

A photograph of two people riding electric scooters on a paved path. The person on the left is wearing a black t-shirt and red shorts, while the person on the right is wearing a patterned shirt and blue jeans. The background is a blurred green landscape with trees. The title text is overlaid on the left side of the image.

Rider-centric Approach to Micromobility Safety

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Research motivation

- Micromobility and active travel is more sustainable compared with driving.
- Yet, the adoption rate remain **LOW** in the U.S.
- Enhanced understanding of **subjective travel experiences/perceived safety** plays a key role in promoting micromobility and active travel
 - fearful, unsafe, stressful, vulnerable, discomfort
 - Cheerful, refreshing, exciting



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How to measure subjective experiences?

Self-Report Survey



Directly ask respondents to rate the travel stress level

*Gold standard

Heart Rate Tracker



Collect heartbeat data to calculate metrics to evaluate stress level

*Most frequently used in active travel stress literature

EDA (GSR)



Collect skin conductivity data to evaluate stress level

*Widely used in active travel stress literature

** motion and humidity sensitive

Eye Trackers



Collect eye gaze behaviors to understand traveler's workload

*Emerging and inconclusive

** weather and eye constraints



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Semi-naturalistic E-scooter Riding Experiment



Biometrics Sensors

- Eye Tracking Glass
- Galvanic Skin Response (GSR) Sensor
- Heart Rate Monitor

GPS Sensor Phone



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Semi-naturalistic E-scooter Riding Experiment



Eye Tracking Glass

Data Collected

- World View Video
- Eye Fixation Point
- Pupil Dilation

Measurements

- Gaze patterns
- Gaze metrics-based stress level measurement



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Semi-naturalistic E-scooter Riding Experiment



Galvanic Skin Response (GSR) Sensor

Data Collected

- Skin Conductance Level

Measurements

- Emotion arousal (sad, anger, excitement, scared)



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Semi-naturalistic E-scooter Riding Experiment



Heart Rate Monitor

Data Collected

- Heart Rate Beat to Beat Time

Measurements

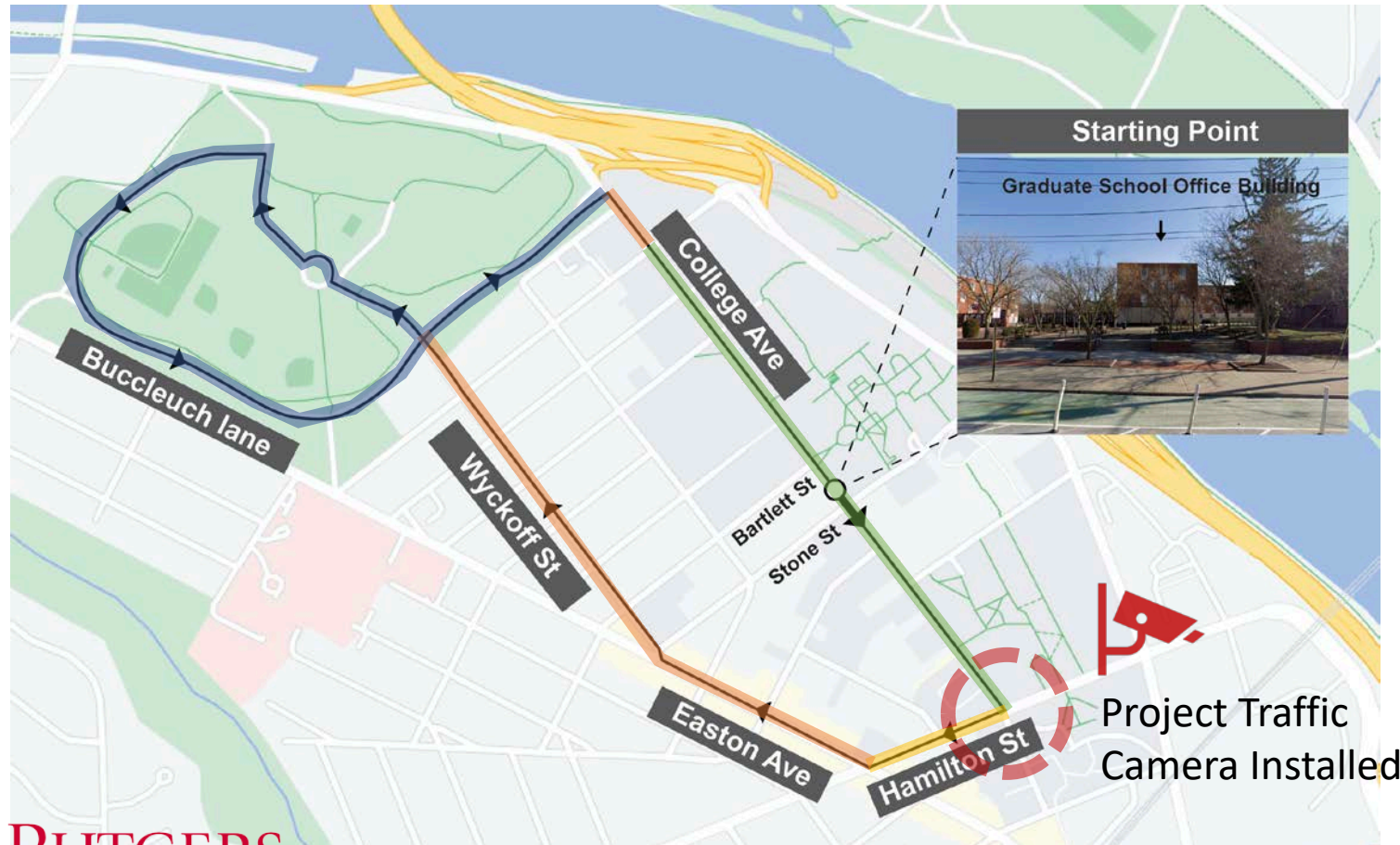
- Heart Rate Variability (HRV) to measure stress level



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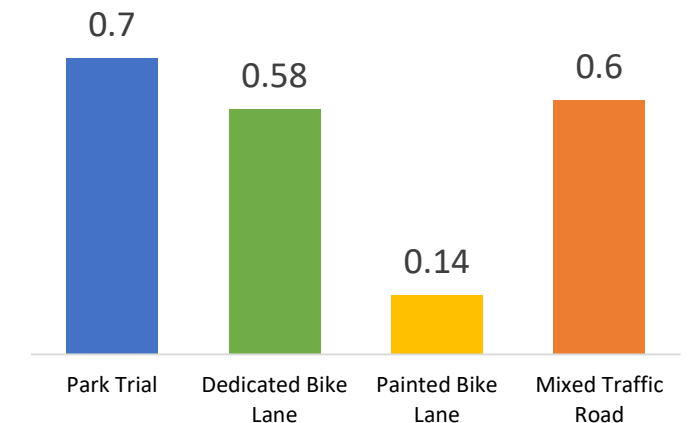
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Semi-naturalistic E-scooter Riding Experiment



