Real Time Implementation Of AI In BCI Application

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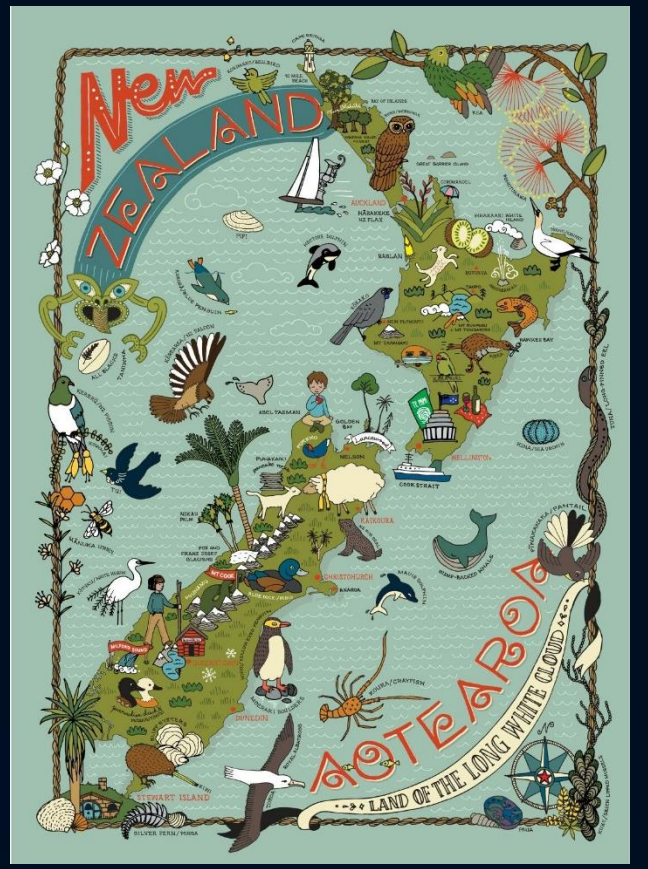
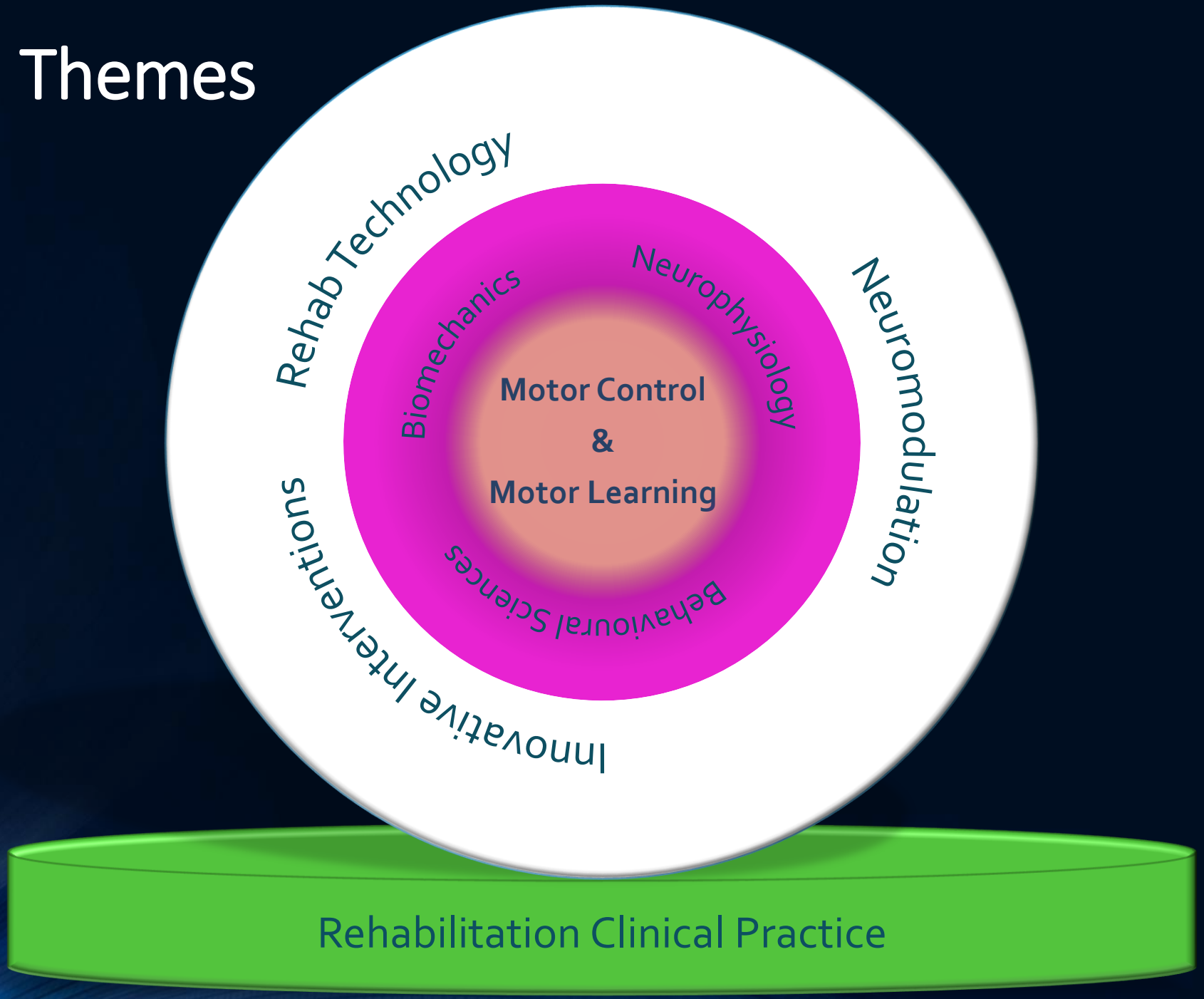


New Zealand College of Chiropractic

- Centre for Chiropractic Research
- 17 full-time research-only staff
  - Bioengineers
  - Electronic Engineers
  - Embedded system
  - Control system
  - Software engineers
  - Data scientists
  - Chiropractors
  - Physiotherapists
- 5 part-time
- 10 PhDs

