NEUROERGONOMICS LIVE

LET'S GO BEYOND EEG AND SEE HOW MULTIMODAL RECORDINGS COME TO LIFE

AGENDA

From	To	Topic
10:30	10:45	Welcome & instructions
10:45	11:15	Participant preparation
11:15	11:40	Measurement - Finger tapping & clapping
11:40	11:45	Transfer data
11:45	12:20	Analysis
12:20	12:30	Wrap-up

WHO ARE WE?

WORKSHOP HOSTS

- Melanie Klapprott (Carl von Ossietzky University Oldenburg)
  - Doctoral student
  - Research Focus: measurement of neurocognitive effects of physical exercise with mobile EEG

- Emma Lieker (Leibniz Research centre for Working Environment and Human Factors)
  - Doctoral student
  - Research Focus: interplay of walking and seeing

- Julian Elias Reiser (Leibniz Research centre for Working Environment and Human Factors)
  - Post-Doc
  - Research Focus: Mobile workload measurement, cognitive-motor dual task interference

INTRODUCTION

WHAT SHOULD YOU BRING?

- Laptop (Windows / Mac OS / Linux) running
  - Matlab
    - Additional toolboxes
      - Signal processing
      - Statistics
      - Optimization
      - Image processing
  - Bemobil toolbox (https://github.com/BeMoBIL/bemobil-pipeline)
  - EEGLab (can be requested here: https://sccn.ucsd.edu/eeglab/download.php)
    - Plugins: MoBILAB, XDF Import Plugin, BIOSIG Toolbox, and optionally bva-io.
  - load_xdf function (https://github.com/xdf-modules/xdf-Matlab/tree/master)
  - Lsl_relay_time_alignment python package (pip install lsl_relay_time_alignment before)
  - Visual Studio Code and newest Python version
  - Useful functions (https://github.com/julianreiser/usefulToolbox.git)
- Basic knowledge about EEG / physiological measurements

WHAT'S THE GOAL?

