

HESSEN



TECHNOLOGIELAND
HESSEN

HIK2024

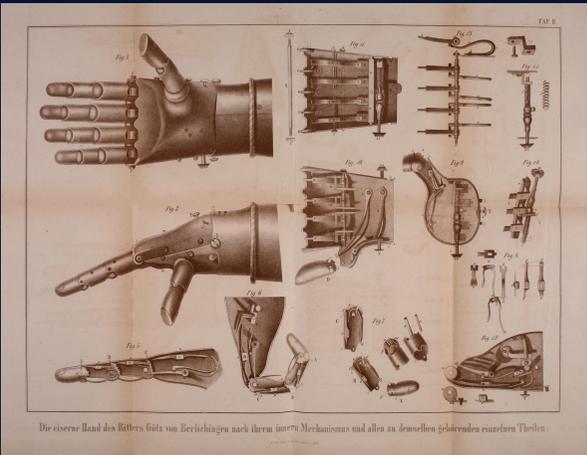
WOHL
STAND
NEU
DENKEN

Hybridmind: Wenn Maschinen mit dem Gehirn verschmelzen

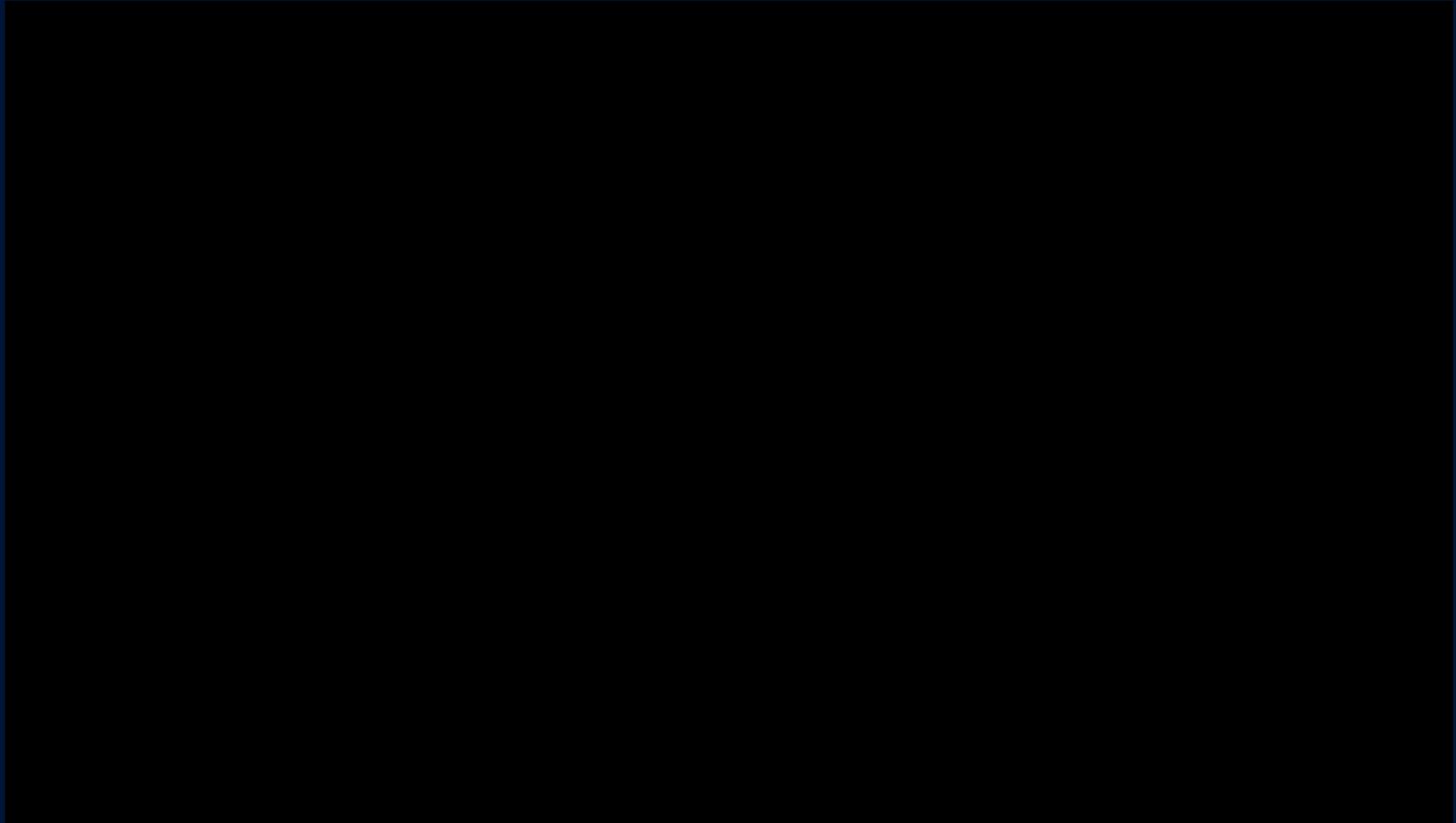
Surjo R. Soekadar



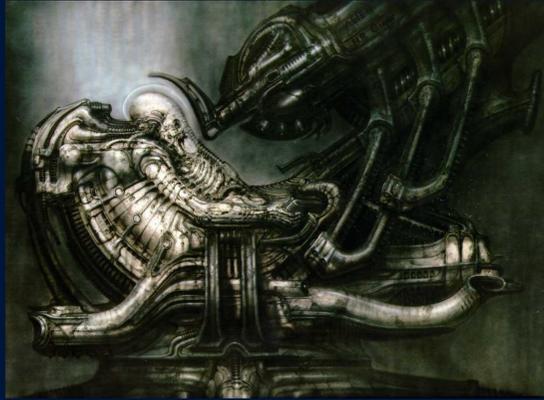
Eiserne Hand, G. v. Berlichingen, 1480-1562



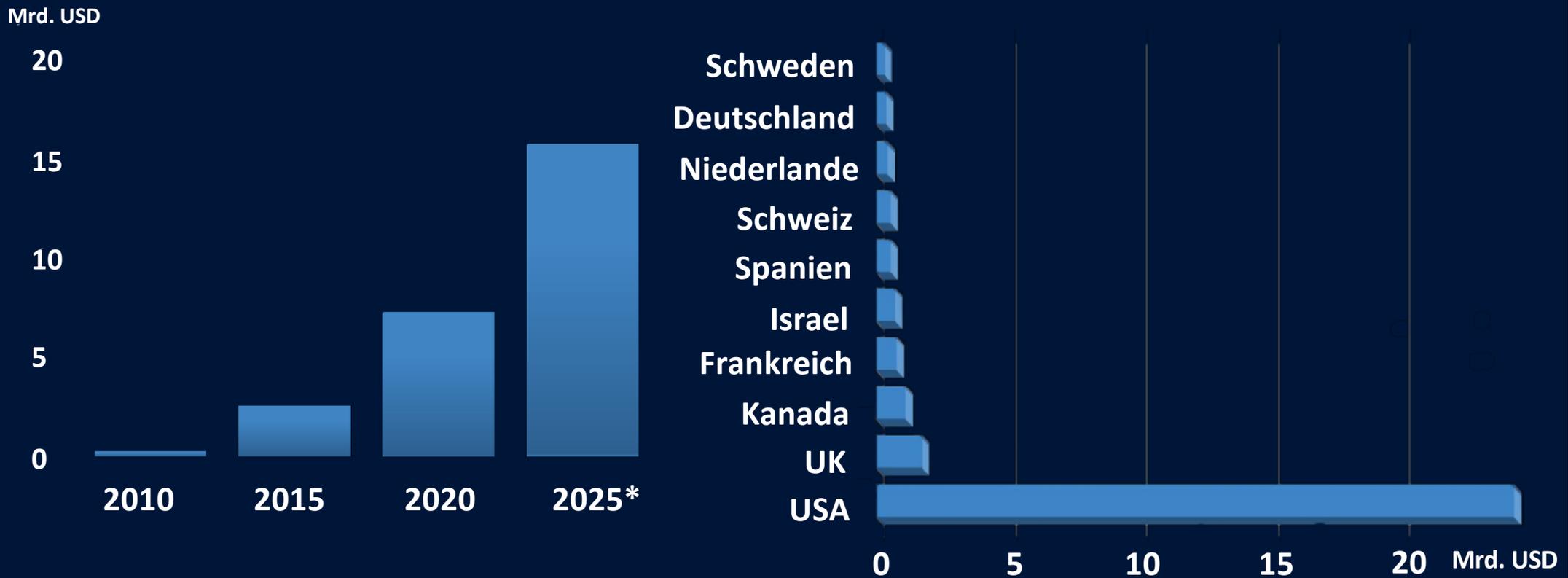
Christian von Mechel, Stahlstich von 1815



