Neurotechnologies

Opportunities, Risks, and Pathways to Responsible Application

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nach Daly & Wolpaw, *Lancet Neurology*, 2008

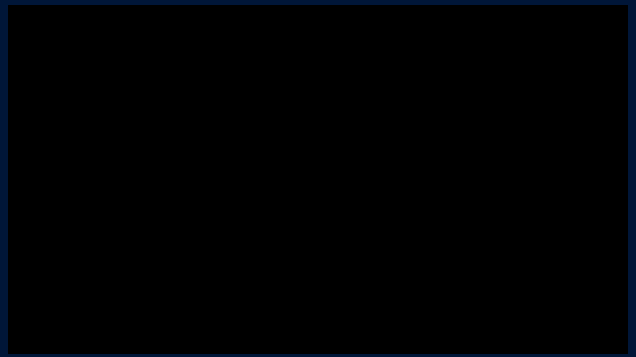
LIEBER-HERR-BIRBAUMER-

HOFFENTLICH-KOMMEN-SIE-MICH-BESUCHEN,-WENN-DIESER-BRIEF-SIE-ERREICHT-HAT-.ICH-DANKE-IHNEN-UND-IHREM-TEAM-UND-BESONDERS-FRAU-KÜBLER-SEHR-HERZLICH,-DENN-SIE-ALLE-HABEN-MICH-ZUM-ABC-SCHÜTZEN-GEMACHT,-DER-OFT-DIE-RICHTIGEN-BUCHSTABEN-TRIFFT.FRAU-KÜBLER-IST-EINE-MOTIVATIONSKÜNSTLERIN.OHNE-SIE-WÄRE-DIESER-BRIEF-NICHT-ZUSTANDE-GEKOMMEN.-ER-MUSS-GEFEIERT-WERDEN.-DAZU-MÖCHTE-ICH-SIE-UND-IHR-TEAM-HERZLICH-EINLADEN-.
EINE-GELEGENHEIT-FINDET-SICH-HOFFENTLICH-BALD.

MIT-BESTEN-GRÜSSEN-
IHR-HANS-PETER-SALZMANN

Birbaumer et al. 1999, *Nature*

John Donoghue Lab, Brown University 2012



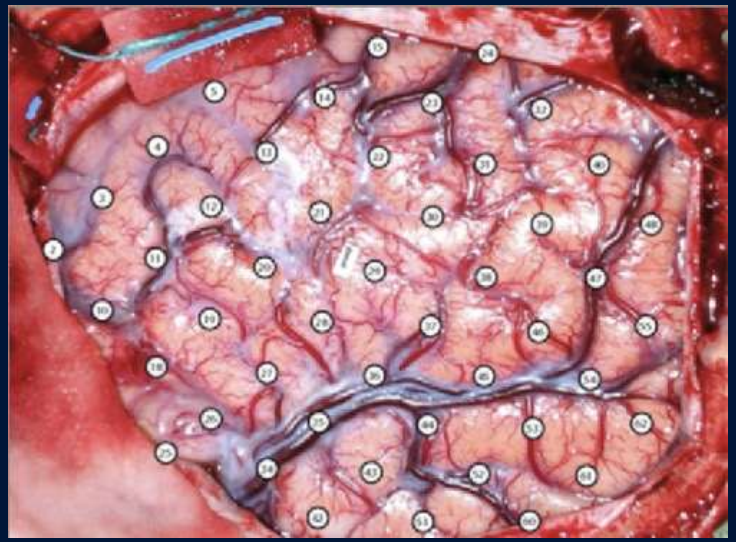
Bolu Ajioboye, Case Western University, 2018

