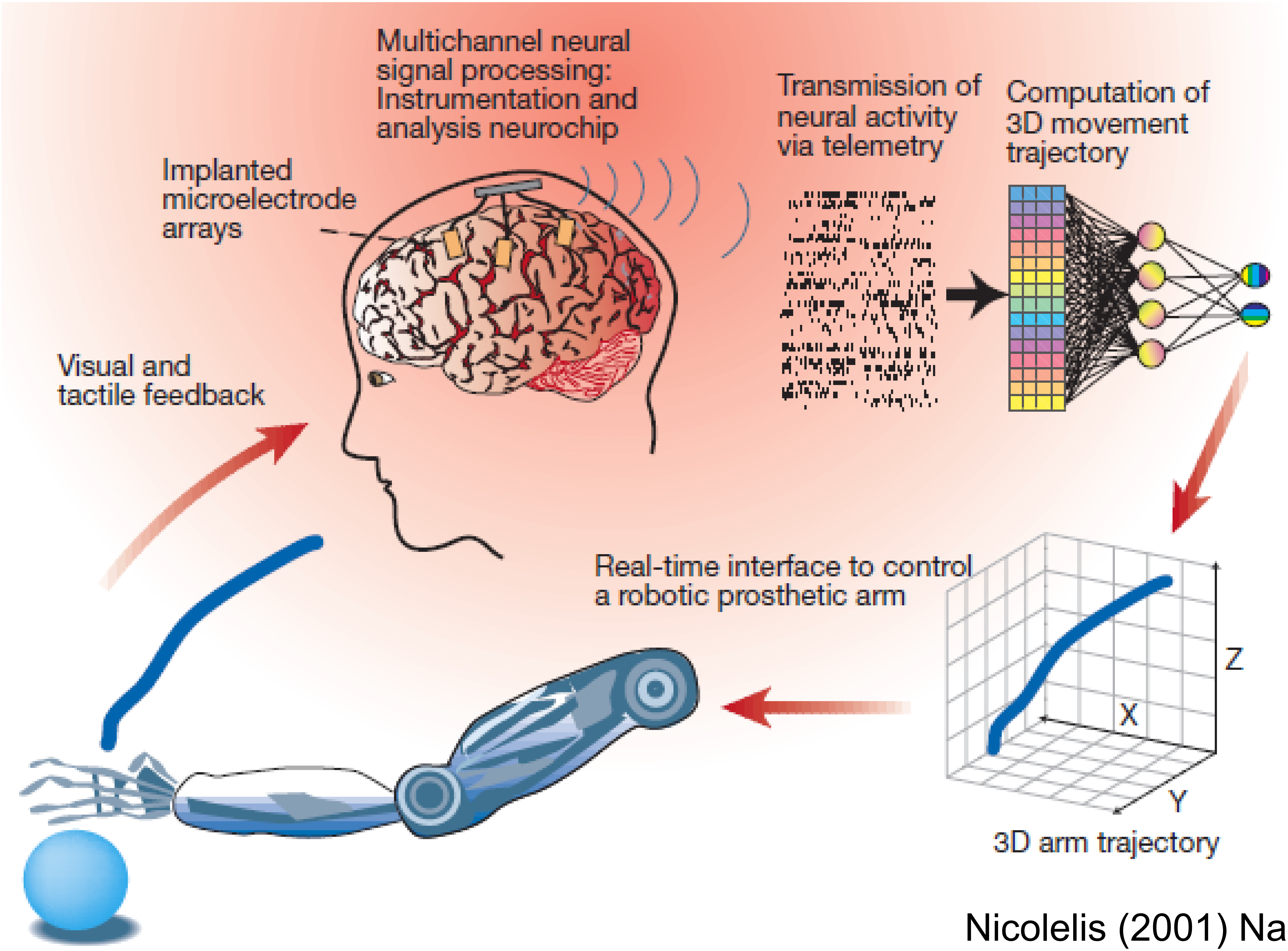
МЕЖДУНАРОДНЫЙ
СИМПОЗИУМ
«СОЗДАВАЯ БУДУЩЕЕ»

МИХАИЛ ЛЕБЕДЕВ

ПРОФЕССОР

ЭВОЛЮЦИЯ МОЗГА: КАК МИР МЕНЯЕТ НАС

Нейроинтерфейс



Multichannel neural signal processing: Instrumentation and analysis neurochip
Implanted microelectrode arrays
Transmission of neural activity via telemetry
Computation of 3D movement trajectory
Visual and tactile feedback
Real-time interface to control a robotic prosthetic arm
Z
X
Y
3D arm trajectory

