
VIRGINIA TECH
TRANSPORTATION
INSTITUTE

VIRGINIA TECH TRANSPORTATION INSTITUTE

RECENT ADVANCES WITH WEARABLES FOR DRIVER HEALTH MONITORING

ABHIJIT SARKAR

WE ARE INCREASINGLY AWARE OF OUR HEALTH

COGNITIVE AND PHYSICAL LOAD

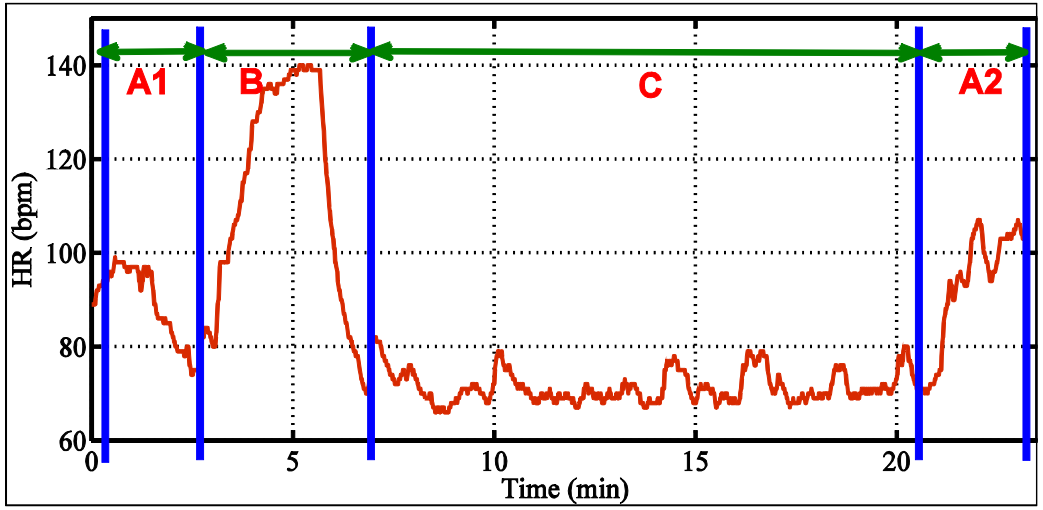
- Monitor psychophysiology
  - Improve performance
  - Improve safety
  - Improve lifestyle
- How to measure them?
  - Individually
  - Collectively
  - Continuously

Images from: amazon.com, flickr.com

WHY SHOULD WE MEASURE?

DRIVING EXAMPLE

- Understand psychophysiological condition of a person
  - Cognitive load
  - Drowsiness
  - Effect of Alcohol/ drug / other impairment
  - Effectivity of training
  - Chronic depression
- Short term and long term trends



A1 and A2 – City driving – high cognitive load
C – Interstate driving – low cognitive load
B – Panic – High cognitive load

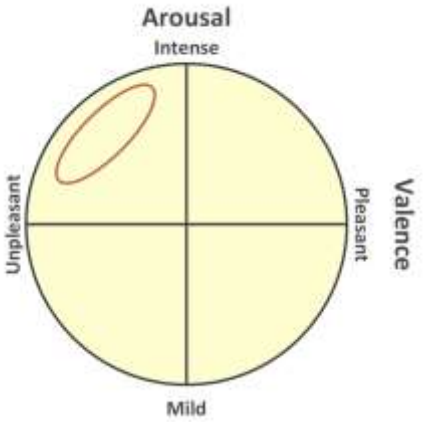
A. Sarkar, A. L. Abbott and Z. Doerzaph, "Assessment of psychophysiological characteristics using heart rate from naturalistic face video data," *IEEE International Joint Conference on Biometrics*, 2014, pp. 1-6, doi: 10.1109/BTAS.2014.6996264.