- Park Trial
- Dedicated Bike Lane
- Painted Bike Lane
- Mixed Traffic

Total 2 mi, ~15-min ride



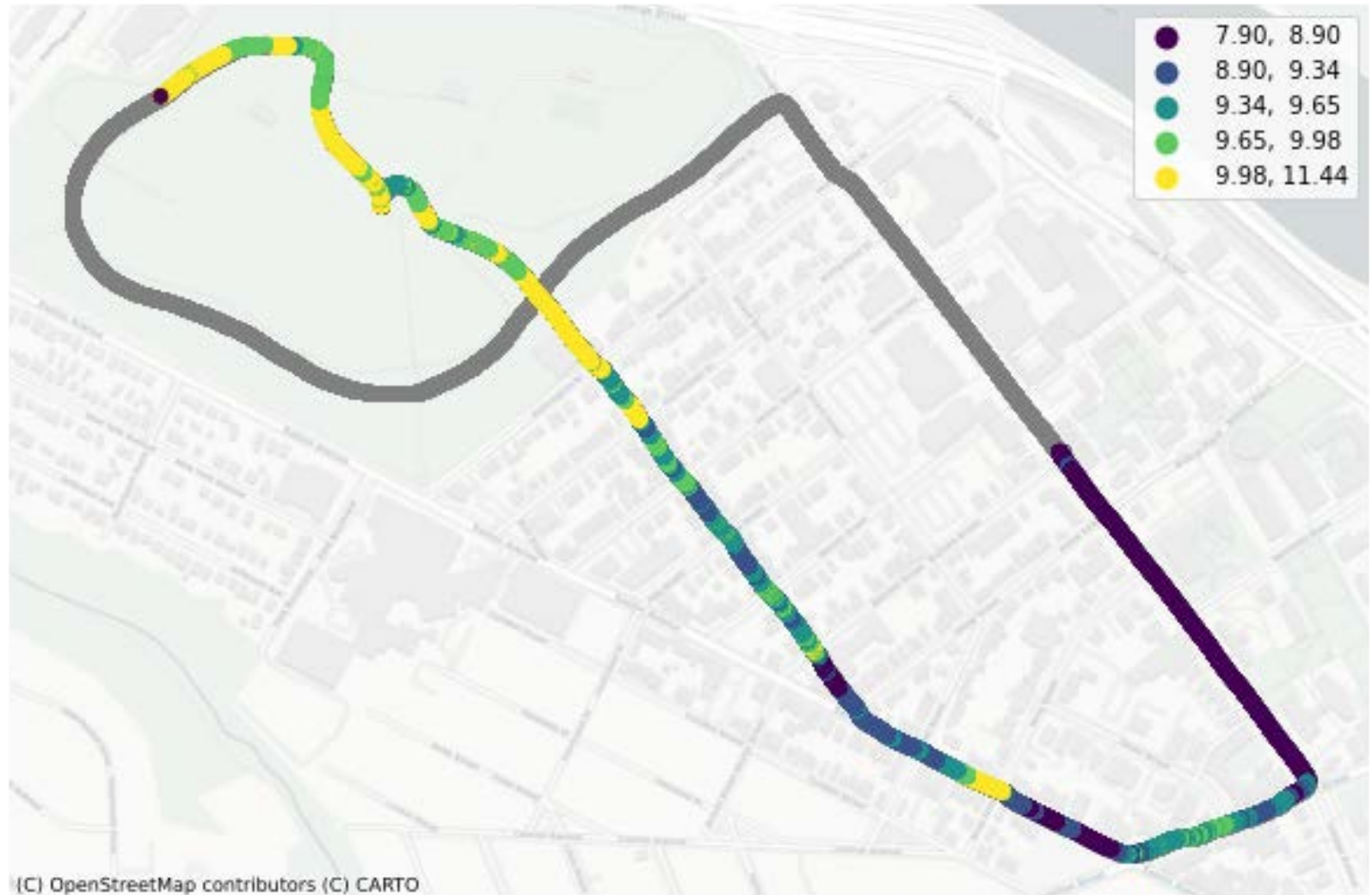
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Stress Level

- Sensor dropped in park due to uneven pavement

GSR, Skin Conductance Level (μs)



*Quantile color scheme



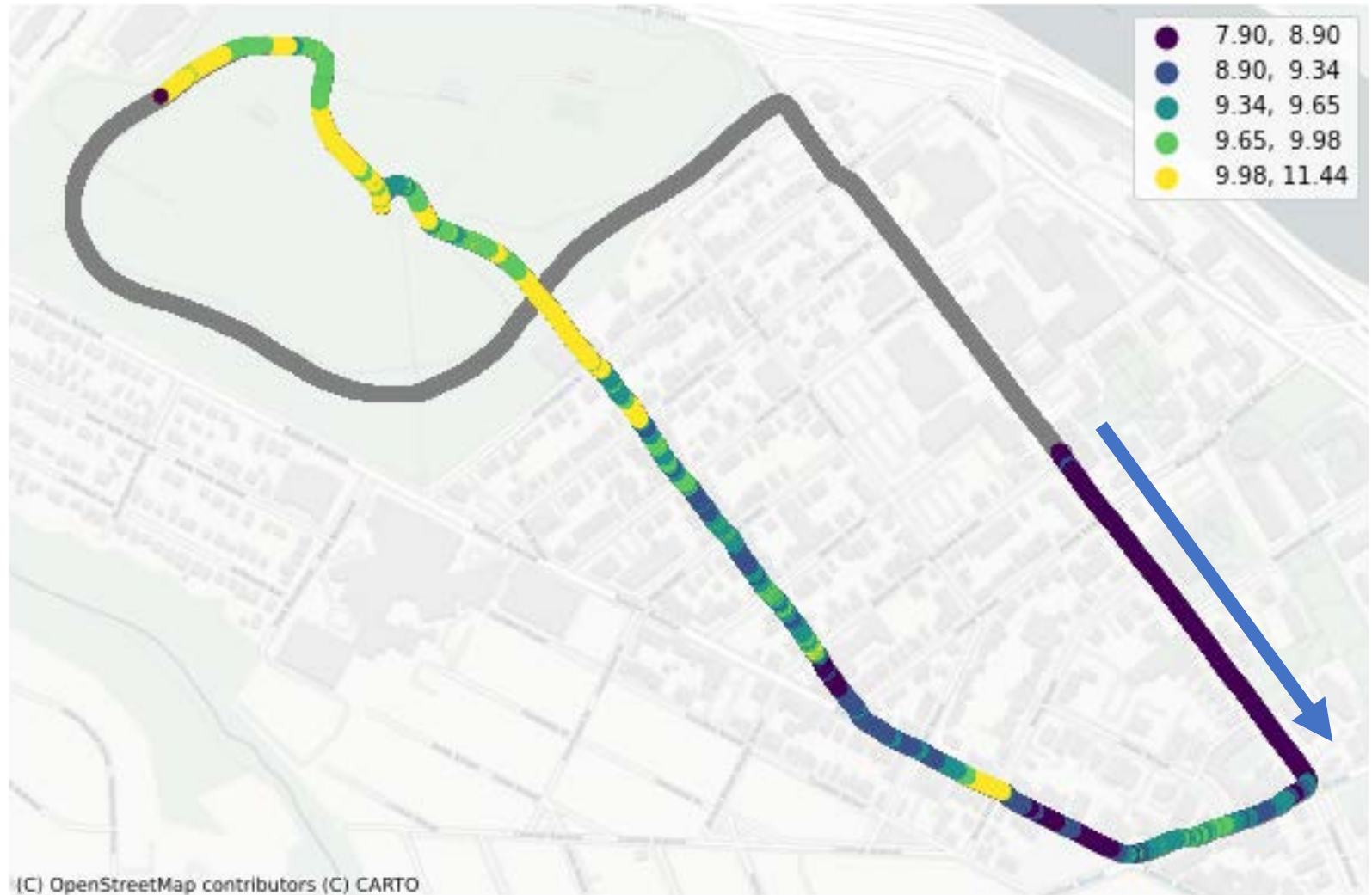
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Stress Level

