

# **The prospects of brain-computer interfaces in communication for disabled children**

Waynflete evening presentation

Tahmid Azam

This project is dedicated to my brother, Tahsin

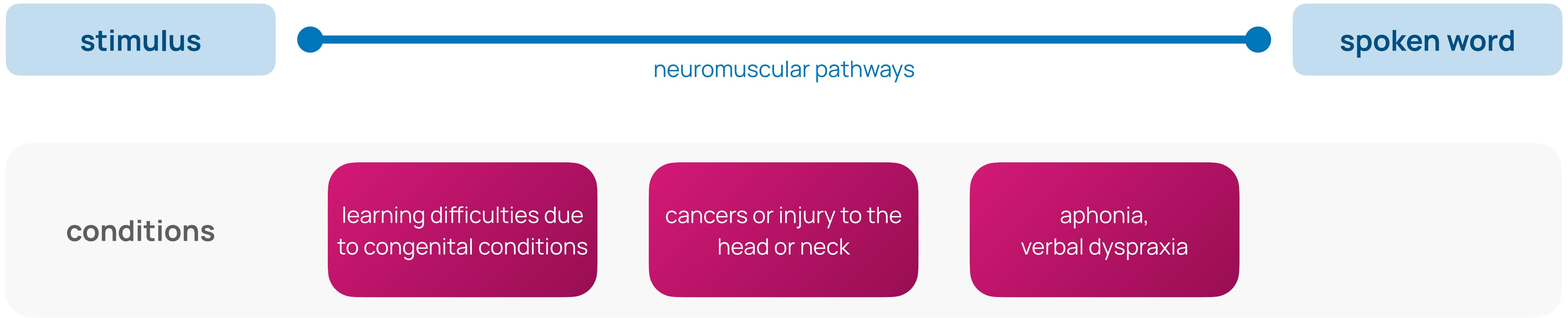
February 3rd 2023

Speech, language, and communication needs (SLCN) describes an individual for whom spoken language is insufficient for supporting conversation and peer interaction.

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Speech, language and communication needs (SLCN)

# Conditions that cause SLCN affect the coordination of responses to stimuli



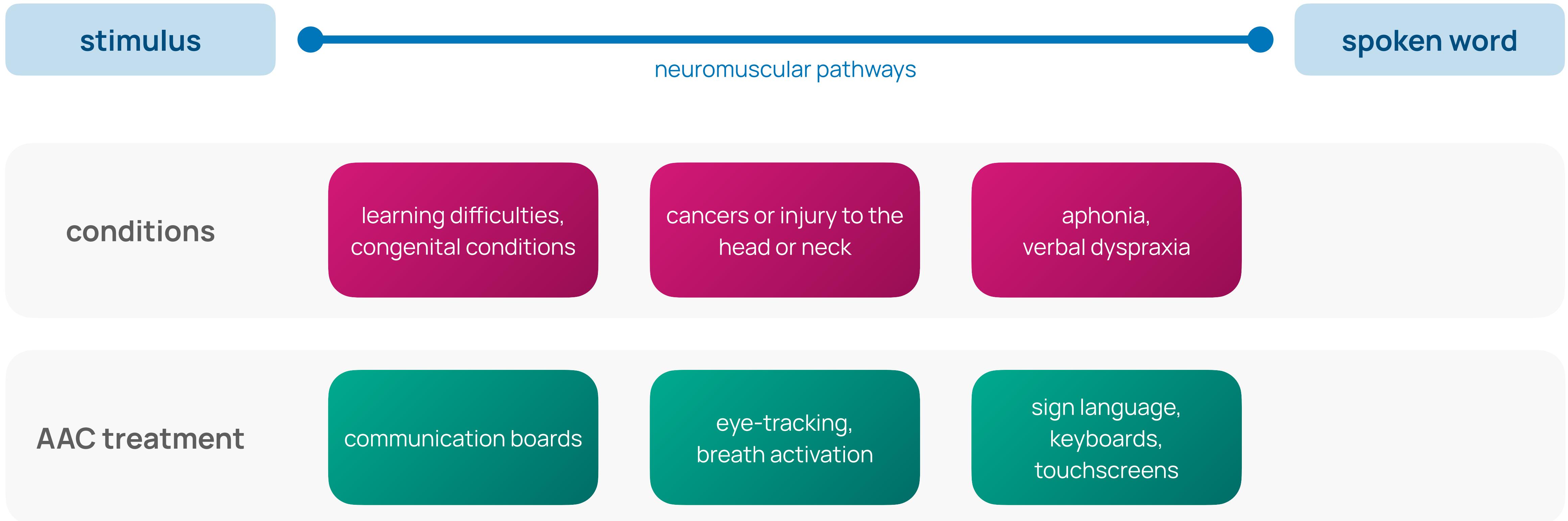
**SLCN is the most common special education need at school entry and can severely affect development**