Nicolelis (2001) Nature 409: 409–407

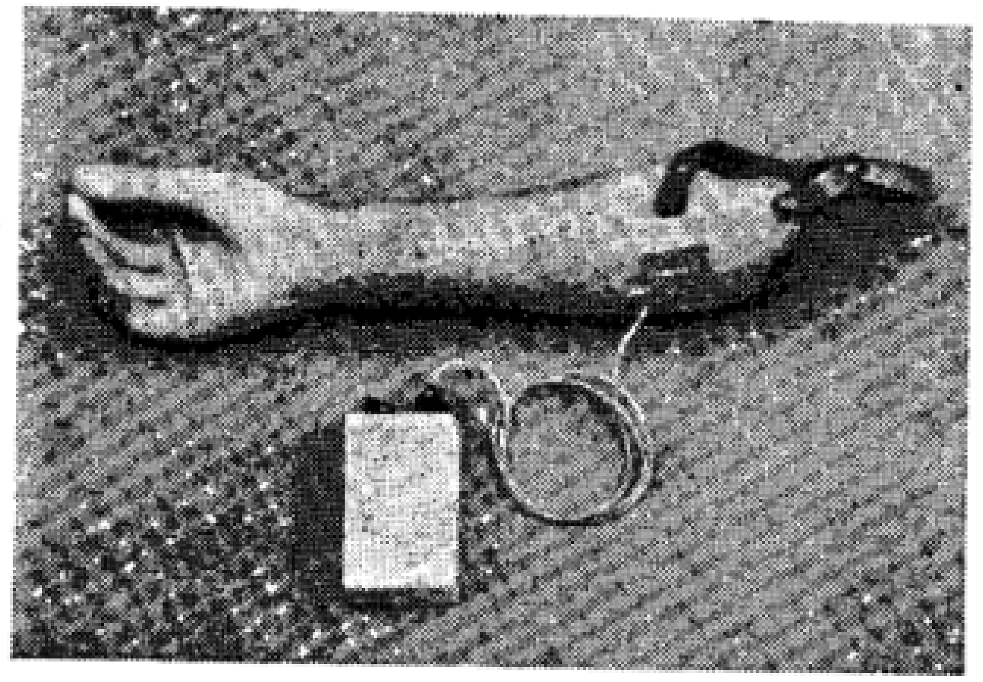
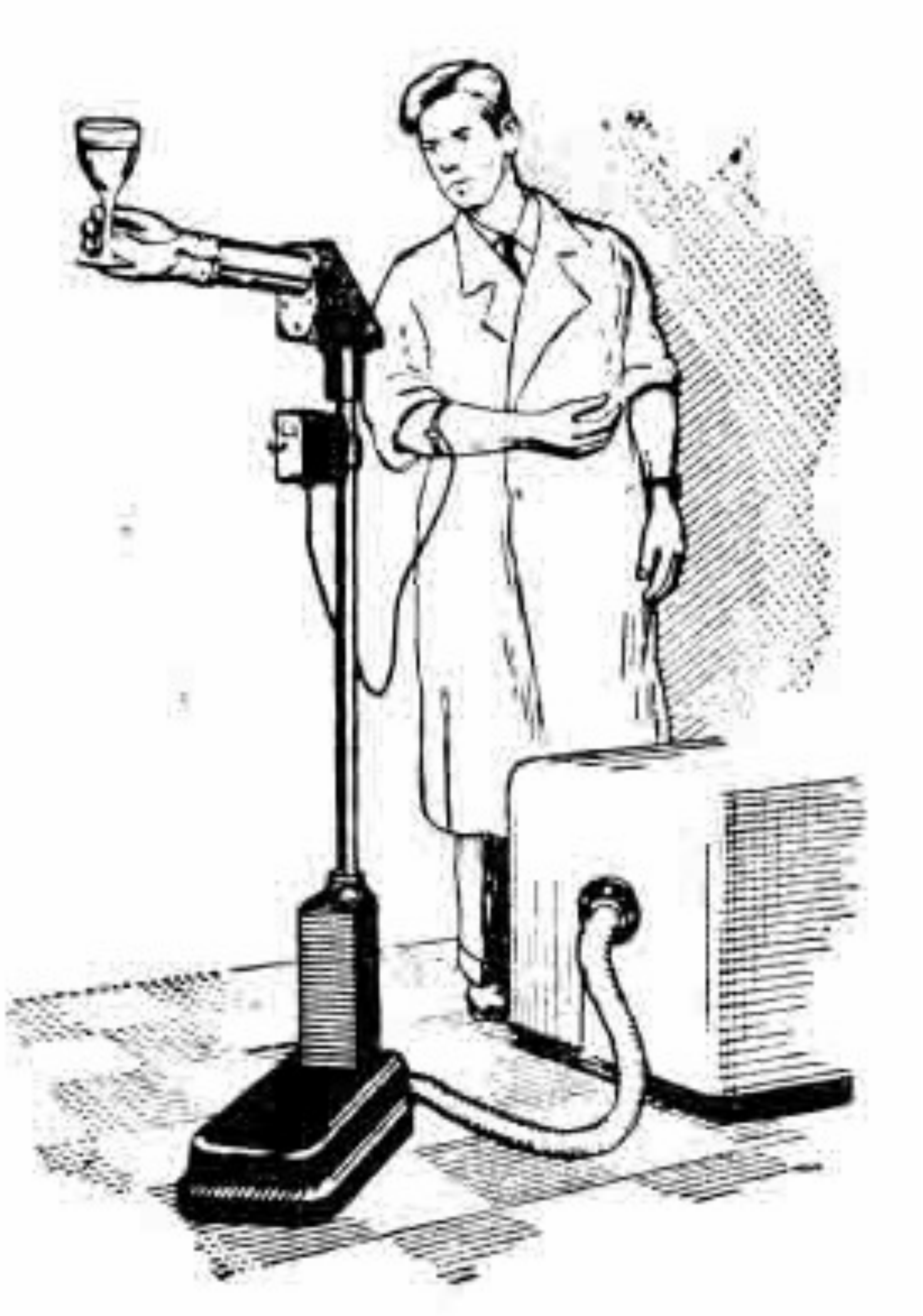
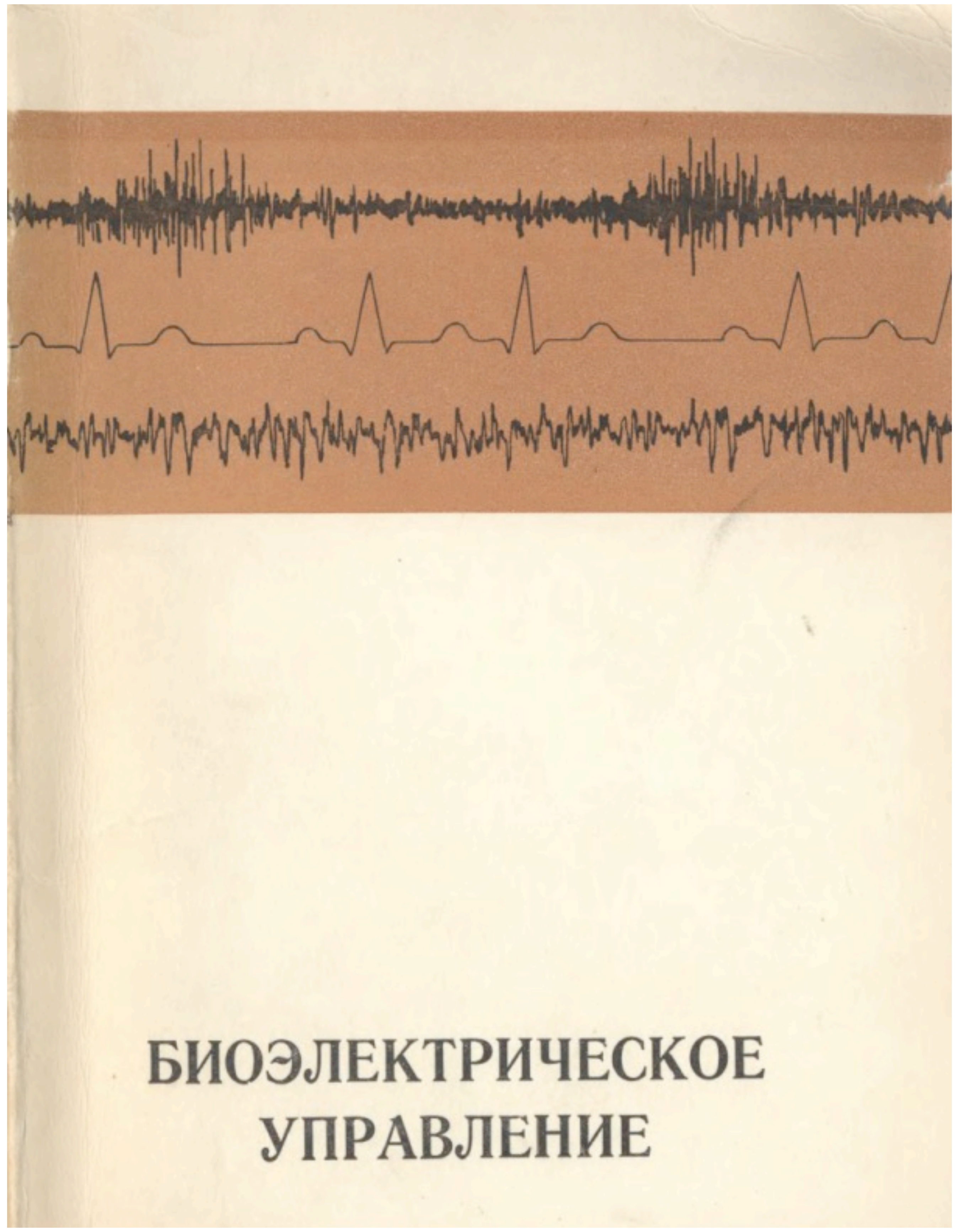


Рис. 18. Внешний вид серийного советского биоэлектрического протеза предплечья с пороговым управлением



Виктор Гурфинкель
(1922—2020)