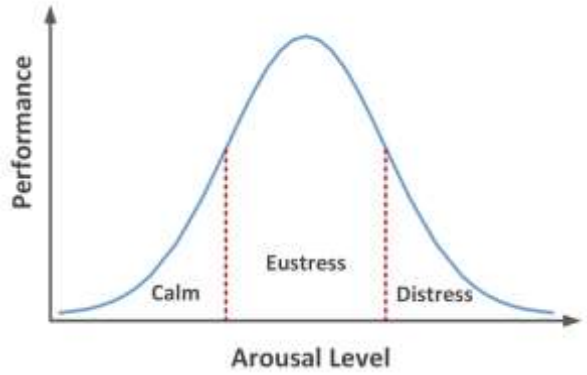
COMMERCIAL DRIVER SAFETY RISK FACTORS STUDY

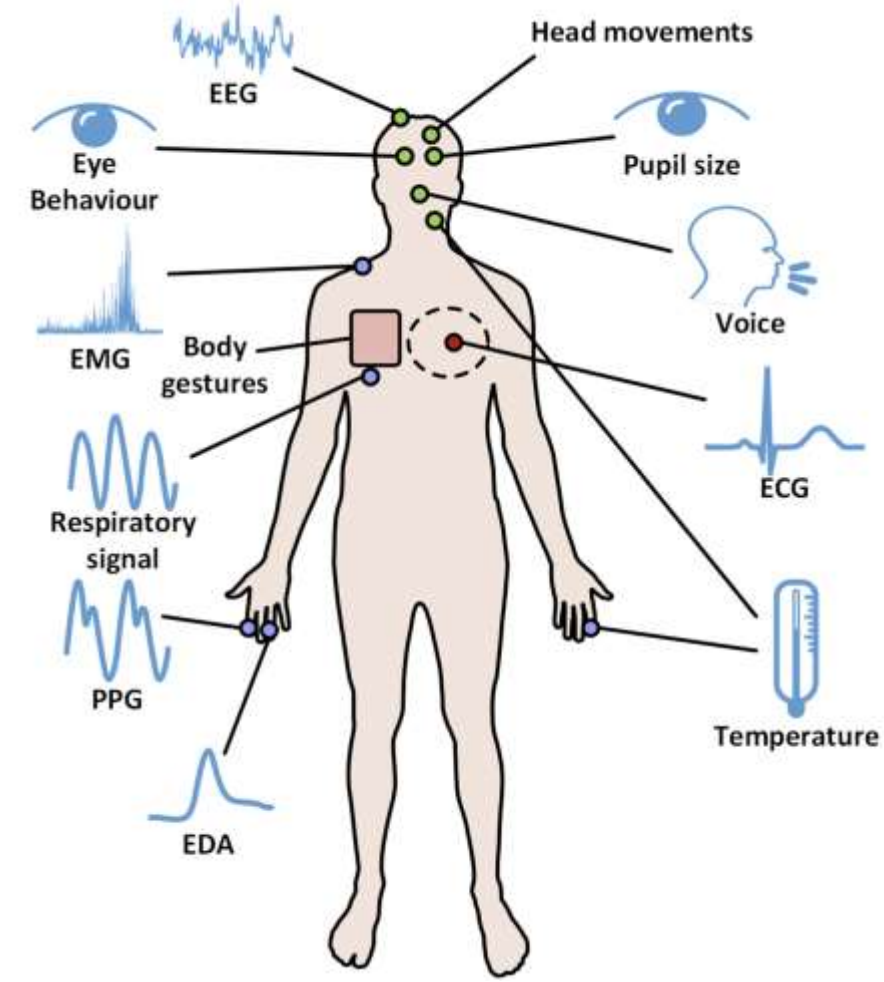
- Goal: examine driver and situational factors that impact CMV safety
  - Demographic characteristics, work experience, lifestyle and behavioral habits, medical conditions
  - Identify personal, medical, and situational factors that increase crash or violation risk
  - Identify factors associated with presence of obstructive sleep apnea (OSA)
  - Follow CMV drivers' safety records for up to three years
- Demographics
  - 29% overweight; 58% obese
  - 88% not or sometimes on a regular sleep schedule
- Predictive factors for OSA: BMI, hypertension, age, and Berlin Questionnaire
- Drivers being treated for medical conditions were no riskier than drivers without the same medical conditions
  - OSA treatment reduced crash risk ~40%
  - non-treatment increased risk by ~200%