2 pupils in every primary school class

universal obstruction to social, emotional and educational development

affects children's sense of self and identity

# Augmentative and alternative communication (AAC) systems attempt to break down the barriers of SLCN

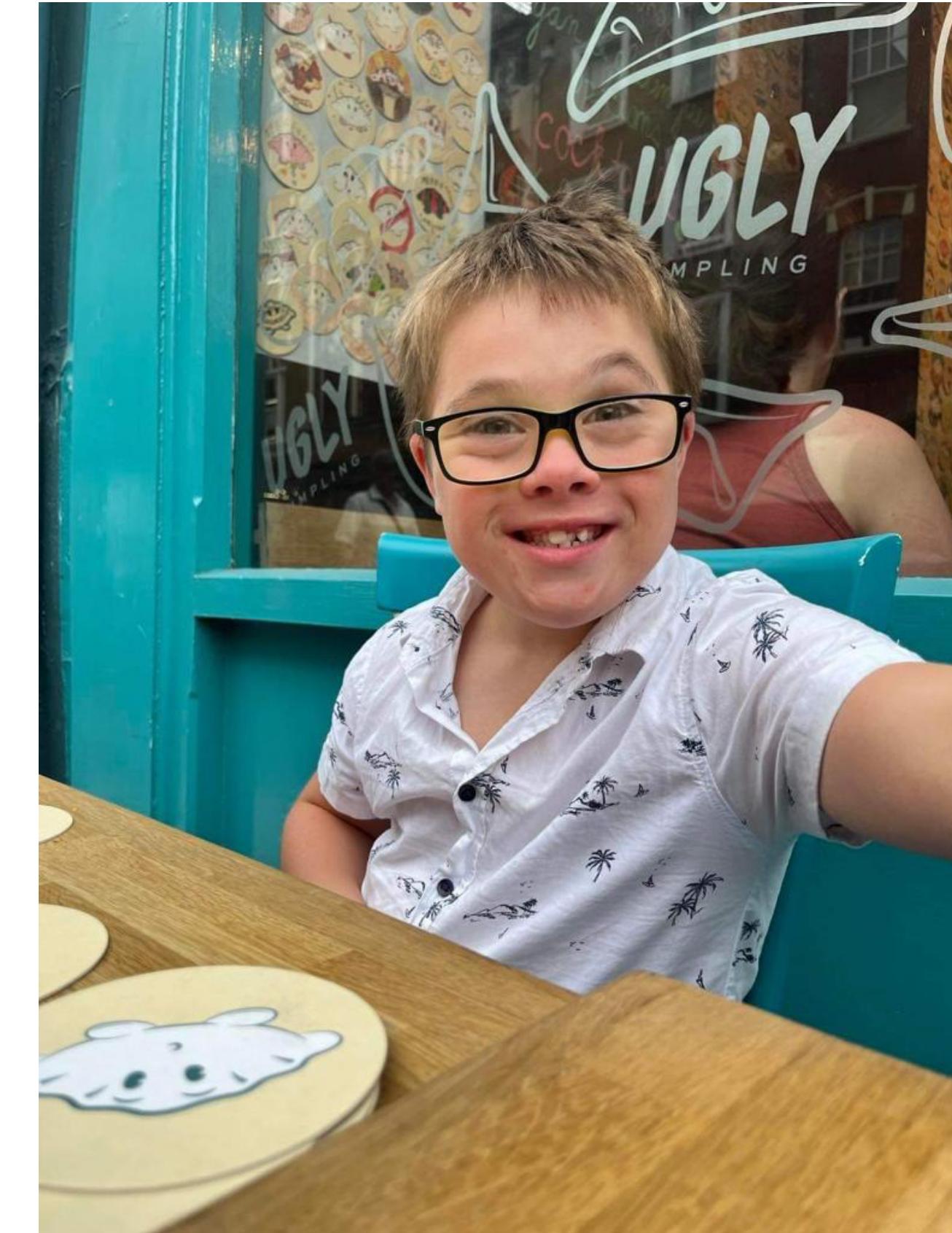


Augmentative and alternative communication (AAC) systems

# Without AAC, children are little understood and often underestimated

Amos (pictured right) has Down's syndrome and verbal dyspraxia

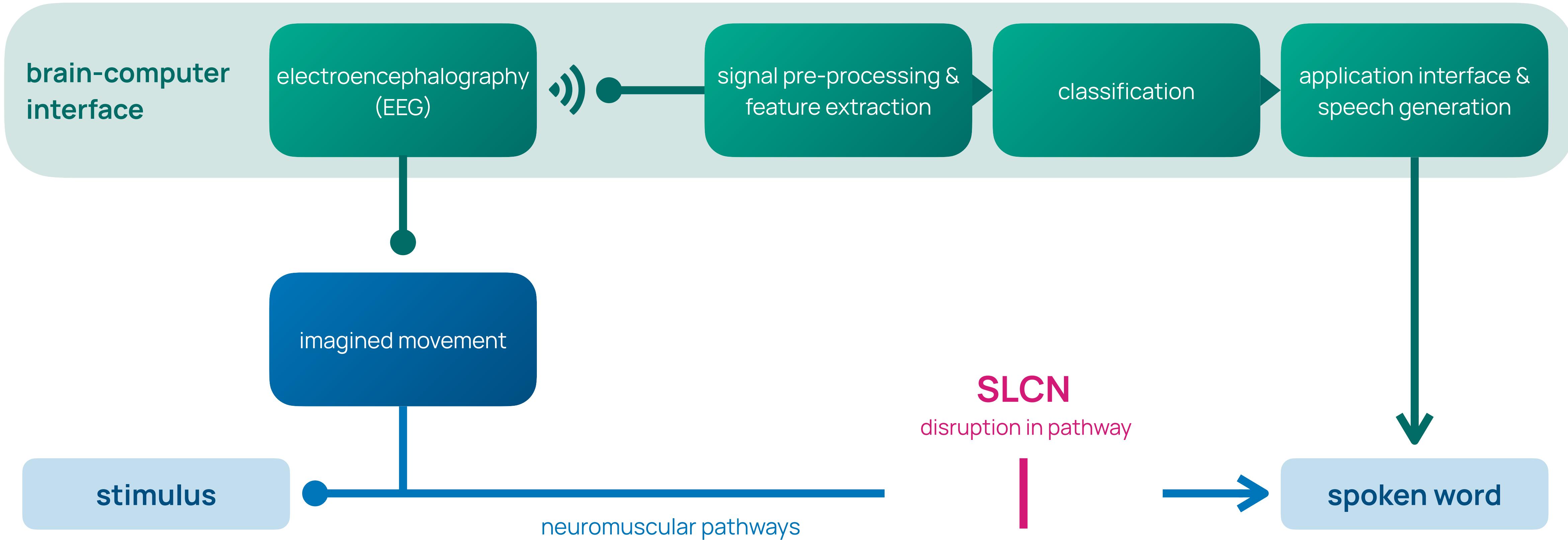
He uses sign language with a tablet-driven AAC



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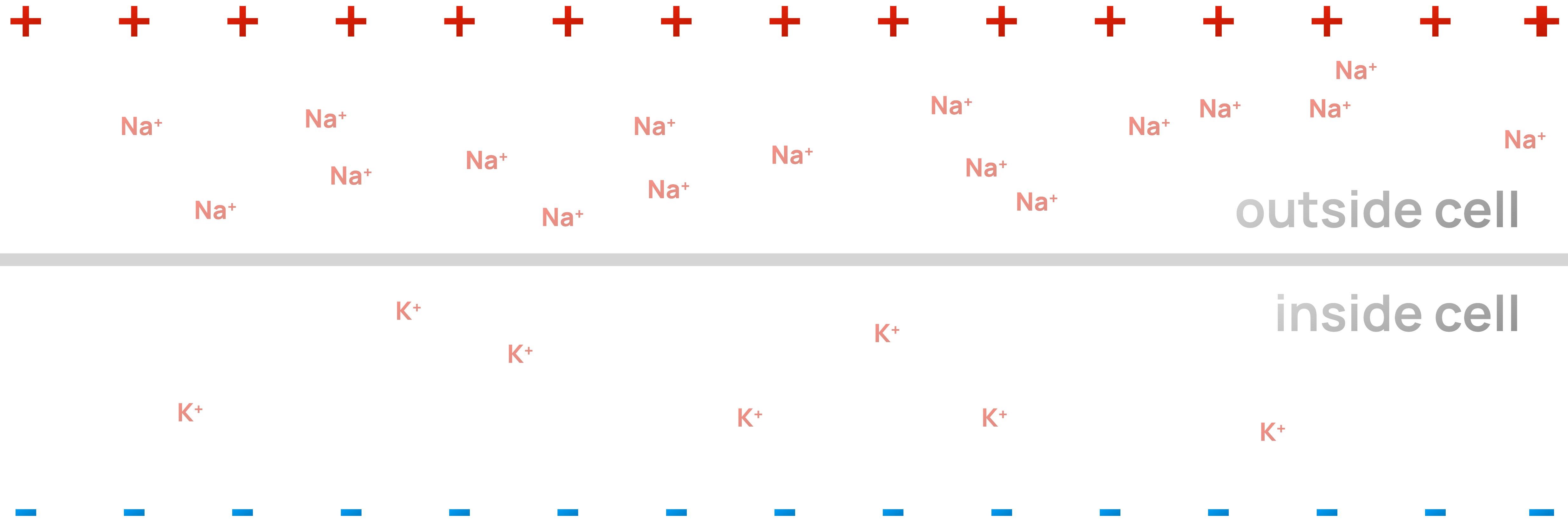
Augmentative and alternative communication (AAC) systems