Research Themes



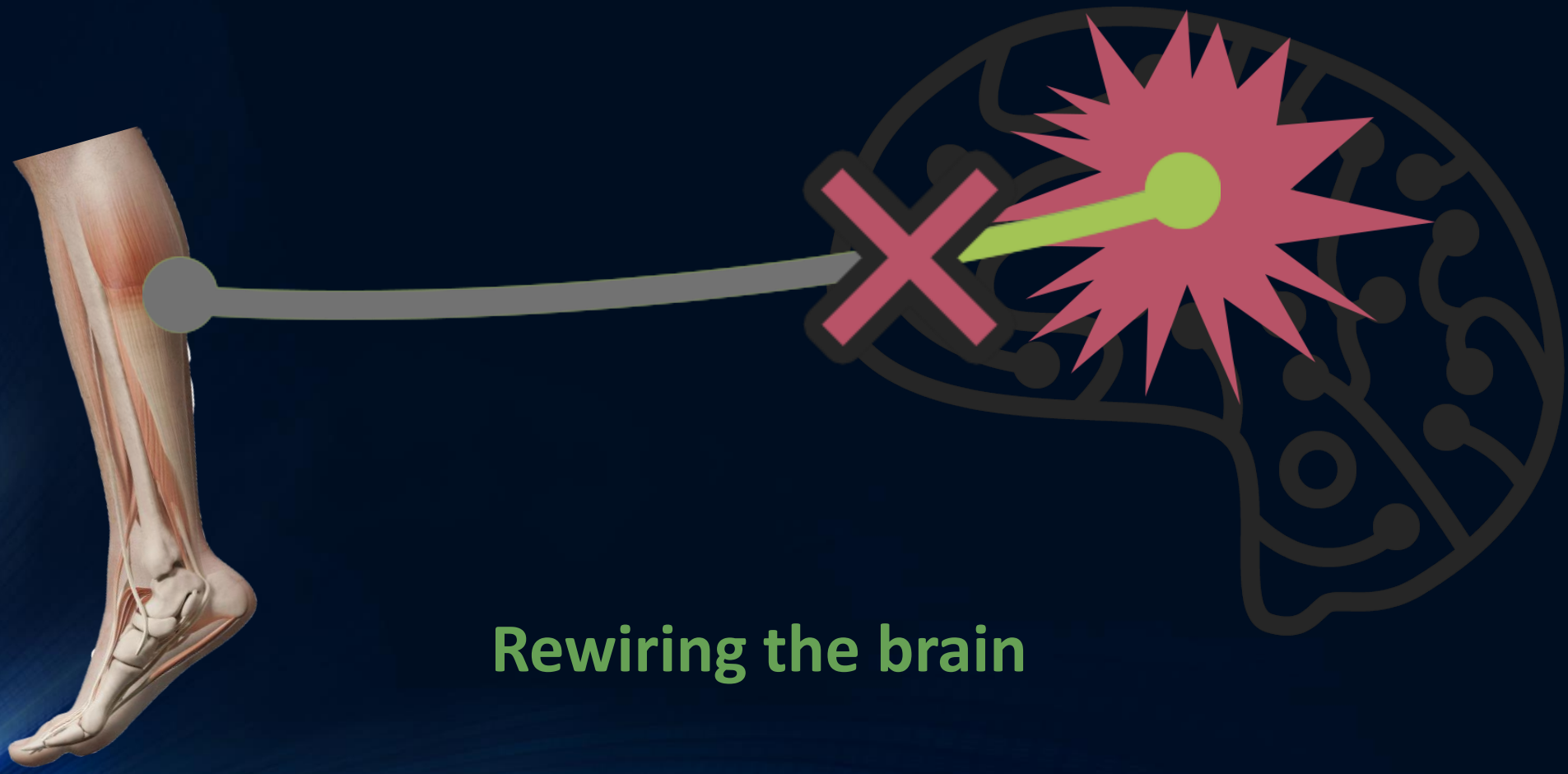
Coming up…

- Stroke
- Problem in Stroke rehab
- Brain Computer interface(BCI) intervention for Rehab
- BCI Studies
- Development of a wearable BCI for stroke rehab
- Summary and questions

Stroke is life changing

40,000 strokes a day…

What happens with a stroke



Rewiring the brain

How many repetitions are needed ?

- Animal evidence in the UL to improve hand and fine motor control – 400-600 repetitions per session
- In animals, changes in primary motor cortex synaptic density occur after 400 (but not 60) reaches (Remple et al, 2001)

- Animal evidence in the LL to improve gait – 1000+ repetitions per session

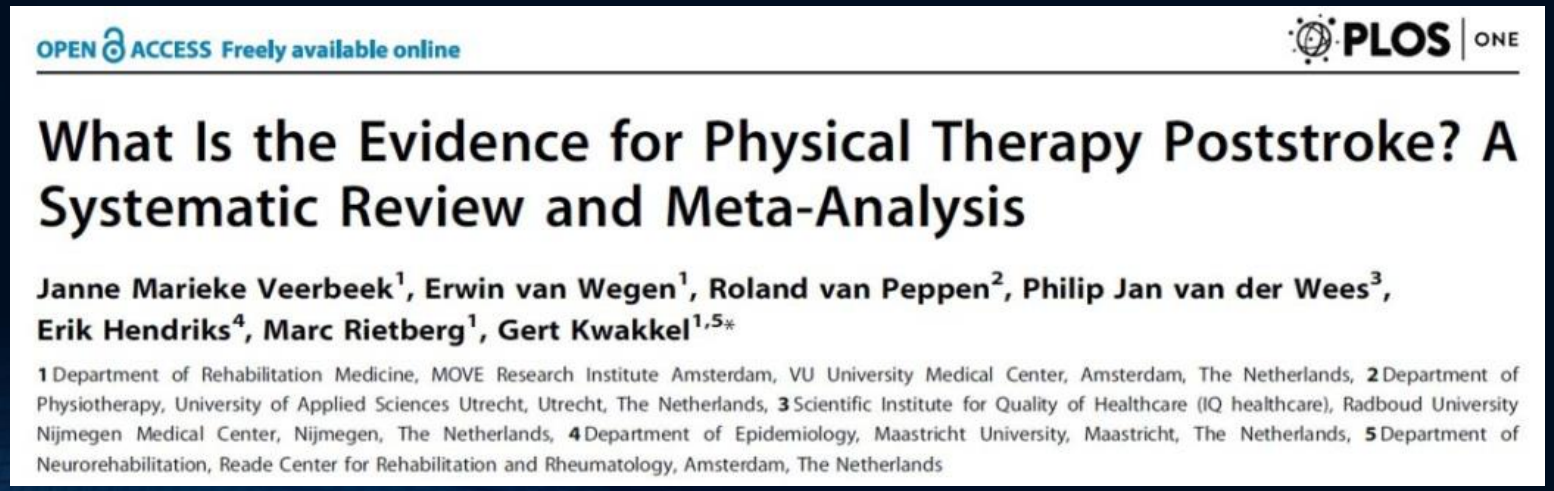
Evidence for more rehab

Is there evidence to support ‘increased dose’ - time on task?

- ‘Increased dose’ studies have high variability in design
  - *extra* = 2 hrs/week to 3 hrs/day
  - some initiated early, some late

Strong evidence for …

- higher dose of practice
- high intensity repetitive task-oriented practice



OPEN ACCESS Freely available online

PLOS ONE

What Is the Evidence for Physical Therapy Poststroke? A Systematic Review and Meta-Analysis

Janne Marieke Veerbeek[1], Erwin van Wegen[1], Roland van Peppen[2], Philip Jan van der Wees[3], Erik Hendriks[4], Marc Rietberg[1], Gert Kwakkel[1,5]*

1 Department of Rehabilitation Medicine, MOVE Research Institute Amsterdam, VU University Medical Center, Amsterdam, The Netherlands, **2** Department of Physiotherapy, University of Applied Sciences Utrecht, Utrecht, The Netherlands, **3** Scientific Institute for Quality of Healthcare (IQ healthcare), Radboud University Nijmegen Medical Center, Nijmegen, The Netherlands, **4** Department of Epidemiology, Maastricht University, Maastricht, The Netherlands, **5** Department of Neurorehabilitation, Reade Center for Rehabilitation and Rheumatology, Amsterdam, The Netherlands

Doing more rehab

300hrs of UL therapy for 5 weeks

= 8-11 point improvement on UL-FM

ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2015;96:981-90

ORIGINAL RESEARCH

Comparison of Robotics, Functional Electrical Stimulation, and Motor Learning Methods for Treatment of Persistent Upper Extremity Dysfunction After Stroke: A Randomized Controlled Trial

Jessica McCabe, MPT,[a] Michelle Monkiewicz, DPT,[a] John Holcomb, PhD,[b] Svetlana Pundik, MD, MS,[a] Janis J. Daly, PhD, MS[a]

In stroke… what is the story in reality?

