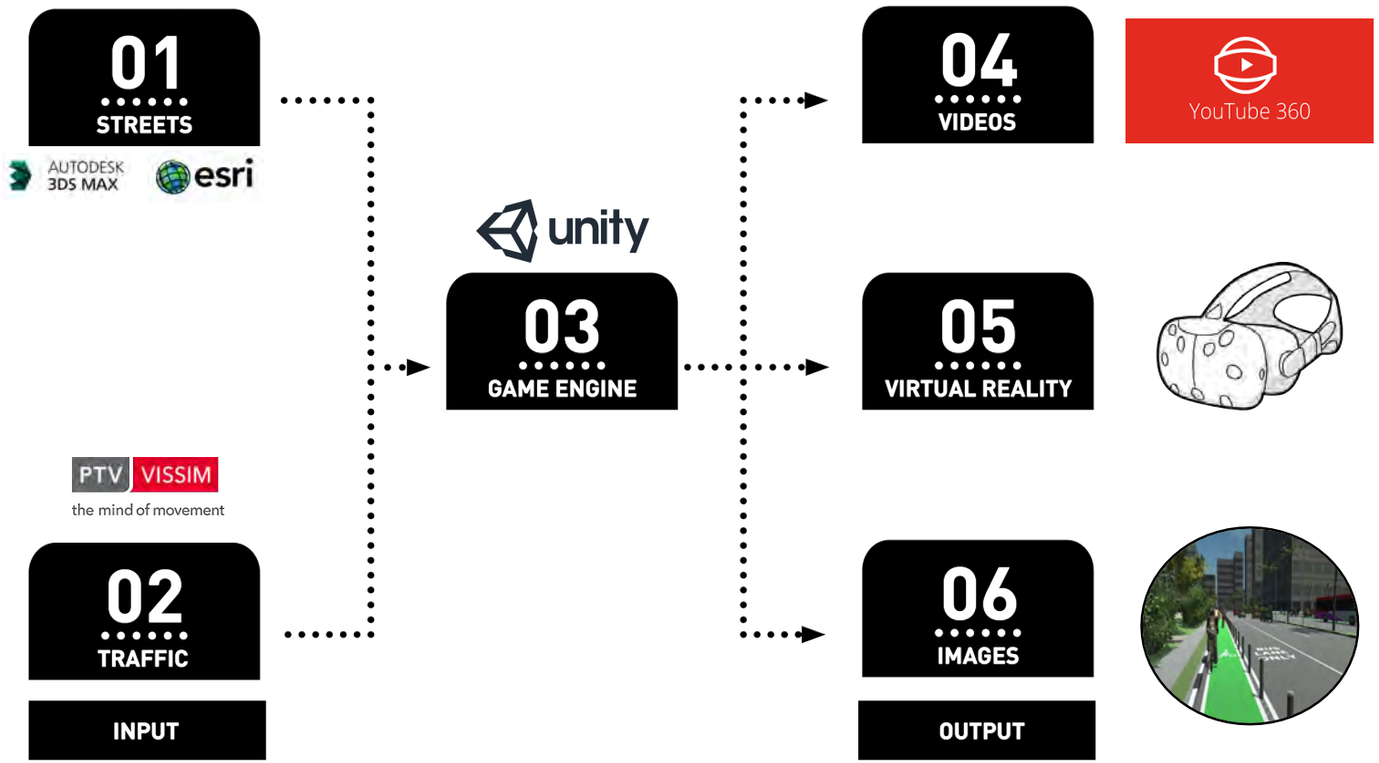
/ How to **effectively generate realistic streetscapes** in VR?

/ **Behaviour** in Virtual Reality, and how does it compare to real-life (reproducibility)

/ **Limitations** of VR in **research**? And **public participation**?

VR-enhanced survey ”Bike to the Future”

GENERATING VIRTUAL ENVIRONMENTS



Usage of parametric models and 3D models to generate virtual environments.

Traffic is taken from a traffic microsimulation.

