

INTRODUCTION TO NEUROTECH

WORKSHOP #1

Workshop Aims

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1. INTRODUCE THE SOCIETY

- Who we are
- What we provide
- How you can be involved

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- What we provide
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2. INTRODUCTION TO NEUROTECH

- What is Neurotechnology?
- What is a Brain-Computer Interface?
- Overview of the field (devices, companies, applications)
- Future directions of the field

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2. INTRODUCTION TO NEUROTECH
 - What is Neurotechnology?
 - What is a Brain-Computer Interface?
 - Overview of the field (devices, companies, applications)
 - Future directions of the field
3. HOW TO INTERACT WITH NEUROTECH WHILE AT UNI

01 What is Neurotech

01 What is Neurotech

Neurotechnology refers to the tools and technologies used to understand, interact with, or modify the brain and nervous system



01 What is Neurotech

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Includes

Brain Computer Interfaces



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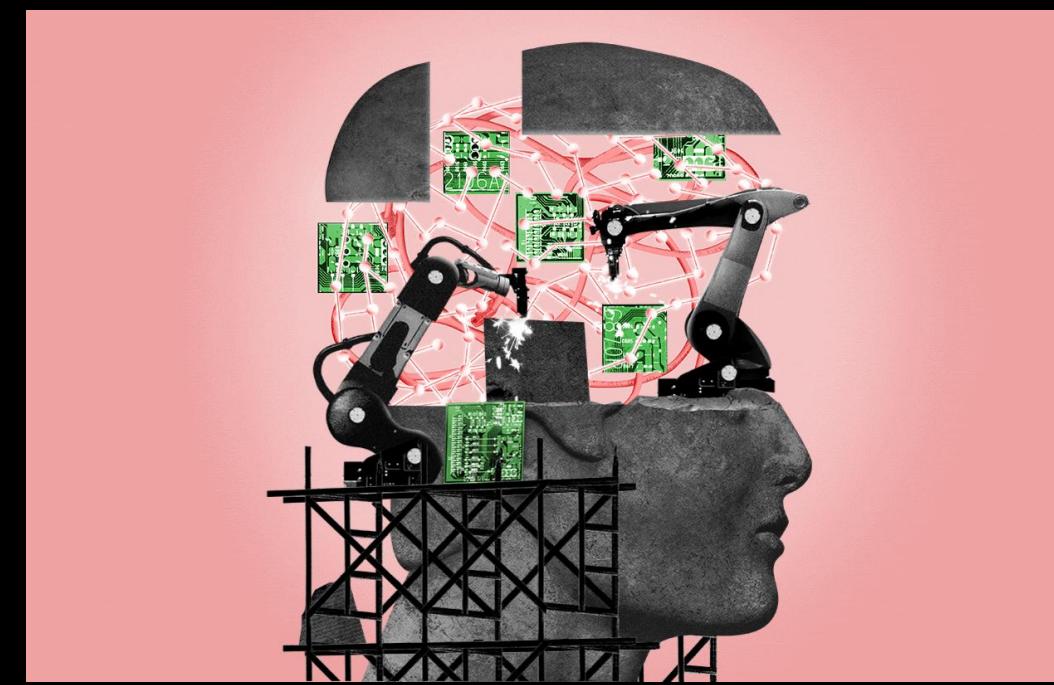
Includes

Brain Computer Interfaces

Invasive
Non-invasive



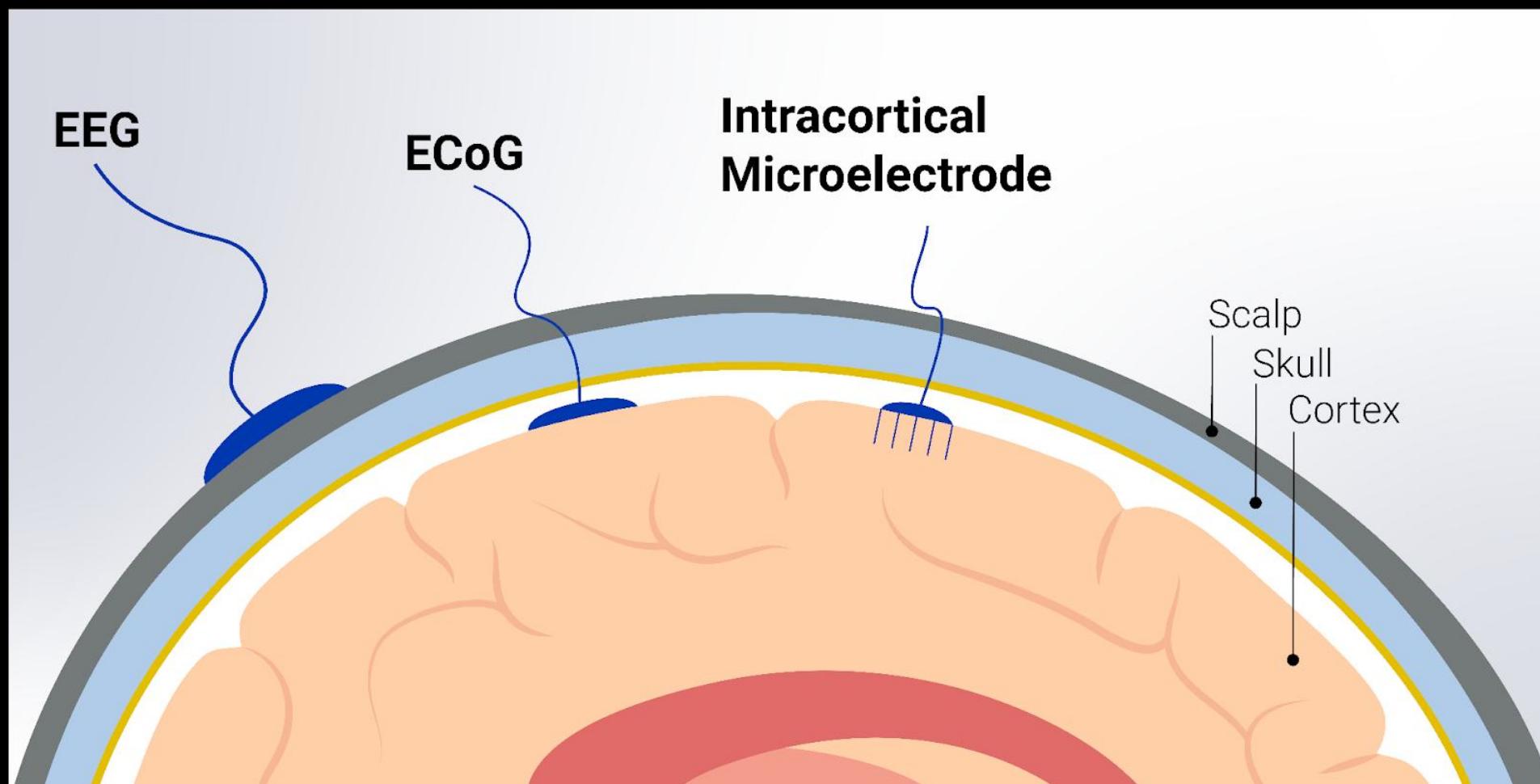
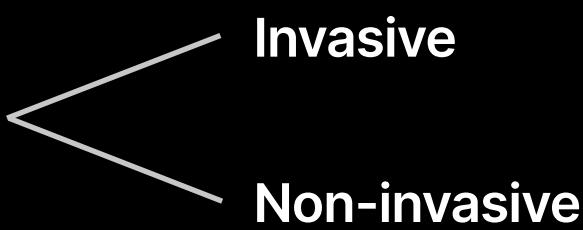
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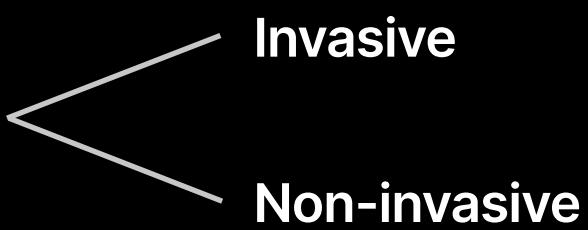
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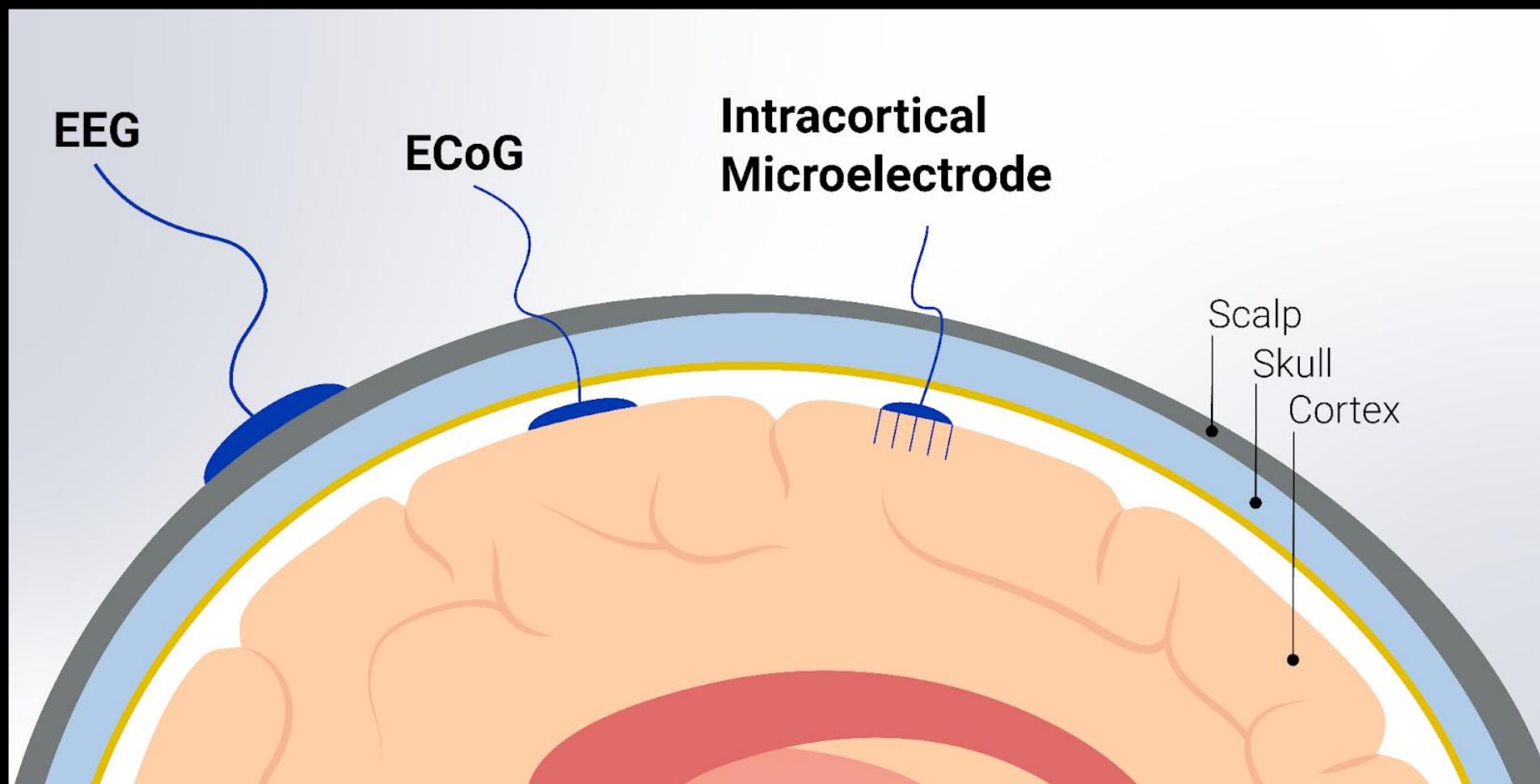
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Neuroprosthetics

