DIGITAL HEALTH: TRACKING MENTAL STRESS AND MOOD USING WEARABLE DATA AND MACHINE LEARNING

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GLOBAL CHALLENGES

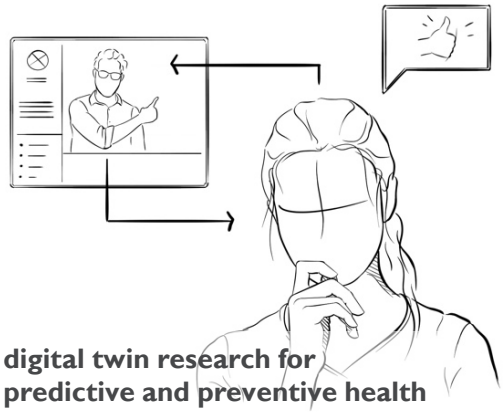
reduce our impact on the environment

ensure healthy food & nutrition

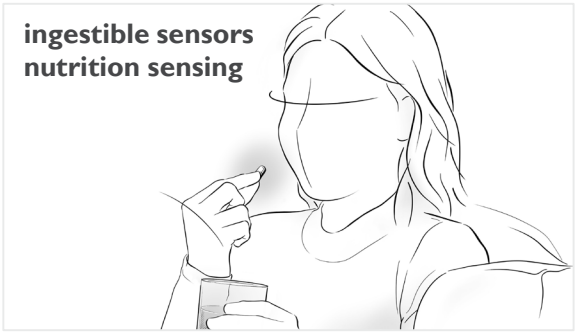
prevent disease

R&D AREAS

- Creation of hardware and analytics
- Validation through large-scale pilots and trials
- Roadmap driven

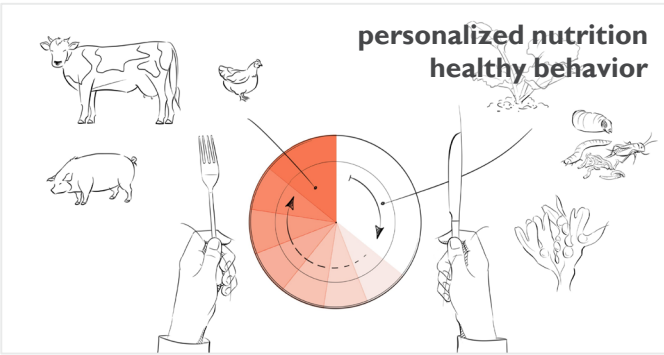


digital twin research for predictive and preventive health

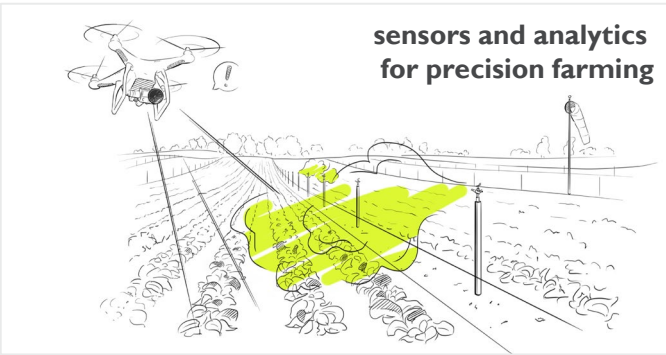


ingestible sensors
nutrition sensing

water quality sensing
soil sensing



personalized nutrition
healthy behavior



sensors and analytics
for precision farming

MONITORING THE BODY

- Accelerometer
- Altimeter
- Digital camera
- Electrocardiogram
- Electromyograph
- Electroencephalogram
- Electrodermograph
- Location GPS
- Microphone
- Oximeter
- Bluetooth proximity
- Pressure
- Thermometer

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CAN WEARABLE TECHNOLOGY HELP PREVENTING MENTAL HEALTH DISORDERS?

UNDERSTANDING WHAT **STRESSES** YOU AND WHEN

IMEC SWEET STUDY – STRESS IN THE WORK ENVIRONMENT

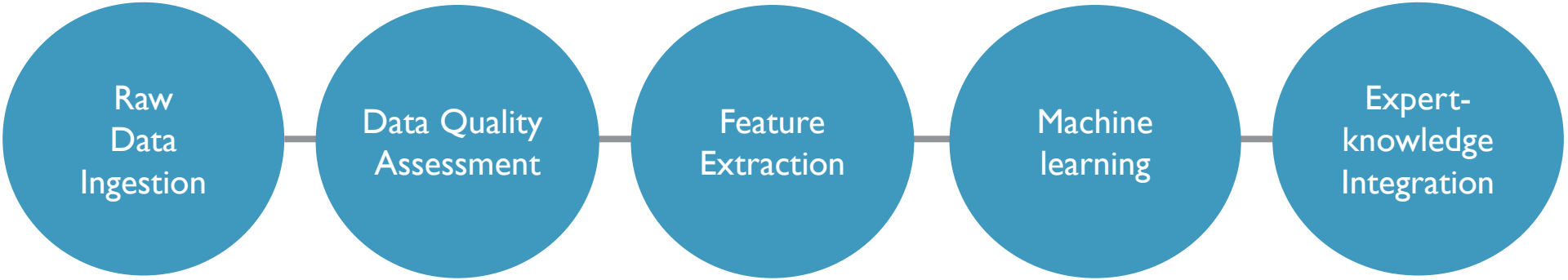
5 days
- Daily life
- Week and weekend
- At work, at home, on the move