- Recovery poor
- Amount of received rehab low
- Amount of practice for Motor Learning
- Does more rehab/practice result in better outcomes?

McNaughton article - specific to NZ

TABLE 1: Comparison of New Zealand and US centers in PSROP[16] Study

Mean	New Zealand (n = 130)	United States (n = 1161)	P < 0.05
Length of stay (days)			
Acute	10.4	8.6	Yes
Rehab	30	16.6	Yes
Physiotherapy			
Days in rehab	13.3	13.5	No
Minutes in rehab	460	800	Yes
Occupational therapy			
Days in rehab	5.8	11.7	Yes
Minutes in rehab	208	715	Yes
Outcomes at hospital discharge			
Increase in FIM	21	26	Yes
Discharge home (%)	71	78	Yes
Discharge to institutional care (%)	22	13	Yes

FIM, functional independence measure.

How much rehab?

McNaughton et al 2014

McNaughton article - specific to NZ

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How much rehab?

McNaughton et al 2014

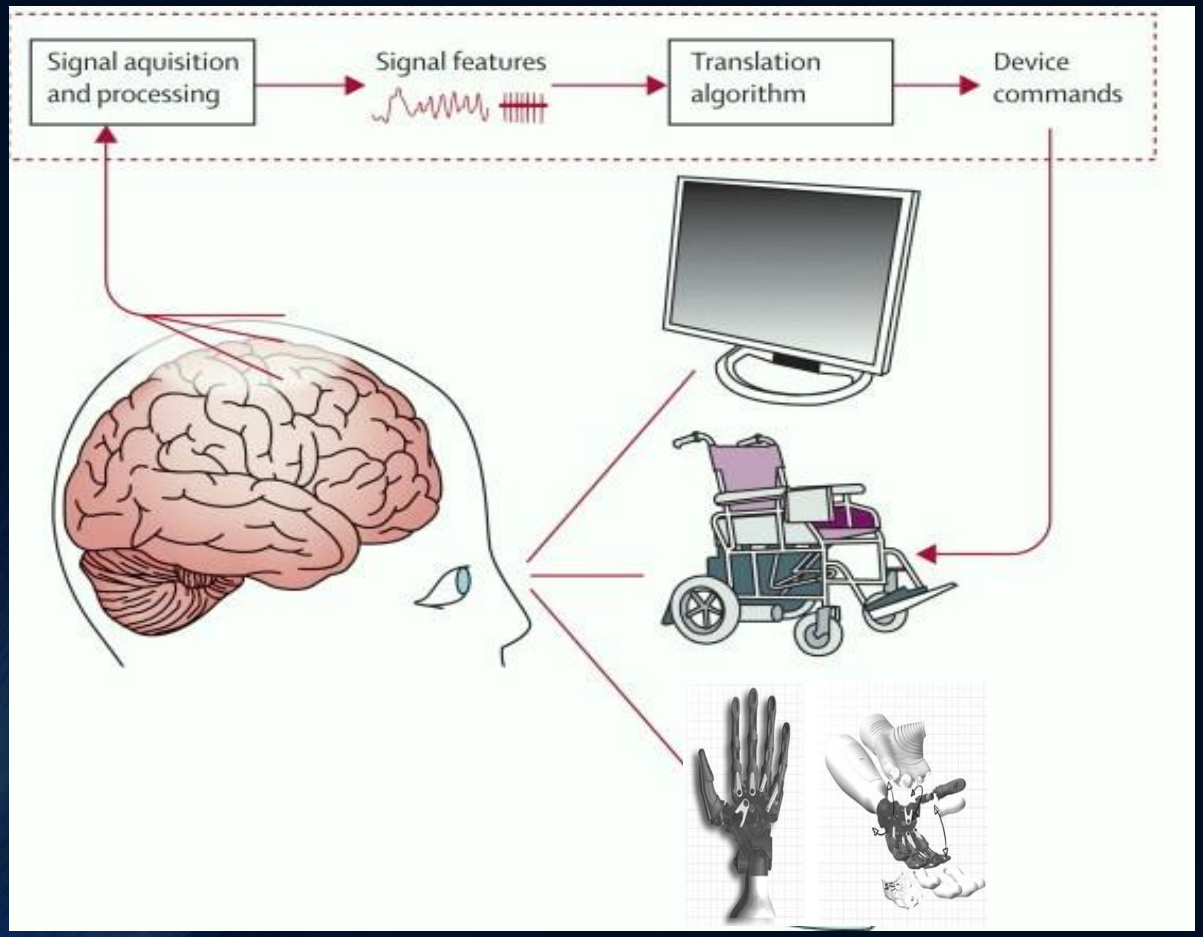
Amount of time in UL rehab

- **Acute setting within 4 weeks post stroke**
- **Observational studies**
- **Receiving Physiotherapy and/or Occupational Therapy;**
- **Amount of therapy time devoted to UL interventions.**
- **From the 94 studies reviewed, seven studies involving 3236 participants met the inclusion criteria**

Systematic review (Serrada et al 2016)

7.9 min/day of a total 36.7 min/day combined PT and OT session

Brain Computer Interface (BCI)



[* adapted from Daly & Wolpaw, 2008]

Application:

- Communication
- Gaming
- Rehabilitation

Signal Acquisition:

- Invasive (ECoG, etc.)
- Non-invasive (EEG)

Modes:

- Synchronous/cued
- Asynchronous/self-paced

Brain Signals:

- ERD/ERS, P300
- CNV/MRCP
- SSVEP

BCI in Rehabilitation

Assistive BCI

- control of external device

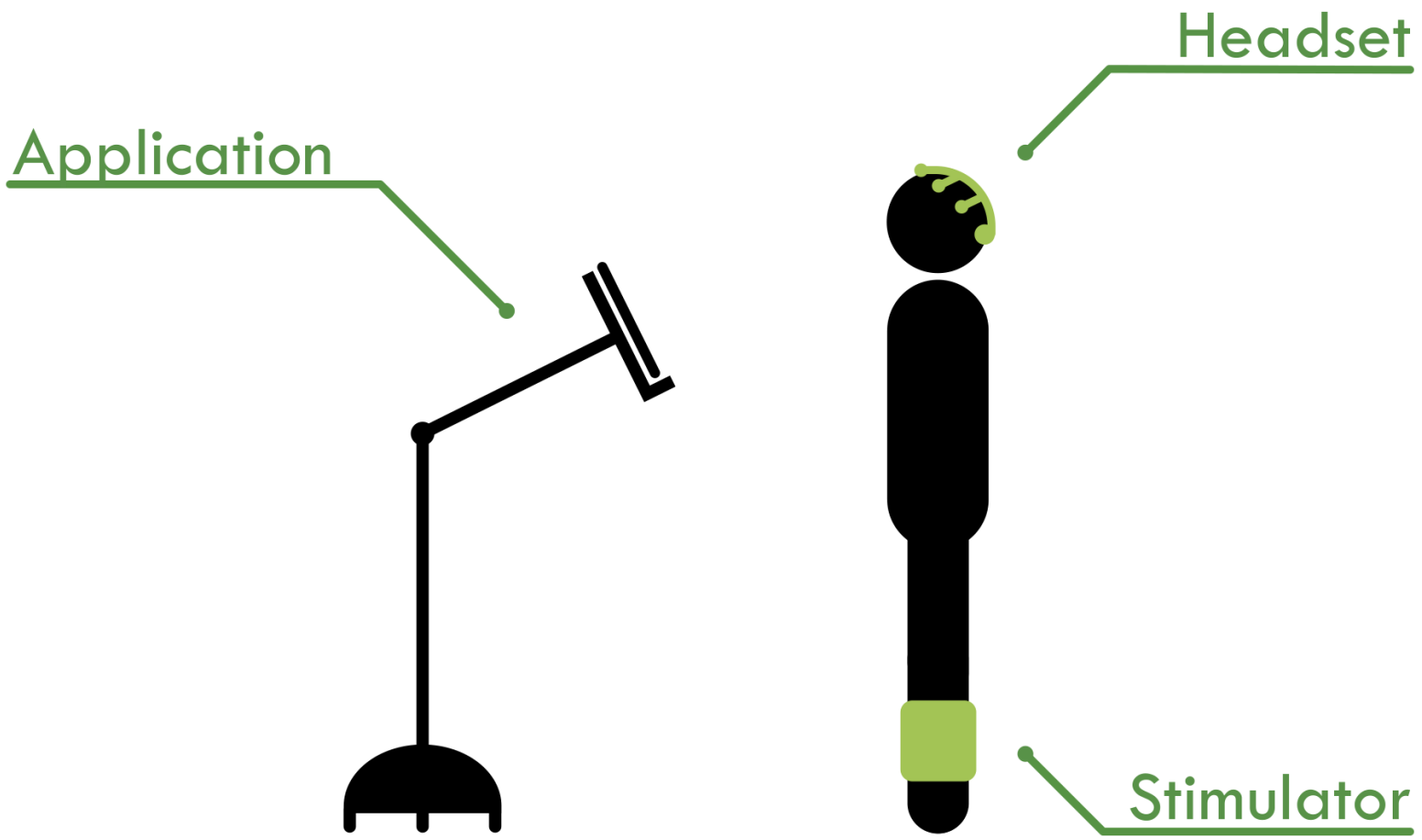
Restorative BCI

- robotic orthosis

BCI in Rehabilitation

- Rehabilitation and plasticty go hand in hand
- One of the possible mechanism based on Hebbian plasticity:
  - Coincident activation of pre-synaptic and post-synaptic neurons reinforces synaptic strength, resulting in increased and more reliable communication between the activated neurons.
- Different Methods to induce plasticity artificially e.g. Transcranial Direct current stimulation (tDCS) , Paired Associative Stimulation (PAS)

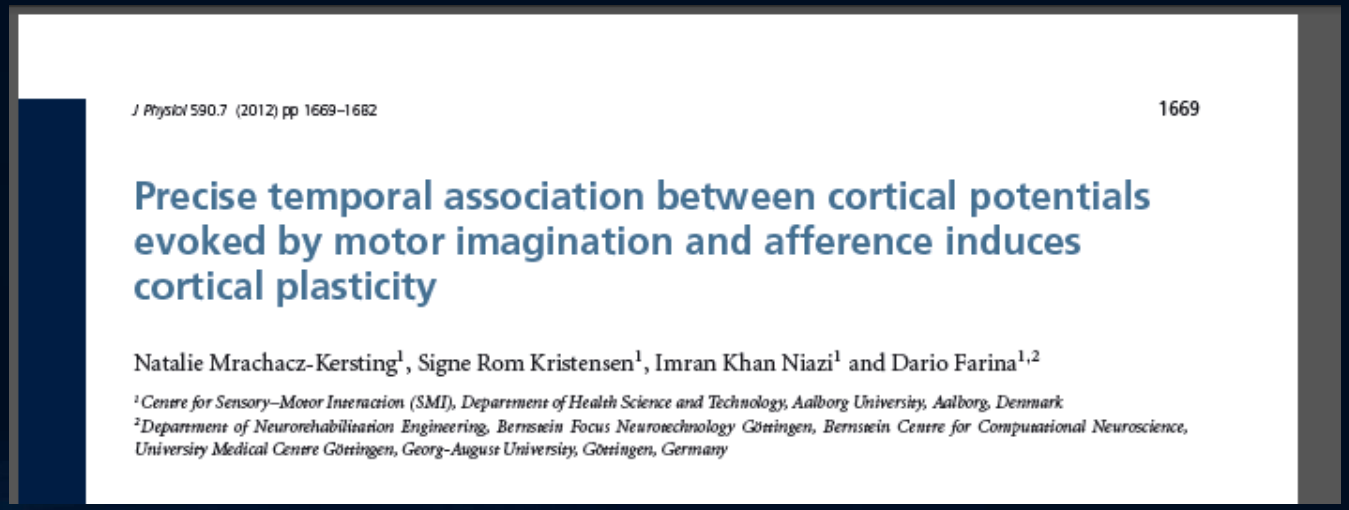
Introducing… exciteBCI



First paper back in 2012

- The results presented prove the possibility of using neurofeedback systems, based on BCI concepts, for efficient and targeted induction of plastic changes in the motor cortex in stroke therapy.

Published in Journal of Neurophysiology:



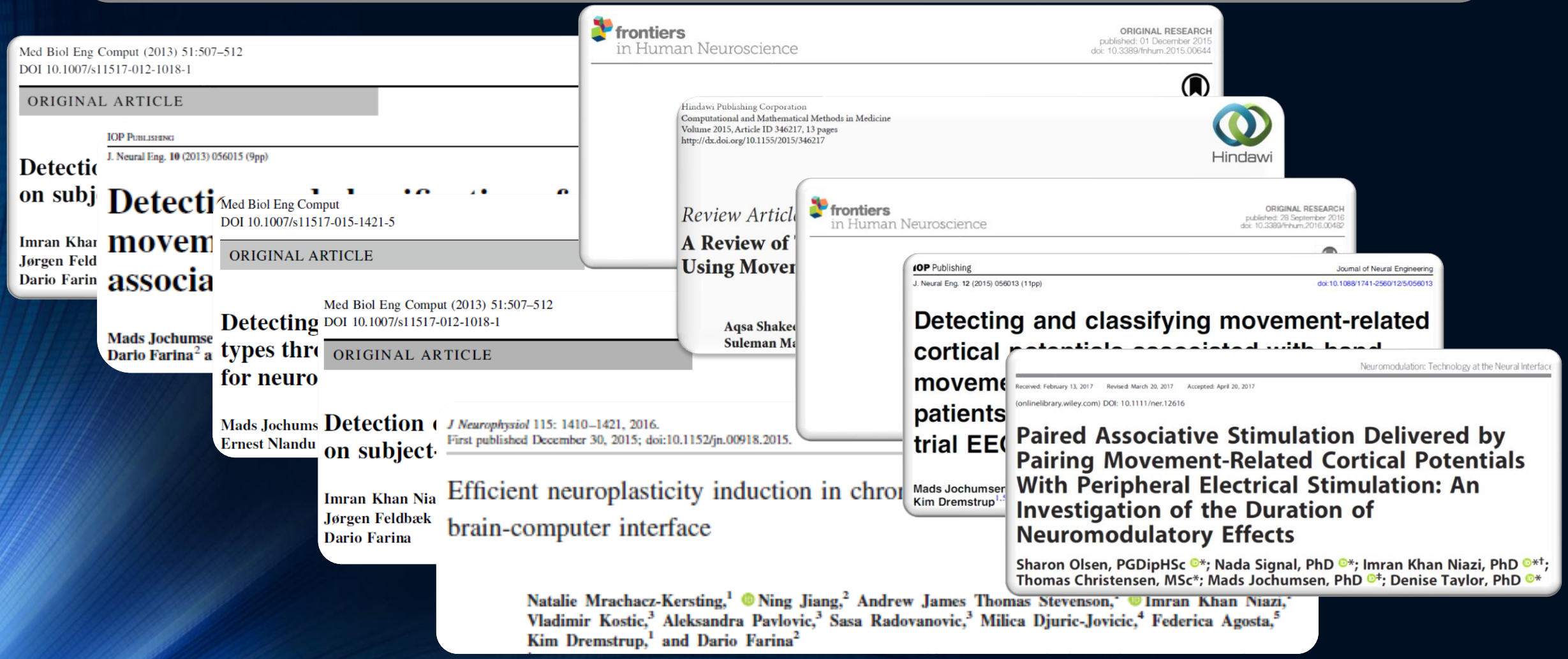
J Physiol 590.7 (2012) pp 1669–1682

Precise temporal association between cortical potentials evoked by motor imagination and afference induces cortical plasticity