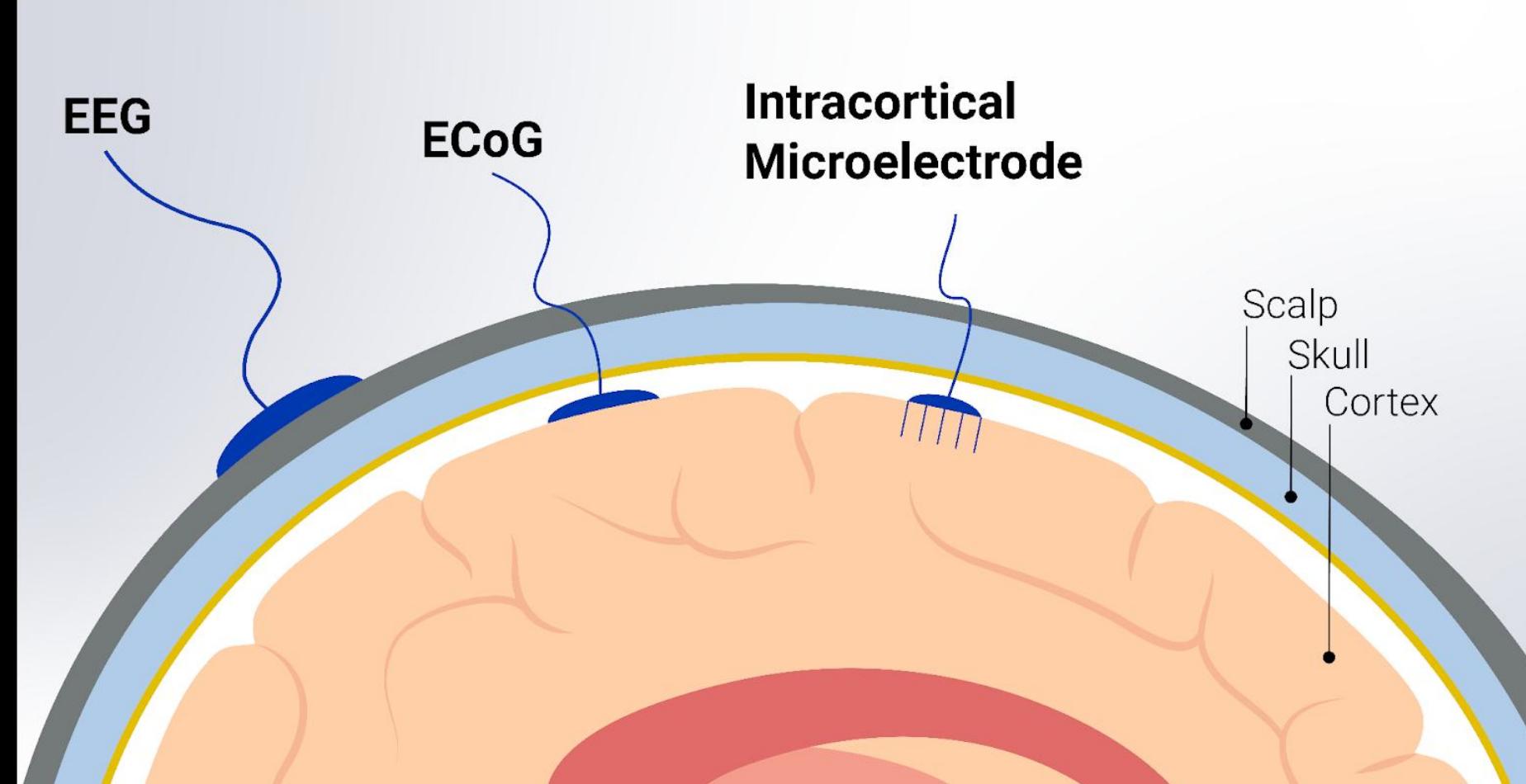


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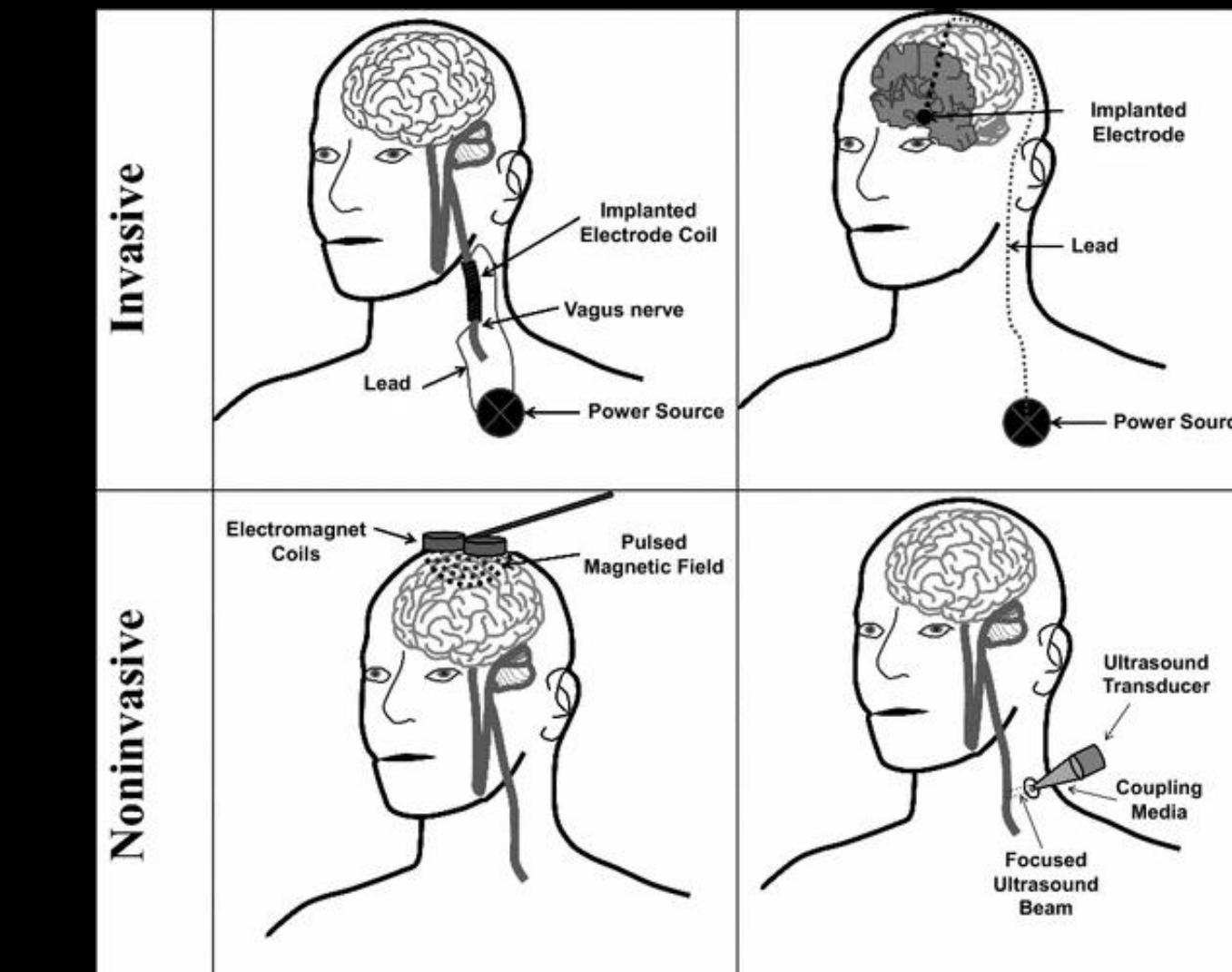
Brain Computer Interfaces