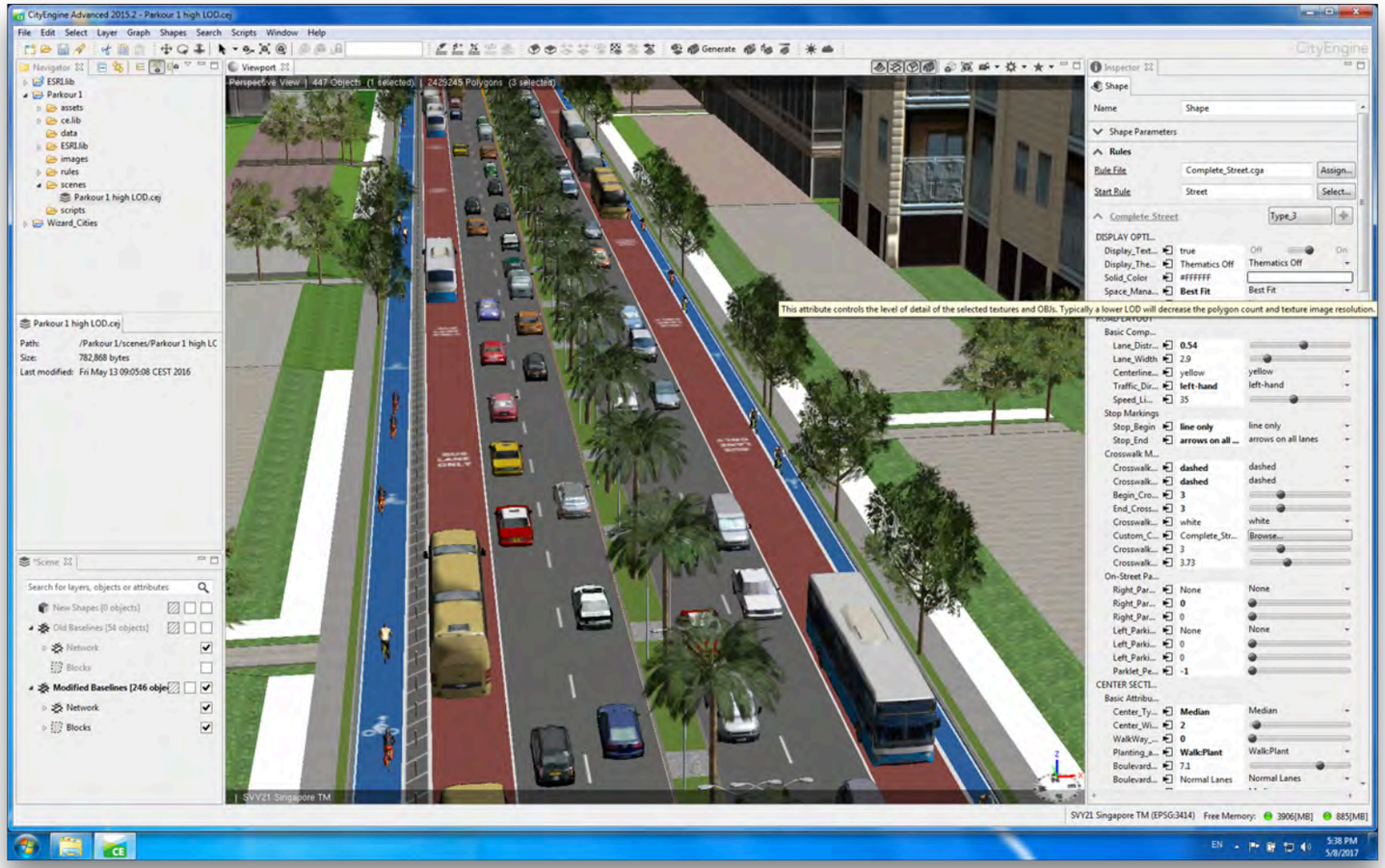
Both are integrated into a game engine.

Given the resources required, videos are used as well for other surveys and engagement.