Natalie Mrachacz-Kersting[1], Signe Rom Kristensen[1], Imran Khan Niazi[1] and Dario Farina[1,2]

[1] Centre for Sensory–Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Aalborg, Denmark
[2] Department of Neurorehabilitation Engineering, Bernstein Focus Neurotechnology Göttingen, Bernstein Centre for Computational Neuroscience, University Medical Centre Göttingen, Georg-August University, Göttingen, Germany

Scientific validation



Signal Processing:

IOP Publishing
Journal of Neural Engineering
J. Neural Eng. 12 (2015) 056003 (10pp)
doi:10.1088/1741-2560/12/5/056003

Comparison of spatial filters and features for the detection and classification of movement-related cortical potentials in healthy individuals and stroke patients

Mads Jochumsen[1], Imran Khan Niazi[1,2,3], Natalie Mrachacz-Kersting[1], Ning Jiang[4], Dario Farina[5] and Kim Dremstrup[1,6]

Spatial filter comparison in healthy and stroke patients

Feature Comparison between stroke and Healthy subjects

Hindawi Publishing Corporation
Computational Intelligence and Neuroscience
Volume 2015, Article ID 858015, 8 pages
http://dx.doi.org/10.1155/2015/858015

Hindawi

Research Article

Comparison of Features for Movement Prediction from Single-Trial Movement-Related Cortical Potentials in Healthy Subjects and Stroke Patients

Ernest Nlandu Kamavuako,[1] Mads Jochumsen,[1] Imran Khan Niazi,[1,2,3] and Kim Dremstrup[1]

[1]*Department of Health Science and Technology, Aalborg University, 9220 Aalborg, Denmark*

In IEEE Transaction of Neural systems and Rehabilitation

EMD-Based Temporal and Spectral Features for the Classification of EEG Signals Using Supervised Learning

Farhan Riaz, Ali Hassan, Saad Rehman, Imran Khan Niazi, and Kim Dremstrup

Review Article for movement Intention detection

Hindawi Publishing Corporation
Computational and Mathematical Methods in Medicine
Volume 2015, Article ID 346217, 13 pages
http://dx.doi.org/10.1155/2015/346217

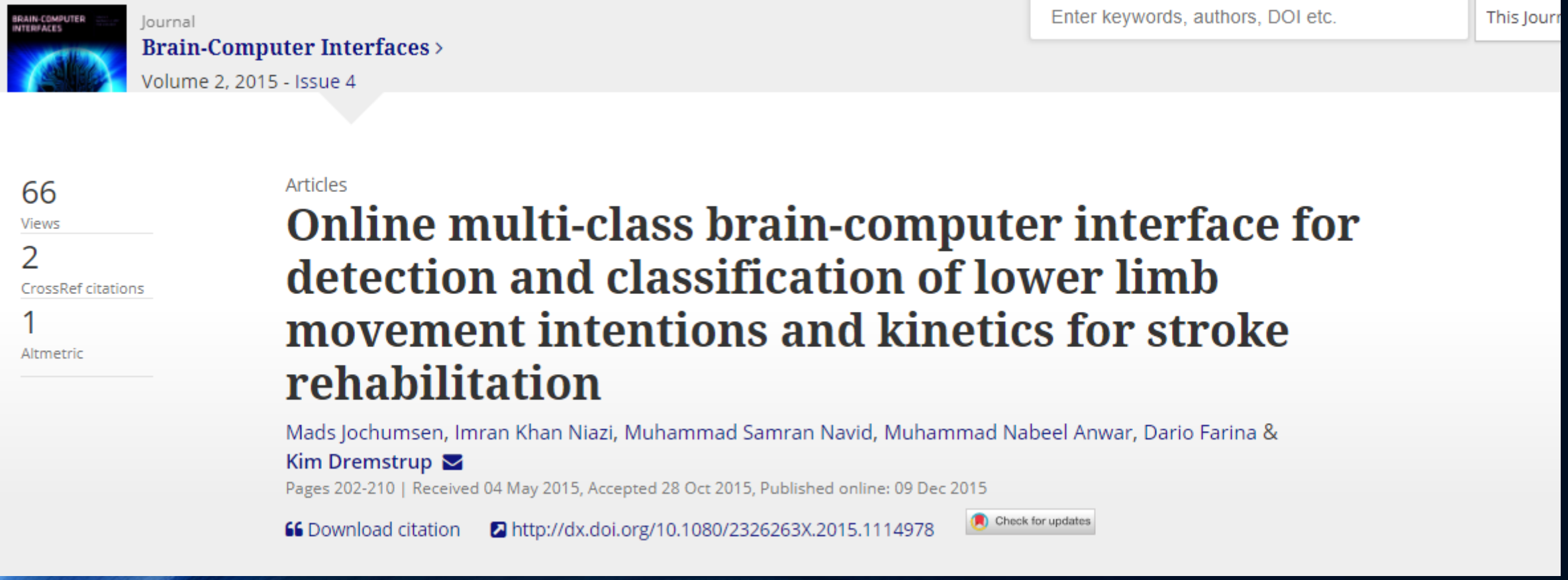
Hindawi

Review Article

A Review of Techniques for Detection of Movement Intention Using Movement-Related Cortical Potentials

Aqsa Shakeel,[1] Muhammad Samran Navid,[1] Muhammad Nabeel Anwar,[1] Suleman Mazhar,[2] Mads Jochumsen,[3] and Imran Khan Niazi[3,4,5]

Real time detection and Classification system with out feedback



Journal
Brain-Computer Interfaces ›
Volume 2, 2015 - Issue 4

Enter keywords, authors, DOI etc.