# Brain-computer interface offer a universal, non-muscular channel for communication



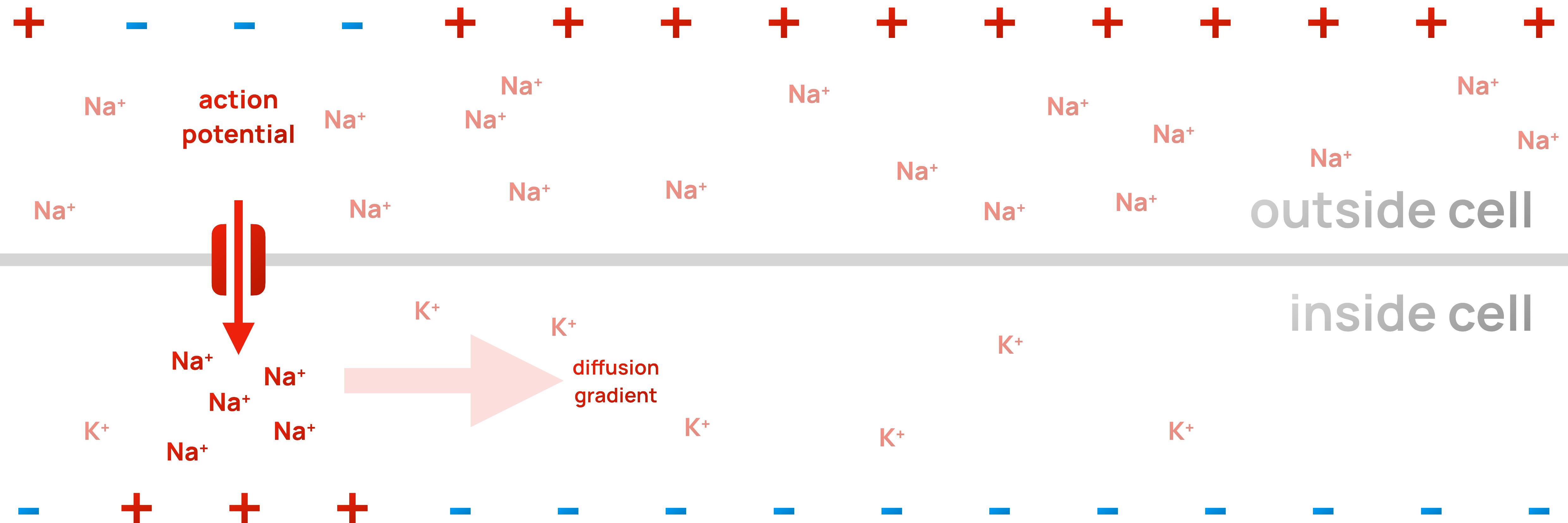
Brain-computer interfaces (BCI)

The brain is a forest of interconnected neurones that communicate via electrical impulses



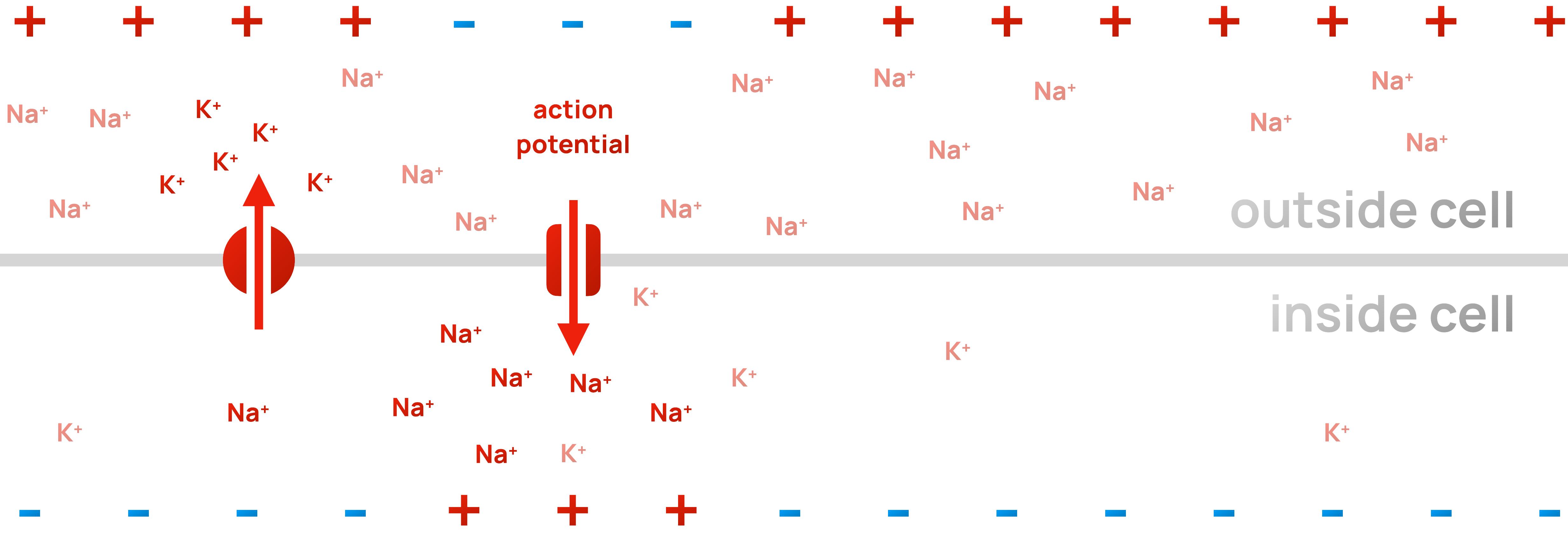
Electroencephalography (EEG)

The brain is a forest of interconnected neurones that communicate via electrical impulses



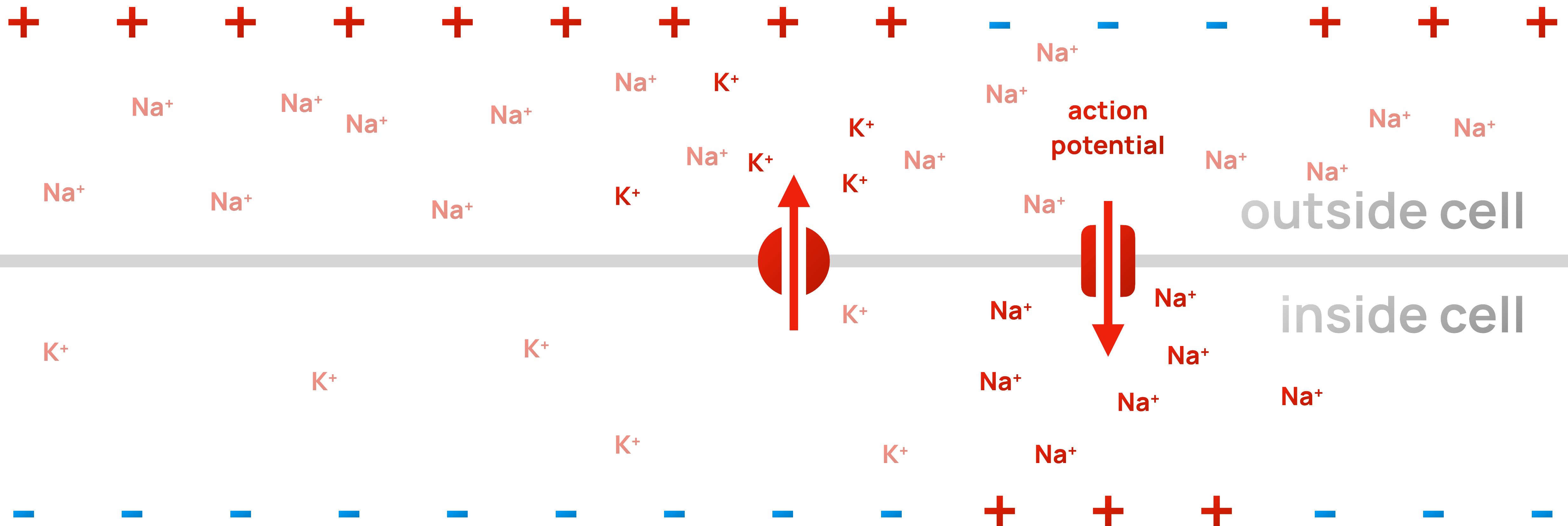
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Electroencephalography (EEG)