STRESS MEASUREMENT

- Stress has three major components:
  - Psychological, behavioral, physical
- Biosignal features are involuntary
- Surveys can be biased and manipulated







Giannakakis, G., Grigoriadis, D., Giannakaki, K., Simantiraki, O., Roniotis, A., & Tsiknakis, M. (2019). Review on psychological stress detection using biosignals. *IEEE Transactions on Affective Computing*, *13*(1), 440-460.

WEARABLES ARE GREAT SOURCE OF INFORMATION ABOUT OUR HEALTH AND LIFESTYLE

WHAT CAN WE MEASURE?

- Heart rate
- Pulse rate
- Breathing rate
- Galvanic skin response
- Electrical activity in brain
- Heart rate variability
- Sleep
- Stress
- Step counts
- SpO2
- Gyroscopic data
- Blood glucose level
- Blood pressure
- …

Non Invasive measurement – greater usability

Feature	Studies	↑	↓	=
HR	23 [109], [131], [132], [151], [154], [160], [165], [180], [182], [187], [188], [189], [190], [191], [192], [193], [194], [195], [196], [197], [198], [199], [200]	18	0	5
STD HR	1 [198]	0	0	1
RR	8 [180], [198], [200], [201], [202], [203], [204], [205]	0	6	2
SDNN	12 [180], [187], [193], [194], [197], [198], [200], [201], [203], [204], [205], [206]	1	7	4
RMSSD	6 [187], [190], [197], [198], [203], [204]	0	5	1
NN50	2 [187], [200]	0	2	0
pNN50	6 [116], [194], [198], [200], [203], [207]	0	6	0
HRV triangular	2 [198], [200]	0	1	1
Total power	4 [133], [197], [204], [206]	0	4	0
VLF	3 [187], [204]	0	0	3
LF	12 [180], [187], [192], [193], [194], [195], [197], [199], [203], [204], [205], [208]	5	3	4
HF	14 [180], [187], [192], [193], [194], [197], [199], [201], [203], [204], [205], [208], [209], [210]	1	6	7
LF/HF	17 [165], [180], [187], [188], [192], [193], [194], [198], [199], [200], [202], [203], [204], [207], [208], [209], [210]	10	0	7
VLF relative	2 [187], [188]	2	0	0
LF relative	8 [187], [188], [200], [201], [202], [204], [208]	4	1	3
HF relative	7 [187], [200], [201], [202], [204], [208]	0	4	3
SD1	1 [211]	0	0	1
SD2	1 [211]	0	1	0
D2	2 [211]	0	2	0
BR	5 [165], [180], [193], [199], [204]	2	0	3
SBP	15 [129], [132], [151], [154], [160], [188], [189], [190], [191], [195], [201], [206], [212], [213], [214]	15	0	0
DBP	15 [129], [132], [151], [154], [160], [188], [189], [190], [191], [195], [201], [209], [212], [213], [214]	15	0	0
BP HF	1 [206]	1	0	0
ApEn	1 [211]	0	1	0
SampEn	1 [192]	0	0	1

↑: significant increase ($p < 0.05$) during stress.
↓: significant decrease ($p < 0.05$) during stress.
=: no significant difference.