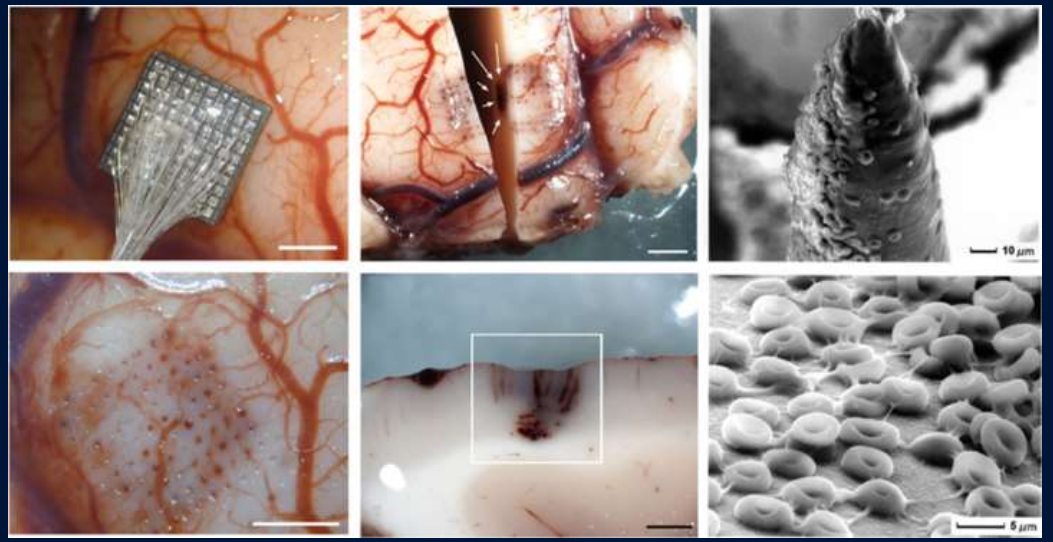
Brock Wester, Johns Hopkins University, 2019

THE LINK

Neuralink Inc.

- Involves risks of infections and bleedings
- Removal or repair requires another surgery
- Does not scale
- Mainly interesting for 24/7 assistive BCIs





Fernández et al. 2014, *Front Neuroeng*; Bublitz, Gilbert & Soekadar 2023, *Nature Medicine*

nature

Abandoned

The human cost of neurotechnology failure

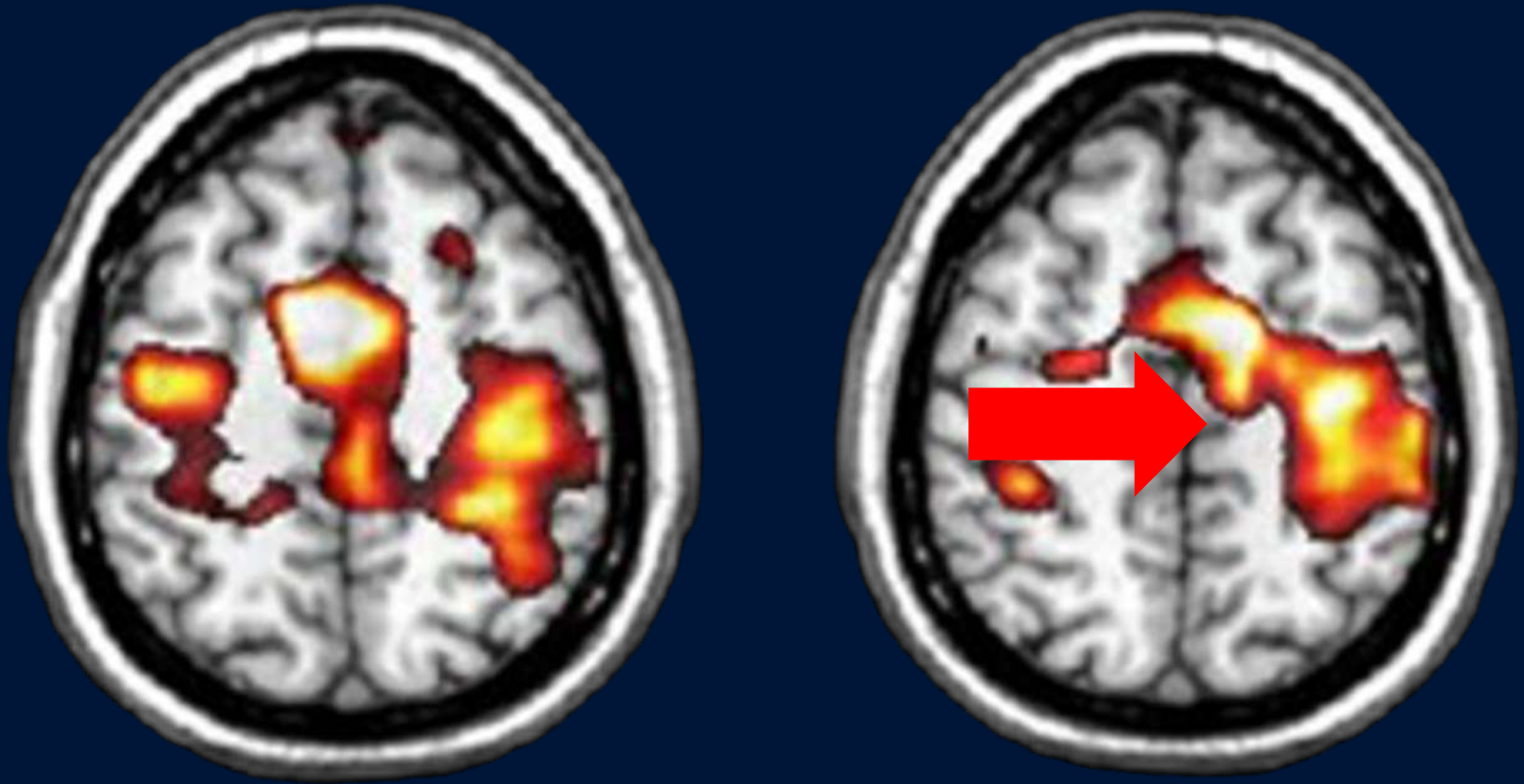
When the makers of electronic implants abandon their projects, people who rely on the devices have everything to lose.