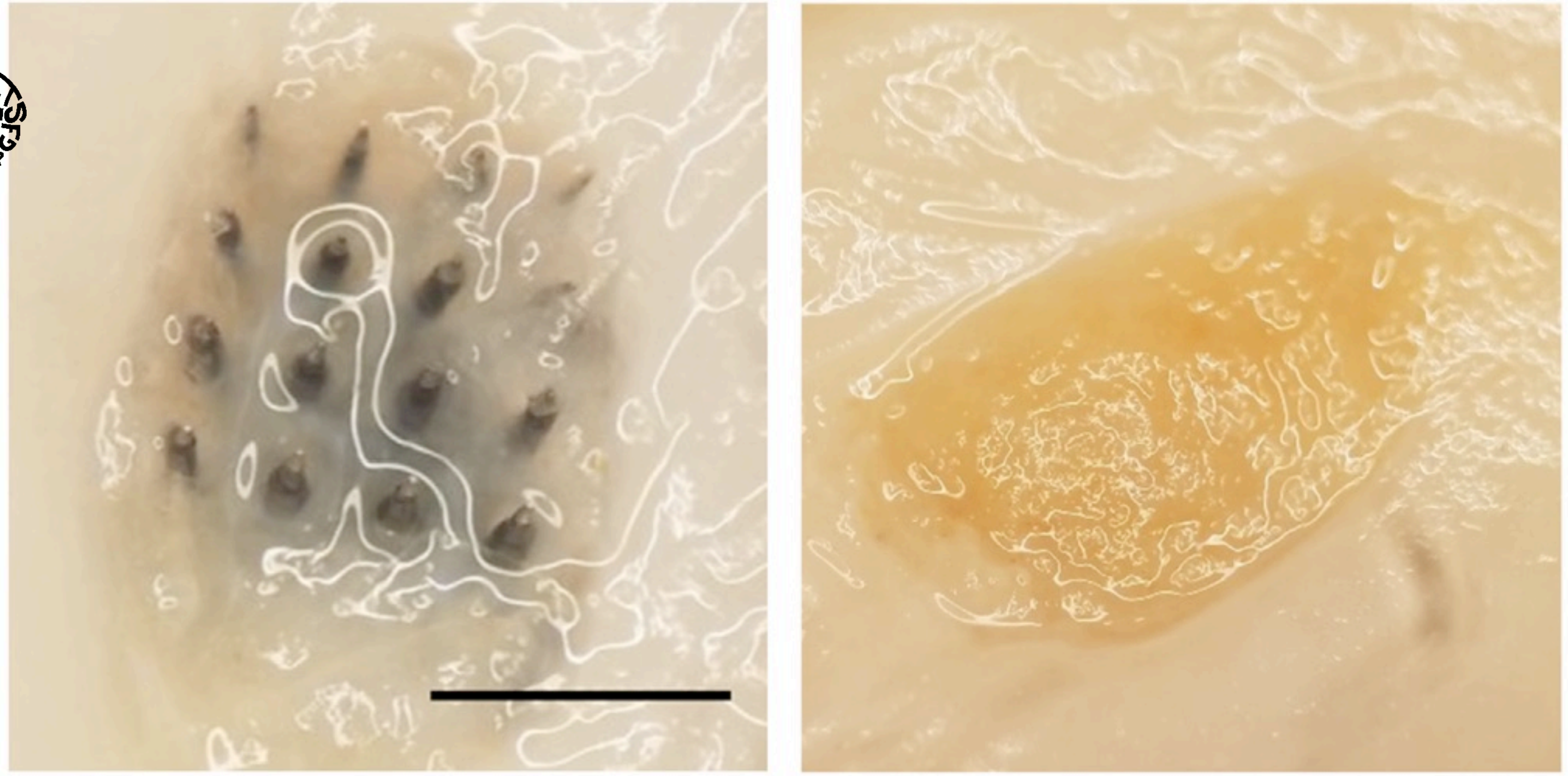
БИОЭЛЕКТРИЧЕСКОЕ
УПРАВЛЕНИЕ

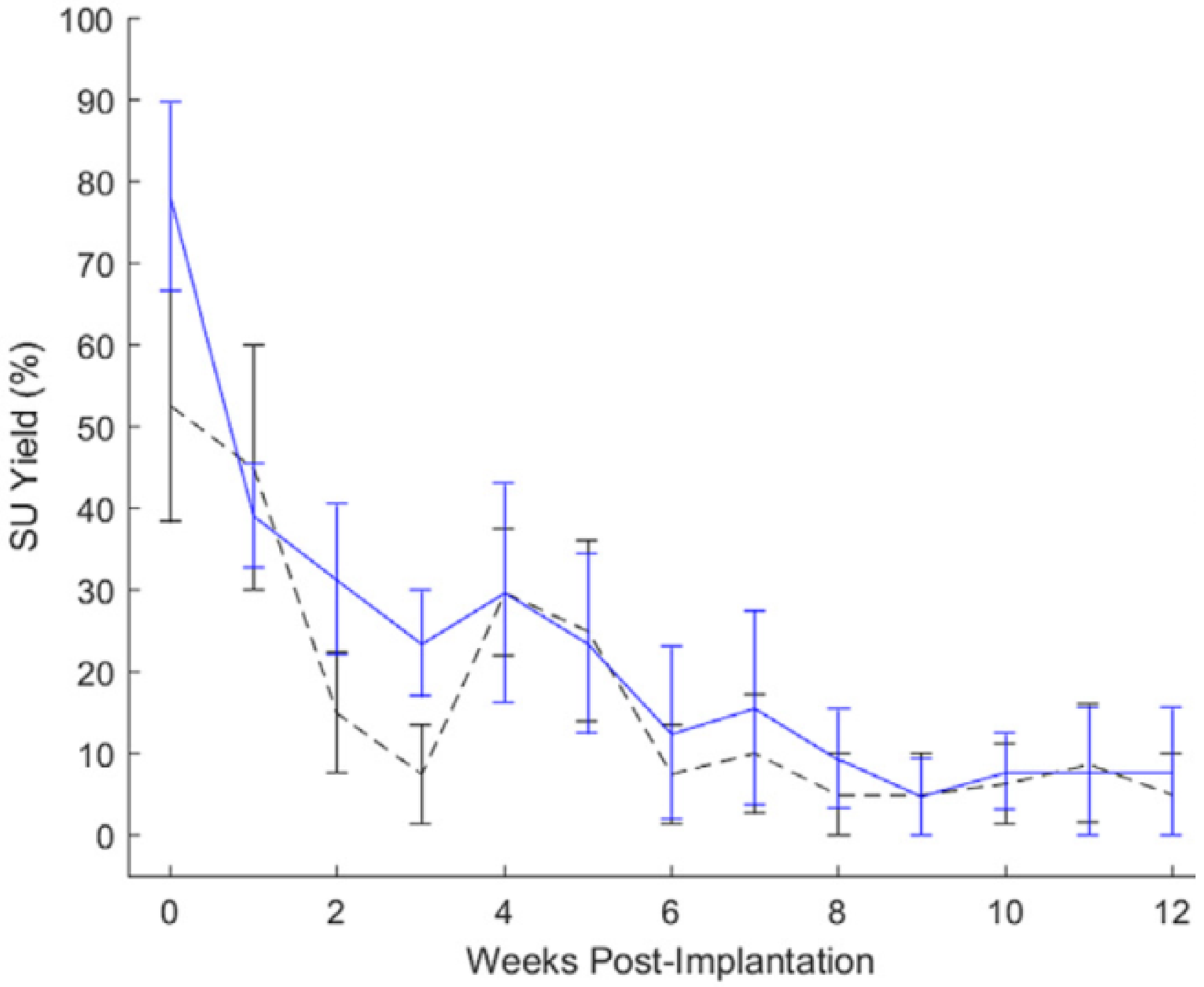
Коллектив авторов:
В. С. ГУРФИНКЕЛЬ, В. Б. МАЛКИН,
М. Л. ЦЕТЛИН, А. Ю. ШНЕЙДЕР.

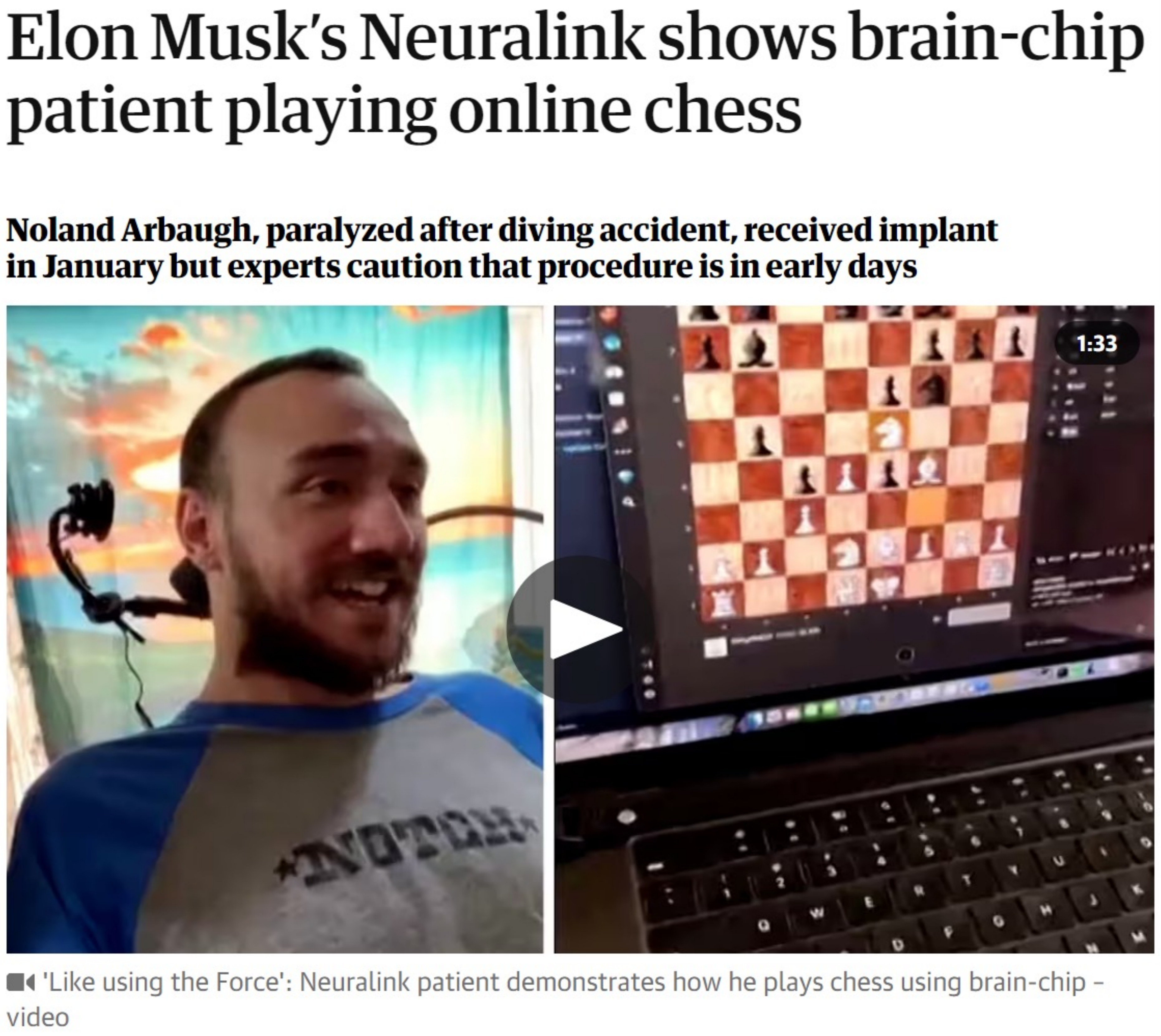
В 1956—1957 гг. группой сотрудников Центрального научно-исследовательского института протезирования и протезостроения (ЦНИИПП), Института машиноведения АН СССР и Института прикладной математики АН СССР М. Г. Брейдо, В. С. Гурфинкелем, А. Е. Кобринским, А. Я. Сысиным, М. Л. Цетлиным и Я. С. Якобсоном был построен первый действующий макет искусственной руки с биоэлектрическим управлением [89, 90].

