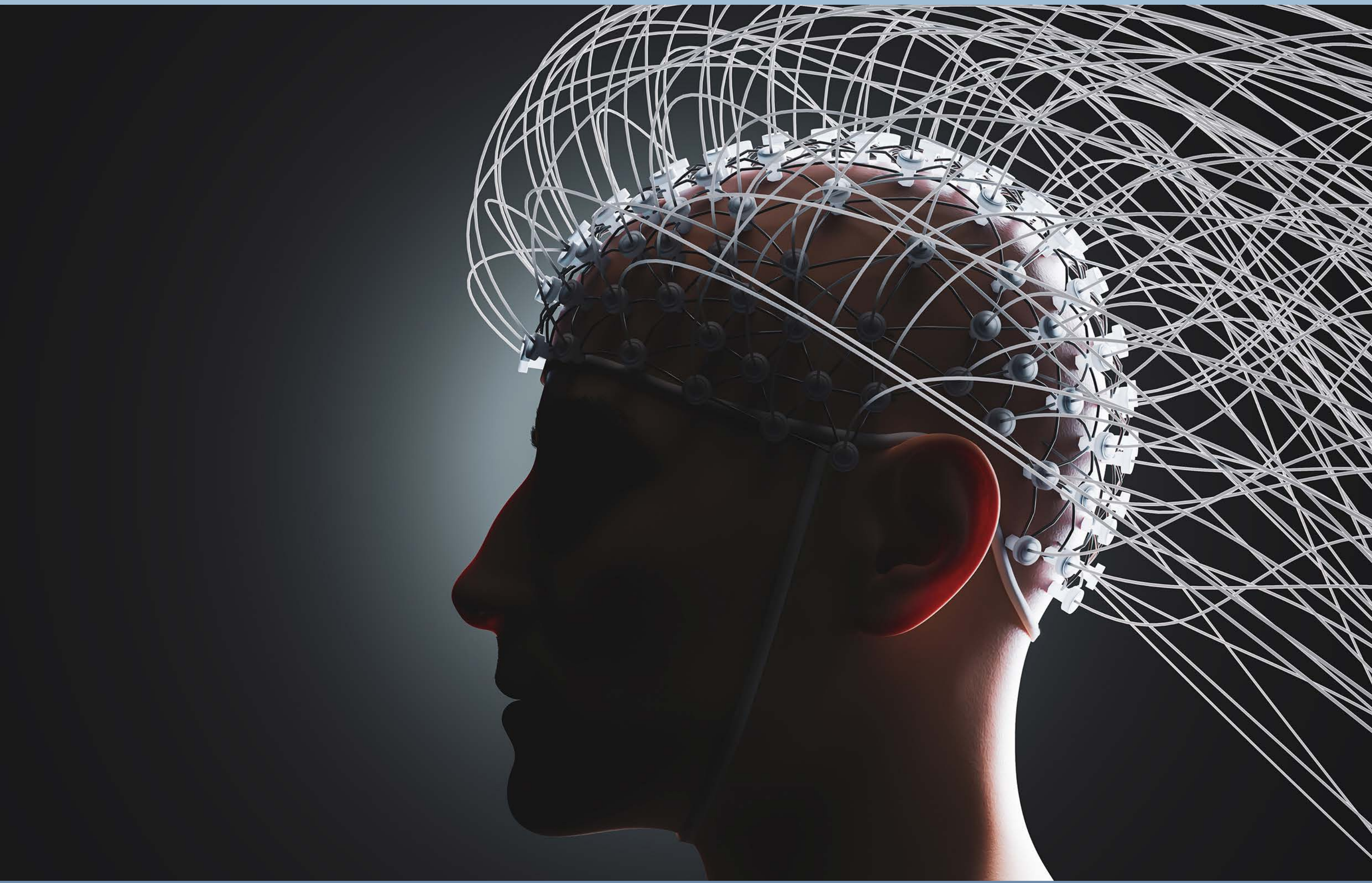
Deutscher Ethikrat



ÖFFENTLICHE ANHÖRUNG

Neue Neurotechnologien – Entwicklungen und Trends

Donnerstag, 18. September 2025, 13:30 – 18:00 Uhr
Online im Livestream

#Neurotech

Inhalt

Allgemeine Hinweise

Die Veranstaltung findet auf Englisch statt und wird unter **Ethikrat LIVE*** gestreamt – wahlweise auch mit deutscher Simultanübersetzung. Eine Anmeldung ist nicht nötig.