HEART RATE VARIABILITY, BLOOD PRESSURE

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VIRGINIA TECH TRANSPORTATION INSTITUTE

REAL WORLD TESTING

PRONTO

VIRGINIA TECH TRANSPORTATION INSTITUTE

Texas A&M Transportation Institute

Testing Active on ADS Fleet Concept of Operations

- Purpose: understand how driver monitoring systems can be integrated with ADS vehicles and monitor ADS safety operators.
  1. Identify current technology
  2. Interview technology ADS and monitoring developers
  3. Test performance on a closed test-track

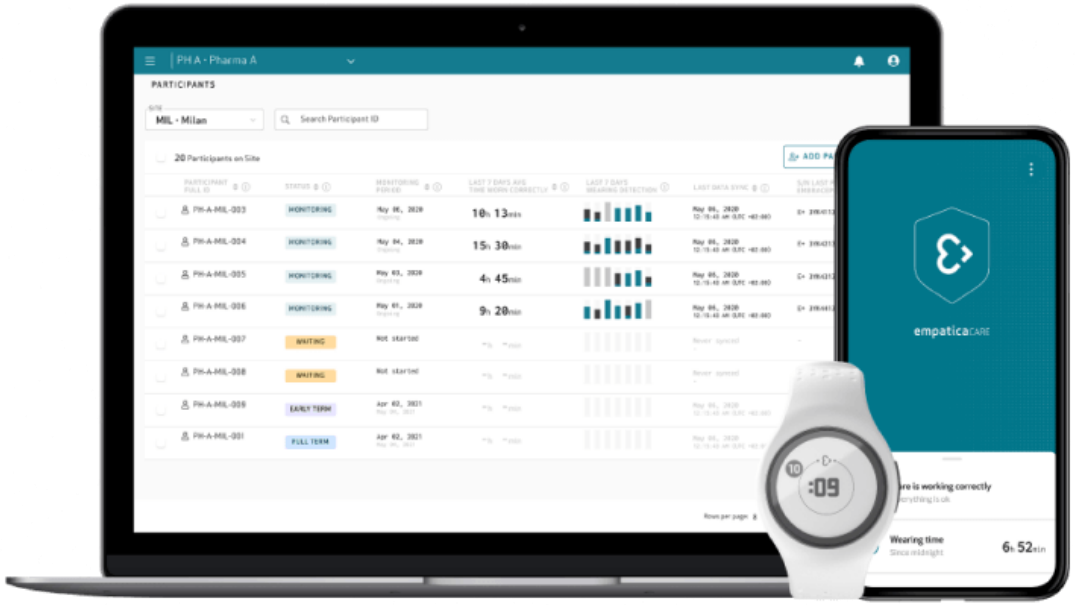
  - Measure drowsiness, distraction, mental workload, substance impairment, emotions
  - Match the human interface needs of the driver
  - Easy to maintain and calibrate