Invasive
Non-invasive

Neuromodulation

Neuroprosthetics

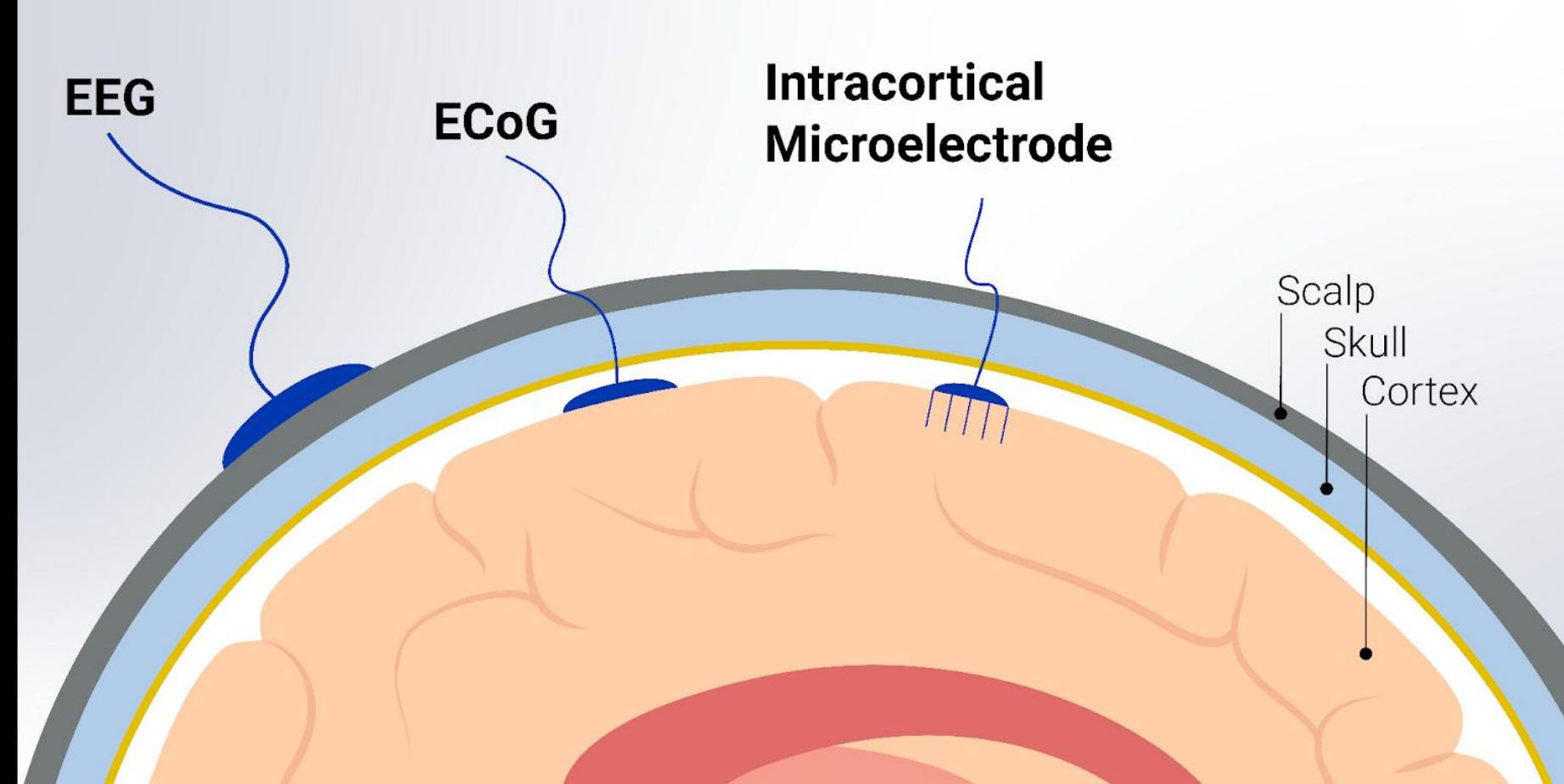


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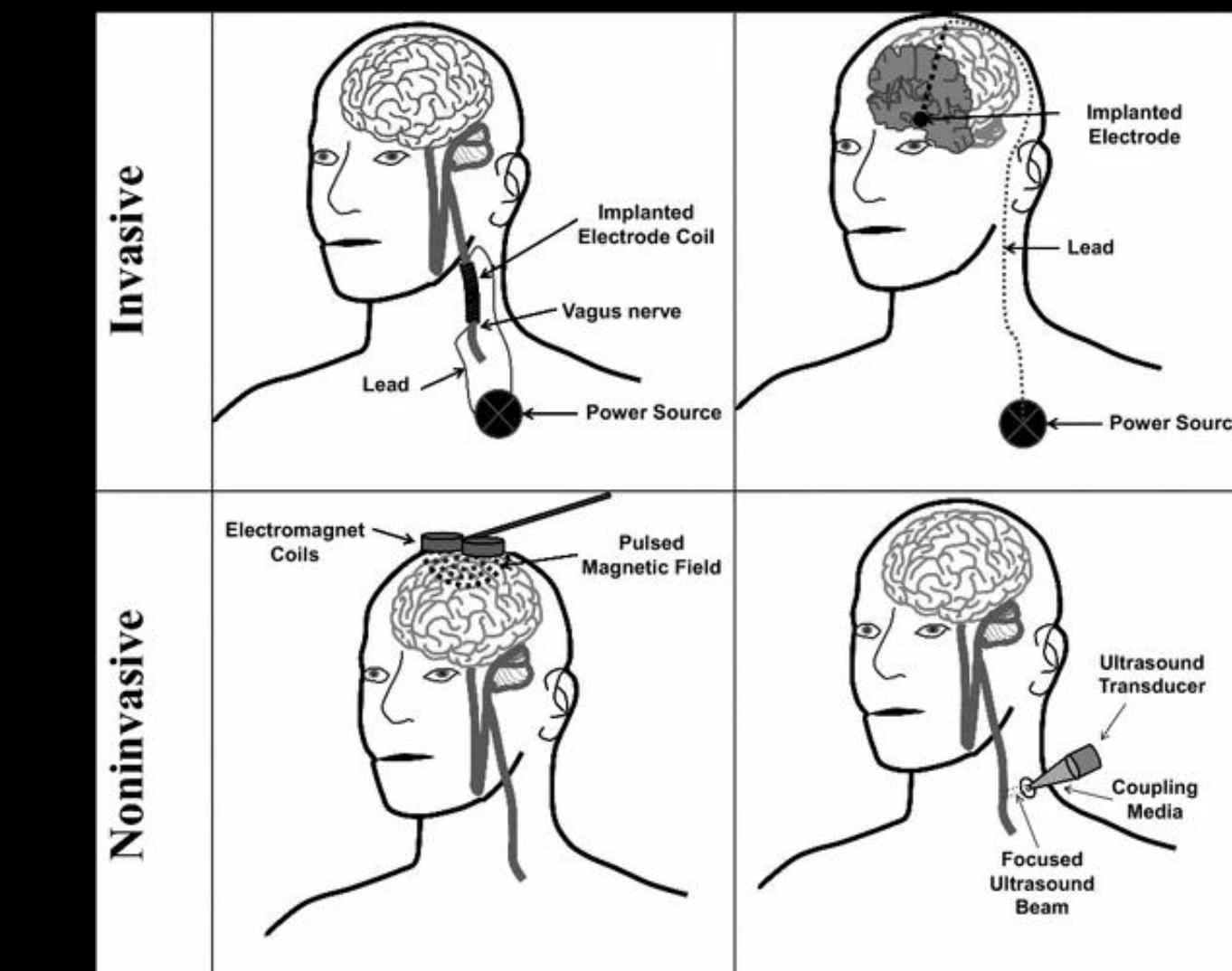
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Non-invasive

Neuromodulation



Neuroprosthetics

Neural Data Analysis

Neurotech is extremely cross-disciplinary

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- **Neuroscience** Understanding brain mechanisms

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- **Electrical Engineering** Device creation and manufacturing. Signal Processing
- **Biomedical Engineering** Medical device development

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- **Computer Science** Data analysis. Machine Learning. Neural Decoding

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- **Philosophy and Law** Data privacy. Neuroethics

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- **Psychology** Brain enhancement. Therapeutic applications

And a whole bunch more

Biology

Biomedical Sciences

Biomedical Engineering

Biochemistry

Electrical Engineering

Biotechnology

Chemistry

Design Engineering

Computer Science

Materials

Medicine

Maths

Medical Biosciences

Physics

Mechanical Engineering

02 Brain Computer Interfaces

02 Brain Computer Interfaces

BCIs enable direct communication between the brain and external devices

They broadly come in two categories:

**Neuroimaging
Devices**

**Brain Stimulation
Devices**

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You can also categorise by:

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You can also categorise by:

INVASIVE

NON-INVASIVE

02 Brain Computer Interfaces

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**Neuroimaging
Devices**

INVASIVE

**Brain Stimulation
Devices**

NON-INVASIVE

02 Brain Computer Interfaces

DISCLAIMER

There are a lot of technical details in the following slides

They are not important - **you are more than welcome to zone out for the next 15 minutes** - but they will be incredibly useful if you want to really engage with the field

Neuroimaging

INVASIVE

| | |
|---------------------------------|--------------------------------------|
| Neuroimaging Devices | Brain Stimulation Devices |
| INVASIVE | NON-INVASIVE |

Neuroimaging

INVASIVE

Intracortical Microelectrodes

Arrays of electrodes implanted directly into the cortex to record electrical signals from individual neurons.

Neuroimaging

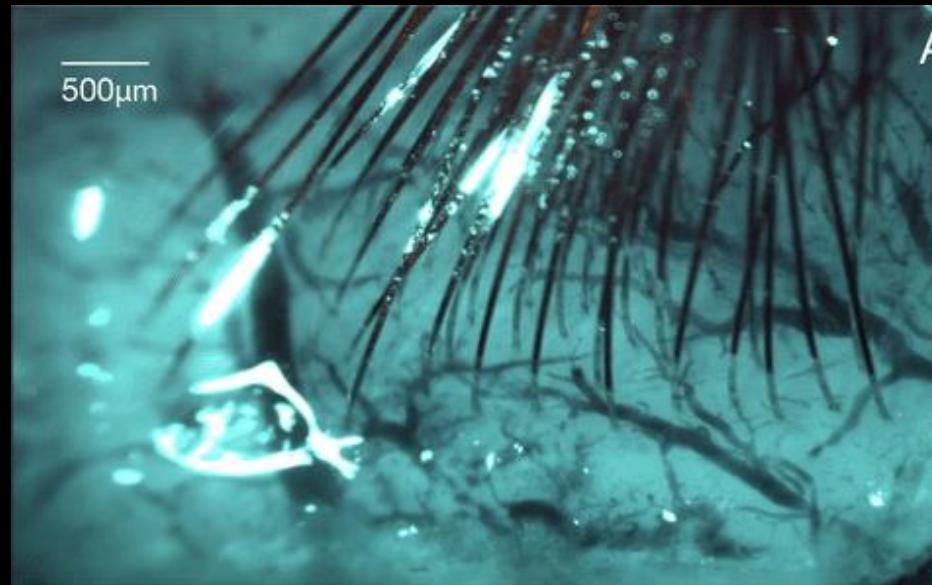
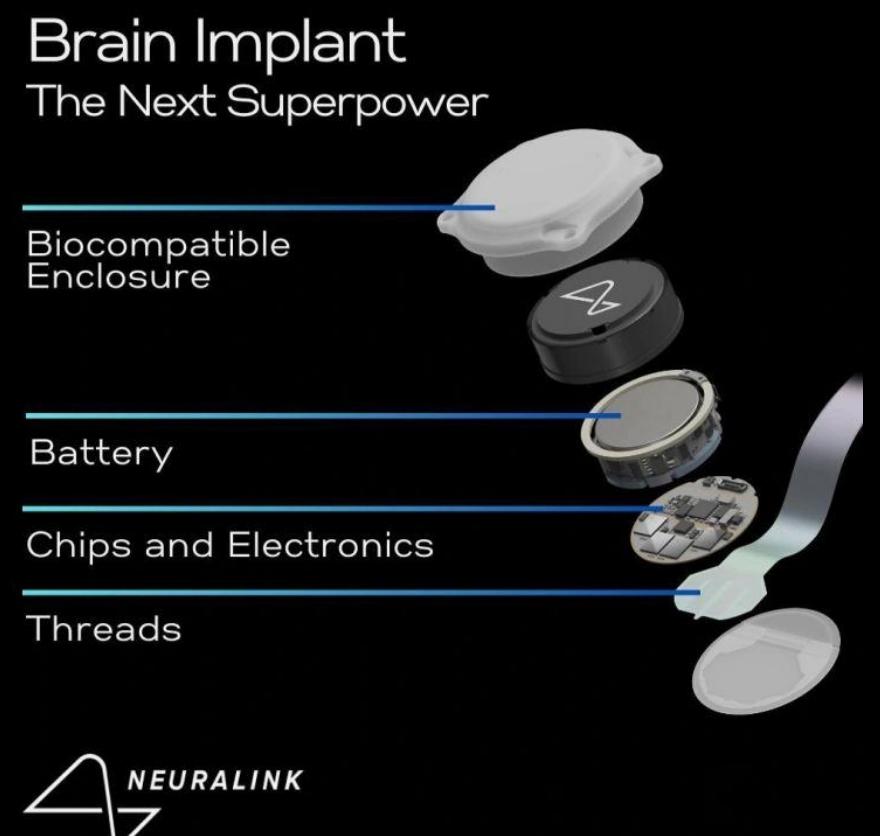
INVASIVE

Examples

Intracortical Microelectrodes

Arrays of electrodes implanted directly into the cortex to record electrical signals from individual neurons.

- UTAH array
- Link implant



Neuroimaging

INVASIVE

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Electrocorticography (ECoG)

Electrodes placed on the brain's surface (under the skull) to record brain activity with high temporal and spatial resolution.

