# Нейроинтерфейсы

## — самый провальный проект Илона Маска?

**Сергей Шишкин**

Группа нейрокогнитивных интерфейсов
МЭГ-центра МГППУ https://bci.megmoscow.ru

Телеграм-канал «Нейроинтерфейсы»
https://t.me/bci_ru

# Moscow MEG Center

**MEG+EEG**

**Optically Pumped Magnetometers (OPM)**


Quspin QZFM Gen 3

A division of Moscow University of Psychology and Education

- The only multichannel MEG system in Russia
- Main research areas: autism, decision making, BCI

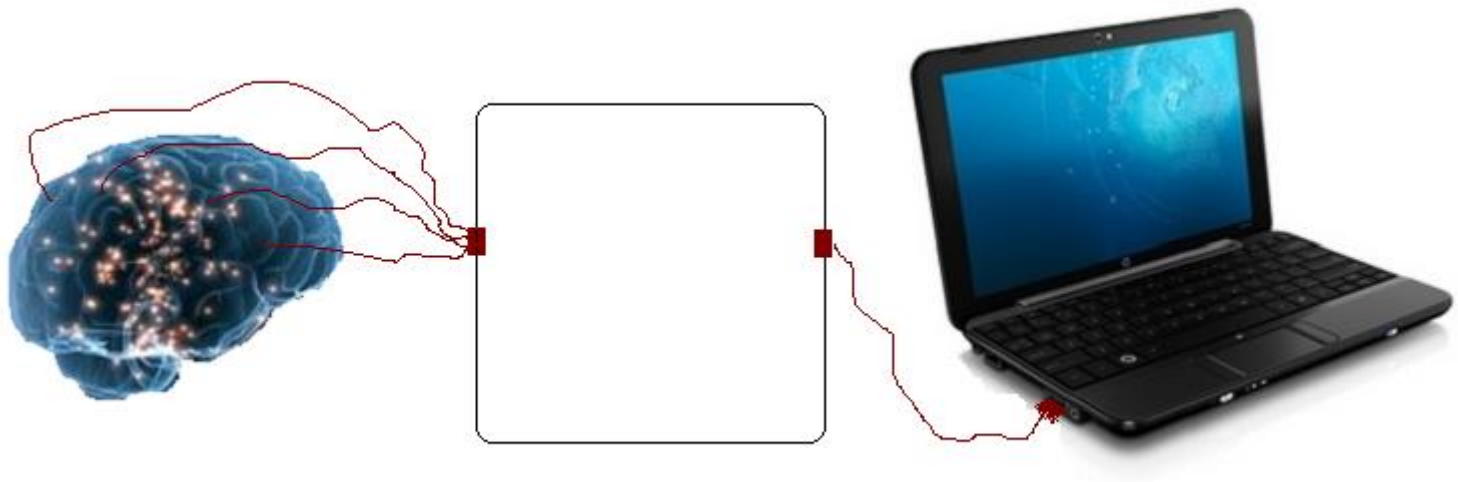
megmoscow.ru

**MEG + eye tracking**

# Термины

- Нейроинтерфейсы
- Интерфейсы мозг-компьютер (ИМК)
- Brain-Computer Interfaces (BCI)
- ~~Нейрочипы~~

– устройства, обеспечивающие взаимодействие мозга с компьютером без использования мышц [и периферических нервов]



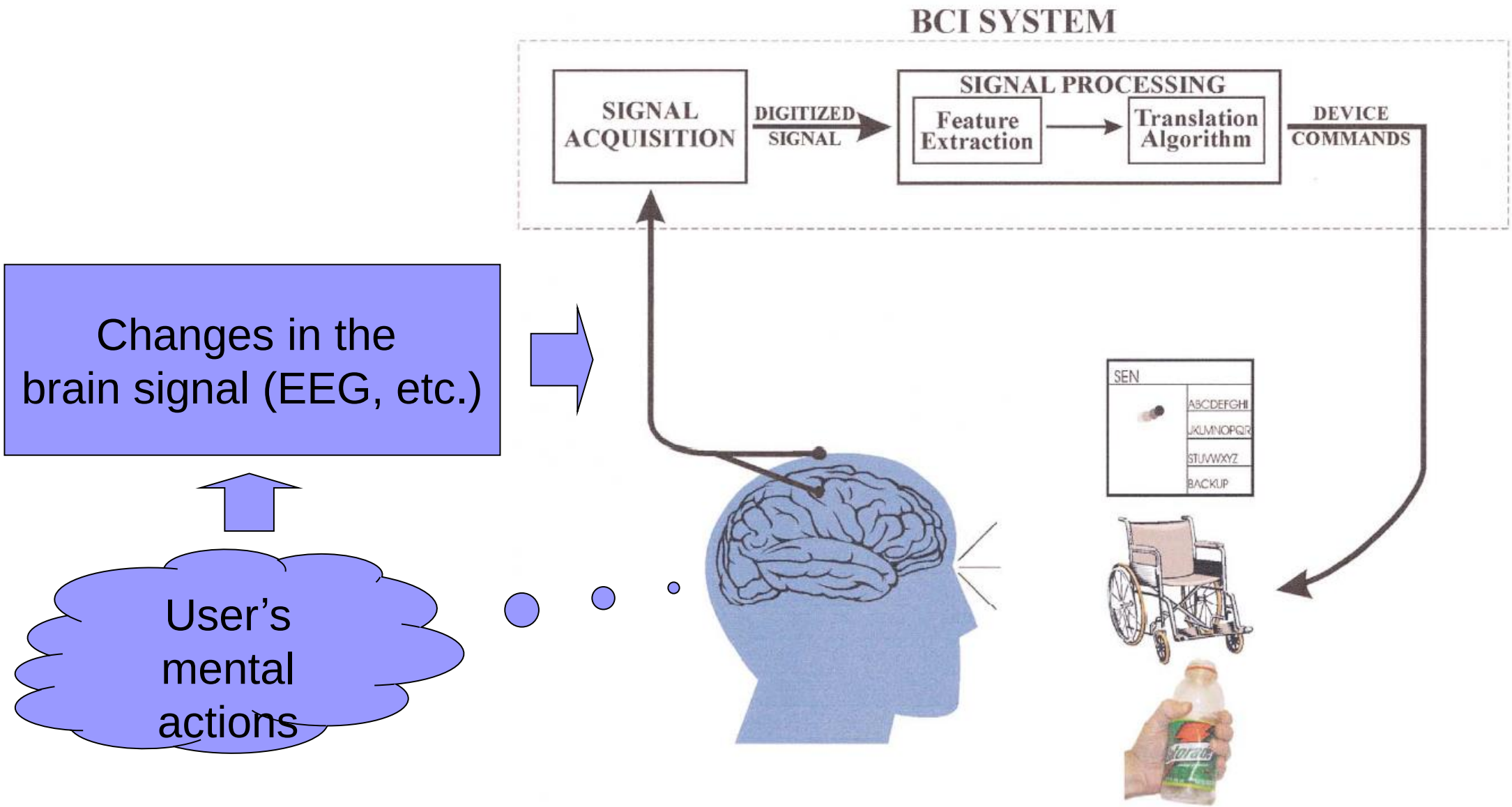



Fig. 1. Basic design and operation of any BCI system. Signals from the brain are acquired by electrodes on the scalp or in the head and processed to extract


CBS News

Dec 31, 2012

https://youtu.be/Z3a5u6djGnE?t=479


- Основан в 2016 году, название куплено в 2017м

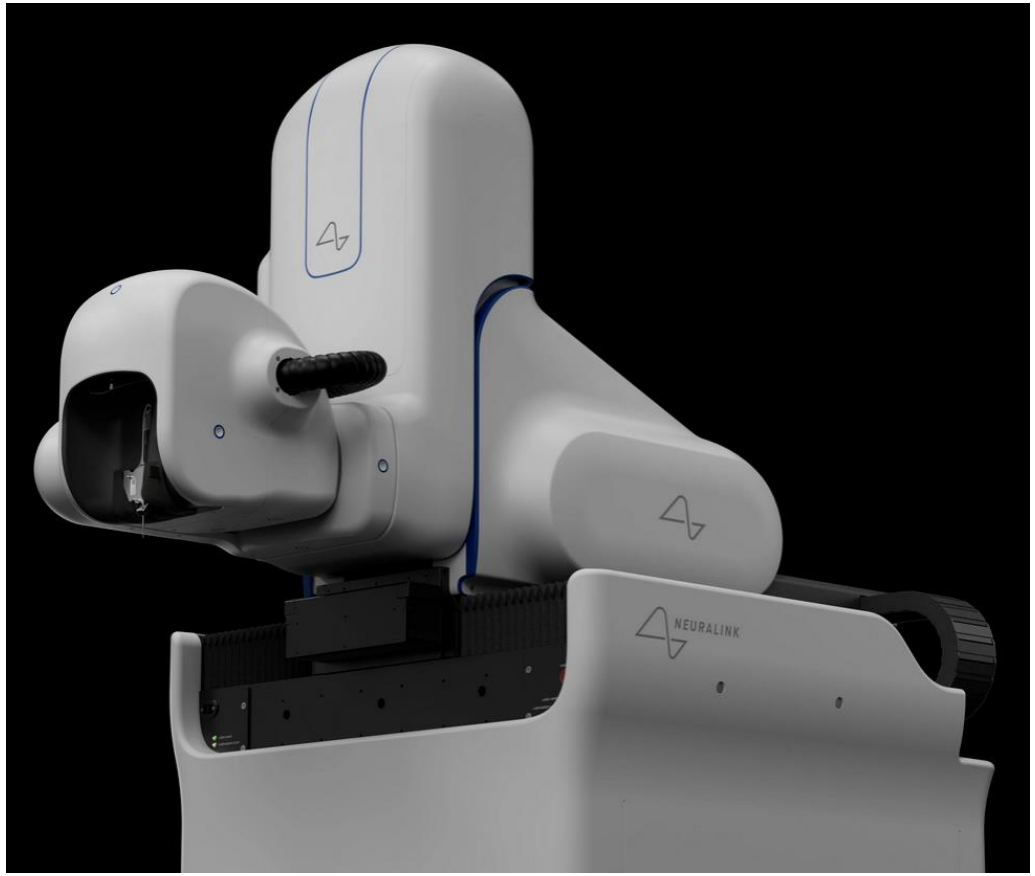
**Published on 31.10.2019 in Vol 21, No 10 (2019):October**

Preprints (earlier versions) of this paper are available at https://preprints.jmir.org/preprint/16194, first published September 09, 2019.