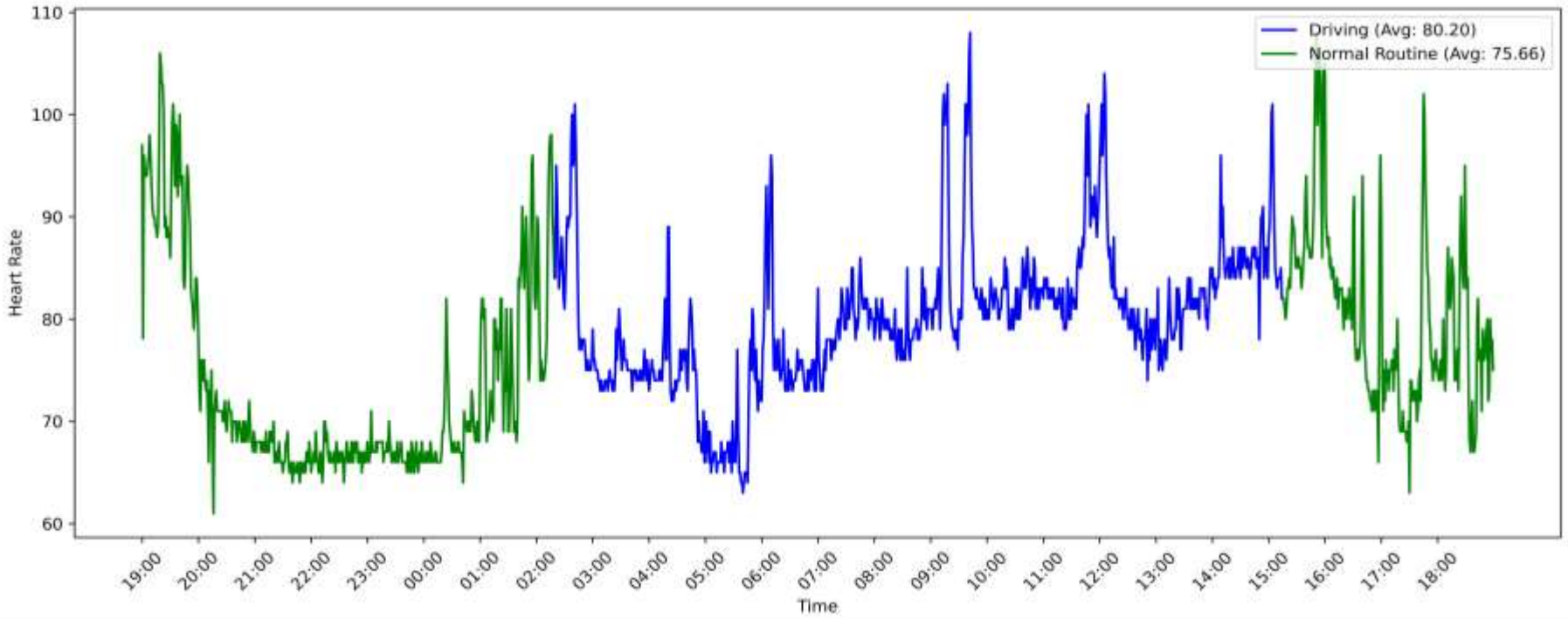
U.S. Department of Transportation

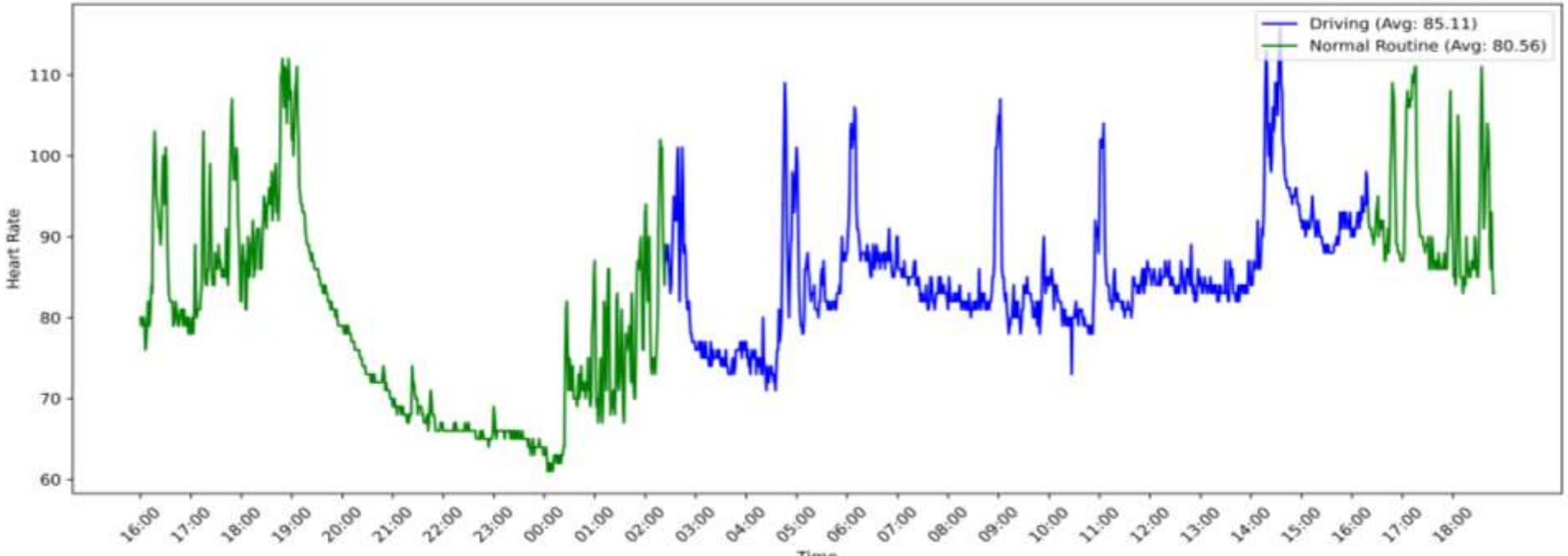
Federal Motor Carrier Safety Administration