- Sensor dropped in park due to uneven pavement
- Lowest when there is dedicated bike lane

GSR, Skin Conductance Level (μs)



*Quantile color scheme



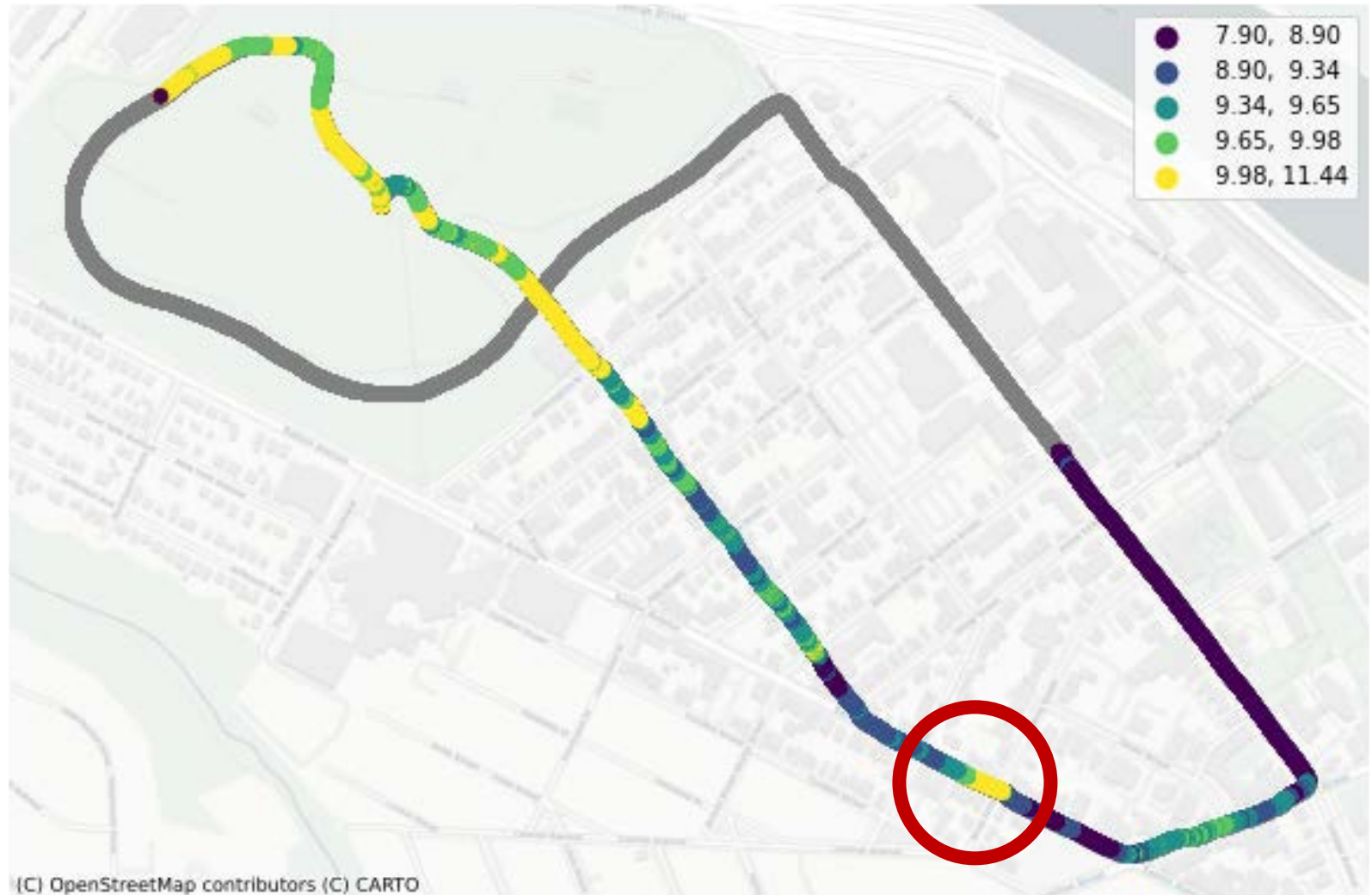
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Stress Level

- Sensor dropped in park due to uneven pavement
- Lowest when there is dedicated bike lane
- Captured a **near-miss** event Easton & Mine Street
- High in the park due to bad pavement condition

GSR, Skin Conductance Level (μs)