Pleasure
Arousal
Dominance

1000 participants
- Healthy (working)
- 40 ± 10 years old

DATA ANALYSIS TOOLCHAIN

STEPS TOWARDS PERSONALIZED, ACTIONABLE INSIGHTS AND FEEDBACK



jupyter

dmlc XGBoost

R

scikits learn machine learning in Python

python

{api}

TensorFlow

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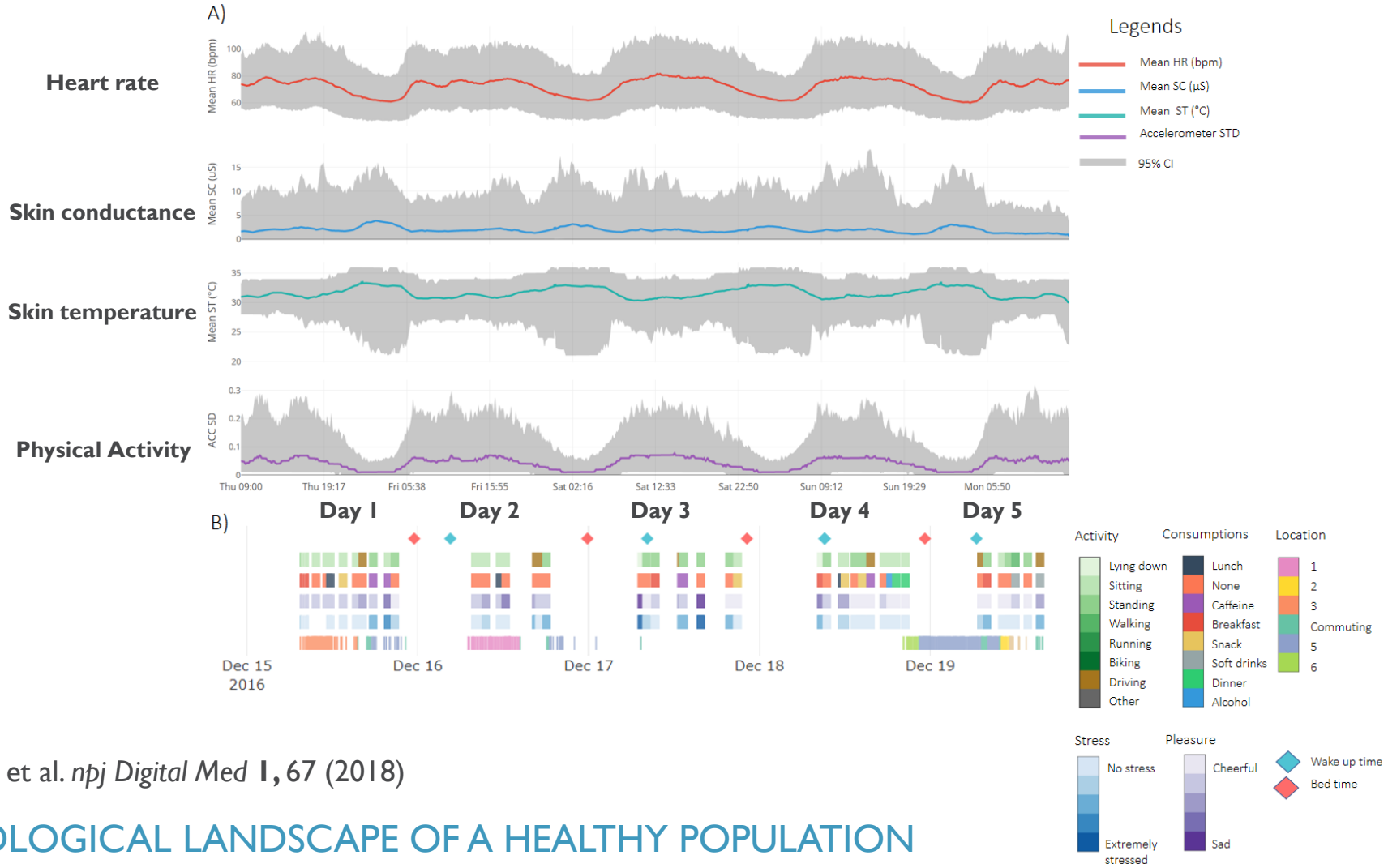
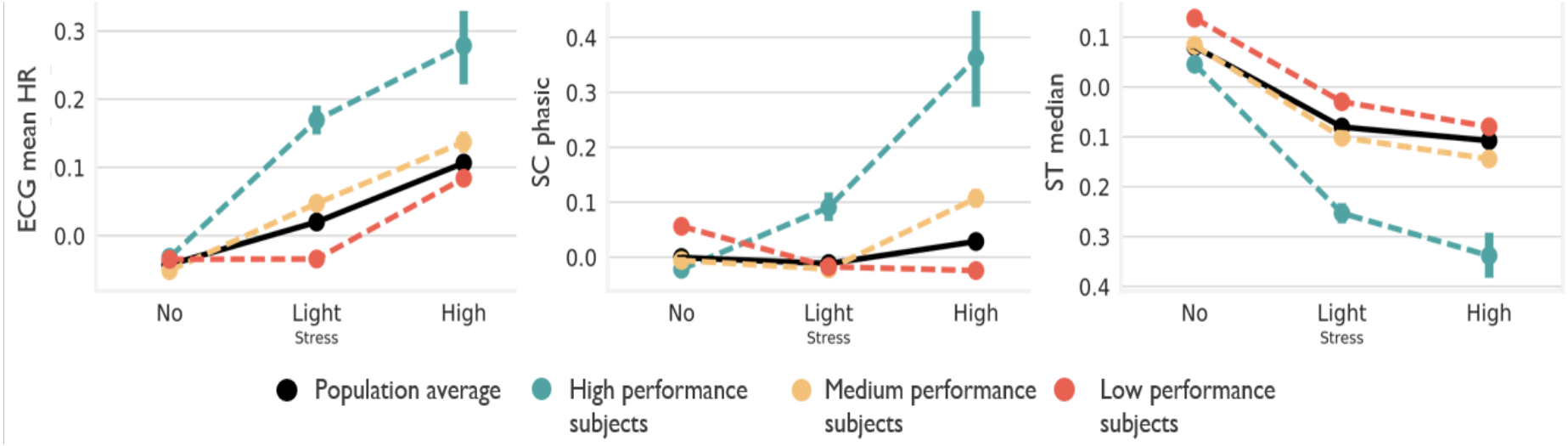