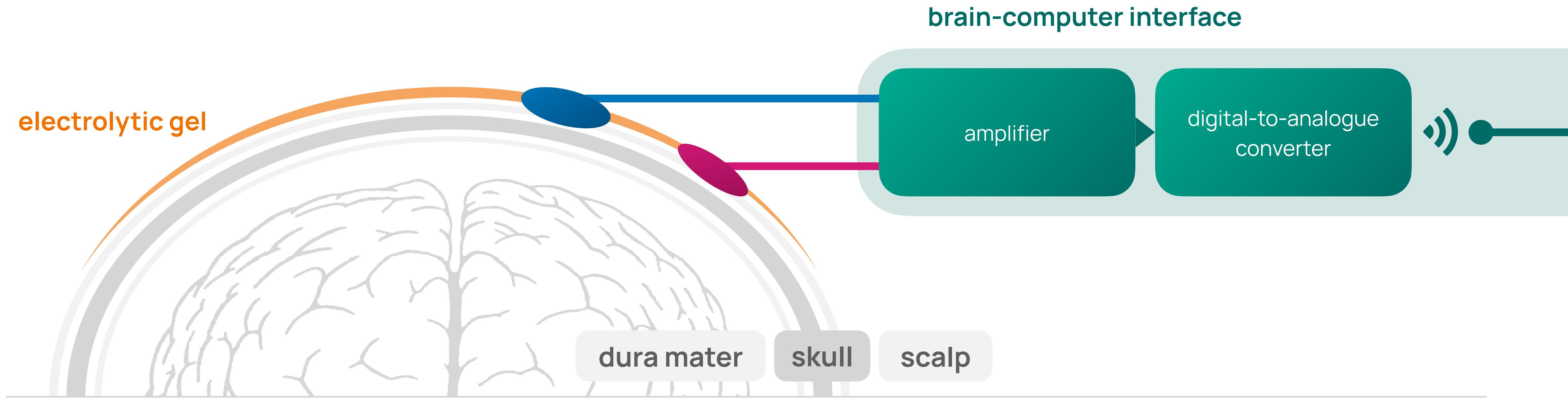
The brain is a forest of interconnected neurones that communicate via electrical impulses



Electroencephalography (EEG)

# Electroencephalography measures the electrical activity of the brain

Voltage between **active** and **reference** electrode is measured over time



Electroencephalography (EEG)

**EEG is the most viable brain imaging method for brain-computer interfaces, over fMRI and MEG**

## Advantages

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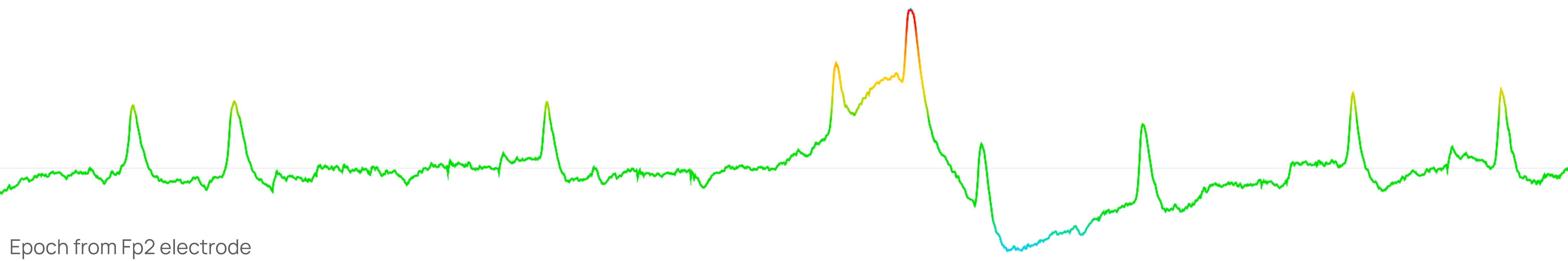
- low-cost
- power-efficient
- portable
- high time resolution

## Disadvantages

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- poor spatial resolution
- artefact prone

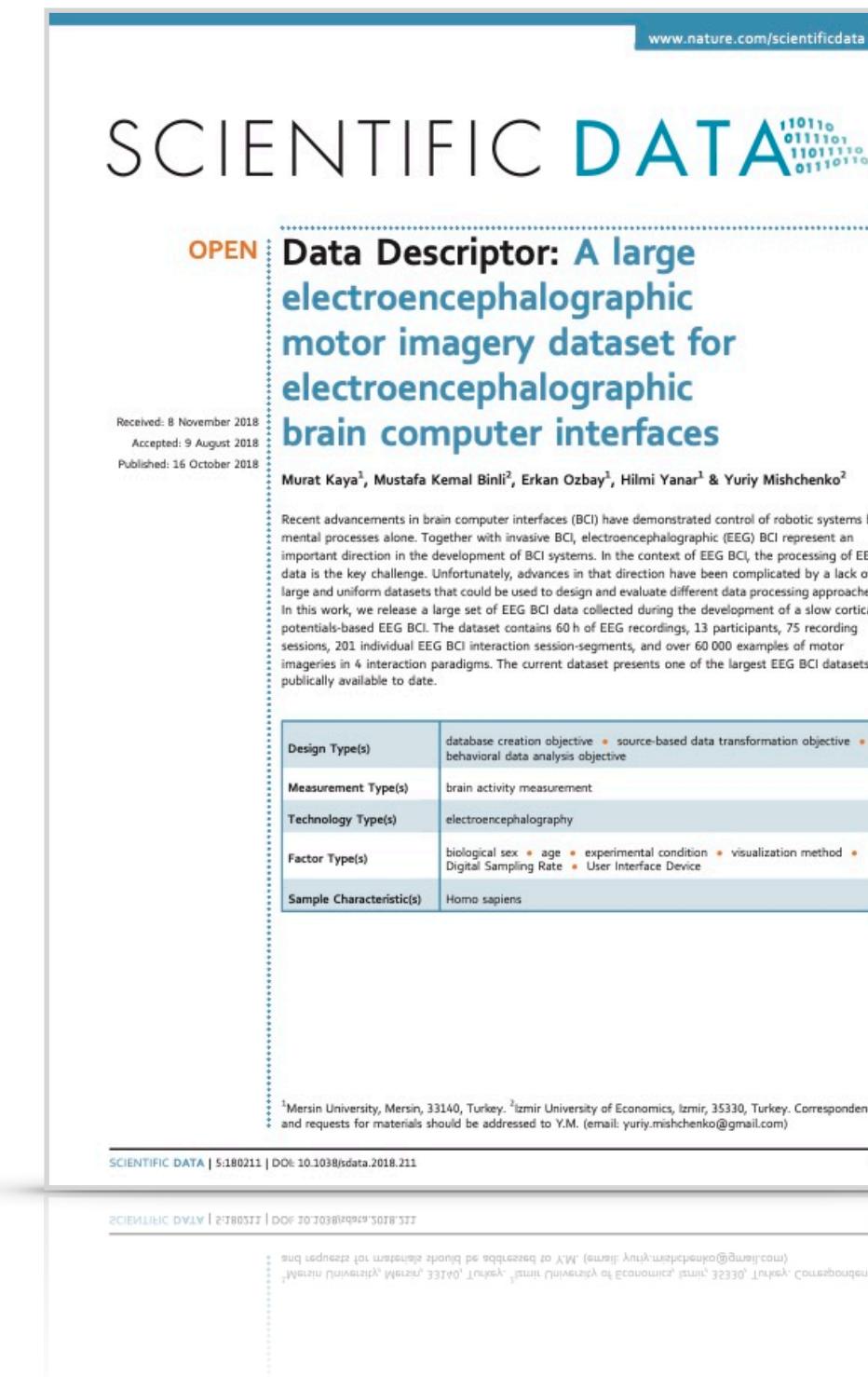
# Simultaneous action potentials are required for on-scalp voltages to be measurable