Neuroimaging

INVASIVE

Examples

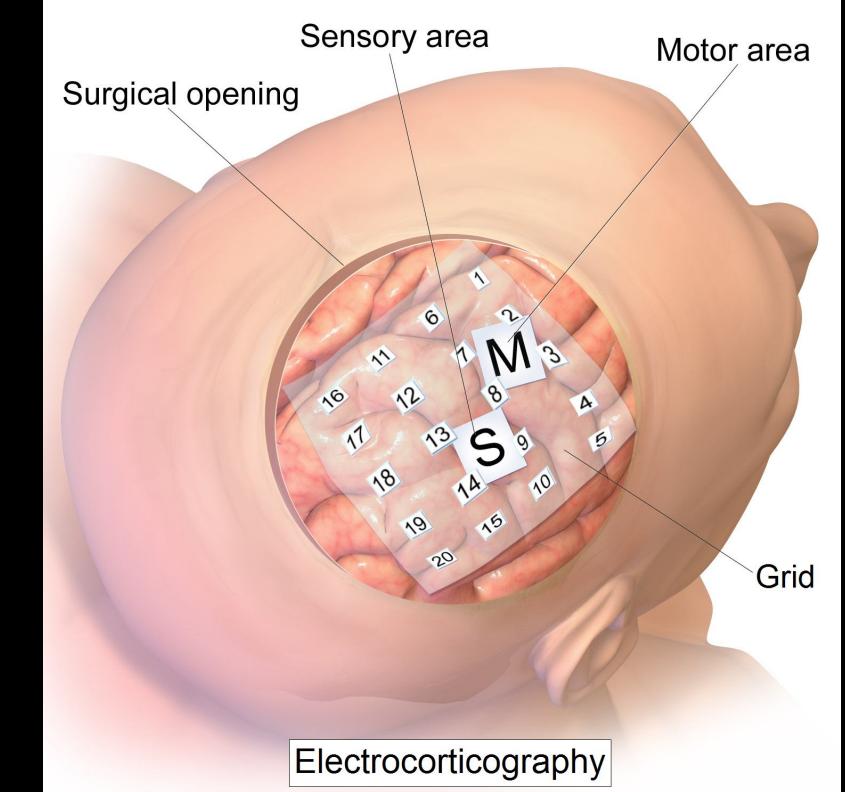
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Neuroimaging

INVASIVE

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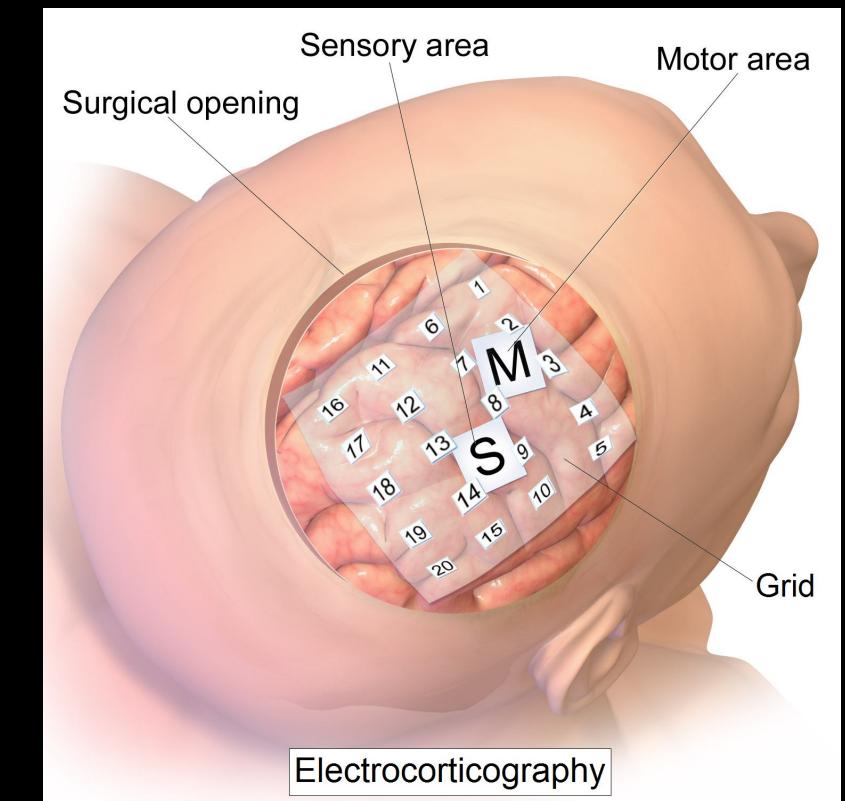
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Advantages

- High signal fidelity
- Ability to read from specific neural populations

Disadvantages

- Invasiveness (surgical operation)
- Risk of infection
- Tissue damage

Neuroimaging

NON-INVASIVE

**Neuroimaging
Devices**

INVASIVE

**Brain Stimulation
Devices**

NON-INVASIVE

Neuroimaging

NON-INVASIVE

Applications

Electroencephalography (EEG)

Measures electrical activity from the scalp using electrodes. Widely used in clinical settings and research.

- Monitoring brain activity during cognitive tasks

Neuroimaging

NON-INVASIVE



Applications

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Magnetoencephalography (MEG)

Measures magnetic fields generated by neural activity. Offers high temporal resolution.

- Mapping brain function pre-surgery

Neuroimaging

NON-INVASIVE



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Functional Near-Infrared Spectroscopy (fNIRS)

Measures changes in blood oxygenation in the brain.

- Mobile brain-oxygenation monitoring

Neuroimaging

NON-INVASIVE (continued)

Neuroimaging

NON-INVASIVE (continued)

Applications

Functional Magnetic Resonance Imaging (fMRI)

Detects changes in blood flow to measure associated brain activity.

- In vivo, high resolution imaging

Neuroimaging

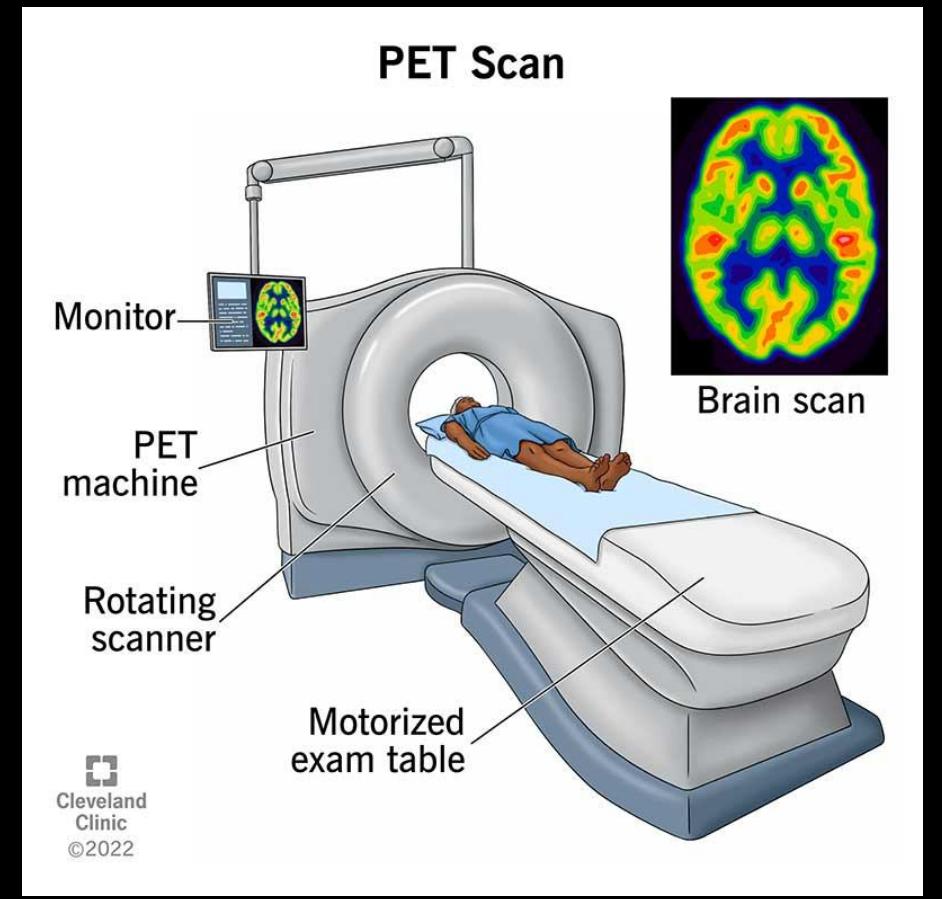
NON-INVASIVE (continued)

Functional Magnetic Resonance Imaging (fMRI)

Detects changes in blood flow to measure associated brain activity.

Positron Emission Tomography (PET)

Measures metabolism (glucose metabolism or blood flow) via radioactive position-emitting tracers



Applications

- In vivo, high resolution imaging
- Cancer detection

Neuroimaging

NON-INVASIVE (continued)

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Applications

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Advantages

- Generally cheap, and even consumer grade
- Safe and less ethically intensive

Disadvantages

- Signal distortion (skull and scalp)
- Typically lower spatial resolution
- Highly sensitive to noise (e.g. eye blinks)
- Indirect measurements