Smets, E., et al. *npj Digital Med* **1**, 67 (2018)

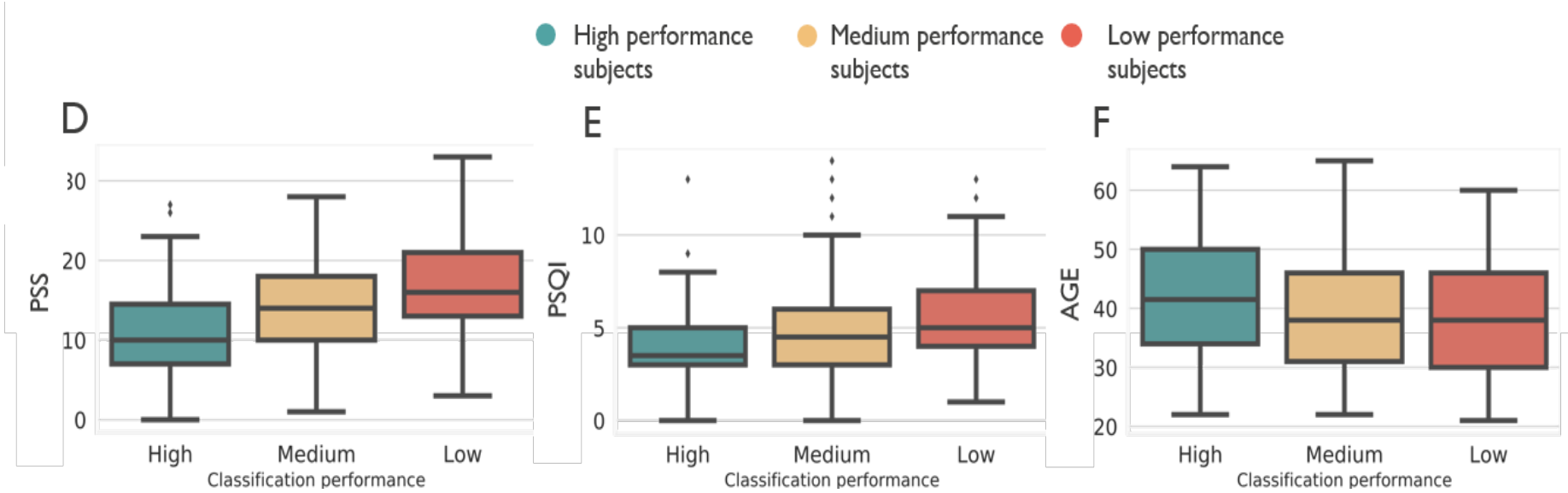
PHYSIOLOGICAL LANDSCAPE OF A HEALTHY POPULATION

PHYSIOLOGICAL DYNAMIC RANGE AND MENTAL STRESS



Smets, E., et al. *npj Digital Med* **1**, 67 (2018)

