

Novartis Hackathon
25-27 October 2019
Prague / Czech Republic
CogniTeam



CogniService: continuous health data collection, analytics, research and Personalized eHealth care

CogniTeam

Martin Holovský, Ludovit Scholtz, Martin Kubajda, Ocean Leung, Michal Škop

Disclaimer

- These slides are based on work of our team during Novartis Neurological Hackathon held in Prague 25-27 October 2019 and describes our vision, but hypothetical services, environments and offerings
- Services described in this presentation does not exist and aren't related to any Novartis service, product or offering
- These slides are based on publicly available information (including data relating to non-Novartis products or approaches)
- The views presented are the views of the presenter, not necessarily those of Novartis
- These slides are intended for educational purposes only and for the personal use of the audience
- The content of this slide deck is accurate to the best of the presenter's knowledge at the time of production

Novartis Hackathon Multiple sclerosis

What we tried to help with

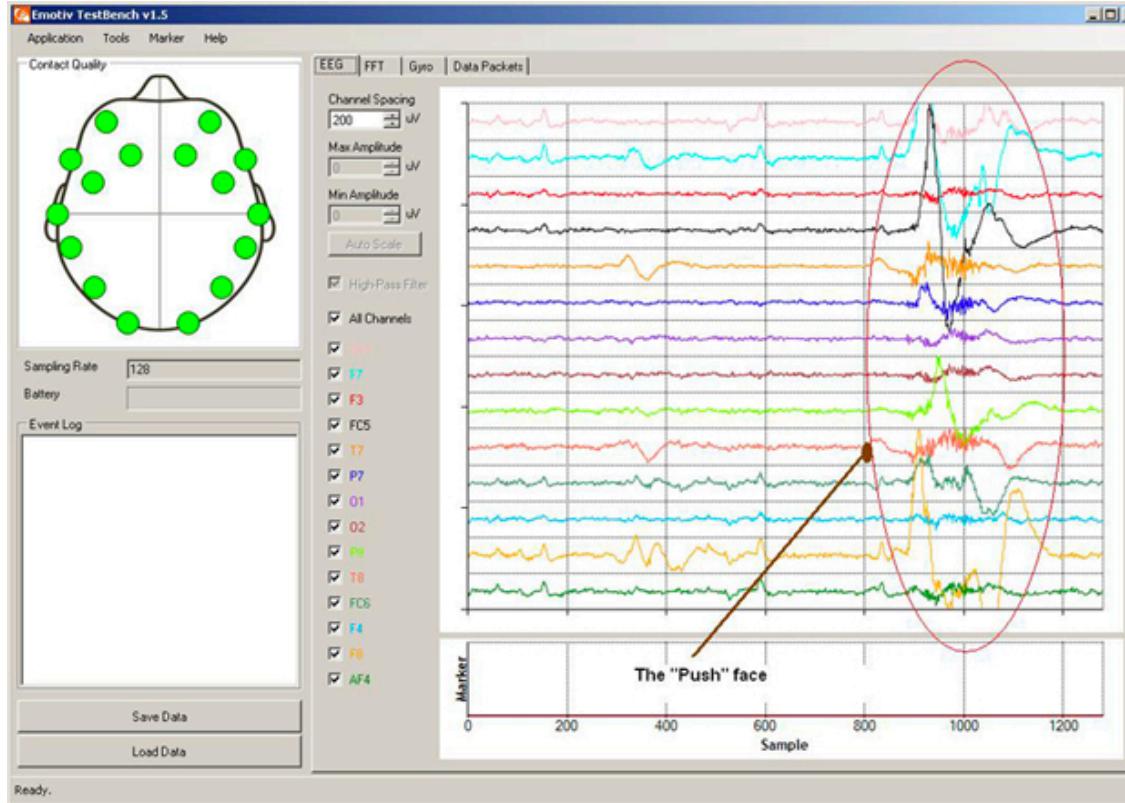
Hackathon challenges

1. Personal Motivator
2. Stress detector
3. Rehabilitation device
4. Measurements needed for diagnosis

We did our best to cover not one, but all of them within 24-ish hours of hacking marathon

In this presentation we focus on Multiple Sclerosis (MS), but same approach can be used even for other neural diseases / brain disorders