Im Nachgang werden ein **Videomitschnitt** und ein **Transkript** online zur Verfügung gestellt.

*** QR-Code und Weblink finden Sie auf der letzten Seite.**

Zum Thema

Neurotechnologien entwickeln sich aktuell mithilfe von KI und modernem Gerätedesign rasant weiter. Es entstehen neue und vielseitigere Einsatzmöglichkeiten, auch im Alltag, Berufsleben oder in der Freizeit. Das Spektrum reicht von Headsets zur Förderung von Konzentration oder Wohlbefinden über Prothesen und Exoskelette bis hin zu Hirnimplantaten, die Gedanken in Bewegung oder Sprache übersetzen.

Der Deutsche Ethikrat untersucht derzeit die ethischen Fragen, die mit diesen Entwicklungen verbunden sind. In dieser Anhörung will er sich zunächst einen Überblick verschaffen: Welche Innovationen prägen die Forschung? Welche Ziele verfolgen Wissenschaft und Industrie – und welche Erwartungen sind realistisch?

Mit Sachverständigen aus Deutschland, England und den USA diskutiert der Ethikrat folgende Fragen:

- Welche Neurotechnologien könnten bald im Alltag ankommen – etwa in der Bildung, Arbeitswelt oder Freizeit?
- Können Neurotechnologien Gedanken lesen – oder sogar beeinflussen?
- Welche Möglichkeiten gibt es, mithilfe von Neurotechnologien Emotionen, Aufmerksamkeit oder psychische Zustände zu erfassen – und vielleicht auch zu steuern?
- Welche künftigen Einsatzmöglichkeiten sind für neurotechnologisch gestützte Exoskelette und andere Formen körperlicher Unterstützung oder Erweiterung denkbar?
- Welche ethischen Herausforderungen sehen die Sachverständigen in ihrem jeweiligen Forschungsfeld?

Programm

13:30 **Welcoming address**
Helmut Frister · Chair of the German Ethics Council

13:35 **Introduction**
Aldo Faisal · German Ethics Council

I. NEUROBIOLOGICAL FOUNDATIONS AND NON-INVASIVE APPROACHES

13:40 **What does neurotechnology do to the brain? Neurobiological foundations of plasticity**
Tamar Makin · University of Cambridge

14:10 **Neurotechnologies – opportunities, risks and pathways to responsible application**
Surjo Soekadar · Charité – Universitätsmedizin Berlin

14:40 **A window into the brain – how can neurotechnology measure and influence attention and emotions?**
Daniel Strauss · Saarland University

15:10 **Neurotech for everyone? Potential applications of AI-supported neurotechnologies to improve cognitive functions**
Nataliya Kosmyna · Massachusetts Institute of Technology

15:40 Coffee break

16:00 **Joint discussion**

II. NEURAL IMPLANTS

16:45 **Do not implant! Risks and long-term consequences of neural implants** (video input)
Ulrich G. Hofmann · University of Freiburg

17:00 **Brain implants for speech restoration**
Frank Willett · Stanford University

17:30 **Joint discussion**

17:55 **Closing remarks**
Helmut Frister · Chair of the German Ethics Council

18:00 End

Tamar Makin
University of Cambridge

Short biography

Tamar Makin is Professor of Cognitive Neuroscience at the MRC Cognition and Brain Sciences Unit, University of Cambridge, where she leads the Plasticity Lab. Her research investigates how body representation changes in the brain (plasticity), focusing on hand function and dysfunction, and how technology can enhance functionality in both able-bodied and disabled individuals at all ages. She established her programme at Oxford (Research Fellow 2009, PI 2014), became Professor at University College London in 2019, and moved to Cambridge in 2022. She has been supported by the European Research Council (Starting and Consolidator Grants, now UKRI), the Wellcome Trust (Henry Dale and Senior Research Fellow), the Engineering and Physical Sciences Research Council, and the MRC Cognition and Brain Sciences Unit.