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Electroencephalography (EEG)

# A large set of data is needed to understand how EEG measurements respond to imagined movement



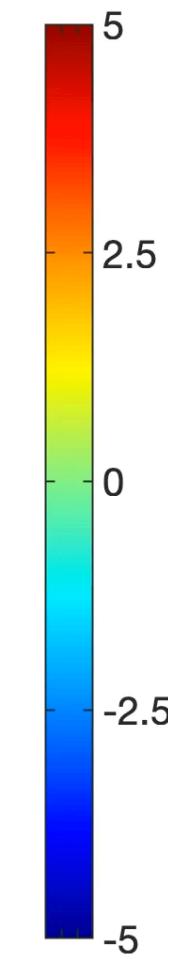
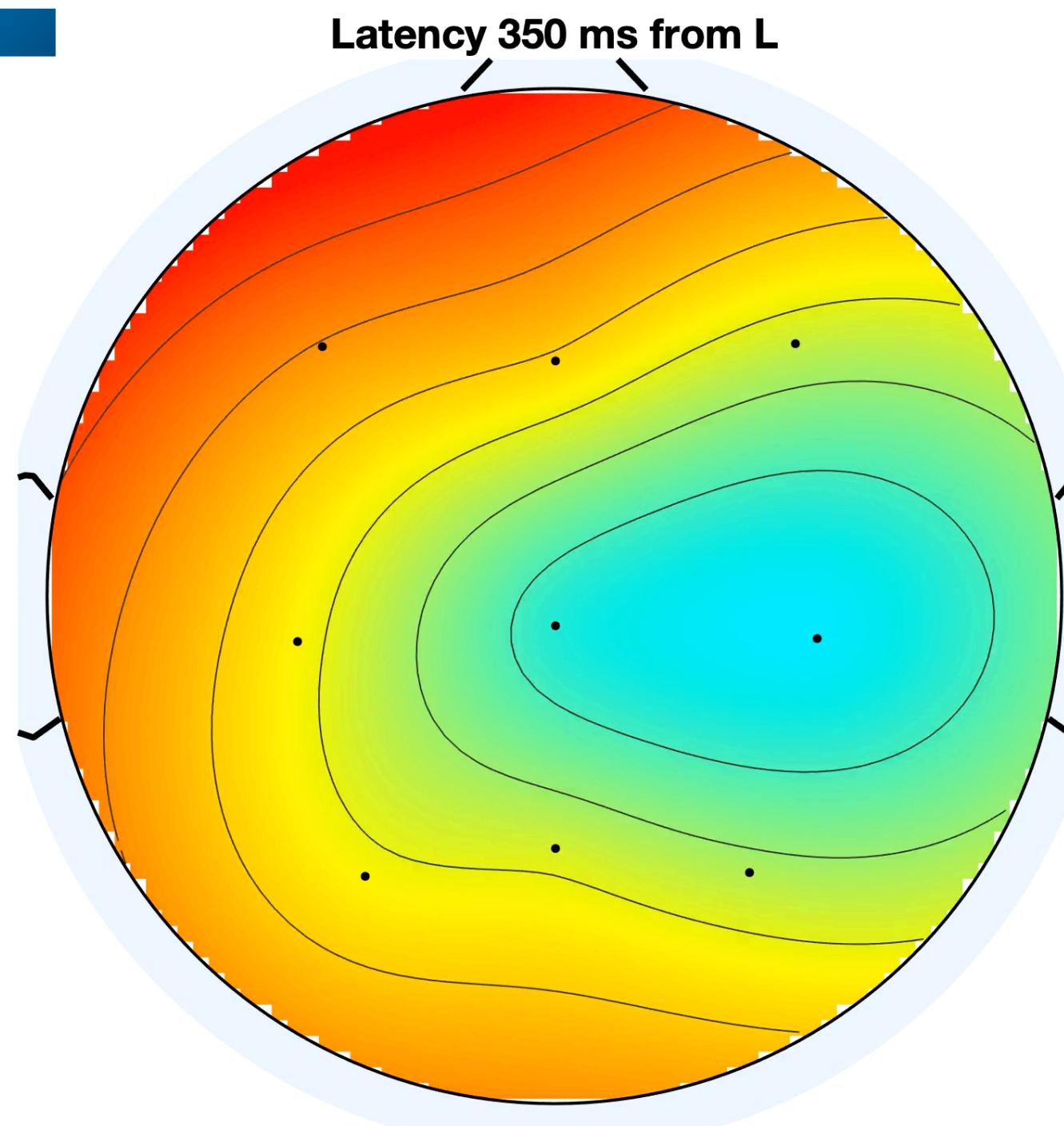
Kaya et. al

A large electroencephalographic motor imagery dataset for electroencephalographic brain computer interfaces