Virtual Reality is generated and images are rendered out for usage in surveys

Erath et al. (2016) “Visualizing Transport Futures: The Potential of Integrating Procedural 3d Modelling and Traffic Micro-Simulation in Virtual Reality Applications.”, Paper presented at the 96th Annual Meeting of the Transporation Research Board, Washtington DC

VIRTUAL ENVIRONMENTS



Code available at
https://github.com/fcl-engaging-mobility/Complete_Street_Rule

Procedural modelling

Computer graphics technique to create 3D models and texture from a set of rules

Programmable visualisation saves a lot of modelling efforts

Interactive rendering allows new applications

Complete streets rule

Developed by ESRI Research

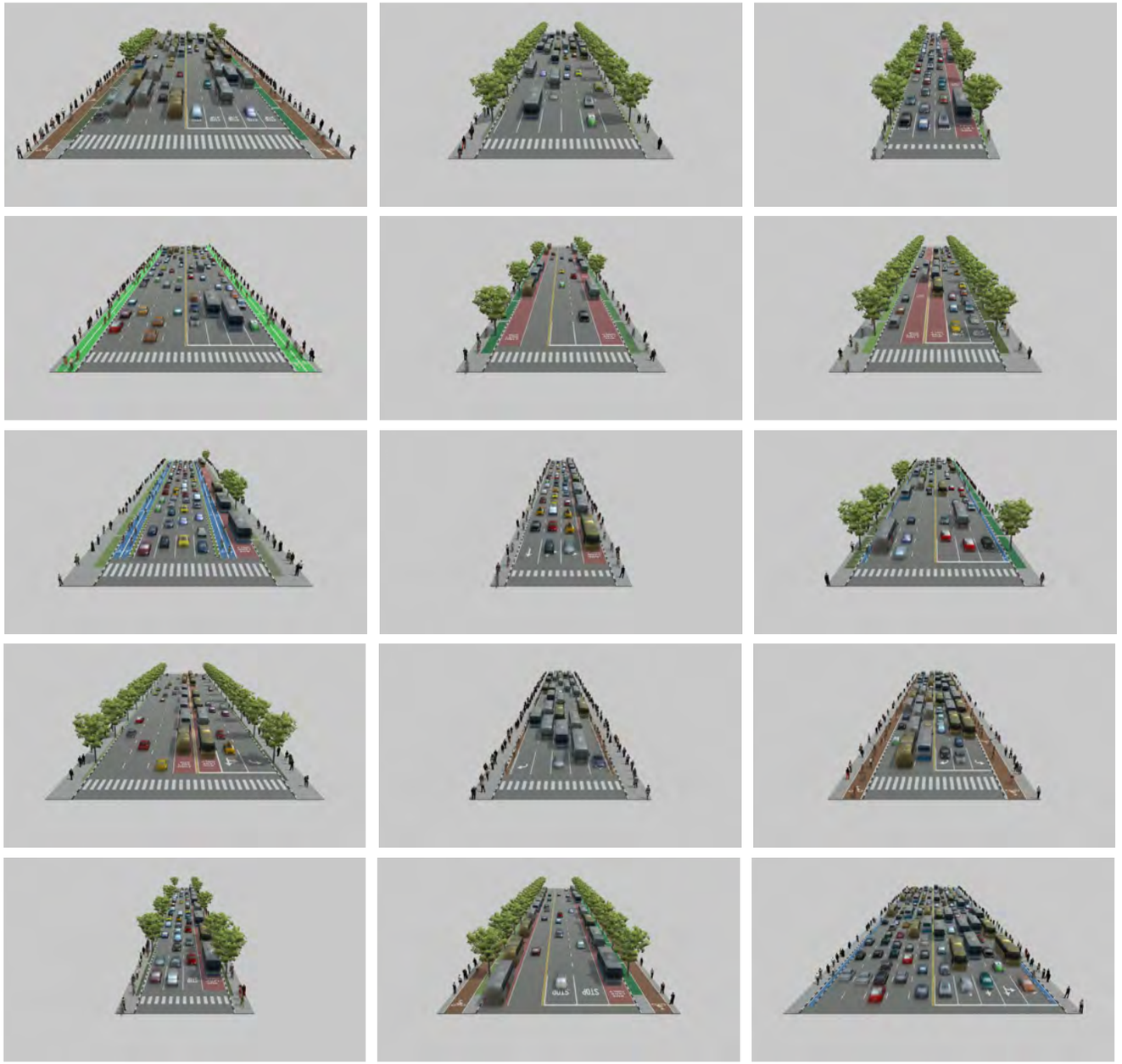
Robust procedural street rule

Further developed to fit Singapore conditions and our modelling needs

Challenges

The generated virtual environment require additional effort in Unity to reduce the complexity

MATERIALS
APPLICATIONS



TRAFFIC SIMULATION

Streets are **not** traversed **empty.**

People might find other pedestrians and cars, interesting,

Experience anxiety and stress from pedestrians and cars,

Lines of sight changes, and pedestrians / cars divert attention

Challenges

Realistic movement of pedestrians and vehicles

Interaction between participant and simulation

EXPERIMENTAL SET-UP

Participants are seated on a cycling simulator.