DEMOGRAPHICS AND PSYCHOLOGICAL BASELINE

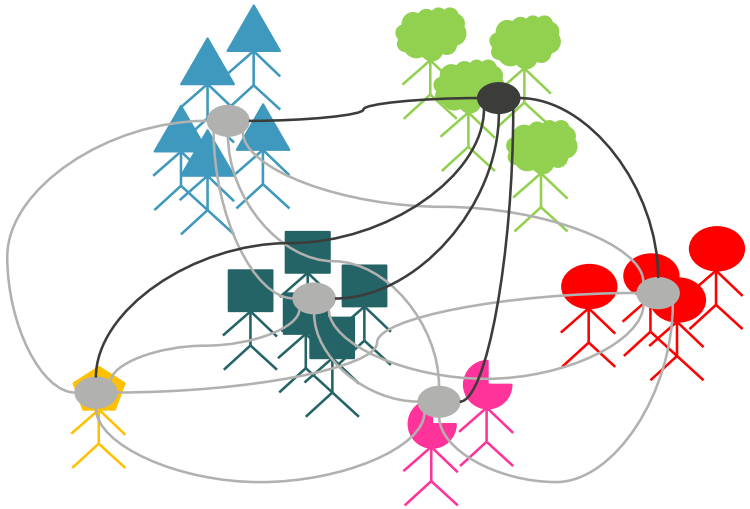


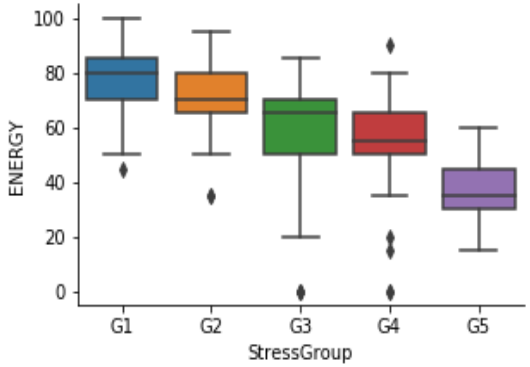
Self-reported poor health and high depression scores are negatively correlated with physiological reactivity

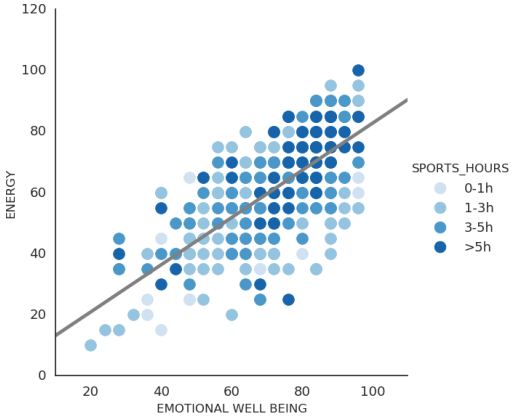
Smets, E., et al. *npj Digital Med* **1**, 67 (2018)