Selected publications

- Schone, H. R.; Maimon-Mor, R. O.; Kollamkulam, M.; Gerrand, C.; Woollard, A.; Kang, N. V.; Baker, C. I.; Makin, T. R. (2025): Stable cortical body maps before and after arm amputation. *Nature Neuroscience*. DOI: 10.1038/s41593-025-02037-7.
- Güemes, A.; da Silva Costa, T.; Makin, T. R. (2025): Foundational guidelines for enhancing neurotechnology research and development through end-user involvement. *Journal of Neural Engineering*, 22: 012001. DOI: 10.1088/1741-2552/adac0d.
- Nisky, I.; Makin T. R. (2024): A neurocognitive pathway for engineering artificial touch. *Science Advances*, 10: eadq6290. DOI: 10.1126/sciadv.adq6290.
- Clode, D.; Dowdall, L.; da Silva, E.; Selén, K.; Cowie, D.; Dominijanni, G.; Makin, T. R. (2024): Evaluating initial usability of a hand augmentation device across a large and diverse sample. *Science Robotics*, 9: eadk5183. DOI: 10.1126/scirobotics.adk5183.
- Makin, T. R.; Micera, S.; Miller, L. E. (2023): Neurocognitive and motor-control challenges for the realization of bionic augmentation. *Nature Biomedical Engineering*, 7 (4), 344–348. DOI: 10.1038/s41551-022-00930-1.

What does neurotechnology do to the brain? Neurobiological foundations of plasticity

Brain plasticity describes the brain's remarkable ability to adapt in response to experience and interaction. This adaptive capacity is not only central to recovery after injury but also underpins how humans integrate novel technologies. My research shows that non-invasive interfaces, such as wearable robotic devices, can reshape how the brain represents both the body and the technology itself, revealing how seamlessly tools can be incorporated into our neural circuitry. These findings highlight that "invasiveness" should not be understood merely in terms of whether a device penetrates the skull, but in terms of how it reshapes daily life and self-experience. From brain–computer interfaces to wearable augmentation, the success of neurotechnology depends on recognising plasticity as a shared substrate for medical and non-medical applications, and on aligning design with what matters most to users: functionality, comfort, privacy and agency.

Surjo Soekadar
Charité – Universitätsmedizin Berlin

Short biography

Surjo R. Soekadar, MD, is Einstein Professor of Clinical Neurotechnology at Charité – Universitätsmedizin Berlin and Head of the Center for Neuromodulation. He studied medicine in Mainz, Heidelberg, and Baltimore, and trained at the National Institute of Neurological Disorders and Stroke (NINDS, NIH, USA) before transitioning back to the University of Tübingen in Germany. In 2018, he was appointed to the Charité as Germany's first Professor of Clinical Neurotechnology, supported by the Einstein Foundation Berlin. His research focuses on cortical plasticity, brain-computer interfaces (BCI), non-invasive brain stimulation, and mechanisms of learning and memory. He has received major awards including the International BCI Research Award, the BIOMAG and NARSAD Young Investigator Awards, and three European Research Council grants.