Participants can brake and pedal; steering is disabled (but possible).

To ease the transition between VR and reality, the leg movement in VR is synchronized, and participants see their hands on the steering wheel.

Schramka et al., (2017) “Development of Virtual Reality Cycling Simulator.”, 3rd International Conference on Virtual Reality, Hong Kong

BIKE TO THE FUTURE

Redesign streets around to accommodate cycling infrastructure.

Invite people to cycle on these three different streets designed for active mobility in Virtual Reality

Engage and get feedback on how **safe** and **comfortable** they feel cycling given the new design.

van Eggermond et al. (2017), “Probing the Potential of Virtual Reality for Research and Engagement in Mobility and Urban Design.”, Working Paper

BIKE TO THE FUTURE

Aim
Develop integration between 3D models, Unity and PTV Vissim
Evaluate the usage of Virtual Reality for Engagement

Virtual environment
3D model from Singapore's Urban Redevelopment Authority

Redesign
In SketchUp, 3D Max and Unity

Motion
Pre-defined recorded trajectory and speed through the virtual environment

2D: https://www.youtube.com/watch?v=sTmHHMcaHnA
3D: https://www.youtube.com/watch?v=2sgPp9Dbar0

BIKE TO THE FUTURE 2

Aim
Perception of safety and comfort in a laboratory environment
Perception of speed and space

Virtual environment
Parametric models, 3D Max and Unity

Design
In SketchUp, 3D Max and Unity

Motion
Cycling simulator, respondents can steer, brake, pedal. Virtual environment rendering according to position participant

PERCEPTION OF SPEED

PERCEPTION OF SPEED AND SPACE

Response frequency to speed sequence A

Answer \ Treatment	X30.km.hr	X20.km.hr	X10.km.hr
a lot faster		7	1
somewhat faster	2	40	1
as fast as		7	25
somewhat slower	44	1	23
a lot slower	9		5

Response frequency to speed sequence B

Answer \ Treatment	X30.km.hr	X20.km.hr	X10.km.hr
a lot faster	23		
somewhat faster	23	1	18
as fast as		4	26
somewhat slower		37	2
a lot slower		4	

q	Speed variation [km/hr]		
	30	20	10
Accuracy	98%	87%	46%

Interpretation
Speed differences are perceived of 30 km/h and 20 km/h.

Differences of 10 km/h are not perceived clearly by almost 50% of the participants.

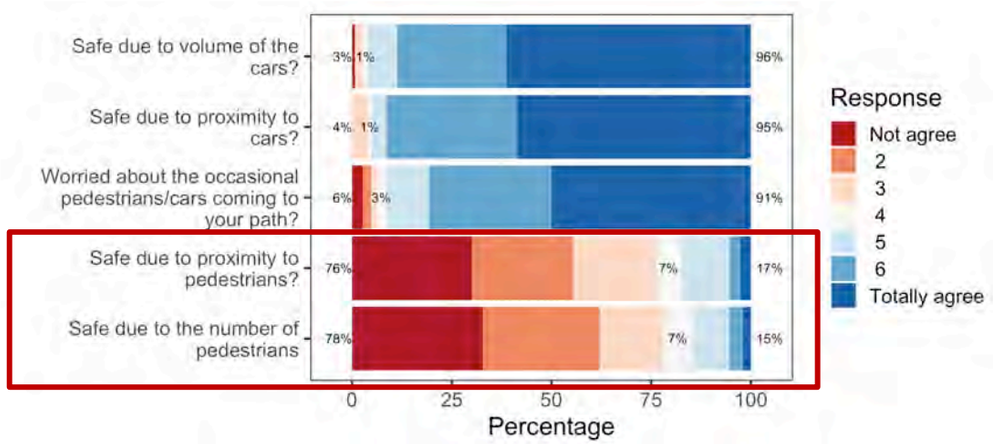
Other experiment
Similarly, differences in lane width of 30cm were not perceived by 50% of the participants.

