PADERBORN UNIVERSITY

HITS
Human Centered IT Security

Usable Security and Privacy Lab: Hardening and Harnessing Neurotechnology

Project Group 2024-2025

Emiram Kablo, Yorick Last, Patricia Arias Cabarcos

August 2024

Motivation

Neurotechnology is becoming available to the general public

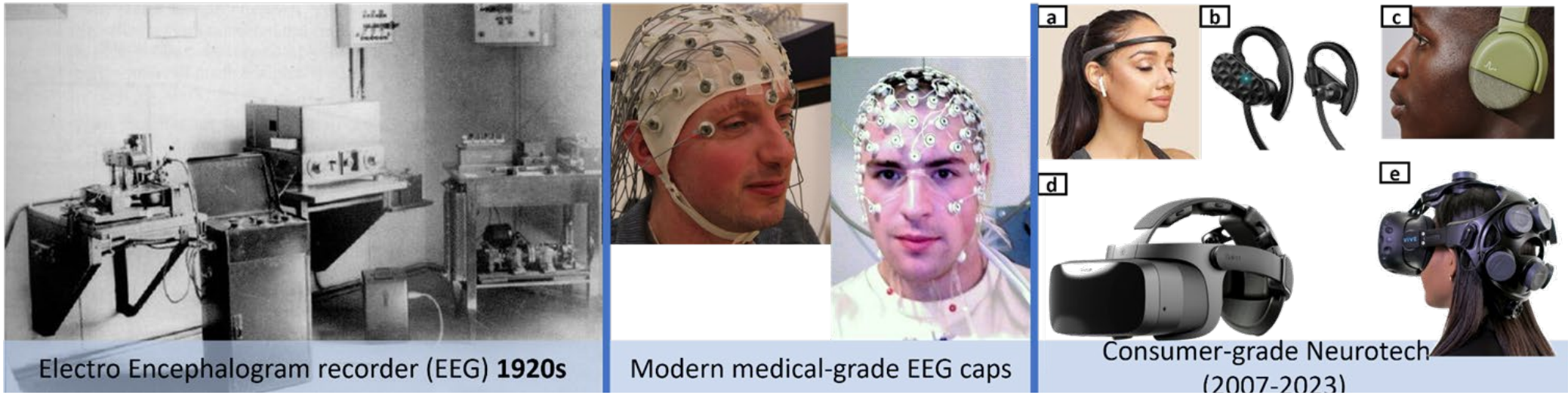


Figure 1: Evolution of neurotechnology from room-sized EEG machines used in the 1920s (left), to modern medical-grade caps dense in sensors and cables (center), up to current non-invasive wearable neurotechnology (a, b, c, d- right)

PADERBORN UNIVERSITY

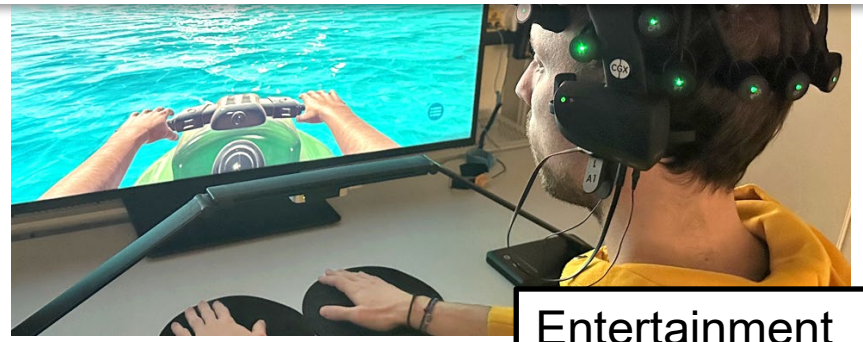
Workplace Safety

Brain Computer Interface Market is forecasted to reach USD 8.9 Billion by 2032, growing at a 16.8% CAGR from 2023 to 2032

Acumen Research and Consulting recently published report titled “Brain Computer Interface Market Forecast, 2023 - 2032”