Selected publications

- Bublitz, C.; Molnár-Gábor, F.; Soekadar, S. R. (2024): Implications of the novel EU AI Act for neurotechnologies. In: *Neuron*, 112 (18), 3013–3016, DOI: 10.1016/j.neuron.2024.08.011.
- Haslacher, D.; Cavallo, A.; Reber, P.; Kattein, A.; Thiele, M.; Nasr, K.; Hashemi, K.; Sokoliuk, R.; Thut, G.; Soekadar, S. R. (2024): Working memory enhancement using real-time phase-tuned transcranial alternating current stimulation. In: *Brain Stimulation*, 17 (4), 850–859, DOI: 10.1016/j.brs.2024.07.007.
- Nasr, K.; Haslacher, D.; Dayan, E.; Censor, N.; Cohen, L. G.; Soekadar, S. R. (2022): Breaking the boundaries of interacting with the human brain using adaptive closed-loop stimulation. *Progress in Neurobiology*, 216: 102311, DOI: 10.1016/j.pneurobio.2022.102311.
- Clausen, J.; Fetz, E.; Donoghue, J.; Ushiba, J.; Spörhase, U.; Chandler, J.; Birbaumer, N.; Soekadar, S. R. (2017): Help, hope, and hype: ethical dimensions of neuroprosthetics. In: *Science*, 356 (6345), 1338–1339, DOI: 10.1126/science.aam7731.
- Soekadar, S. R.; Witkowski, M.; Gómez, C.; Opisso, E.; Medina, J.; Cortese, M.; Cempini, M.; Carrozza, M. C.; Cohen, L. G.; Birbaumer, N.; Vitiello, N. (2016): Hybrid EEG/EOG-based brain/neural hand exoskeleton restores fully independent daily living activities after quadriplegia. In: *Science Robotics*, 1: eaag3296, DOI: 10.1126/scirobotics.aag3296.

Neurotechnologies – opportunities, risks and pathways to responsible application

Advances in neuroscience and neurotechnology now enable real-time, bi-directional brain-computer interaction: neural activity can be decoded while the brain itself is directly stimulated to restore function or modulate states. Initially driven by medical needs, the field is increasingly shaped by multi-billion-dollar investments that aim to extend applications beyond therapy – into human-machine interaction, education, work, and consumer markets. While such prospects hold promise, they also raise risks of new dependencies and erosion of human abilities. To safeguard responsible progress, I argue for mandatory Mental Impact Assessment (MIA) for risky neurotechnologies (including invasive, non-medical system), ensuring systematic evaluation of psychological and societal consequences. At the same time, overregulation must be avoided to not hinder innovation. Building dedicated NeuroTech Innovation ecosystems and providing structured administrative guidance ("NeuroTech Sherpas") will be key to maintain technological sovereignty and protect societal well-being in Europe.

Daniel Strauss
Saarland University

Short biography

Daniel J. Strauss holds a PhD in Mathematics/Computer Science from the University of Mannheim and a PhD in Theoretical Medicine, as well as a Habilitation from Saarland University. As Full Professor (W3) of Systems Neuroscience & Neurotechnology, he directs the Systems Neuroscience & Neurotechnology Unit at Saarland University's Medical Faculty and University of Applied Sciences' (htw saar's) School of Engineering. He is also a founding member and spokesperson of the international Center for Digital Neurotechnologies Saar in Germany's state of Saarland. His research focuses on the systems neuroscience of multimodal attention and effort, and its interaction with affect. Applications include non-intrusive neurotechnologies as part of an affective artificial intelligence that decode physical but also mental states in human-machine interaction, immersive environments, and human medicine. His research projects in this domain have received extensive funding from the Federal Ministry of Research, Technology and Space, the German Research Foundation, the Federal Ministry for Economic Affairs and Energy, the Federal Ministry of Transport, the European Union, the State of Saarland, and industry.

Selected publications

- Strauss, D. J.; Corona-Strauss, F. I.; Mai, A.; Hillyard, S. A. (2025): Unraveling the effects of selective auditory attention in ERPs: From the brainstem to the cortex. *NeuroImage*, 316: 121295. DOI: 10.1016/j.neuroimage.2025.121295.
- Bhamborae, M.; Schneider, E. N.; Flotho, P.; Francis, A. L.; Strauss, D. J. (2025): LumEDA: image luminance based contactless correlates of electrodermal responses. *Physiological Measurement*, 46: 025010. DOI: 10.1088/1361-6579/adb369.
- Lehser, C.; Hillyard, S. A.; Strauss, D. J. (2024): Feeling senseless sensations: a crossmodal EEG study of mismatched tactile and visual experiences in virtual reality. *Journal of Neural Engineering*, 21: 056042. DOI: 10.1088/1741-2552/ad83f5.
- Buchheit, B.; Schneider, E. N.; Alayan, M.; Dauth, F.; Strauss, D. J. (2022): Motion sickness prediction in self-driving cars using the 6DOF-SVC Model. *IEEE Transactions on Intelligent Transportation Systems*, 23 (8), 13582–13591. DOI: 10.1109/TITS.2021.3125802.
- Strauss, D. J.; Corona-Strauss, F. I.; Schroeer, A.; Flotho, P.; Hannemann, R.; Hackley, S. A. (2020): Vestigial auriculomotor activity indicates the direction of auditory attention in humans. *eLife*, 9: e54536. DOI: 10.7554/eLife.54536.