Нейроинтерфейсы

- Инвазивные
- Неинвазивные



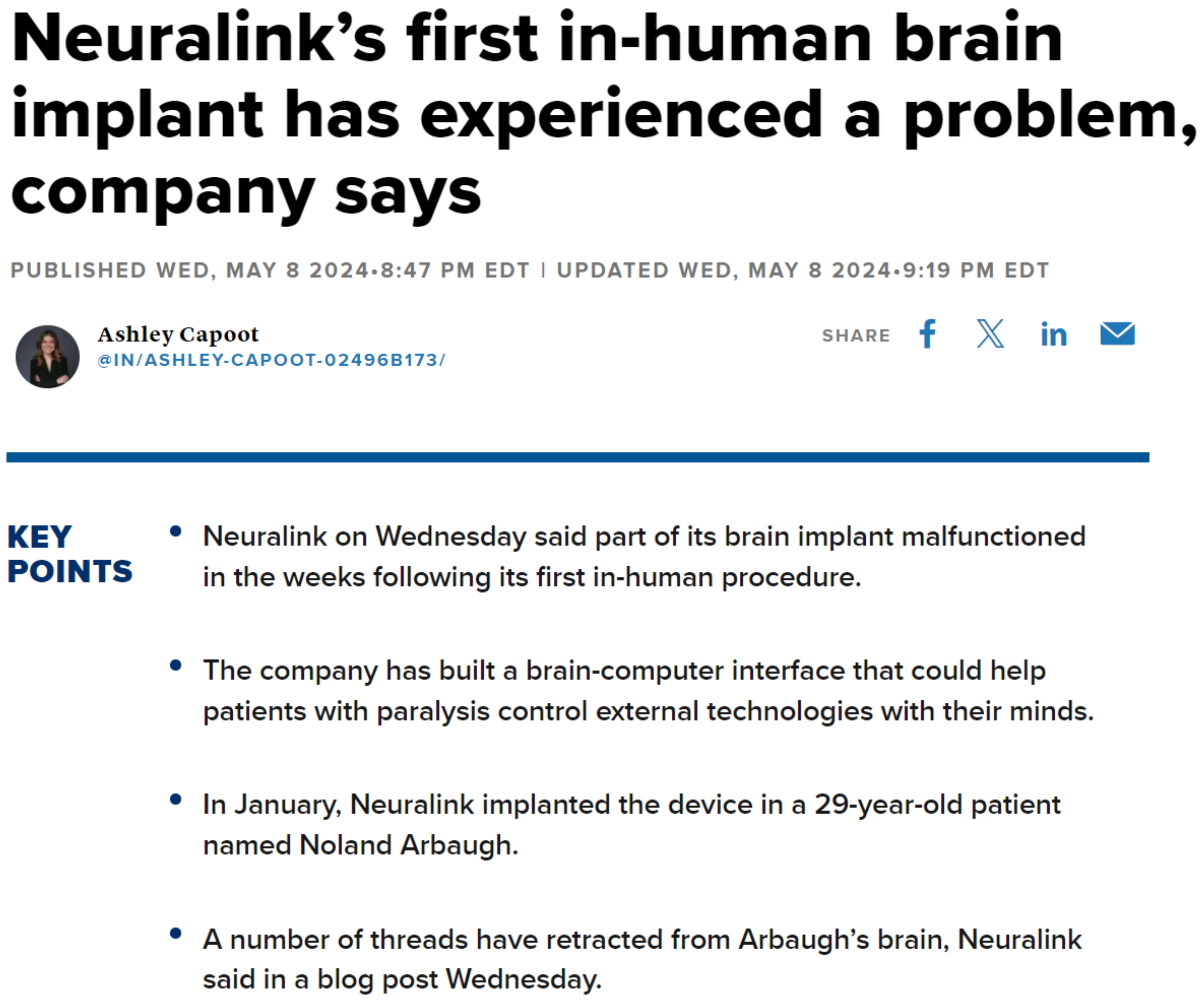




Elon Musk's Neuralink shows brain-chip patient playing online chess

Noland Arbaugh, paralyzed after diving accident, received implant in January but experts caution that procedure is in early days

'Like using the Force': Neuralink patient demonstrates how he plays chess using brain-chip – video



Neuralink's first in-human brain implant has experienced a problem, company says

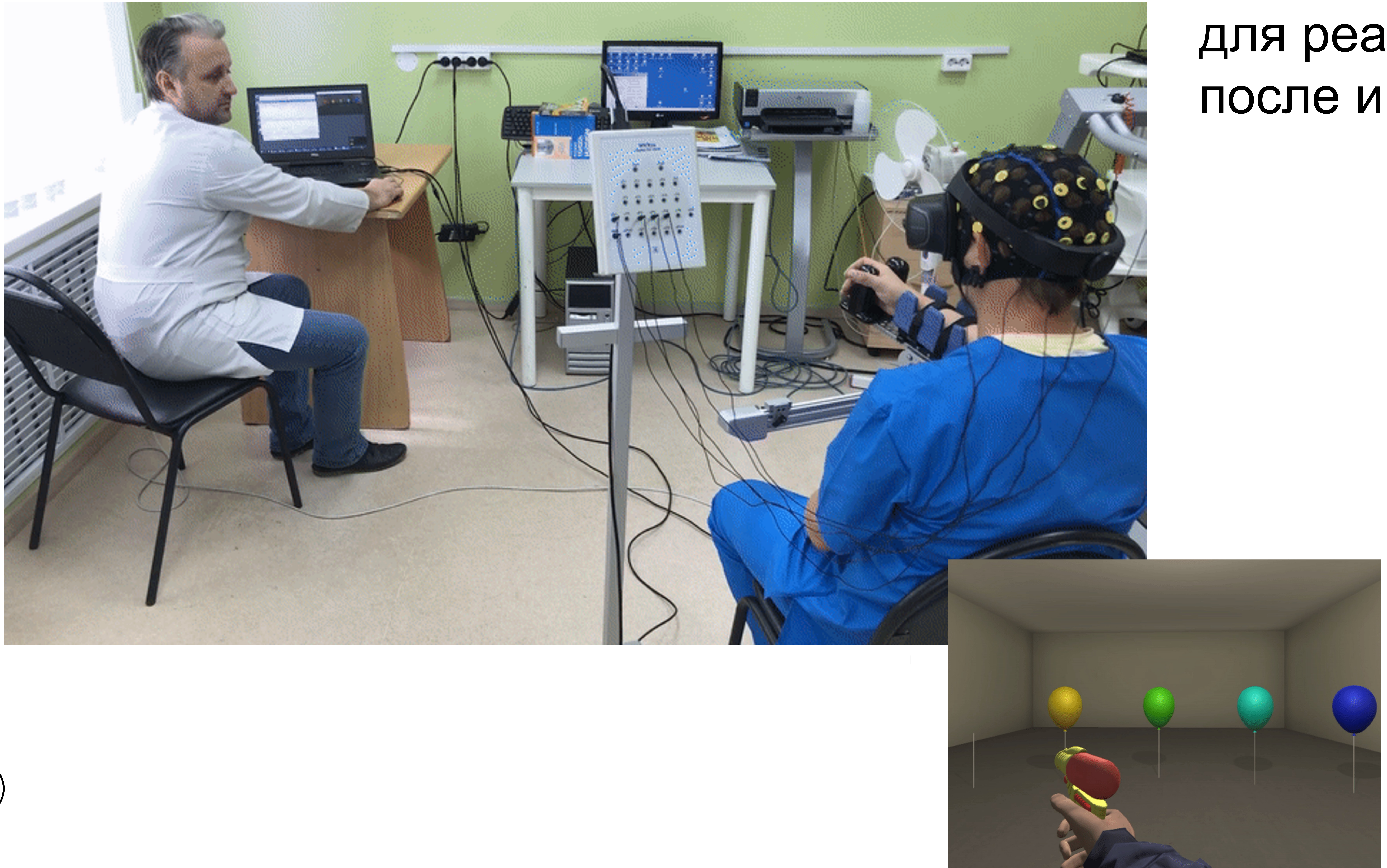
PUBLISHED WED, MAY 8 2024•8:47 PM EDT | UPDATED WED, MAY 8 2024•9:19 PM EDT

Ashley Capoot
@IN/ASHLEY-CAPOOT-02496B173/

KEY POINTS

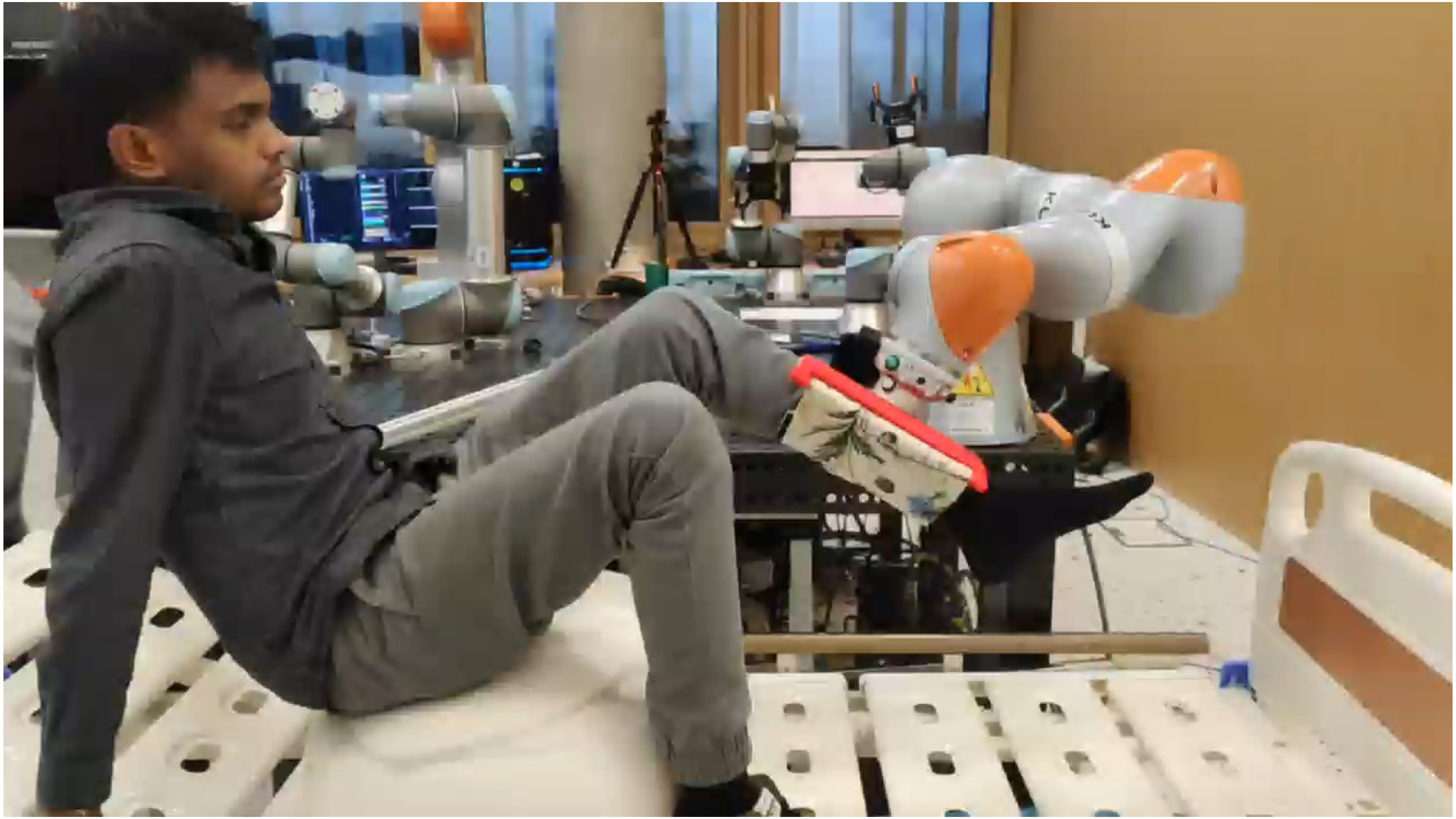
- Neuralink on Wednesday said part of its brain implant malfunctioned in the weeks following its first in-human procedure.
- The company has built a brain-computer interface that could help patients with paralysis control external technologies with their minds.
- In January, Neuralink implanted the device in a 29-year-old patient named Noland Arbaugh.
- A number of threads have retracted from Arbaugh's brain, Neuralink said in a blog post Wednesday.