Listen to your brain... waves



Rationale of using EEG

for MS pattern recognition, prediction and stress level monitoring

- Multiple sclerosis demyelinates the axons
- Reduction of electrical insulation → potential frequency shifts
 - Patients with multiple sclerosis had a significant increase of θ power in the frontotemporal-central regions (Leocani et al. 2000)
 - EGG stress signature (Tran et al. 2007)
 - Decrease of alpha power (11 to 12 Hz)
 - Increase of beta activity (23–36 Hz)
 - Frontal EEG alpha hemispheric asymmetry: left hemisphere for +ve emotions VS right hemisphere for -ve emotions
- Disadvantage of EEG signal:
 - Noisy, low spatial resolution
- Solve by large amount of data readily collectable by Emotiv, NeuroSky or OpenBCI

Key Challenges

Lack of continuous EEG datasets

Problem description

- Existing MS EEG datasets were gathered mostly during hospital/clinic visit
 - Lack of data before and after visit (majority of data)
- Many studies are based on those ad-hoc EEG data gatherings

Why its important?

“The EEG is used to evaluate several types of brain disorders” (Johns Hopkins Medicine)

“Continuous electroencephalogram (CEEG) monitoring is increasingly being used for brain monitoring in neurocritical care setting.” (Biomed Central)

What can be identified by EEG: epilepsy, lesions, psychoses, Alzheimer, trauma, impaired consciousness, encephalitis, inflammation, stroke, altered mental state...

Up to: drug intoxication, brain damage, sleep disorders, HIV, ...

Source: Johns Hopkins Medicine, PubMed.gov, BioMed Intensive care

MRI device cost \$150,000-300,000 and is super-heavy

Our Idea

Lack of continuous EEG datasets

Proposed Solution

Non-invasive, safe and inexpensive method for diagnosing brain disorders

Usage of commercially available Emotiv / NeuroSky device to record raw EEG

OR

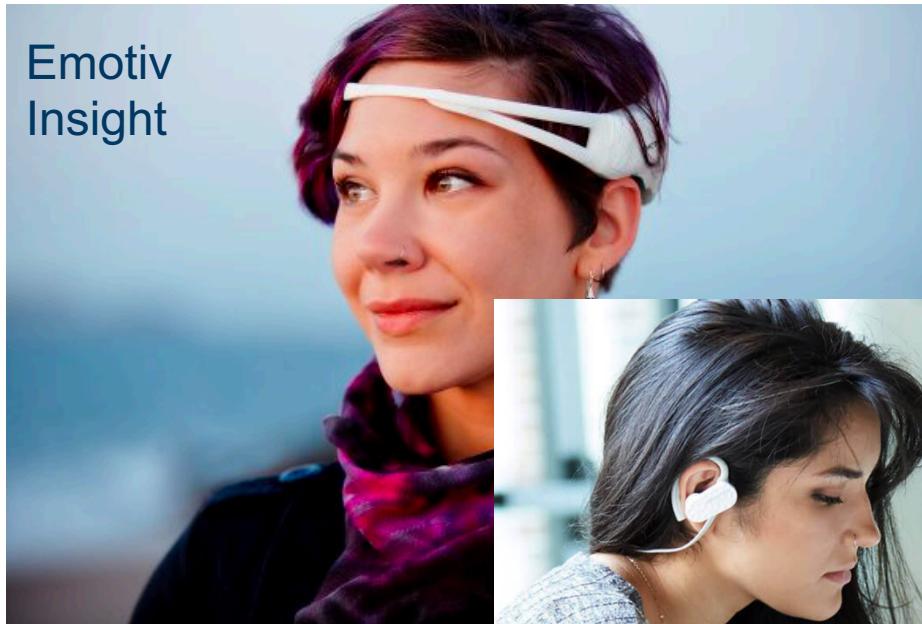
- Affordable device using open-source, 3D printable, components (OpenBCI)
 - Continuous EEG monitoring (whole one day/week) for individual baseline
 - **Playing cognitive game** (using brain waves only) during stabilized & relapse state
 - Compare data, find differences and patterns, create DL model
 - **Record stress levels** (observable by EEG) and notify user when stress is too high
 - **Record EEG change** on various medications
 - **Build EEG datasets** for further research



Our Idea

Lack of continuous EEG datasets

Doesn't need to look like this



Emotiv MN8

Key Challenges

unknown cause of MS disease

Problem description

Cause of multiple sclerosis is still not known

Why its important?

