

LEADING MEDICINE: **A TOWN HALL CONVERSATION** WITH DR. MARC BOOM

Town Hall Conversation LI

HOUSTON
Methodist[®]
LEADING MEDICINE



Scientific Advancements in Neurosurgery

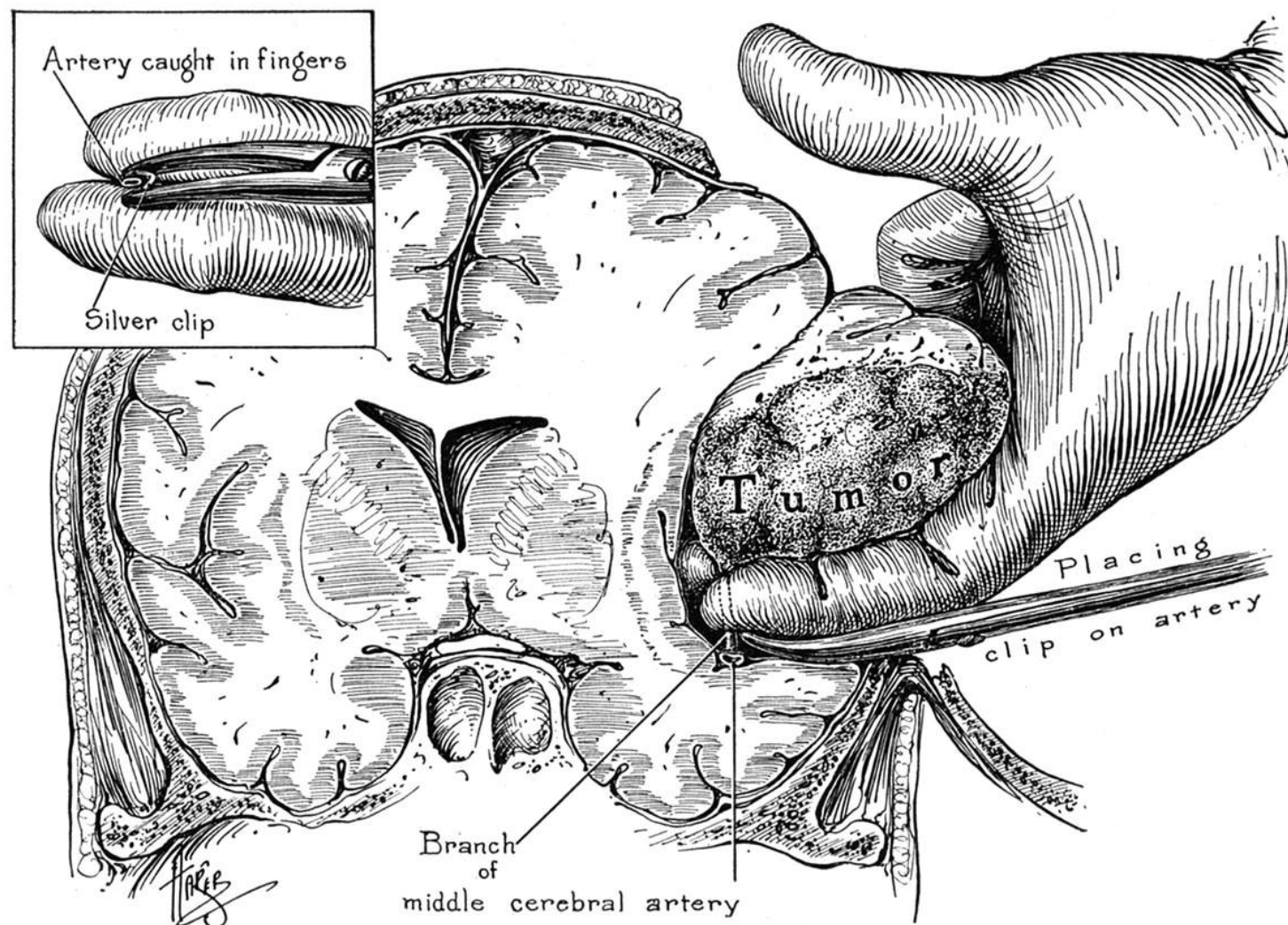
Gavin W. Britz, MD, MPH, MBA, FAANS, FACS

Professor and Chairman, Department of Neurosurgery, Houston Methodist

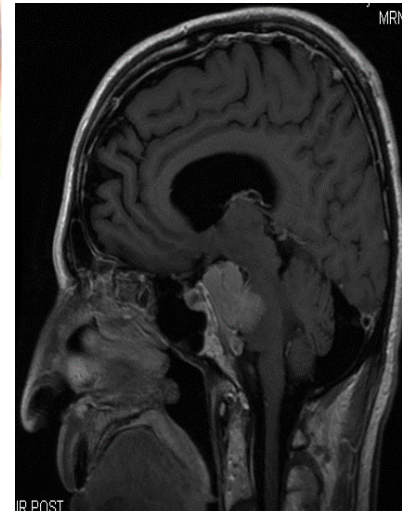
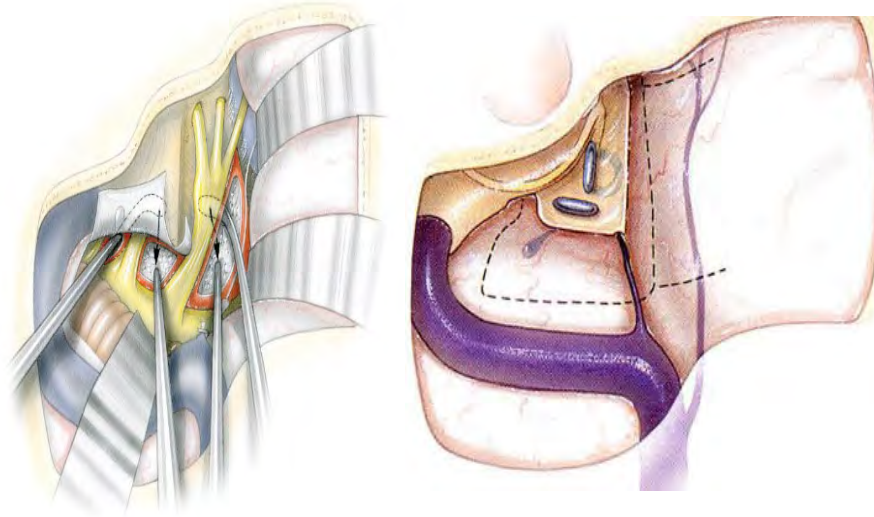
Professor, Weill Cornell

Adjunct Professor, Neuroengineering, Rice University

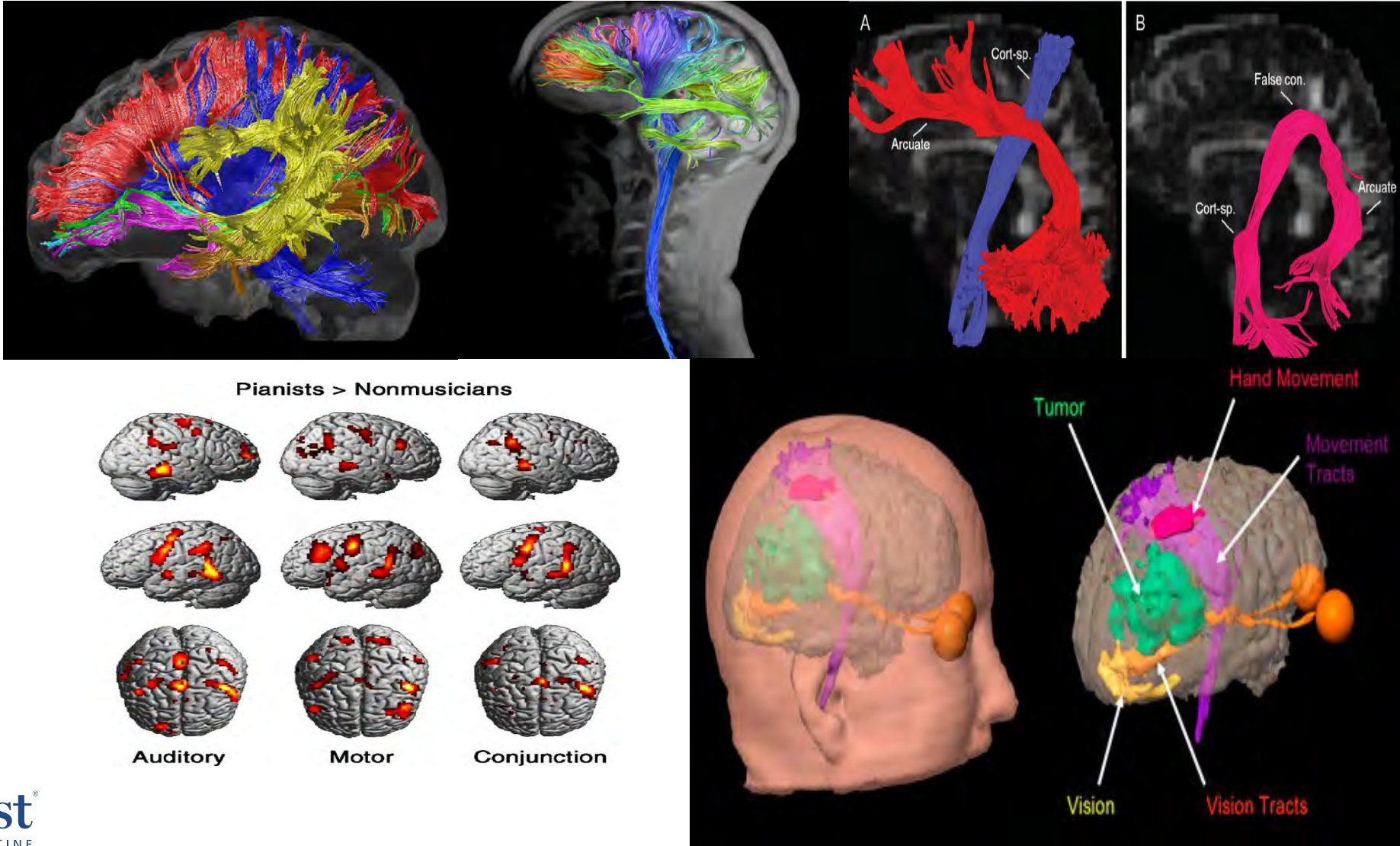
Neurosurgery has undergone major changes in the past 100 years