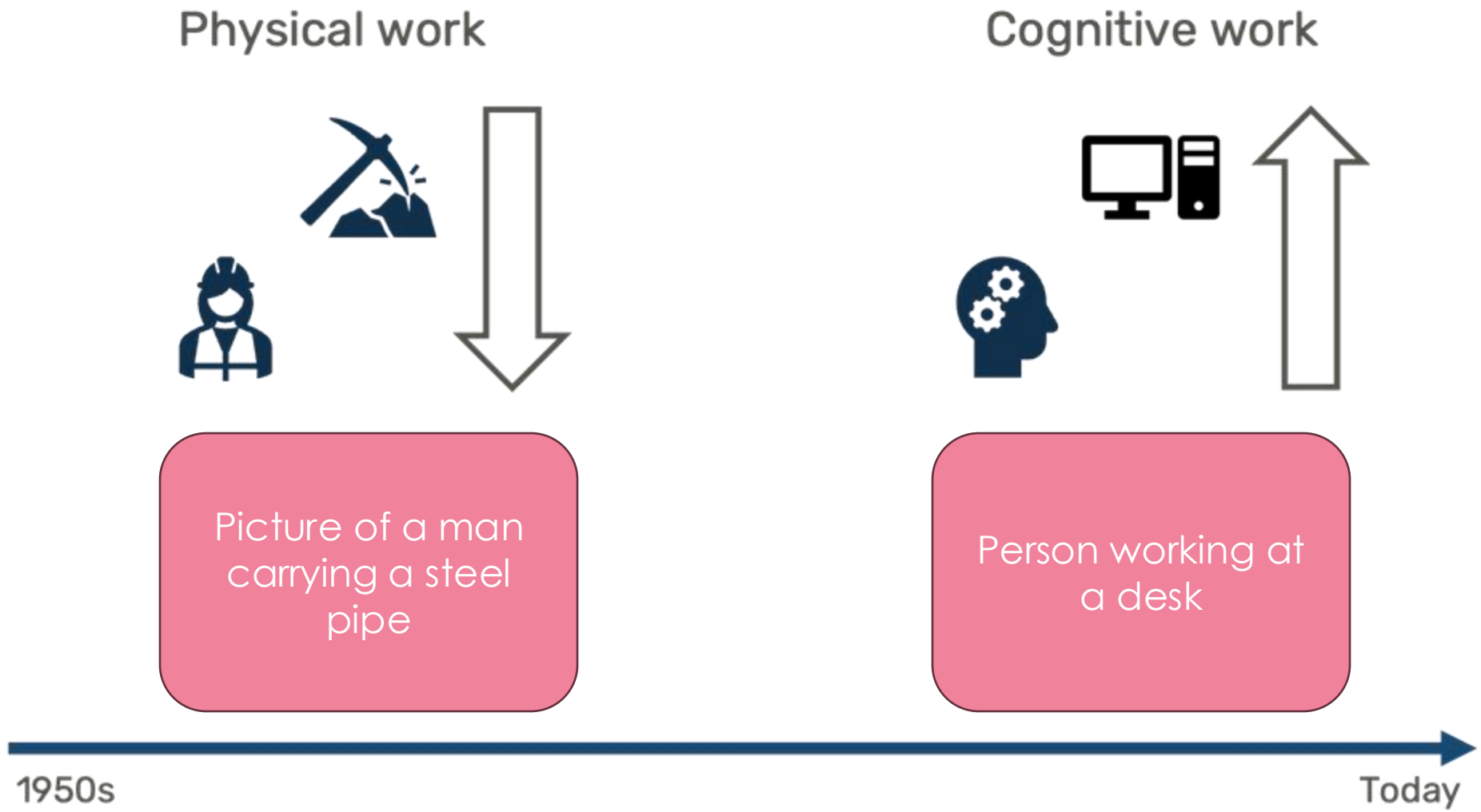
- This workshop is about:
  - Introduction to multi-modal recording and analysis

- The goal of this workshop is to:
  - Give you basic knowledge about how to record EEG with other data streams and running a mobile experiment

- After this workshop you will have the skills to:
  - Identify use-cases for mobile EEG experimentation
  - Record EEG mobily