LINKING HABITS AND MENTAL HEALTH INDICATORS

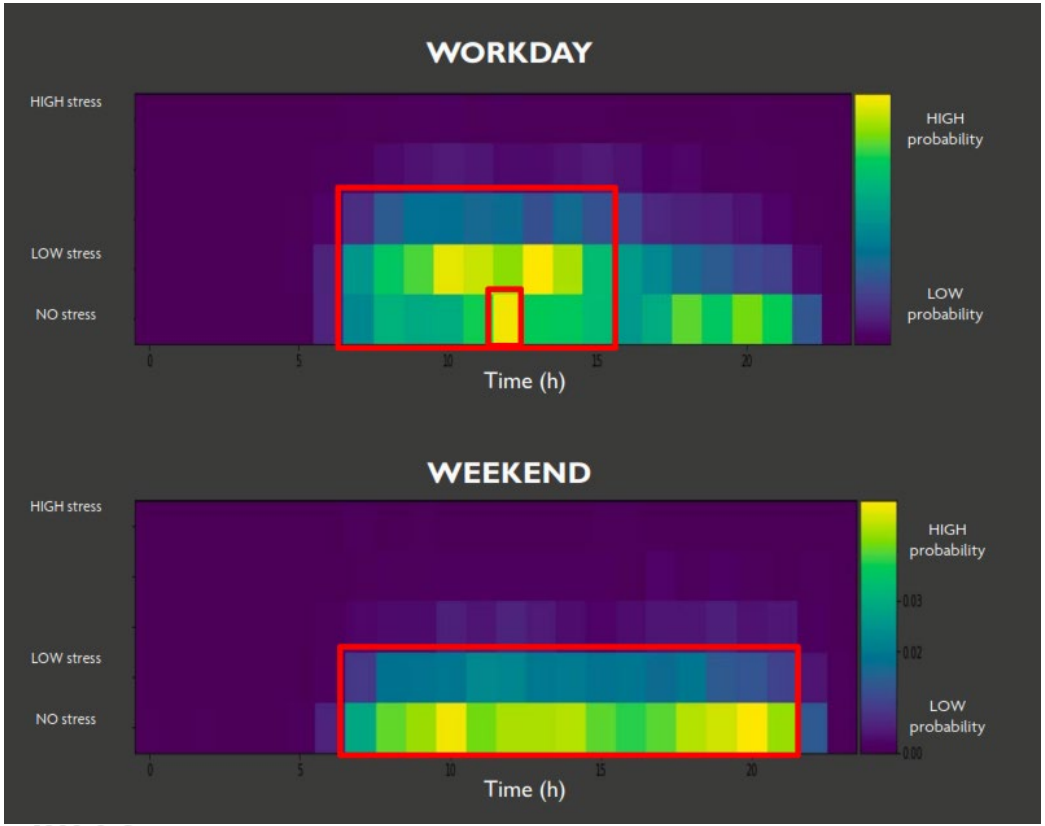
Persona's profiling







CONTEXTUAL INSIGHTS ON STRESS



LOCATION

VOICE

PHONE DATA

PHYSICAL ACTIVITY

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INTERNET & DATA LAB

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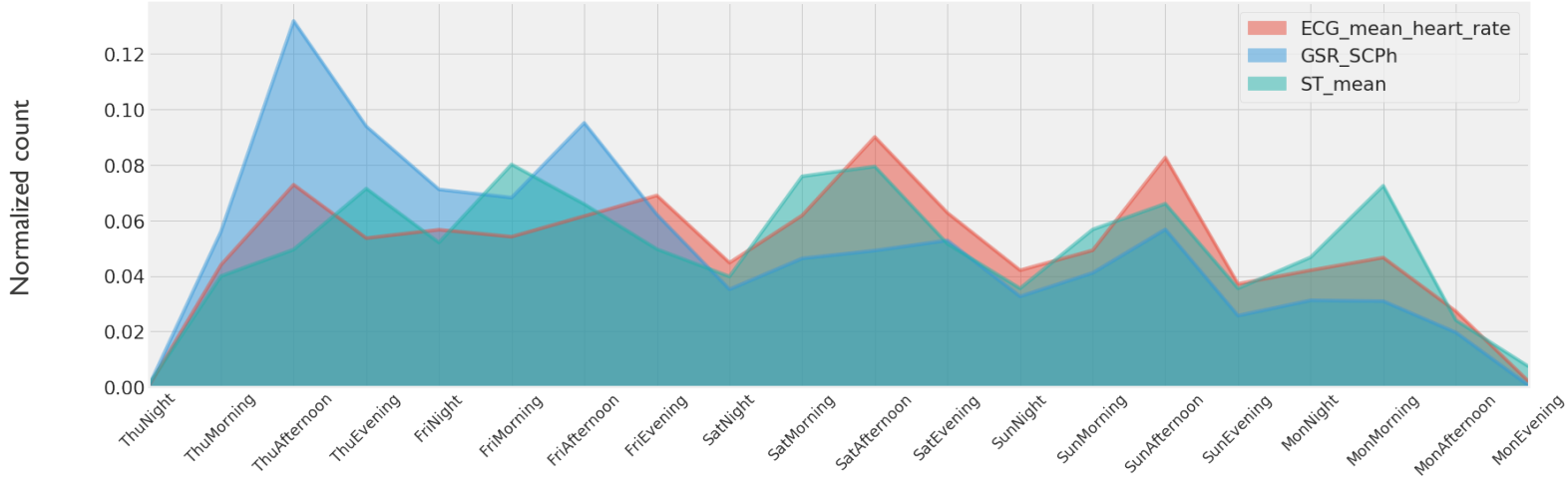
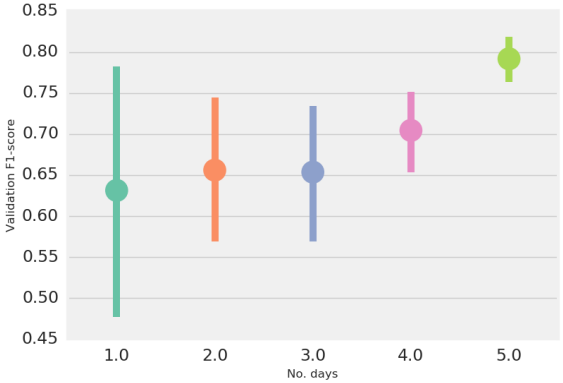
PERSONALIZED STRESS MODELS

SUBJECT-SPECIFIC TEMPORAL SPLIT





Train Day 1

Test Day2

Increased F1-scores compared to group models

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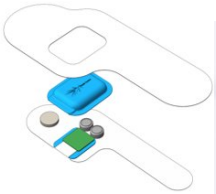
BEHAVIORAL MULTI-SENSING PLATFORM FOR (MENTAL) HEALTH

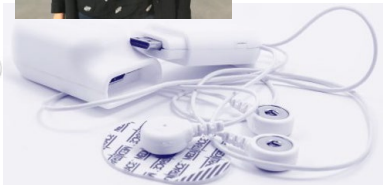
ONEPLANET - EXPLORE-VALIDATE NEW USE-CASES

TECHNOLOGY and MODELS

Wearables for raw data input supporting model development

- Stress – mental health
- Activity recognition: Sleep / Driving Sitting / Walking / Cycling
- Fitness levels ...
- Respiration rate, ECG, ...