- We don't know how to cure this disease
- We don't know what all factors can trigger it, so we don't know what to avoid
- We don't know how identify/predict onset
- We don't know what are the other factors (DNA, microbiome, ...)

Our Idea

unknown cause of MS disease

Proposed Solution (CogniCloud)

Global Data Analytics platform which can evaluate and compare all other factors:

- **DNA genotyping**: “*variations in dozens of genes are thought to be involved in multiple sclerosis risk*”
- **Microbiome**: “*Microbiome is growingly involved in dysimmune conditions such as allergy, asthma, autoimmunity, and primary or acquired immune deficiencies.*”
- **Blood test results**: vitamin (e.g. vitamin D) and mineral (magnesium) deficiencies
- **Family anamnesis**: e.g. predisposition for neural disease
- **Data from wearables**: HBR, ECG, Body Measurables, Nutrition, Sleep, Vitals
- **Integration** with Apple HealthKit, GoogleFit, 23andMe, uBiome, ...
- **Data Privacy and Anonymization**
- **Deep Learning research**

Smart Watch

Example of what you can get out of it

Accelerometer/Gyroscope

- **Fall Detection** (can call emergency automatically)
- **Movement anomalies** (initial research)
- **Hand movements**: washing your hands, washing utensils, scrolling, using a remote, typing
- Sleep quality (HBR, REM, Deep, Awake, Readiness, Effectivity)

Microphone

- Snoring rhythm (sleep apnea)

Heart Rate sensor

- Continuous monitoring, notifications in case of low/high levels
 - Useful during exercise to see effectivity

ECG

- Irregular sinus rhythm, which may be suggestive of atrial fibrillation (AFib)

All data typically stored securely in HealthKit or GoogleFit

11 Source: Carnegie Mellon University, ResearchGate

Exercise in a right way

When you have MS, exercise is one of the most important part of treatment.

When you have MS and you exercise, it can improve your fitness, endurance, and strength in your arms and legs.

Personalized trainer can help you to exercise in a right and safe way.



Smart bathroom scale

weight is now the less important thing



Muscle



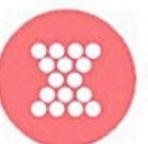
Moisture



Visceral fat



Bone mass



Body fat rate



BMI



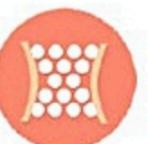
Body age



Standard weight



Weight control



Body fat



BMR



Weight



Protein rate



Water content



Fat level



Muscle weight



Weight without fat



Key Challenges

No centralized health information repository

Problem description

Information is not easily digestible and patient might overlook or misunderstand something very important

Why its important?

- Very time consuming to go through all data
- Often you need to be PhD or Scientists to understand context or what researches wanted to say
- Information is not on one place (like wikipedia) but spread across whole Internet
- Patient view / feedback is one of them most important and valuable, though missing in most cases

NIH Public Access
Author Manuscript
Published in final edited form as:
Cell. 2014 March 27; 157(1): 121–141. doi:10.1016/j.cell.2014.03.011.

Role of the Microbiota in Immunity and Inflammation

Yasmin Belkaid and Timothy Hand
Mucosal Immunology Section, Laboratory of Parasitic Diseases, National Institute of Allergy and Infectious Disease, NIH, Bethesda 20892, USA

Abstract
The microbiota plays a fundamental role on the induction, training and function of the best immune system. In return, the immune system has largely evolved as a means to maintain the symbiotic relationship of the host with these highly diverse and evolving microbes. When operating optimally this immune system-microbiota alliance allows the induction of protective responses to pathogens and the maintenance of regulatory pathways involved in the maintenance of tolerance to innocuous antigens. However, in high-income countries overuse of antibiotics, changes in diet, and elimination of commensal partners such as nematodes has selected for a microbiota that lack the resilience and diversity required to establish balanced immune responses. This phenomenon is proposed to account for some of the dramatic rise in autoimmune and inflammatory disorders in parts of the world where our symbiotic relationship with the microbiota has been the most affected.