By Liam Drew | 6 December 2022

S. R. Sreekalar et al./Science Robotics, 2016

Science Robotics releases its inaugural issue!

Science | Dec. 6, 2016



BEFORE

AFTER

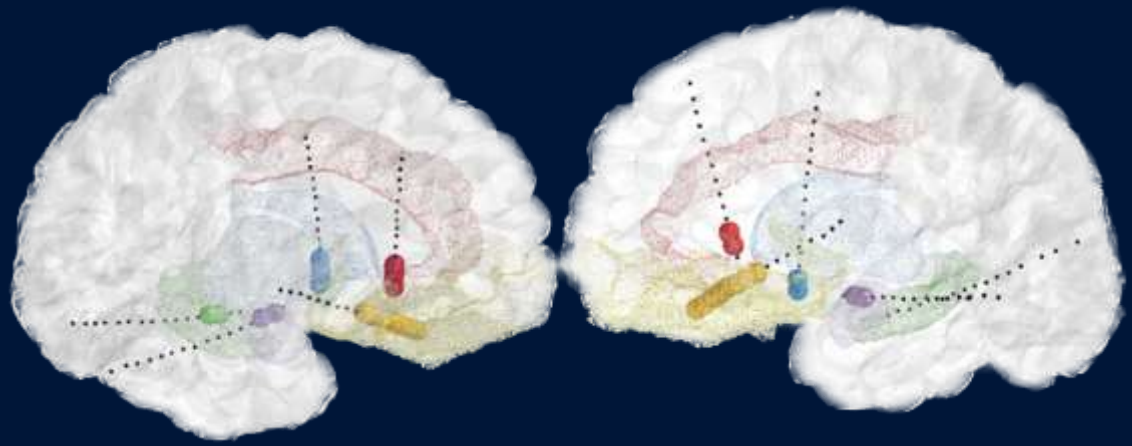
Ramos-Murguialday et al. 2013

Colucci et al. 2025, *Stroke*

Summary I

- Implantable BCIs are relevant for **24/7 assistive systems** in groups that cannot achieve comparable assistance otherwise
- **Repeated use** of brain/neural exoskeletons can lead to **neuroplasticity** triggering neurological recovery
- There's no reason to doubt that such p**lasticity extends beyond the motor domain**; it likely also applies to other brain functions, such as **cognitive control** and **emotion regulation**