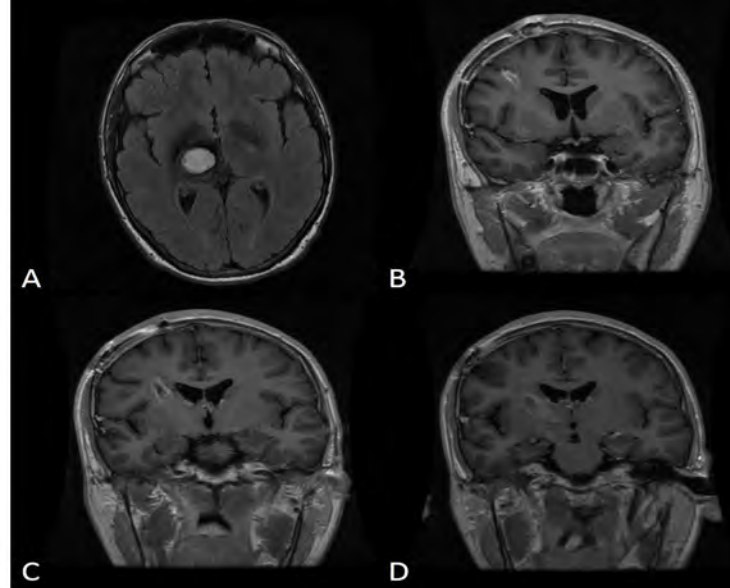
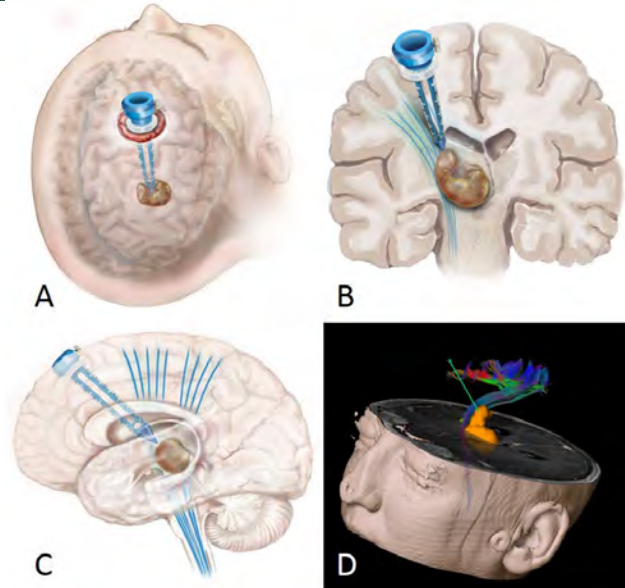
Neurosurgery has come a long way and continues to grow



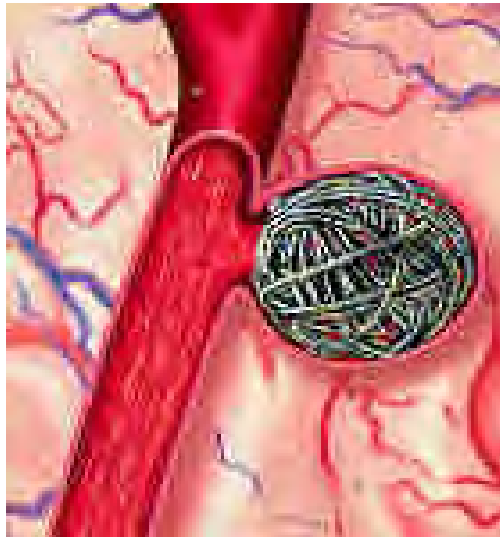
For the intrinsic tumors



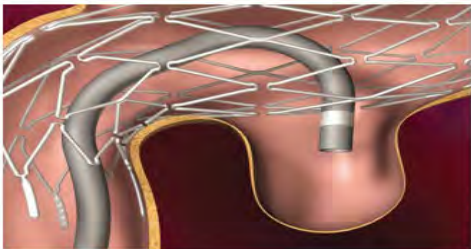
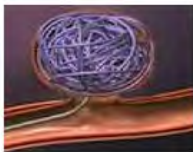
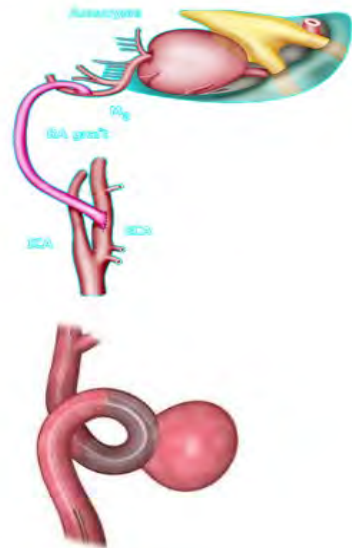
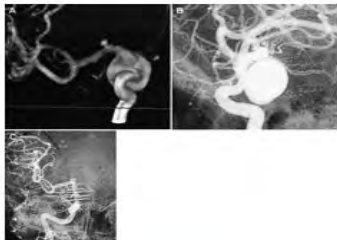
Deep-seated tumors



Vascular neurosurgery

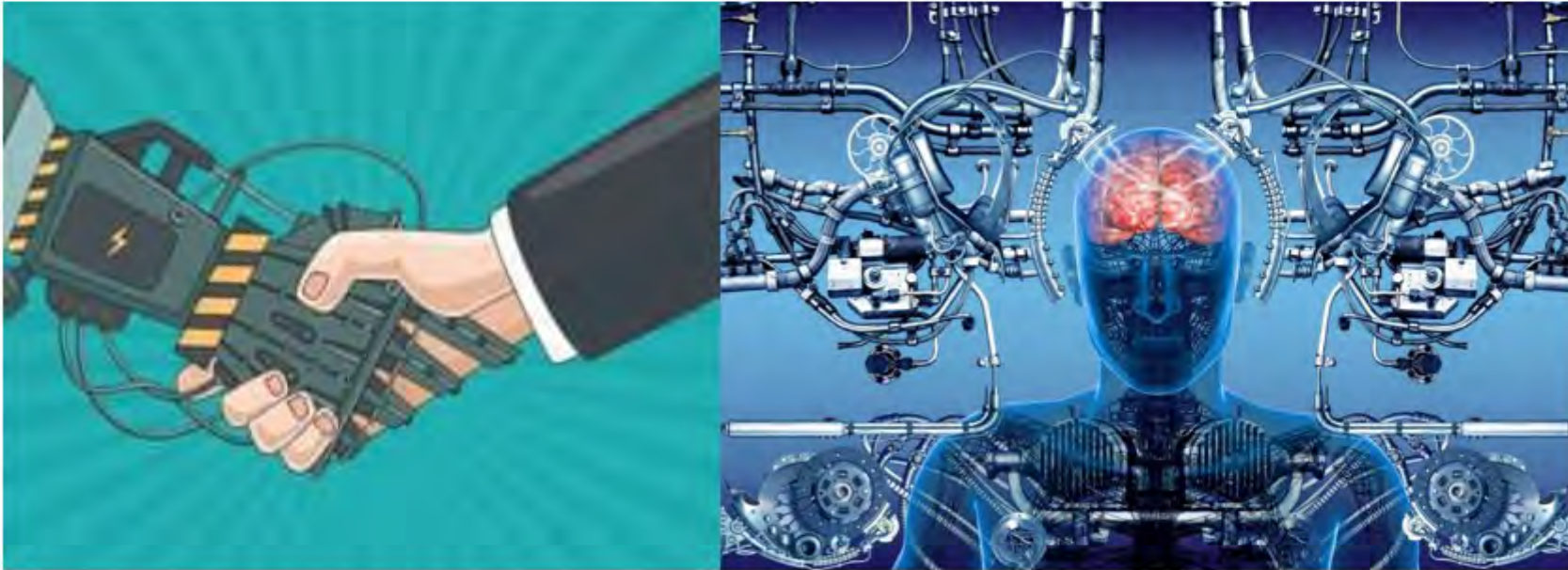


High flow bypasses



Robotics

THE “MATRIX” IS HERE – ROBOTICS AND AI
ARE OUR FUTURE



First in Man

> [Neurosurgery](#). 2021 Feb 16;88(3):506-514. doi: 10.1093/neuros/nyaa461.

First in Man Pilot Feasibility Study in Extracranial Carotid Robotic-Assisted Endovascular Intervention

Virendra R Desai ¹, Jonathan J Lee ¹, Trevis Sample ², Neal S Kleiman ³, Alan Lumsden ⁴, Gavin W Britz ¹

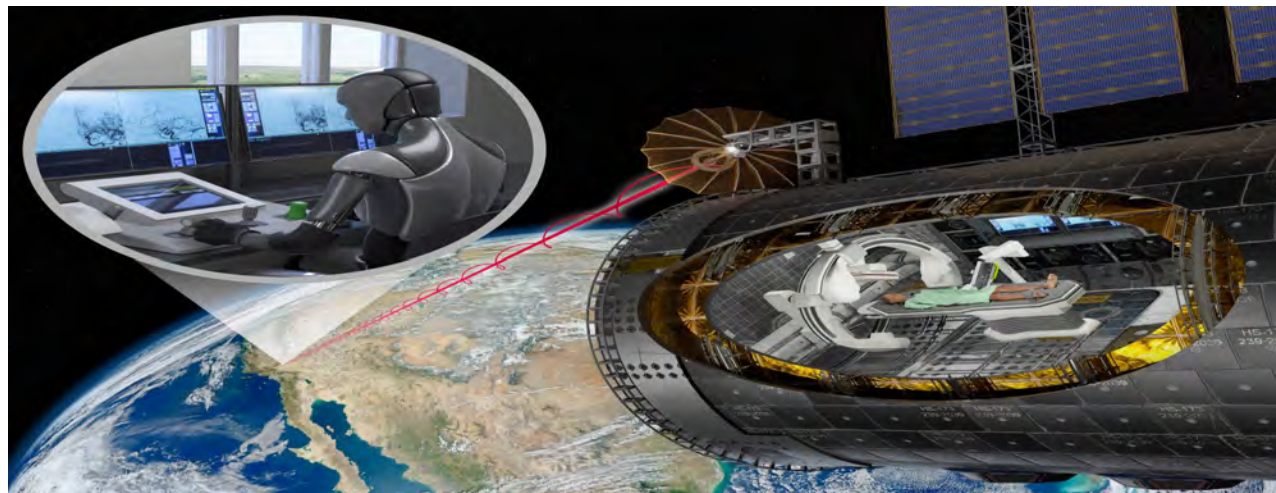
Background: Robotic-assistance in endovascular intervention represents a nascent yet promising innovation.