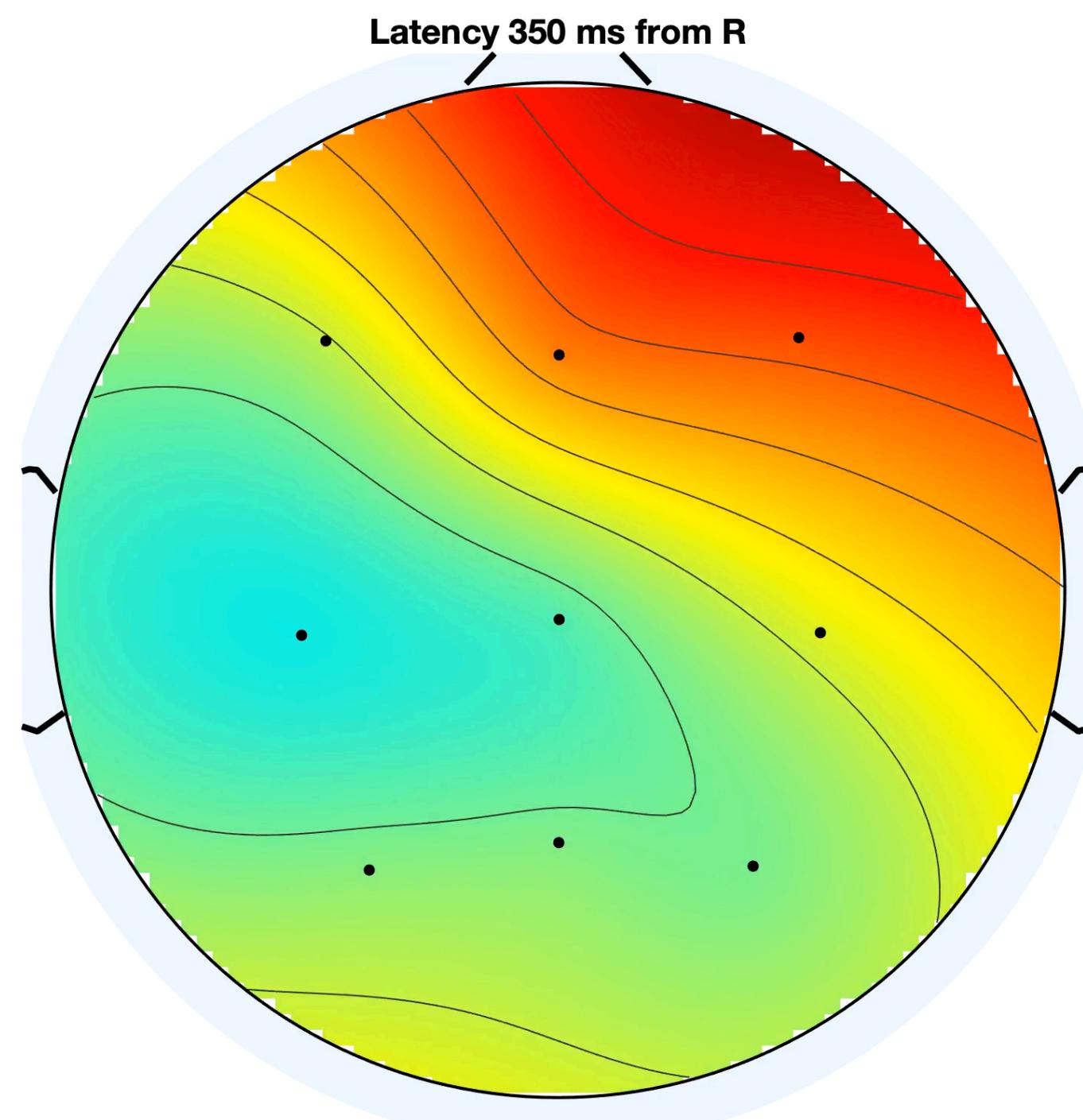
Electroencephalography (EEG)

# Color-based visualisation helps us recognise patterns in EEG recordings

L



Latency 350 ms from R

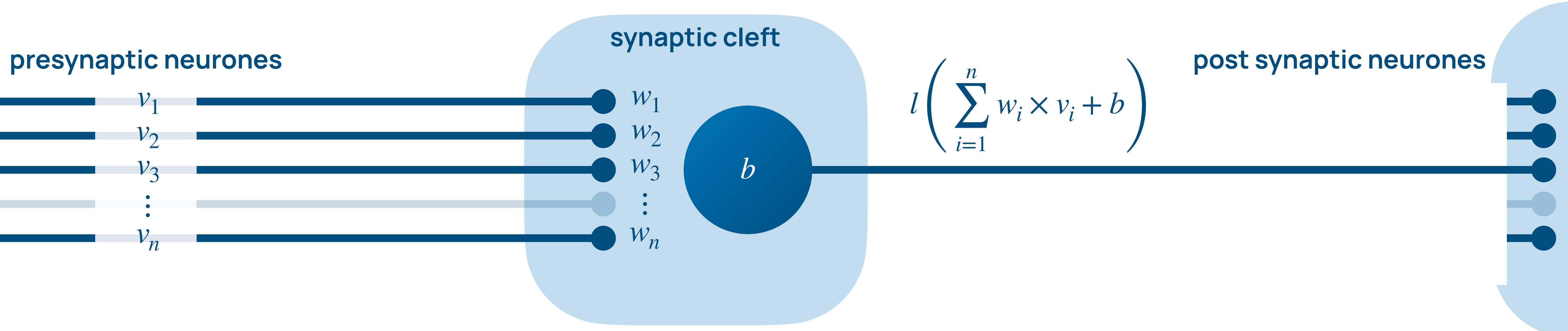


R

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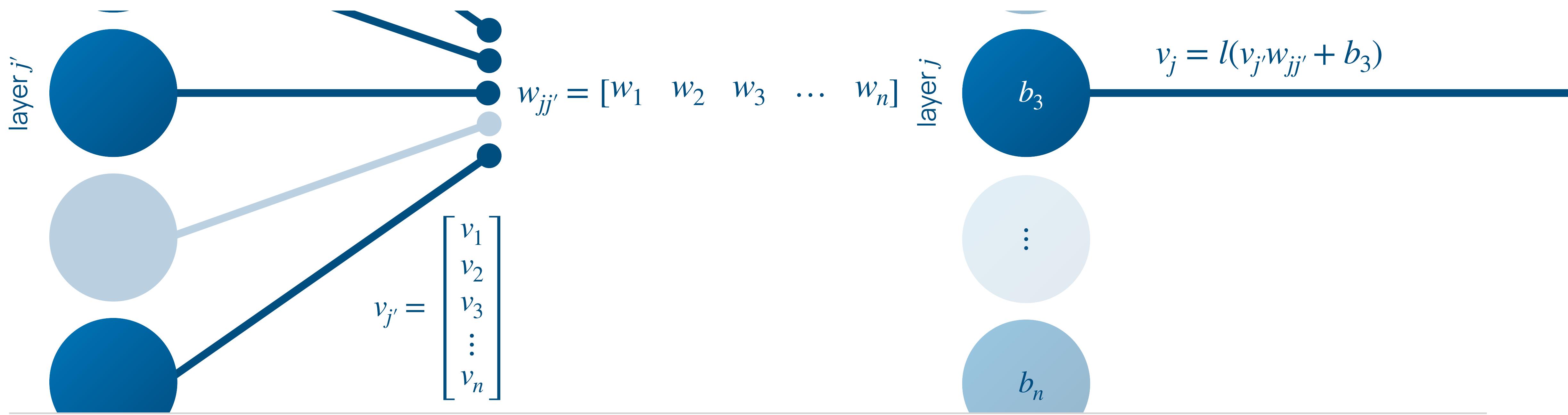
Electroencephalography (EEG)