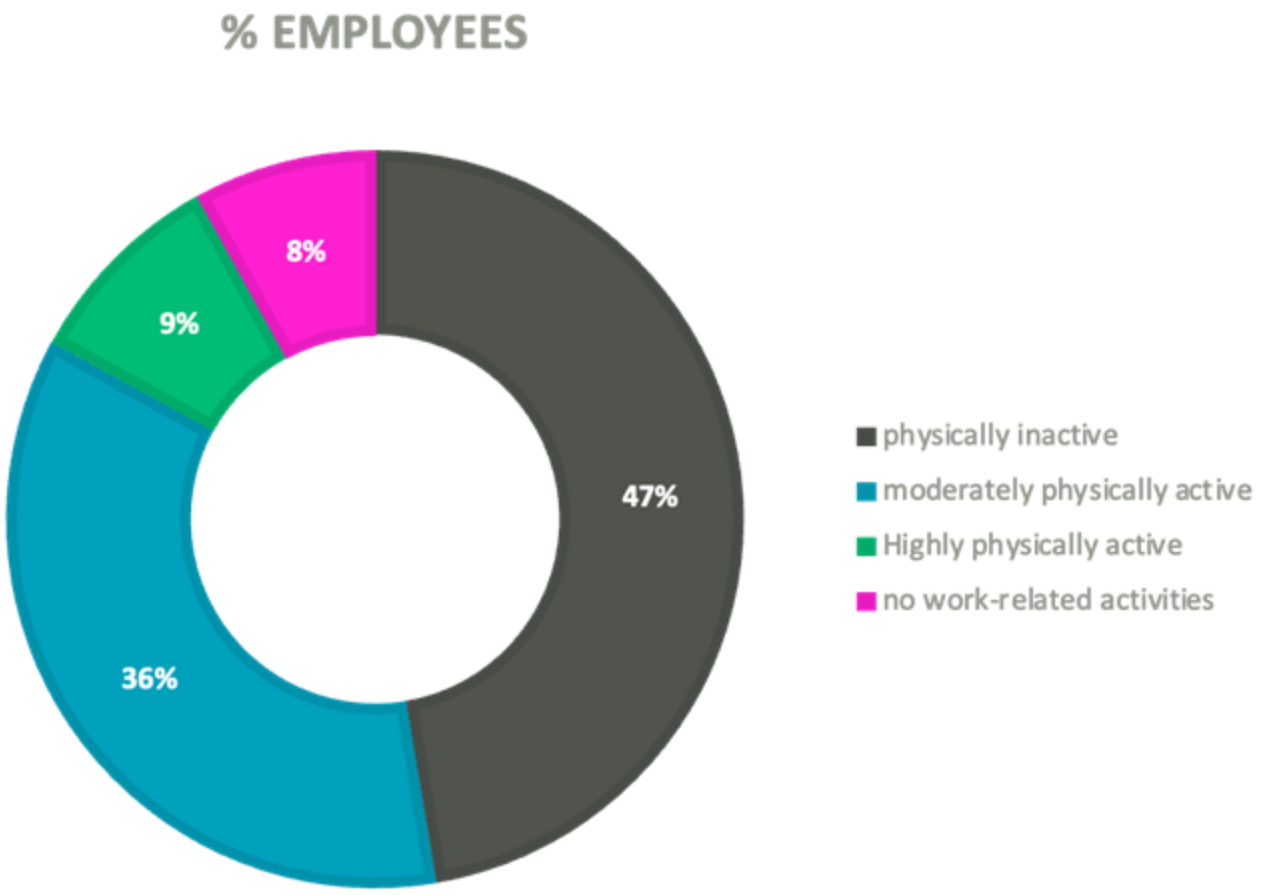
- Important links & material
  - Repository for functions: https://github.com/julianreiser/usefulToolbox.git
  - Datasets: https://nextcloud.mbraintrain.com/s/GgCqTpkHmxedjGs

WHY DO WE NEED PHYSIOLOGY?



WHY THE HASSLE?

- High proportion of employees who either
  - sit (47%) or
  - sit / walk (36%)
- Only **9% of workers** perform heavy physical work such as carrying loads.
- Only a few of the methods for measuring physical stress can be used for cognitive activities.
- Increasing need to validate objective methods for cognitive risk assessment



WHY NOT ASK PEOPLE?

Questionnaires

- Low temporal resolution
- Measurement of the evaluation of the activity performed
- Cannot be used during the activity
- Can be distorted