Objective: To present the first human experience utilizing robotic-assisted angiography in the extracranial carotid circulation.

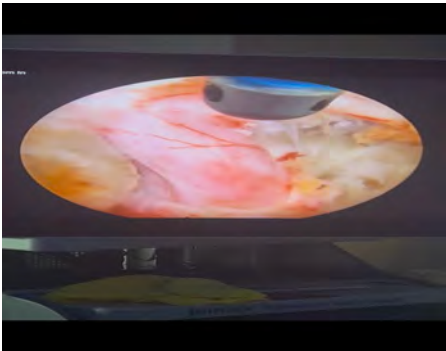
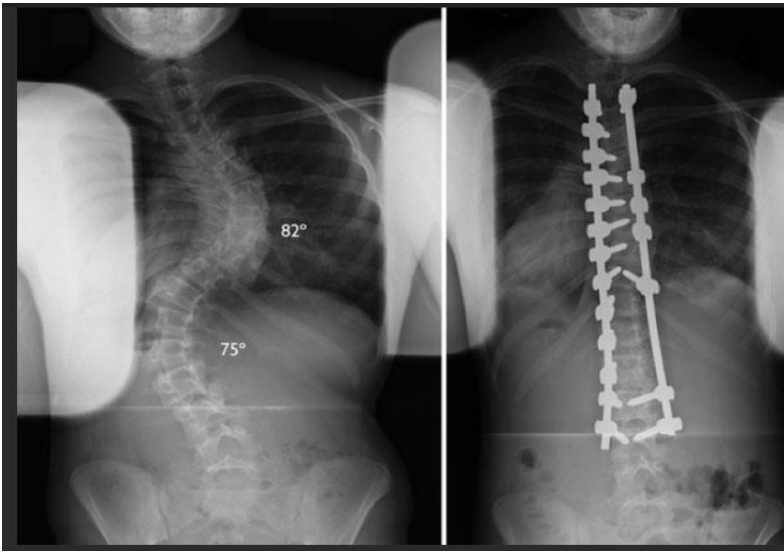
Methods: Between March 2019 and September 2019, patients with extracranial carotid circulation pathology presenting to Houston Methodist Hospital were enrolled.

Results: A total of 6 patients met inclusion criteria: 5 underwent diagnostic angiography only with robotic-assisted catheter manipulation, while 1 underwent both diagnostic followed by delayed therapeutic intervention. Mean age was 51 +/- 17.5 yr. Mean anesthesia time was 158.7 +/- 37.9 min, mean fluoroscopic time was 22.0 +/- 7.3 min, and mean radiation dose was 815.0 +/- 517.0 mGy. There were no technical complications and no clinical deficits postprocedure. None of the cases required conversion to manual neurovascular intervention (NVI).

Conclusion: Incorporating robotic technology in NVI can enhance procedural technique and diminish occupational hazards. Its application in the coronary and peripheral vascular settings has established safety and efficacy, but in the neurovascular setting, this has yet to be demonstrated. This study presents the first in human feasibility experience of robotic-assisted NVI in the extracranial carotid circulation.



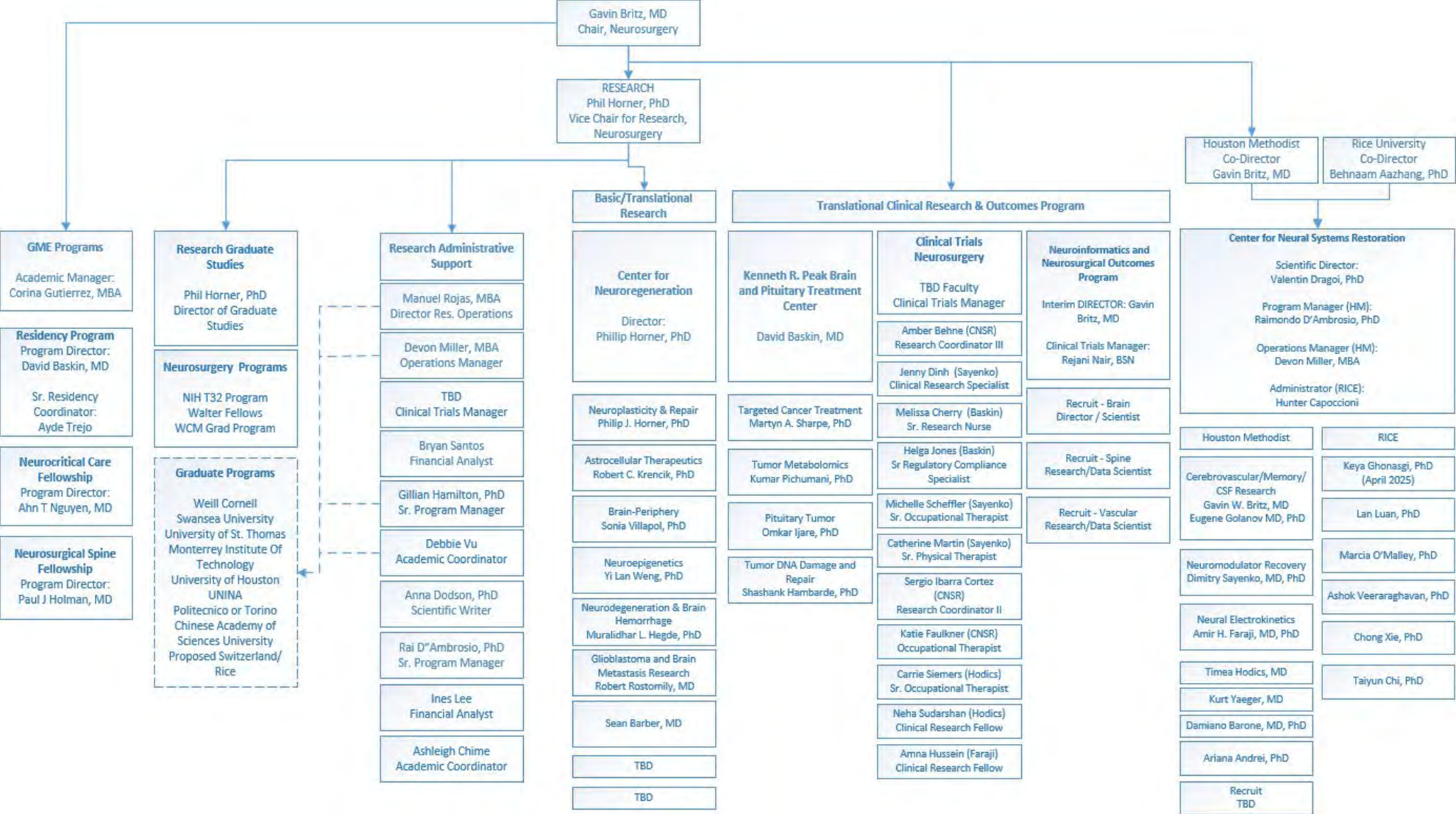
Spine



What is going to drive the field even further?

- **Scientific Advancements**
- We are going to move from “deconstructive surgery” (taking things out and purely technical surgery) to reconstructive surgery based on science
- Even making superhumans

Research Labs in Neurosurgery

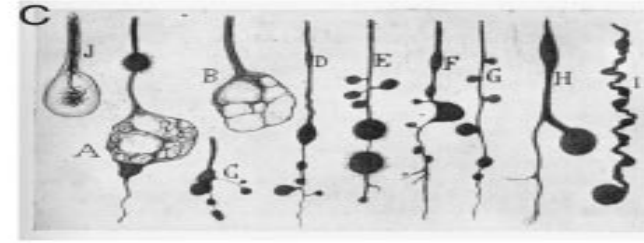
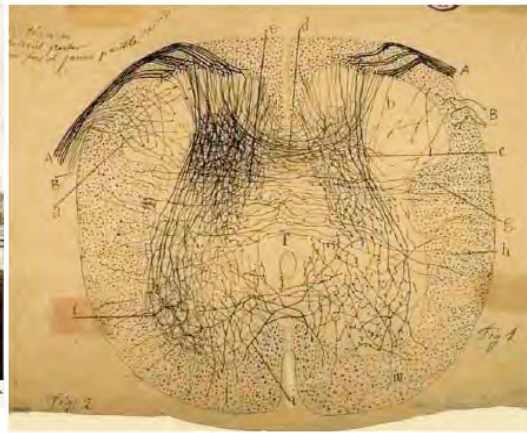


Introduction

- Many of us are sadly old enough to have grown up and believed the old doctrine that the brain and spinal cord cannot repair itself ~ 30 years ago
- Until the 1990s, neurologists were practicing their profession under the doctrine established in the late 19th to early 20th century by the prominent histologist Ramon Y Cajal



