Investigating Stress-Induced Driving Behaviors: A Psychophysiological Analysis using Wearable Sensors

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A presentation to Choose Ohio First Poster Symposium
Case Western Reserve University
Cleveland, OH
April 7, 2024

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Abstract

- **Driving Stress**
  - Driving stress can result in negative emotions and unsafe actions, which can contribute to accidents.
- **Wearable Devices & Stress**
  - The study utilizes the Empatica E4 device, emphasizing wristband sensors to analyze stress induction in driving scenarios.
- **Research Methodology**
  - The research links vulnerability factors to stress, using a validated questionnaire and evaluating participants' performance in a **driving simulator and virtual reality**.
- **Participants & Target**
  - Three subjects (nine driving sessions) took part in three experimental conditions: Low-Risk Driving, Medium-Risk Driving, and High-Risk Driving.
- **The study aims to provide insights into the correlation between driving conditions and stress levels.**

What Others Have Done

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Who did the simulation?	Where was the simulation taken place?	How many subjects?	What was their outcome?	Link to the simulation
Yi-Cheng Lee and Flaura K. Winston	Philadelphia, PA	33	Their results showed that the proposed stress induction manipulations were effective in causing participant drivers to react emotionally and behaviorally.	Drivers' Emotions
Myron L. Braunstein, William J. White, and Robert C. Sugarman	Cornell Aeronautical Laboratory	4	A glare produced the largest effect on the road, which made it harder to drive	Use of Stress in Part-Task Driving Simulators
Zontone, Affanni, Bernardini, Del Linz, Piras, Rinaldo	University of Udine, Italy	13	During manual driving, the researchers noticed a greater variability than during autonomous driving.	Stress Evaluation in Simulated Autonomous and Manual Driving
Jungyoon Kim, Jangwoon Park, Jaehyun Park	Kent State University, Texas A&M University, and Incheon National University	10	The overall classification performance in terms of accuracy of the developed model is 85.3%, and the accuracy of cross validation with real road data is 83.2%.	Hum Ftrs Erg Mfg Svc - 2020 - Kim - Development of a statistical model to classify driving stress levels using galvanic.pdf

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Project Description

Objective:

- The aim of this research is to gain insights into **how different traffic conditions impact driver stress levels**, utilizing a semi-realistic driving simulator.

Research Goals:

- Predict what might **affect stress** while driving.
- Use our data to create a **model** that improves real-world driving conditions.

Methodology:

- Participants experienced three distinct driving scenarios within the City Car Driving game & our simulator:

1. A peaceful low-traffic country road
2. An average traffic suburban area
3. A congested metropolitan area with heavy traffic

Expected Outcomes (Hypothesis):

- Heightened level of stress in denser traffic conditions.
- The more aggressive the surrounding drivers are, the higher one's stress should be.