Introduction
“The states of health or disease are the expressions of the success or failure experienced by the organism in its efforts to respond adaptively to environmental challenges”
(René Dubos, 1965).

Multicellular organisms exist as meta-organisms comprised of both the macroscopic host and its symbiotic commensal microbiota. With an estimated composition of 100 trillion cells, human symbionts outnumber host cells by at least a factor of 10 and express at least 10 fold more unique genes than their host’s genome (Ley et al., 2006a). These complex communities of microbes, which include bacteria, fungi, protists, and eukaryotic species, provide a tremendous enzymatic capability and play a fundamental role in controlling most aspects of host physiology. Over the past few years, the field of immunology has been revolutionized by the growing understanding of the fundamental role of the microbiota in the induction, education and function of the mammalian immune system.

What the...

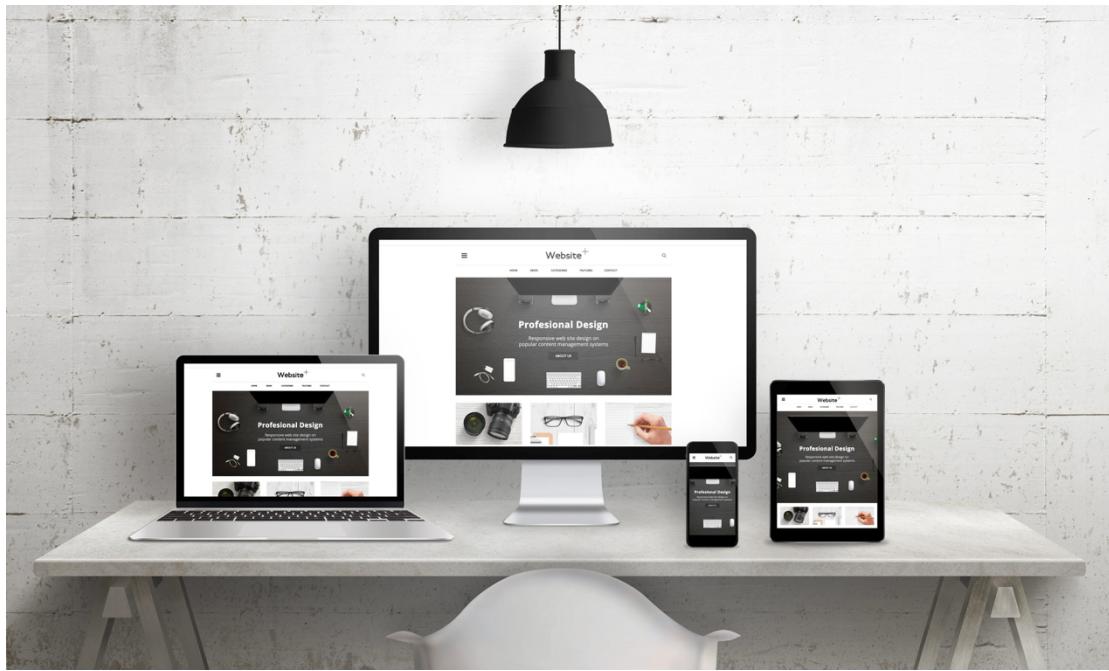
Corresponding author: ybelkaid@niaid.nih.gov.
Publisher's Note: This is a pre-peer-reviewed manuscript that has been accepted for publication. As a service to our authors we are providing early versions of the accepted manuscripts. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal persist.

Our Idea

No centralized health information repository

CogniService

- Clean and responsive web
- Community-driven and specialists redacted information in one place
- Active feed of new information with references to related studies, clinical trials and CogniService research
- Aggregated view and feedback from patients
- Personalized eHealth advisory & individual care



Our Idea in summary



CogniApp

- Cognitive game to learn normal/relapse state
- Continuous normal/relapse monitoring
- Monitoring of health anomalies
- Monitoring response on medication
- Prediction of next relapse
- Continuous stress level monitoring
- Personalized exercise trainer to gain motivation