PERCEPTION OF SAFETY

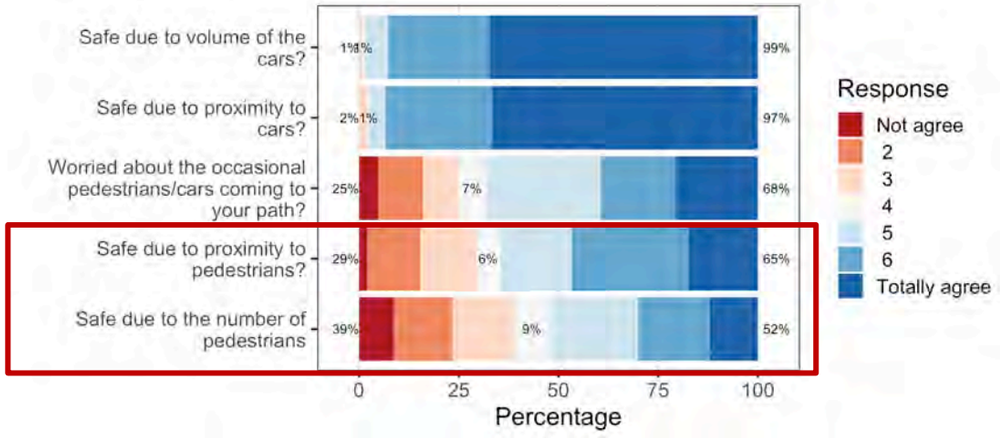
Nazemi et al. (2019) “Studying Bicyclists’ Perceived Level of Safety Using a Cycling Simulator Combined with Immersive Virtual Reality.”, To be presented at the International Cycling Safety Conference 2019, November 2019, Brisbane, Australia