Santiago Ramon Y Cajal



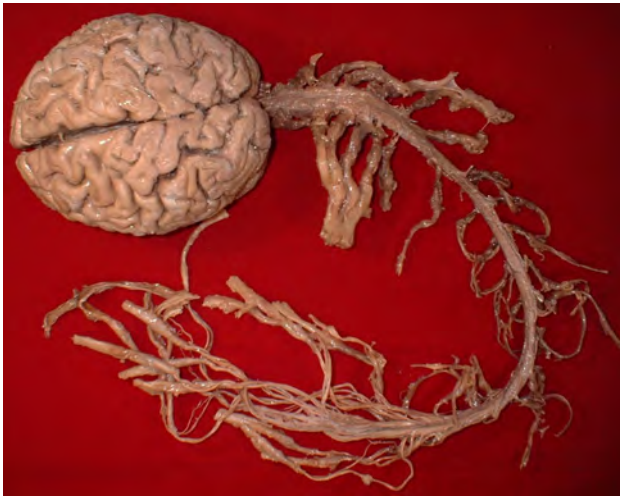
Santiago Ramón y Cajal (born May 1, 1852, Petilla de Aragón, Spain—died Oct. 17, 1934, Madrid) was a Spanish histologist who (with Camillo Golgi) received the 1906 Nobel Prize for Physiology or Medicine for establishing the neuron, or nerve cell, as the basic unit of nervous structure

RAMON Y CAJAL: ***“ONCE THE DEVELOPMENT WAS ENDED, THE FOUNTS OF GROWTH AND REGENERATION OF THE AXONS AND DENDRITES DRIED UP IRREVOCABLY. IN THE ADULT CENTERS, THE NERVE PATHS ARE SOMETHING FIXED, ENDED, AND IMMUTABLE. EVERYTHING MAY DIE, NOTHING MAY BE REGENERATED.”***

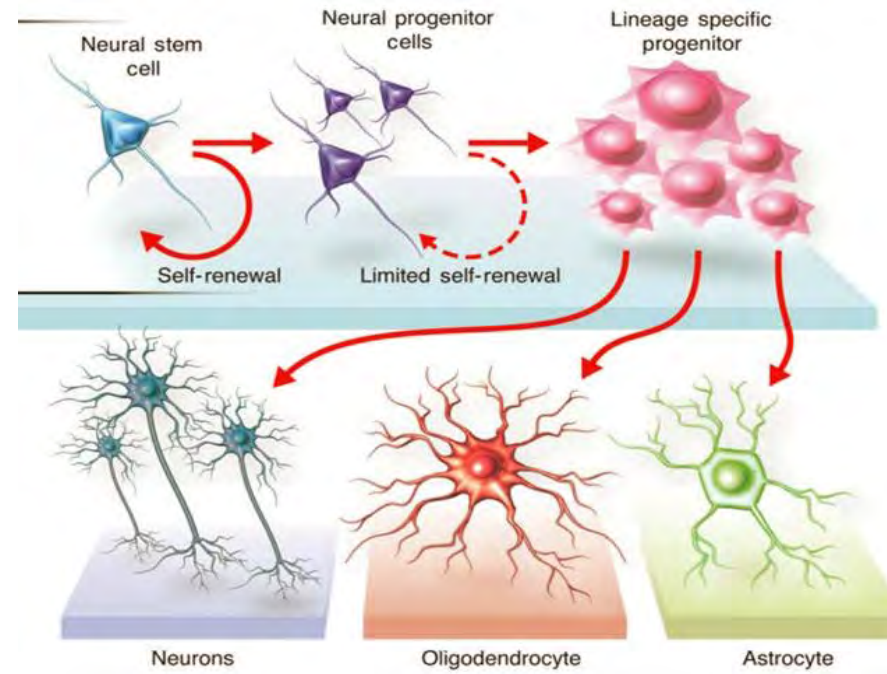
IT IS FOR THE SCIENCE OF THE FUTURE TO CHANGE, IF POSSIBLE, THIS HARSH DECREE.

Cells of the Brain and Spinal Cord

CAN WE RECREATE OR REPAIR THIS COMPLEX STRUCTURE?



100 billion neurons
500 trillion connections or
synapses



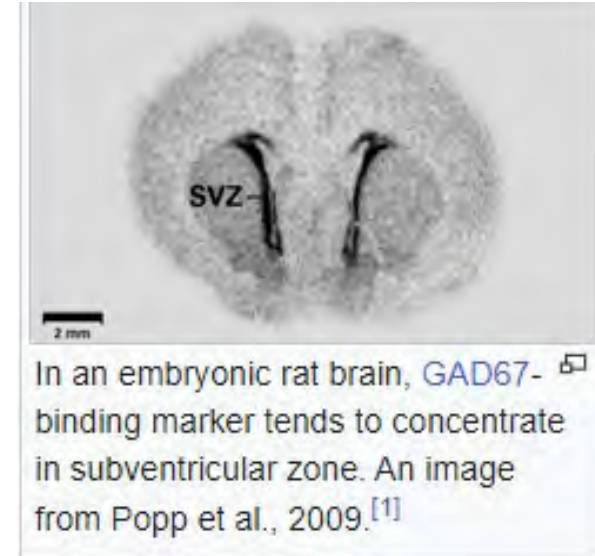
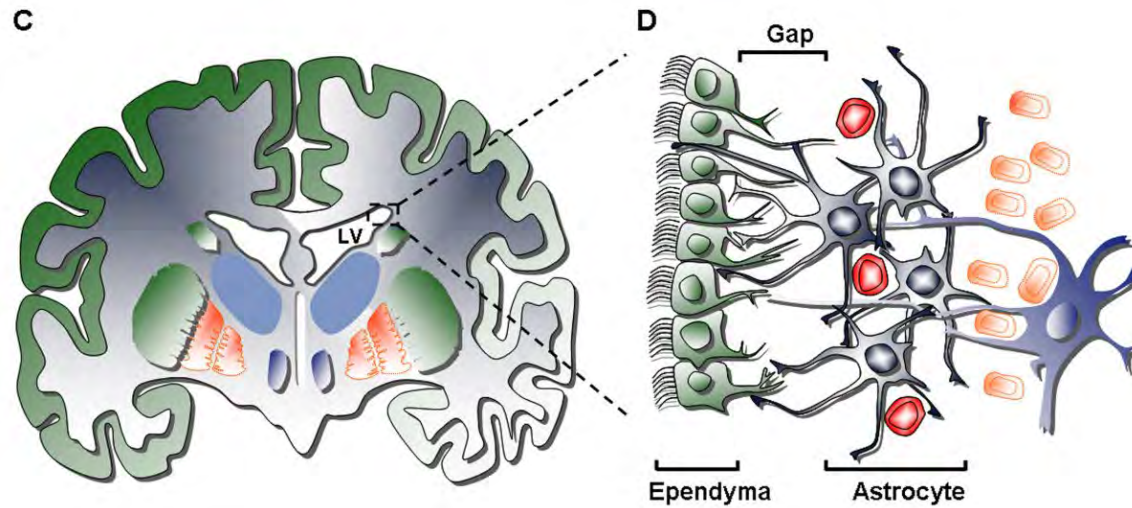
Regeneration does occur



For example:
In the salamander
limb regeneration
occurs **but requires**
the nerve/neurons

From Helen Pearson, Nature, Nov 22, 2001

Is this possible in humans?



HUMAN SUBVENTRICULAR ZONE. From a paper by Oscar Arias-Carrión, 2008

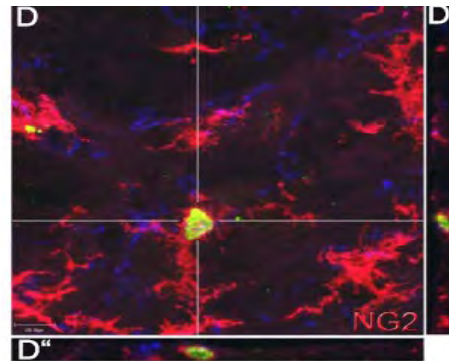
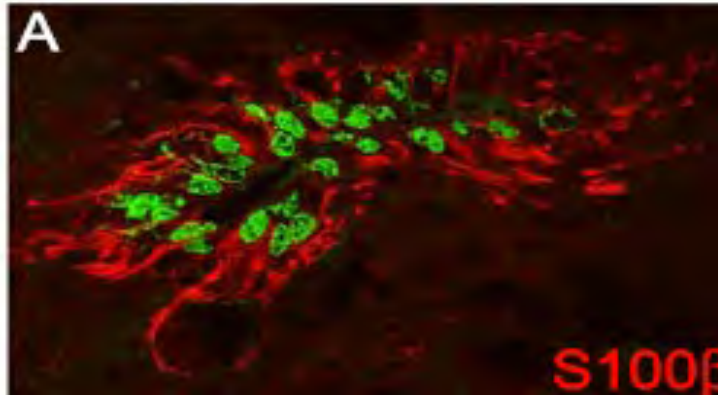
The periventricular region (PVR)

The periventricular region (PVR) of the brain contains neuroprogenitor cells (NPCs) and adult neural stem cells (aNSCs) that are involved in neurogenesis:

- **Neuroprogenitor cells**
These cells are present in the PVR during development but gradually decrease with age.
- **Adult neural stem cells**
These cells can be found in the PVR, as well as other brain regions. The proliferation, migration, and differentiation of aNSCs are regulated by both cell-intrinsic and cell-extrinsic mechanisms.
- **Subventricular zone**
This region of the lateral ventricles is the main periventricular germinal niche (PGN) in the adult brain. It produces new neurons for the olfactory bulb.
- **Periventricular region bordering the third ventricle**
This region is the PGN for adult hypothalamic neurogenesis. It contains a variety of cells, including tanycytes, subventricular and parenchymal glial cells, and adult stem and progenitor cells.