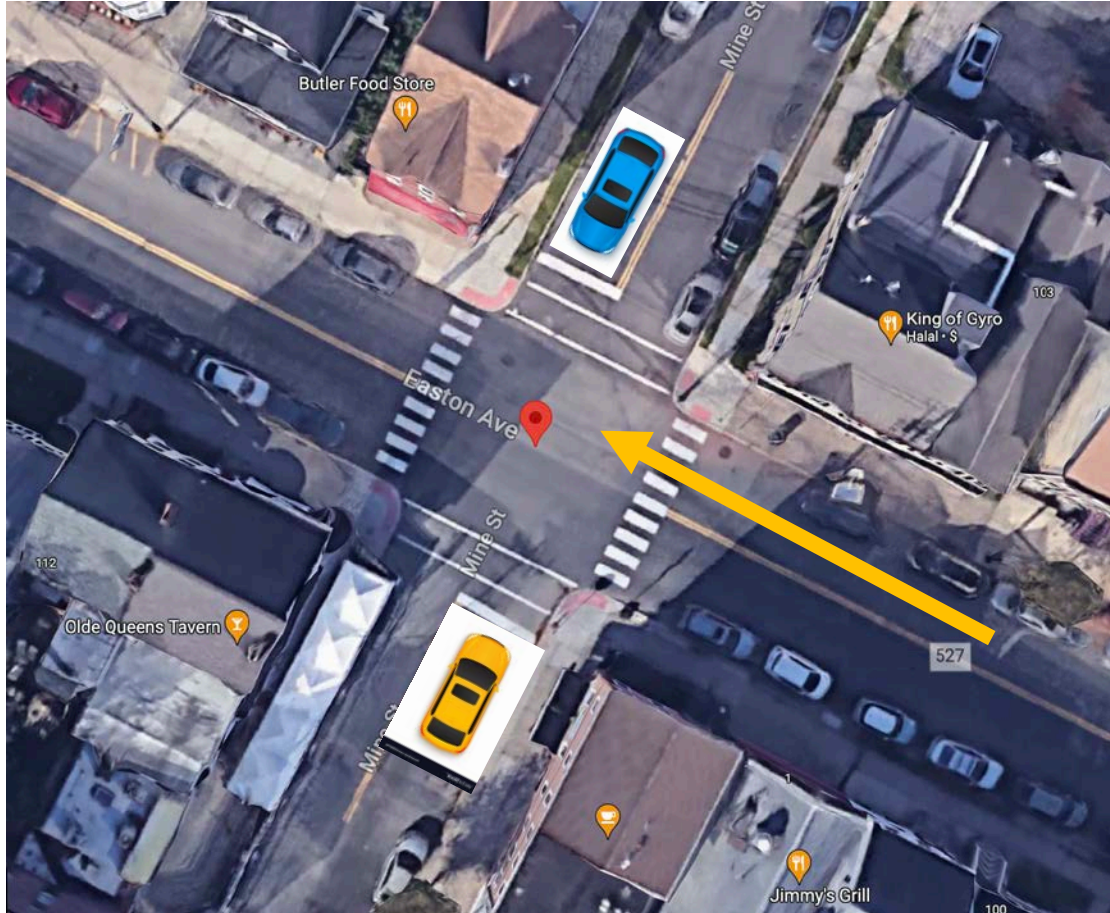
*Quantile color scheme



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Near Miss Event



- Non-signalized intersection with Stop Sign on Mine St.
- E-scooter traveling on Easton Ave
- One vehicle (yellow car) traveling from west bound Mine Street, yielded to e-scooter
- One vehicle traveling from the east bound Mine Street, fail to yield



While we are still collecting more e-scooter data,
We have completed our **WALKING**
experiment data collection.



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Walking Experiment

Apparatus

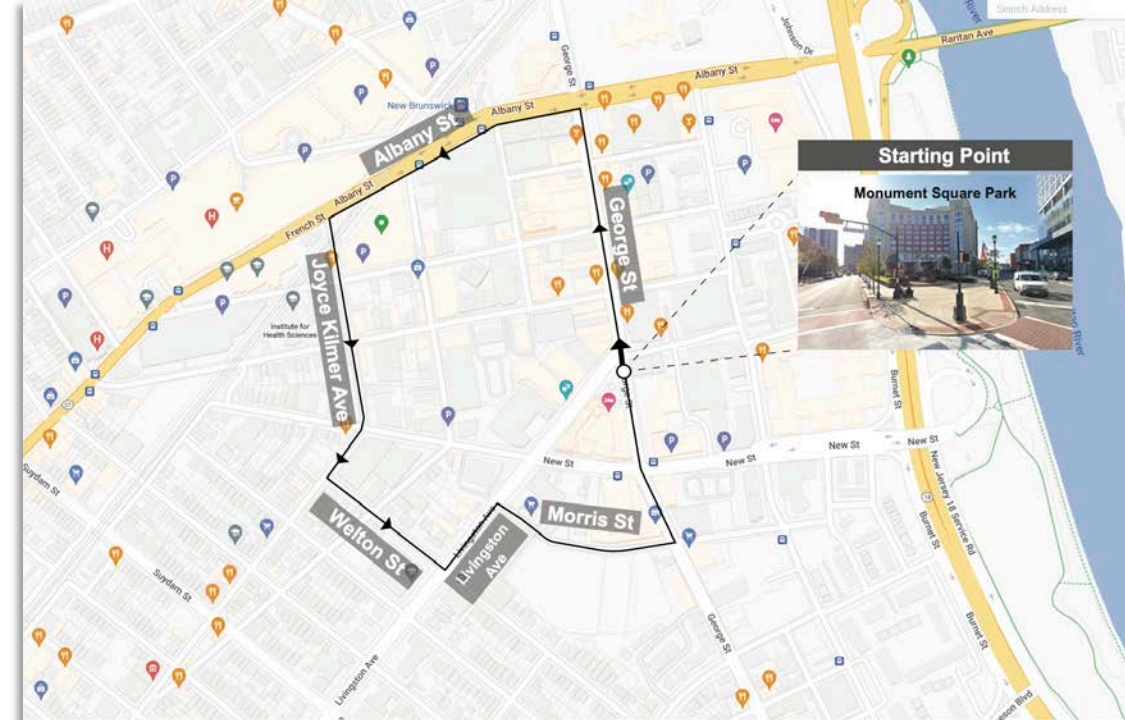
- Shimmer 3 (GSR)
- Garmin Watch (HR, GPS)
- Tobii Pro 3 (Eye movement)

1.2 Miles (~25 minutes) Route

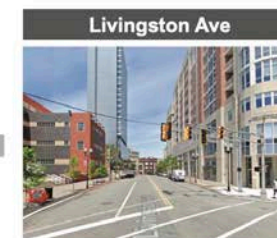
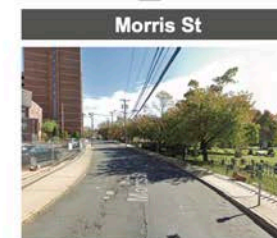
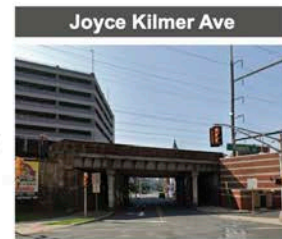
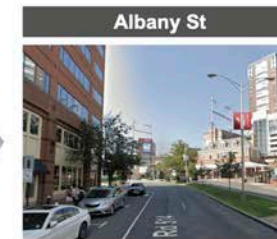
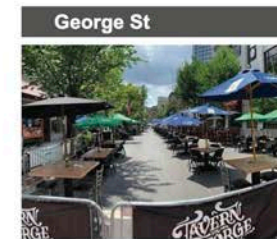
Surveys

- Pre-experiment: eligibility criteria
- Post-experiment: trip perception, travel behavior, demographics