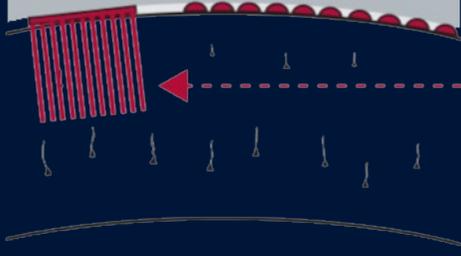
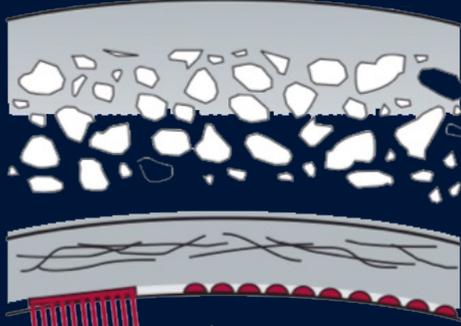
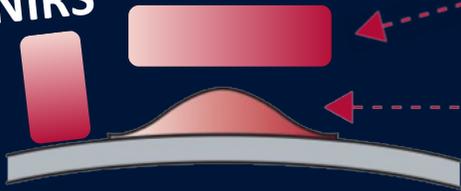
i-Limb Quantum Bionic Hand, Össur



- **500%** mehr Neurotech-Patente in den letzten 12 Jahren
- **2026: Vergrößerung des Marktes +75% auf 17.1 Mrd. USD**



