DMSN SEMINAR

INVESTIGATION OF WEARABLES FOR AFFECTIVE RESEARCH

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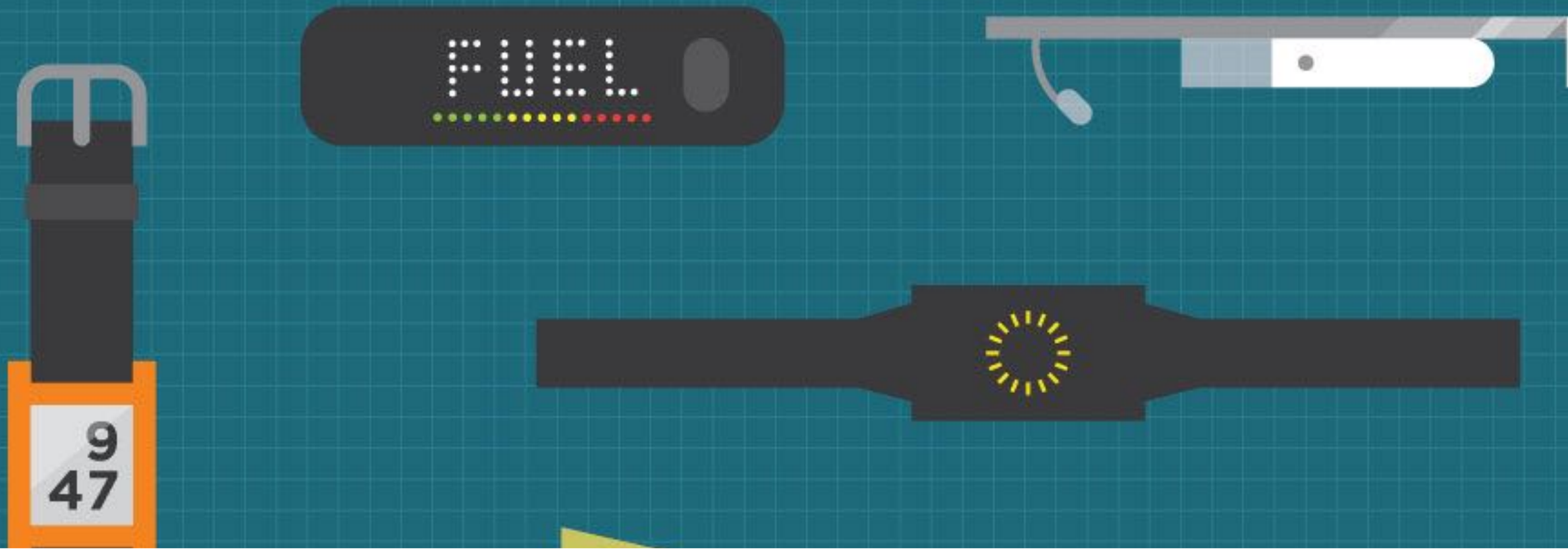
ABOUT ME

- 4th year PhD student at QMUL
- B.Sc. and M.Sc. from University of Applied Sciences, Mittweida
- Research interests:
  - Mobile and wearable sensing to promote wellbeing and facilitate social connectedness
  - Emotion Sensing

AGENDA

- 1. Can we sense emotions with wearables in the Lab?
- Can wearables detect social synchronisations when people interact?



DOES YOUR SMARTWATCH MISS A (HEART) BEAT?