# An Integrated Brain-Machine Interface Platform With Thousands of Channels

Elon Musk [1]; Neuralink [1]

# Основные достижения Нейралинка: хирургический робот («швейная машинка»)



# Основные достижения Нейралинка: хирургический робот («швейная машинка»)

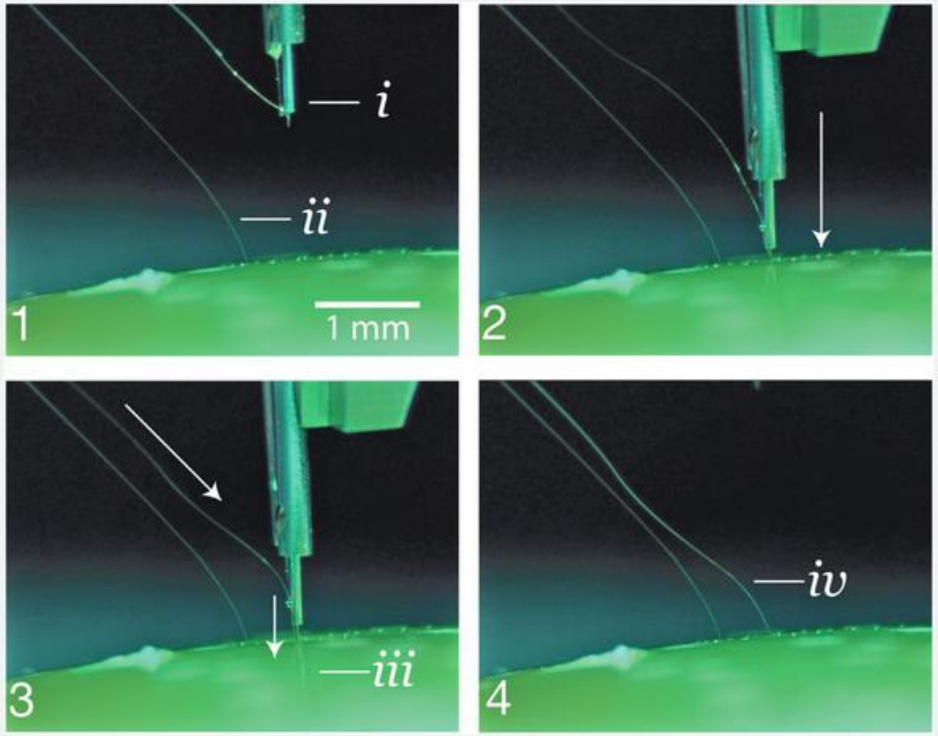



Figure 3. Insertion process into an agarose brain proxy. (1) The inserter approaches the brain proxy with a thread. (i) needle and cannula. (ii) Previously inserted thread. (2) Inserter touches down on the brain proxy surface. (3) Needle penetrates tissue proxy, advancing the thread to the desired depth. (iii) Inserting thread. (4) Inserter pulls away, leaving the thread behind in the tissue proxy. (iv) Inserted thread.

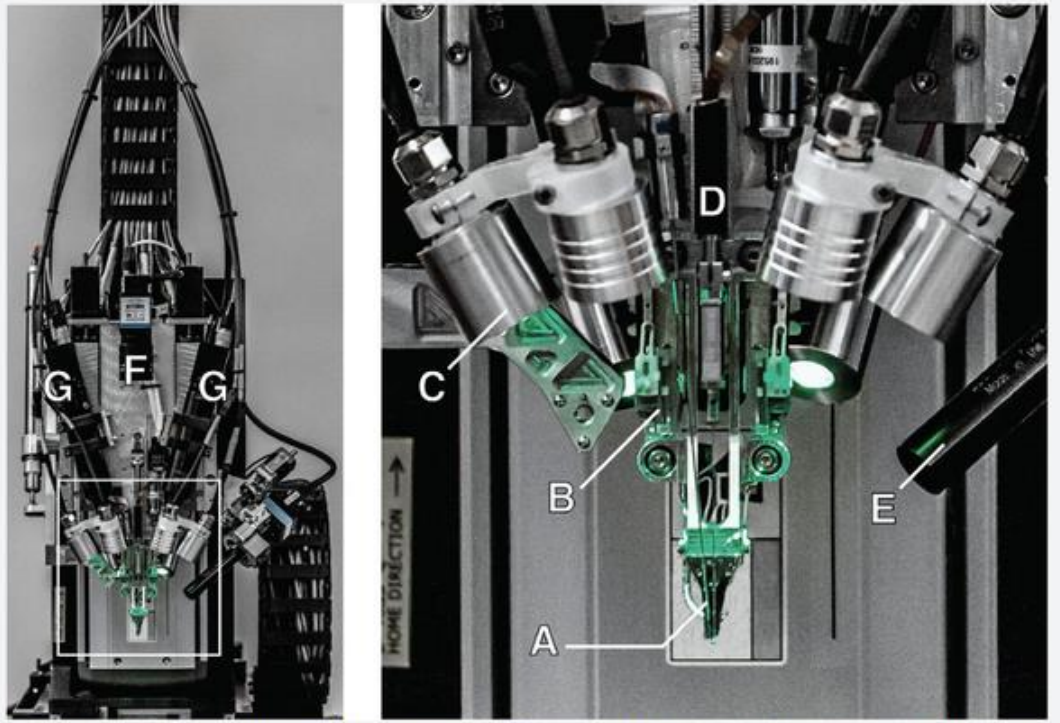
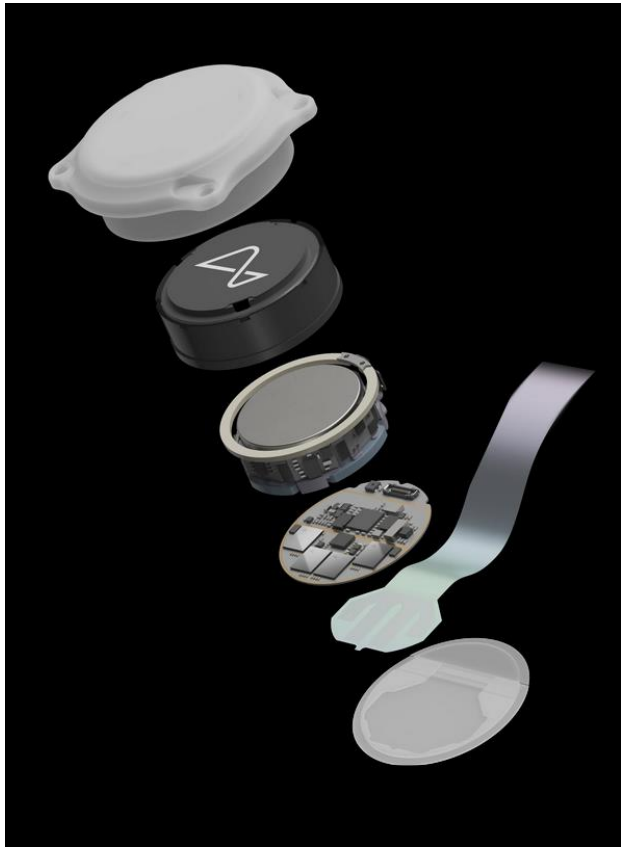



Figure 4. The robotic electrode inserter; enlarged view of the inserter-head shown in the inset. (A) Loaded needle pincher cartridge. (B) Low-force contact brain position sensor. (C) Light modules with multiple independent wavelengths. (D) Needle motor. (E) One of four cameras focused on the needle during insertion. (F) Camera with wide angle view of the surgical field. (G) Stereoscopic cameras.

https://www.jmir.org/2019/10/e16194/

# Основные достижения Нейралинка: компактный беспроводной «чип» с гибкими электродными системами («probes»)



# Проблемы Нейралинка

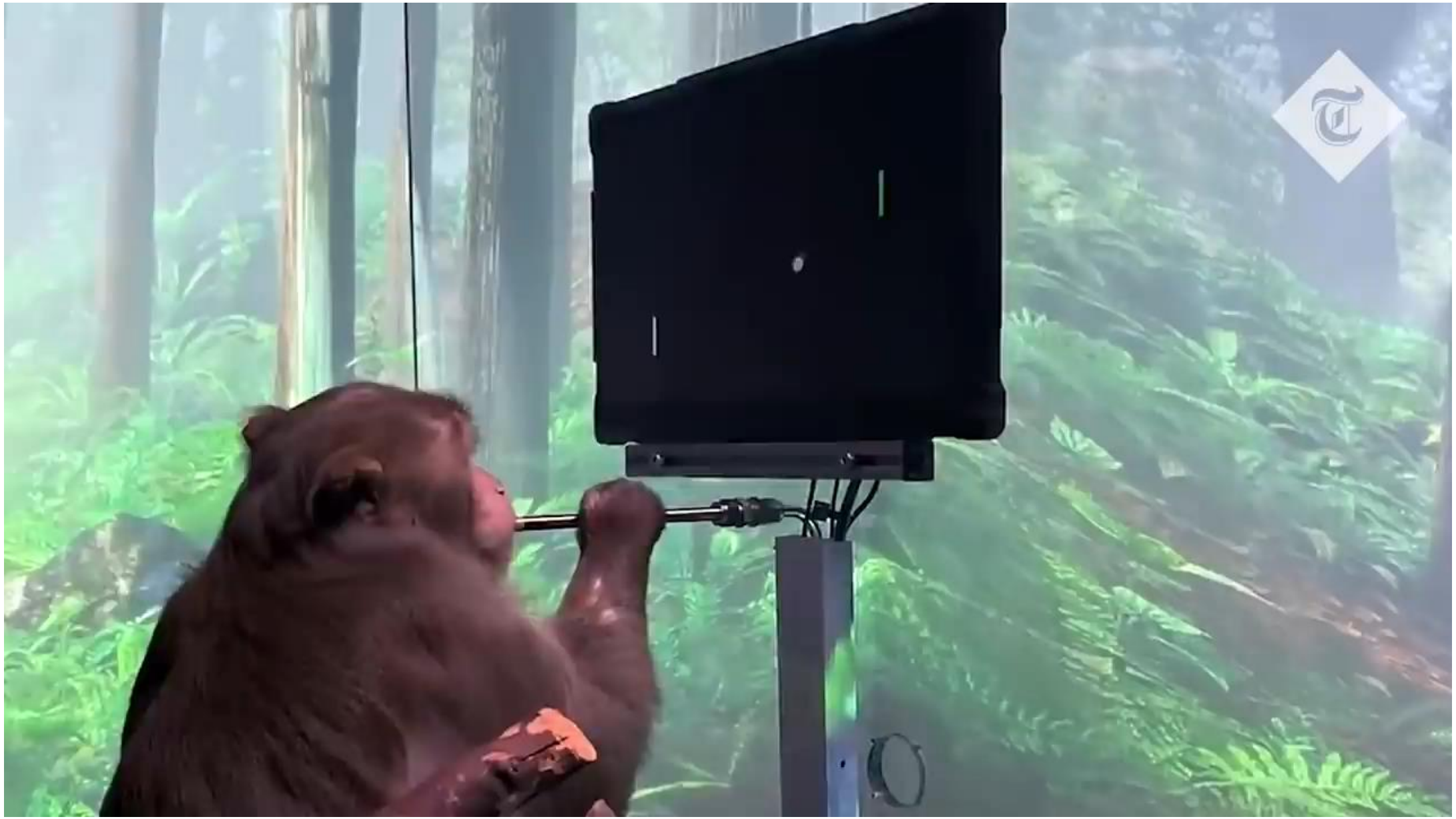
Подробности:

A REUTERS SPECIAL REPORT
U.S. regulators rejected Elon Musk’s bid to test brain chips in humans, citing safety risks
RACHAEL LEVY and MARISA TAYLOR
March 2, 2023
https://www.reuters.com/investigates/special-report/neuralink-musk-fda/

# Проблемы Нейралинка

Кратко:

- Ушли почти все сооснователи
- Провальные презентации



https://www.youtube.com/watch?v=rsCul1sp4hQ

# Проблемы Нейралинка

Нереалистичная мотивация

*the idea behind Neuralink ... is to try to more tightly couple collective human world to digital superintelligence*

– из интервью главе TED Крису Андерсону 6 апреля 2022 года
https://www.ted.com/talks/elon_musk_a_future_worth_getting_excited_about/

Фундаментальные препятствия перед радикальным расширением возможностей мозга:

**ВХОД**

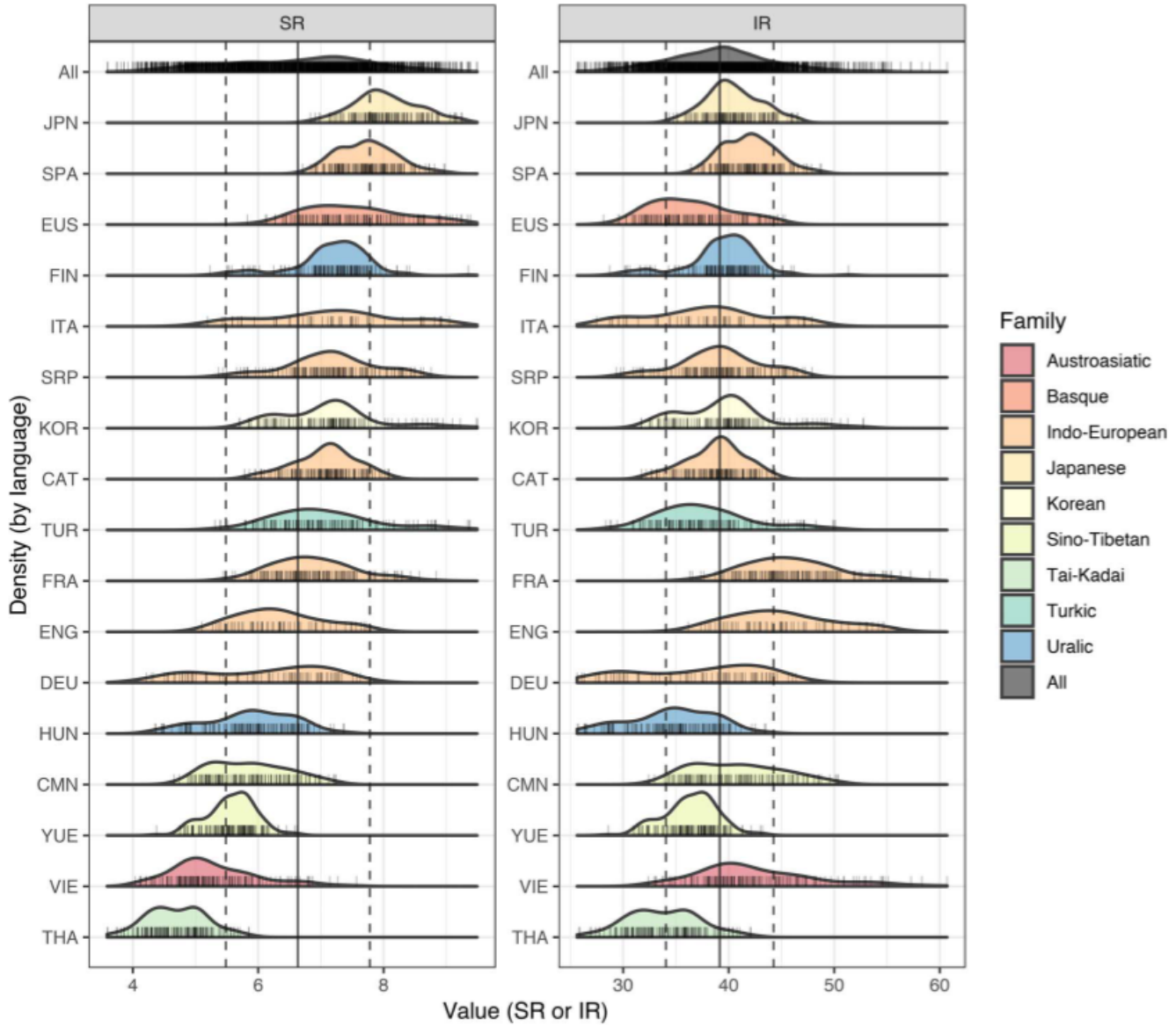



**Fig. 1. SR and IR.** The distribution of SR (in syllables per second) (left) and IR (in bits per second) (right) within the languages in our database (colored areas; colors represent the language families) and across them (black areas at the top) using a Gaussian kernel density estimate. The black vertical lines spanning the whole plot represent the means (solid lines) ± 1 SD (dashed lines). The short black vertical lines represent the actual data points.

Скорость передачи информации приблизительно одна и та же для 17 различных языков: ~40 бит в секунду

Когнитивные ограничения!

Coupé C, Oh YM, Dediu D, Pellegrino F (2019) Different languages, similar encoding efficiency: Comparable information rates across the human communicative niche. *Science Advances* 5:eaaw2594.

Фундаментальные препятствия перед радикальным расширением возможностей мозга:
**ВЫХОД**

The Washington Post
Democracy Dies in Darkness

# An Amazon Echo recorded a family's conversation, then sent it to a random person in their contacts, report says

By **Hamza Shaban**

May 25, 2018 at 1:40 a.m. GMT+3


A family in Portland, Ore., received a nightmarish phone call two weeks ago.

"Unplug your Alexa devices right now," a voice on the other line said. "You're being hacked."

Apparently, one of Amazon.com's Alexa-powered Echo devices in their house had silently sent recordings to the caller without the family's permission, according to KIRO 7, a news station covering Seattle and western Washington state that first reported the story. The person, an employee of the husband, was in the family's contact list.

Отсутствие сознательного контроля ведет к серьезным проблемам!

https://www.washingtonpost.com/news/the-switch/wp/2018/05/24/an-amazon-echo-recorded-a-familys-conversation-then-sent-it-to-a-random-person-in-their-contacts-report-says/

Фундаментальные препятствия перед радикальным расширением возможностей мозга при подключении к **внутренним компонентам**

Мы доверяем своему бессознательному – но насколько сможем ли доверять ему, если в него внедрится ИИ?

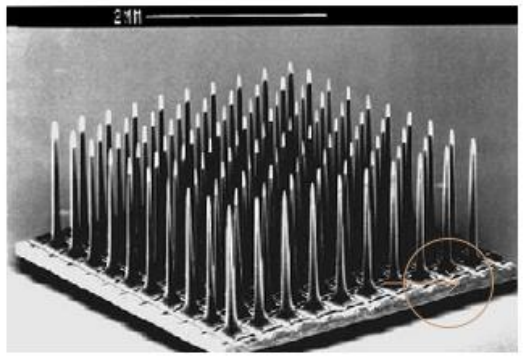
(Те же проблемы, что и с выходом: отсутствие сознательного контроля создает проблемы в случае ошибок или умышленных искажений)

Blackrock Neurotech

1989

## The invention of the Utah Array

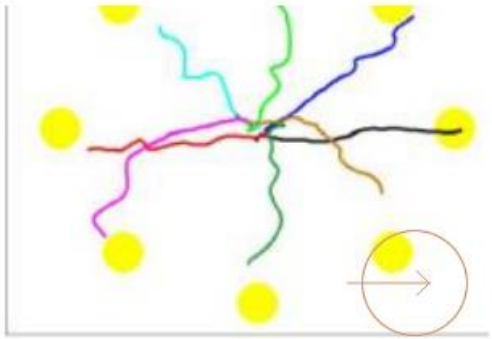
The Utah Array is invented by Richard A. Normann (University of Utah.)



2002

## Monkeys control computer cursor

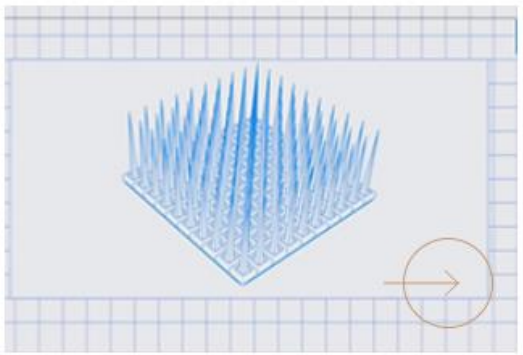
Three monkeys implanted with Utah Arrays successfully control a computer cursor to click on-screen targets with high speed and accuracy in a study at Brown University.



2004

## Utah Array is implanted in humans

As part of BrainGate's clinical trials, Matt Nagle is implanted with the Utah Array. One year later, he controls an artificial hand with his BCI.



2008

## Blackrock Microsystems is founded

Blackrock Microsystems acquires Cyberkinetics, which includes the Utah Array and other interfaces developed at the University of Utah

Utah array используется в ИМК с 2004 года

https://blackrockneurotech.com/

Blackrock Neurotech

2021

## A high-bandwidth wireless iBCI is tested for at-home use

Using Blackrock's hardware and transmitter, BrainGate researchers demonstrated the first human use of a wireless transmitter capable of delivering high-bandwidth neural signals.


2021

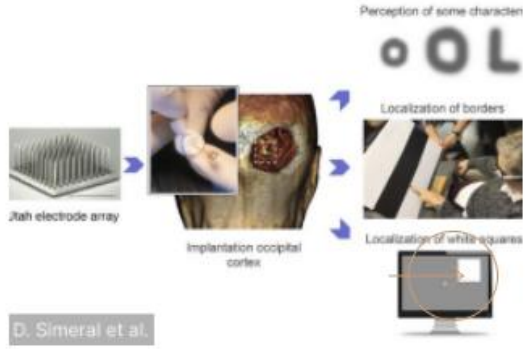
## Whole words decoded from thought

Researchers at University of California San Francisco use a Blackrock-built electrode and recording system to successfully decode whole words from a set of 50 with 93% accuracy.


2021

## Cortical Neuroprosthetic produces artificial vision

Simple shapes were projected into subjects' visual fields using stimulation from a Utah Array in an early demonstration of a visual prosthetic at the University of Utah & Universidad Miguel Hernández.




2022

## First portable at-home system trial

University of Pittsburgh launches trial with Blackrock's first portable at-home system


Utah array используется в ИМК с 2004 года

https://blackrockneurotech.com/

Blackrock Neurotech


10,000+ каналов, обещают с 2024 года для исследовательских лабораторий

( Илон Маск в 2016 году обещал «neural lace», которая будет работать как «digital layer above the cortex» )

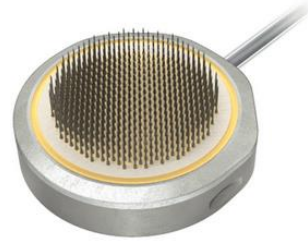
Paradromics

## Direct data from 1600+ neurons

The Connexus Cortical Modules target neurons just below the surface of the brain, accessing neural signals that surface electrodes cannot. The system supports up to four modules for more cortical coverage and improved capabilities.

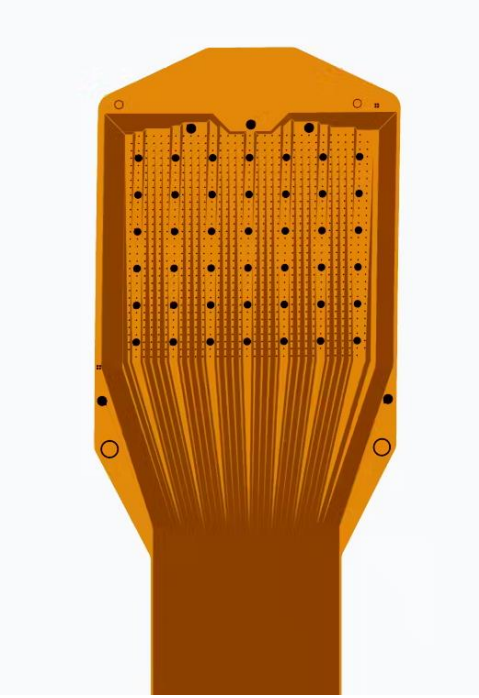
## Cortical Module

An array of 421 miniature electrodes (< 40-µm) achieve an industry-leading high data rate while limiting tissue impact. The hermetically-sealed, on-chip Quartet® Neural Signal Transform, provides reliable, low-power conversion of neural signals to usable data.