CogniCloud & CogniService

- Crowd Data Analytics to research new MS relations/indicators/triggers
- Personalized eHealth care and centralized Healthcare information repository

CogniService

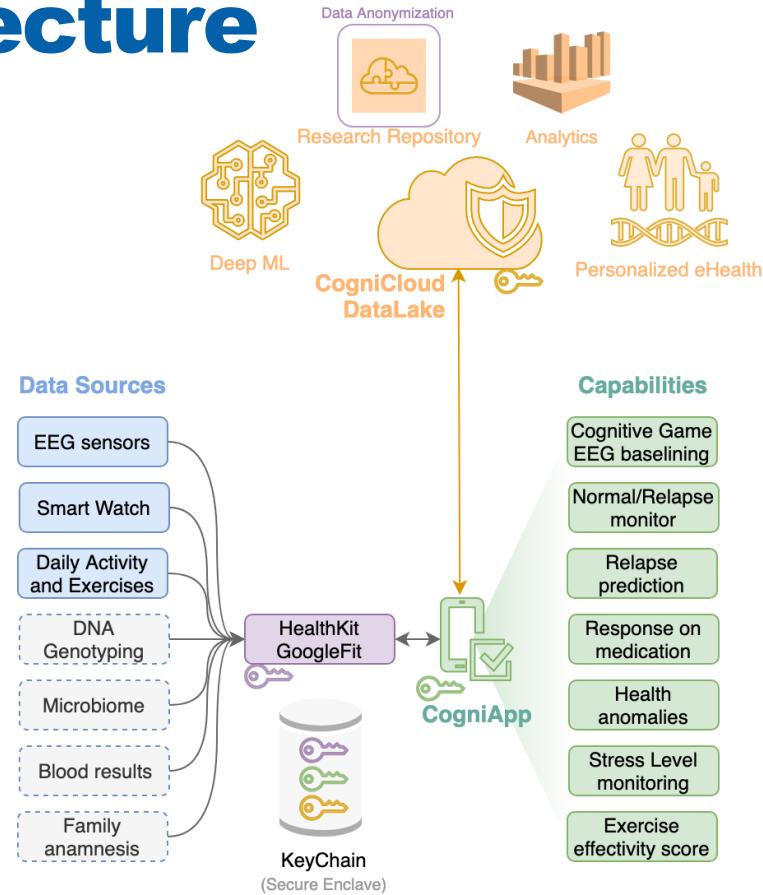
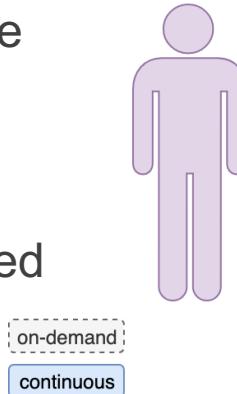
"hypothetical price list "

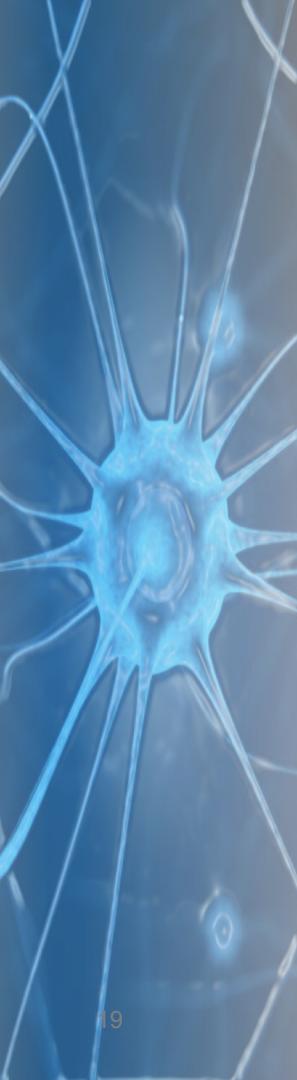
- **CogniApp** on App/Google store \$9.99
- **CogniCloud** monthly subscription \$5.99
 - Includes CogniService Personalized eHealth care
- DNA genotyping \$80
- Microbiome testing \$50
- EEG equipment \$200-600
- Advanced personalized trainer (Xbox Kinect + App)
- Support and recommendation for wearables