VR Headset

Wearable

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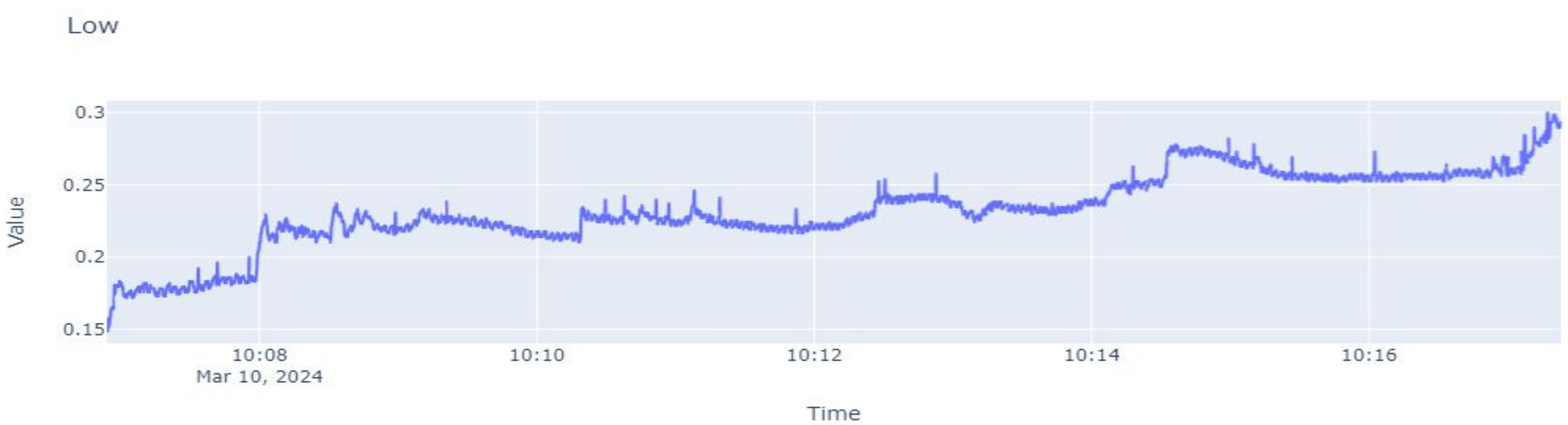
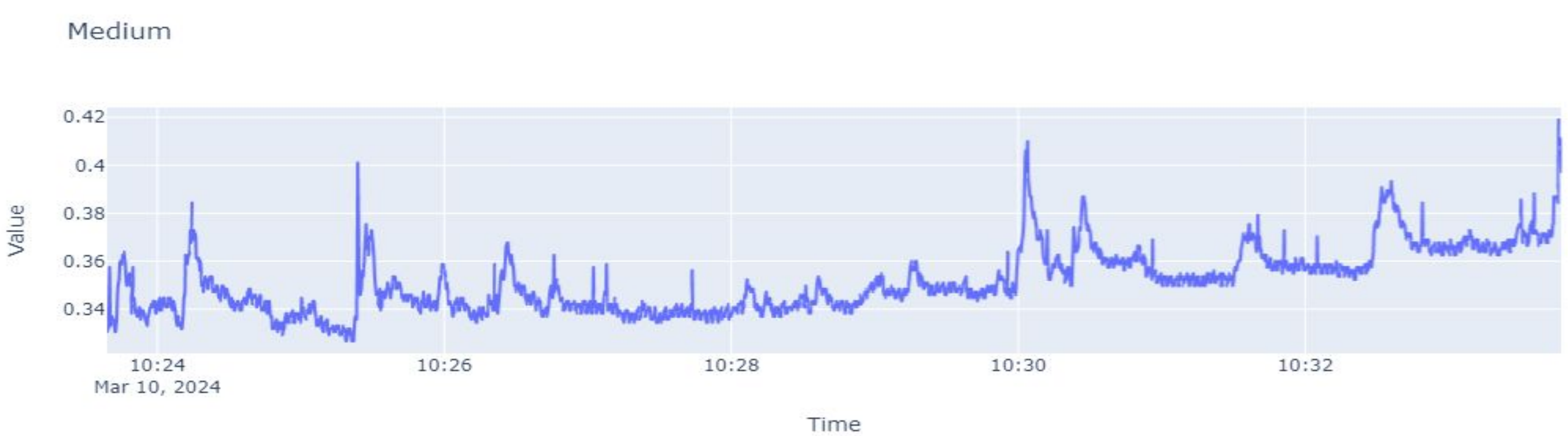
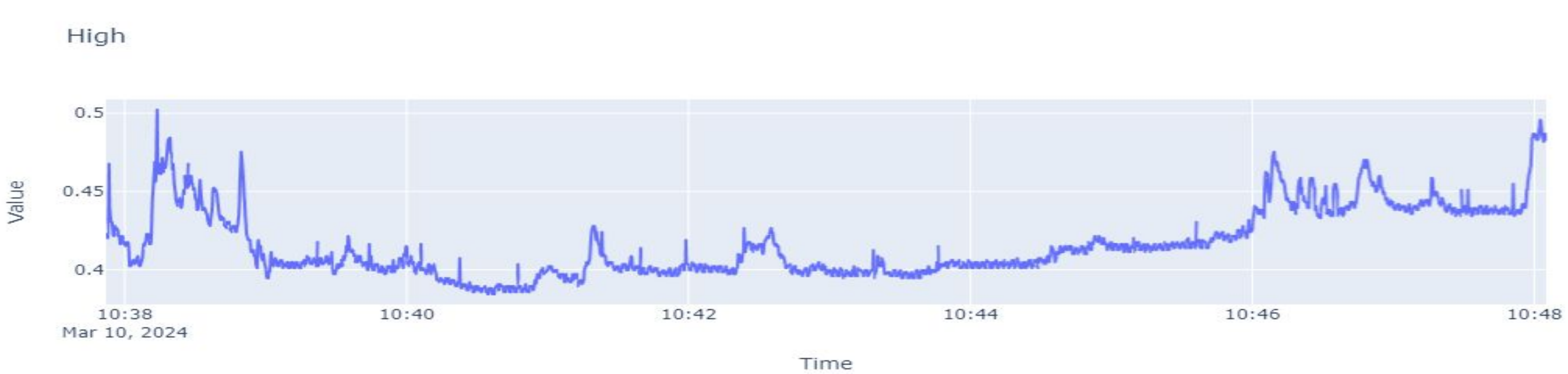
Data Collected - Physiological Signal