Неинвазивный нейроинтерфейс для реабилитации после инсульта

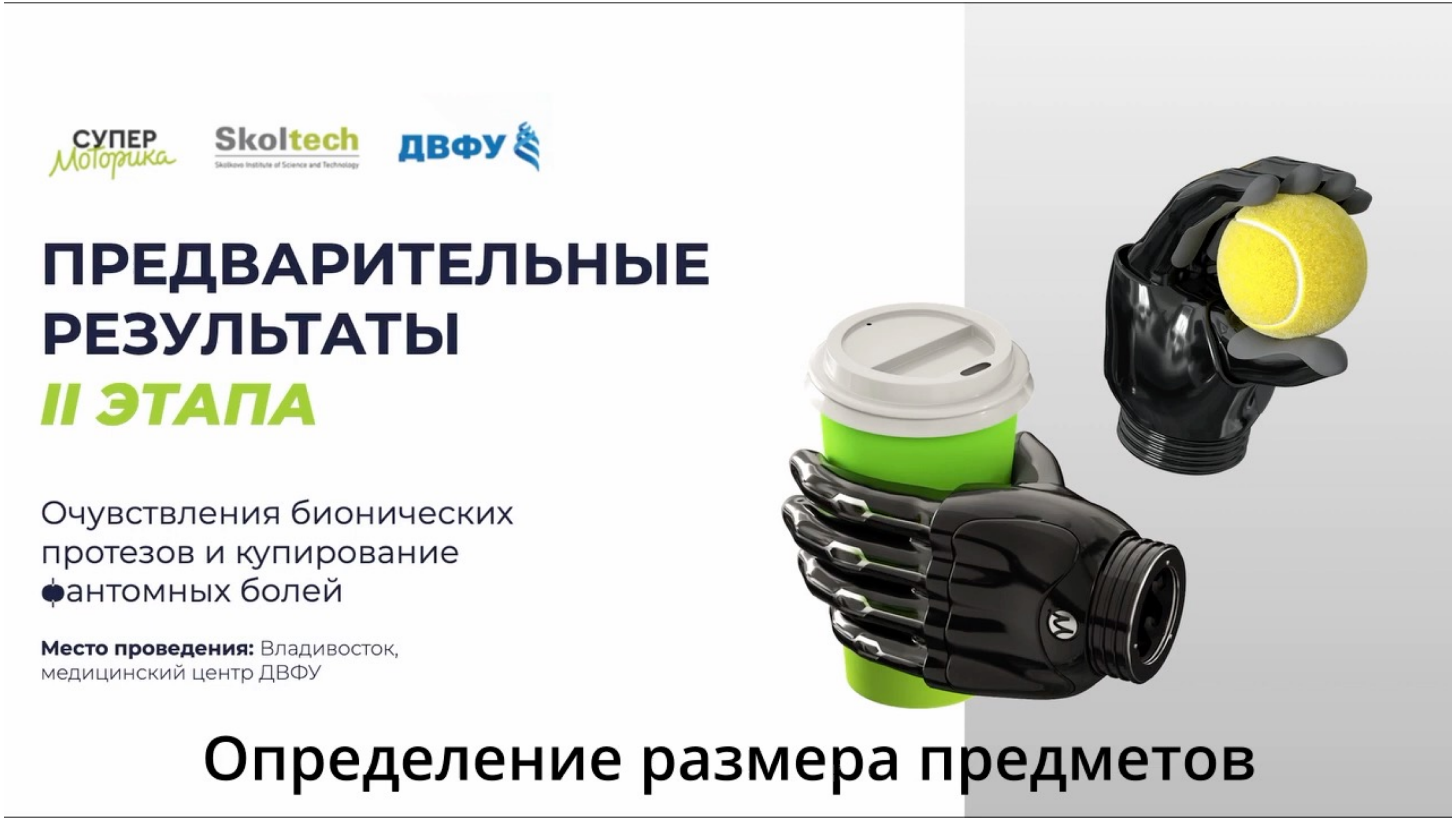


Bulanov et al.

Реабилитация нижней конечности



Тактильные ощущения для протеза


СУПЕР Моторика
Skoltech
Skolkovo Institute of Science and Technology
ДВФУ

ПРЕДВАРИТЕЛЬНЫЕ РЕЗУЛЬТАТЫ
II ЭТАПА

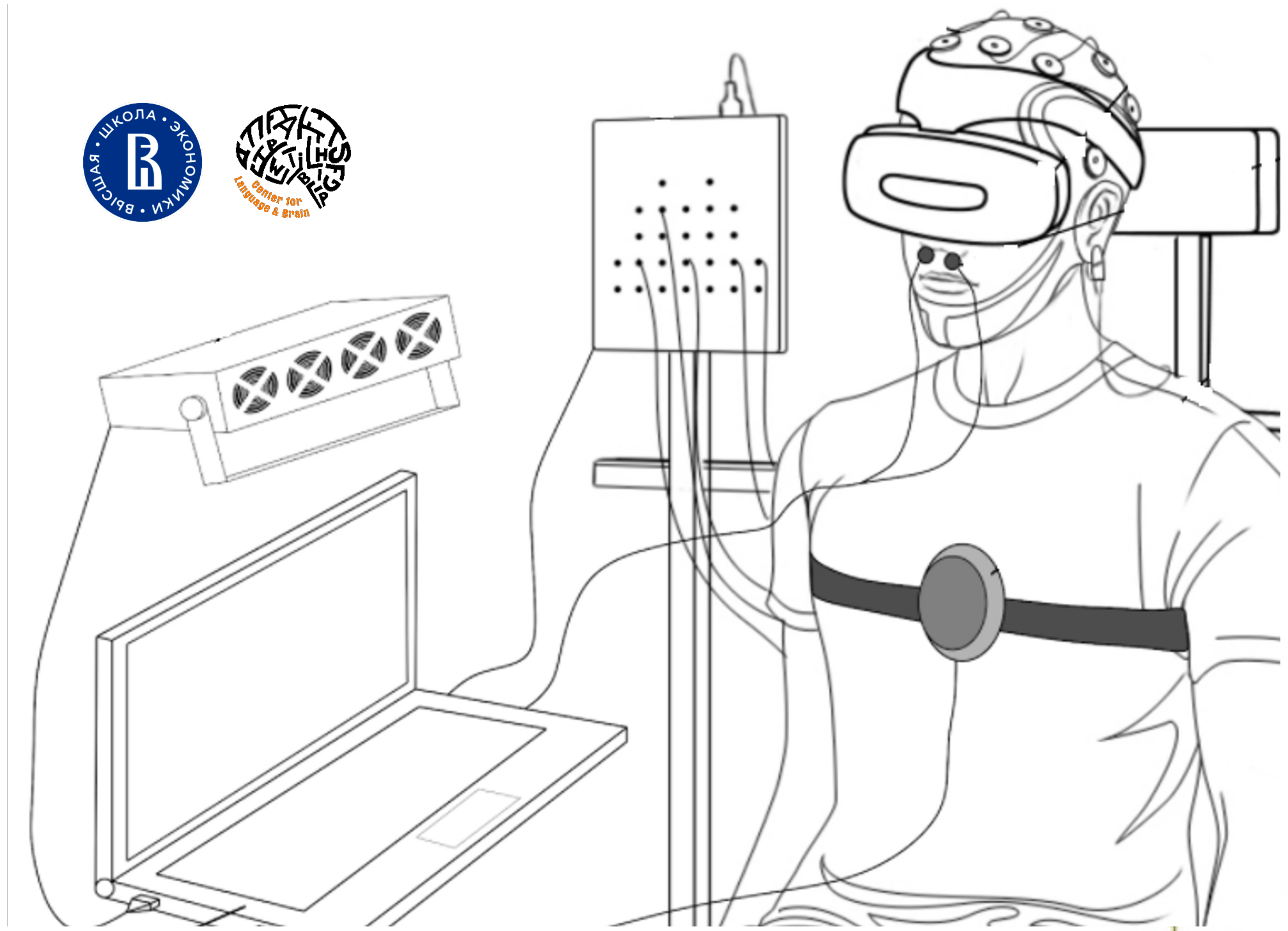
Очувствления бионических
протезов и купирование
фантомных болей