Основана в 2015 году
CEO: Matt Angle
https://www.paradromics.com/

Precision

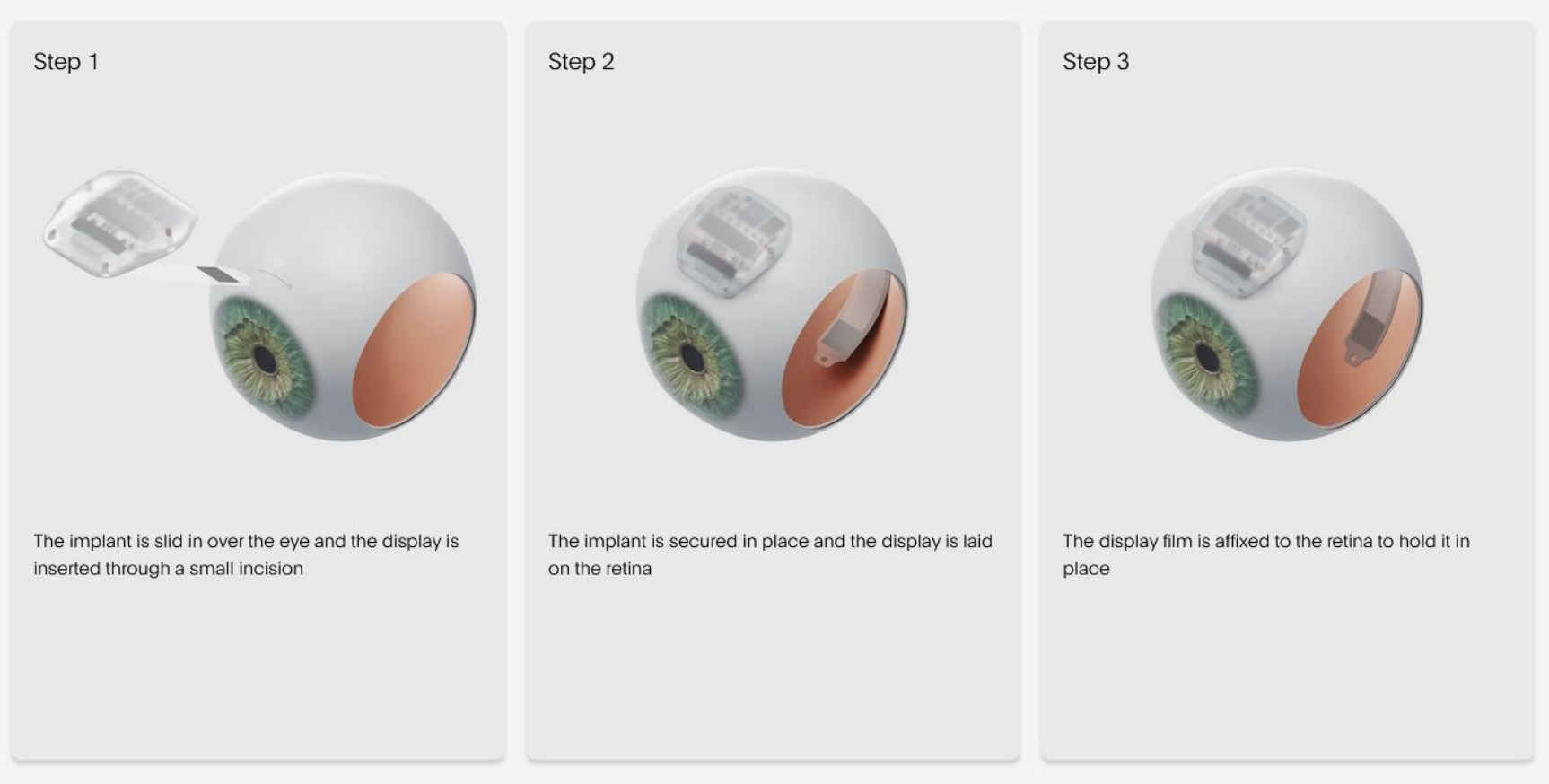


Layer 7:
тонкопленочный массив со 1024 электродами для ЭКоГ

Вводится через узкую щель, с возможностью удаления

*Precision Neuroscience*
2020: co-founded by Michael Mager and Benjamin Rapoport
(co-founders of *Neuralink*)
https://precisionneuro.io/

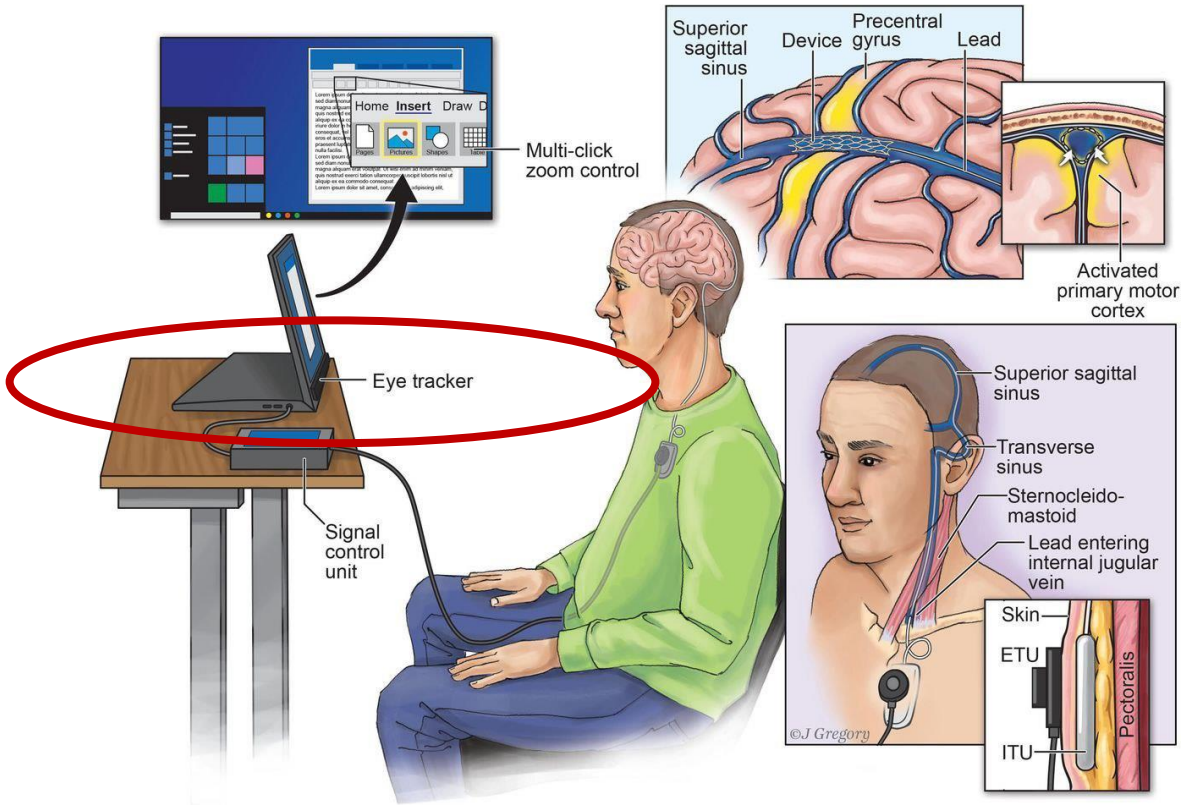
Science




Science Corporation
Основана Максом Ходаком
Сейчас разрабатывают *Science Eye*
https://science.xyz/

synchron

# Эндоваскулярный интерфейс («стентроды»)




Основана в 2011 году в Австралии, далее переезд в США

Испытания в Австралии: 4 пациента, 1 год без серьезных осложнений

Первая установка в США – июль 2022 года

Инвестиции от Джеффа Безоса и Билла Гейтса – декабрь 2022

Научные публикации: Oxley et al., J. of Neurointerventional Surgery, 2021; Mitchell ... Oxley, Campbell, JAMA Neurology, 2023

# Проблемы всех инвазивных технологий


Создание инвазивных технологий реалистично в случае четких целей (напр., восстановление конкретной функции) и наличии убедительных научных данных, доказывающих возможность решения основных проблем

# Спасибо!

Группа нейрокогнитивных интерфейсов МЭГ-центра МГППУ
https://bci.megmoscow.ru

Телеграм-канал «Нейроинтерфейсы»
https://t.me/bci_ru

# Neurocognitive Interfaces Group at MEG Center

**Sergei Shishkin**, PhD
psychophysiology

**Anatoly Vasilyev**, PhD
psychophysiology,
data analysis

**Ignat Dubynin**, PhD
psychophysiology,
engineering

**Darisiy Zhao**
PhD student (NRC
Kurchatov Inst.)
computer science

**Artem Yashin**
PhD student (MSU)
philosophy,
psychophysiology

**Yulia Shevtsova**
psychophysiology,
computer science

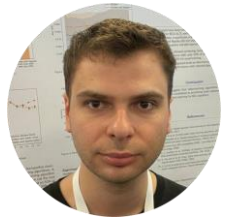
**Daniil Berdyshev**
PhD student
(MSU)
machine learning

**Egor Chetkin**
PhD student
(MSU)
machine learning

# Current active collaborators

**Yuri Nuzhdin**
software engineering
(the Netherlands)

Dr. **Bogdan Kozyrskiy**
machine learning
(France)



Dr. **Artem Grachev**
machine learning
(Germany)

Prof. **Tatiana Stroganova**
MEG Center, MSUPE

Prof. **Alexei Ossadtchi**
Center for Bioelectric
Interfaces, HSE

Dr. **Vadim Nikulin**
HSE / MPI CBS (Germany)

# Research directions

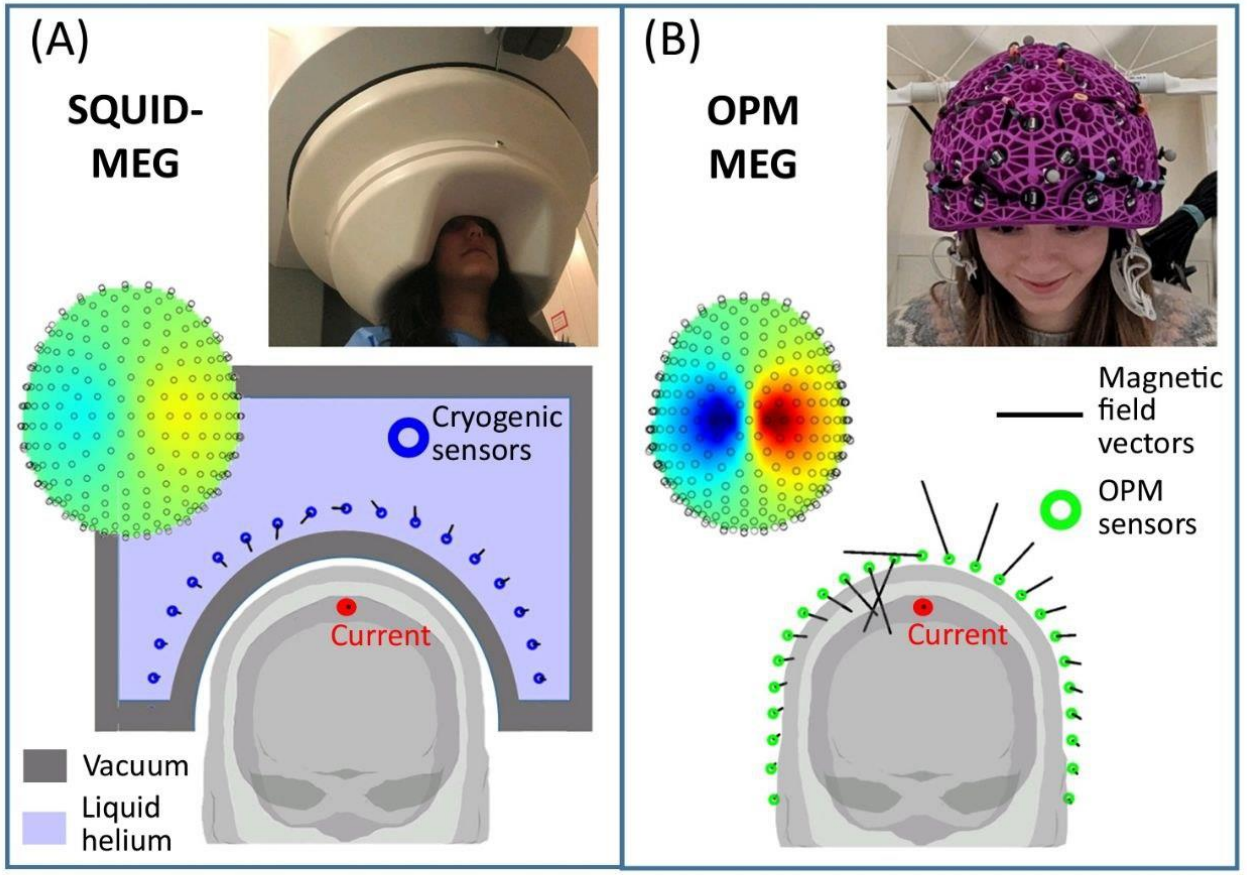
- Advanced/hybrid EEG/MEG BCIs
- Gaze interaction
- OPM MEG
- Intention, action, agency, consciousness