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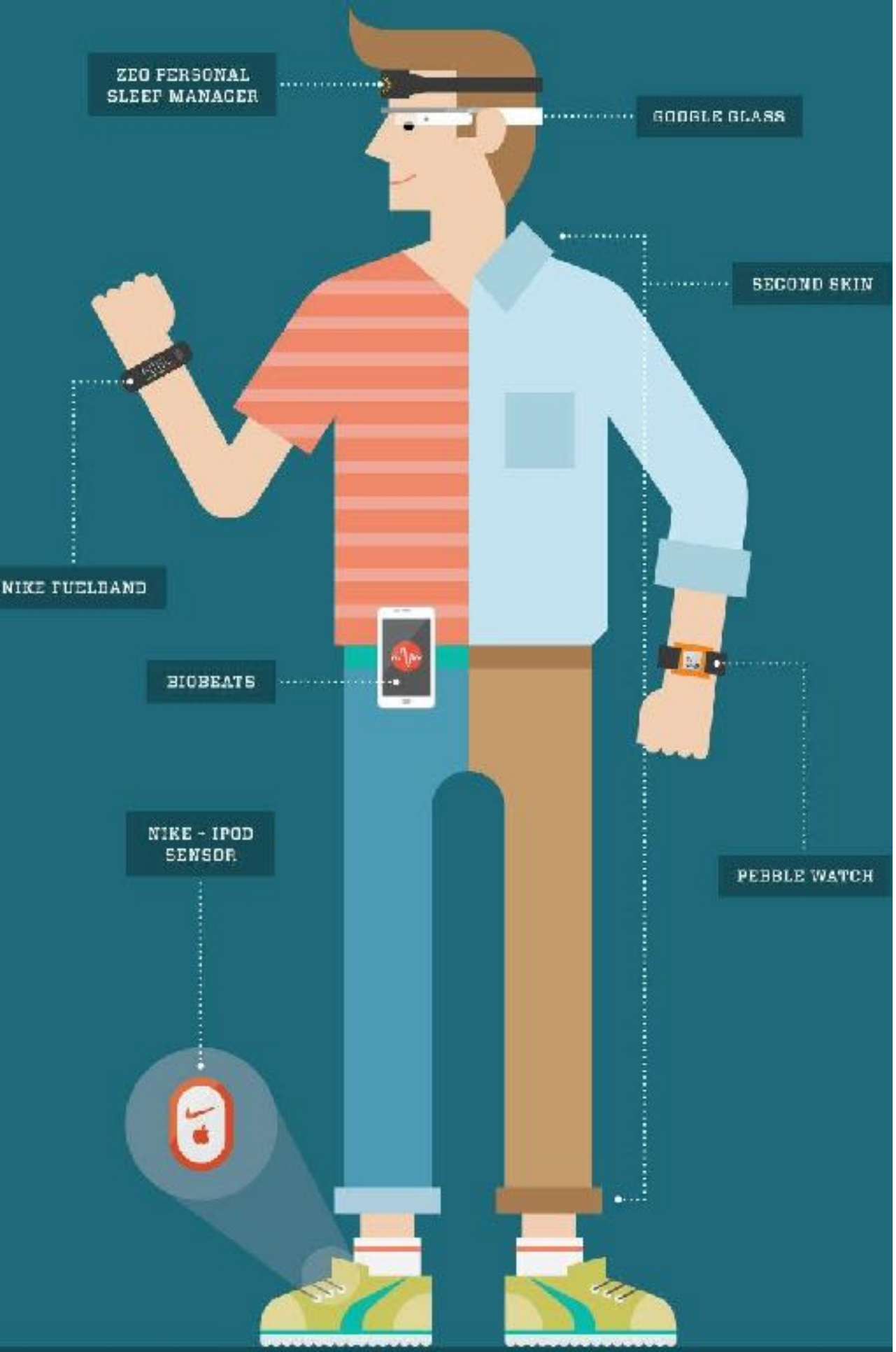
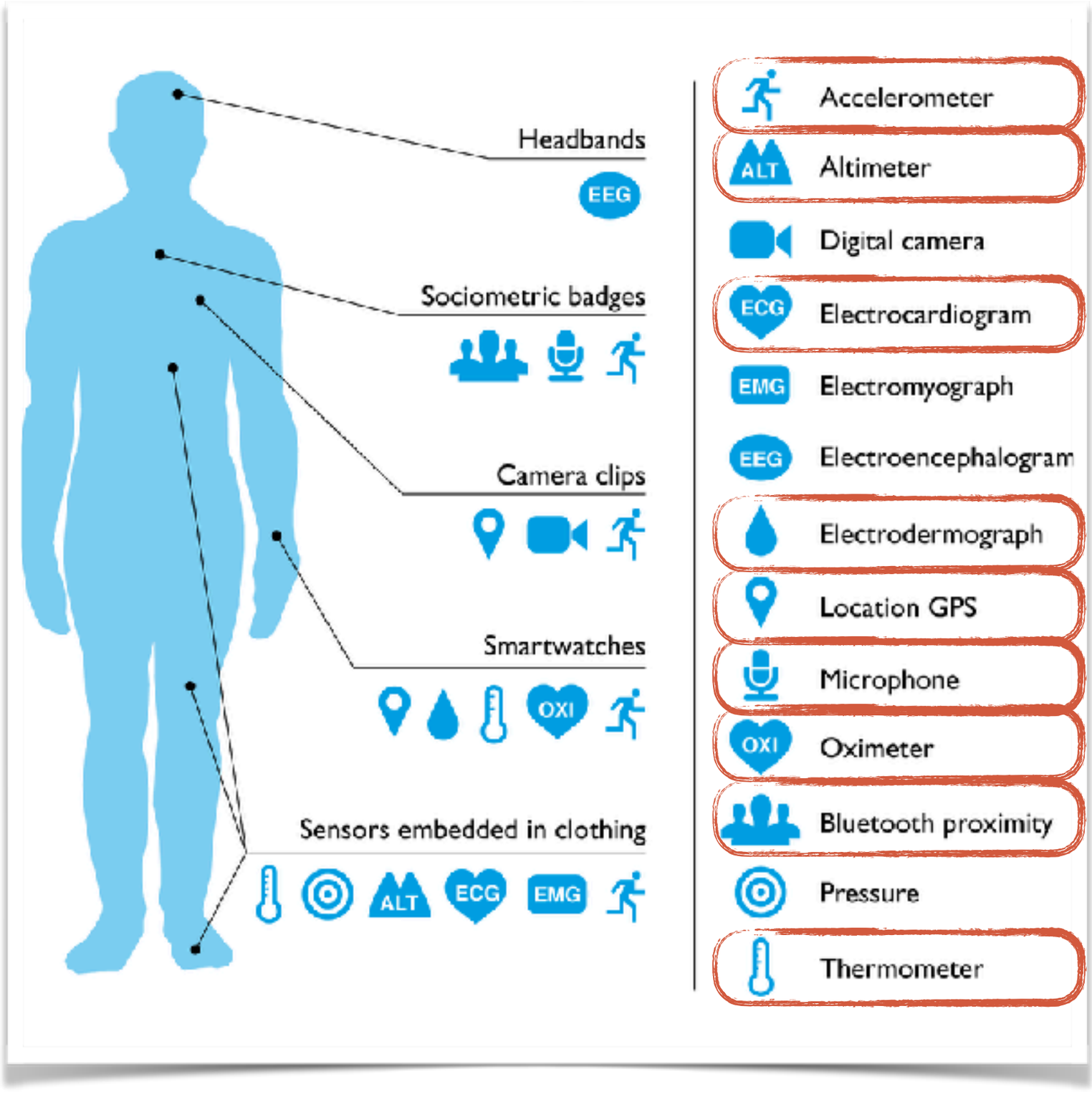