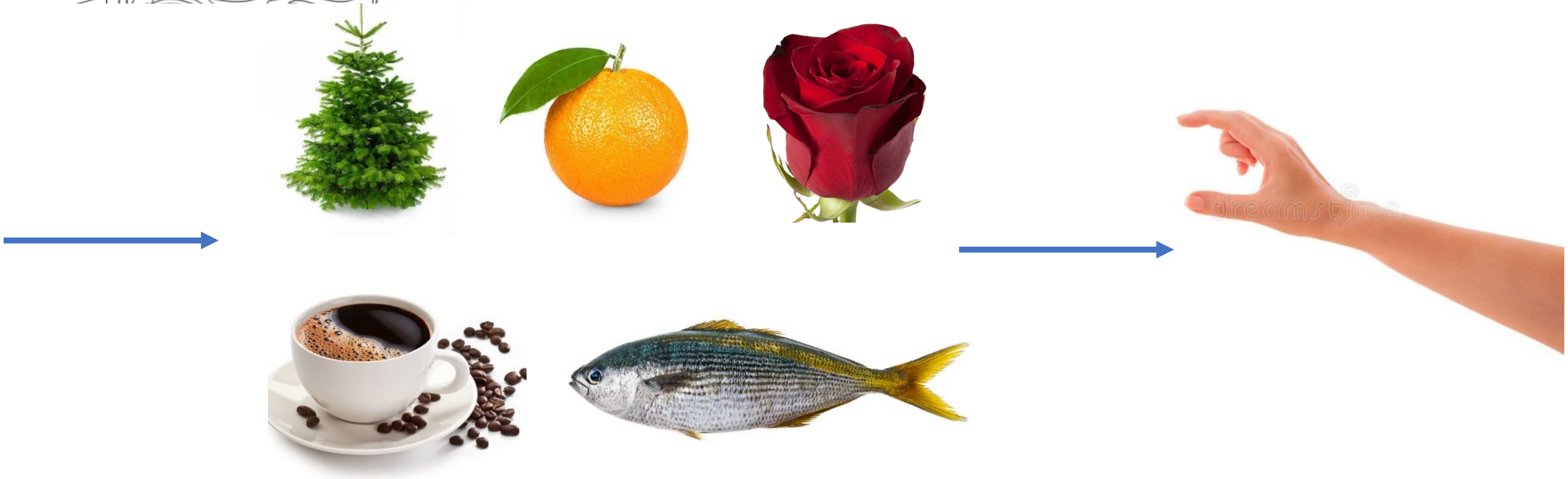
Место проведения: Владивосток,
медицинский центр ДВФУ

Определение размера предметов

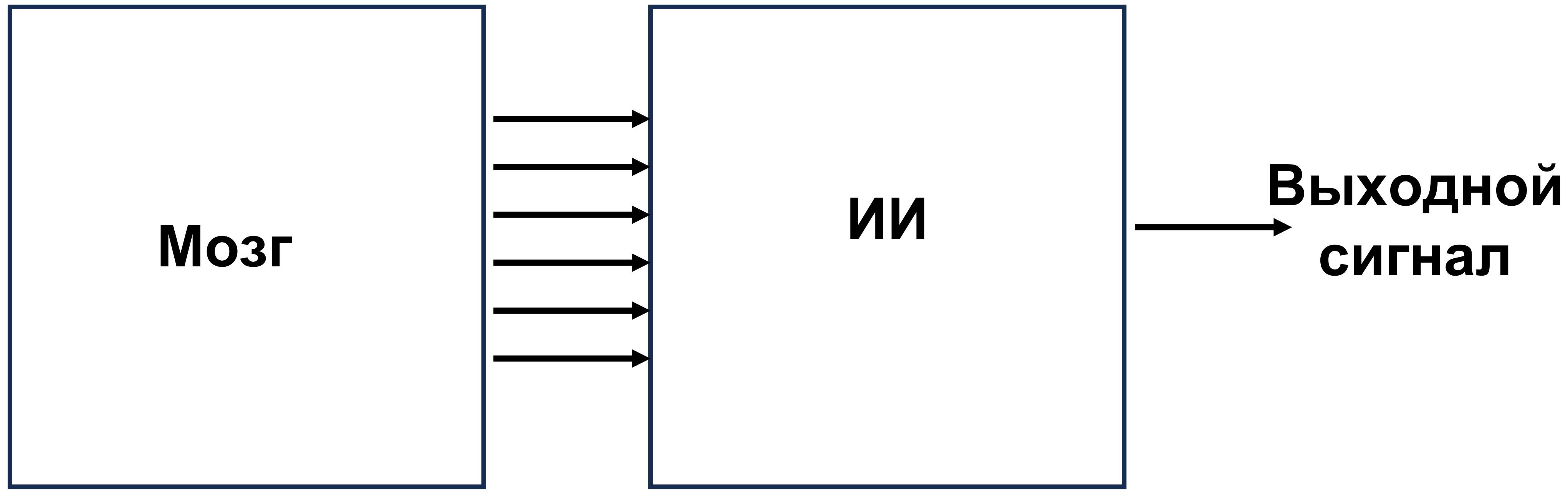
Soghoyan et al.