Moscow State University (Kaplan’s lab) -> Kurchatov Inst. -> MEG Center

# MEG with Optically Pumped Magnetometers (OPM)

*In collaboration with Alexei Ossadtchi (HSE)*


Quspin QZFM Gen 3




Trends in Neurosciences

Figure 2. Advantages of optically pumped magnetometer (OPM)-magnetoencephalography (MEG) compared with conventional MEG. (A) A schematic representation of conventional MEG [superconducting quantum interference

Brookes *et al.* Magnetoencephalography with optically pumped magnetometers (OPM-MEG): the next generation of functional neuroimaging. *Trends in Neurosciences*, 2022.

# MEG with Optically Pumped Magnetometers (OPM)

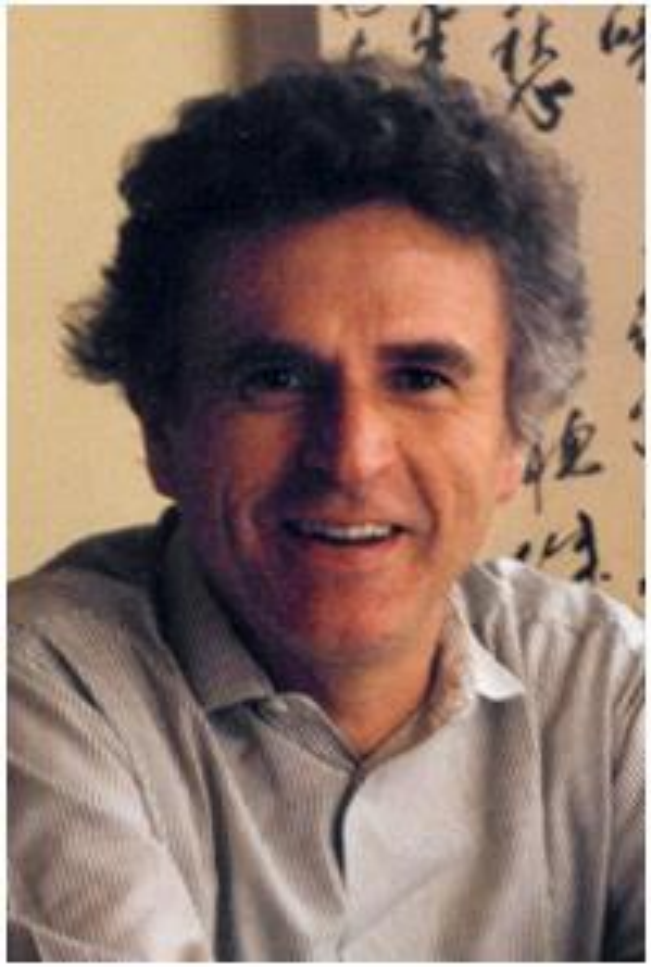
*In collaboration with Alexei Ossadtchi (HSE)*


Quspin QZFM Gen 3

*Toyota-RIKEN wheelchair (2009)*

https://www.csmonitor.com/Technology/Horizons/2009/0629/toyota-develops-thought-controlled-wheelchair

# «Устройство для передачи мыслей» Нильса Бирбаумера



Exp Brain Res (1999) 124:223–232



RESEARCH ARTICLE

Andrea Kübler · Boris Kotchoubey
Thilo Hinterberger · Nimr Ghanayim
Juri Perelmouter · Margarete Schauer
Christoph Fritsch · Edward Taub · Niels Birbaumer

## The thought translation device: a neurophysiological approach to communication in total motor paralysis

Received: 8 May 1998 / Accepted: 4 August 1998

**Abstract** A thought translation device (TTD) for brain-computer communication is described. Three patients diagnosed with amyotrophic lateral sclerosis (ALS), with total motor paralysis, were trained for several months. In

**Key words** Slow cortical potentials · Brain-computer communication · Amyotrophic lateral sclerosis · EEG

Kübler et al. Exp Brain Res. 1999;124:223-32.

Basically, a BCI provides new non-muscular and non-nervous channels for sending messages and commands to the external world. In the authors' opinion BCI is not only a brand-new neurologically based technology for clinics, but a new paradigm in neuroscience that can reveal previously unknown brain possibilities to develop the behavior "without nerves and muscles" and to integrate the person into new "thought driven" reality. The user has to

*Intern. J. Neuroscience,* 115:781–802, 2005

# UNCONSCIOUS OPERANT CONDITIONING IN THE PARADIGM OF BRAIN-COMPUTER INTERFACE BASED ON COLOR PERCEPTION

**ALEXANDER YA. KAPLAN**

Department of Human Physiology
Biological Faculty, Moscow State University
Moscow, Russian Federation

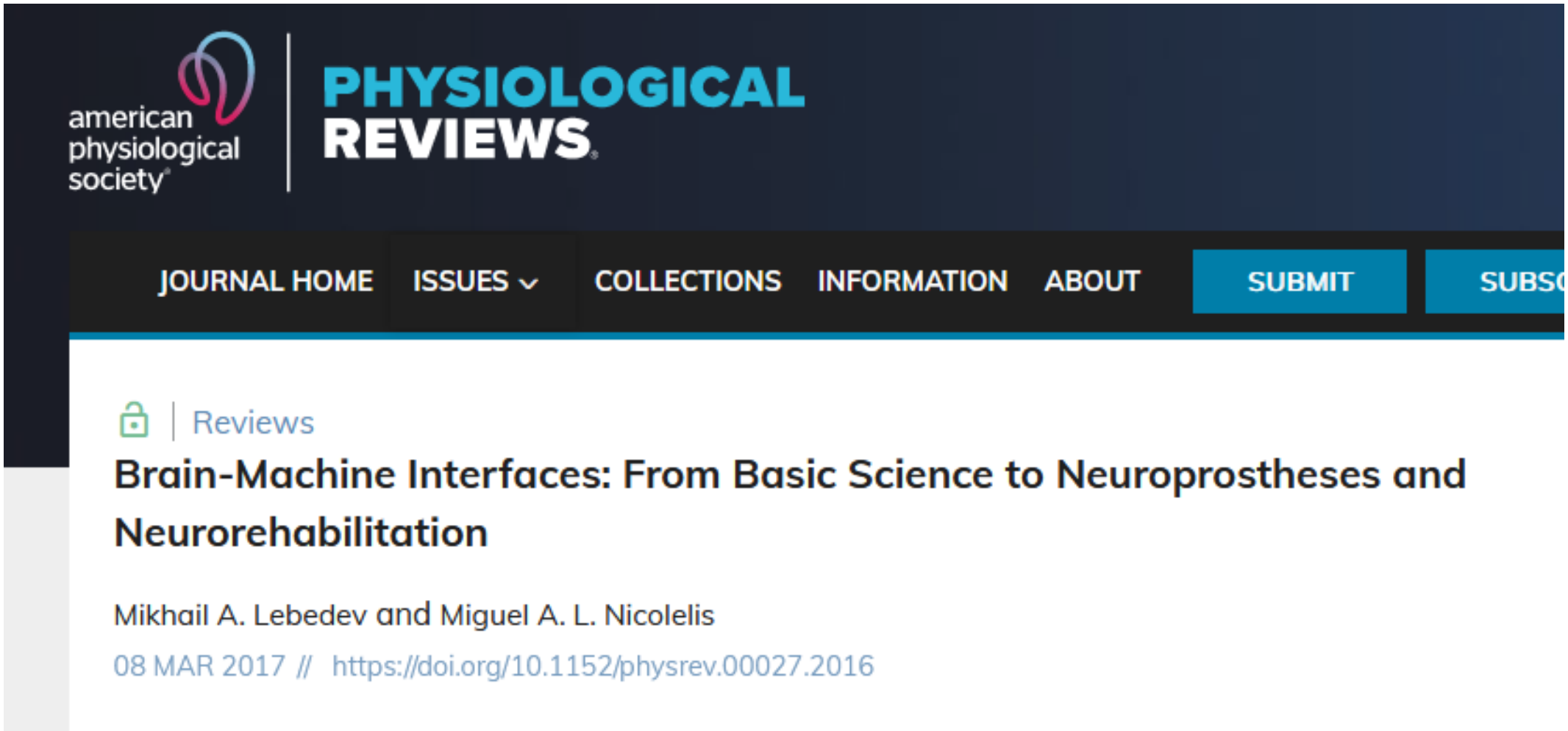
**JONG-GIL BYEON**

Chungbuk National University
School of Electronic and Computer Engineering
Chungcheongbuk-do, Republic of Korea

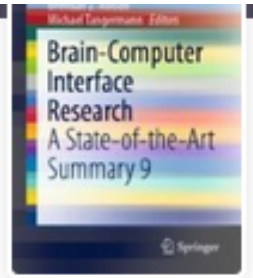
**JONG-JIN LIM**

Neuro-Telemetry Team

http://brain.bio.msu.ru/papers/Kaplan_Lim_Jin_Park_Byeon_Tarasova_2005_IntJNeuroSci_UnconscCondition_ColorBCI.pdf




https://journals.physiology.org/doi/pdf/10.1152/physrev.00027.2016




**Brain-Computer Interface Research** pp 65–77 | Cite as

# Final Results of Multi-center Randomized Controlled Trials of BCI-Controlled Hand Exoskeleton Complex Assisting Post-stroke Motor Function Recovery

Alexander Frolov, Elena Biryukova, Pavel Bobrov ✉, Dmirty Bobrov, Alexander Lekin, Olesya Mokienko, Roman Lyukmanov, Sergey Kotov, Anna Kondur, Galina Ivanova & Yulia Bushkova