PERCEPTION OF SAFETY

Sidewalk



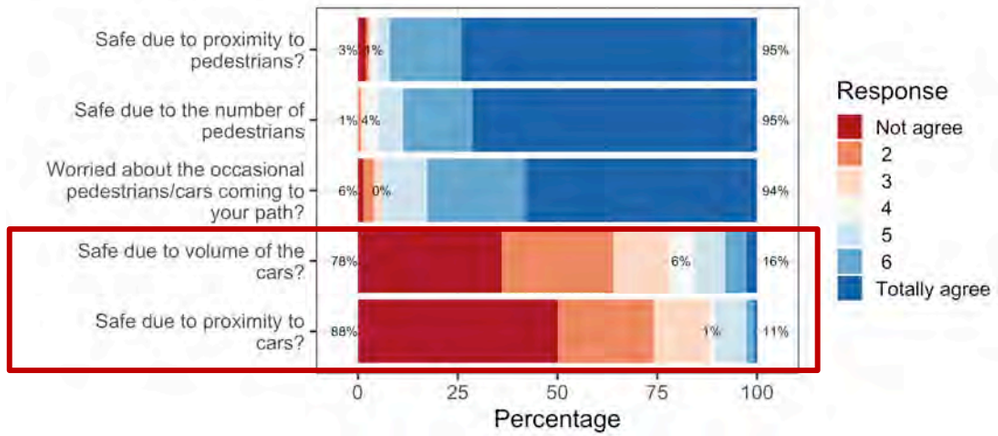
Painted bicycle path on the sidewalk



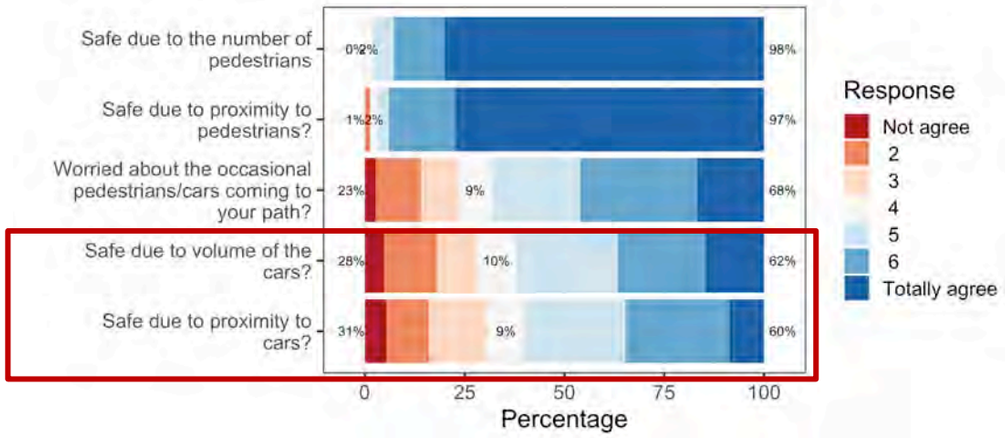
When cycling on the sidewalk pedestrian were clearly concerned about pedestrians entering their path; these concerns can be alleviated by introducing a painted lane on the sidewalk. In both cases, the cycling track has a similar width.