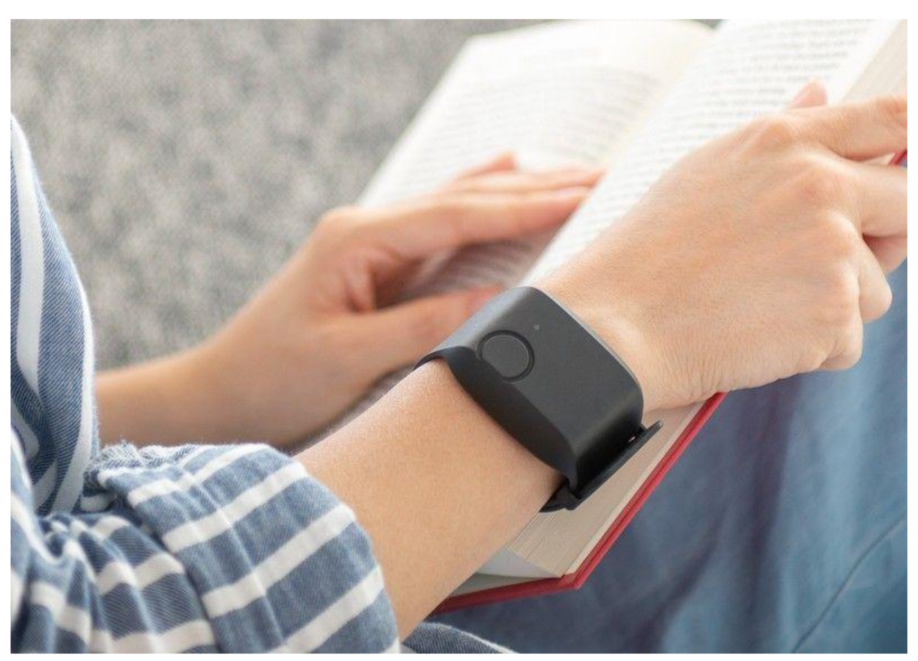
Data From Subject #1

Data Collection:
Wearable (Empatica E4):
Participants will wear the Empatica E4, a sophisticated wearable device, to gather real-time physiological data:

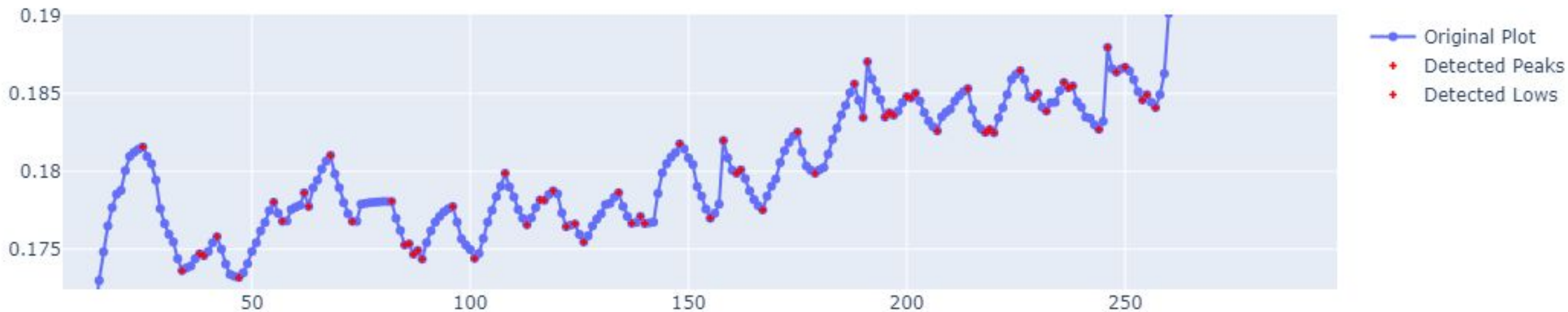
- Heart rate to measure stress levels.
- Skin conductance to assess emotional stimulus.
- Temperature variations related to stress responses.
- Basic acceleration data for context on driving dynamics.

Electrodermal Activity (EDA) is our main data piece in this iteration of data collection.

EDA measures the change in conductivity produced in the skin due to the increases in the activity of sweat glands.