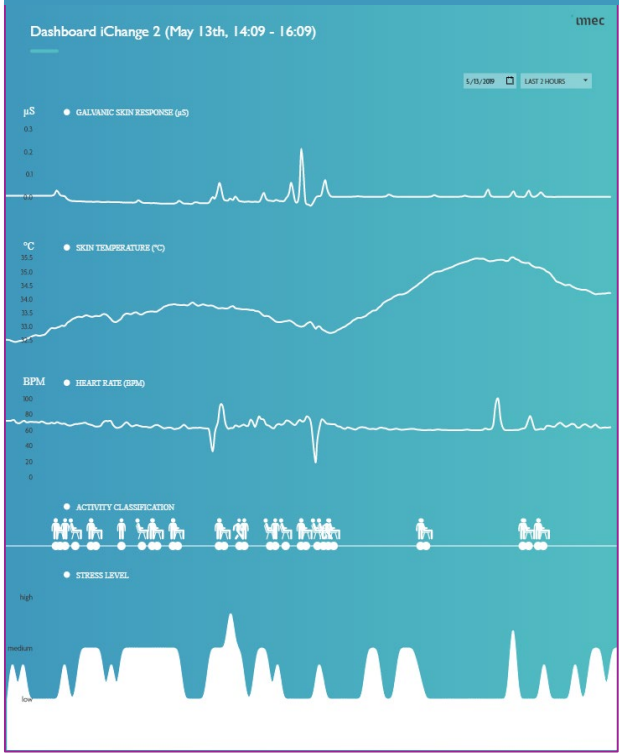




SMARTPHONE / Ecological Momentary Assessments

- Phone sensors: noise, light, GPS
- Self-annotations: emotion, medication, diet

CUSTOMIZED DATA PLATFORM



NERVOCITY

Gain new insights in how, when and where citizens experience stress in the city

MAAK DAT MEE

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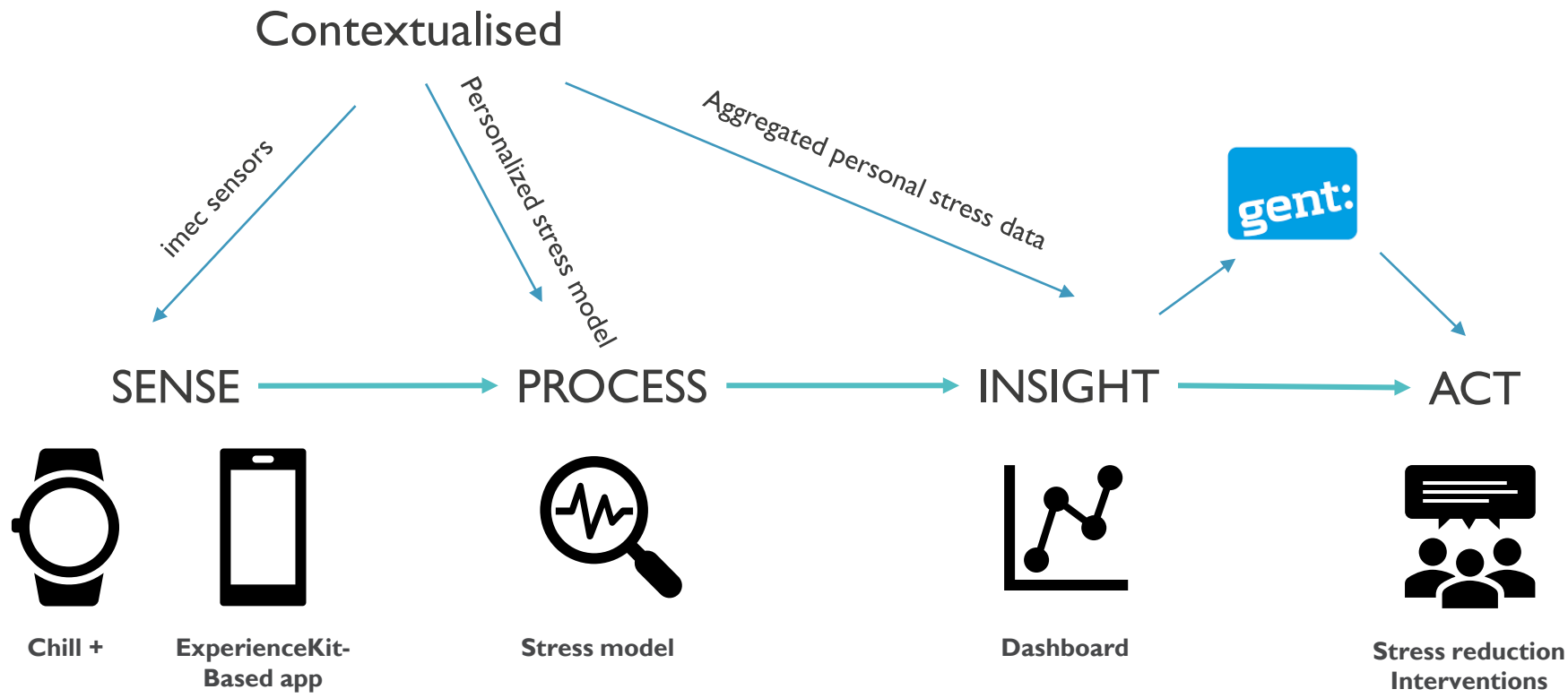
NERVOCITY – MEASURING URBAN STRESS