NIRS

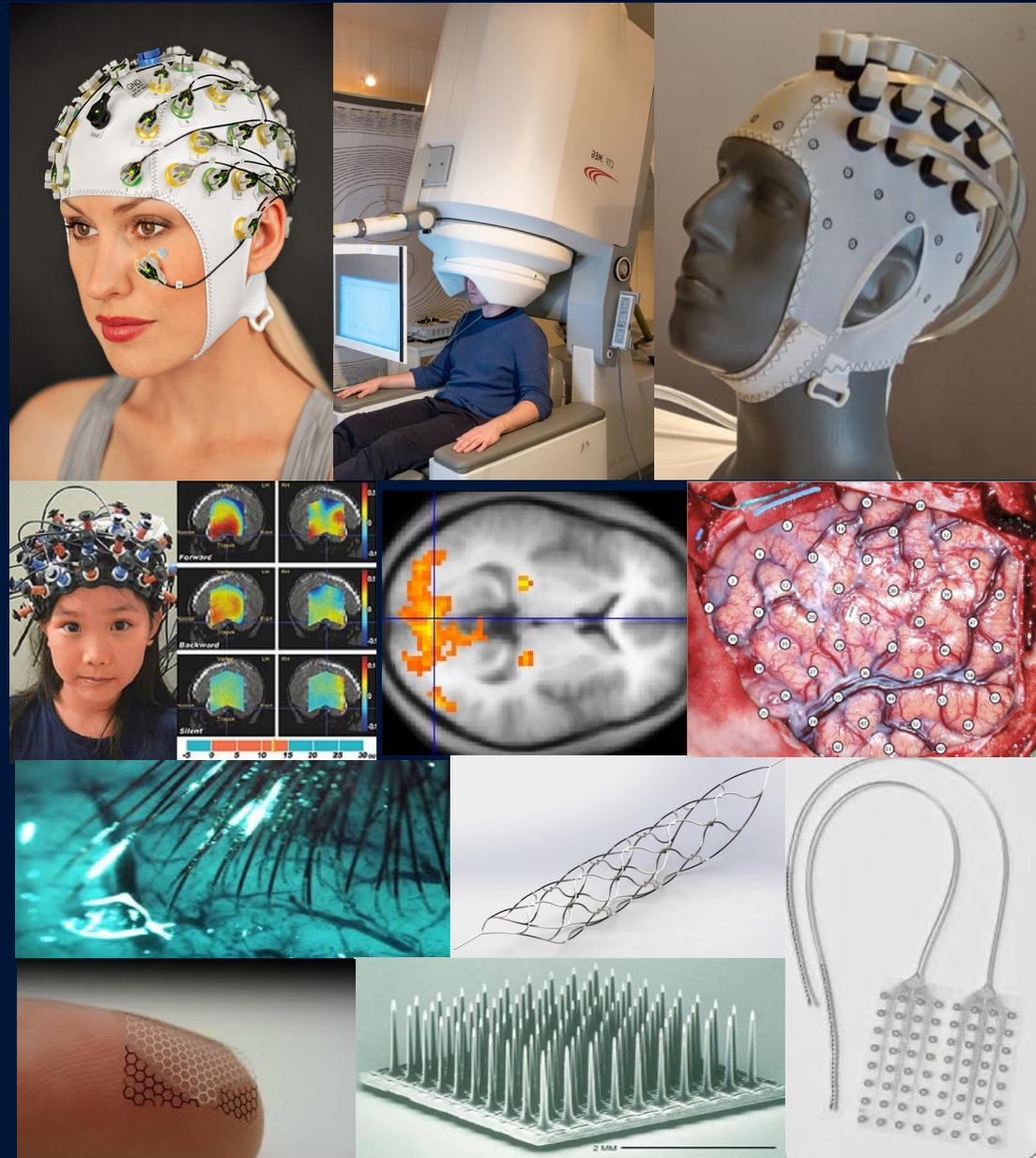


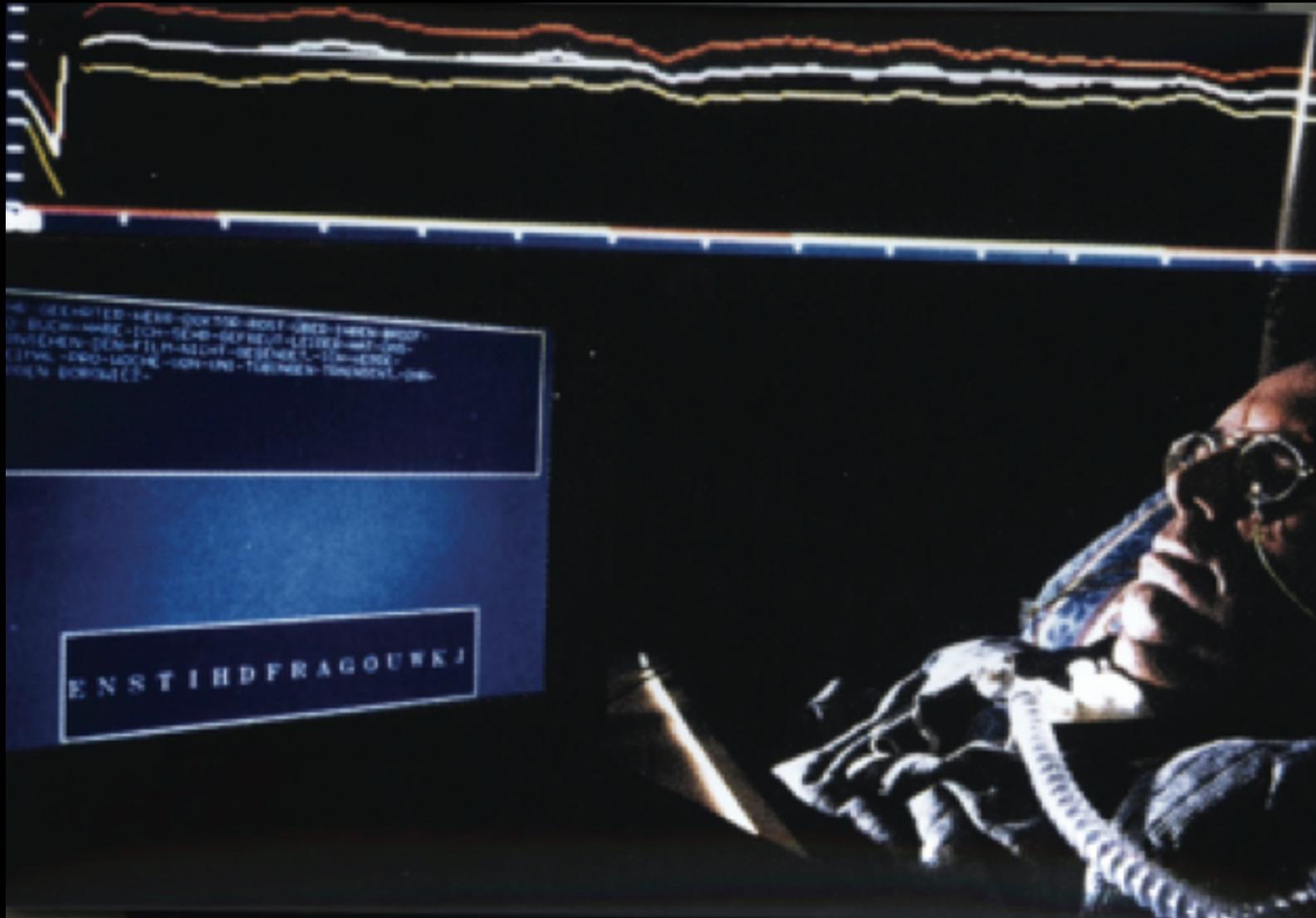
MEG EEG

ECoG

Spikes LFP

nach Daly & Wolpaw, *Lancet Neurology*, 2008

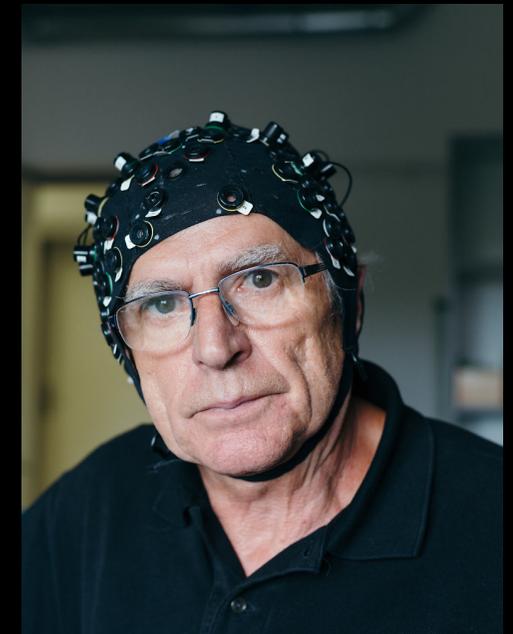




LIEBER-HERR-BIRBAUMER-

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*