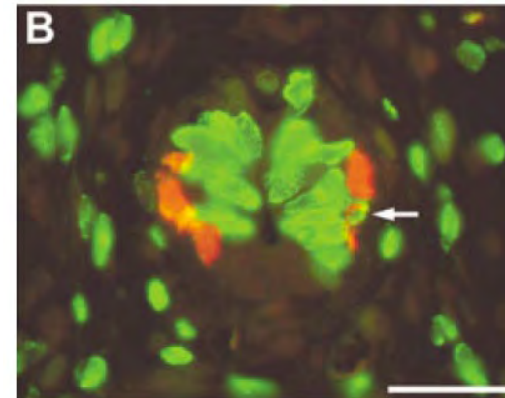
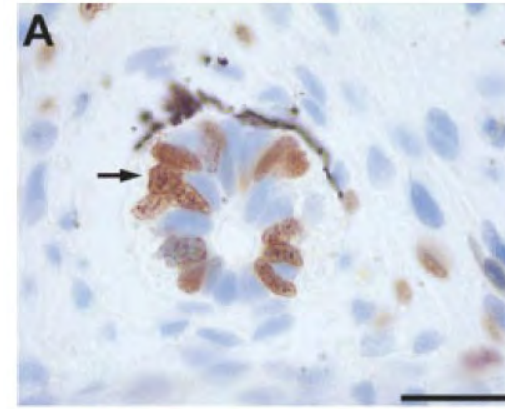
Compare mammalian vs. salamander spinal regeneration: Looks the same but is fundamentally different

THE MAMMALIAN: POST-INJURY NICHE:
RAPID GLIOGENESIS



Instead of
making
neurons,
mammals
make glia

SALAMANDERS: POST-INJURY
RAPID BIRTH OF NEURONS



We know now

Work by Fred “Rusty” Gage, PhD, president and a professor at the Salk Institute for Biological Studies and an adjunct professor at UC San Diego, and others found that **new brain cells are continually produced in the hippocampus and subventricular zone, replenishing these brain regions throughout life.**



[nature](#) > [articles](#) > article

Article | Published: 15 April 2020

Injured adult neurons regress to an embryonic transcriptional growth state

[Gunnar H. D. Poplawski](#) , [Riki Kawaguchi](#), [Erna Van Niekerk](#), [Paul Lu](#), [Neil Mehta](#), [Philip Canete](#), [Richard Lie](#), [Ioannis Dragatsis](#), [Jessica M. Meves](#), [Binhai Zheng](#), [Giovanni Coppola](#) & [Mark H. Tuszynski](#) 

[Nature](#) **581**, 77–82 (2020) | [Cite this article](#)

Using a mouse model, Tuszynski and colleagues discovered that after injury, mature neurons in adult brains revert back to an embryonic state. “Who would have thought,” said Tuszynski. “Only 20 years ago, we were thinking of the adult brain as static, terminally differentiated, fully established and immutable.”

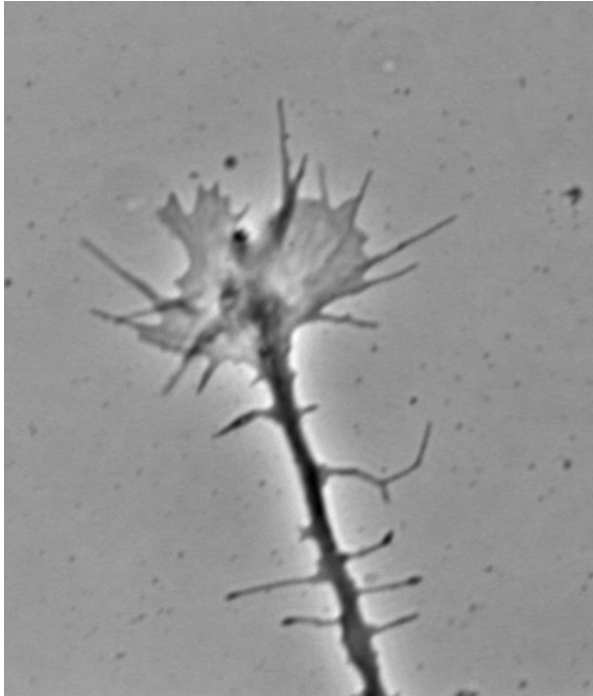
IN ADDITION, IN CERTAIN CIRCUMSTANCES NEURONS
CAN REVERT BACK TO THE EMBRYONIC STATE

Neuroplasticity

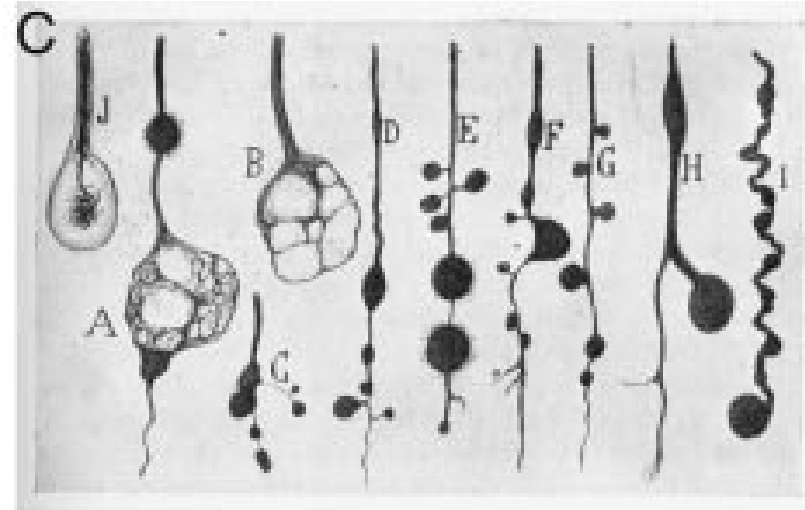
- Is a process that involves adaptive structural and functional changes to the brain
- It is defined as the **ability of the nervous system to change its activity in response to intrinsic or extrinsic stimuli** by
 - reorganizing its structure,
 - functions, or
 - connections
- After injuries, such as a stroke or traumatic brain injury

THIS ALREADY OCCURS

Mammalian neurons can grow!!!

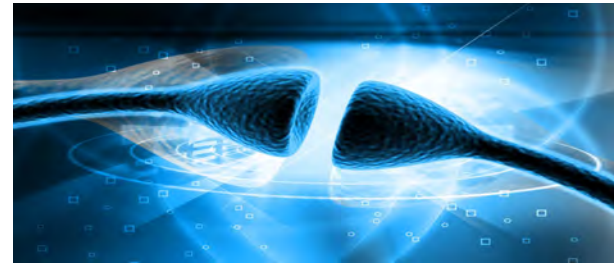


Regenerating tip – *injured neurons convert to growth in the presence of electrical activity, physical activity and growth factors.*



Dystrophic – chronic fibers after stroke/trauma, they retract but do not die – an opportunity?

Important concepts

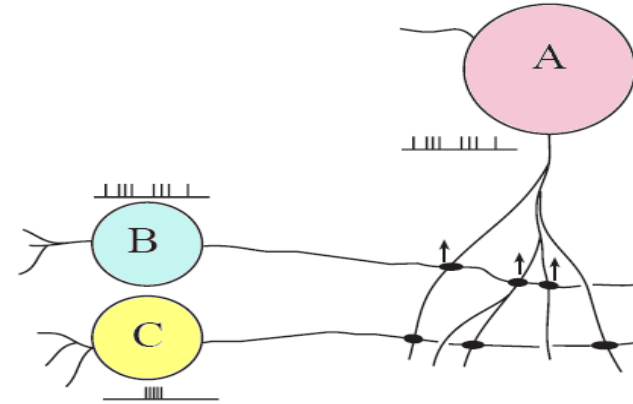


REMEMBER FROM BEFORE:

- Salamander develops new **neurons** unlike humans which produce supporting cells such as GLIA
- Just showed you neurons grow in the presence of **electrical activity**
- We have stem cells in the brain

HEBBIAN THEORY

- Neurons that wire together fire together



- 1) Need to engineer the right replacement neuron
- 2) Drive circuit formation through physical or electrical activity

In summary

- We are now in a time that we thought was impossible. Regenerating brain and spinal cord is possible.
- We as scientists and physicians have provided the correct environment to allow the healing process.

CENTER FOR
NEUROREGENERATION

CNCR

OUTCOMES

ANN KIMBALL AND JOHN
W. JOHNSON CENTER FOR
CELLULAR THERAPEUTICS

Neurorestoration

A New Synthesis

Repair – Replace – Optimize

Neurosurgery/Neurology/Psychiatry/Neurorehabilitation
Neural Engineering/Computational Neuroscience/Regenerative Medicine

Opinion

The Brain Implants That Could Change Humanity

Brains are talking to computers, and computers to brains. Are our daydreams safe?