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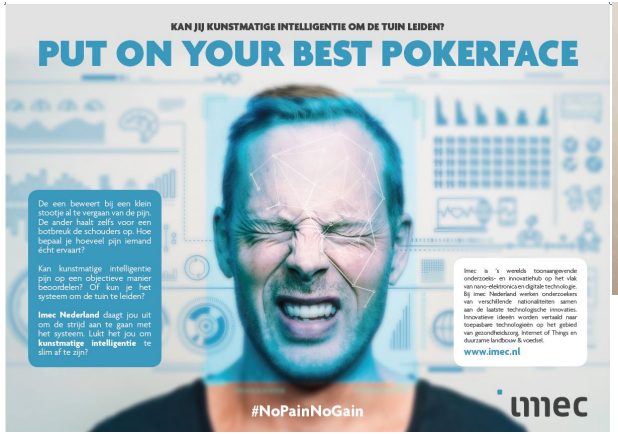
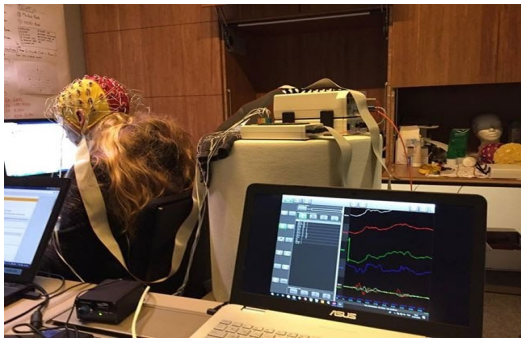
FIRST FEASIBILITY TESTS ON PAIN – FATIGUE – COGNITIVE LOAD