BACKGROUND

- the market is flooded with smartwatches, fitness trackers, etc.
- most wearables are targeted to improve health and wellbeing
  - steps, activity, burned calories
  - sleep quality
  - heart rate and stress
  - meditation support
  - ...



- Large proportion of available Consumer wearables are equipped with multitude of sensors
- Lots of those sensors provide interesting data for researchers
  - Activity, Movement
  - Heart Rate/Stress
  - Skin Conductance
  - Skin Temperature
  - Social Environment
  - Ambient Environment

Image Source: Piwek L, Ellis DA, Andrews S, Joinson A (2016). The Rise of Consumer Health Wearables: Promises and Barriers. PLOS Medicine 13(2): e1001953.

Can we use those consumer wearables in (affective) research?

Can we use those wearables to detect physiological arousal in stressful situations?

WHAT IS STRESS?

Stress is the presence of situation where demands outweigh the available resources

Physical reaction to adjust to higher demands/stimuli

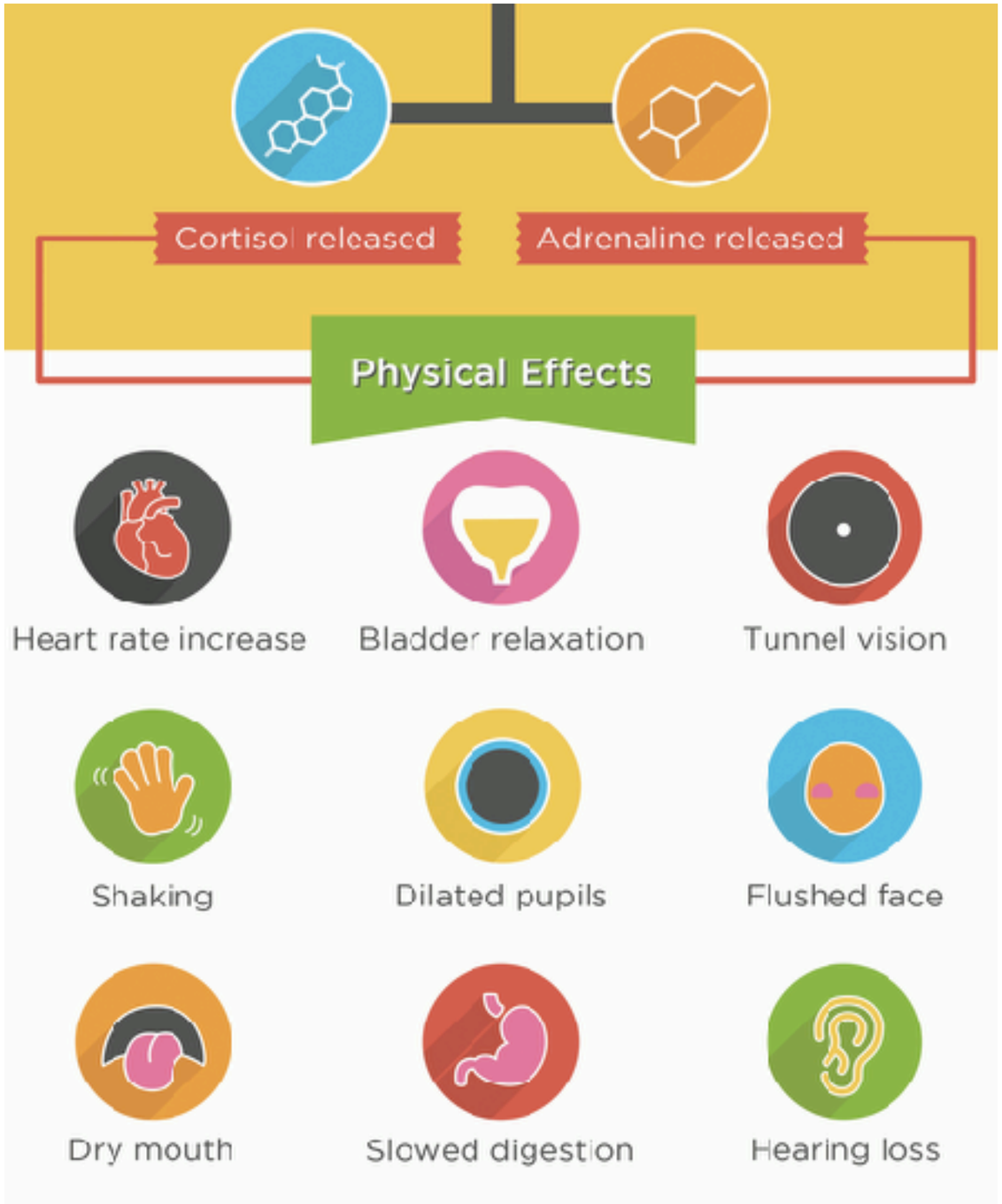
➡ "Fight or Flight" reaction

Long-term, chronic stress causes psychological and physical illnesses:

- ➤ Cardiovascular diseases and cancer
- ➤ Depression
- ➤ Shorter Lifespan

PHYSIOLOGICAL CHANGES INDICATING STRESS RESPONSE

- Heart Rate ⬆
- Skin Conductance ⬆
- Skin Temperature ⬇
- Variation in Inter-Beat Intervals (HRV) ⬇



Can we Measure Stress Responses with Consumer Wearables?