The Brain Implants That Could Change ... - The New York Times

<https://www.nytimes.com/2020/08/28/opinion/sunday/brain-machine-artificial...>

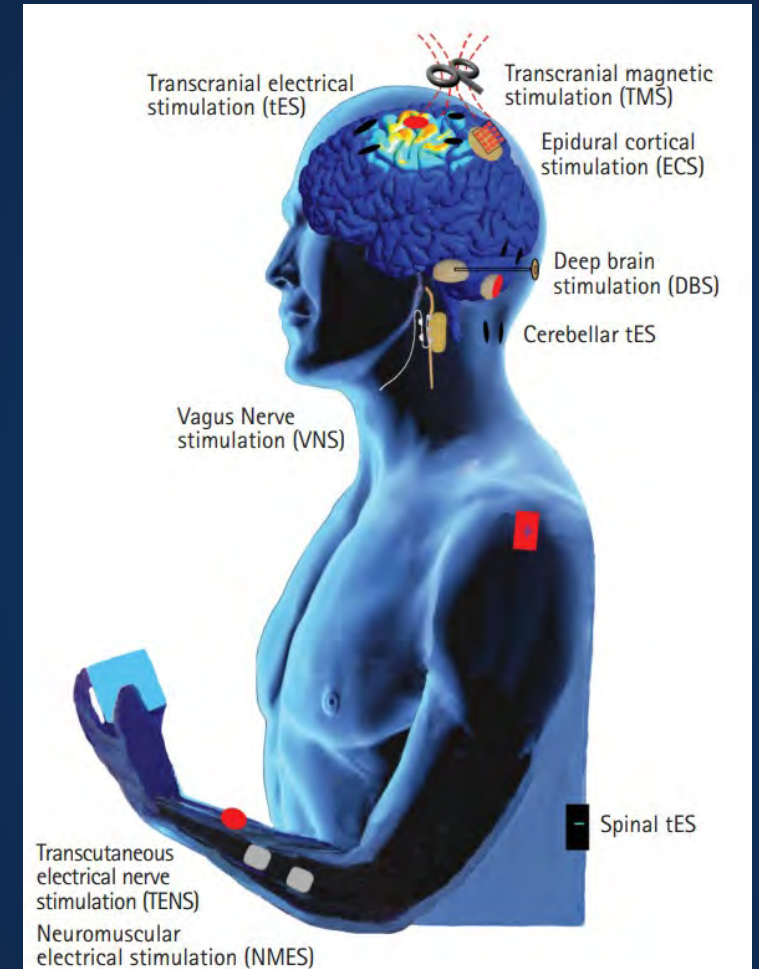
But!! Many different approaches

- Stem cell or cell therapy
- Neuromodulation
- Deep brain stimulation and focused ultrasound
- Brain “chips” (brain computer interface)

NEW NEUROSURGERY PROCEDURES
BASED ON SCIENCE

Neuromodulation is the new frontier

- The term Neuromodulation is a targeted artificial modification of neuronal activity through the delivery of chemical agents or electroceutical stimulation to specific neurological parts
- Neuromodulation advances are increasingly included in clinical practice
 - Vagus nerve stimulation FDA approved
 - rTMS level A (subacute hand, neglect)
 - tES -tDCS level B (chronic motor, special indications)
 - Spinal tES
- Home therapy applications provide equivalent efficacy to in-clinic therapy, more motivational and convenient

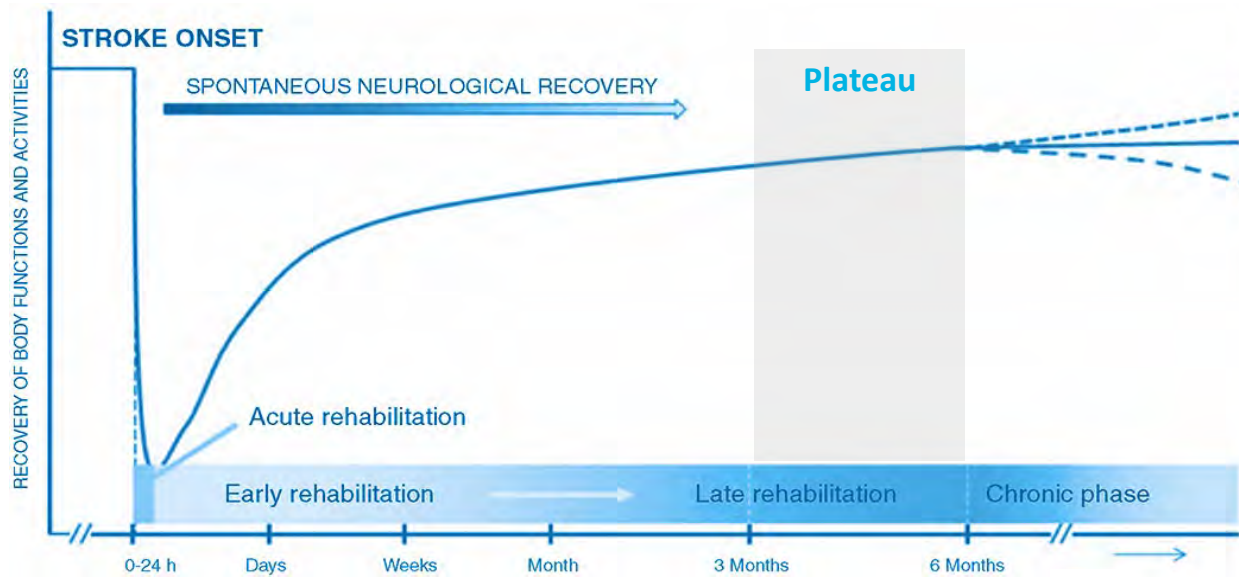


New Approaches to Stroke Recovery

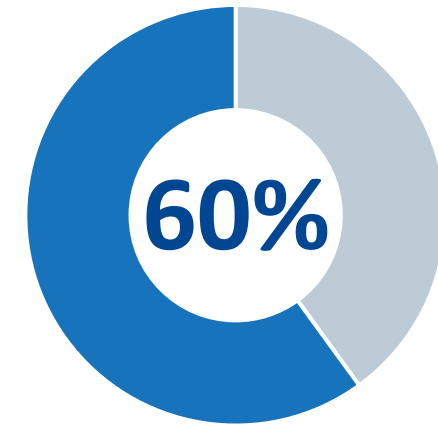
Timea Hodics, MD

Director, Interventional Neuro-Recovery Program





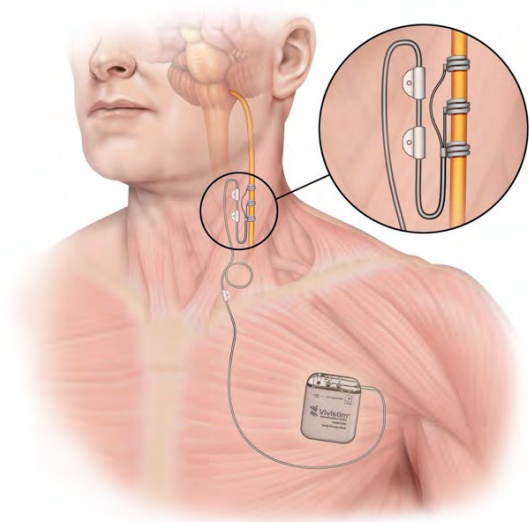
Impairments can worsen over time, with significant deterioration in functional and motor outcomes seen from 6 months to 5 years



Up to 60% have upper extremity impairment in the chronic phase of stroke

Pollock, A., et al. Cochrane Database Syst Rev. 2014
 Hatem SM et al. Front Hum Neurosci. 2016,
 Hussain N, et al. Front Neurol. 2018;
 Meyer S, et al.. Stroke. 2015

Implanted and non-invasive VNS

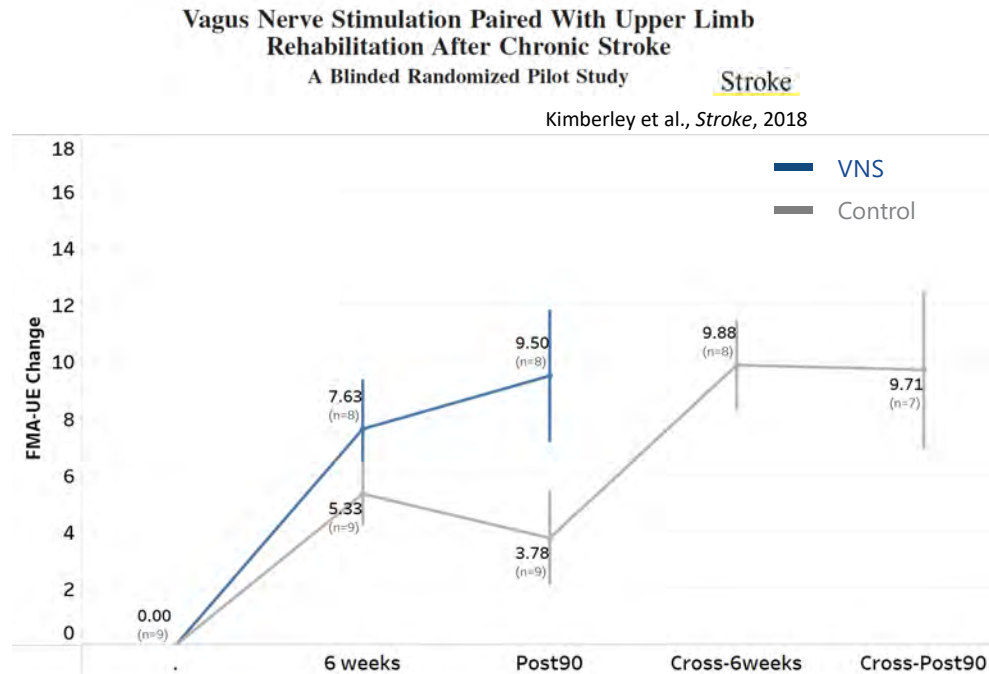


Implantable Pulse Generator (IPG)
is placed underneath the chest wall.

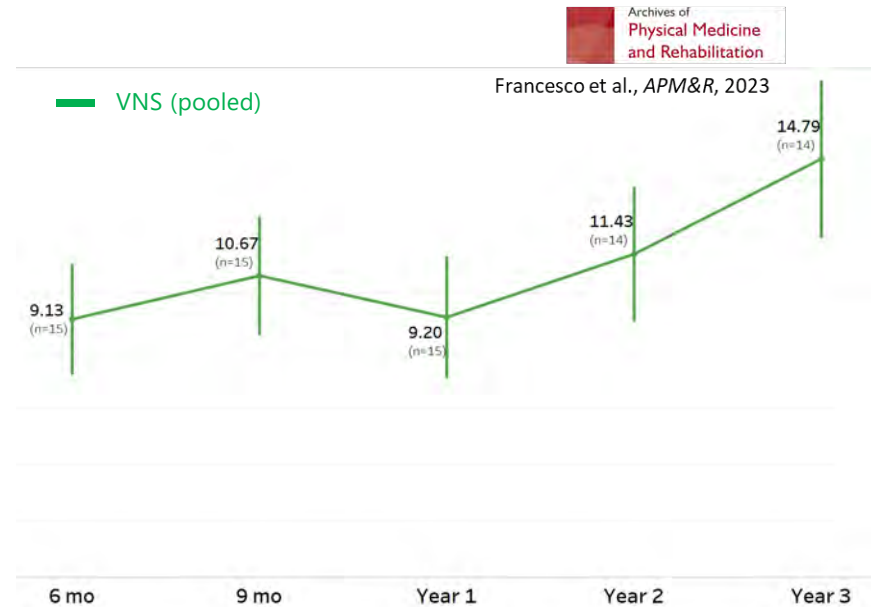
Lead electrodes are attached to the **left vagus nerve** in the neck and connected to the IPG.