Andy Schwartz Lab,
University of Pittsburgh 2008



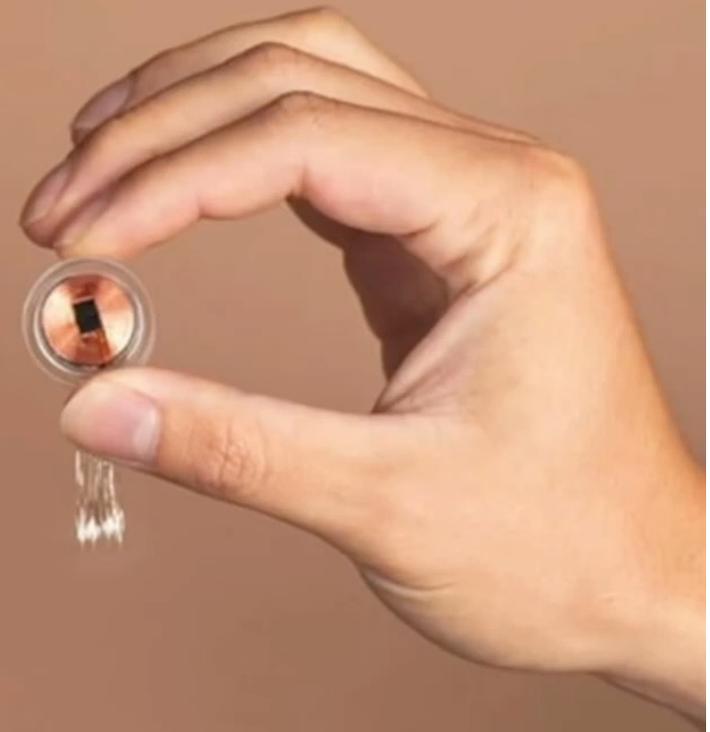
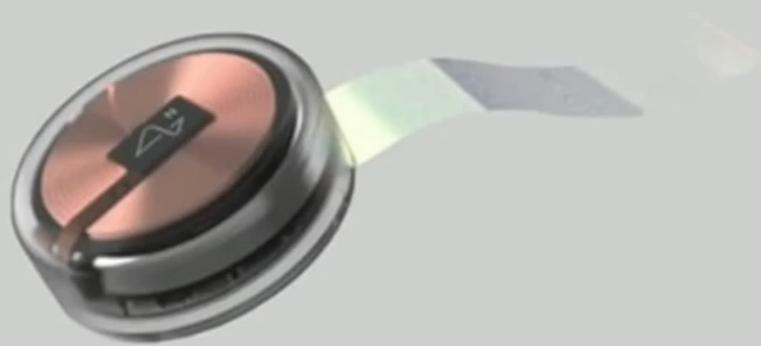
Bolu Ajoboye, Case Western
University, 2018

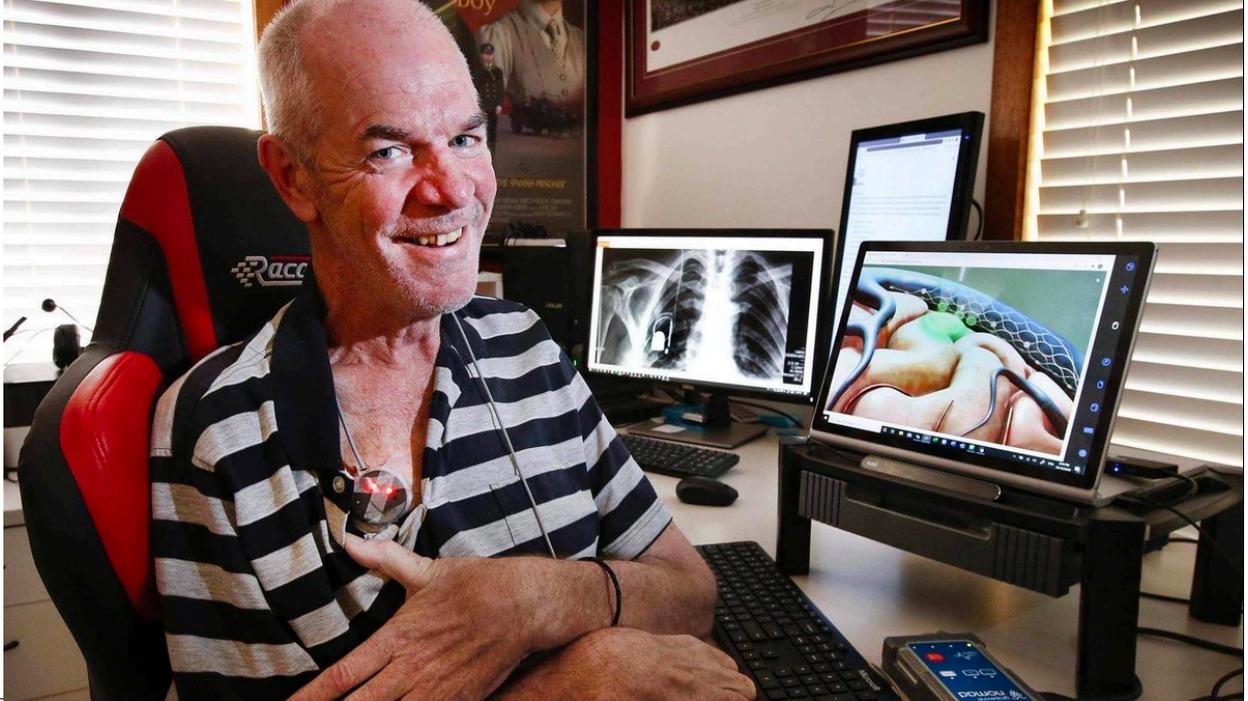
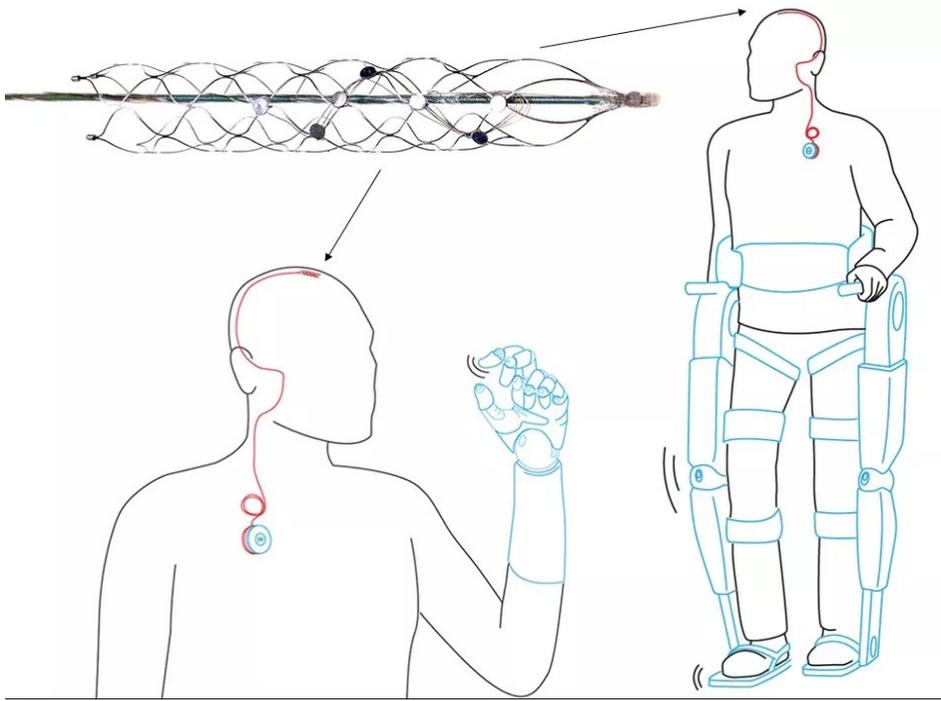
Brock Wester, Johns Hopkins
University, 2019