October 05, 2023 11:13 ET

Education

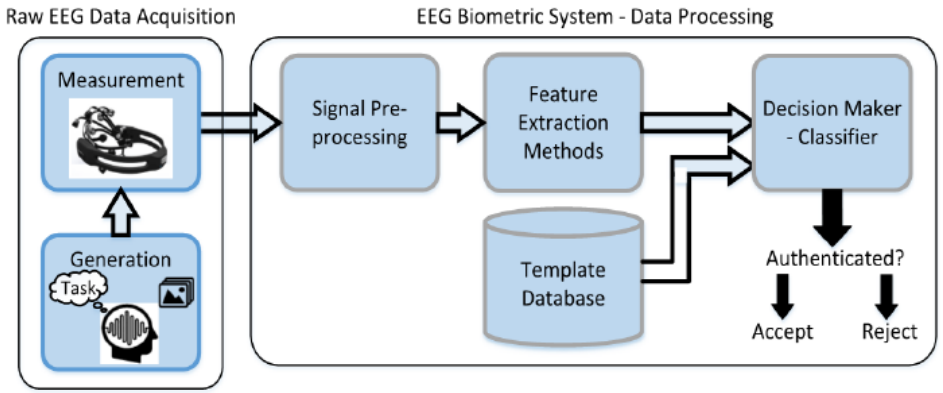


Entertainment

New Opportunities and Threats in the field of Security & Privacy

Neurotech for S&P

- Example: Consumer Neurotech can be used for user authentication based on brain biometrics to secure access to devices and services



S&P for Neurotech

- Example: Protection against mental privacy needed

decoded
from
MEG activity

decoded from fMRI activity

Arias-Cabarcos, P., et al. (2021). "Inexpensive Brainwave Authentication: New Techniques and Insights on User Acceptance". USENIX Security'21.

Röse, Markus, Emiram Kablo, and Patricia Arias-Cabarcos. "Overcoming theory: Designing brainwave authentication for the real world." *Proceedings of the 2023 European Symposium on Usable Security*. 2023.

https://ai.meta.com/blog/brain-ai-image-decoding-meg-magnetoencephalography/

First Phase: Research and Technical Training (WiSe 2024–25)

Research

Systematization of Knowledge

- How can neurotechnology be used to improve security and privacy?
- What are existing research gaps?

- What are current threats to neurotechnology-based applications?
- What is the state of countermeasures? What are the gaps?

Output:

- Survey paper consolidating existing opportunities and threats (similar to [1]) and associated website
- Starting point to develop prototype implementations for hardening and harnessing neurotechnology

[1] Similar survey with different technology: Katsini, C., Abdrabou, Y., Raptis, G.E., Khamis, M. and Alt, F., 2020, April. The role of eye gaze in security and privacy applications: Survey and future HCI research directions. In *Proceedings of the 2020 CHI conference on human factors in computing systems* (pp. 1-21). https://dl.acm.org/doi/pdf/10.1145/3313831.3376840

PADERBORN UNIVERSITY

Technical Training

Tasks

- Familiarization with libraries for EEG data processing, specially MNE https://mne.tools/stable/index.html
- Learning and programming basic EEG data processing pipelines, including visualization
- Design and execution of protocols for brain data collection

Second Phase: Implementation. Hardening and Harnessing Neurotechnology for S&P (SS 25)

Implementation

Mini-projects of two types:

A) build (or extend) applications that use neurotechnology to improve S&P or that improve the S&P of neurotechnology-based apps