Brain Stimulation

INVASIVE

Neuroimaging
Devices

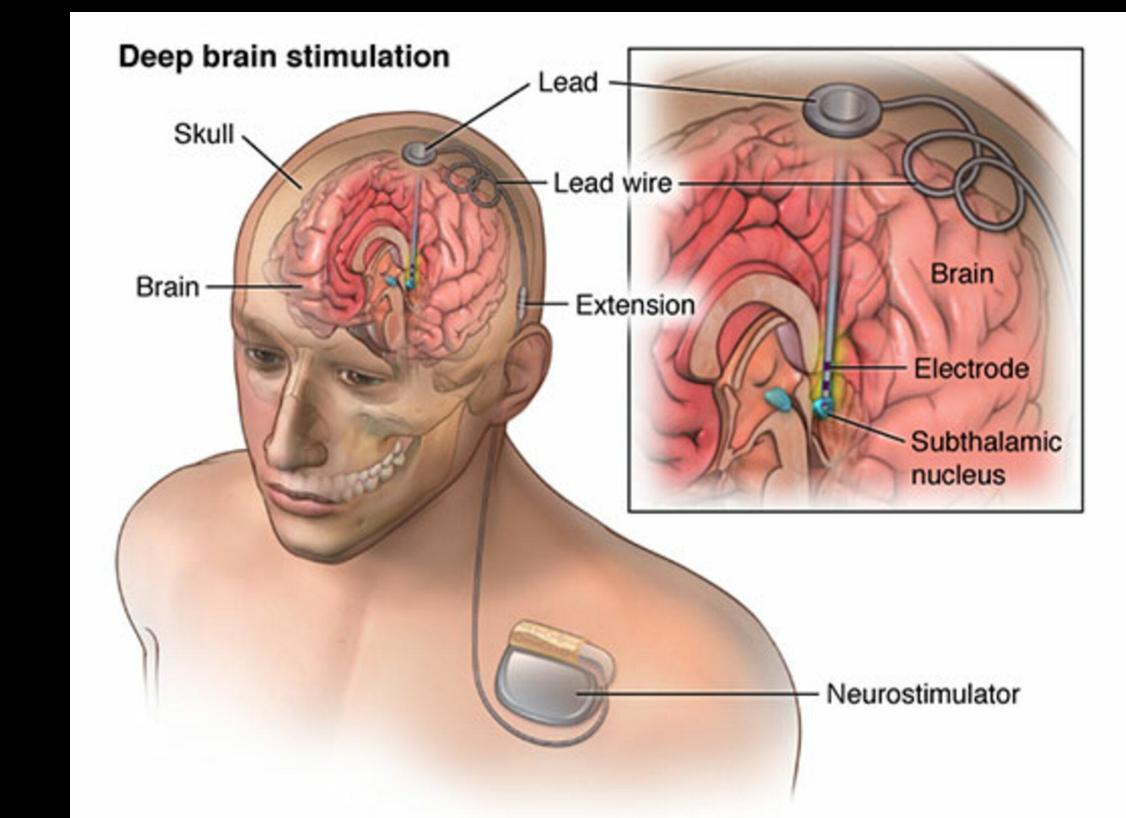
INVASIVE

Brain Stimulation
Devices

NON-INVASIVE

Brain Stimulation

INVASIVE



Applications

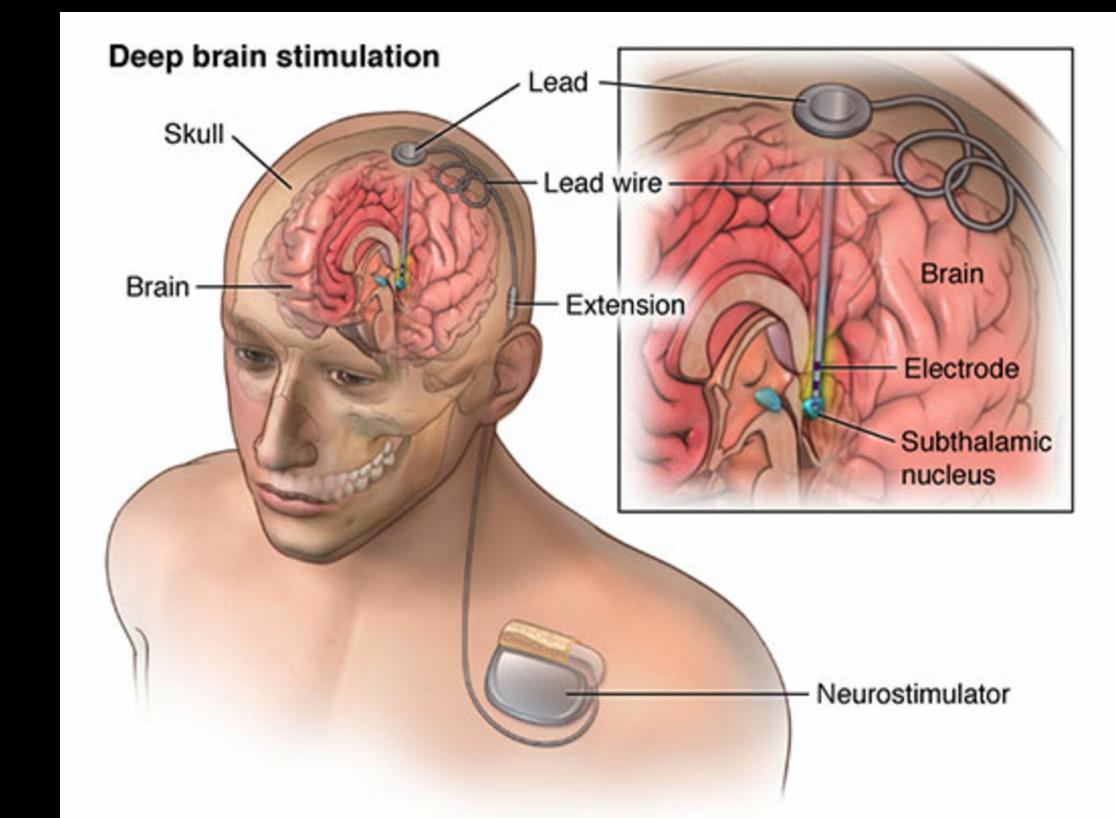
Deep Brain Stimulation (DBS)

Electrodes implanted deep in specific brain regions. High-frequency electrical pulses disrupt abnormal activity patterns.

- Parkinson's disease
- Treatment-resistant depression

Brain Stimulation

INVASIVE



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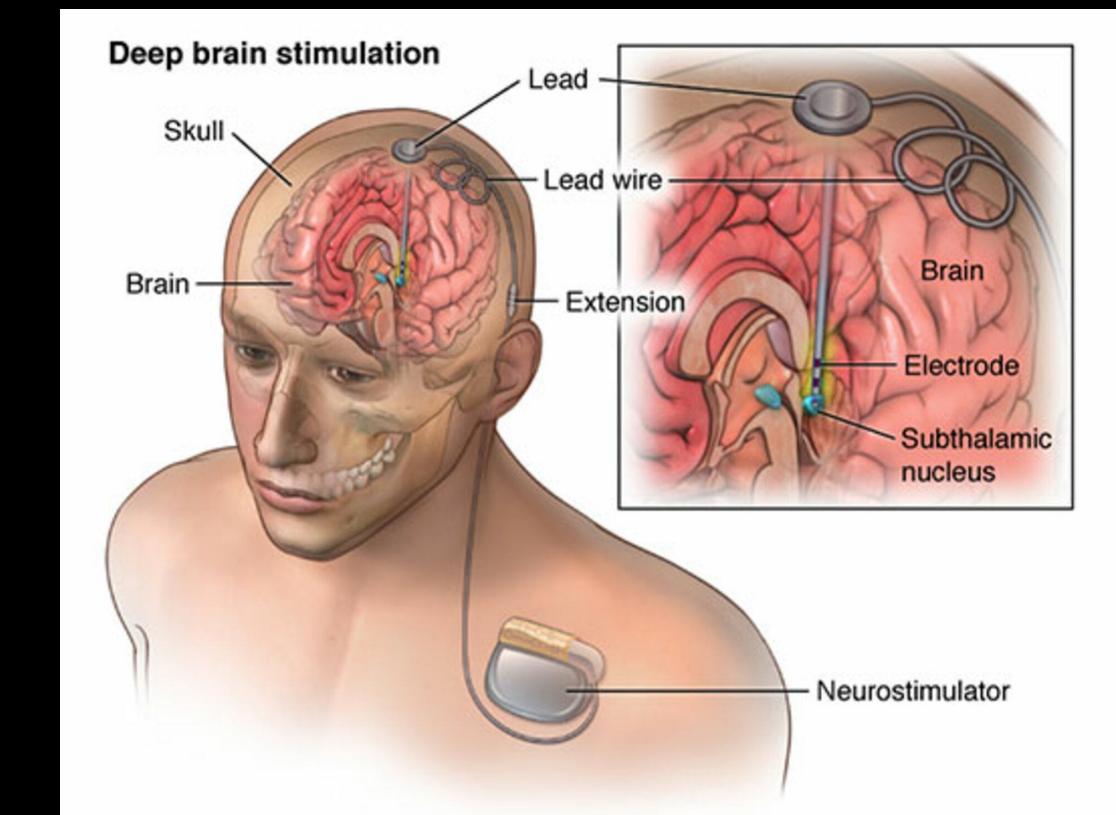
Cortical Microstimulation

Direct stimulation of cerebral cortex using implanted electrode arrays

- Restoring tactile sensation or visual perception (through stimulation of the somatosensory cortex)

Brain Stimulation

INVASIVE



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Vagus Nerve Stimulation

Implanted device stimulates the vagus nerve, which interfaces with the brainstem to influence various peripheral neural circuits.

- Epilepsy treatment (FDA-approved)
- Migraine prevention (under investigation)

Brain Stimulation

NON-INVASIVE

Neuroimaging
Devices

INVASIVE

Brain Stimulation
Devices

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Brain Stimulation

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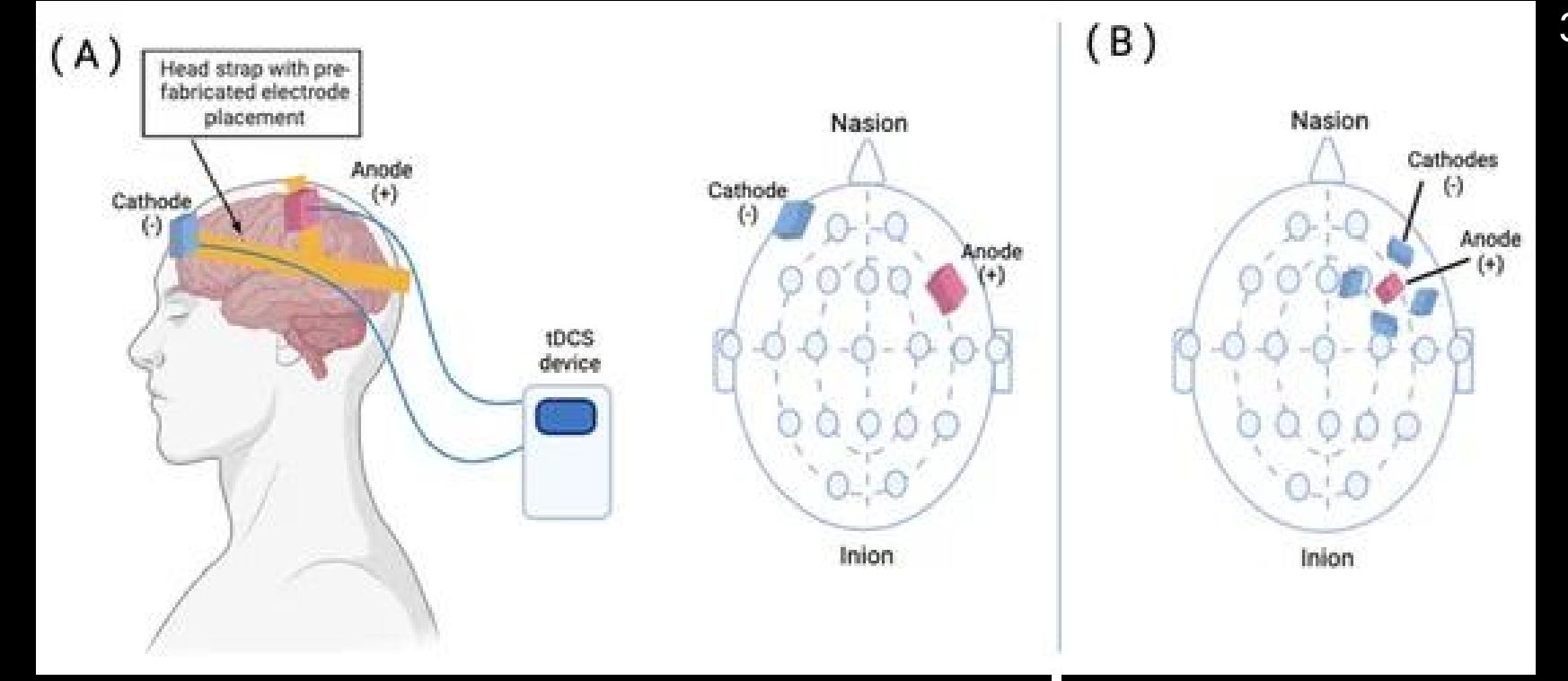
Transcranial Electric Stimulation (tES)

Applying electric currents through the scalp

- Treat pain disorders (e.g. migraine, fibromyalgia, craniofacial pain)
- Improve emotional state¹
- Reduce fatigue²

Brain Stimulation

NON-INVASIVE



Traditional tDCS

High-definition tDCS

Transcranial Electric Stimulation (tES)

Applying electric currents through the scalp

Transcranial Direct Current Stimulation (tDCS): Constant current that either increases or decreases cortical excitability

Transcranial Alternating Current Stimulation (tACS): Oscillating currents to entrain neural oscillations, influencing brain rhythms.

Transcranial Pulsed Current Stimulation (tPCS): Converts direct current into pulses with adjustable parameters

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Frontiers in Psychology, 25 October 2022

³ Transcranial Direct Current Stimulation to Ameliorate Post-Stroke Cognitive Impairment, K. Sloane, R. Hamilton