VITAL SIGNS FOR LONG HAUL DRIVING

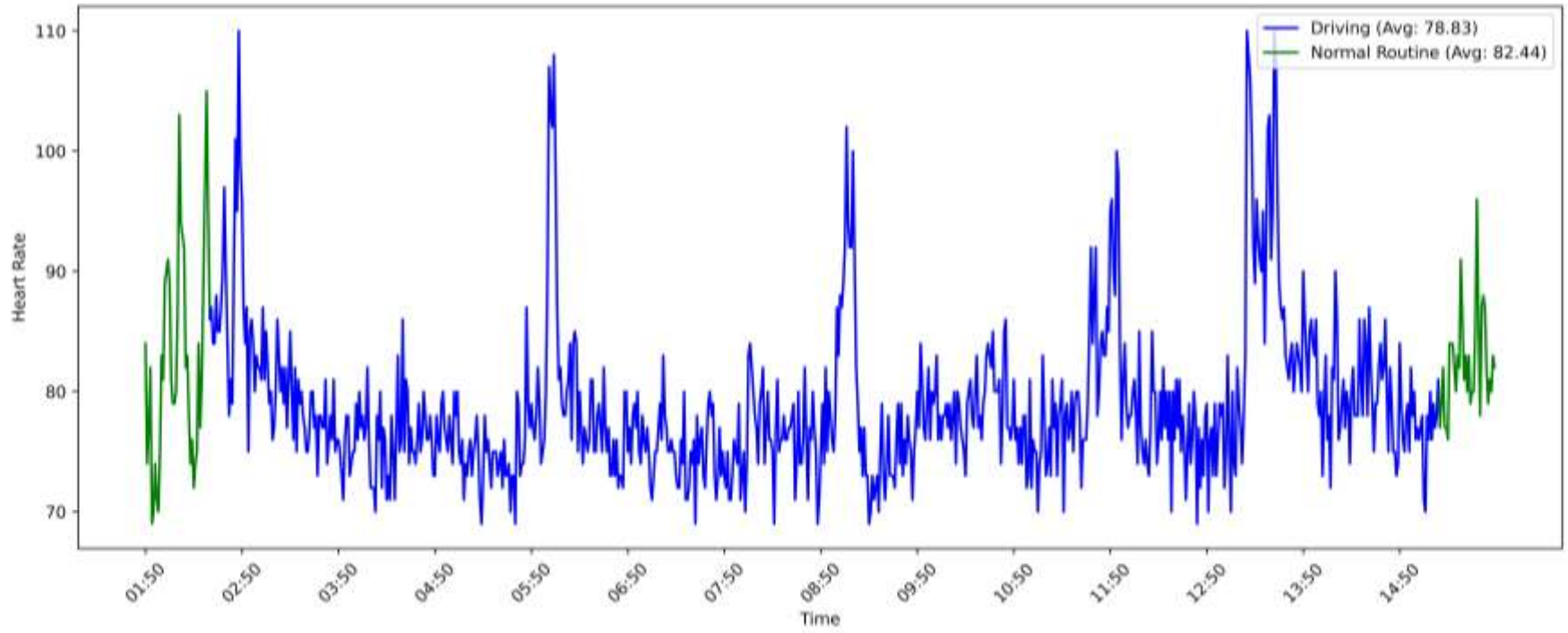
- 10 drivers
- Driving long haul including cross country
- Continuous vital sign measurements
  - gyroscope, accelerometer data, heart rate (HR), Electrodermal activity (EDA), skin temperature, blood volume pulse (BVP) information, systolic peaks, and daily step counts