This Journ

66
Views
2
CrossRef citations
1
Altmetric

Articles

Online multi-class brain-computer interface for detection and classification of lower limb movement intentions and kinetics for stroke rehabilitation

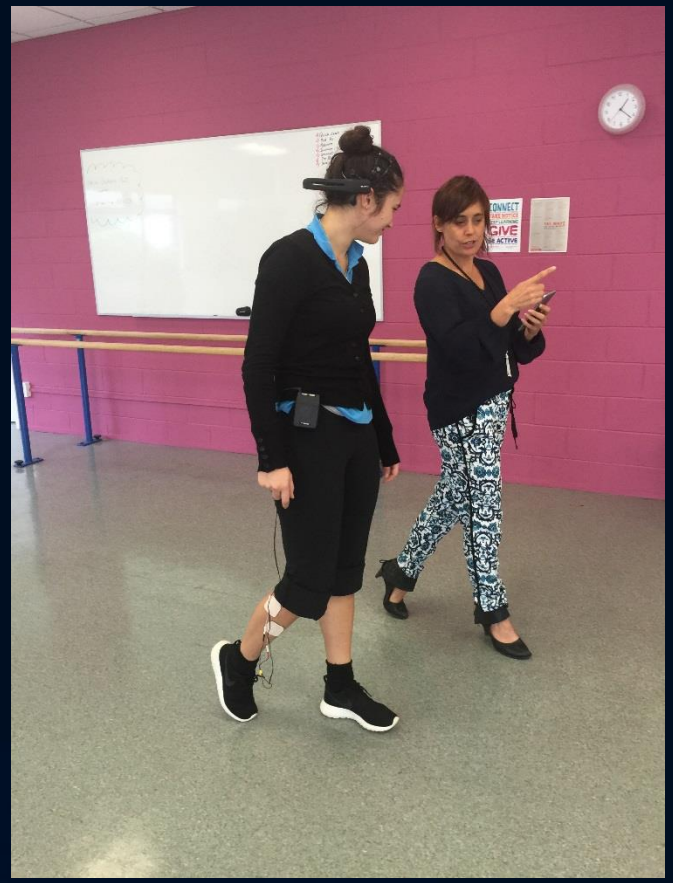
Mads Jochumsen, Imran Khan Niazi, Muhammad Samran Navid, Muhammad Nabeel Anwar, Dario Farina & Kim Dremstrup

Pages 202-210 | Received 04 May 2015, Accepted 28 Oct 2015, Published online: 09 Dec 2015

Download citation http://dx.doi.org/10.1080/2326263X.2015.1114978 Check for updates

Current BCI system

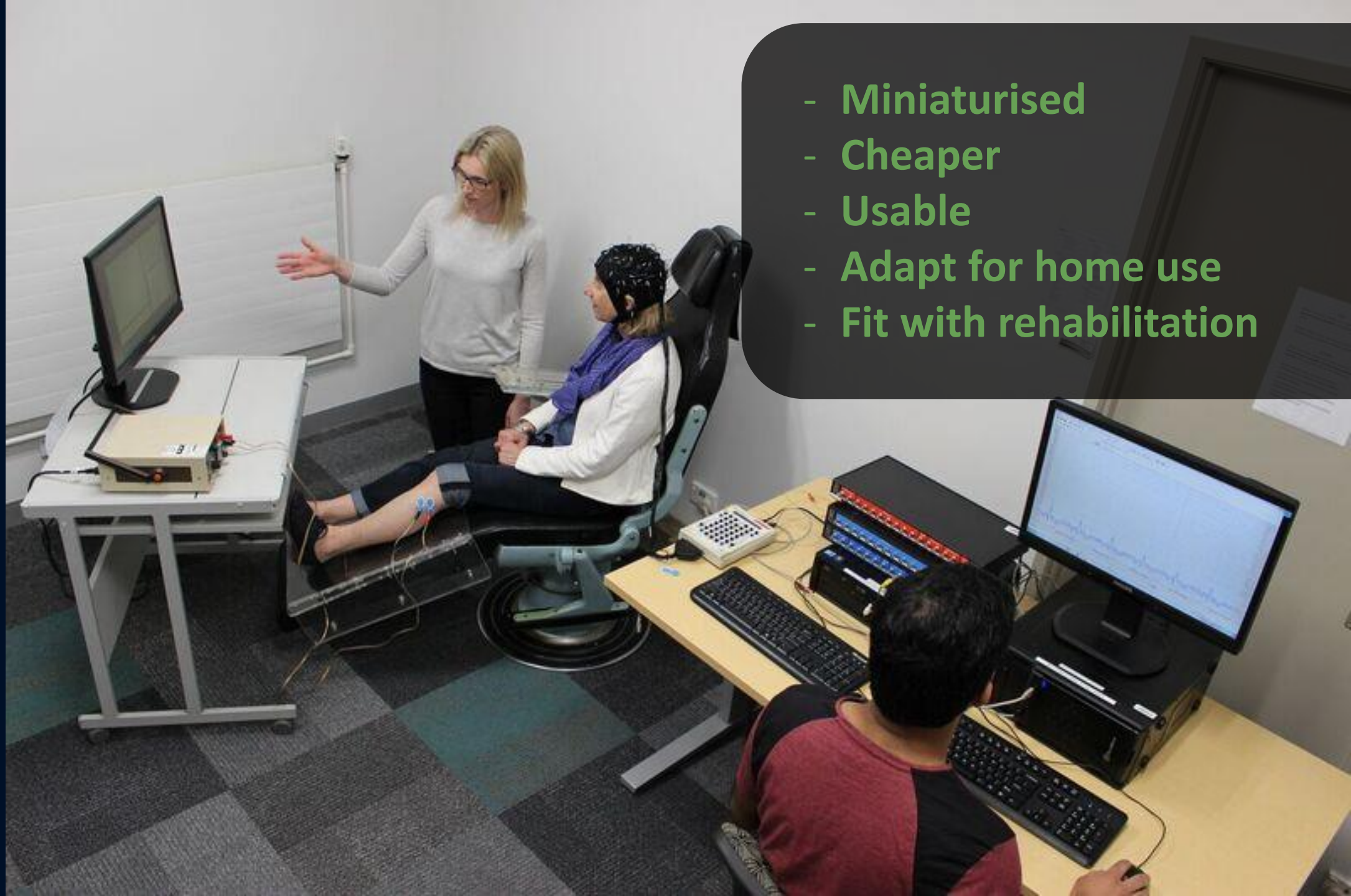
RIC's version of BCI's



Requirements for restorative BCI's in stroke

- Assistance that is flexible and related to the amount needed 'now'
- Facilitate enough practice and repetition
- Linked to meaningful tasks
- Fit with the philosophy of rehabilitation
- Fit with patients
- Fit with clinicians
- Be possible within our health systems (now and imminent future

The Lab Set Up

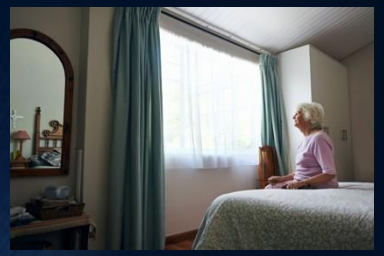


- Miniaturised
- Cheaper
- Usable
- Adapt for home use
- Fit with rehabilitation

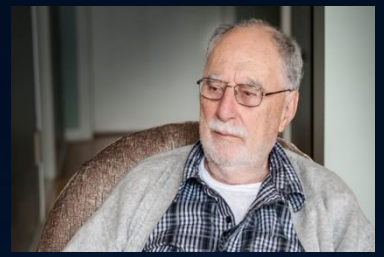
Rehabilitation… the status quo

What's my current situation?