* Bicycle and e-scooter experiments are on the way

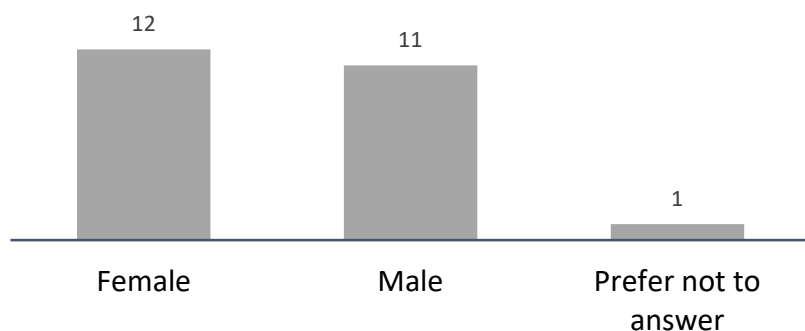


Walking Route Map

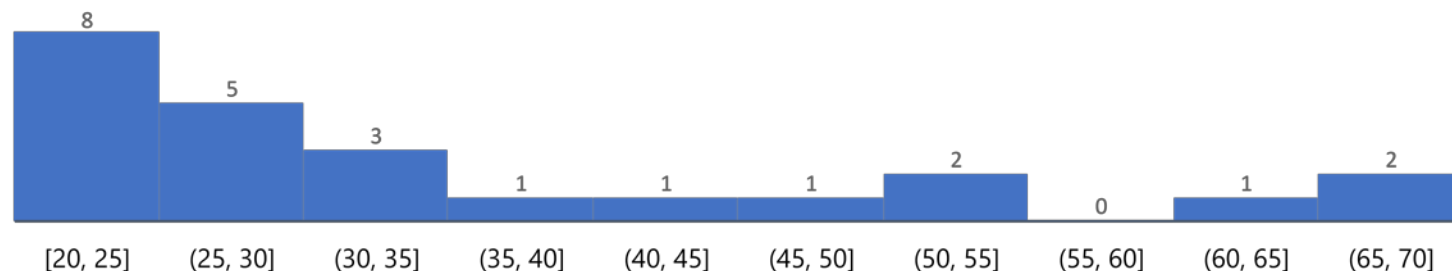


Participant recruitment result : 24 volunteers

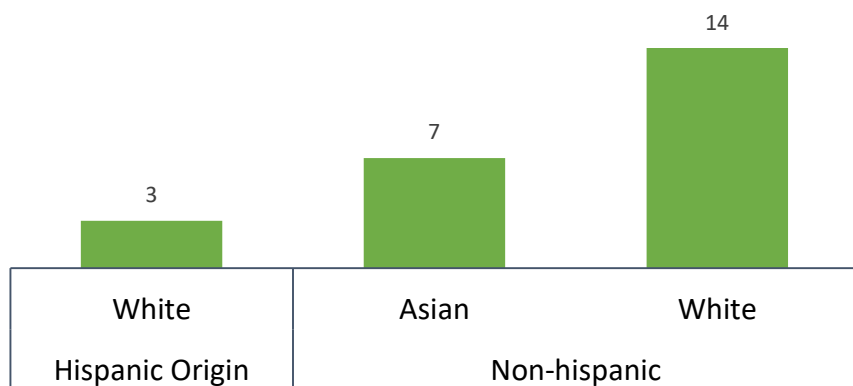
Gender Distribution



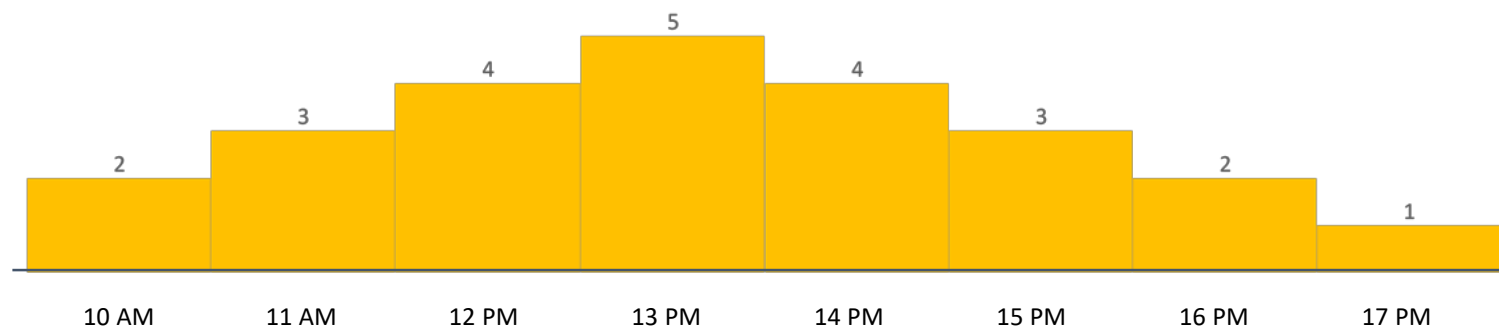
Age distribution



Race Distribution

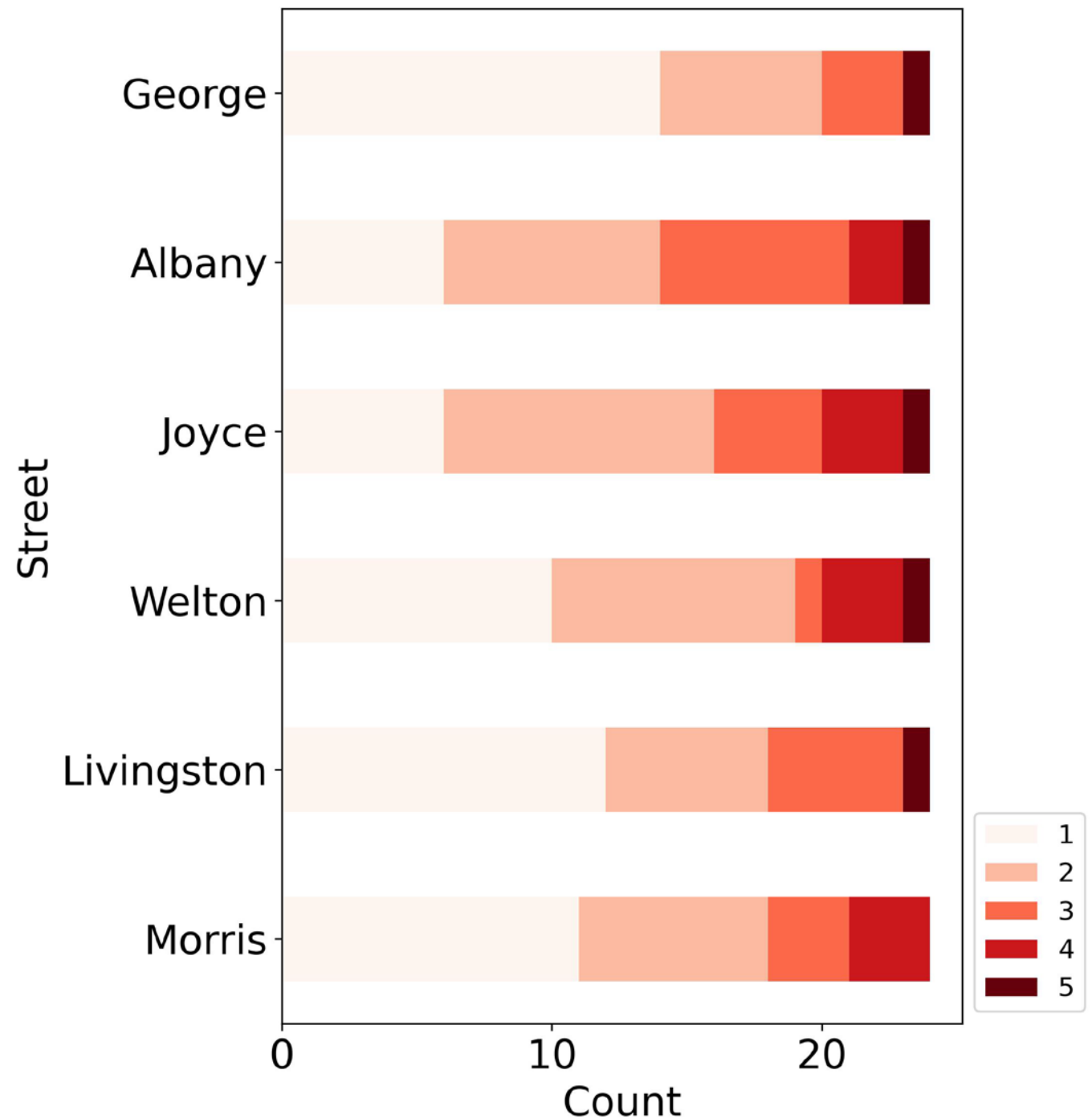


Experiment Start Time



Survey Results

- George street is considered as most relaxing
- Most people feel stressful on Albany and Joyce Kilmer streets



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Survey Results

- George street is considered as most relaxing
 - I like that there are **no cars** and a lot of **business** and **people** hanging out