CogniService Architecture

High-Level view

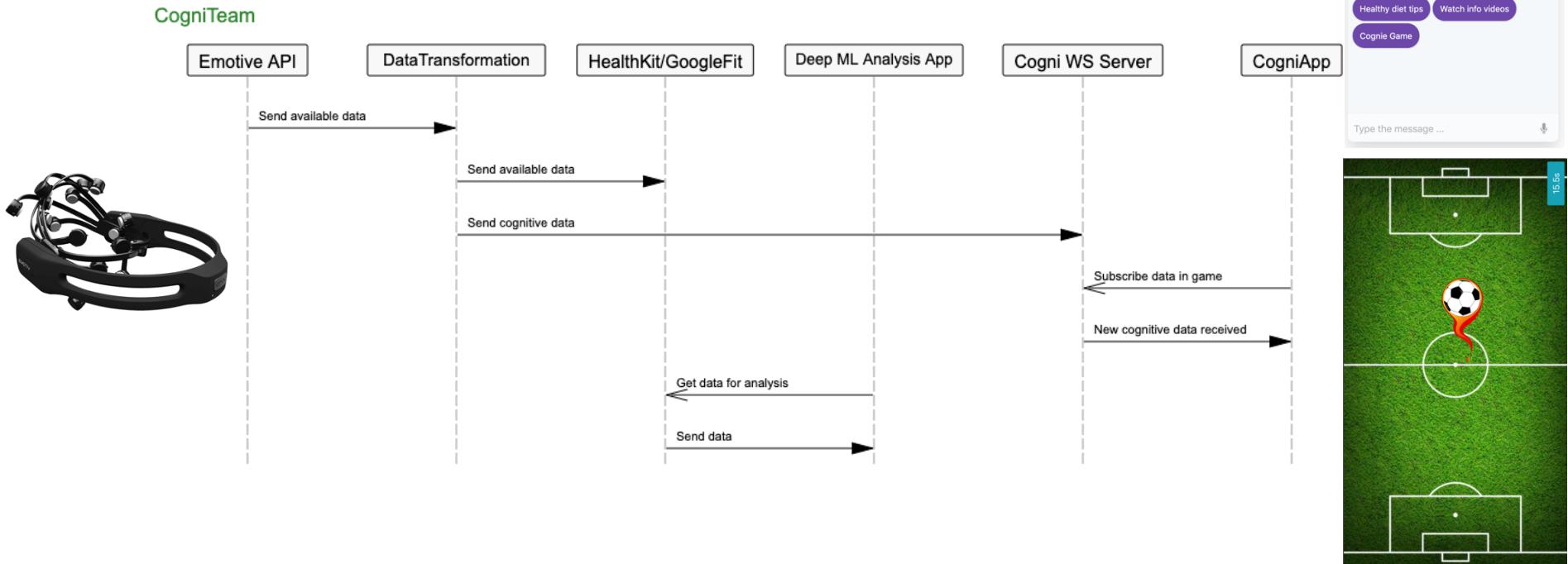
- User owns and control its medical data
- User can opt-out from research
- Initial Deep Learning is offloaded to Cloud (resource intensive)
- Research (crowd) data are anonymized
- Research findings are shared with whole crowd
- Personalized eHealth





Where we are?