A window into the brain – how can neurotechnology measure and influence attention and emotions?

Technologies capable of decoding our intentions and emotions in everyday life may evoke unease in many of us – and understandably so. In recent years, neurotechnology has made a remarkable transition: from specialized medical applications to early attempts at integration into everyday devices such as smartphones, vehicles, and earbuds. Largely driven by tech giants, it marks the next evolution in human-machine interaction – moving beyond keyboard, mouse, gestures, and speech toward a direct link between the human nervous system and technology. But what are the benefits of neurotechnology in our digital world, especially for personalized experiences? In this talk, I will present examples from our research in neurotechnology-based affective AI to decode human intentions and emotions. I will also reflect on the balance between personalization and ethical responsibility.

Nataliya Kosmyna
Massachusetts Institute of Technology

Short biography

Dr. Kosmyna is a research scientist at MIT Media Lab and a visiting researcher at Google. She has over 15 years of experience in developing and designing end-to-end brain-computer interfaces (BCIs). Most of her projects are focused around BCIs in the context of consumer grade applications. Dr. Kosmyna often collaborates with teams from Boston Dynamics, Microsoft Research, NASA. Her solutions and art projects are successfully deployed in the classrooms, hospitals, workspaces, aerospace, Lower Earth Orbit, and on the Moon. Dr. Kosmyna has won multiple awards for her work, among which is L'Oréal-UNESCO Women in Science award she received in 2016. She served as one of 24 international experts for UNESCO to help prepare a first draft of the Recommendation on the Ethics of Neurotechnology, and on the Expert Advisory Group on Neurotechnology and Children for UNICEF. Her work has been covered in more than 400 TV appearances, radio and other news outlets all around the world including but not limited to: New York Times, The New Yorker, CNN, Washington Post, Time, Nature, CBS News, The Telegraph, The Wall Street Journal, The Economist, MIT Tech Review and more.

Selected publications

- Kosmyna, N.; Hauptmann, E.; Yuan, Y. T.; Situ, J.; Liao, X.-H.; Beresnitzky, A. V.; Braunstein, I.; Maes, P. (2025): Your brain on ChatGPT: accumulation of cognitive debt when using an AI assistant for essay writing task. *arXiv*:2506.08872, DOI: 10.48550/arXiv.2506.08872.
- Guenther, S.; Kosmyna, N.; Maes, P. (2024): Image classification and reconstruction from low-density EEG. *Scientific Reports*, 14: 16436. DOI: 10.1038/s41598-024-66228-1.
- Kosmyna, N.; Morris, C.; Nguyen, T.; Zepf, S.; Hernandez, J.; Maes, P. (2019): AttentivU: designing EEG and EOG compatible glasses for physiological sensing and feedback in the car. In: Association for Computing Machinery (ed.): Proceedings of the 11th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications. New York, 355–368. DOI: 10.1145/3342197.3344516.
- Kosmyna, N.; Lindgren, J. T.; Lécuyer, A. (2018): Attending to visual stimuli versus performing visual imagery as a control strategy for EEG-based brain-computer interfaces. *Scientific Reports*, 8: 13222. DOI: 10.1038/s41598-018-31472-9.
- Kosmyna, N.; Tarpin-Bernard, F.; Bonnefond, N.; Rivet, B. (2016): Feasibility of BCI control in a realistic smart home environment. *Frontiers in Human Neuroscience*, 10: 416. DOI: 10.3389/fnhum.2016.00416.