I receive limited rehabilitation




I have no control

I have become sedentary and dependent on other people

What I want

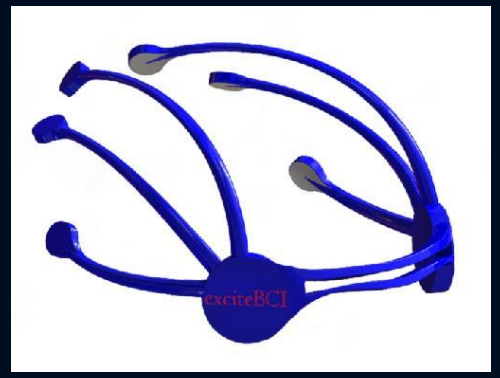

I want more therapy to help me


I want control

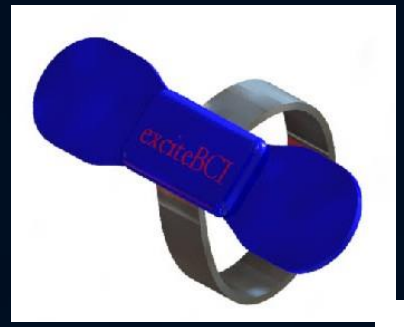

I want to do the things I used to do

A simple solution for faster recovery

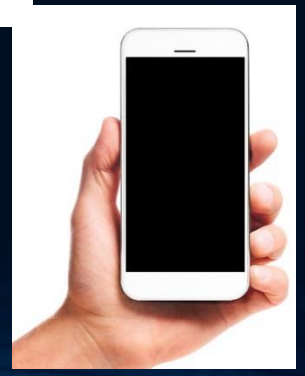
1. Put on a wireless head-set



2. Strap a wireless muscle stimulator over the selected muscle



3. Use a smart phone to select exercise mode or specified activity



Consultation Vs Team work

Some of the reasons why an understanding of patients, the process of rehabilitation and motor control are important…

Nortek Labs (Startup):

Current Version Hardware and App

WiBCI-16T SPECIFICATIONS

Channel Specification

- Channels: 16 Analog
- Ground: Active
- Reference : Selectable

(Multiple channels can be referenced)

- Sample rate: 250Hz
- Resolution: 24 bit
- Noise: less than 1.3uV
- CMMR: -110dB
- Bandwidth: 0~65Hz
- Gain: 24
- Channels type: Referential
- Antialiasing Protection: Yes
- I/P range: (-185mV) to (+185mV)
- Impedance measurement: Yes

Android API

- Capable of realtime data acquisition recording and processing with Wi-Fi

Communication

- Wireless Wi-Fi *(10 meters)*

Battery Powered

- Chargeable via USB type B
- Continuous data recording time : *(5 Hrs at full charge)*

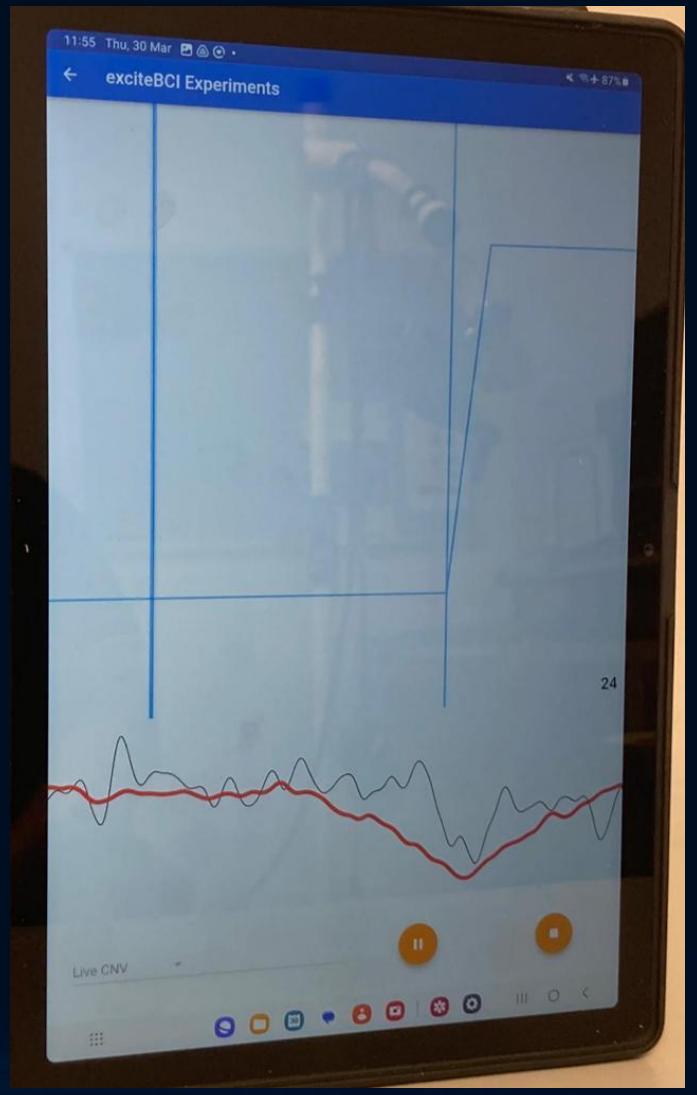
Connector

- IDC header 2.54 mm 20 pin *(Customized cap support available)*
- DIN 42802 connectors *(EEG , ECG , standard cap support available)*
- Isolated external trigger input connector. *(supports TTL logic)*

Form Factor

- Table mount version
- Size : 03" X 06" X 1.5"
- Weight : 100 grams *(with battery)*

WiBCI-16T



Journey

- ☑ Proof of Concept
  - 6 peer reviewed articles
- ☑ Preliminary trials in people with stroke
- ☑ Product Development
  - Engineering, Product Design, Software
- Randomised Controlled Trial
  - Multi-site, International, Sub-group
- Regulatory approval

Norteklab

Market –Requirement Gap in Research Labs

Taking the matter into our own hands

Market –Requirement Gap in Research Labs

- Clinical grade equipment
- Proprietarty Software
- Hard to Customise
- Ease of use

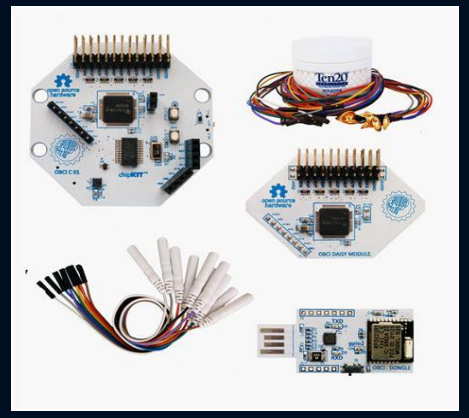
> US $30,000

- Based on User Requirement
- Customiseable Software
- Fixed mobile or desktop Hardware
- Stackable (multiple units)
- **You don't need to sell your Kidney**

{Gap}

Range:US$8,000-$12,000

- Off the shelf amplifier
- Need an expert engineer
- For customization
- Economical



<US$5,000

COST

Norteklab

16, 24, 40, 72 Channels **EEG/EMG** Amplifier series

Complete Solution:

- Android and Window Apps
- Rich feature apps for EEG data
- Built-in Impedance Verification
- Easy Setup and Data Export