 - specialty shops, food **places**, little markets
 - **nice** **ambience**
 - sometimes **cars** go on red from the cross streets since george st is closed. they assume pedestrians don't matter
 - busy sidewalk, **confusing** temporary barriers
 - a little **crowded**
 - Very high **police** **presence**

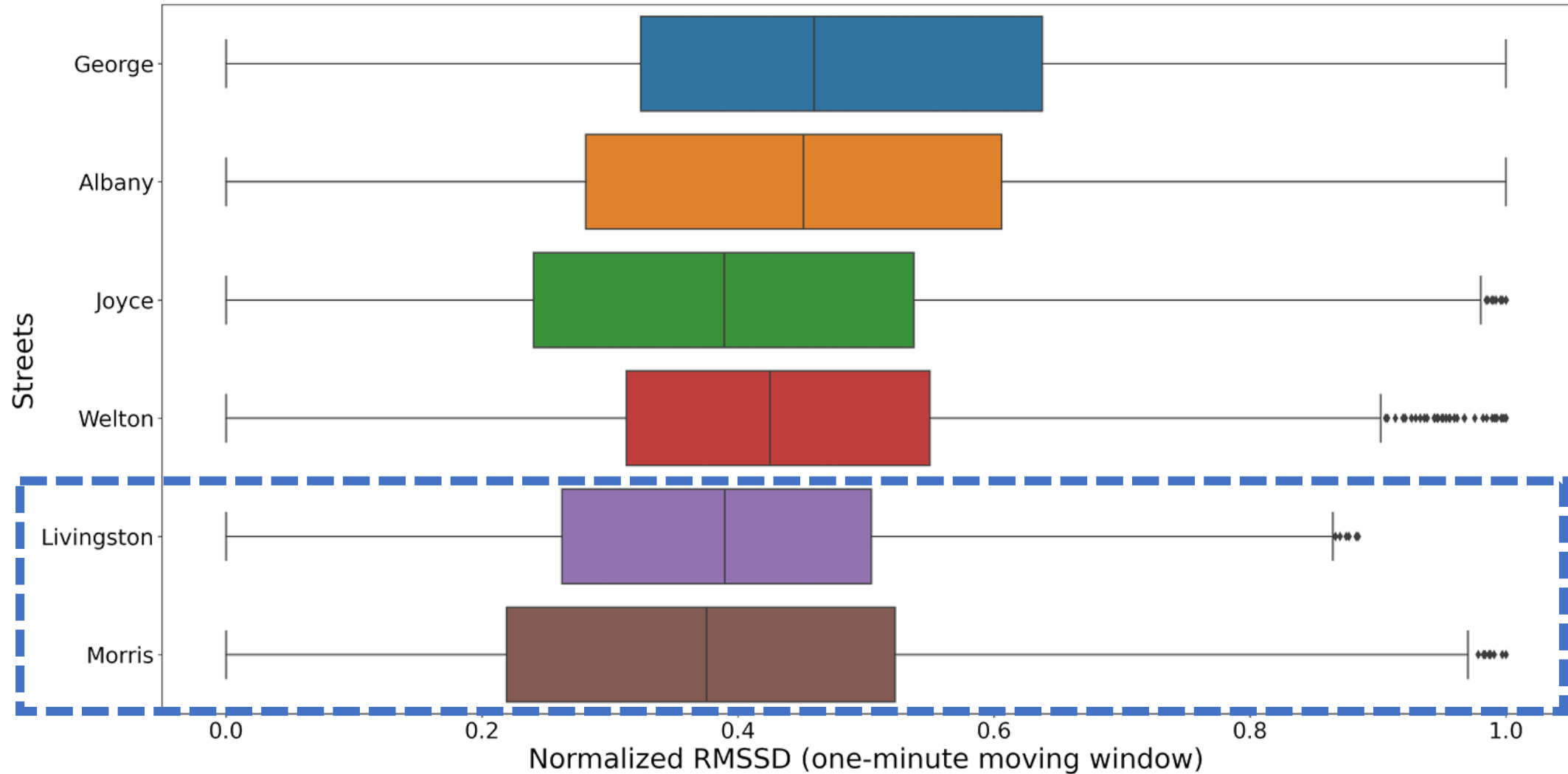


Survey Results

- Albany and Joyce is considered as most stressful
 - **wide sidewalks** sometimes
 - long sight lines, **train tracks**
 - **too many cars** and trucks. **intersection w/ easton** is bad
 - **Not enough green** here too much traffic
 - **High police presence. water dripping** from overpasses
 - cars honking, car parked on crosswalk, people stranded in the median, **driver yelling**