USING AUTONOMIC NERVOUS SYSTEM | EEG | .... MEASUREMENTS



Acute pain sensing

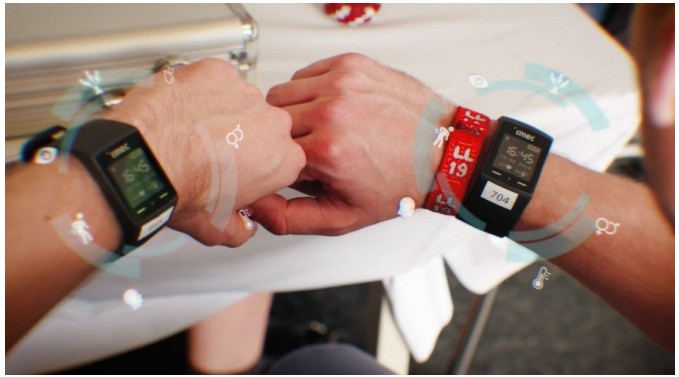
Pain – Fatigue sensing



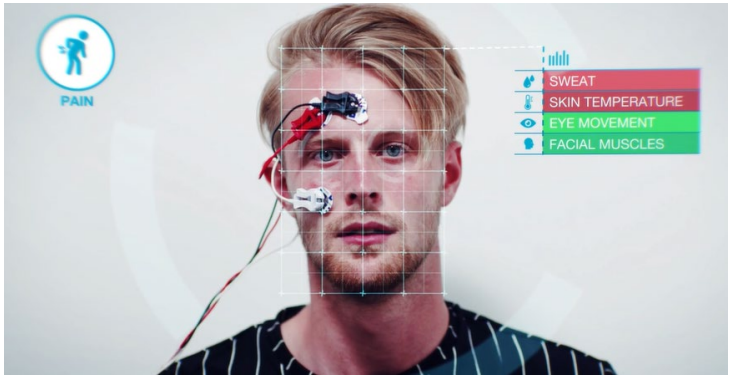
Cognitive load sensing

FIRST FEASIBILITY TEST ACUTE PAIN

132 TEST PERSONS (48% M | 52% F) MEASURES OF GSR/ECG/PPG/EOG/TEMPERATURE



Thermal Pain test



5 QUESTIONS

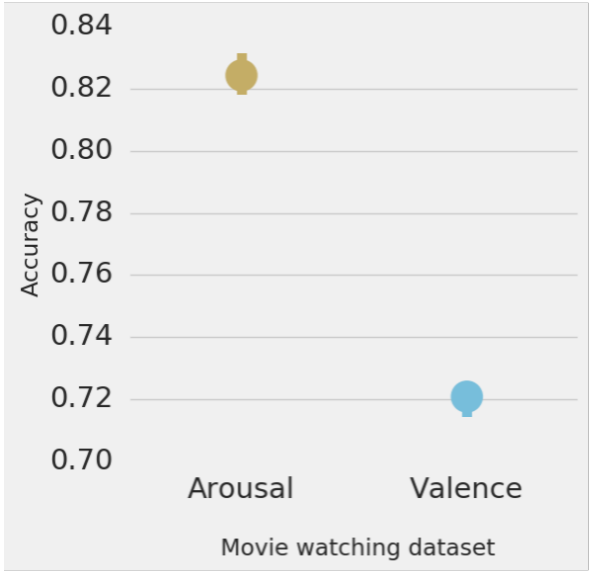
Randomized order

PROTOCOL

RELAX	PAIN TEST	AFTER PAIN	STRESS TEST	AFTER STRESS	RELAX
▪ VAS for stress/calm every – 2 times	▪ Ice bath - max 3 mins; ▪ VAS for pain every 20 secs	▪ VAS for pain every 20 sec	▪ 2 minutes	▪ VAS for stress/calm every – 2 times	▪ VAS for stress/calm every – 2 times

EEG-BASED COGNITION ESTIMATION

PERSONALIZED MODELS FOR EMOTIONAL STATES



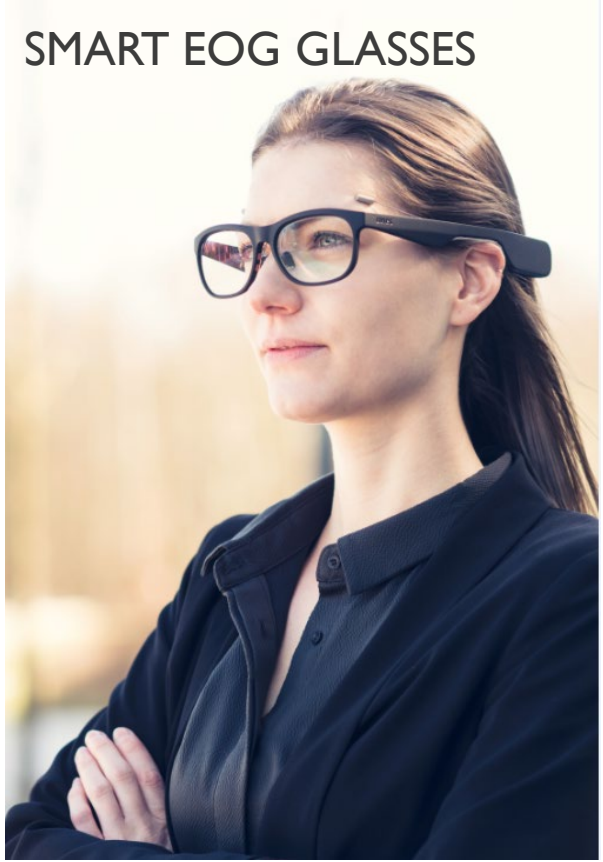
What's your mood today?

EEG based prediction model

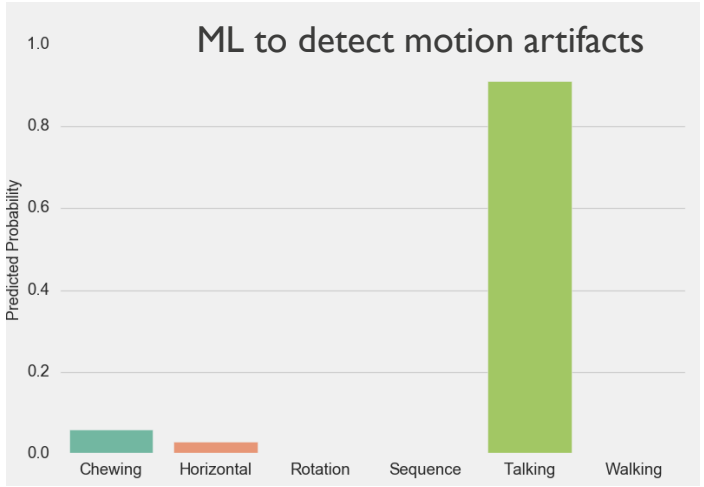
Excited
80%

Scared
20%

CAN WE IDENTIFY YOUR FACIAL EXPRESSION



Happy	Disgust
74%	**6%**
Neutral	Sad
8%	**4%**
Fear	Surprise
3%	**5%**



FUTURE

DIGITAL PHENOTYPING for PERSONALIZED PREVENTIVE HEALTH

What's my mood today?

My diet and activity today?

My sleep last night?

Just-in-time FEEDBACK

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embracing a better life

THANK YOU FOR YOUR ATTENTION

EMMANUEL RIOS VELAZQUEZ, PHD

CONNECTED HEALTH SOLUTIONS – IMEC THE NETHERLANDS