PERCEPTION OF SAFETY

Roadside



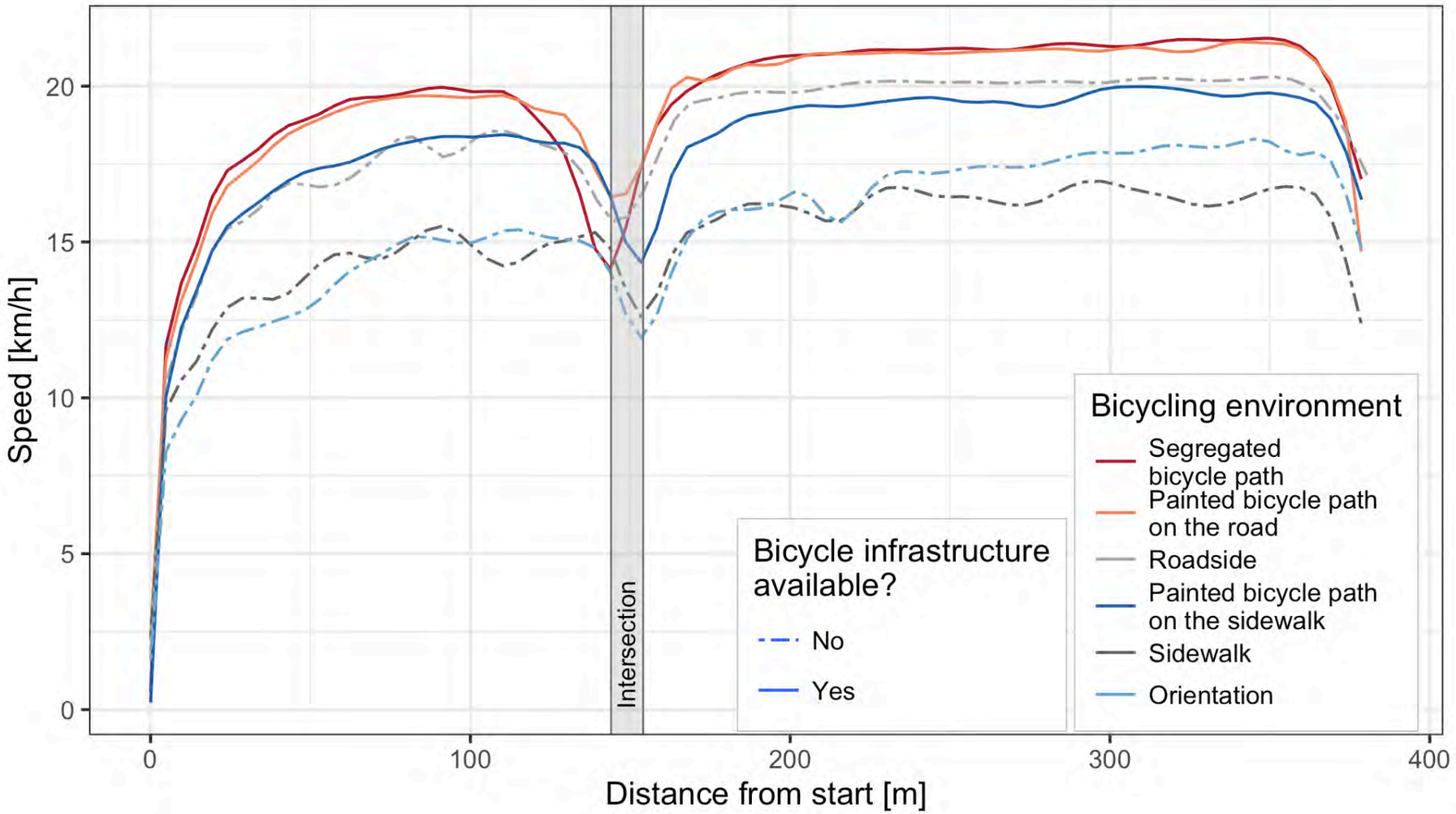
Painted bicycle path on the road



CYCLING SIMULATOR OUTPUT

Nazemi et al., (2019) “Studying Cyclists’ Behavior in a Non-Naturalistic Experiment Utilizing Cycling Simulator with Immersive Virtual Reality.” Paper presented at the 98th Annual Meeting of the Transporation Research Board, Washtington DC

CYCLING SIMULATOR OUTPUT



Participants choose a different speed based on the cycling facilities available.

SUMMARY & NEXT STEPS

Lessons learned

Virtual Reality is an exciting & promising tool for travel behavior research.

Sitting on a bicycle already **provides engagement** and makes an immersive video exciting, an **instrumented bicycle** even **more**.

Moreover, it is possible to **create a wide range of designs,** and **vary pedestrian volumes** and **traffic volumes** and obtain plausible responses.

When using an **instrumented bicycle** with **immersive virtual reality**, it is only possible to reach a **limited number** of people and expose them to a **limited number of environments**.

Lots of effort, interdisciplinary team required , new outputs / changes require somebody on board with game design experience.

Measurement

Preferably, **responses** should be measured from a **variety of sources**, especially when using physiological measurements.

More work needs to be done to **collect responses** '**on the go**' in VR for elicited responses

Next steps

More experiments:
(a) online video-based survey for perception of safety,
(b) instrumented bicycle in real-life

More 3D model generation:
Generation of 3D models using available models to cities from different sources (e.g. drive throughts, low LOD models, etc)

More statistical models and data analysis: physiological data analysis.

STAY IN TOUCH

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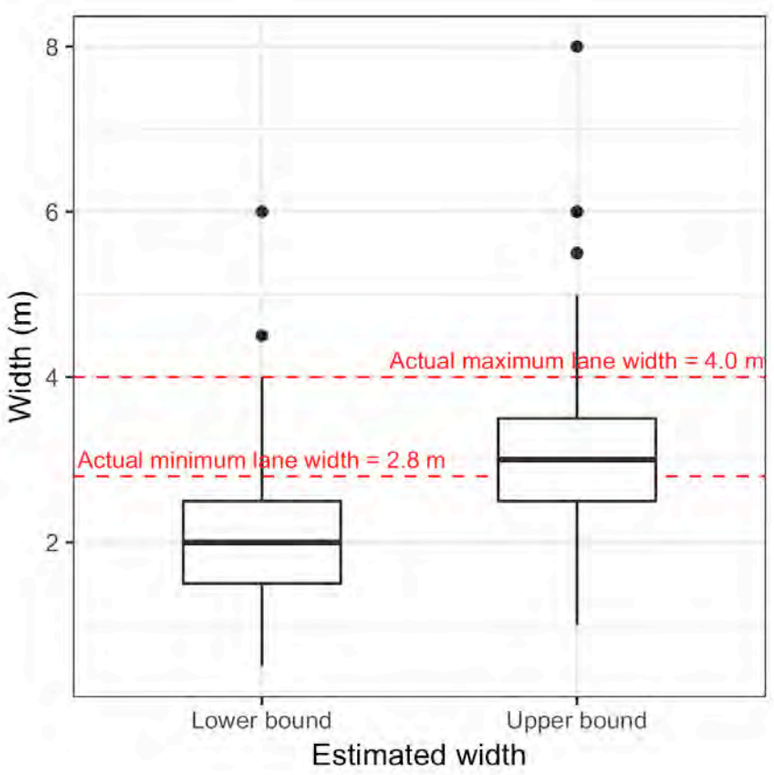
APPENDIX

PERCEPTION OF SPACE - ESTIMATION



PERCEPTION OF SPEED - ESTIMATION