Sequence diagram in Speeder



CogniApp showtime

chatbot - text, touch and voice control

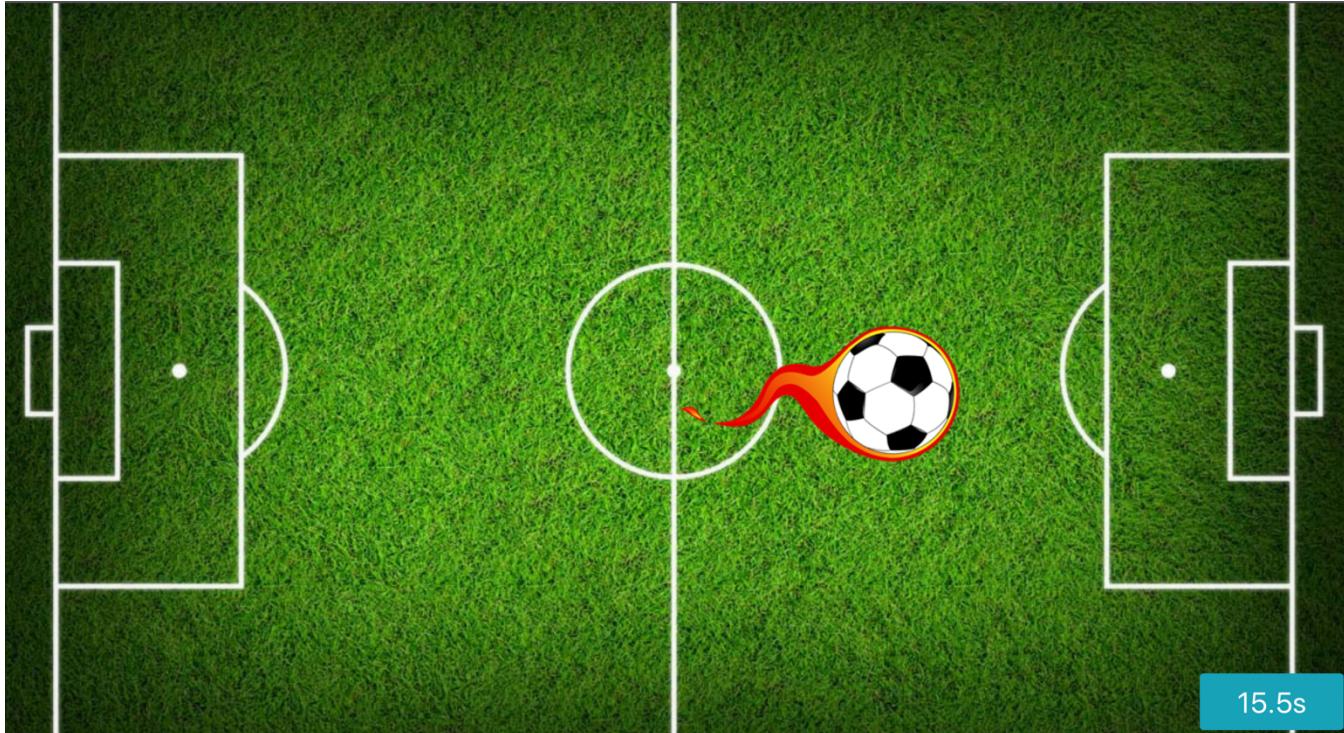
The image displays four separate screenshots of the CogniApp mobile application interface, each showing a different interaction or feature:

- Mood Tracking:** The first screenshot shows a purple header "CogniApp". A blue robot icon says "Hi, how are we feeling today?". Below are three buttons: "Great", "So so", and "Not good". At the bottom is a text input field "Type the message ...".
- Diet Tips:** The second screenshot shows a purple header "CogniApp". The robot says "Hi, how are we feeling today?". The user replies "So so". The robot then says "Ok, let's try to make it better than. How about trying some of these?". It lists "Healthy diet tips" and "Watch info videos". At the bottom is a text input field "Type the message ...".
- Video Player:** The third screenshot shows a purple header "CogniApp". The robot says "Healthy diet tips". It displays a large text block about healthy diet tips and another about foods to limit/avoid. At the top right is a "Healthy diet tips" button and a user profile icon. At the bottom is a video player showing a woman in a pink shirt with the text "MULTIPLE SCLEROSIS" and "Living".
- Message Input:** The fourth screenshot shows a purple header "CogniApp". It displays two buttons at the bottom: "Let's continue" and "Thanks, enough for today.". At the bottom is a text input field "Type the message ...".