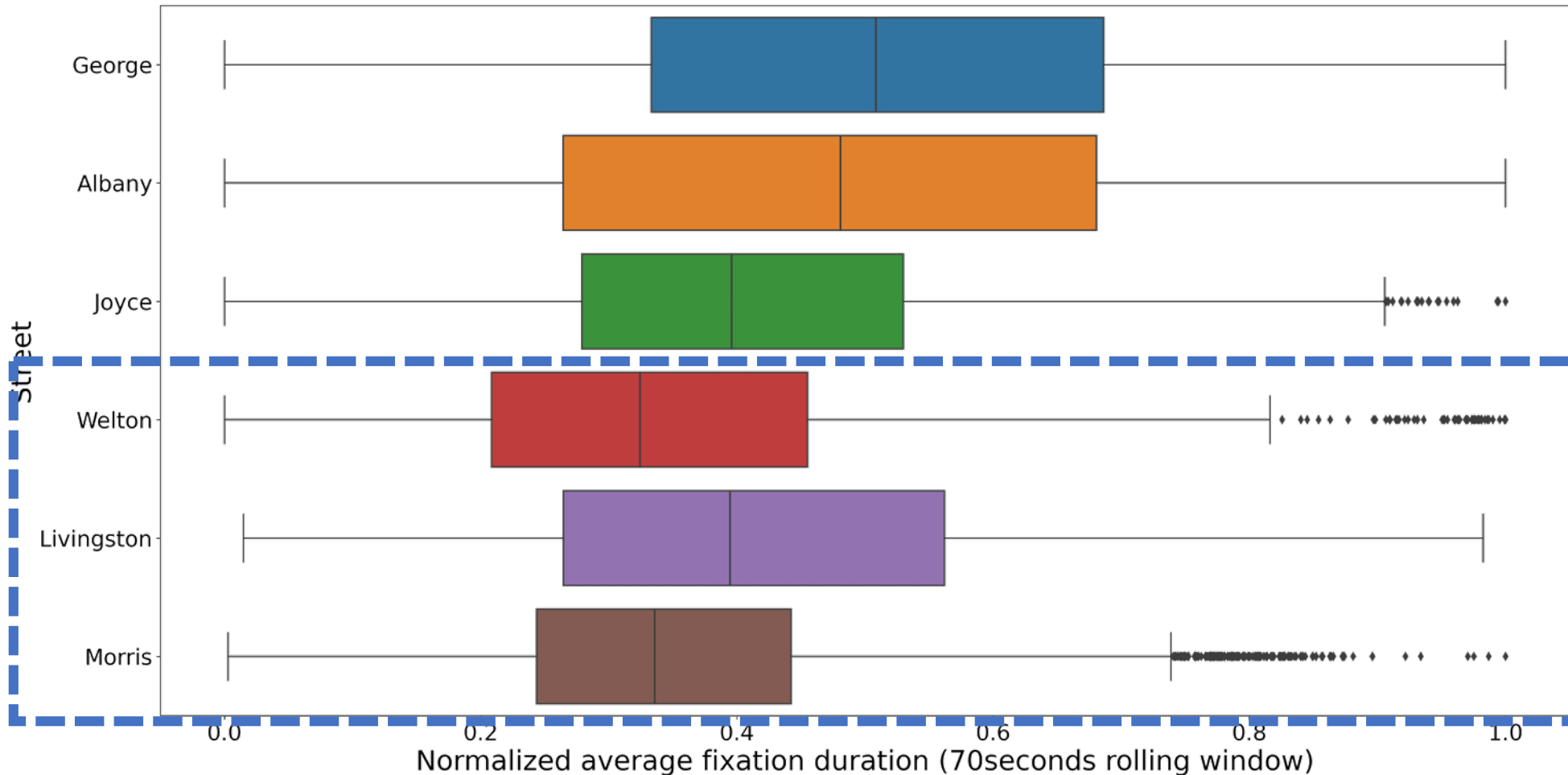


Heart Rate Variability



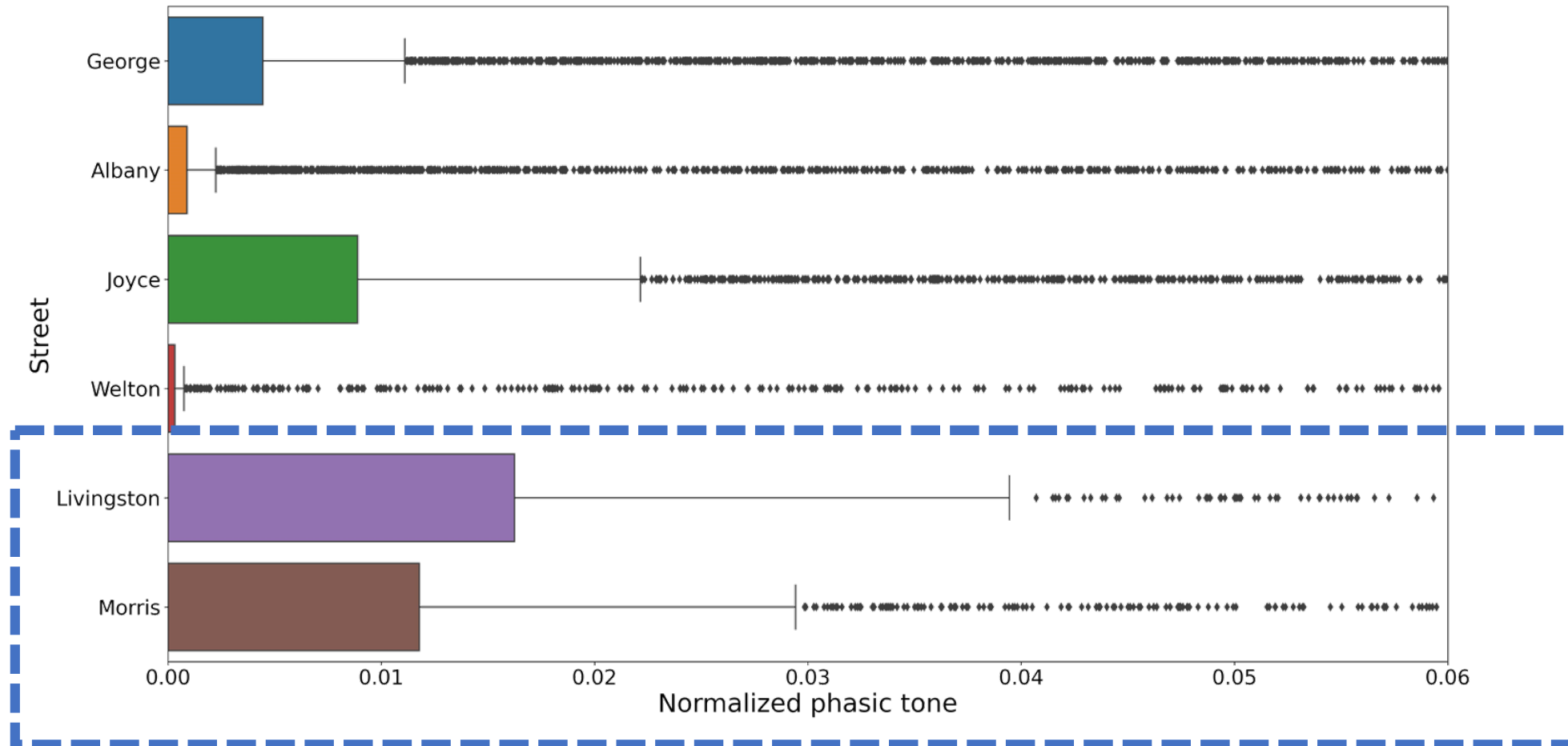
Eye tracking – Average Fixation Duration

- + Some observation periods are removed due to low eye tracking rates, especially on Albany Street when walking towards the sun.