Neurotech for everyone? Potential applications of AI-supported neurotechnologies to improve cognitive functions

- Orwellian future is no more — it's today. From governments willing to go to great lengths to access your private messages, it is not such a distant step for them to advocate for your thoughts to be deposited in digital format. Your most intimate brain experiences paraded before a jury that hides its own mind. How far is too far?
- In America, a few billionaires already do this. There's a long line of tech CEOs who want to follow.
- At present, all advances in neurotech come from the advantages and disadvantages of people with significant health challenges and who require medical attention. Under U.S. law, invasive Brain-Computer Interfaces (BCIs) cannot be prescribed to a patient by a doctor without such medical necessity in

the first place. That is where the U.S. Food and Drug Administration (FDA) attempts to regulate the unknown. And this is the very same FDA that recently added AI to screen potential trials submitted by for-profit corporations.

- "A computer can never be held accountable; therefore, a computer must never make a management decision." – IBM Training Manual, 1979
- I'm afraid that in the future we will need a manual titled How to Be Human 101.
- In this talk, I will attempt to describe potential futures where Minority Report looks too "positive" and "precogs" resemble the outcome humans desire.
- Here's another quote from the futuristic Matrix, in a conversation between Agent Smith (AI) and Cypher (a person who betrayed Neo, the protagonist): "I know this steak doesn't exist. I know that when I put it in my mouth, the Matrix is telling my brain that it is juicy and delicious. After nine years, you know what I've realized? Ignorance is bliss."

Ulrich G. Hofmann
University of Freiburg

Short biography
Prof. Dr. Ulrich G. Hofmann has been head of the Section of Neuroelectronic Systems at the Department of Neurosurgery of Freiburg University's Medical Centre since 2012. After obtaining his doctorate in (bio-)physics and working in Turku and at Caltech, Hofmann conducted research into biosignal processing and neuroengineering in Lübeck, where he qualified as a professor in computer science. Hofmann conducts interdisciplinary research at the interface of physics, medicine and technology. He works on neural microelectrodes, biomedical electronics, medical signal processing, deep brain stimulation and recurrent neural interfaces. Hofmann was co-founder and chair of the first Gordon Research Conference on Neuroelectronic Interfacing, is co-editor of journals such as Frontiers in Neuroscience: Neural Technology, and has received numerous awards for his work, including Distinguished International Scholar at the University of Rhode Island. He has also played a leading role in excellence projects such as the Graduate School in Lübeck, the BrainLinks-BrainTools Cluster of Excellence, and the Spemann Graduate School for Medicine and Biology in Freiburg.

Selected publications

- Jariwala, V. D.; Ravi, V. M.; Beck, J.; Hofmann, U. G.; Joseph, K. (2025): Spatiotemporal analysis of microglial morphometrics along recovery from microinjury reveals bifurcated cellular response post injury. *Nature Communications*, submitted 2025.
- Ahmed, A. A. A.; […] Hofmann, U. G.; […] Parak, W. J. (2025): Interfacing with the brain: how nanotechnology can contribute. ACS Nano, 19 (11), 10630–10717. DOI: 10.1021/acsnano.4c10525.
- Joseph, K.; Kirsch, M.; Johnston, M.; Münkel, C.; Stieglitz, T.; Haas, C. A.; Hofmann, U. G. (2021): Transcriptional characterization of the glial response due to chronic neural implantation of flexible microprobes. *Biomaterials*, 279: 121230. DOI: 10.1016/j.biomaterials.2021.121230.
- Weltin, A.; Ganatra, D.; König, K.; Joseph, K.; Hofmann, U. G.; Urban, G. A.; Kieninger, J. (2019): New life for old wires: electrochemical sensor method for neural implants. *Journal of Neural Engineering*, 17: 016007. DOI: 10.1088/1741-2552/ab4c69.
- Böhm, T.; Joseph, K.; Kirsch, M.; Moroni, R.; Hilger, A.; Osenberg, M.; Manke, I.; Johnston, M.; Stieglitz, T.; Hofmann, U. G.; Haas, C. A.; Thiele, S. (2019): Quantitative synchrotron X-ray tomography of the material-tissue interface in rat cortex implanted with neural probes. *Scientific Reports*, 9: 7646. DOI: 10.1038/s41598-019-42544-9.
- Boehler, C.; Kleber, C.; Martini, N.; Xie, Y.; Dryg, I.; Stieglitz, T.; Hofmann, U. G.; Asplund, M. (2017): Actively controlled release of Dexamethasone from neural microelectrodes in a chronic in vivo study. *Biomaterials*, 129, 176–187. DOI: 10.1016/j.biomaterials.2017.03.019.