Нейроинтерфейс для обоняния





ИИ для декодирования



Мозг

ИИ

Выходной сигнал

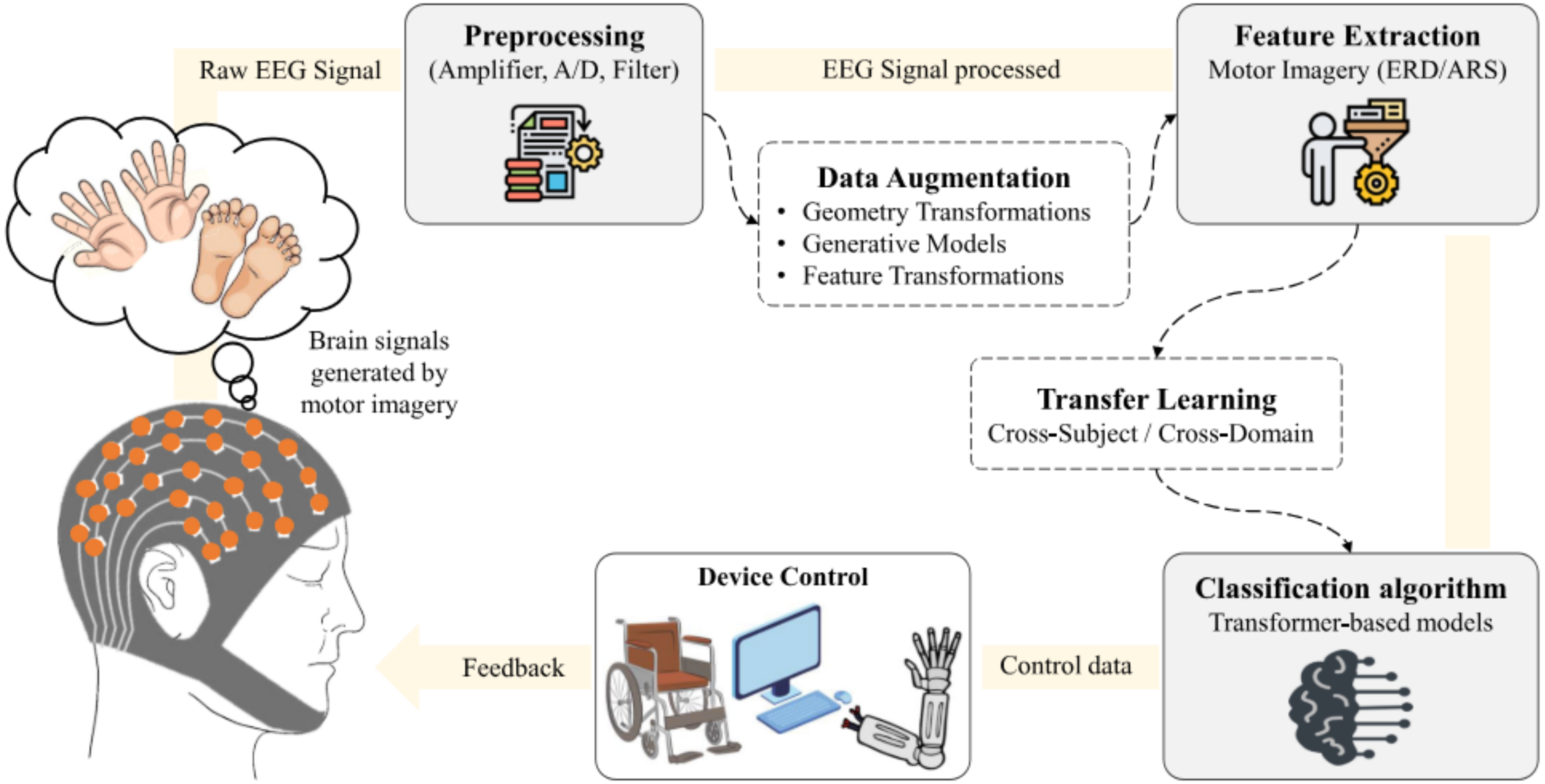
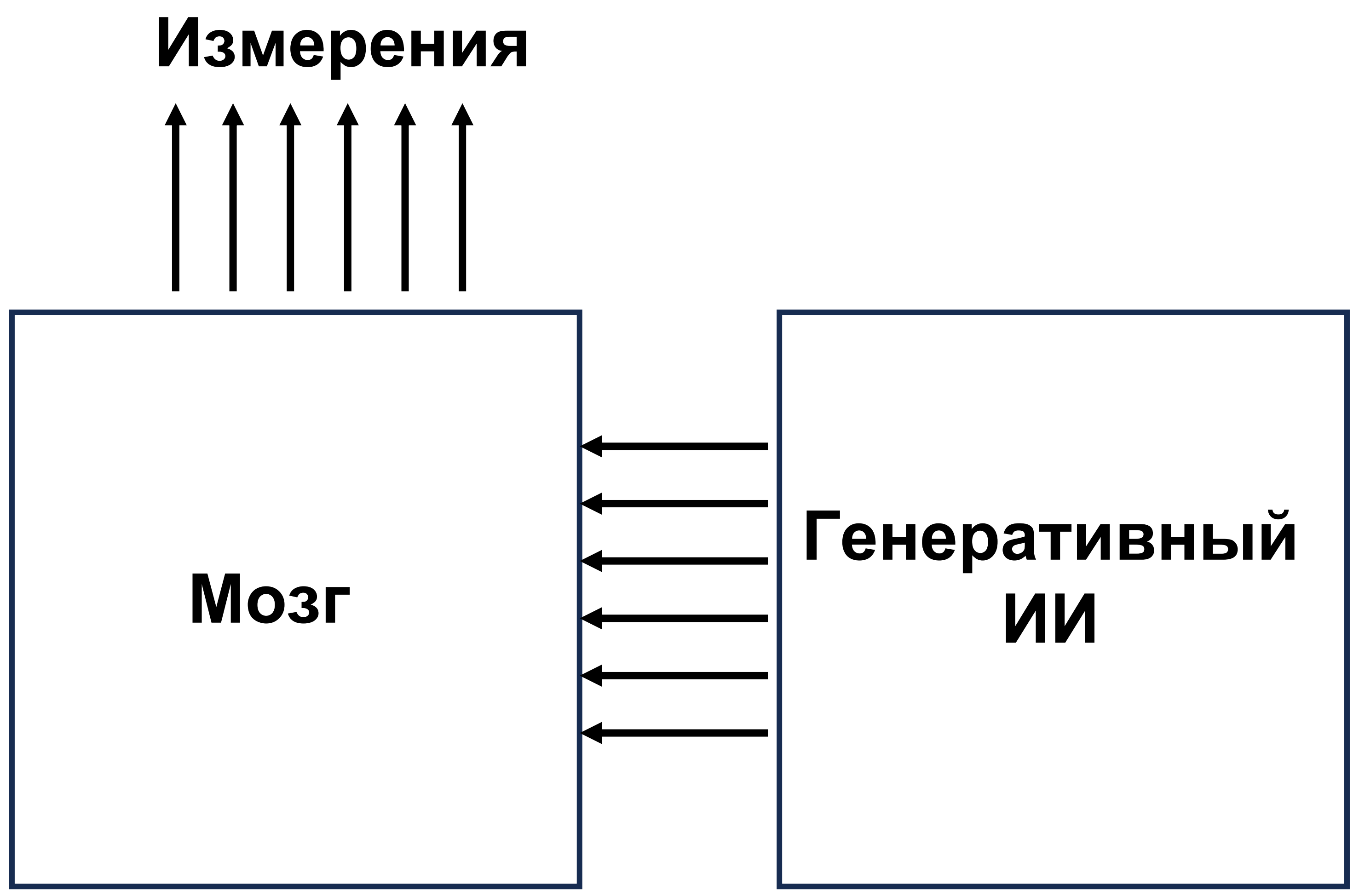

Raw EEG Signal
Preprocessing
(Amplifier, A/D, Filter)
EEG Signal processed
Feature Extraction
Motor Imagery (ERD/ARS)
Data Augmentation
• Geometry Transformations
• Generative Models
• Feature Transformations
Brain signals generated by motor imagery
Transfer Learning
Cross-Subject / Cross-Domain
Device Control
Feedback
Control data
Classification algorithm
Transformer-based models

FIGURE 1. **Schematic of EEG-based BCI framework, illustrating the stages from signal acquisition to device control using Transformer-based classification, highlighting preprocessing, data augmentation, and transfer learning steps.**

ИИ для генерации стимулов



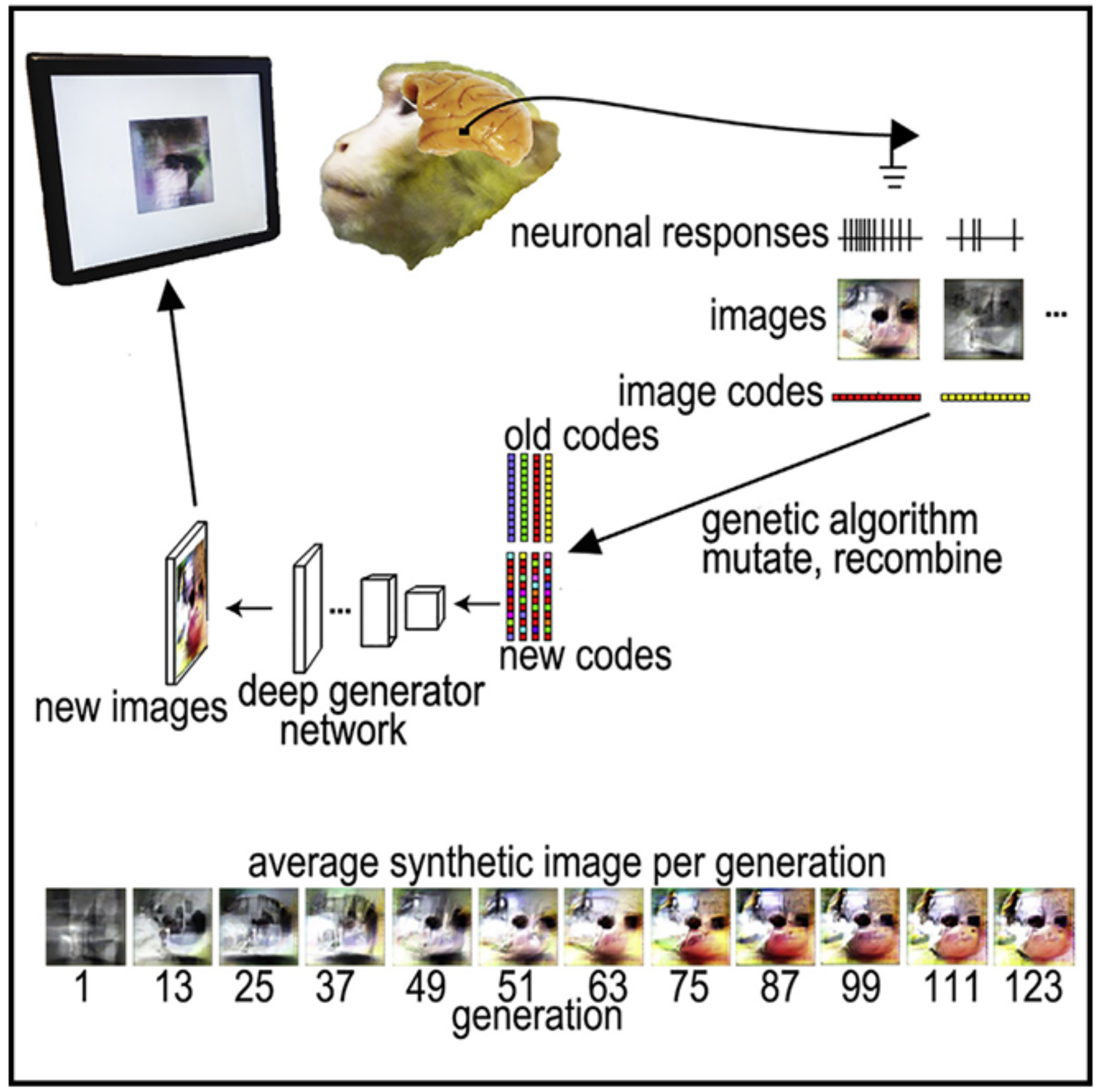
Измерения

Мозг

Генеративный ИИ

Evolving Images for Visual Neurons Using a Deep Generative Network Reveals Coding Principles and Neuronal Preferences

Graphical Abstract


neuronal responses
images
image codes
old codes
genetic algorithm
mutate, recombine
new codes
new images
deep generator network
average synthetic image per generation
1
13
25
37
49
51
63
75
87
99
111
123
generation