Preliminary GSR Results

- Still exploring various GSR data preprocessing and phasic tones extraction algorithms



Livingston & Morris Intersection



○ Survey comments

- “Crossing Livingston intersection to morris is **stressful**”
- “The intersection **needs signal**”



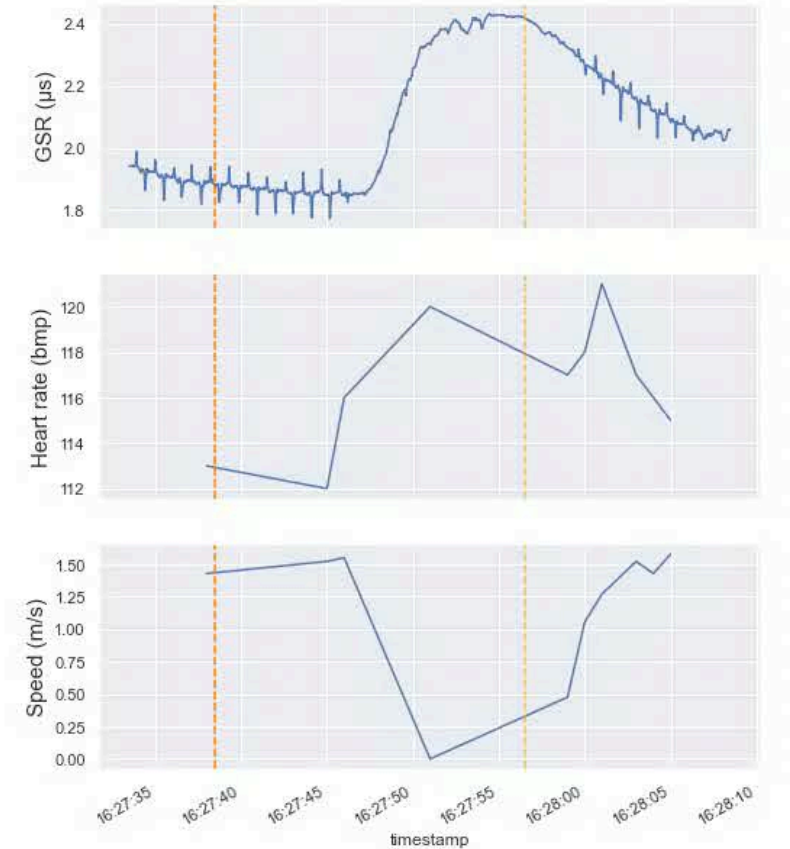
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GSR does capture stress level in real-time



GSR also captures positive feelings



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Navigation Patterns

- Area of Interest (Aoi) analysis
- Deep learning image segmentation
- Automatically classifies images into over 40 categories

Video Image



PSPNet Segmented Video Image



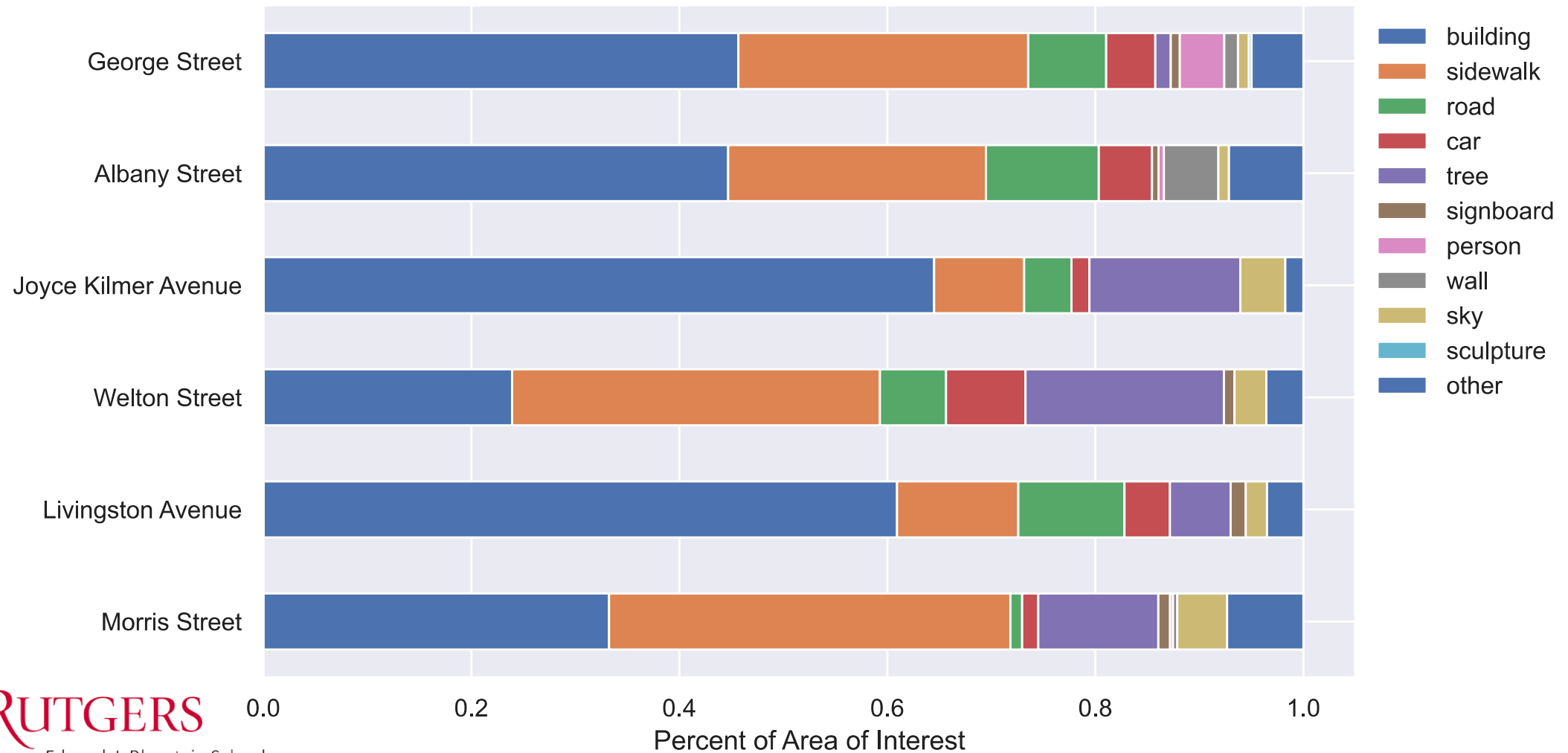
- car
- tree
- grass
- sky
- ceiling
- road
- person
- building
- sidewalk
- fence



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Navigation Patterns



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Next Steps

- Collect more sample data
- Develop descriptive statistics and models to explore the association between perceived environment and physical environment, and perceived environment and stress level
- Explore heterogeneity in risk perception (by gender, age)



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PARTICIPANTS NEEDED

Earn \$25 in a 30-minute ride

Join us in the field experiment of an e-scooter research



We are looking for participants to take part in an exciting study where you'll wear 3 sensors - eye tracking glasses, GSR and Garmin watch - and ride an e-scooter around the campus.

After the trip, you'll be asked to complete a survey about your experience. All participants will remain anonymous, and your data will be kept confidential.

To be eligible, you must have normal vision or corrected-to-normal vision with contact lenses. A VEO E-scooter will be provided for the experiment. If you're interested in participating, scan the QR code to complete a pre-experiment survey and check your eligibility.

Don't miss this unique opportunity to contribute to research and enjoy a ride!



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Thank you!

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