Behavioral measures

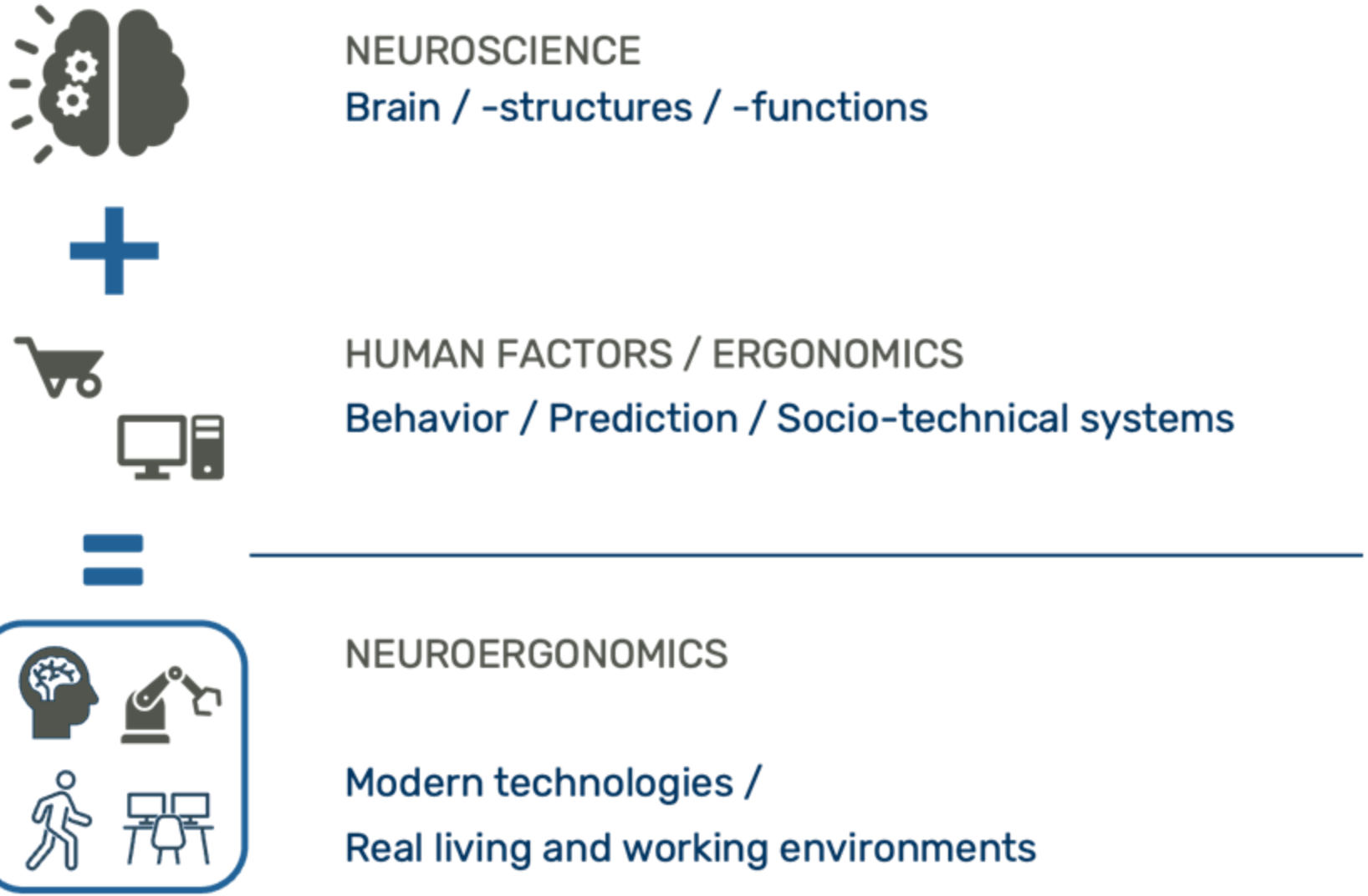
- High temporal resolution
- Measurement of the activity performed
- Can only be used during the activity
- Cannot be falsified

Physiology

- High temporal resolution
- Measurement of the effect of the activity performed
- Can only be used during the activity
- Cannot be falsified

Problems:
The different measures each cover different facets of stress.
The different measures are rarely correlated.

WHAT'S NEUROERGONOMICS?



NEUROSCIENCE

Brain / -structures / -functions

HUMAN FACTORS / ERGONOMICS

Behavior / Prediction / Socio-technical systems

NEUROERGONOMICS

Modern technologies /

Real living and working environments

WHAT'S NEUROERGONOMICS?

neuronal basis sensory & cognitive functions

modern technologies

real living environments

Dehais, F., & Ayaz, H. (2018). Progress and direction in neuroergonomics. In *Neuroergonomics: The Brain at Work and in Everyday Life* (pp. 3–7). Elsevier. https://doi.org/10.1016/B978-0-12-811926-6.00001-4

WHICH DATA DO WE MEASURE?