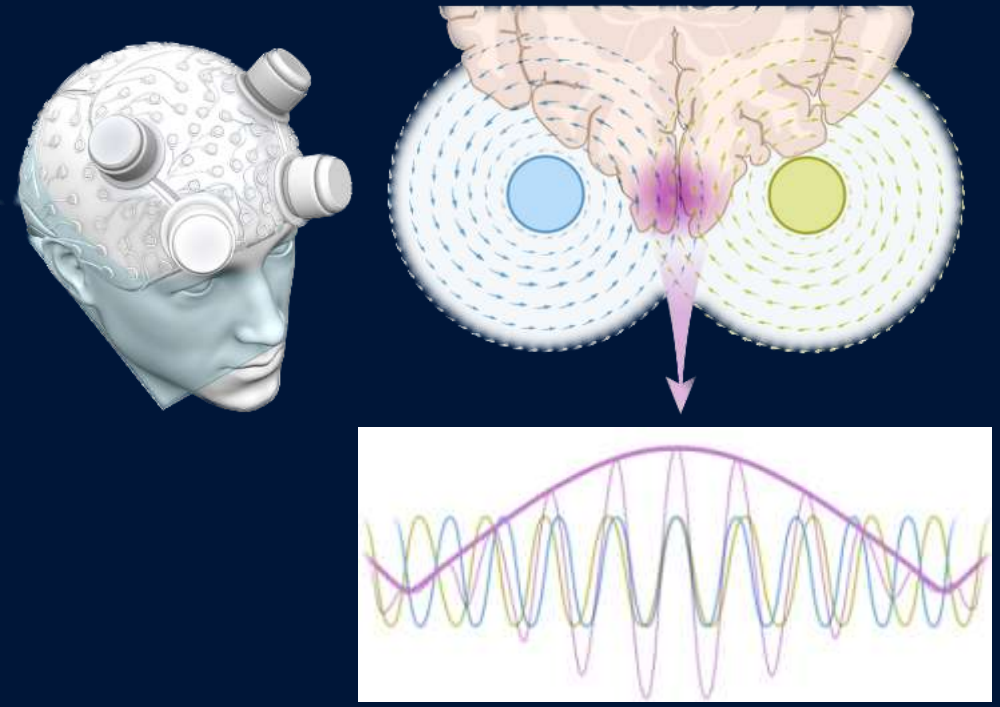
„(…) the emotions and the darkness were overwhelming“



“At first, within a few weeks, the suicidal thoughts just disappeared. Then it was just a gradual process. It was like my lens on the world changed“

Scangos et al. 2021, *Nature Medicine*

Temporal Interference Magnetic Stimulation (TIMS)



- no implantation
- mm-precise modulation of the deep brain
- flexible targeting
- no sensory confound (muscle/nerve stimulation or clicking)

SPARK BIH

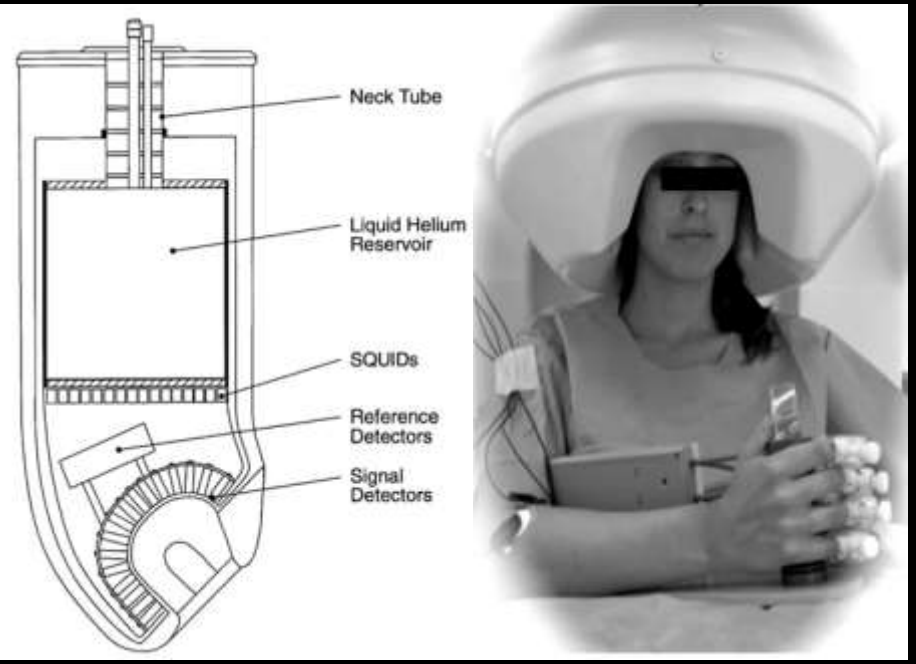
BIH Innovations
The Technology Transfer Office of BIH and Charité