# Neural network structure mimics interconnected web of neurones in our brains



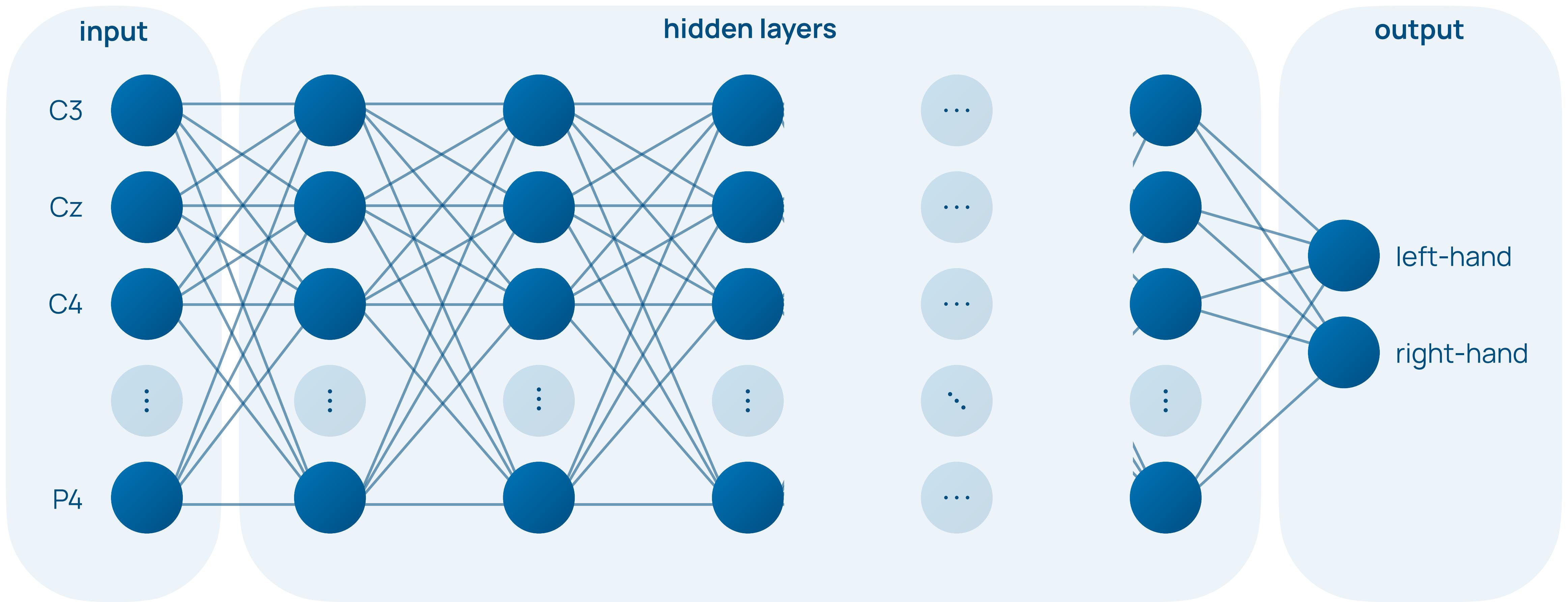
Unidirectional long short-term memory recurrent neural networks (LSTM RNN)

# Data is passed forward through layers of nodes



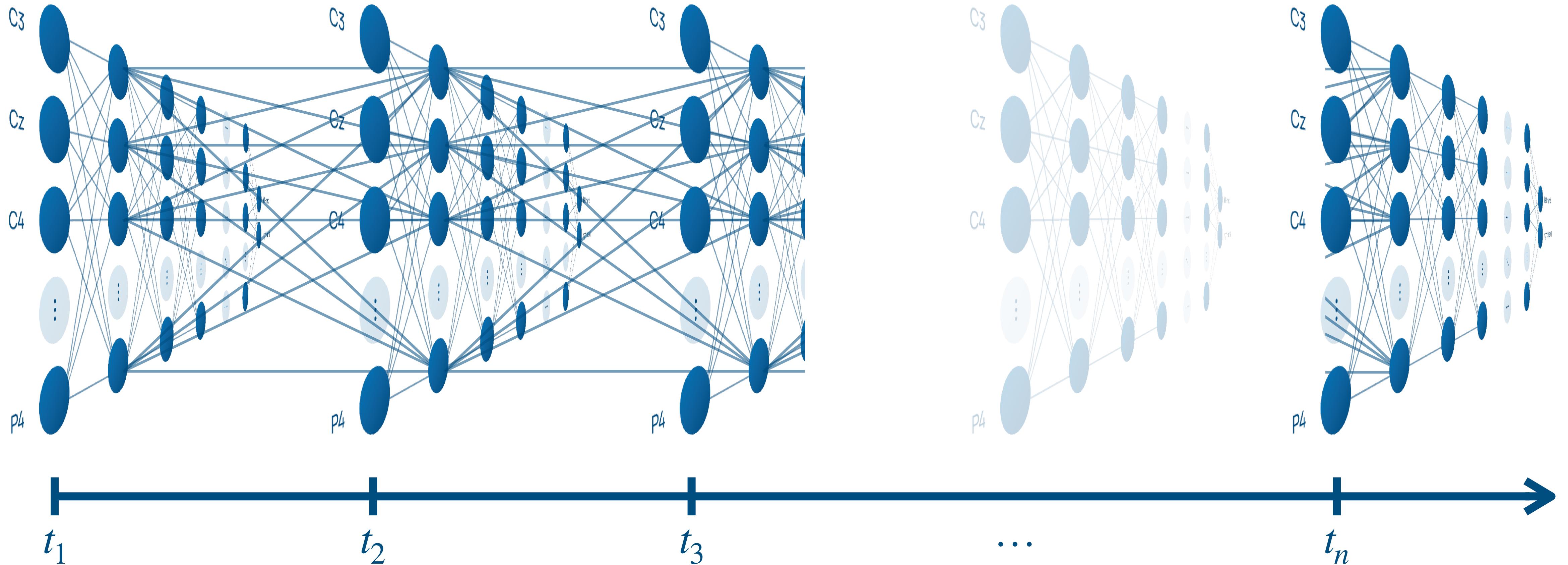
Unidirectional long short-term memory recurrent neural networks (LSTM RNN)

The neural network takes electrodes as input, hidden layers process their data and output a confidence for each class



Unidirectional long short-term memory recurrent neural networks (LSTM RNN)