Covered in this workshop:

- **EEG**, mBrainTrain Pro X: voltage changes we measure on the scalp surface using tiny electrodes
- **ECG**, Bittium Faros 180: electrical activity of the heart measured using strip electrodes
- **Eye-Tracking**, Pupil Labs Neon: position of the gaze vector relative to the field of view

Common, but not covered:

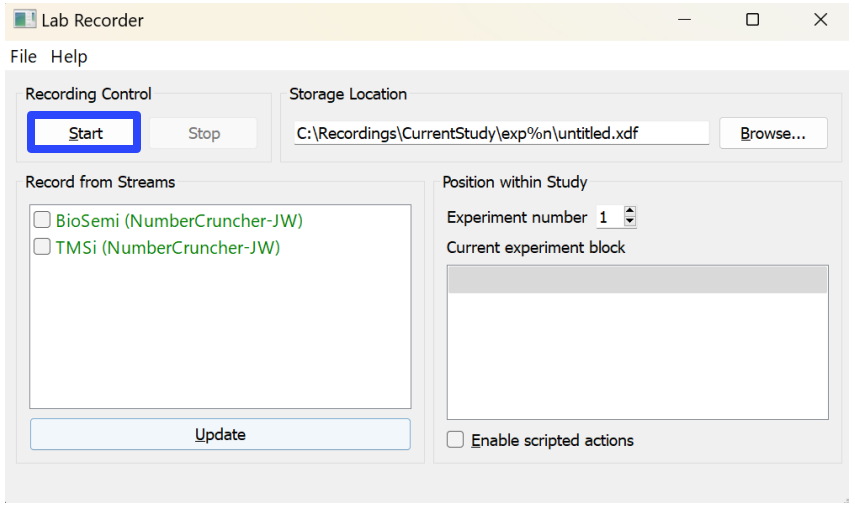
- Motion Capturing
- EDA / skin conductance
- fNIRS
- …

SYNCHRONIZATION OF ALL MEASURES

The key: **Lab Streaming Layer** (LSL)

- LSL allows to use one or more applications to stream data from one or more devices (e.g., EEG and Eye Tracker) over the local network and record the with the LabRecorder.
- Prerequisite: devices have to support LSL
- Steps to use LSL:
  1. Create LSL outlet
  2. Fetch data from device
  3. Push data to LSL outlet