Nasr et al. 2023, *Brain Stim Conf.*

EEG: very limited spatial precision, 5 - 25 Hz

MEG: best noninvasive imaging tool, 0 - 250 Hz

but: helium-cooled, static



Helium-cooled MEG

Soekadar et al. 2015, *Cereb Cortex*

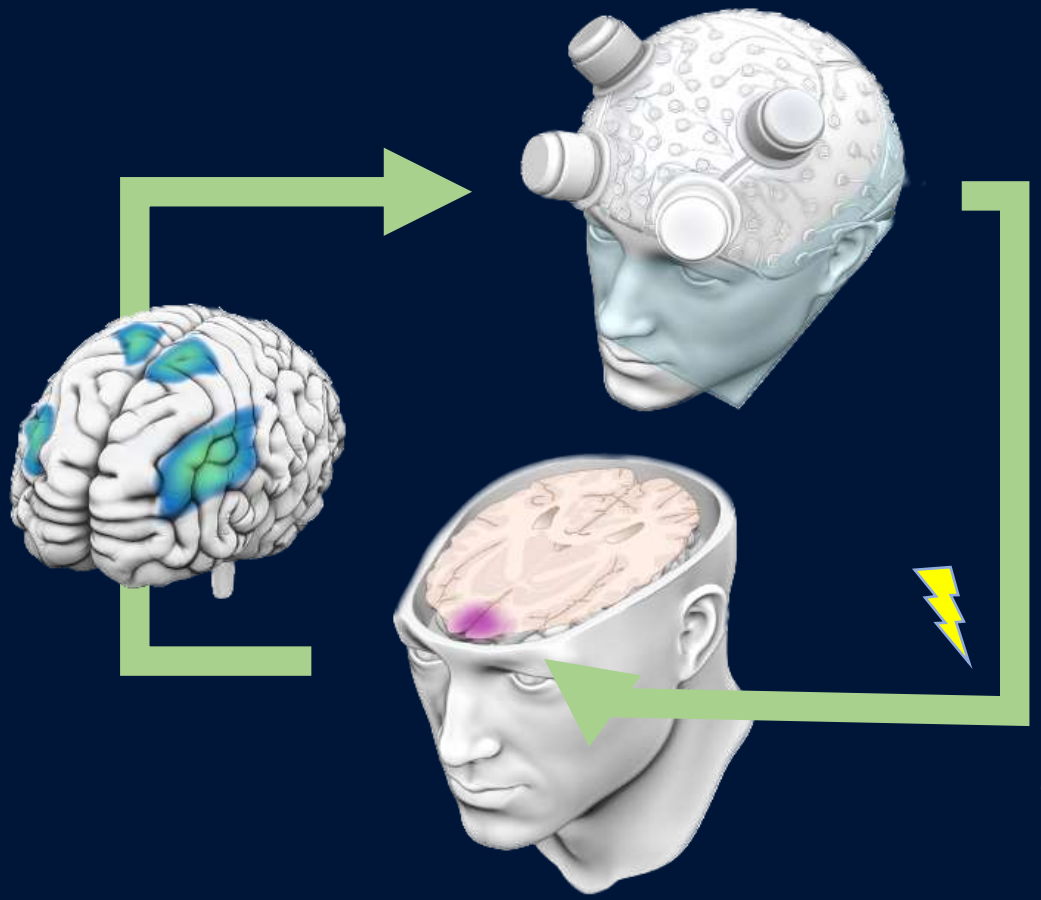
Quantum Sensors

Zerfowski et al. 2021, *ICBEM*

Zerfowski et al. 2022, *BioMag*

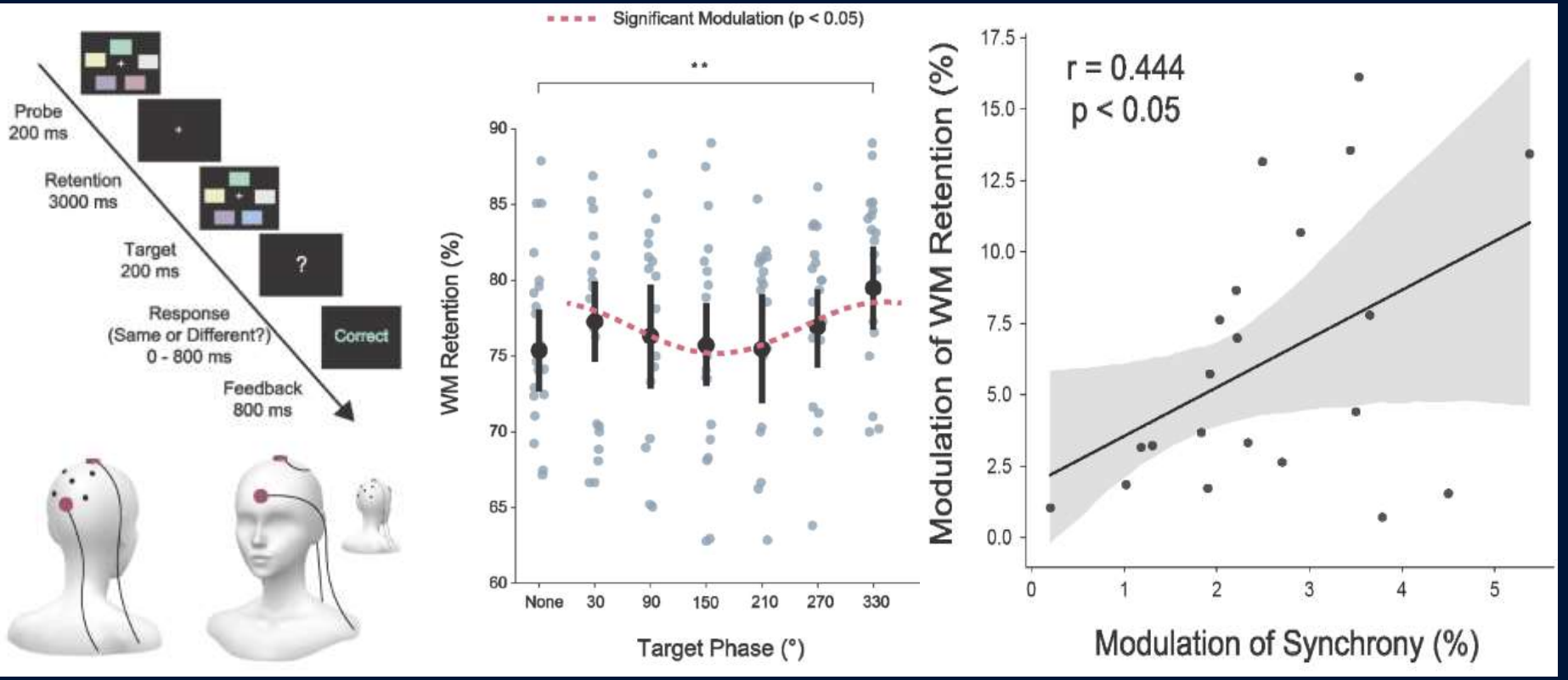
Nasr et al. 2024

Sheng et al. 2022



BNCI²
Consolidator Grant
2025-2030

Closed-loop tACS to enhance working memory function



Haslacher et al. 2024, *Brain Stimulation*

Neuroethics und Neurorights

New Era of Human-Machine Interaction

before: **Human decides, machine/tool follows**

now: Machine/AI decides autonomously, *or*
Human decides, machine finds best solution
(collaborative interaction)

future: **scenario 1: fusion of brain/mind and machine**
(transhumanism, tech extends and sets the limits)

scenario 2: humanistic augmentation
→ *Technology augments human capabilities, but remains a tool at service to the human user*

European NeuroTech Innovation Ecosystems

- **Open Innovation Hub**: Academic-Industrial Partnership & *Clinician Innovators*
- **Regulation:** NeuroTech Sherpas & Simplification
- **Financial Support:** VC-Funds >15 Mio. €
- **Harmonization:** Simplification of reimbursement across health care systems
- **Entrepreneurship:** Education & Support

Summary

- Neurotechnology **improves quality of life** in various conditions (stroke, SCI, ALS etc.)
- For 24/7 assistive and bidirectional BCI technologies, a **Mental Impact Assessment (MIA) is essential**
- The **combination of BCI with neuromodulation and AI** extends applicability towards **mental health**
- NeuroTech innovation ecosystems for **human-centred technological sovereignty**





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