Personalized assistant, trainer, cognitive game, health bodyguard and latest information at the fingertips

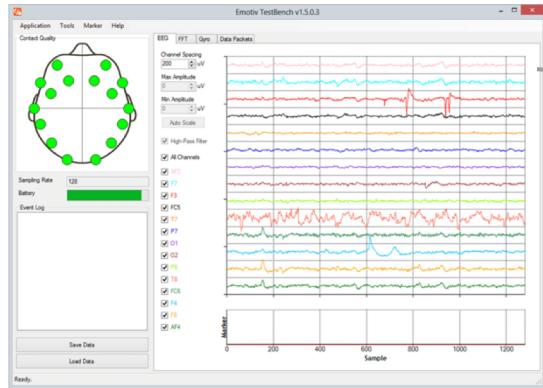
CogniApp showtime

CogniGame – EEG controlled, using your focus

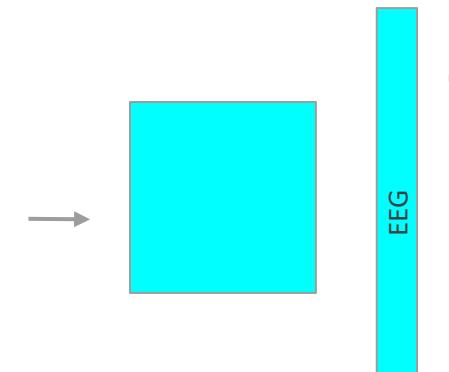
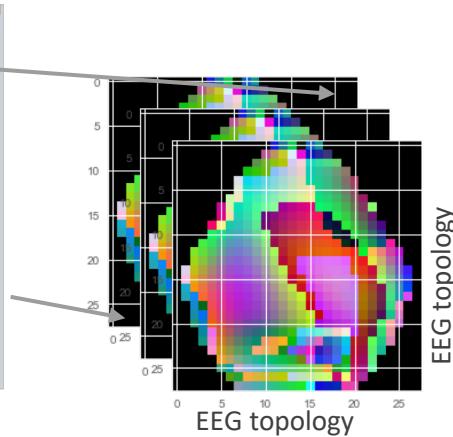


Use your focus to move ball from one side to the other. Better you focus, the better time you will have.

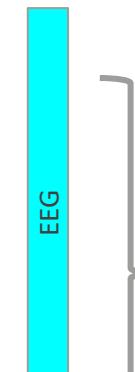
ML model for day to day drug variant recommendation



EEG data recording from
Emotiv



Convolutional layer



+

Weather

+

Vital Signs

XGboost layer

(Fan et al, 2018)

Decision of
drug use

Predict risk of
relapse



Train on
patient group



Personalize
prediction
(Transfer
Learning)

2. A) Frequency decomposition (+GRU)
(EEG-Classification, Tevis Gehr)

+

B) Online weather (openweather)
Feature extraction (detect abrupt weather
changes)

+

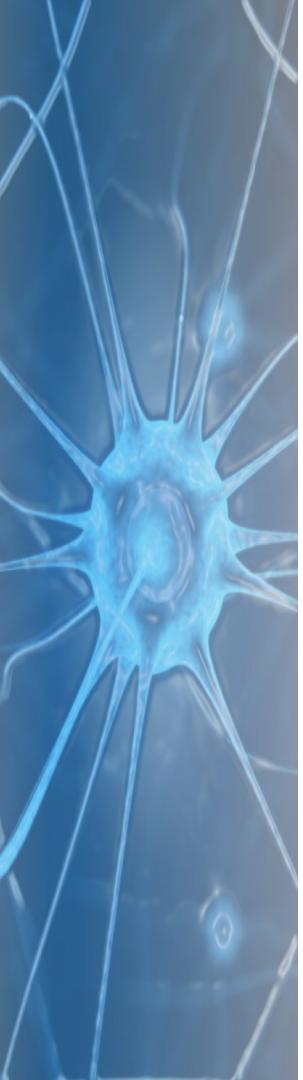
C) HealthKit data

Used technologies

- CogniApp + Game: React, React-ChatBot, Bootstrap, WebSocket
- Cogni WS Server: Node.js, WebSocket
- Data Transformation: WebSocket4NET, Emotive API, Google APIs Fitness
- Deep ML Analysis: Tensorflow, Keras, Open Weather
- HW: Emotive EPOC & EPOC+

All new / custom code made by us

Source code available on Github: <https://github.com/scholtz/CogniApp>



Michal Škop
MS research
Chatbot content

Ludovit Scholtz
Epoc HW + GoogleFit
interface, CogniGame

Martin Kubajda
Chatbot and
Data Transformation

Martin Holovský
Vision, Neuro research
& Architecture



Yeung-Yeung Leung
Neuro research and
Deep Learning model

Thank you

CogniTeam