Chapter | First Online: 02 April 2021

https://doi.org/10.1007/978-3-030-60460-8_6

# Письмо полностью парализованного пациента



---EXPERIENCES OF A TTD USER---
FIRST I BRIEFLY WANT TO DESCRIBE THE STRATEGY WHICH I HAVE DEVELOPED. TO PRODUCE POSITIVE POTENTIAL SHIFTS I TRY TO GENERATE PRESSURE IN THE BRAIN DURING THE FEEDBACK PHASE. IN CONTRAST, TO PRODUCE NEGATIVE POTENTIAL SHIFTS, I TRY TO CREATE A KIND OF MENTAL VOID BY RELAXING THE BRAIN BOTH DURING THE BASELINE PHASE AND THE FOLLOWING FEEDBACK PHASE.
----TO PRODUCE PRESSURE, I USE DIFFERENT MENTAL STRATEGIES. FOR EXAMPLE I IMAGINE A SET OF TRAFFIC LIGHTS TURNING GREEN WITH THE SECOND TONE INDICATING THE BEGINNING OF THE FEEDBACK PHASE, OR I IMAGINE AN ATHLETE STARTING TO RUN WITH THE STARTING SIGNAL OR AN ARROW SHOOTING UP FROM THE BOW OR THE CURSOR JUMPING INTO THE LETTER RECTANGLE. HOWEVER, THE EFFICACY OF THESE MENTAL STRATEGIES DEPENDS ON BUILDING UP ENOUGH TENSION OR EXPECTANCY DURING THE BASELINE PHASE. IN CASE OF THE TRAFFIC LIGHTS I IMAGINE THE YELLOW LIGHT, IN THE IMAGE OF THE ARROW THE DRAWING OF THE BOW, ETC. THE BUILD-UP OF TENSION IN THE BRAIN INDUCED BY MENTAL IMAGES MAY BE LOCALIZED AT THE CENTRAL ELECTRODE CZ IN DIRECTION OF ELECTRODE FZ. LET'S CALL THIS THE PHYSIOLOGICAL BASIS OF THE PRESSURE MENTIONED ABOVE. IN CONTRAST, IT IS NOT POSSIBLE TO LOCALIZE THE GENESIS OF THE MENTAL IMAGES THEMSELVES, WHICH ARISE INSOFAR FROM NOWHERE. UNFORTUNATELY, THE USE OF THESE IMAGES CAN NOT BE REPEATED CONSTANTLY, DIRECTLY AND INFINITELY. THIS MAY BE ATTRIBUTABLE TO THE LACK OF CONCENTRATION OR TO THE TRANSIENT NATURE OF THOUGHTS AND IMAGES WHICH ENTAILS THAT NO THOUGHT OR IMAGE OF THE SAME CONTENT CAN BE REPRODUCED IDENTICALLY. ONE SOURCE OF ERROR IS THE UNPRECISE USAGE OF THE IMAGES IN THE BASELINE PHASE, UNPRECISE MEANING PARTICULARLY TOO SHORT AND FUZZY. SOMETIMES I FORGET TO USE THE MENTAL IMAGES IN THE HEAT OF THE MOMENT WHILE FIGHTING WITH THE LETTERS. THIS IS USUALLY ACCOMPANIED BY A SUBJECTIVE REDUCTION OF TIME IN WHICH BOTH PHASES BLEND INTO EACH OTHER.
IN ADDITION THOUGHTS WITH A STRONG AFFECTIVE CONTENT, LIKE EVENTS OR NAMES, ARE SUITED TO PRODUCE POSITIVE POTENTIAL SHIFTS. BECAUSE OF THEIR EMOTIONAL QUALITY NO ADDITIONAL TENSION IS REQUIRED. AT THE SAME TIME THIS CONSTITUTES A DISADVANTAGE, FOR THE EXISTING POTENTIAL CAN LEAD TO AN UNINTENDED POSITIVE SHIFT IN THE NEXT TRIAL, TOO. THE SAME PHENOMENON CAN BE OBSERVED IN THE DESCRIBED BUILD-UP OF TENSION. IN SUCH A CASE IT IS ALREADY WITH THE FIRST TONE, I.E. THE BEGINNING OF THE FOLLOWING TRIAL'S BASELINE PHASE, THAT I REALIZE THAT A POSITIVE SHIFT WILL OCCUR. HERE IT IS UNCLEAR WHETHER THIS WAS DUE TO A DELAYED INCREASE IN TENSION OR TO AN INSUFFICIENT DISCHARGE OF TENSION.

SOMETIMES NO MENTAL STRATEGY IS REQUIRED, WHICH IS ALSO TRUE FOR THE PRODUCTION OF NEGATIVE POTENTIAL SHIFTS DESCRIBED BELOW. THEN THE SEQUENCE RUNS AUTOMATICALLY INDEPENDENT OF THE ALTERNATION OF

Fig. 4. Text written by patient HS. The complete text was written using self-regulation of slow cortical potentials only.

N. Neumann et al. / Neuropsychologia 41 (2003) 1028–1036

NEGATIVE AND POSITIVE SHIFTS AND ITS PLAYFUL EASE GIVES THE IMPRESSION AS IF THE BRAIN AND THE MACHINE OSCILLATE IN THE SAME RHYTHM. THEN I GET THE IMPRESSION OF BEING BOTH FULLY ENGAGED IN THE TASK AND OF BEING ABLE TO WATCH MYSELF FROM THE OUTSIDE.

TO PRODUCE NEGATIVE SHIFTS I TRY TO ACHIEVE A MENTAL VOID BY RELAXATION. WITH RELAXATION I MEAN TO LET GO, TO SAY GOOD-BYE TO MY THOUGHTS. HOWEVER, IT TURNS OUT THAT ALMOST REGULARLY NEW, UNINVITED THOUGHTS DISTURB THE VOID. THIS CAN LEAD TO A POSITIVE POTENTIAL SHIFT DEPENDING ON THEIR EMOTIONAL QUALITY. TO FORCE ONESELF TO IMAGINE THE VOID DOES NOT HELP MUCH, SINCE MY BRAIN BEHAVES IN A COMPLETELY "UN-PRUSSIAN" WAY. I FOUND AN IMAGE FOR THIS SITUATION: THERE IS A "REAR AREA" FREE OF THOUGHTS AGAINST WHICH UNINVITED THOUGHTS FORM A "FRONT AREA" MAKING THE REAR AREA DISAPPEAR. THE EMOTIONAL QUALITY OF A THOUGHT CANNOT BE CHANGED DIRECTLY. HOWEVER, IT TURNED OUT THAT THIS IS POSSIBLE WITH THE AID OF THE SPATIAL ARRANGEMENT OF THE TWO AREAS, WITH THE "INNER EYE" CHANGING THE PERSPECTIVE TO WATCH BOTH AREAS AND OBSERVING THE THOUGHT. THIS IS ASSOCIATED WITH A SPATIAL DISSOCIATION FROM THE TOPIC AND LEADS TO A REDUCTION OF THE EMOTIONAL QUALITY. SINCE THE MENTAL STRATEGIES HAVE THE SAME EFFECT AS THE UNINVITED THOUGHTS, THERE IS EVIDENCE THAT THEY ALSO APPEAR IN THE FRONT AREA.
THIS MAY REPRESENT AN APPROACH TO AUTOMATION OF WRITING WITH THE TTD AS PROPOSED BY NIELS BIRBAUMER. LAST BUT NOT LEAST THE EXPERIENCE WITH AUTOMATICALLY RUNNING SEQUENCES POINTS TO THIS FACT, AND PROXIMITY AND DISTANCE SEEM TO HARMONIZE WELL IN THEIR DOUBLE MEANING. IT REMAINS AN EXCITING QUESTION WHETHER OR NOT AUTOMATION SUCCEEDS COMPLETELY IN THIS KIND OF WORKING WITH THOUGHTS.
(Patient's name)

Fig. 4. (*Continued*).

Neumann, … Birbaumer (2003) *Neuropsychologia*

# ~ 2 буквы в минуту, медленные потенциалы

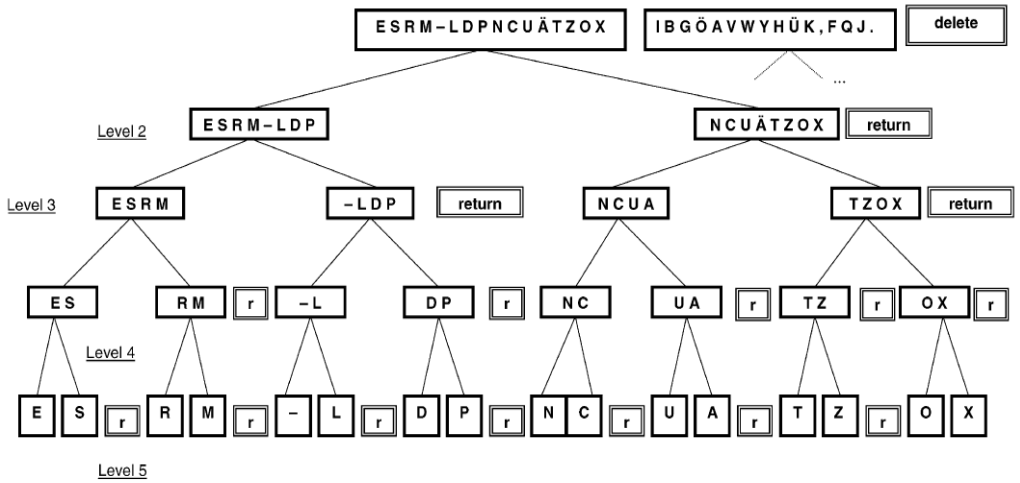



Fig. 3. Letter presentation in the thought translation device. Letters were arranged according to their frequency in the German language and presented in a dichotomous way: a letter bank comprising the German alphabet and punctuation marks (32 symbols) was split in two subsets of 16 symbols. The subsets were presented successively to be either selected with a cursor movement exceeding a preset threshold level (7.7 μV), or rejected with a cursor movement falling below the threshold level. After selection a subset was again split in two and this was continued until a single letter was presented for selection. Thus the patient had to overcome five levels ($2^5 = 32$) to select a single letter. At every level he had the possibility to return to the preceding level. At the first level, a delete option was presented which allowed the correction of an erroneously selected letter.

- 6 месяцев
- 52 дней
- ~ 160 часов

- 128,900 бинарных выборов
- 454 слов
- 4733 символов

Neumann N, Kübler A, Kaiser J, Hinterberger T, Birbaumer N (2003) Conscious perception of brain states: mental strategies for brain–computer communication. *Neuropsychologia.* 41(8): 1028-1036.

# Ученый с БАС работает дома, используя ИМК

*Amyotrophic Lateral Sclerosis*, 2010; 00: 1–7

informa
healthcare

ORIGINAL ARTICLE

## A brain-computer interface for long-term independent home use

ERIC W. SELLERS[1,2], THERESA M. VAUGHAN[2] & JONATHAN R. WOLPAW[2]

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*State Department of Health, Albany, New York, USA*

**Abstract**
Our objective was to develop and validate a new brain-computer interface (BCI) system suitable for lon
ent home use by people with severe motor disabilities. The BCI was used by a 51-year-old male with A
longer use conventional assistive devices. Caregivers learned to place the electrode cap, add electrode ge

[Sellers EW, Vaughan TM, Wolpaw JR. A brain-computer interface for long-term independent home use. Amyotrophic Lateral Sclerosis. 2010 Oct 1;11(5):449-55.]