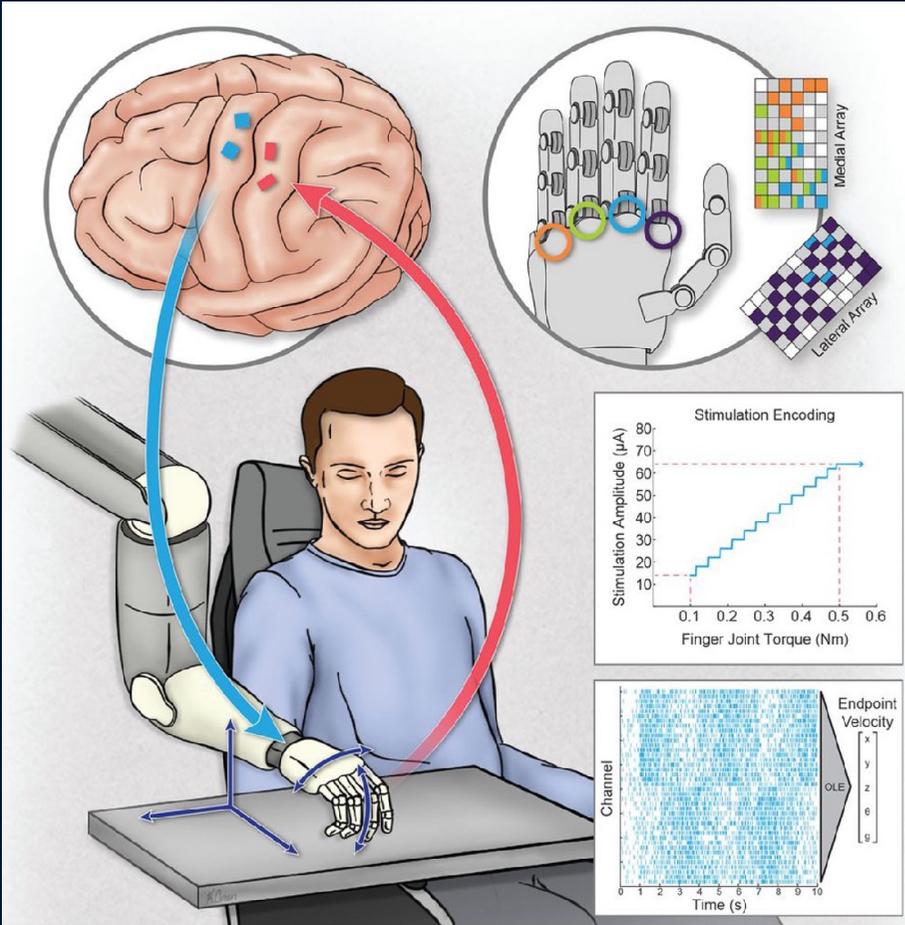


John Donoghue Lab,
Brown University 2012

THE LINK



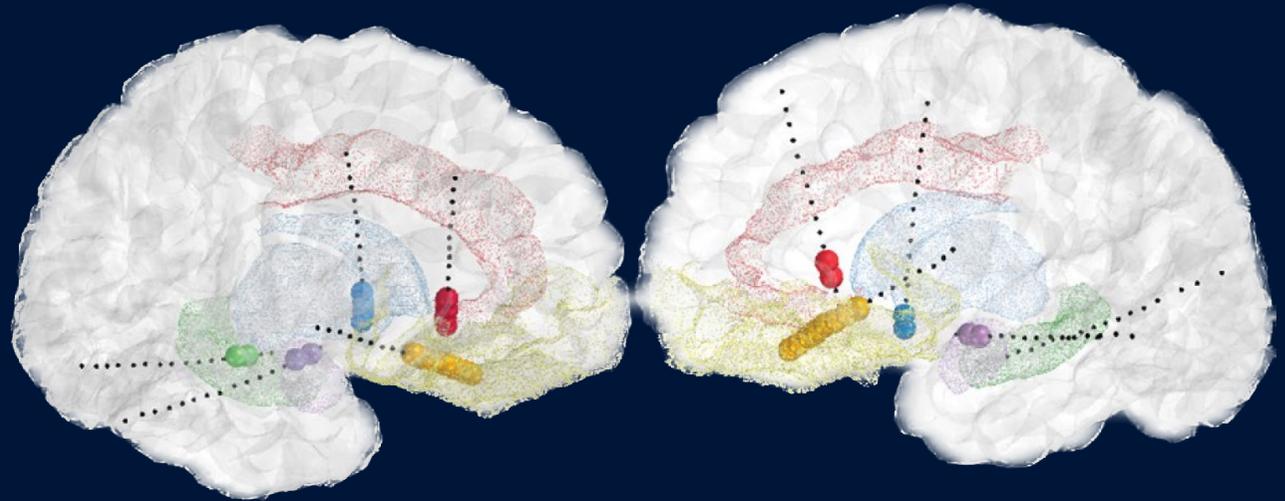




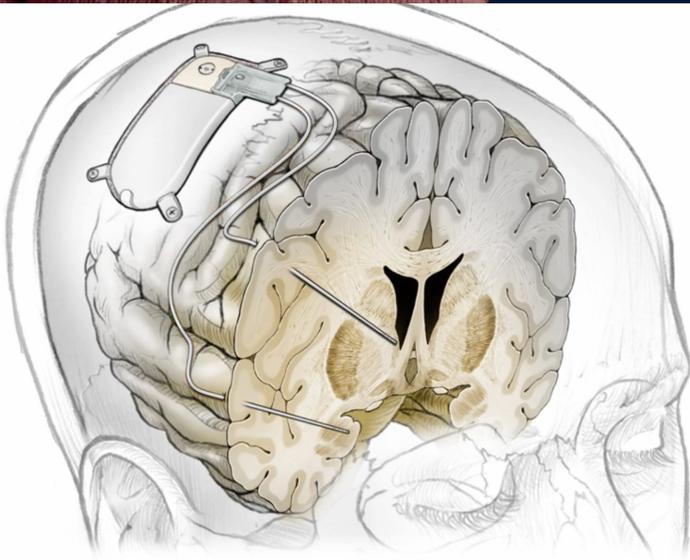
SMALL CYLINDER



**„(...) die Emotionen, die Dunkelheit
waren erdrückend“**



**“Für mich war das Gerät ein
außergewöhnlicher Segen“**

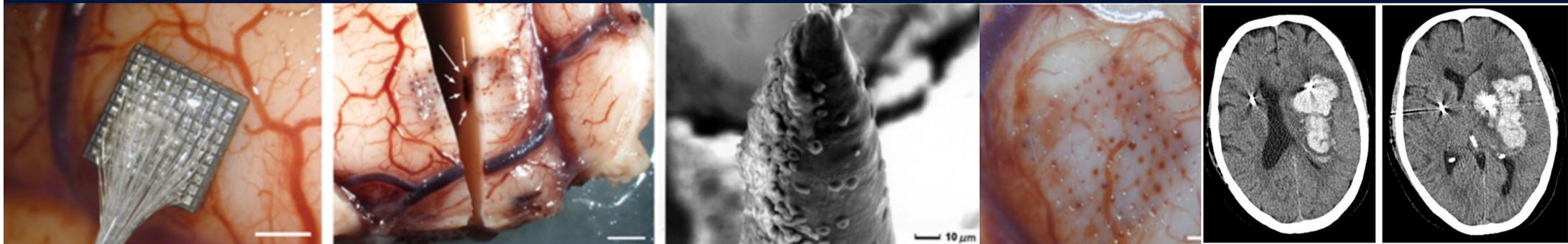


- Risiko von Infektionen und Blutungen
- Reparatur / Entfernung erfordert erneute OP
- Keine realistische Option zur Behandlung psychiatrischer Symptome in der Breite

Motorik / ext. Geräte:

- Keine Zertifizierung für dauerhaften Einsatz
- Kein Einsatz außerhalb des Labors

Bublitz, Gilbert & Soekadar, 2023, *Nature Medicine*
Fernández et al. 2014, *Front Neuroeng.*; Xu et al. 2018, *Interdiscipl. Neurosurgery*

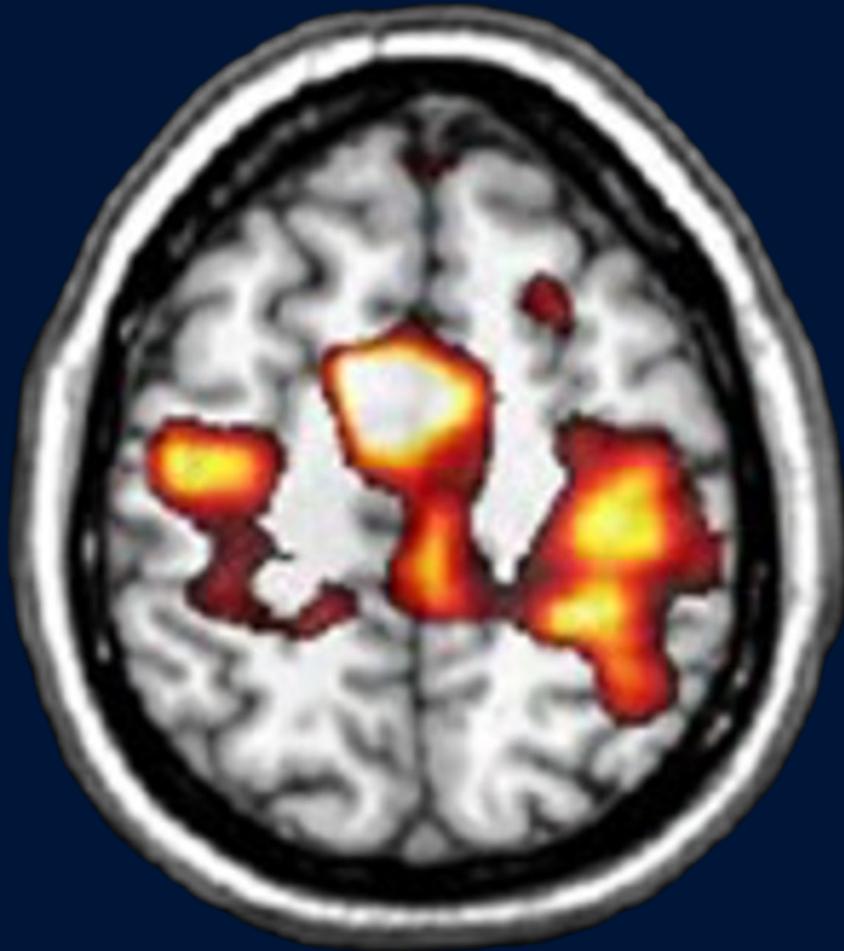




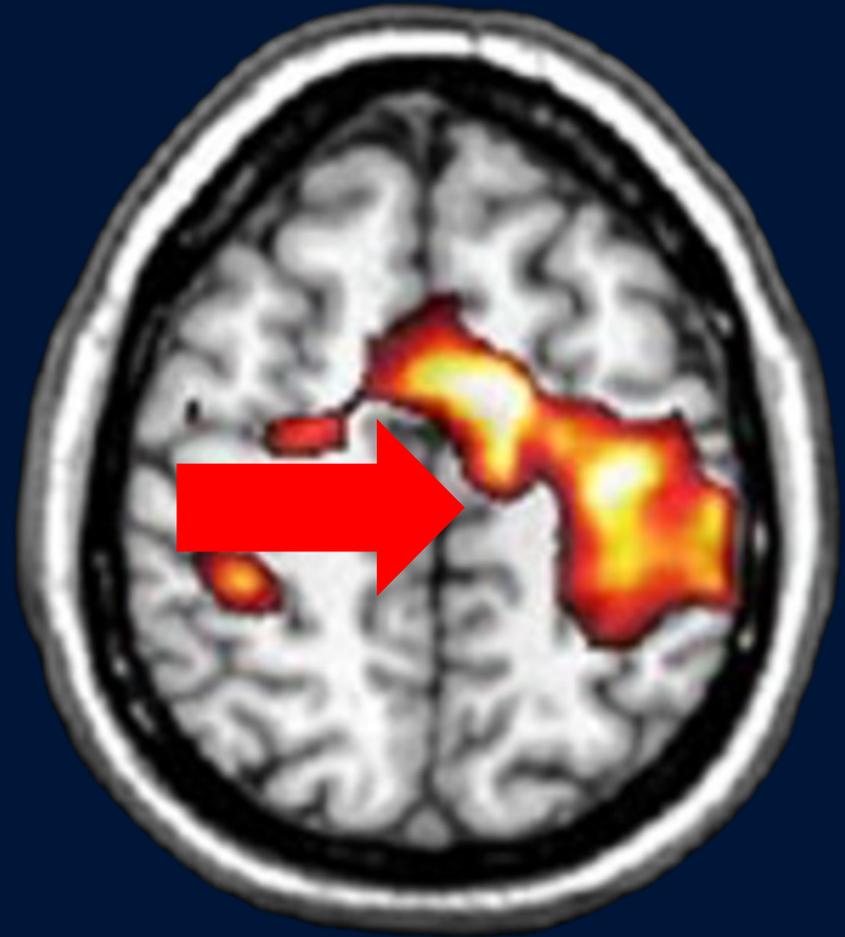
Science Robotics releases its inaugural issue!