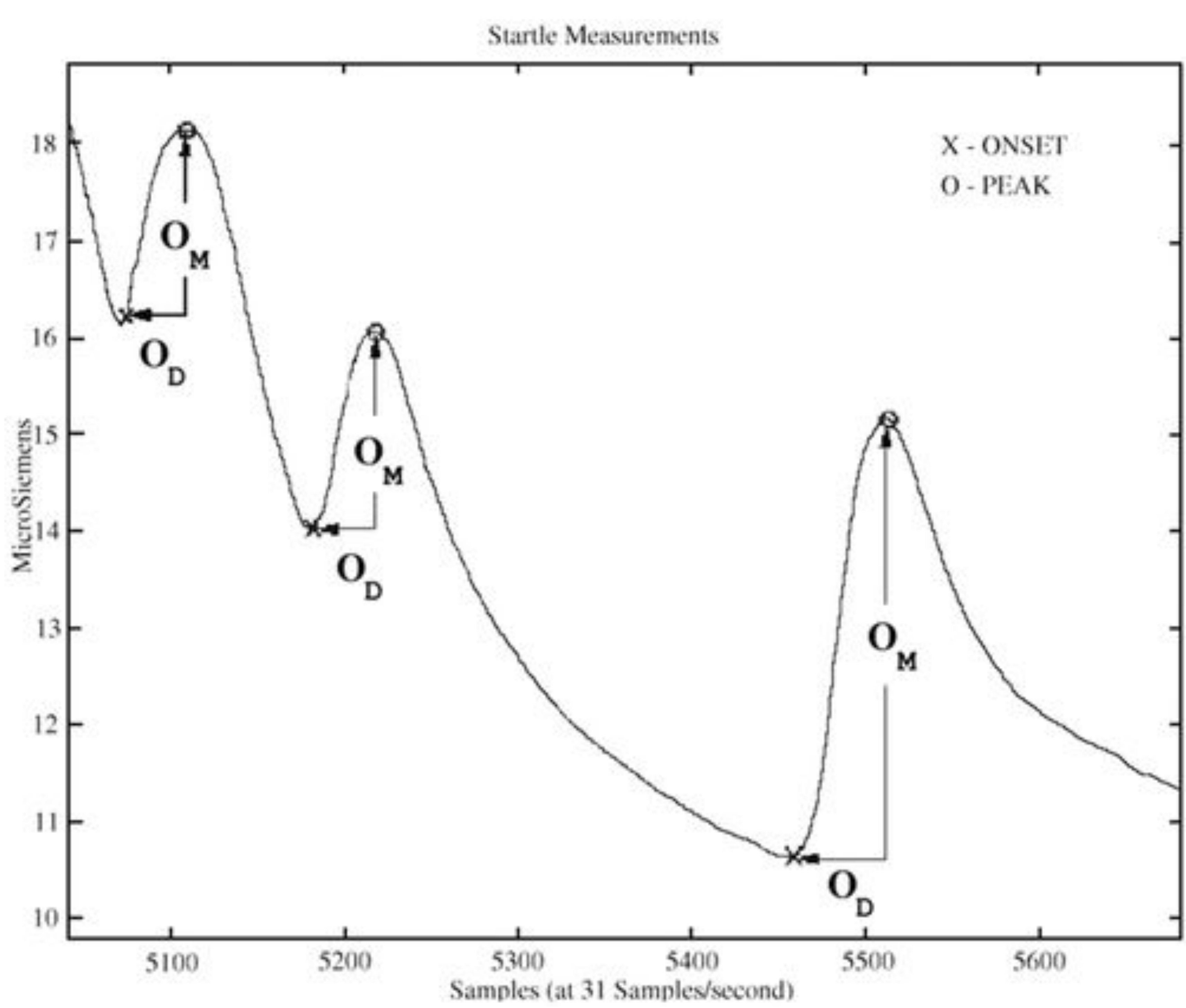


Feature Extraction



- **Based on Two Key Features**
  - Vertical Amplitude (OM) - shows Peaks/Lows
  - Horizontal Amplitude (OD) - duration of these Peaks/Lows

  - Peaks & Lows are determined by **Binary Classification**
    - Anything **greater than 0.5** is classified as a Peak
    - Anything **lower than 0.5** is classified as a Low



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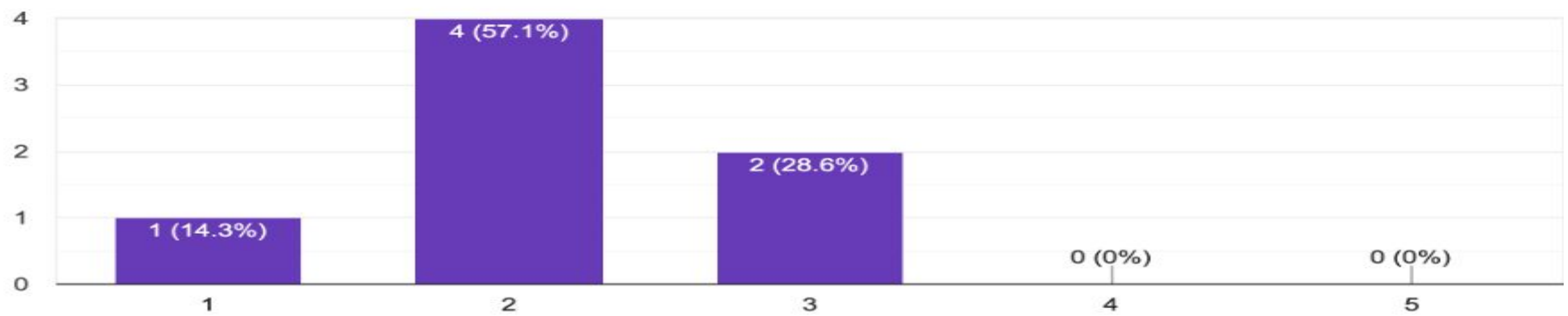
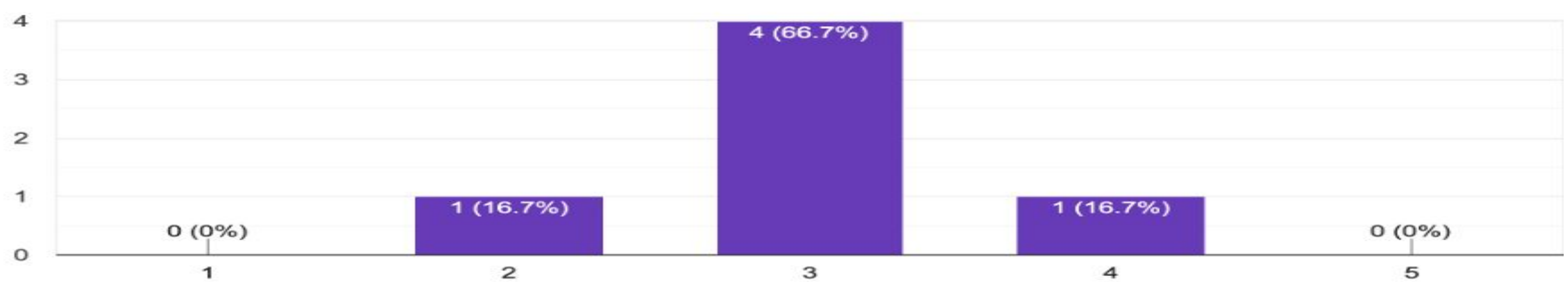
Data Collected - Survey Data