Norteklab

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WiBCI-16T

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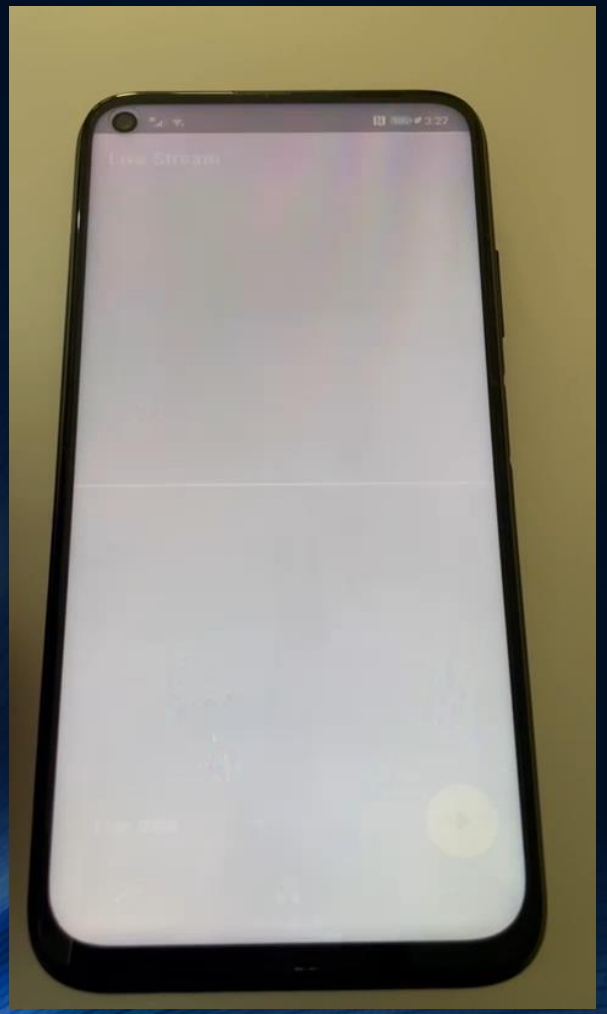
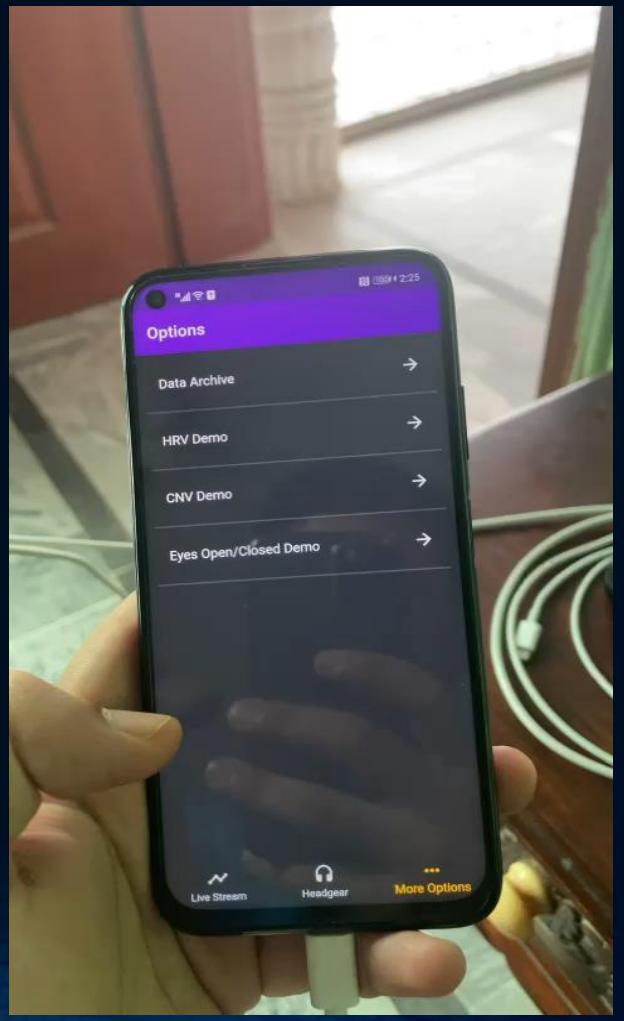
Edge Computing Features

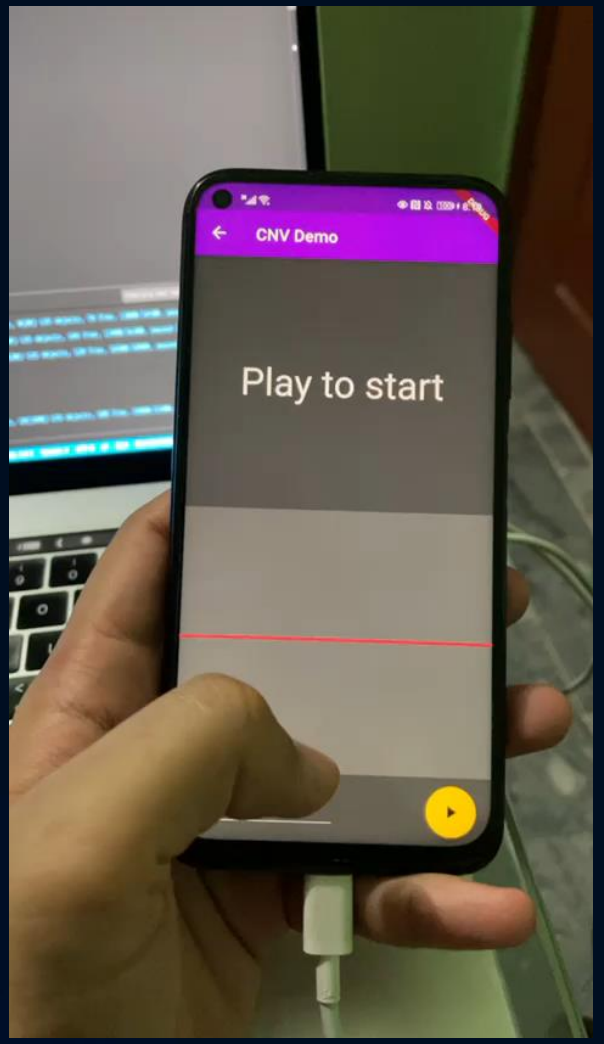
HRV



Eyes open & Close



MRCP /CNV



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WiBCI Amplifiers Global Presence

- To validate the models created in bed side pain management system in a Pancreatic Quantitative Sensory Testing (P-QST) Consortium

1. University of Aalborg, Denmark
2. Johns Hopkins University & University of Pittsburgh, USA
3. Auckland University of technology & New Zealand Chiropractic College, New Zealand
4. National University of Science and technology & Riphah International Univerisity, Pakistan
5. Delhi and Hyderabad Hospitals, India

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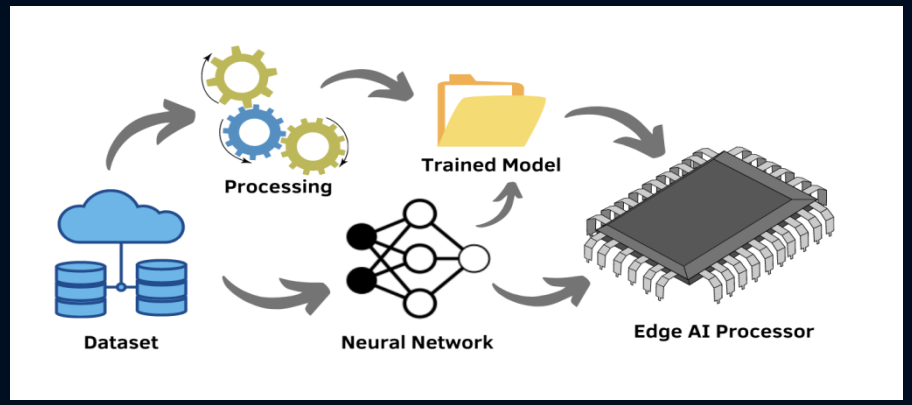
Technology Challenges

- Edge Computing (AI based)
- Task: Complex ML models to be implemented right into the Amplifier
- Challenge: Models are way too big to be fit into Embedded devices



Collaborators

Thank You !!!

Contact:
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