Science | Dec. 6, 2016

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



VORHER

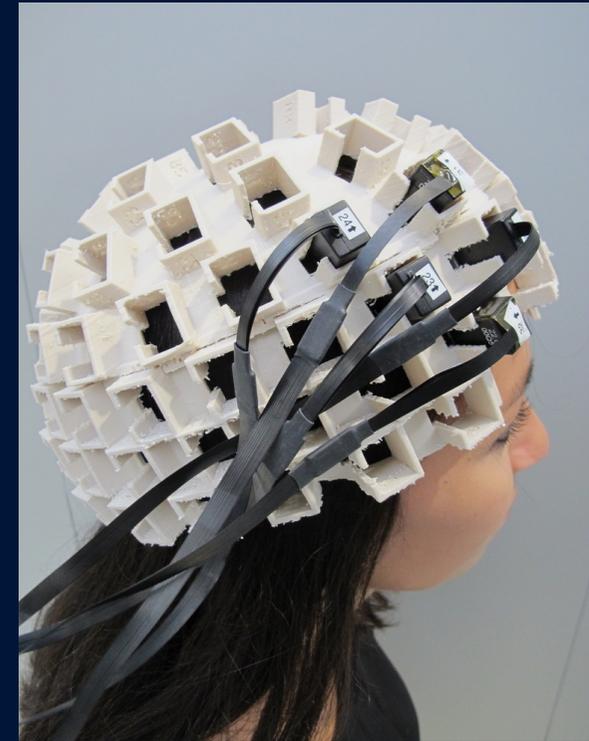
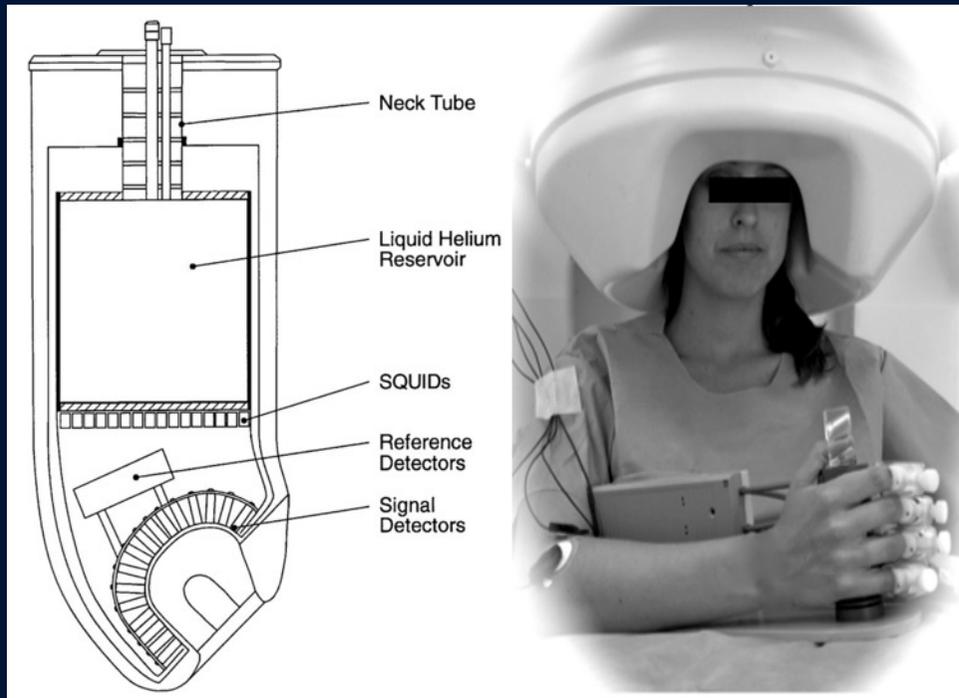


NACHHER

EEG: begrenzte räumliche Auflösung, 5 - 25 Hz

MEG: hohe räumliche Auflösung, 0 - 250 Hz

aber: Helium-Kühlung, statisch



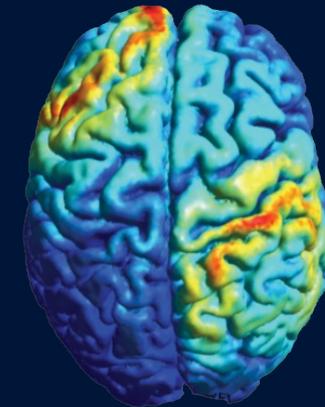
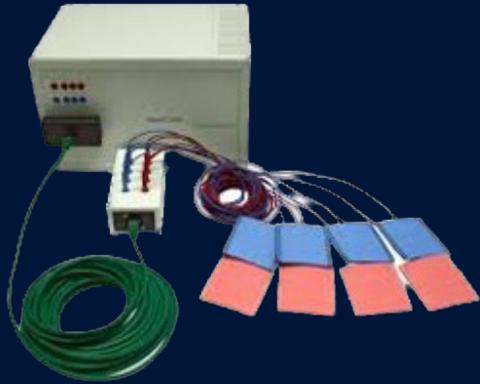
Helium-gekühltes MEG

Soekadar et al. 2015, *Cereb Cortex*

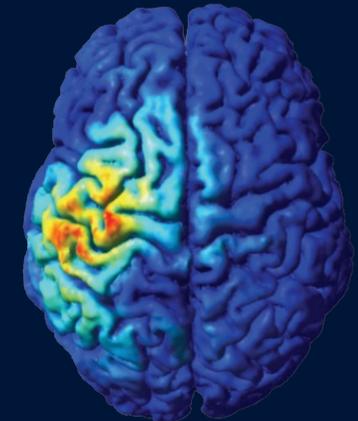
Quantensensoren

Zerfowski et al. 2021, *ICBEM*; Zerfowski et al. 2022, *BioMag*

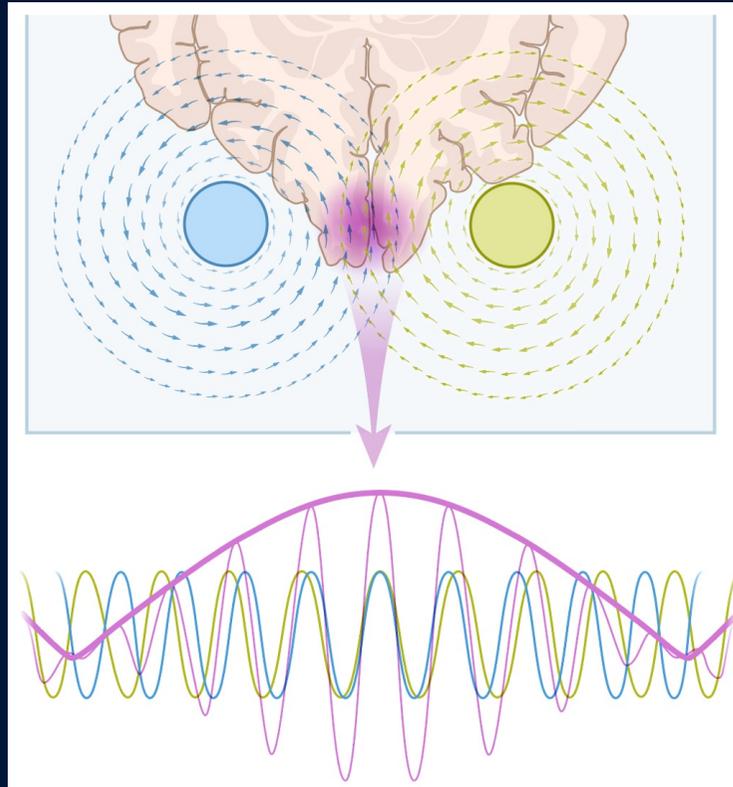
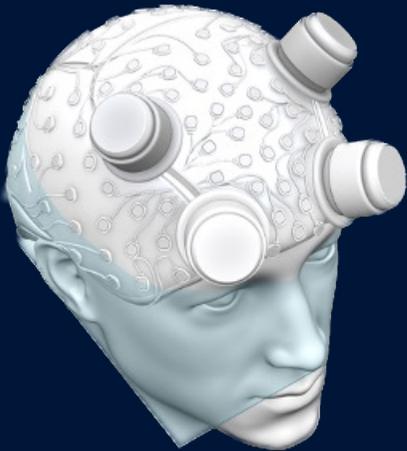
Transkranielle elektrische Stimulation