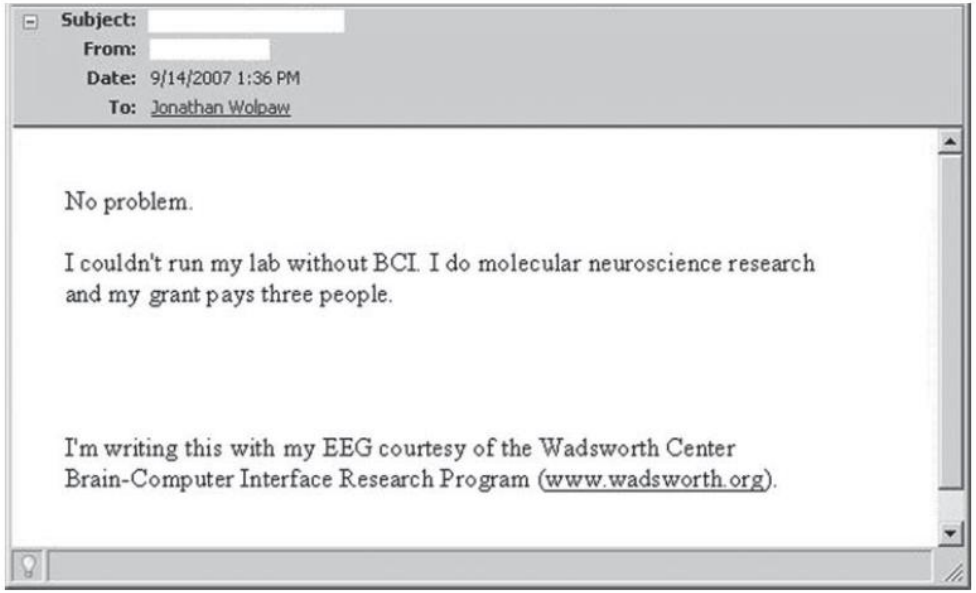
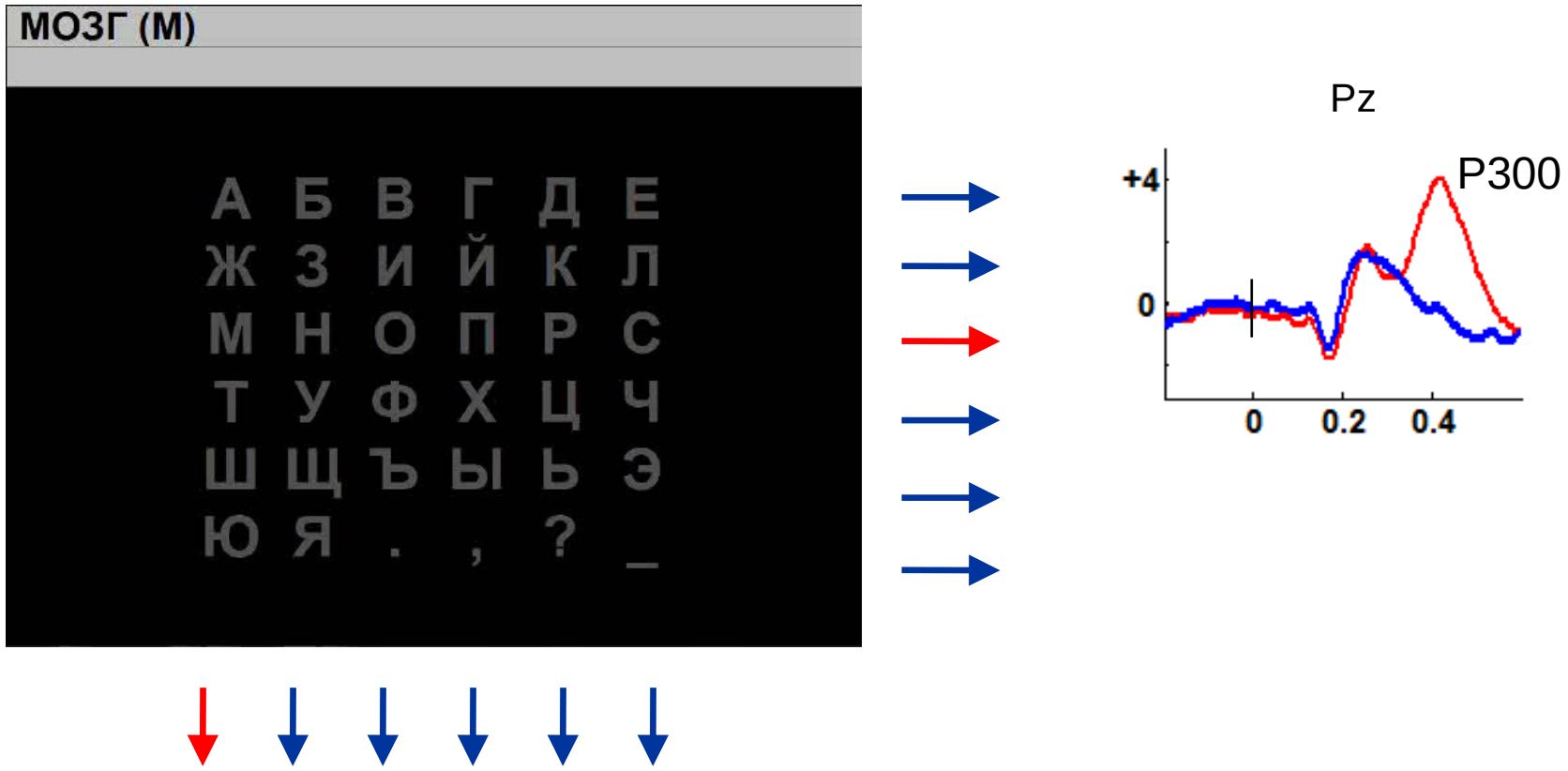



Figure 4. Asked to describe the impact of the BCI on his life, the user sent this message using the BCI. The statement at the bottom is included in all of his e-mails.

# Интерфейс мозг-компьютер на основе волны P300



Right now, Sept 24, 2011, there is no evidence that implanted BCIs are substantially more capable than non-invasive BCIs.

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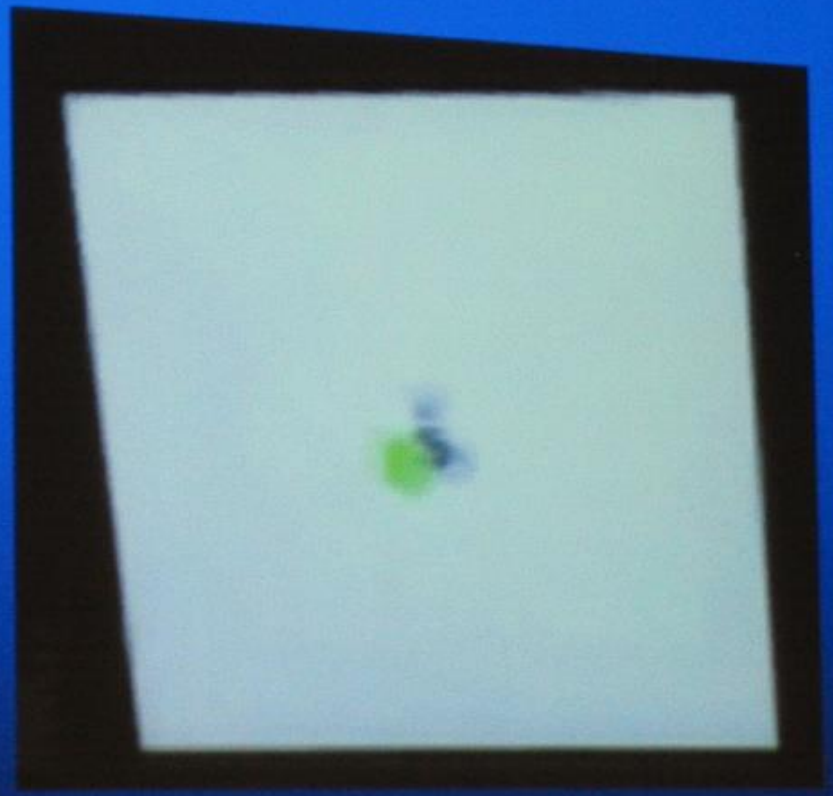
Jonathan R.Wolpaw
Invited lecture at 5th Int. BCI Conference, Graz, 24 Oct. 2011

# 2-D BCI Movement Control in Humans



Wolpaw and McFarland, 2004

Hochberg et al., 2006

Jonathan R.Wolpaw
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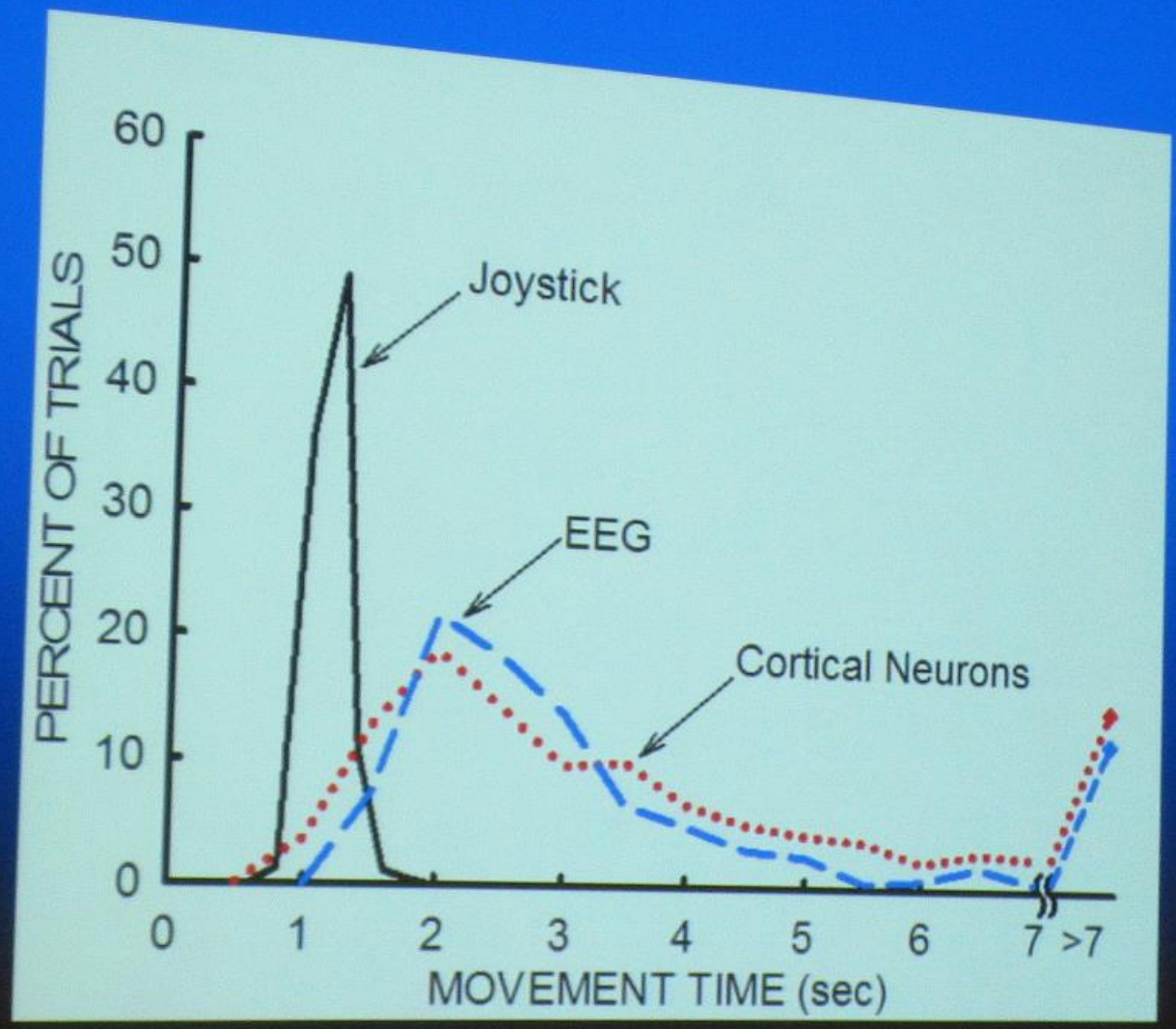
# BCIs vs. Muscles:




Hochberg et al, 2006; Wolpaw & McFarland, 2004

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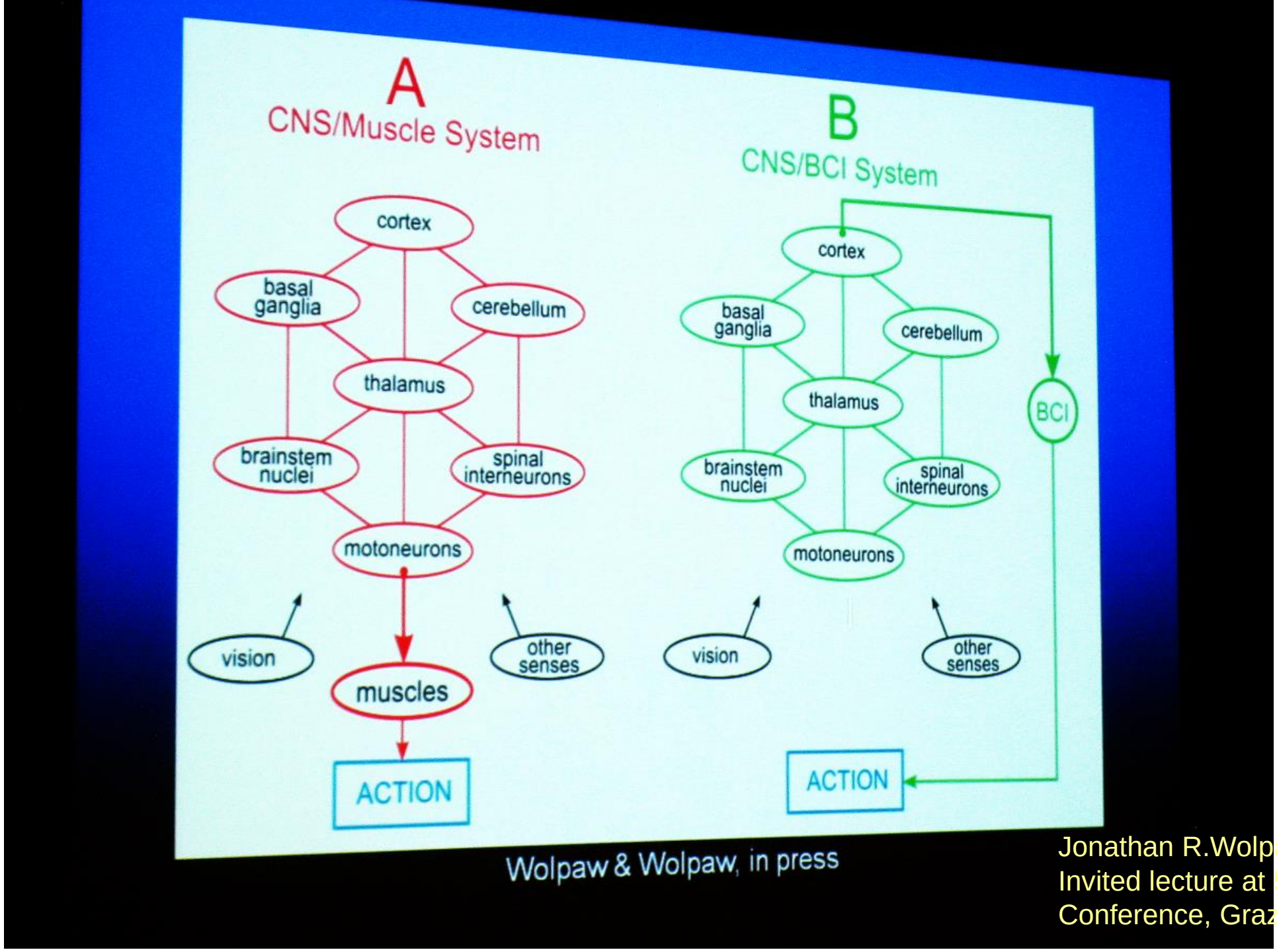


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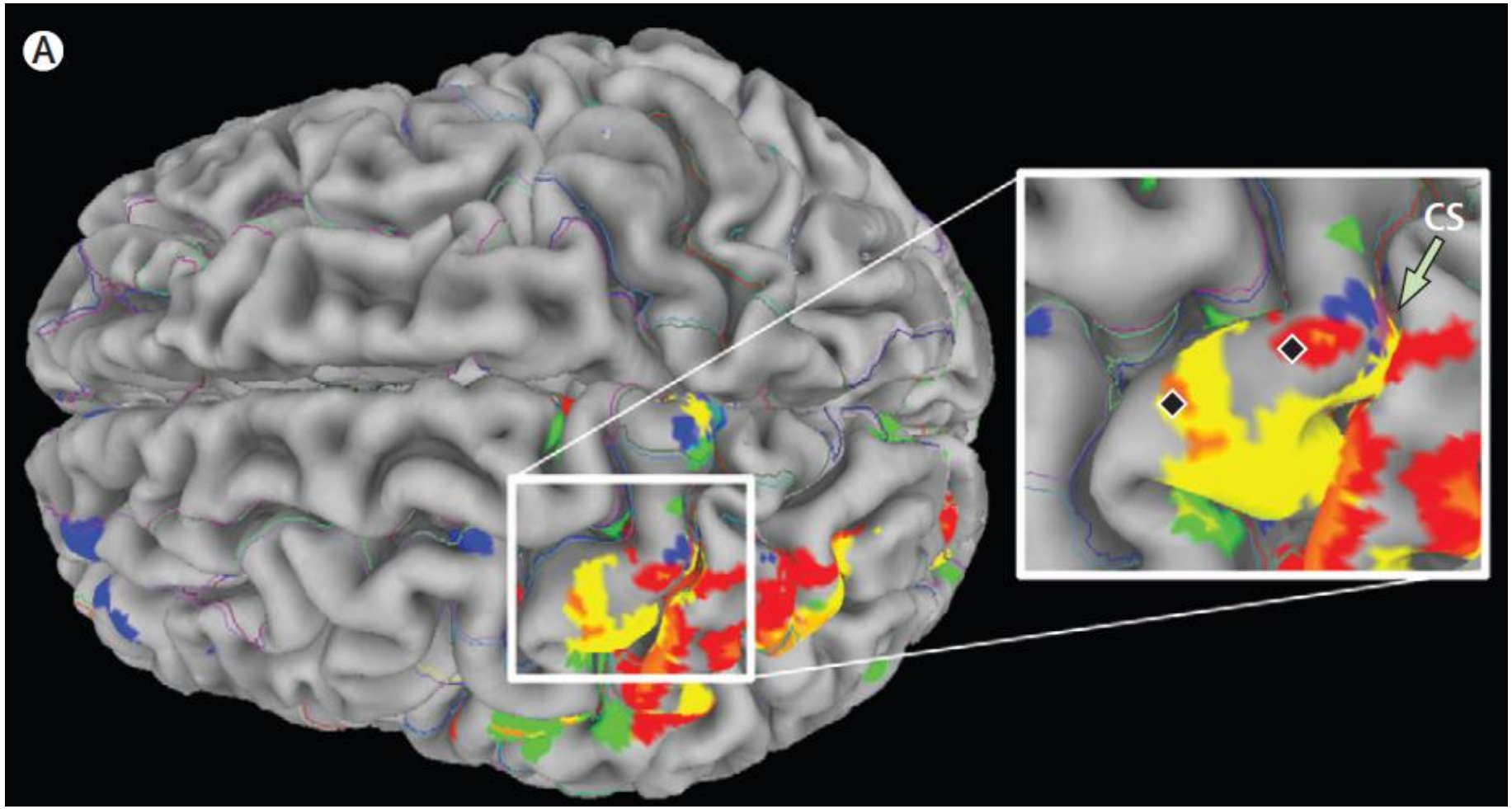


**Preoperative functional MRI activation maps of a participant-specific brain model during video-guided attempted movement**

*Collinger et al. High-performance neuroprosthetic control by an individual with tetraplegia. Lancet, 17 December 2012.*

- Как работает рука с 7 dof, и вообще ИМК:
- - эксперимент с движением руки обезьяны в VR, кодирование направления
- - схема Уольпоу с моей модифик?
- История Нейралинка
- Главная специфика: Мотивация Маска
- Известные технологии Нейралинка, видео с роботом - шв машинкой
- Достижения: робот, "чип"
- Отношение научного сообщества
- Блумберг - лонгрид для желающих узнать, что происходило в компании и вокруг (в тч люди, этич скандалы про животных и др) - в это не будем углубляться
- Получение разреш fda [, тип разрешения,] что это значит, планируется первая операция в этом году
- Главные проблемы: ушли почти все фаундеры; провальные демки
- Демки Нейралинка, и что с ними не так (в тч читинг обезьяны)
- Сравнение результатов с аналогичными, но более старыми достижениями в инвазивных ИМК (в тч видео, ссылку на которое я давал Артему)
- Сравнение с soa в исследованиях
- Почему вообще может плохо получаться: (1) неестеств ситуация: нет обратной связи привычного типа, заменить ее искусственной очень непросто; (2) недостаточно изучено "кодирование" в мозге, кроме наиболее "лежащего на поверхности", типа направления целенаправленного движения; (3) много неясности в проблеме биосовместимости; (4) опасность инваз технол. - инфекции, воспаление, отторжение, возможность гибели важных нейронов и т.п., хороший хирург, операция в целом, постоперац уход стоят дорооо, (5) мотивация без научн обоснования
- С безоп связана проблема медленных циклов в инваз ИМК: напр., массив Юта - иссл [17] лет эксплуатации у людей (см в канале) и Попков - в 2013 вышло исследование, где ретроспективно анализировали имплантацию матриц Юта (тоже нейроимпланты) 27 обезьянам (а не нескольким свиньям) в течении 17 лет. Менее чем за год половина устройств выходила из строя. http://neuronovosti.ru/neuralink2/ - из-за безопасности фундаментально невозможно существенно ускоряться
- О мотивации Маска - слиянии с машинами, и о его опасности (слайдЫ из швейцарского и самарского докладов, мб, в какой-то новой вариации?); и как тут надо было бы действовать с научной точки зрения
- Какие есть конкуренты, что они разрабатывают, их достижения, когда получали разреш fda - [парадромикс], (кернел загнулась), нейропиксели, Саенс, Синхрон и др - пошукать по каналу (в тч см, кто пришел на разборки по экспортн контр), повспоминать
- Неинвазивные технологии: Провал Цукерберга
- Почему не очень круто (не поможет ИМК) неинваз "декодирование" того, что человек видит или слышит - сослаться на q&a Рафаэля
- Много статей по "декодир" речи - почему это хрень (дать ссылку на гайды по избеганию ошибок в ML и по корректности проведения ИМК и БОС экспериментов , в тч https://inria.hal.science/hal-01620186/document Jeunet C, Debener S, Lotte F, Mattout J, Scherer R, Zich C. Mind the traps! Design guidelines for rigorous BCI experiments. Chapter 32)
- Итак, откуда все проблемы? (1) в разработках технологий надо опираться на науку, (2) мы все еще мало знаем о мозге
- Что реально в области неинваз и малоинваз ИМК:
- Ограничения фМРТ и фНИРС
- Новые возможности МЭГ и ограничения
- Малоинвазивная ЭЭГ
- Что еще есть и что еще возможно в неинвазивных технологиях
- Нейрореаб, в тч для запуска локомоции
- Лучше пытаться, чем воображать
- Айтрекинг + ИМК (в тч у Оксли)
- Выучивание структуры ЭЭГ - вроде бы можно вытащить что-то новое, но пока никто не смог