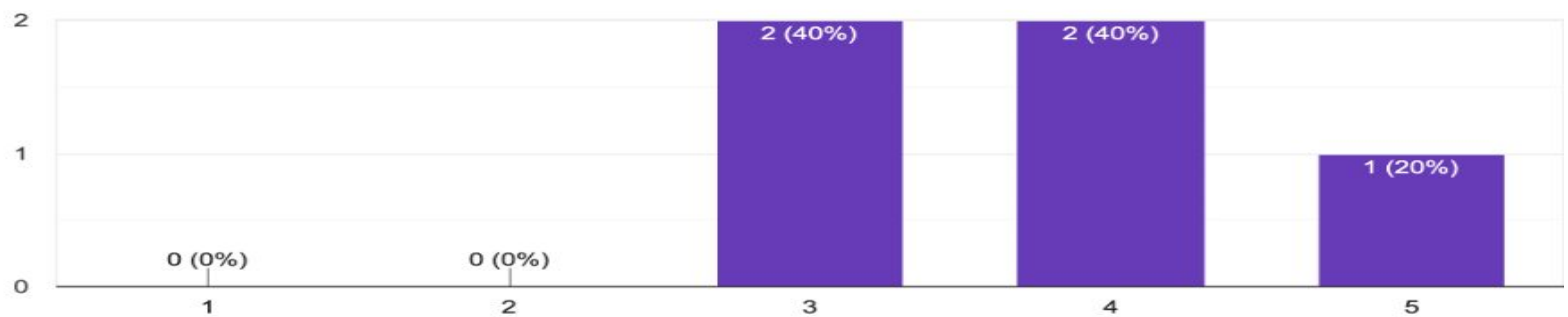
How stressed did you feel during the Low-Risk Driving Simulation?
7 responses



How stressed did you feel during the Medium-Risk Driving Simulation?
6 responses



How stressed did you feel during the High-Risk Driving Simulation?
5 responses



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Machine Learning Model & Data Analysis

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=== Summary ===

Correctly Classified Instances         106               62.3529 %
Incorrectly Classified Instances        64               37.6471 %
Kappa statistic                          0.268
Mean absolute error                      0.429
Root mean squared error                  0.4637
Relative absolute error                 91.6201 %
Root relative squared error             96.2632 %
Total Number of Instances              170

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.742    0.444    0.489      0.742    0.590      0.288    0.716     0.518     Low
                 0.556    0.258    0.789      0.556    0.652      0.288    0.716     0.842     High
Weighted Avg.    0.624    0.326    0.680      0.624    0.629      0.288    0.716     0.724