Long-term outcomes from pilot VNS study



Vagus Nerve Stimulation Paired with Upper-Limb Rehabilitation After Stroke: Two- and Three-Year Follow-up from the Pilot Study



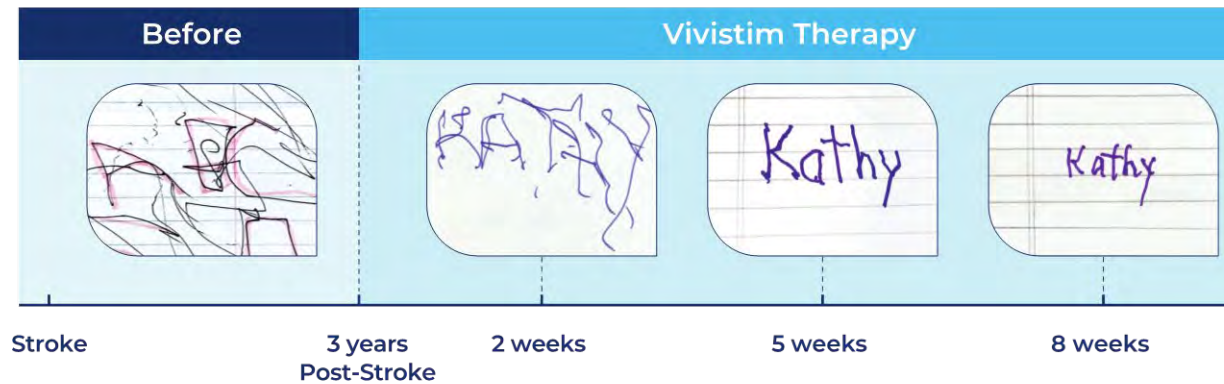
- No participants dropped out of the study owing to complications, intolerance, or lack of efficacy
- Participants did their at-home therapy on average 2.2 hours/week, and often, several times a day over 3 yrs

Francisco G, et al. Archives of Physical Medicine and Rehabilitation. 2023

Patient experience example

"It has been life-changing...I am doing things that I never thought I'd be able to do again."

- Kathy, 69 years old, 3 years post-stroke

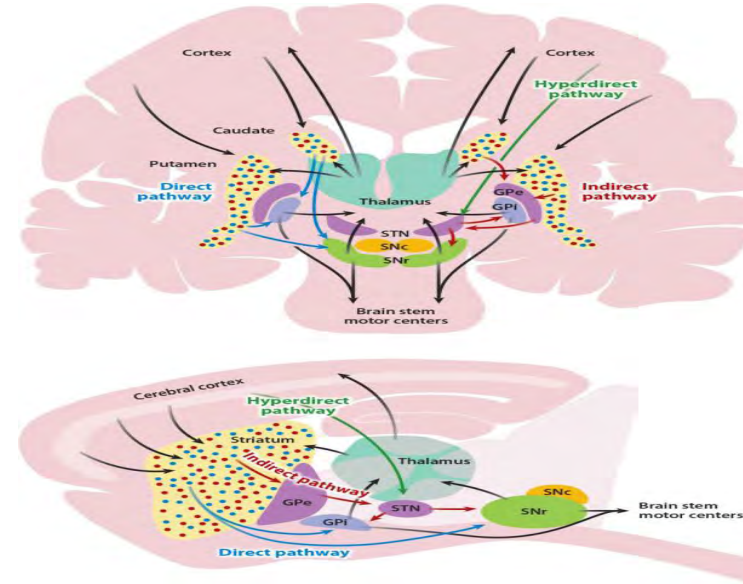
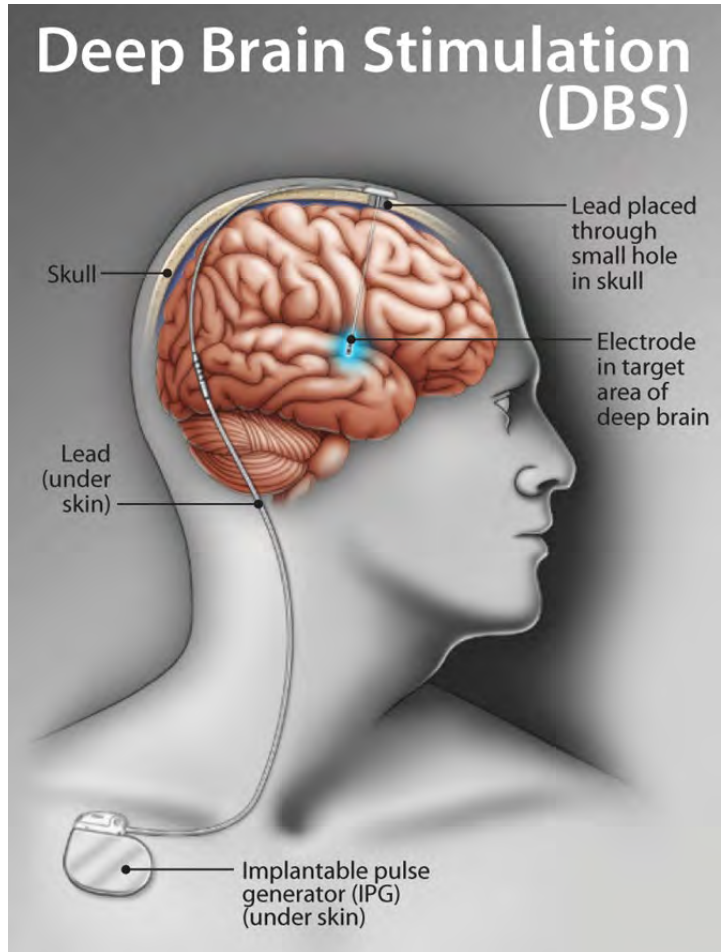


Transcranial direct current stimulation (tDCS)

- Painless stimulation that uses a constant direct current to stimulate the brain under the anode and inhibit under the cathode electrodes
- tDCS is noninvasive, portable, economical intervention that is easy to set up and use.