Do not implant! Risks and long-term consequences of neural implants
Medical interventions must be effective and cause as little damage as possible – but in the case of neuroimplants, there is no reliable evidence to support this. The neurotech community is at times overly euphoric and ignores potential risks. Currently, outdated histological methods are considered sufficient to prove safety, even though only a few markers are examined selectively. Our research uses nanopore sequencing to analyse the transcriptome in the implant environment and shows that brain tissue remains chronically altered, inflammatory reactions also affect distant tissue, neuronal functions are disrupted, and potential oncogenes are overexpressed. Brain implants could therefore increase the risk of brain tumours, similar to trauma. As long as this cannot be ruled out, they should only be used under strict indications and close supervision – and under no circumstances as a mass product.

Frank Willett
Stanford University

Short biography

Frank Willett is co-director of the Neural Prosthetics Translational Laboratory. His group develops brain-computer interfaces (BCIs) to restore movement and communication to people with neurological disorders. Recent contributions include handwriting and speech-based BCIs that set new records for communication speed and accuracy in people with paralysis. More broadly, he is interested in computational approaches to understanding brain function and recordings, with a focus on how the human brain represents movement and language.

Selected publications

- Kunz, E. M.; Krasa, B. A.; Kamdar, F.; Avansino, D. T.; Hahn, N.; Yoon, S.; Singh, A.; Nason-Tomaszewski, S. R.; Card, N. S.; Jude, J. J.; Jacques, B. G.; Bechefsky, P. H.; Iacobacci, C.; Hochberg, L. R.; Rubin, D. B.; Williams, Z. M.; Brandman, D. M.; Stavisky, S. D.; AuYong, N.; Pandarinath, C.; Druckmann, S.; Henderson, J. M.; Willett, F. R. (2025): Inner speech in motor cortex and implications for speech neuroprostheses. *Cell*, 188 (17), 4658–4673. DOI: 10.1016/j.cell.2025.06.015.
- Willett, F. R.; Kunz, E. M.; Fan, C.; Avansino, D. T.; Wilson, G. H.; Choi, E. Y.; Kamdar, F.; Glasser, M. F.; Hochberg, L. R.; Druckmann, S.; Shenoy, K. V.; Henderson, J. M. (2023): A high-performance speech neuroprosthesis. *Nature*, 620 (7976), 1031–1036. DOI: 10.1038/s41586-023-06377-x.
- Willett, F. R.; Avansino, D. T.; Hochberg, L. R.; Henderson, J. M.; Shenoy, K. V. (2021): High-performance brain-to-text communication via handwriting. *Nature*, 593 (7858), 249–254. DOI: 10.1038/s41586-021-03506-2.
- Willett, F. R.; Deo, D. R.; Avansino, D. T.; Rezaii, P.; Hochberg, L. R.; Henderson, J. M.; Shenoy, K. V. (2020): Hand knob area of premotor cortex represents the whole body in a compositional way. *Cell*, 181 (2), 396–409. DOI: 10.1016/j.cell.2020.02.043.

Brain implants for speech restoration

Our recent work has demonstrated that implantable speech brain-computer interfaces (BCIs) can restore rapid communication to people with paralysis. Speech BCIs record neural activity directly from the brain and translate it into the words a person with paralysis is trying to say. This talk will review the trajectory of speech BCI development, including their current capabilities and limitations. I will also review our recent study demonstrating that inner speech (or “inner monologue”) can be decoded from sensors placed in motor areas of the brain. Finally, I will discuss proposed methods for ensuring that BCI output represents only what the user intends to say.

Livestream

https://www.ethikrat.org/live

Dokumentation

https://www.ethikrat.org/veranstaltungen/anhoerungen/neue-neurotechnologien

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