STUDY AIMS

- Compare the physiological data measured by different wearables under stress task and relaxation

- Examine the effect of movement and physical activity

- Investigate relationship between subjective feeling and sensor data

RELATED WORK CONCLUSIONS

- There mainly has been work on accuracy of wearables under different **physical** activity (e.g. sitting, walking, running, cycling)

- Wearables get inaccurate when moving

- Optical Heart Rate monitors tend to be more inaccurate then ECG-based ones

DEVICES

3 Consumer Devices:

- *Apple Watch Series 2 (AW)*
- *Microsoft Band 2 (MSB)*
- *Polar H7*

Laboratory Device (Nexus 10)

- *Professional grade device for biofeedback and research*

HYPOTHESES H1 - PHYSICAL ACTIVITY

- The wearables report similar values when people are sitting still

- The wearables report varying values when people move (e.g. walk)

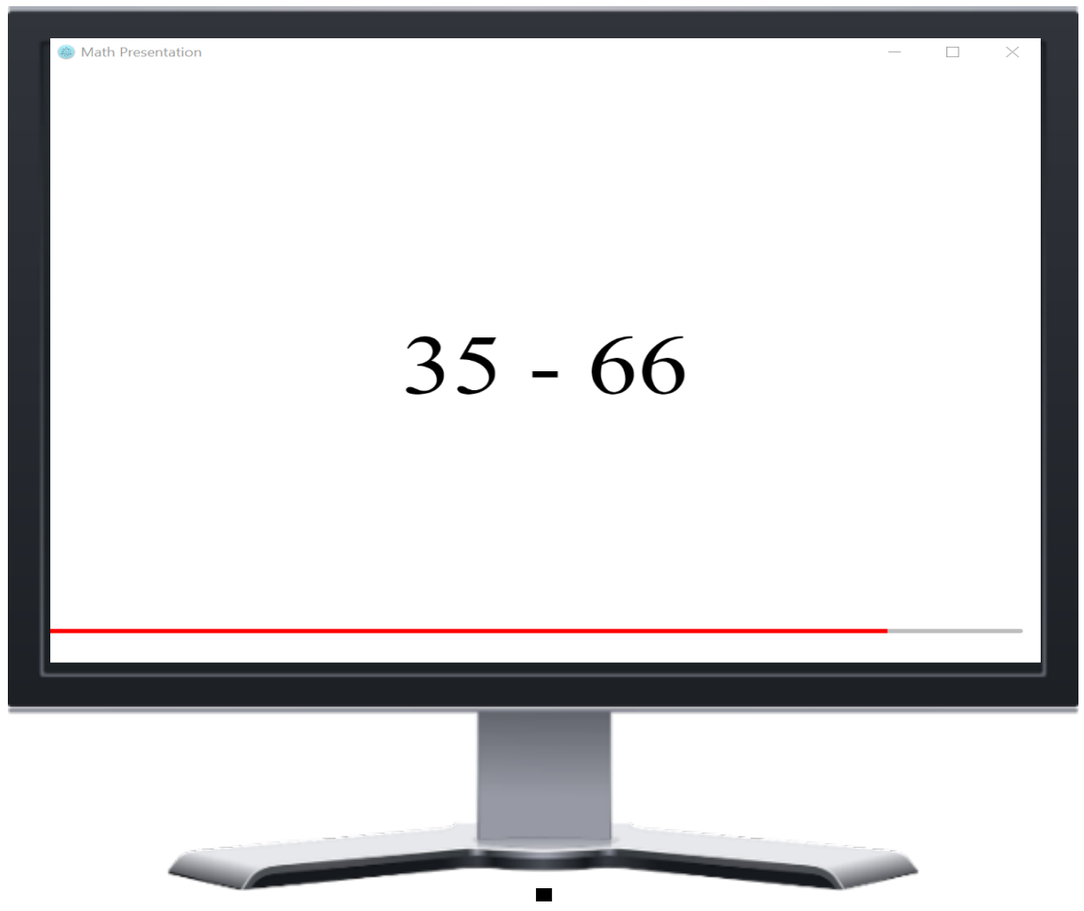
HYPOTHESIS H2 - STRESS VS RELAXED

- There is a difference in the physiological markers when people are stressed vs relaxed