EEG



EMG

EEG LSL outlet

```
lsl_streaminfo(lib,'BioSemi','EEG',8,100,'cf_float32)
```

EMG LSL outlet

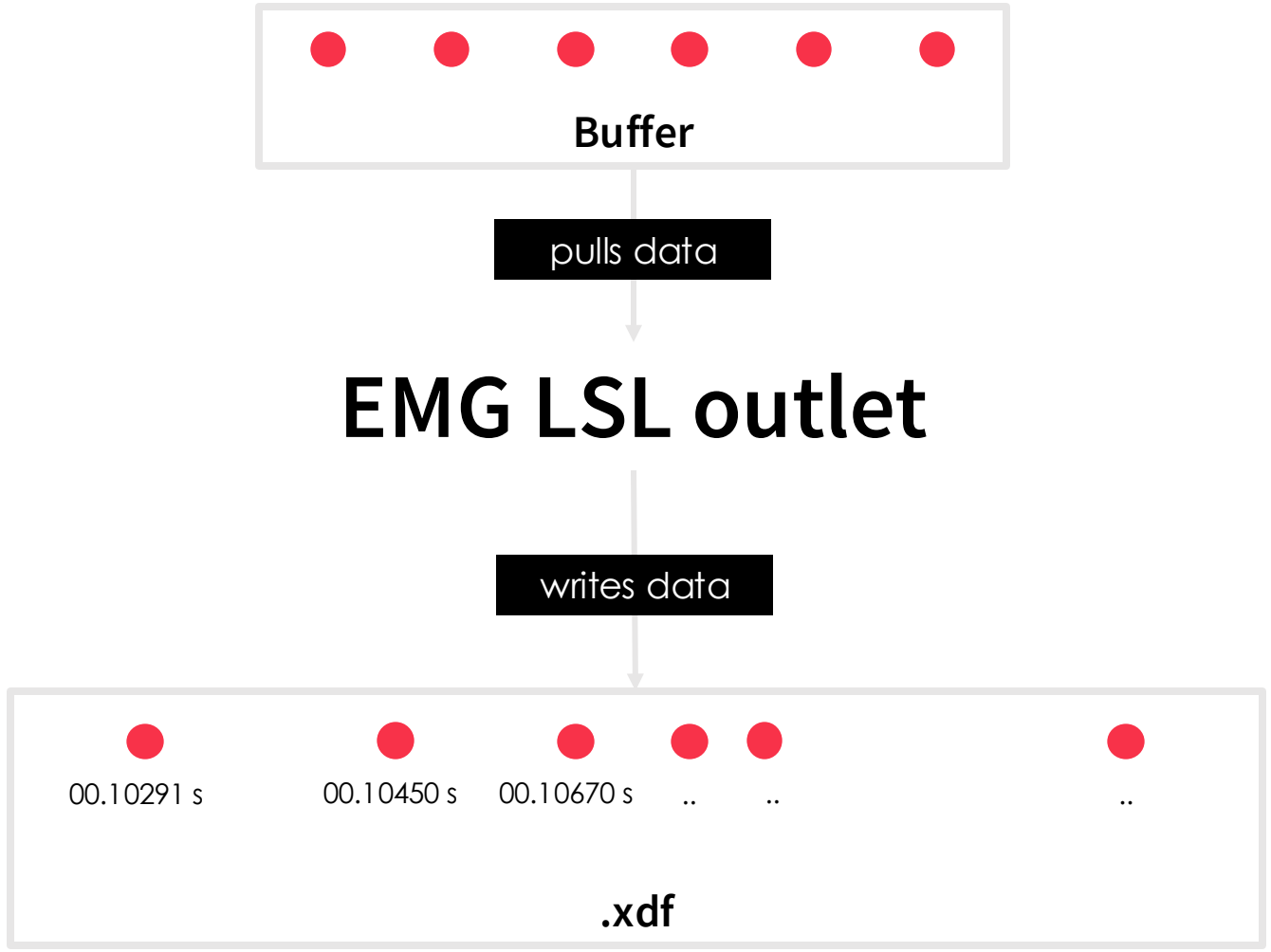
```
lsl_streaminfo(lib,'TMSi','EMG',12,200,'cf_float32)
```

LSL lib

EEG Stream

EMG Stream

EMG


Buffer
pulls data
EMG LSL outlet
writes data
00.10291 s
00.10450 s
00.10670 s
..
..
..
.xdf

WHERE CAN WE MEASURE DATA?

Papin et al. (2024)

Rosenkranz et al. (2025)

Contreras et al. (in review)

Straetmans et al. (2024)

Klapprott & Debener (2024)

Klapprott et al. (in review)

WHICH FIELDS DO WE INVESTIGATE?

Cognitive-motor interference
(Reiser et al., 2022)

Human-machine interaction
(Alyan et al., 2023)

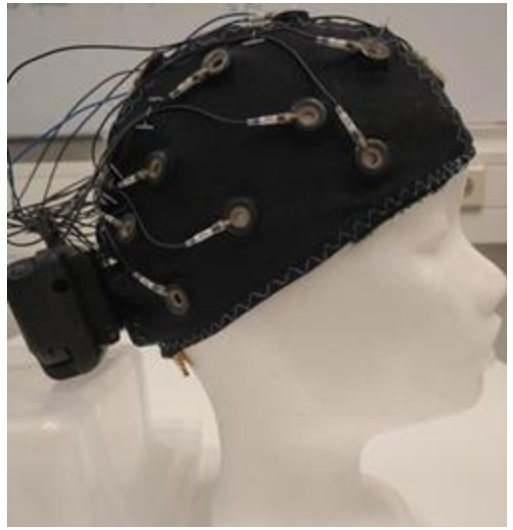
Abstract working environments
(Reiser et al., submitted)

WHAT KIND OF CHALLENGES DO WE MEET?