Brain Stimulation

NON-INVASIVE

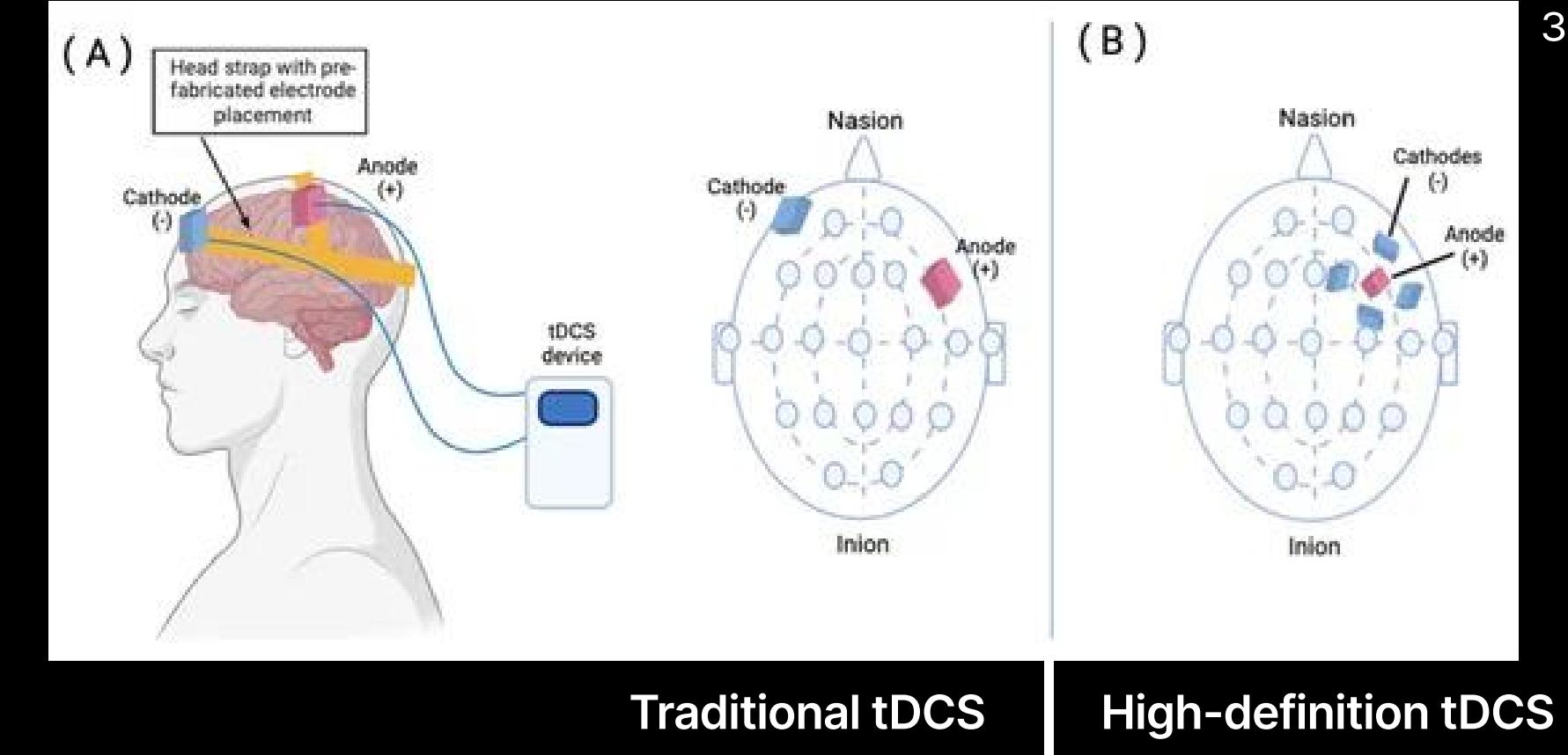
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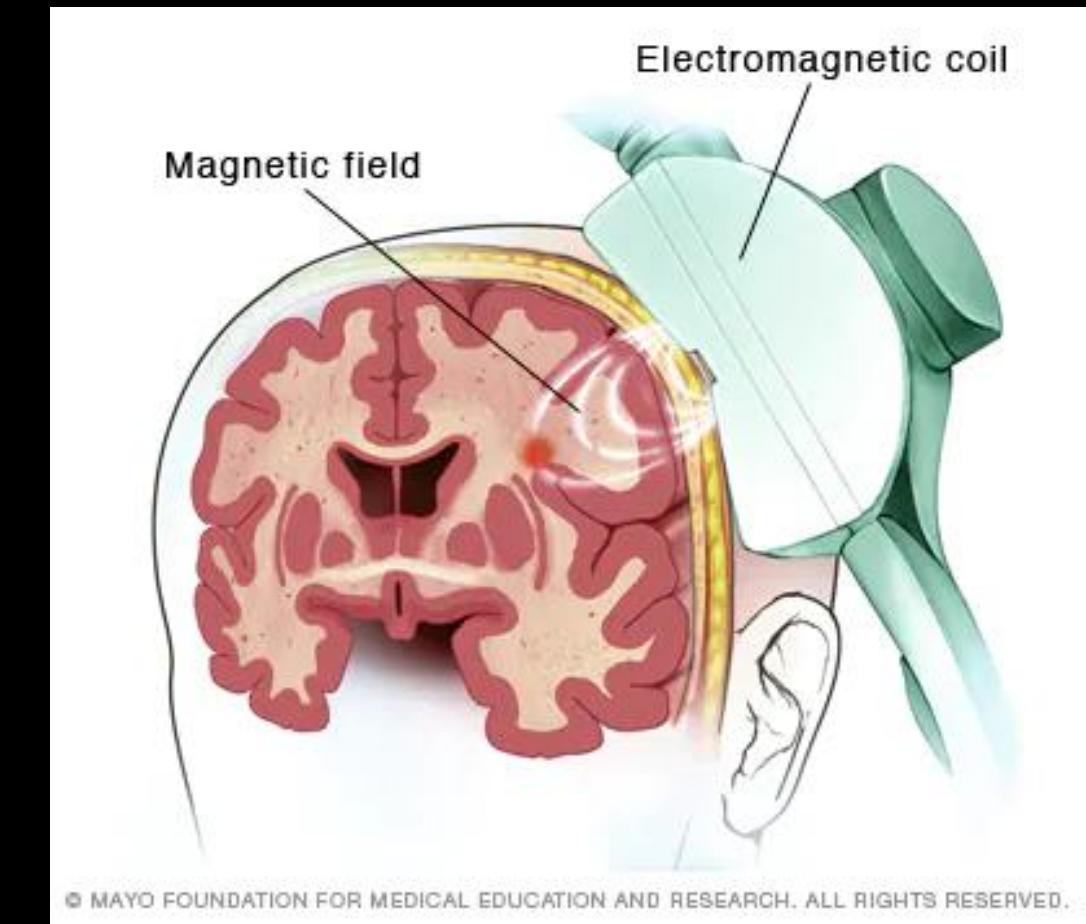
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Brain Stimulation

NON-INVASIVE (continued)

Brain Stimulation

NON-INVASIVE (continued)



Applications

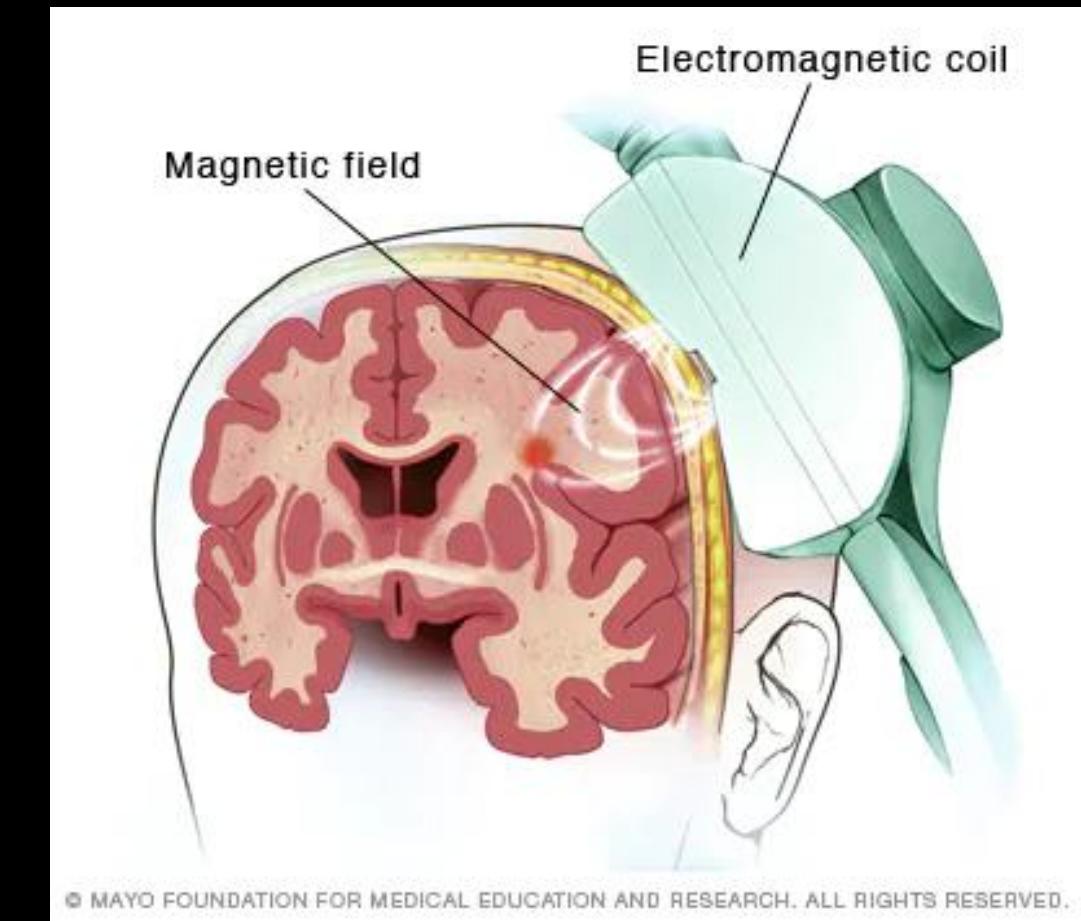
Transcranial Magnetic Stimulation (TMS)

Electromagnetic induction of electric current in brain regions via external coil stimulator

- Obsessive Compulsive Disorder treatment (FDA approved)
- Smoking addiction treatment

Brain Stimulation

NON-INVASIVE (continued)



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Focused Ultrasound (FUS)

Surgical technology utilising ultrasound energy to target specific brain areas

- Create brain lesions (FDA approved treatment for Parkinsonian tremor)
- Open blood-brain barrier

03 Future Progressions

03 Future Progressions

The goals of the field

Brain / Neural Computer Interaction Horizon 2020 project outlined the following as feasible and promising themes:

- **restore** (e.g. unlocking the completely locked in)
- **replace** (e.g. BCI-controlled neuroprosthesis)
- **enhance** (e.g. enhanced user experience in video games)
- **improve** (e.g. upper limb rehabilitation)
- **supplement** (e.g. augmented reality glasses)
- **research tools** (e.g. decoding brain activity with real-time feedback)

03 Future Progressions

Longer term goals

Disease Diagnoses

BCI-driven Artificial Intelligence

Restoring vision

Curing Neuropsychiatric Disorders

Chronic pain, Anxiety, Depression, OCD, Eating Disorders....

Memory enhancement

Cognitive Augmentation

Emotion Detection
and Modulation

Speech Restoration

03 Future Progressions

Some Even Longer term goals

Accelerated Learning

**Subjective Time
Perception control**

Extended Neural Lifespan

Personality Modification

Consciousness Sharing/Mapping

04 ICL Neurotech

We were **founded last academic year** after meeting at different London-based Neurotech events

Last year we had everything from first year undergrads to final year physicists, to MRes Neurotech students in the committee

We are always open to new people joining the society, getting involved with our activities, and being a part of our committee!

04 ICL Neurotech

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Who are we?

04 ICL Neurotech

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Who are we?



Anish
President



Jared
President



Jiwoo
Secretary



Kelly
Treasurer

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Darius
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Dhanvanth
Publicity Officer

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Dhanvant
Publicity Officer



Aishwarya
Project Co-ordinator



Dameer
Project Co-ordinator



Asha
Podcast Officer



Apollo
Podcast Editor



Lara
Podcast Editor

04 ICL Neurotech

What do we do?

Talks

Workshops

Hackathon

Symposium

Podcast

Socials

Projects

04 ICL Neurotech

What do we do?

- Every week*
- Speakers from academia, business, or student-led talks

Some previous speakers:

- **Emil Hewage** (CEO and founder of BIOS health)
- **Andreas Schaefer** (Neuroscientist, Group Leader at the Francis Crick Institute, Co-Founder Paradromics)
- **Shlomi Haar** (Interdisciplinary neuroscientist and bioengineer, Researcher at Imperial)
- **Jane Ollis** (CEO and founder of MindSpire)

Talks

Workshops

Hackathon

Symposium

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04 ICL Neurotech

What do we do?