  - ➡ increase in average heart rate
  - ➡ increase in skin conductance
  - ➡ decrease in skin temperature

MENTAL ARITHMETIC TASK

- Solve addition/subtraction with numbers between 1 and 100
- 5 seconds
- Audio feedback on wrong answers
- Visual feedback



RELAXATION

- Listen to meditation music for 5 minutes

HYPOTHESIS H3 - PHYSIOLOGIC VS SUBJECTIVE

- There is a correlation between physiological data and subjective feeling:
  - Stress perception
  - Valence (happy/sad)
  - Arousal (calm/excited)
  - Dominance
  - Wake/tense arousal

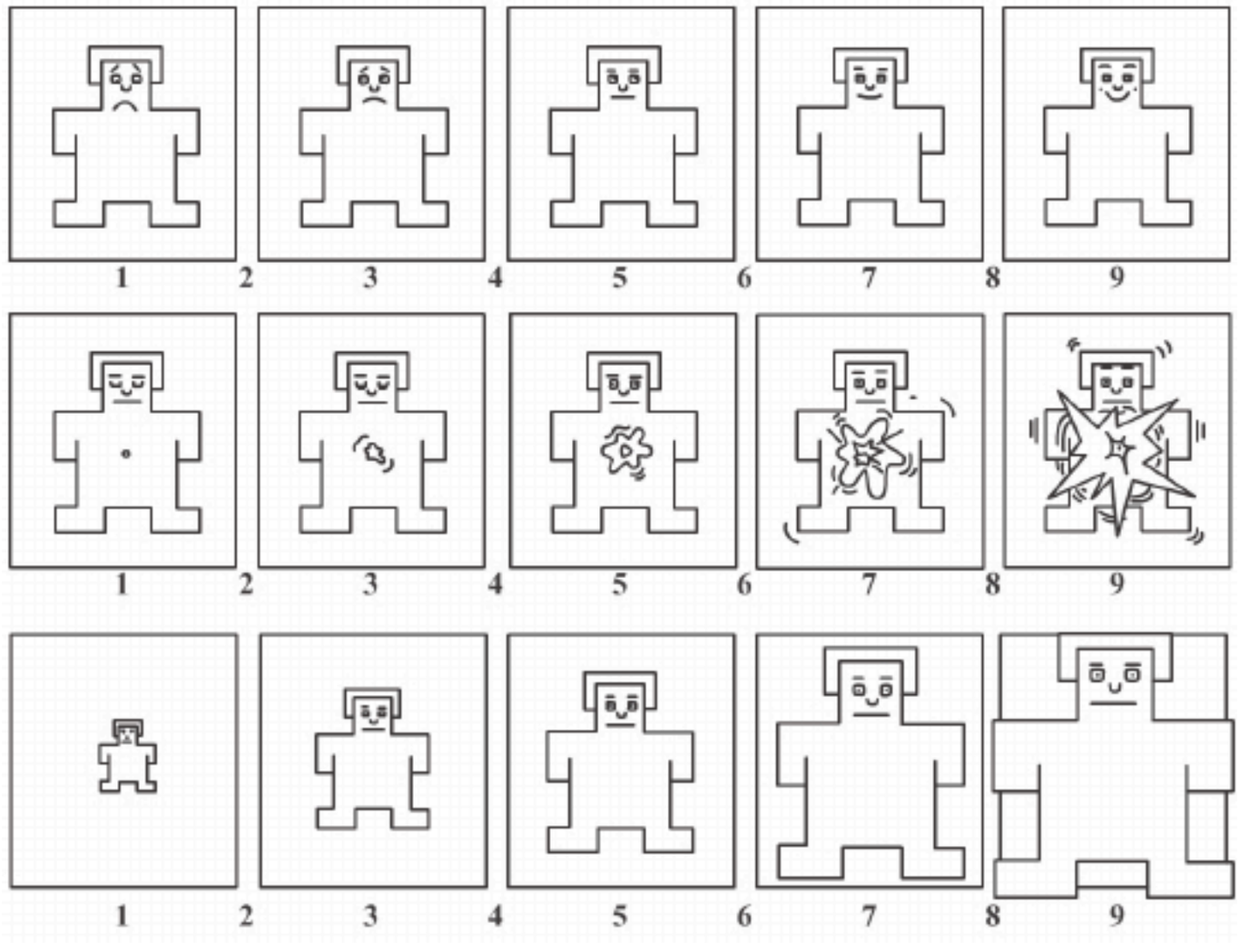


Image Source: Margaret M. Bradley, Peter J. Lang, Measuring emotion: The self-assessment manikin and the semantic differential, Journal of Behavior Therapy and Experimental Psychiatry, Volume 25, Issue 1,1994, Pages 49-59

EXPERIMENTAL SETUP

- Independent Variables:
  - Stress
  - Physical Activity
- Factorial Design with 2 levels each:

	Relaxed	**MAT**
Stationary	RS	MS
Walking	RW	MW

- Dependent Variables:
  - Physiological Sensor Data
  - Subjective Data
    - SAM
    - Perceived Stress
    - Wake and tense arousal

EXPERIMENTAL SETUP - WITHIN SUBJECT DESIGN

Baseline Task: Relaxed	MAT	**Fixed Task:** Relaxed	MAT
			
Stationary	*Walking / Stationary*	*Walking*	*Walking / Stationary*

PARTICIPANTS AND PROCEDURE

- 24 participants including 1 pilot; 2 participants excluded
- Mean age was 29 (SD = 4.4); 8 females, 16 males

- During recruitment it was ensured that participants had no heart, drug/alcohol addiction or mental health issues

- Questionnaires:
  - Demographics, fitness level, baseline mood
  - After each task: current mood and perceived stress