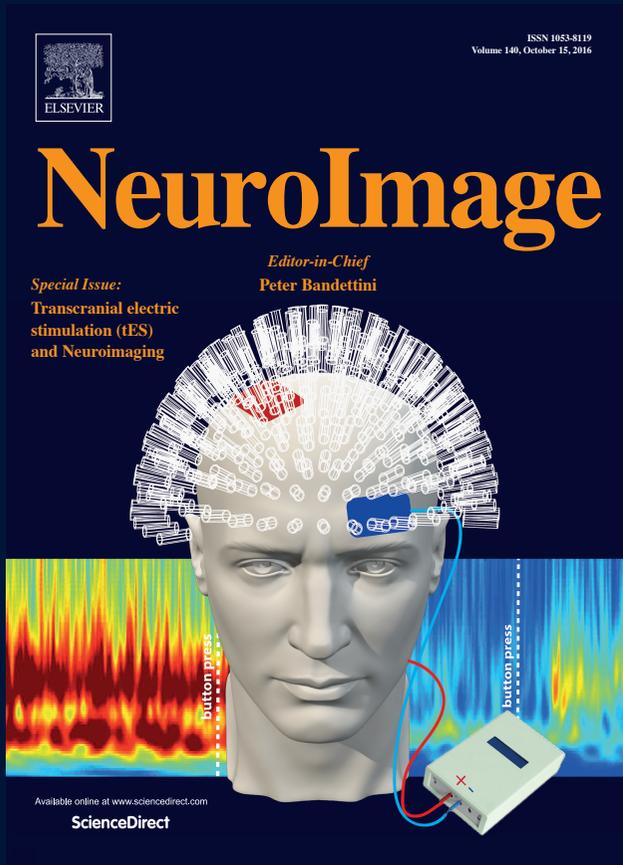
Transkranielle Magnetische Stimulation



Temporale Interferenz Magnet Stimulation (TIMS)

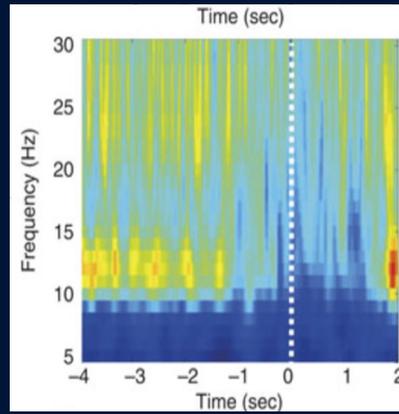


- Keine Implantation
- mm-präzise Modulation tiefer Hirnareale
- flexibles targeting
- Keine sensorische Ko-Stimulation
(Muskel-/Nervenstimulation oder Klick-Geräusche)

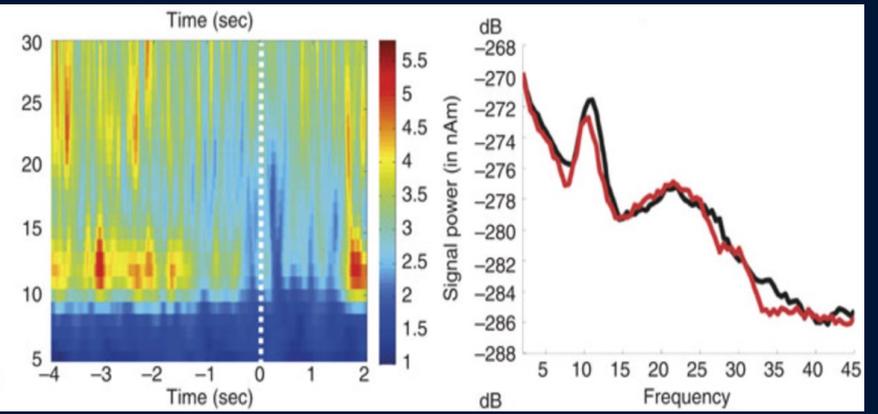


Witkowski et al. 2016, *Neuroimage*
 Haslacher et al. 2021, *Neuroimage*

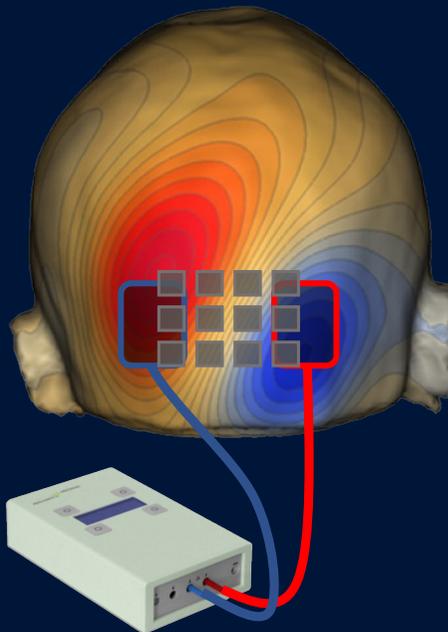
Stimulation AUS



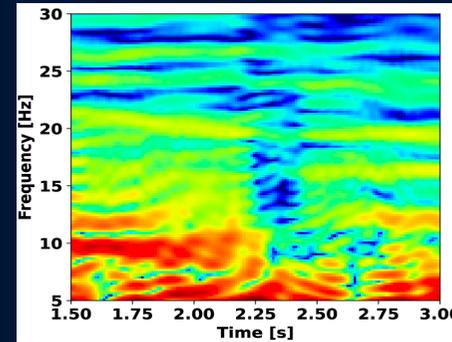
Stimulation EIN



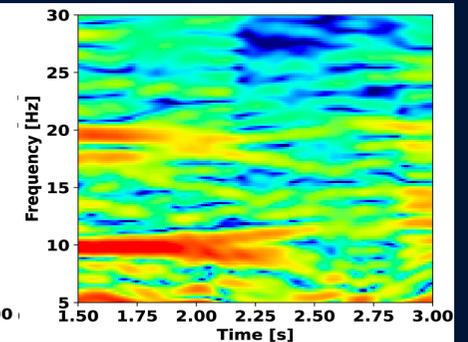
Soekadar et al. 2013, *Nature Communications*



Stimulation Aus



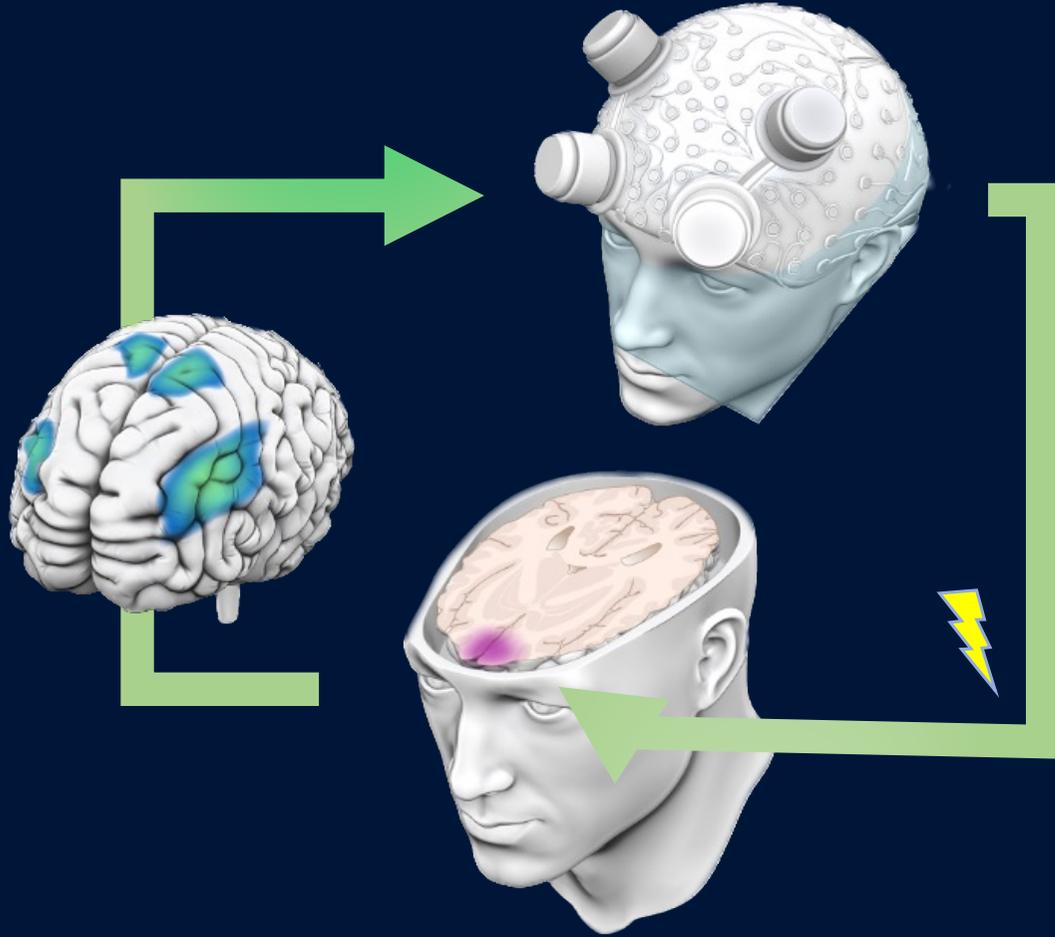
Stimulation AN



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



ERC Consolidator
 BNCI² 2025-2030



BNCI²
Consolidator Grant
2025-2030

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Help, hope, and hype: Ethical dimensions of neuroprosthetics

Accountability, responsibility, privacy, and security are key

APPLIED NEUROTECHNOLOGY LABORATORY

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BRAIN-MACHINE INTERFACES

Help, hope and hype: ethical dimensions of neuroprosthetics

Accountability, responsibility, privacy, and security are key.