- Integration of multimodal measures
  - Embed in LSL previously unsupported devices
  - Maintaining a stable network in out-of-the-lab-settings
- Artefacts related to motion
- Measurement environments sometimes require adjustments in the setup

… making EEG waterproof

(after some more "tries")



(the very first try)

BRAINSTORM TIME

Now join **menti.com** with code **7807 2284**

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PARTICIPANT PREPARATION

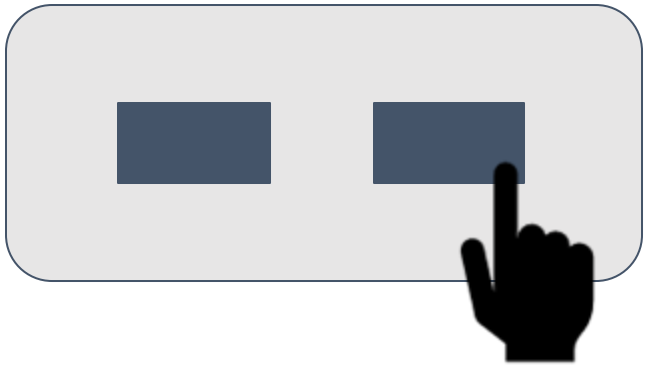
10:45 - 11:15

MEASUREMENT TIME!

11:15 - 11:40

PARADIGMS

Finger tapping



Readiness potential (N100)

The task is to tap either the 1 or the 2 on the screen. Participants should surprise the experimenter with a) when they tap, AND b) if it's left or right.

The task is performed seated and while walking through a hallway.

PARADIGMS

Clapping - audience

P300 to natural stimuli

The participant is seated facing the wall - not the audience. The task for the audience is to clap after a signal from the workshop leaders (left side vs. right side). The clap should surprise the participant.

Rule: 10 claps per side

DATA TRANSFER

11:40 - 11:45

ORGANIZE EVERYTHING TIDILY!

- For a script to run properly, we need to **organize all files in the same way**
- We need a **single folder for each participant** within our **data folder**
- We copy all files we have into this single folder (xdf, edf, bdf, …)
- This folder will be checked by Matlab functions and data will be loaded adaptively
- The **only thing we need for sure** is one **EEG** stream (either within the xdf or as a separate file)

```
data_directory/
├── subject_001/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── some_time_code_and_numbers/
│   │       ├── gaze.csv
│   │       └── time_alignment_parameters.json
├── RP_P002/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── …
```

LSL FILE

- Locate the .xdf file (extendable data format) on your hard drive
- Copy the file into the subject folder
- The more streams we can record directly into the xdf, the less work we will have later on.

```
data_directory/
├── subject_001/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── some_time_code_and_numbers/
│   │       ├── gaze.csv
│   │       └── time_alignment_parameters.json
├── RP_P002/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── …
```

EEG FILE (IF RECORDED SEPARATELY)

- Plug your mbt amplifier into the computer
- Locate the subject file (.bdf) on the amplifier and copy it into the subject folder

ECG FILE (IF RECORDED)

- Plug your Faros amplifier into the computer
- Locate the subject file (.edf) on the amplifier and copy it into the subject folder

```
data_directory/
├── subject_001/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── some_time_code_and_numbers/
│   │       ├── gaze.csv
│   │       └── time_alignment_parameters.json
├── RP_P002/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── …
```

EYE-TRACKING

- Pupil labs / eye-tracking is a bit special here:
  a. The data is analyzed online after an initial (automatic) upload
  b. After the primary analysis by pupil labs, we can download the folder containing gaze, events, etc. (https://cloud.pupil-labs.com/)
  c. Copy the downloaded folder as a whole into the subject folder for the script to work!