KEY RESULTS - H1

The wearables report similar values when people are sitting still, but not when they are moving.

- This was partly confirmed. Consumer devices got inaccurate when in movement.
    - Average heart rate per condition varied in movement but not stationary
    - Skin Temperature showed a consistent difference in general, no matter of the movement mode
    - EDA showed a difference in general, but difference varied widely

KEY RESULTS - H1

Consumer devices got inaccurate when in movement:

➤ Error Rate (%) of heart rate sensors compared to Nexus:

		Polar	Apple Watch	Microsoft Band
Overall	Mean Error	6.84	8.28	12.06
	Std.	12.34	15.52	12.04
Stationary	Mean Error	3.22	3.42	5.44
	Std.	4.07	4.12	5.96
Walking	Mean Error	10.28	14.41	19.03
	Std.	16.03	21.37	12.87

KEY RESULTS - H2

There is a difference in the physiological data in in stressed vs relaxed conditions

- The Nexus picked up a difference (relaxed vs stressed) but just in stationary condition
- No statistical significant results in consumer device data, except for the Skin Conductance of the Microsoft Band

KEY RESULTS - PHYSIOLOGICAL CHANGES (STATIONARY)

	Nexus	AW	Polar	MSB
Heart Rate ⬆	✔	✘	✘	✘
Skin Conductance ⬆	✔	-	-	✔
Skin Temperature ⬇	✔	-	-	✘

KEY RESULTS - CORRELATION PHYS. AND SUBJ. DATA

There is a correlation between physiological data and subjective feeling.

		arousal	wake arousal	tense arousal	perceived stress
Heart Rate	AW	.265*	.244*	-	.252*
	MSB	.244*	-	-	-
	Polar	.235*	.236*	-	.248*
	Nexus	.323**	.277*	-	.284**
EDA	MSB	.361**	.272*	.337**	.376**
	Nexus	.297**	.362**	-	.296**
Skin Temp.	MSB	-	-.221*	-	-
	Nexus	-.259*	-.367**	-	-.262*