By Jens Clausen¹, Eberhard Fetz², John Donoghue³, Junichi Ushiba⁴, Ulrike Spörhase⁵, Jennifer Chandler⁶, Niels Birbaumer^{6*}, Surjo R. Soekadar⁷

Brain-controlled prosthetic robots that restore independent activities of daily living to paralyzed people are about to enter everyday life environments (1). The regained ability to grasp a cup of coffee, hand over a credit card or sign a document with a pen (1) enhances the independence and self-determination of severely paralyzed individuals. However, introducing devices controlled via brain-machine interfaces (BMIs) into everyday environments, possibly

less interactions between mind and machine seem intuitively appealing, creating direct links between a digital machine and our brain may dangerously limit or suspend our capacity to control the interaction between the “inner” personal and outer worlds. For many, such a scenario raises fundamental, even existential fears, including the fear of losing privacy and autonomy, and the basic fear of self-dissolution (as depicted in science fiction movies such as “Star



out and processing could enable more in-depth “mind-reading”, i.e., classification of brain states related to specific perceptions, thoughts, emotions or intentions.

RESPONSIBILITY, ACCOUNTABILITY

In some sense BMI-controlled devices might be seen as just another tool (10,11). However, the inclusion of more and more autonomous components into the tools (12) transforms their

MORALS + MACHINES
INTERDISCIPLINARY GLOBAL CRITICAL

HYBRIDITY

Surjo Soekadar, Jennifer Chandler, Atanuelo Ienca & Christoph Bublitz
On the Verge of the Hybrid Mind

Valentin Jeutner
The Quantum Imperative: Addressing the Legal Dimension of Quantum Computers

Shohini Ghose
Beyond the Binary: Building a Quantum Future

Sofia Ranchordas
Experimental Regulations for AI: Sandboxes for Morals and Mores

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ETHICAL ISSUES OF NEUROTECHNOLOGY

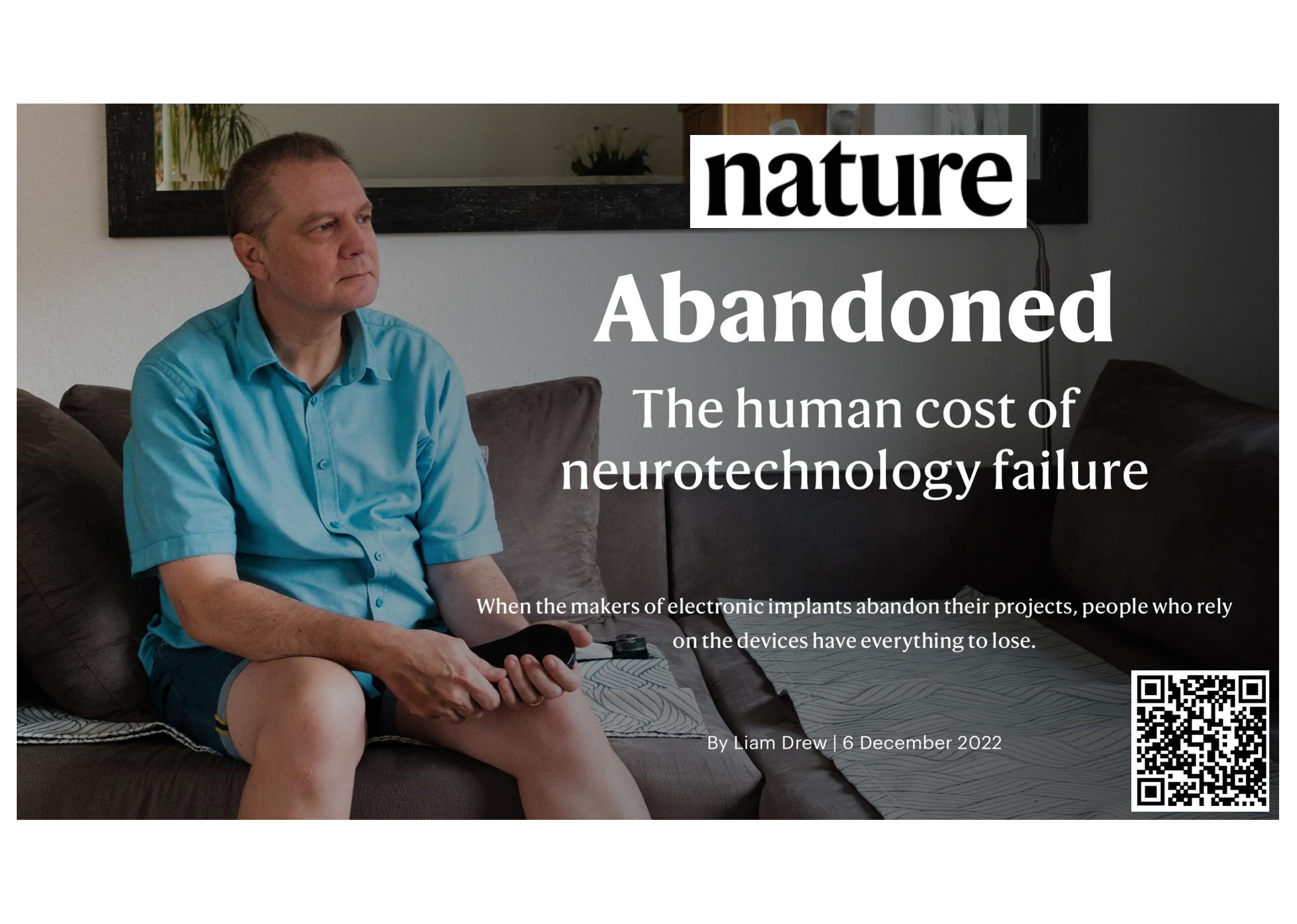
REPORT - Adopted in December 2021

IBC International Bioethics Commission of UNESCO

Hybrid Mind Conference
Geneva
16-18 October 2024

OECD
RECOMMENDATION ON RESPONSIBLE INNOVATION IN NEUROTECHNOLOGY

BETTER POLICIES FOR BETTER LIVES

A man with short hair, wearing a light blue short-sleeved button-down shirt and dark shorts, is sitting on a brown leather couch. He is looking off to the side with a thoughtful or concerned expression. The background shows a living room with a framed picture on the wall and some indoor plants.

nature

Abandoned

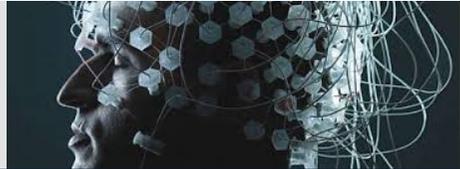
The human cost of neurotechnology failure

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



- **Neurotechnologie in der Medizin: Verbesserung von Lebensqualität**
- **Regelmäßige BCI-Nutzung: Anregung von Neuroplastizität und Wiederherstellung von Hirnfunktionen**
- **Invasive Methoden: kurzfristig effektiver, aber riskant**
- **Nicht-invasive Methoden: perspektivisch massentauglich**
- **Neuroethische Aspekte: UN-Charta: Recht auf BCIs, aber: langfristiger Effekt unklar. OECD/UNESCO Empfehlungen**



Deutsche Forschungsgemeinschaft

BERLIN INSTITUTE OF HEALTH
Charité & Max Delbrück Center



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