Authors

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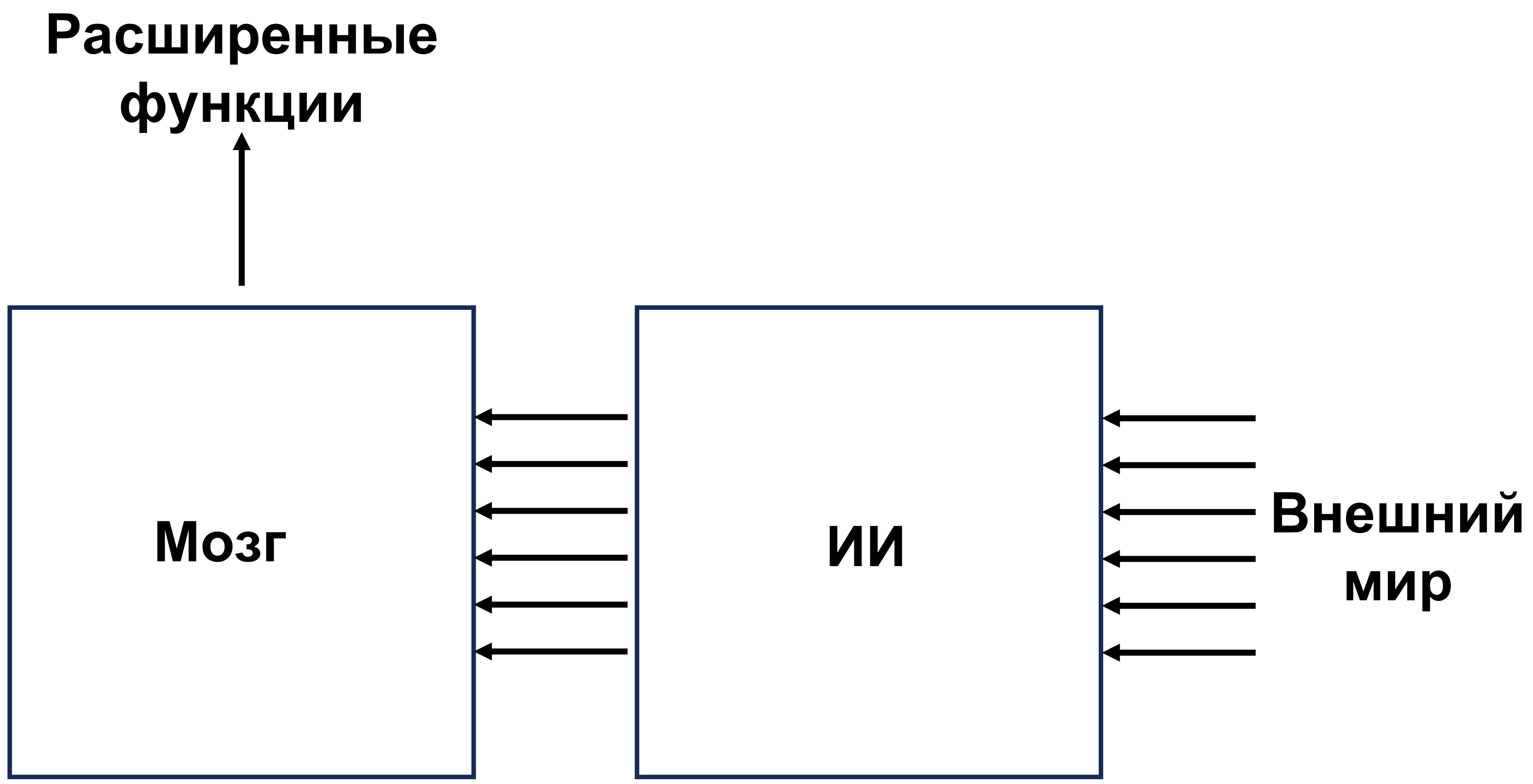
In Brief

Neurons guided the evolution of their own best stimuli with a generative deep neural network.

- A generative deep neural network and a genetic algorithm evolved images guided by neuronal firing
- Evolved images maximized neuronal firing in alert macaque visual cortex
- Evolved images activated neurons more than large numbers of natural images
- Similarity to evolved images predicts response of neurons to novel images

ИИ для лучшего понимания внешнего мира



Расширенные функции

Мозг

ИИ

Внешний мир

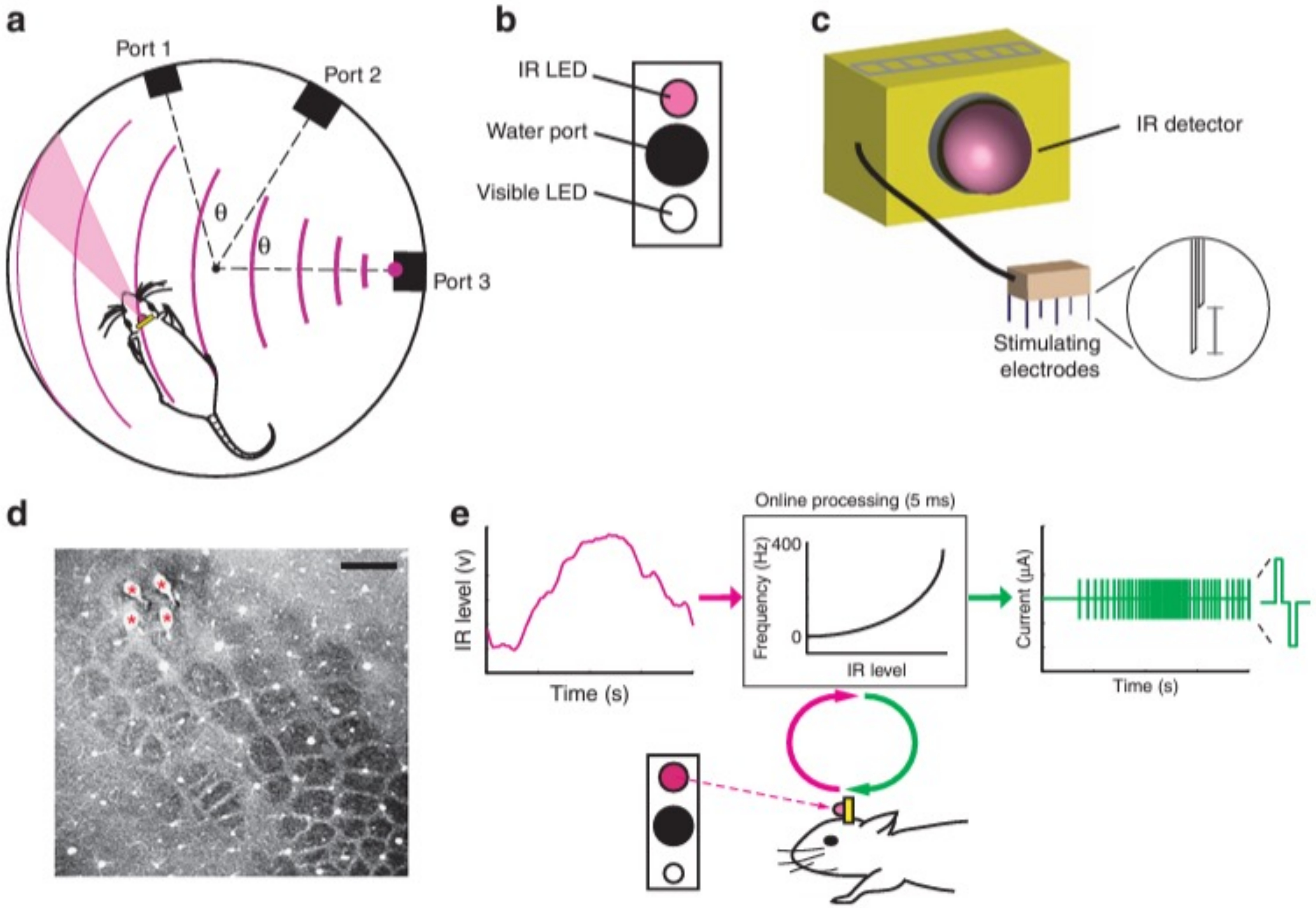

a
Port 1
Port 2
Port 3
θ
θ
b
IR LED
Water port
Visible LED
c
IR detector
Stimulating electrodes
d
e
IR level (v)
Time (s)
Online processing (5 ms)
Frequency (Hz)
400
0
IR level
Current (µA)
Time (s)

Figure 1 | Methods. (**a**) Set-up of the IR behaviour chamber. Three reward ports line the walls of the circular chamber. The proximity of the ports to one another is indicated by the angle θ. The rat has an IR detector (red) affixed to its head, and the cone emanating from the detector represents the area within which it will respond to IR stimuli. The red lines emanating from port 3 represent the IR signal emitted from that IR source. (**b**) Arrangement of each reward port, which includes a recess with a water spout, an IR LED above, and a broad-spectrum visible LED below. (**c**) Design of stimulating electrodes (see Methods for details). The inset shows how each stimulating electrode pair is configured in the array (scale bar, 300 µm). (**d**) Example of electrode placement. Cytochrome oxidase-stained barrel field shows the location of four stimulating electrodes. Each penetration is indicated with a red asterisk. Reference line: 500 µm. (**e**) Coupling IR levels with ICMS. On each trial, the IR light turns on, which activates the IR detector that is mounted on the rat's head. Processing converts the detected IR level into a stimulation frequency. This value is sent to the microstimulator, which produces the desired current pulses. The inset on the right-hand-side illustrates the structure of each biphasic waveform in the pulse train.