** p < .01,* p < .05

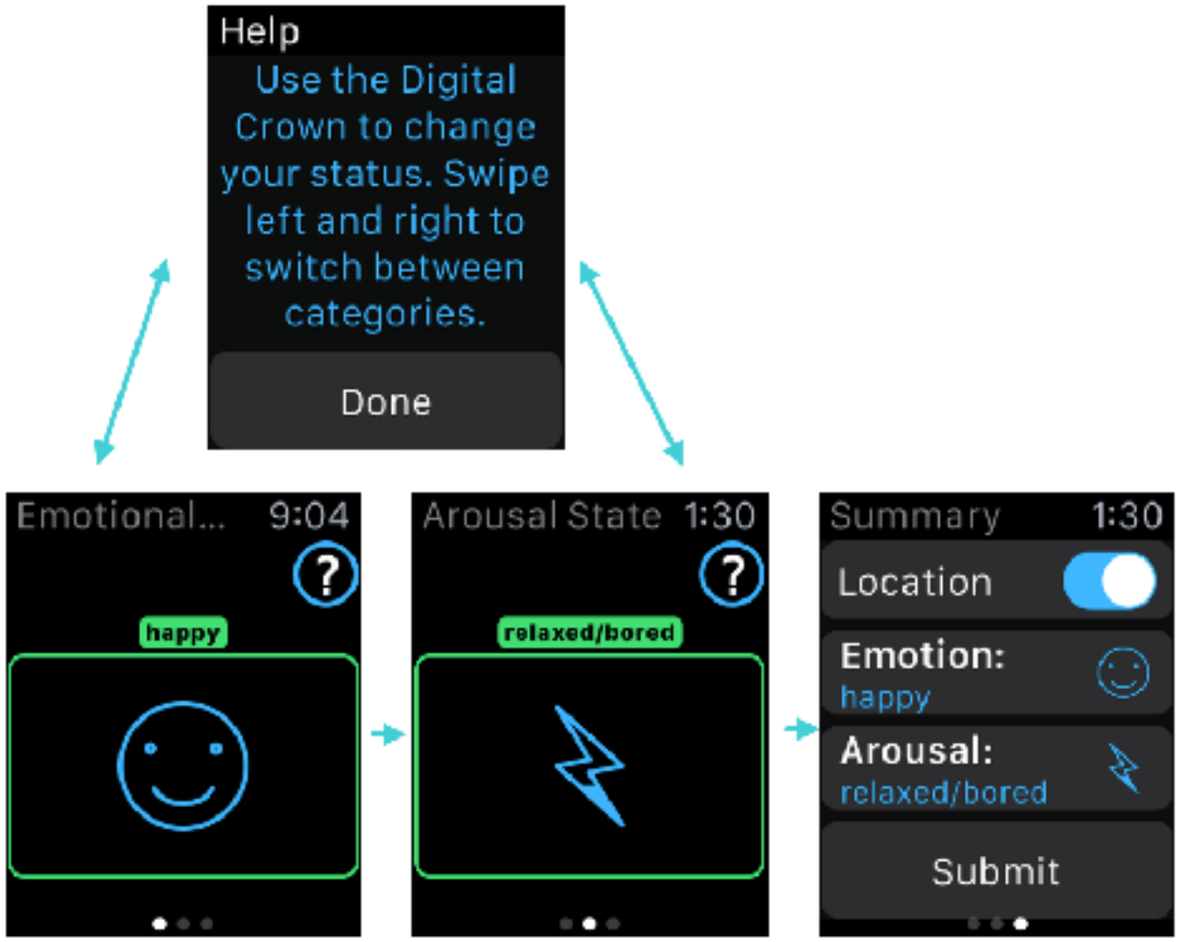
KEY RESULTS - SUMMARY

- Consumer Wearables get inaccurate when participants are moving
  - Error Rate tripled for Polar and quadrupled for MSB and Apple Watch
- Nexus professional device and Microsoft Band (Skin Condutance) were the only one to pick up changes between relaxed and stressed conditions
- But we found weak correlations with subjective measures for all the devices

NEXT STEPS

- Study 1: Using an Apple Watch to assess how people feel in everyday life

- Study 2: on emotion contagion/synchronisation
  - Can wearable pick up synchronisation in physiological data and emotion in interaction?



Thank you!

Researchers involved:

Katrin Hänsel, Romina Kettner, Hamed Haddadi, Akram Alomainy, Albrecht Schmidt.