=== Confusion Matrix ===

  a  b   <-- classified as
 46 16 |  a = Low
 48 60 |  b = High
```

Tested Classifiers:

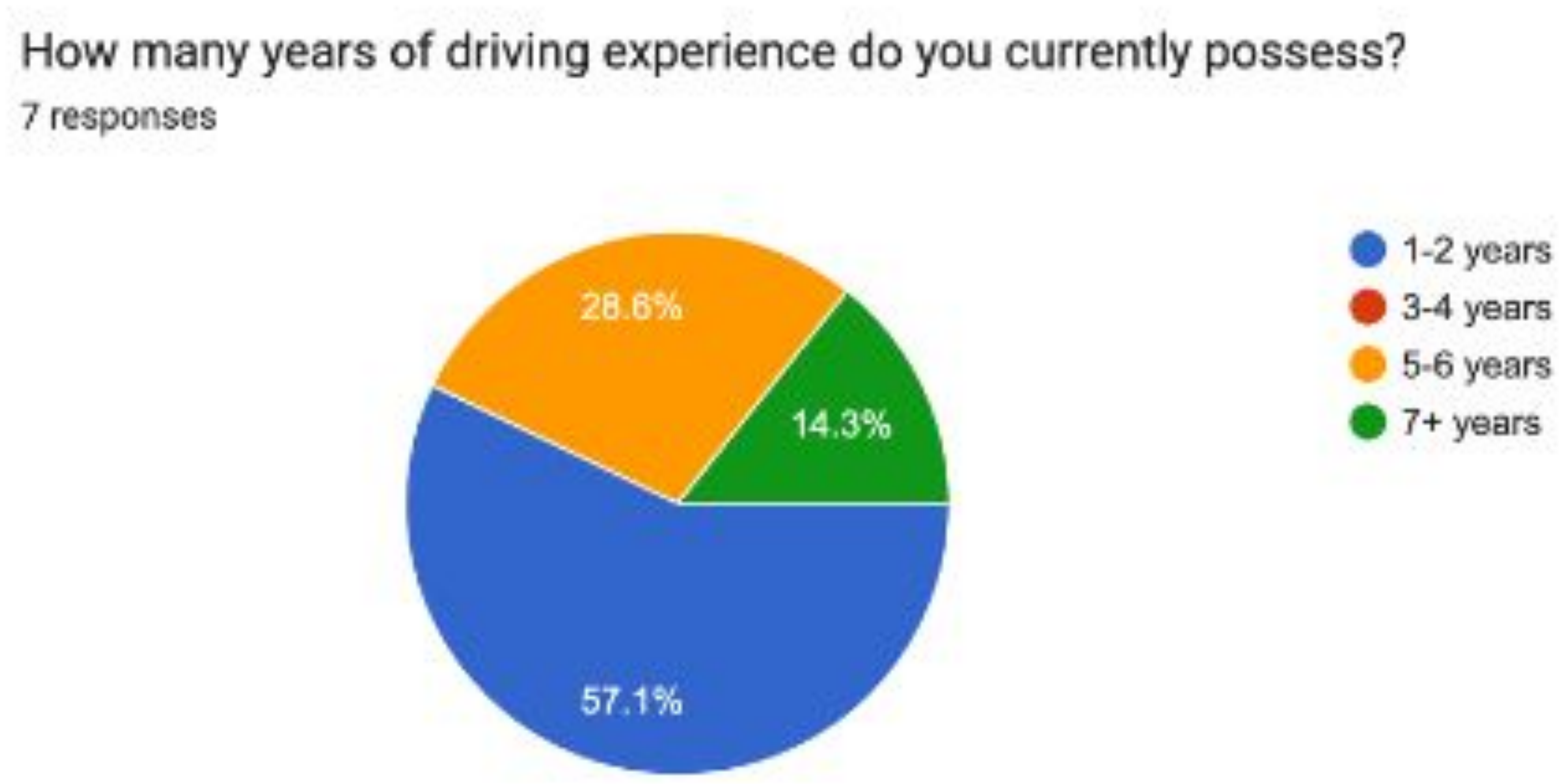
IBk: 60.59% Accuracy

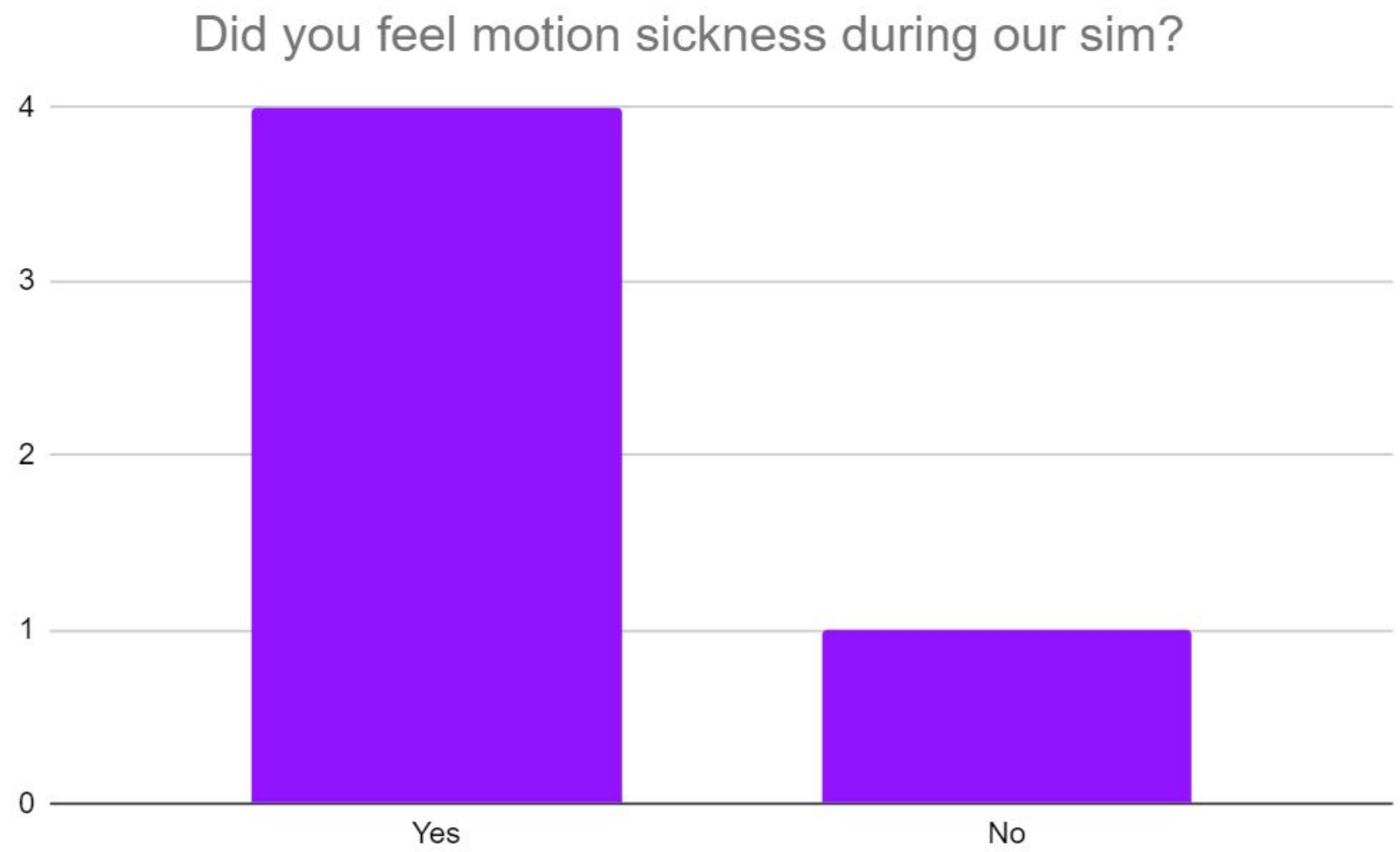
OneR: 61.18% Accuracy

Multilayer Perceptron: **62.35% Accuracy**

Combining High and Medium conditions for machine learning input allowed us to increase the accuracy of overall stress detection

Data Collection Challenges





Motion Sickness

- Use of VR headset resulted in a great deal of motion sickness.
- Nearly all test subjects reported feeling motion sickness. With it severe enough to prevent completion of testing for multiple subjects.

Problem Solved & Lessons Learned

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Problem Solved:

- Our research allows connections to be drawn between driving conditions and stress felt by those in these situations.
- This may prove valuable for transportation planning, as it provides evidence for creating more smooth and efficient roadways.

Lessons Learned:

- Using the driving simulator has been valuable for testing different driving situations safely.
- An unexpected challenge was the occurrence of motion sickness among participants, which was caused by the disconnect between what the driver was seeing happen in VR compared to what was actually happening in real life.

Going Forward:

- We should create time for breaks in between each run & create systems that better allow our testers to be comfortable with our simulation, such as:
    - The addition of a few more monitors, allowing for the option to be in the sim without the VR component
    - The addition of some kind of motion feedback in the sim seat to better represent the motion experienced inside the simulation

Acknowledgement & Reference

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Acknowledgement

This study was supported by the Kent State University Choose Ohio First Research Grant.

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