- Teach people about various aspects of Neurotechnology
- Currently committee led but open to any students to run their own

Talks

Workshops

Hackathon

Symposium

Podcast

Socials

Projects

Some workshops we have planned:

- **Computational Neuroscience** (EEG signal cleaning and processing)
- **Introduction to Neurotech - this one!** (What is Neurotech, Introduction to the brain and the engineering behind interfacing with it)
- **Compression Challenge** (single workshop introduction to compressing neural data)

What do we do?

04 ICL Neurotech

Event(s) Announcement!

- Mid-January
- Two **London-wide** hackathons:
 - 1 - Open-to-all, no experience required hackathon
 - 2 - Smaller, selective hackathon in collaboration with **Entrepreneurs First**
- 4 different streams, 3 *practical* focused, 1 *ideation* focused
- Join hybrid (remote and in-person)*
- Form a team of up to four people

In collaboration with **NeuroTechX** and **Entrepreneurs First**

More details to come!

Talks

Workshops

Hackathon

Symposium

Podcast

Socials

Projects

* subject to decision

What do we do?

04 ICL Neurotech

Another Event Announcement!

We are running a **symposium** in collaboration with UCL

- 30th November
- UCL main campus
- 6 speakers - 3 from Imperial, 3 from UCL
- Careers panel for people wanting to go into Neurotech
- Poster competition
- Refreshments provided
- Covering a wide range of topics from **computational neuroscience** to **molecular biology!**

More details to come!

Talks

Workshops

Hackathon

Symposium

Podcast

Socials

Projects

04 ICL Neurotech

What do we do?

- Podcast interviews with professors, researchers, entrepreneurs, leaders in the field
- Run by our Podcast Officer, Asha



In the past we have interviewed:

- **Tim Constantinou** (Professor in the Bio-Engineering department at Imperial, Founder of MintNeurotechnologies)
- **Andreas Schaefer** (Group Leader at Francis Crick Institute)
- **Pedro Mediano** (Professor of Neural Dynamics in Computing department at Imperial)

Talks

Workshops

Hackathon

Symposium

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Projects

04 ICL Neurotech

What do we do?

- **After Thursday's events** we head to 568 or the Union Bar to chat all things neurotech
- Everyone welcome!
- Organised by our Events Officer, Elif

We have some more events planned for the year:

- **Neurotech Movie Night** - Watch movies related to the field, including Big Hero 6, Minority Report, and The Matrix!
- **Conference Trips** - Travel with the society to a Neurotech-related conference*
- **Picnics, Pubs, and more**

Talks

Workshops

Hackathon

Symposium

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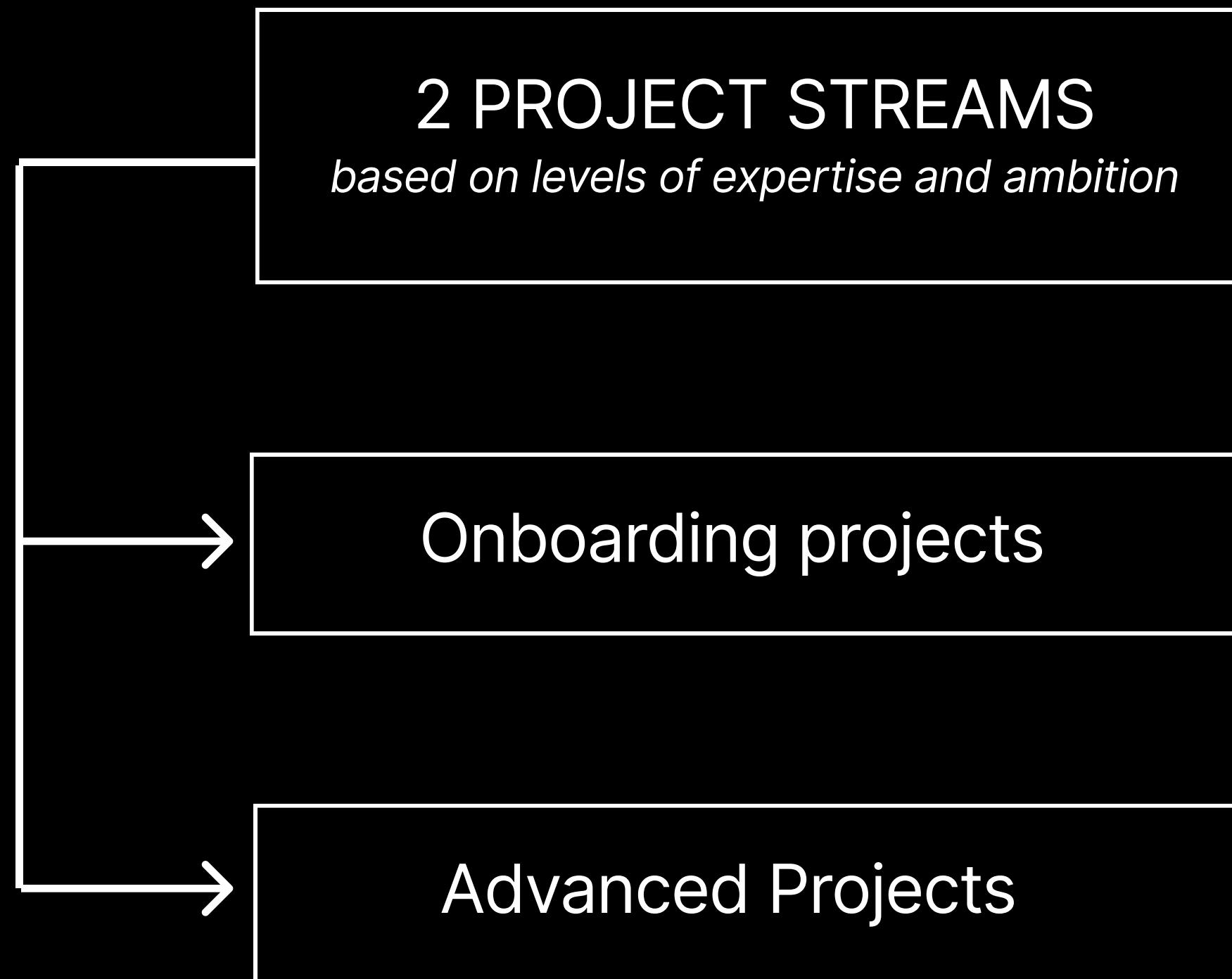
Projects

Projects

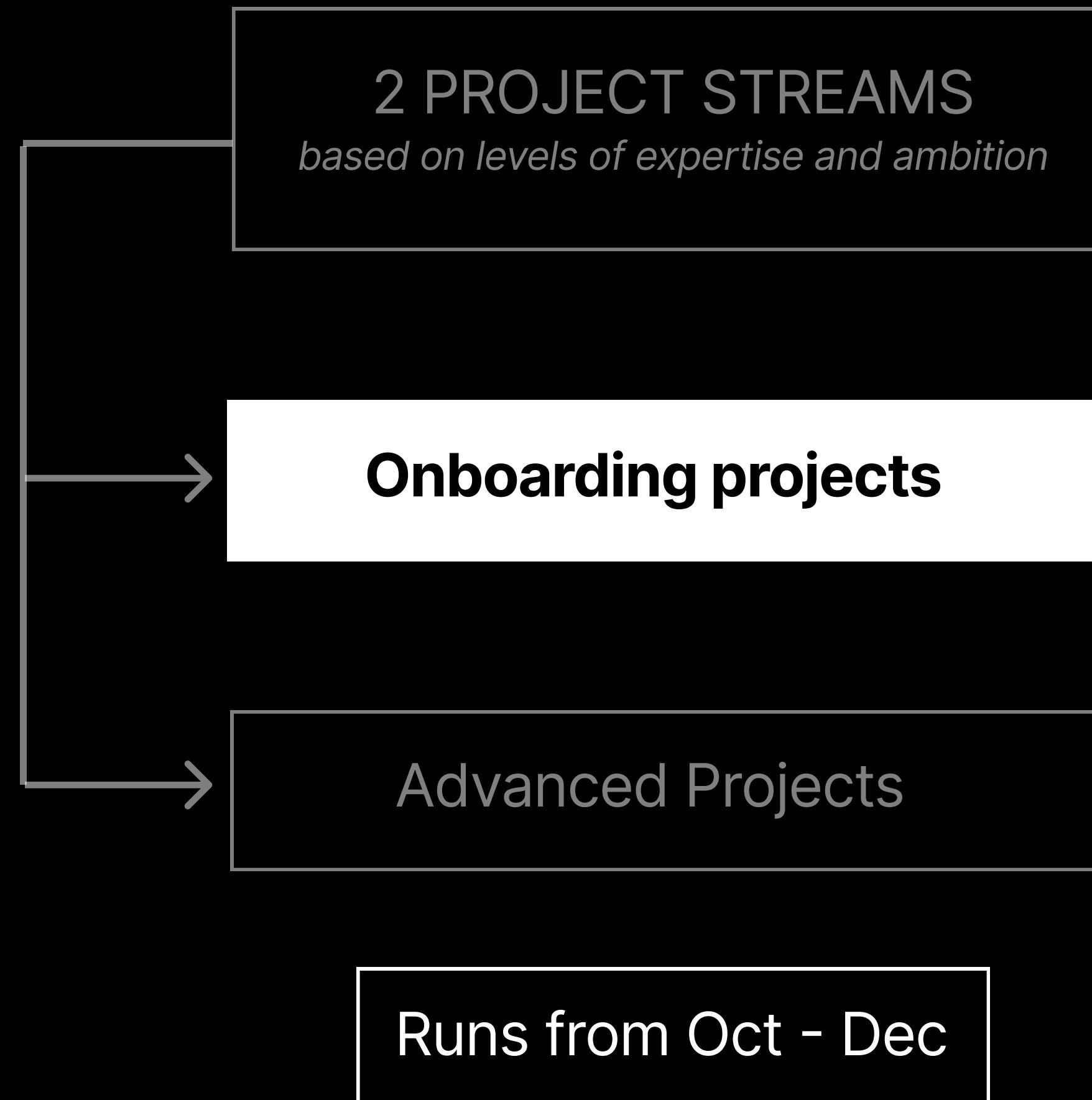
Getting your hands dirty!



01 Project Streams



01 Project Streams



- Handpicked group study
- A thorough guided course
- Emphasis on an enjoyable and engaging learning experience

Begins this October!