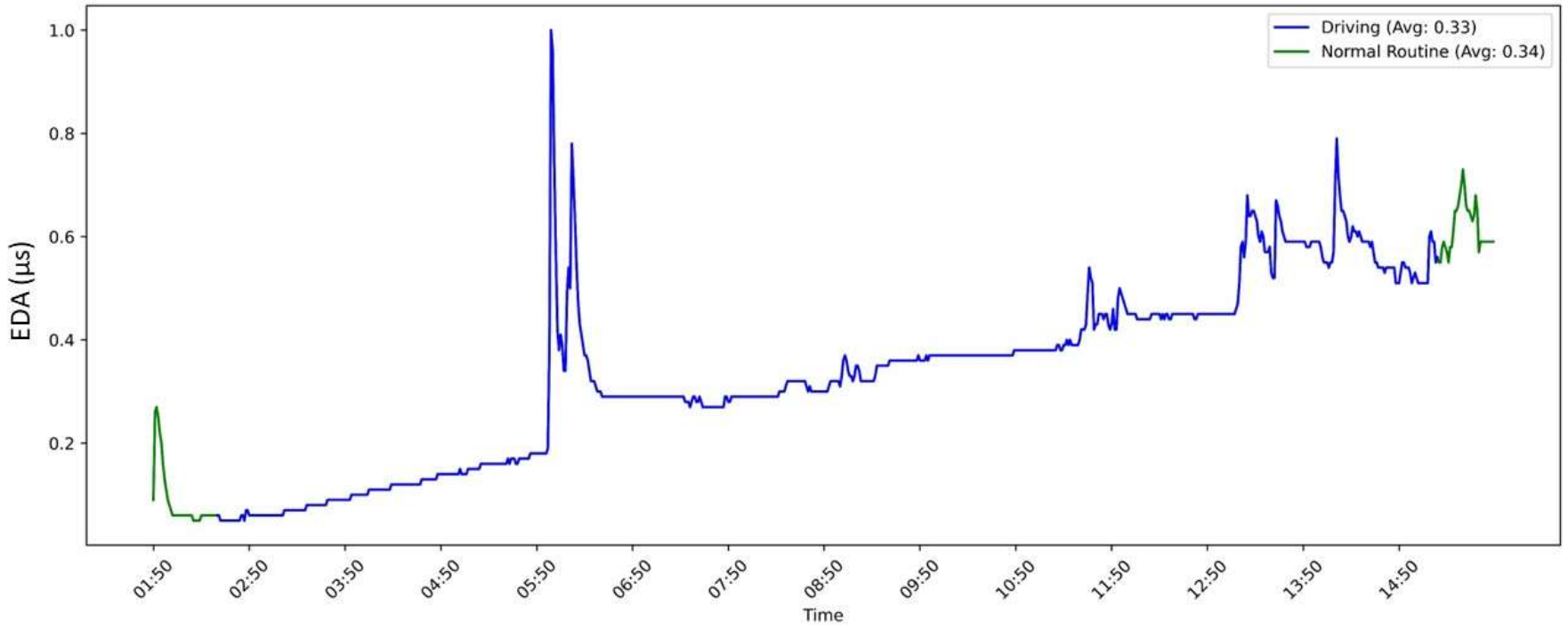

Driving (Avg: 80.20)
Normal Routine (Avg: 75.66)
Heart Rate
Time


Driving (Avg: 85.11)
Normal Routine (Avg: 80.56)
Heart Rate
Time

Heart Rate



Heart Rate



EDA

RESEARCH NEED

WE NEED RESEARCH IN DIFFERENT SCALES

- Effectiveness of wearables: need research with real drivers
  - Understand the use cases better
- Usage practice amongst drivers
  - Are they already using them?
- Understand interpersonal variability
- Understand Data privacy

Generating health awareness

Thank You!

Abhijit Sarkar, PhD
asarkar@vtti.vt.edu