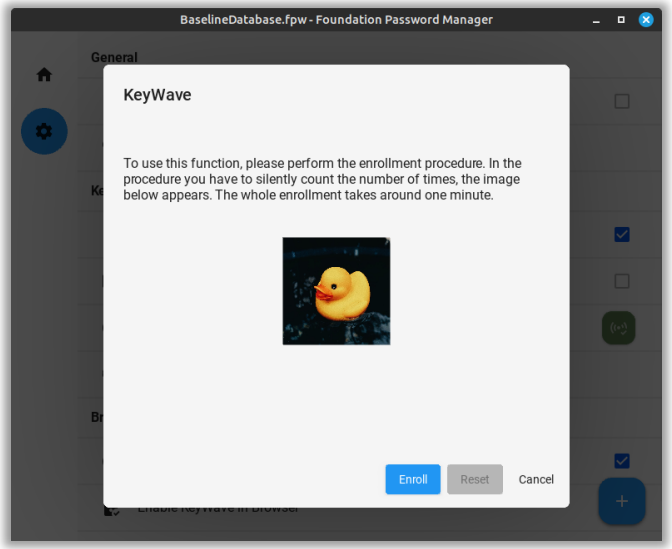
B) conduct novel research to improve understanding of Neurotechnology+S&P

- Number of mini-projects dependent on the number of team members
- Mini-projects informed by the research conducted in Phase I
- Possibility to extend existing projects (see next slide)

Output:

- A) Demonstrators. Extension of the project website with the description/videos of each demonstrator and links to the code repositories
- B) Research report. Extension of the project website with the main findings of the research

Neurotech Projects at HITS*



Authentication

- BrainNET: Code for brainwave-based biometric recognition using Siamese Networks
https://github.com/kit-ps/brainnet

- Inexpensive Brainwave Authentication Dataset: Largest public dataset for consumer-grade EEG authentication
https://github.com/kit-ps/bainwave-authentication

- NeuroIDBench: Benchmarking toolkit for neurotechnology-based identification methods
https://github.com/Avichaurasia/NeuroIDBench

- Brain+PM: Integration of brainwave analysis with password management
https://github.com/markus-ro/fpm https://github.com/markus-ro/fpm-browser-plugin https://github.com/markus-ro/neuropack

Neuroprivacy

- Privacy in the Age of Neurotechnology: Investigating Public Attitudes towards Brain Data Collection and Use
https://gitlab.com/hitsresearchgroup/neuroprivacy

** Sources see last side bibliography*

Neurotech at HITS

Muse 2

5 channels, dry device

https://choosemuse.com/products/muse-2

Emotiv Epoc X

14 channels, semi-dry device

https://www.emotiv.com/products/epoc-x

…and more if needed!

PADERBORN UNIVERSITY

Thank you for your attention

Questions??

Other Information

PG Language

English

Website:

https://en.cs.uni-paderborn.de/its/teaching

Contact for questions

pac@mail.upb.de

General

https://cs.uni-paderborn.de/en/studies/study-elements/project-groups

PADERBORN UNIVERSITY

Bibliography

All BCI related papers and videos from us:

1. Chaurasia, A.K., Fallahi, M., Strufe, T., Terhörst, P. and Cabarcos, P.A., 2024. NeuroIDBench: An open-source benchmark framework for the standardization of methodology in brainwave-based authentication research. *Journal of Information Security and Applications*, *85*, p.103832.
2. Fallahi, M., Strufe, T., and Arias-Cabarcos P. (2023). "BrainNet: Improving Brainwave-based Biometric Recognition with Siamese Networks". PerCom 2023.
3. Arias Cabarcos, P., et al. (2023). "Performance and Usability Evaluation of Brainwave Authentication Techniques with Consumer Devices." ACM TOPS.
4. Kablo, E., Arias-Cabarcos, P. (2023). "Privacy in the Age of Neurotechnology: Investigating Public Attitudes towards Brain Data Collection and Use", ACM CCS'23.
5. Röse, M., Kablo, E. and Arias-Cabarcos, P., 2023, October. Overcoming theory: Designing brainwave authentication for the real world. In Proceedings of the 2023 European Symposium on Usable Security (pp. 175-191).
6. Fallahi, M., Arias-Cabarcos, P. and Strufe, T., 2024. Beyond Gaze Points: Augmenting Eye Movement with Brainwave Data for Multimodal User Authentication in Extended Reality. arXiv preprint arXiv:2404.18694.

Additional resources:

https://neurotechx.com/primer/

https://github.com/NeuroTechX/awesome-bci