01 Project Streams

2 PROJECT STREAMS

based on levels of expertise and ambition

Onboarding projects

Advanced Projects

Occur throughout the year, potentially leading to competitions and hackathons



Hackstarter Grand Final Event

At the end of the programme, selected teams will present their developments at a mini symposium with a judging panel picking the winners and runners up. Those chosen will receive:



Winning Team

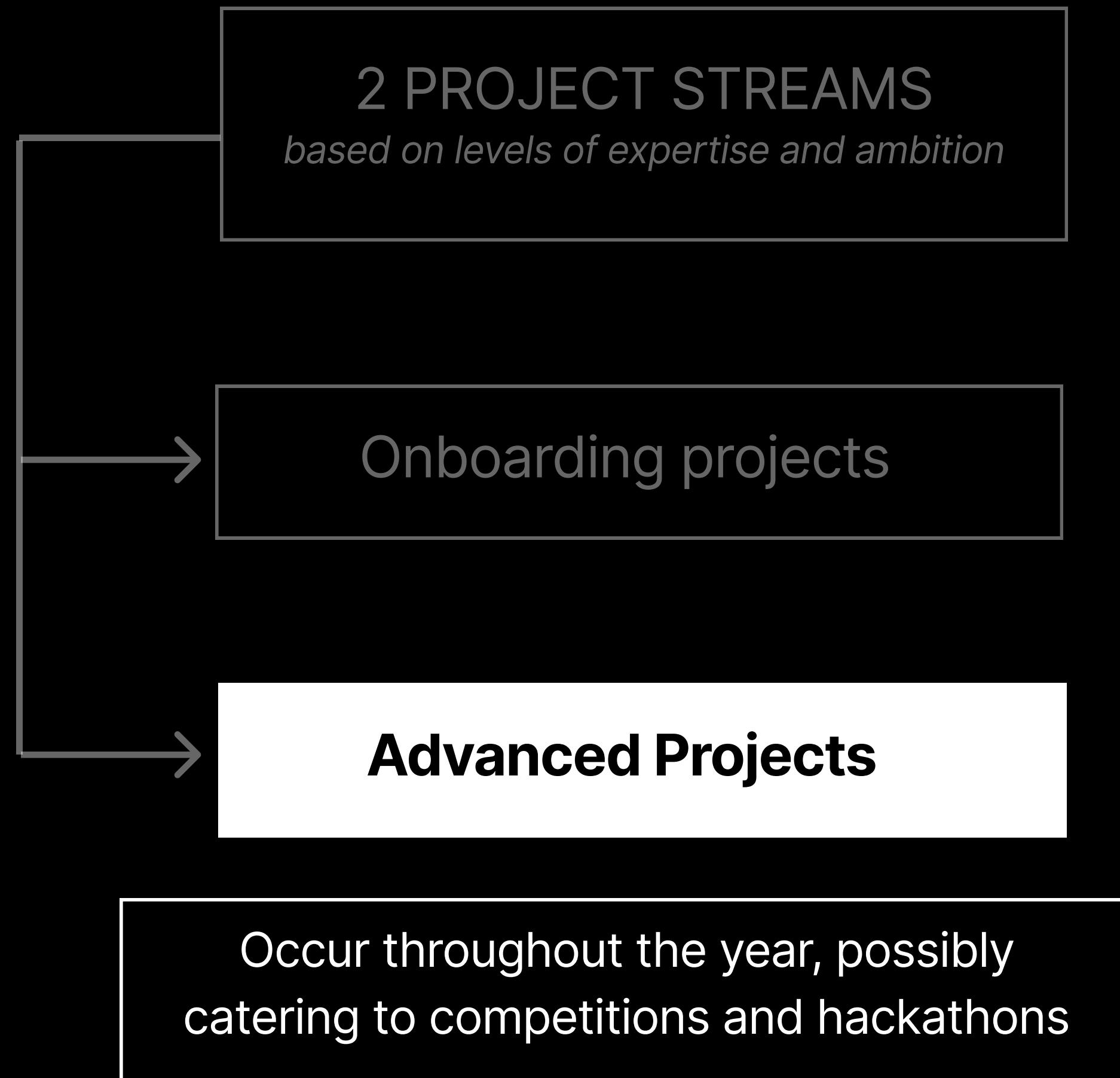
- Additional £2,500 Hack Credits to further develop the winning project
- Hackstarter Trophy
- Winners Certificates for each group member



Runners-up Teams

- Additional £500 Hack Credits to further develop their projects
- Runners-up Certificates for each group member

01 Project Streams



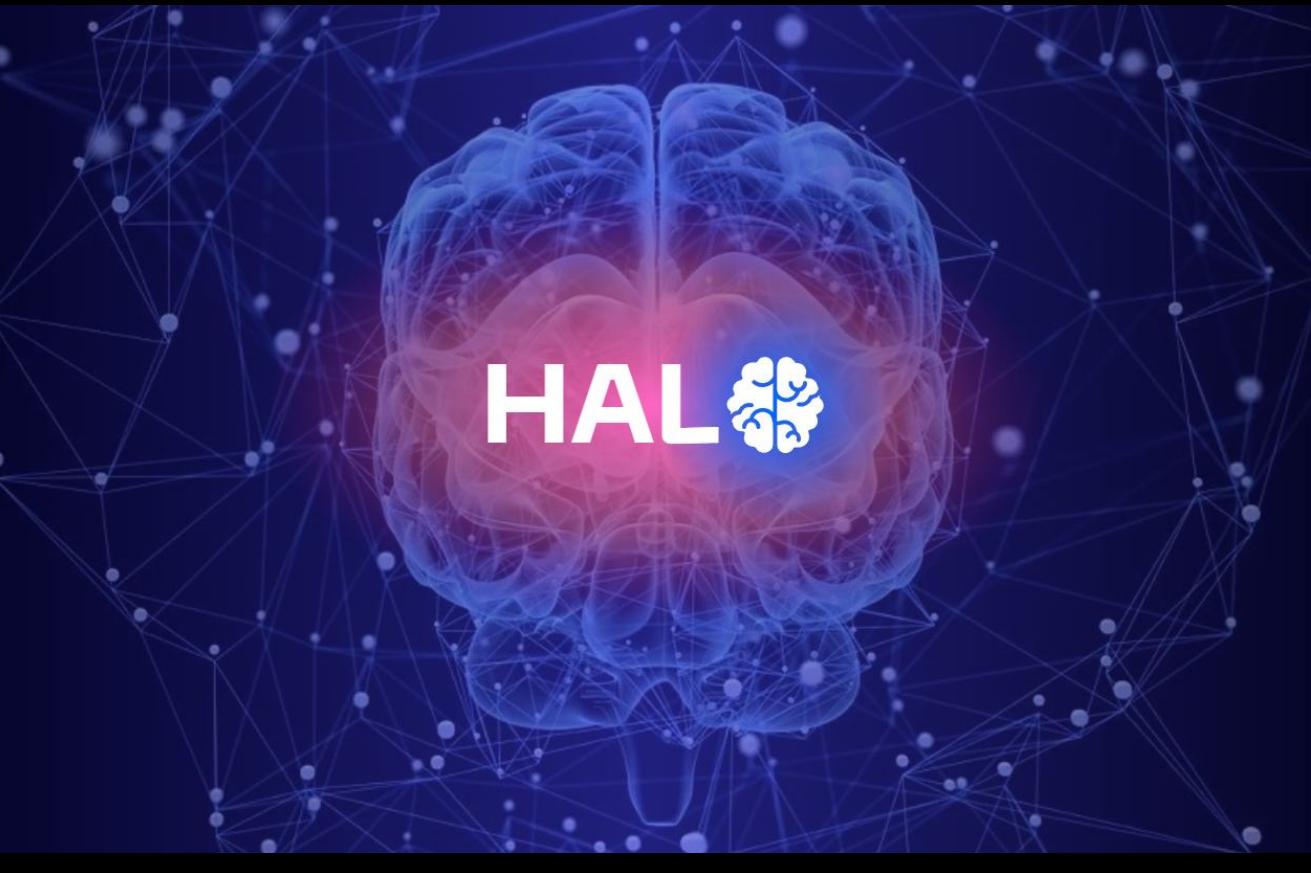
WE NEED YOUR IDEAS!



Everyone is welcome, **regardless** of their expertise, relevance of interests, or the stage of their ideas.

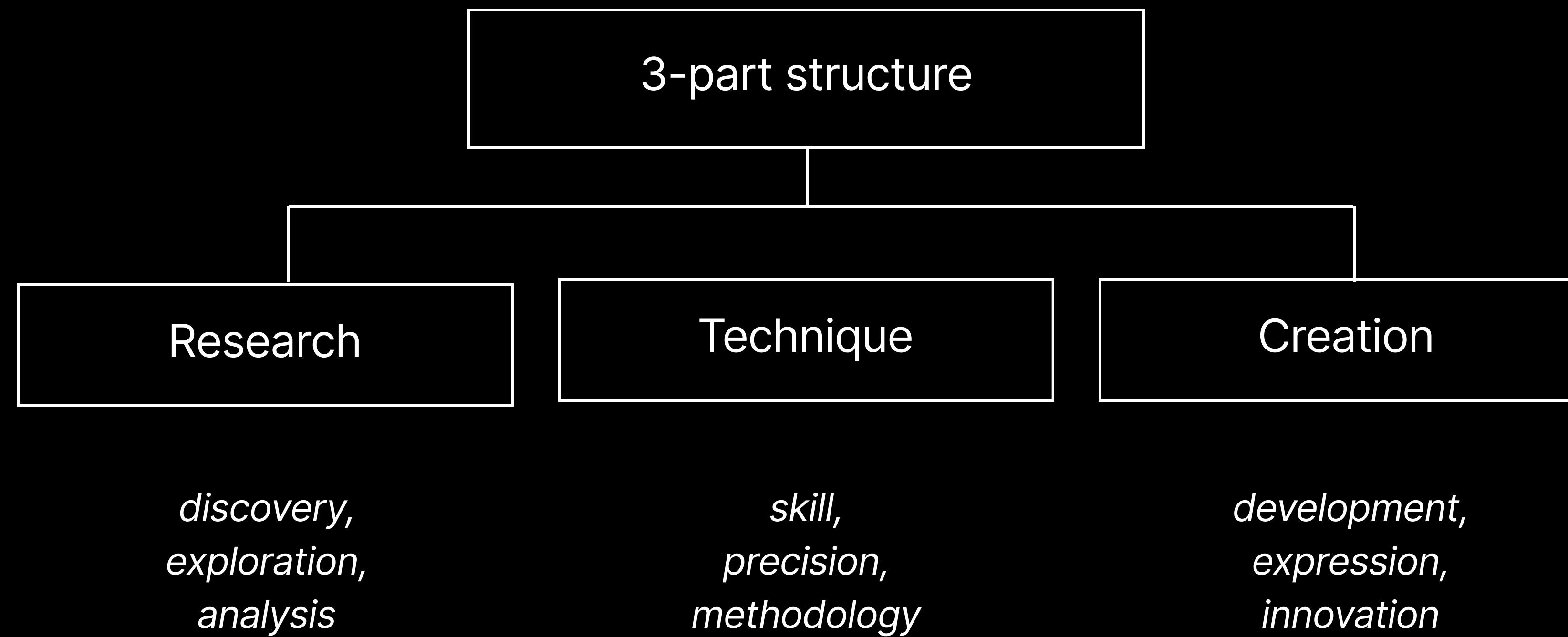
02 What we've done so far

... and what you can
look forward to!



Photos from the Grand final of Imperial's Hackstarter event

03 Project Structure



03 Project Structure

GROUP FORMATION

HOLISTIC groups of 4-5

- Leadership
- Coding
- Creativity

03 Project Structure

GROUP FORMATION

HOLISTIC groups of 4-5

- Leadership
- Coding
- Creativity

QR Code to choose timings and
group partner preferences



We want to empower you to lead your projects

04 What we need from you

We are a community-driven society.

04 What we need from you



DEADLINE: 17th OCTOBER 2024

05 What's next



05 What's next

Continue the **Introduction to Neurotech** workshops series:

Neurotech 102: The Brain

- The **basics of neuroscience** - how the brain processes information
- Whistlestop tour through brain regions and key responsibilities
- **Open questions in neuroscience** that are pivotal for the advancement of Neurotechnology (e.g., *memory encoding, consciousness, neural plasticity*)
- Highlights on ongoing research



Neurotech 103: The Job Market

- Understanding the landscape of companies and start-ups in the space
- Explore the *cutting edge* of business-destined scientific developments
- **Career opportunities** in Neurotech (what roles are emerging, what skillsets are needed)
- How to **stay updated on industry developments**

05 What's next



**Our next speaker is *Dr. Hayriye Cagnan*
'Brain Rhythm Orchestrated Therapies'**

Next Thursday (October 17th) at 6pm

As a Senior Researcher at the Department of Bioengineering, Dr Cagnan's research focuses on developing theoretical tools and experimental approaches to understand how different brain regions control behaviour in health and disease, which are then applied to making therapies for neurological and psychiatric conditions.

Her talk on the 17th of October, '**Brain rhythm orchestrated therapies**', focuses on her work on developing and testing stimulation-based therapies, which aim to help patients overcome neurological conditions.

06 Join us



Thank you!