- Run the python script `mergePupilData.ipynb` to make it mergeble (more later in the analysis section)

```
data_directory/
├── subject_001/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── some_time_code_and_numbers/
│   │       ├── gaze.csv
│   │       └── time_alignment_parameters.json
├── RP_P002/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── …
```

DATA ANALYSIS

11:45 - 12:20

PUPIL LABS (IF PRESENT)

- Open the python script `usefulMergePupilData.ipynb`
- At the very top, you only have to indicate your data-dir for your data

```
# data directory where all participants are stored
data_dir = "/Users/julianreiser/Downloads/mbt_workshop/Piloten/data"
```

- The rest will be taken care of by the script (documentation in the script explains everything in markdown)
- You wil end up with a `timeAlignedGaze.csv in the pupil subfolder`

```
data_directory/
├── subject_001/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── some_time_code_and_numbers/
│   │       ├── gaze.csv
│   │       └── time_alignment_parameters.json
├── RP_P002/
│   ├── subject_001.xdf
│   ├── subject_001.edf
│   ├── subject_001.bdf
│   ├── subject_001_pupil/
│   │   └── …
```

MERGING

- Open the matlab script `usefulLslAlign.m`
- At the very top, you only have to indicate your data-directory for your data to-be-merged (inLocation) and merged data (outLocation)

```
% indicate folder with subjects
pathVars.inLocation = '/Users/julianreiser/Downloads/mbt_workshop/data/melanieData/';
pathVars.outLocation = '/Users/julianreiser/Downloads/mbt_workshop/data/merged/';
```

- The rest will be taken care of by the script (I tried to document everything, please leave feedback!)
- You wil end up with a `timeAlignedGaze.csv in the pupil subfolder`

```
inLocation/
├── subject_001/
│   ├── subject_001.xdf
│   ├── …
├── subject_002/
│   ├── subject_002.xdf
│   ├── …
```

```
outLocation/
├── subject_001_merged.set
├── subject_002_merged.set
├── …
```

ANALYSIS

- Open the matlab script `usefulQuickPrepro.m`
- Due to time limitations we will run a very quick-and-dirty preprocessing pipeline + averaging/plotting

```
pathVars.inLocation = '/Users/julianreiser/Downloads/mbt_workshop/data/merged/';
pathVars.outLocation = '/Users/julianreiser/Downloads/mbt_workshop/data/prepro/';
pathVars.eegLab = '/Users/julianreiser/owncloud/projects/functions/eeglab2023.1';
```


```
inLocation/
├── subject_001_merged.set
├── subject_002_merged.set
├── …
```

```
outLocation
├── ERPs.mat
├── subject_001_prepro.set
├── subject_002_prepro.set
├── …
```

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WRAP UP

12:20 - 12:30

SUMMARY

- Neuroergonomics is about combining modern neurotechnology with real-world work environments
- We do this because physiological measurements capture work-related metrics differently (more objectively) than self reports
- Solutions like LSL help us to record multimodal data in various settings
- Even though the technology has made great advances, we still face some challenges when recording multi-modal data outside of the lab
- A lot of care has to be taken when transfering and merging the data

OUR SUBMISSIONS

- Talks
  - Julian: Tuesday, 10:30
    "**Walking and Cognitive Load: Examining Neural and Behavioral Responses Using a Virtual Environmen**t"
  - Melanie: Tuesday, 10:45
    "**Neurocognitive effects of Physical Exercise and the role of mobile EEG**"

- Posters
  - EEGManySteps: Monday, 16:15
    "**EEGManySteps: Investigating the Influence of Experimental Setups on Gait-Related EEG through Collaborative Data Collection and Analysis**"

THANK YOU FOR YOUR PARTICIPATION!

MBT CONFERENCE 3.0

Neuroergonomics live

Lets go beyond EEG and see how multimodal recordings come to life