# Recurrent neural networks connect the network across time steps



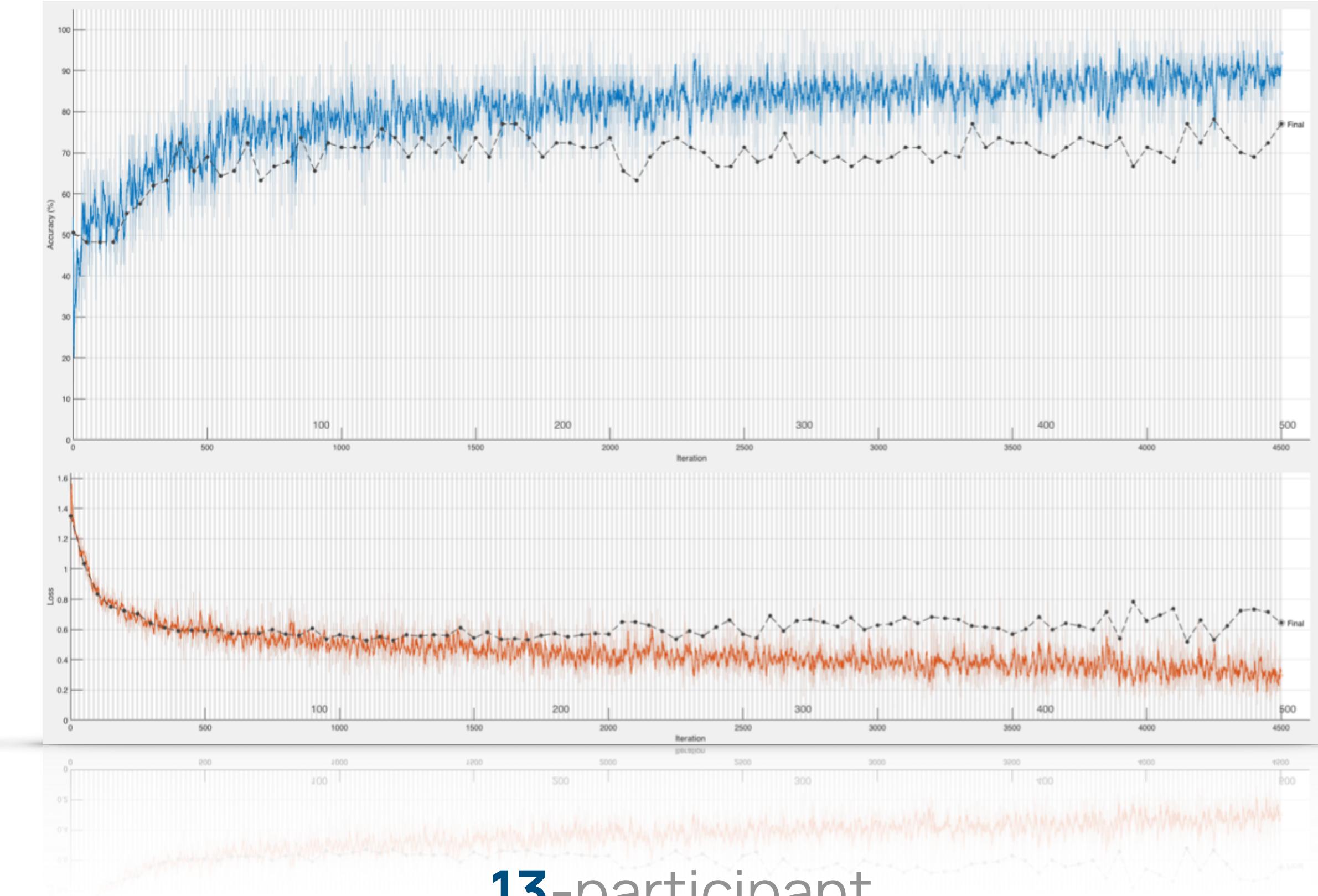
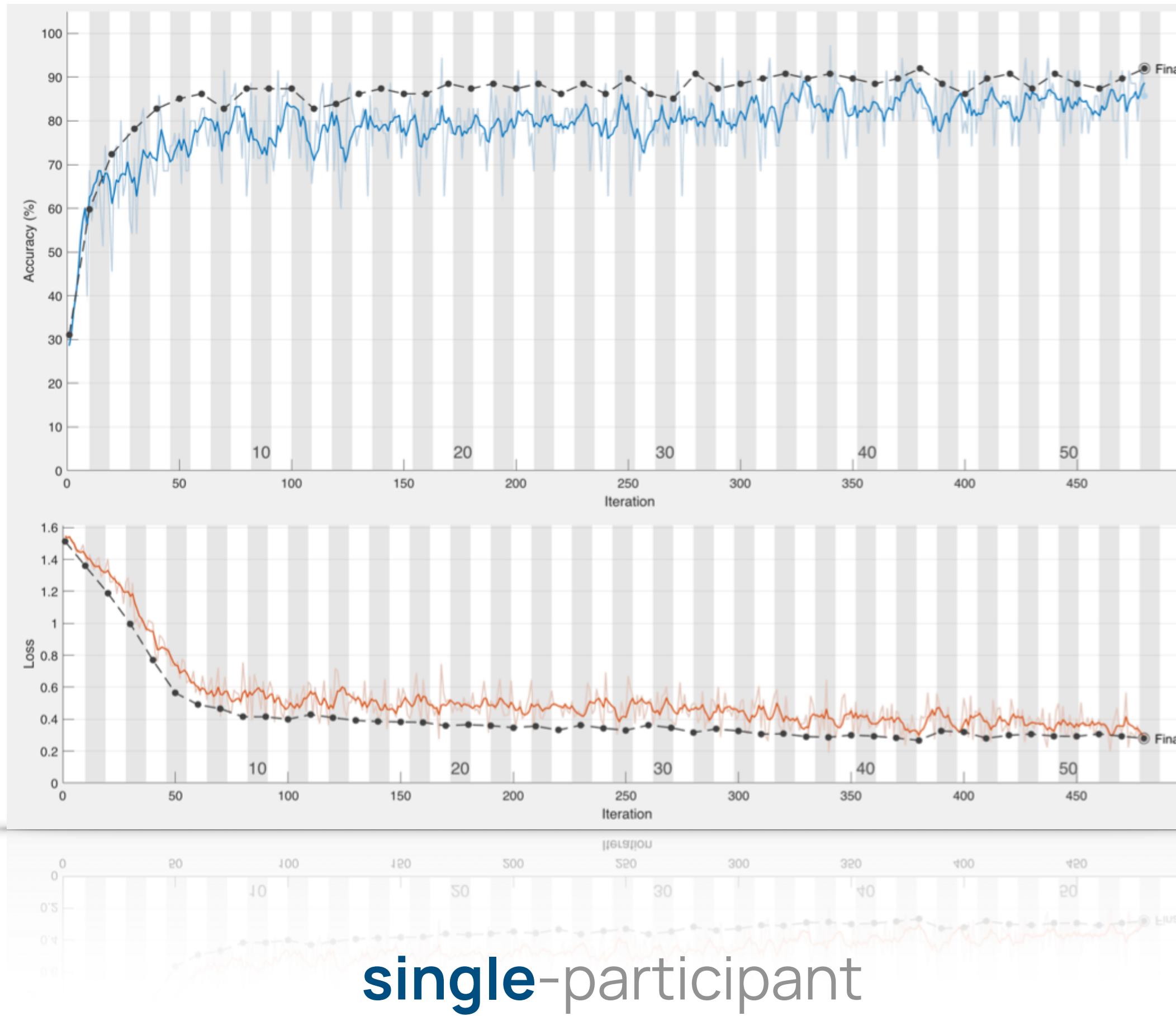
Unidirectional long short-term memory recurrent neural networks (LSTM RNN)

A loss function punishes distance to correct classification and is minimised in training the neural network



Training neural networks involves **minimising** this loss to **improve** accuracy

# As training progresses, loss is minimised and validation accuracy increases



Unidirectional long short-term memory recurrent neural networks (LSTM RNN)

# Patterns of motor imagery are conserved across individuals

**91.95%**

accuracy using a **single**-  
participant dataset

**77.01%**

accuracy using a **13**-participant  
dataset

# Conclusion

Speech, language, and communication needs can be mitigated by augmentative and alternative communication systems

Neural networks are fast and accurate classifiers of electroencephalographic brain data

However, EEG's spatial resolution is too low for an effective bit depth

# Acknowledgements

University of Oxford

Dr Zhu Tingting

mother of Amos

Emma Smith

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Acknowledgements

# Any questions?

Speech, language, and communication needs can be mitigated by augmentative and alternative communication systems

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Question period