Deep brain stimulation

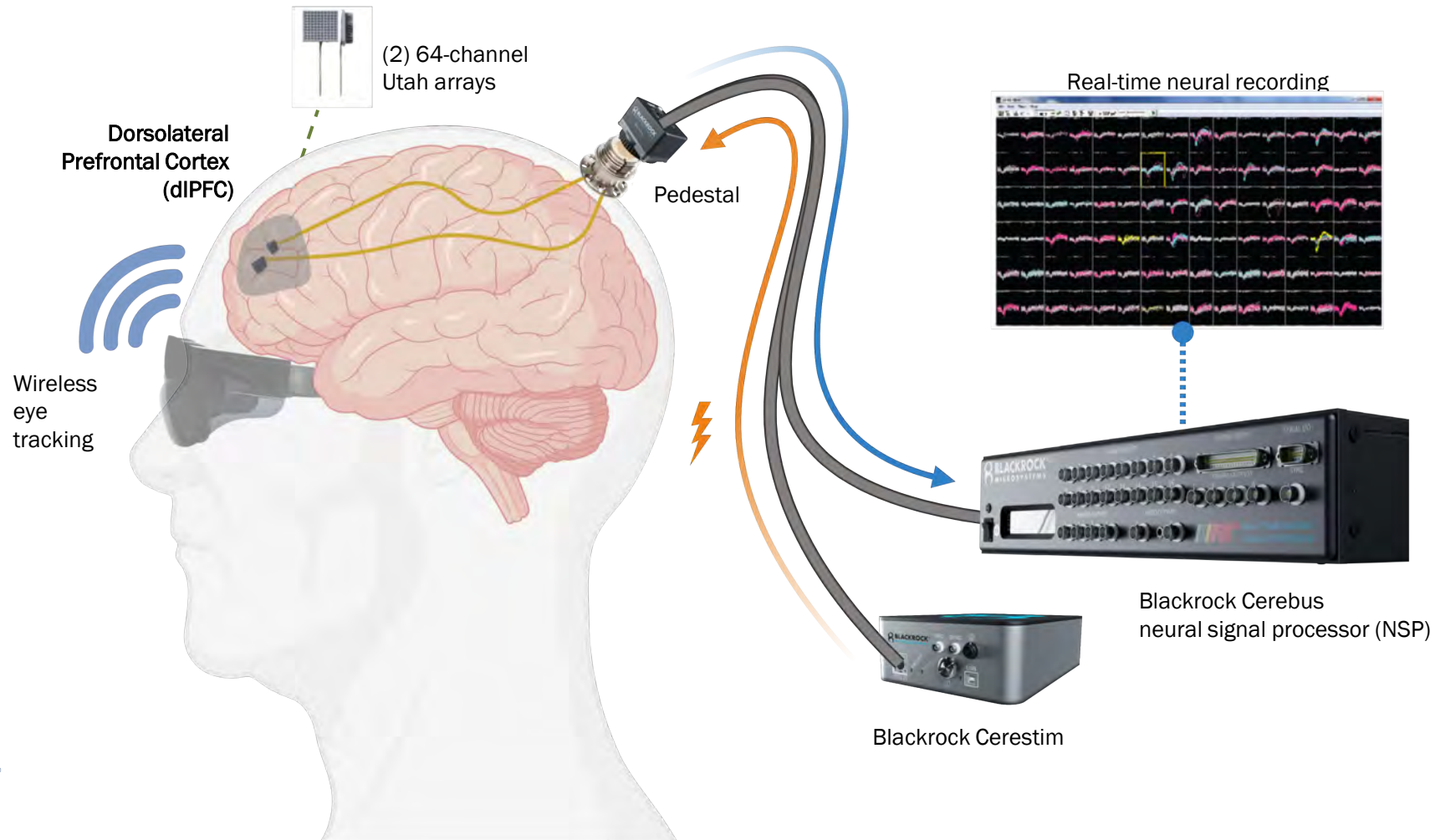


- Parkinson's Disease
- Tremor
- OCD
- Stroke recovery
- Depression
- Addiction

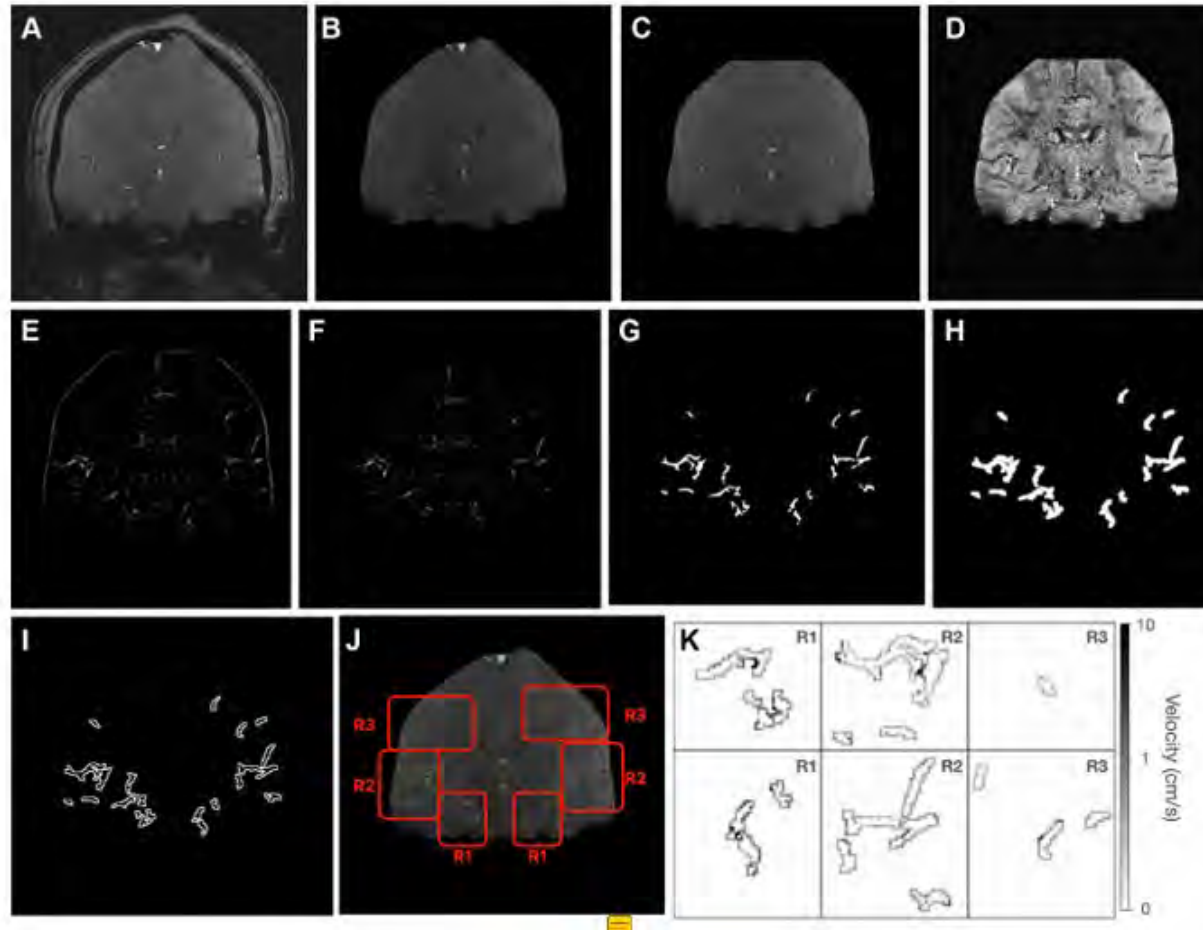
Focused ultrasound



Brain chips: e.g., ich stroke project



G Lymphatic flow and CSF



SURGEONS WILL BE USING INVASIVE AND NON-INVASIVE
MEANS TO DRIVE AND NORMALIZE CSF FLOW

Human performance and sleeping cap

nature neuroscience

Article

<https://doi.org/10.1038/s41593-023-01448-w>

Rapid compensatory plasticity revealed by dynamic correlated activity in monkeys in vivo

Received: 10 March 2022

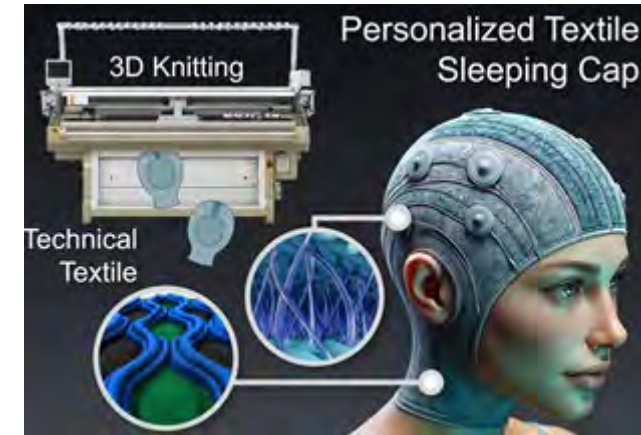
Accepted: 1 September 2023

Published online: 12 October 2023

 Check for updates

Ariana R. Andrei¹, Alan E. Akit², Natasha Kharas¹, Robert Rosenbaum³, Krešimir Josić² & Valentin Dragoi^{1,4}✉

To produce adaptive behavior, neural networks must balance between plasticity and stability. Computational work has demonstrated that network stability requires plasticity mechanisms to be counterbalanced by rapid compensatory processes. However, such processes have yet to be experimentally observed. Here we demonstrate that repeated optogenetic activation of excitatory neurons in monkey visual cortex (area V1) induces a population-wide dynamic reduction in the strength of neuronal interactions over the timescale of minutes during the awake state, but not during rest. This new form of rapid plasticity was observed only in the correlation structure, with firing rates remaining stable across trials. A computational network model operating in the balanced regime confirmed experimental findings and revealed that inhibitory plasticity is responsible for the decrease in correlated activity in response to repeated light stimulation. These results provide the first experimental evidence for rapid homeostatic plasticity that primarily operates during wakefulness, which stabilizes neuronal interactions during strong network co-activation.



Center for Neural Systems Restoration

Vision and Strategy

Valentin Dragoi, PhD

Center for Neural Systems Restoration, Houston Methodist Research Institute
Neuroengineering Initiative, ECE Department, Rice University
Brain and Mind Research Institute, Weill Cornell Medical College

Neural Science: A Century of Progress and the Mysteries that Remain

Review

Thomas D. Albright,* Thomas M. Jessell,†
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Part I. Introduction

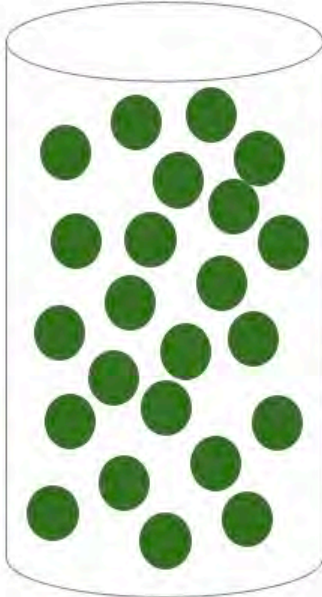
The goal of neural science is to understand the biological mechanisms that account for mental activity. Neural science seeks to understand how the neural circuits that

aspects of cognitive function. Some lesions interfere with comprehension of language, other with the expression of language; still other lesions interfere with the perception of visual motion or of shape, with the storage of long-term memories, or with voluntary action. In the largest sense, these studies revealed that all mental processes, no matter how complex, derive from the brain and that the key to understanding any given mental process resides in understanding how coordinated signaling in interconnected brain regions gives rise to behavior. Thus, one consequence of this top-down analysis has been initial demystification of aspects of mental function: of language perception, action, learning, and memory (Kandel et al., 2000).

A second consequence of the top-down approach came at the beginning of the twentieth century with the work of the Gestalt psychologists, the forerunners of cognitive psychologists. They made us realize that percepts, such as those which arise from viewing a visual scene, cannot simply be dissected into a set of independent sensory elements such as size, color, brightness, movement, and shape. Rather, the Gestaltists found that

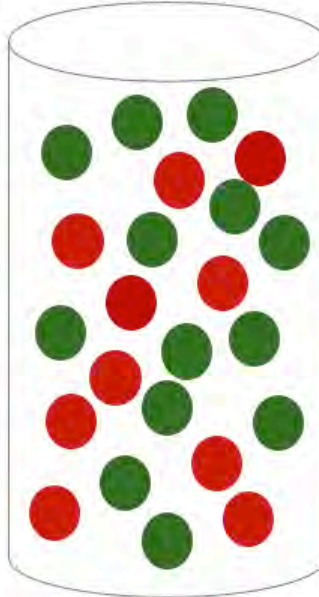
The brain as a complex system

Cup of coffee



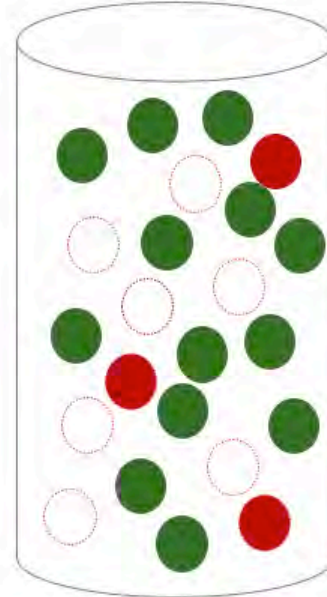
Simple

Computers

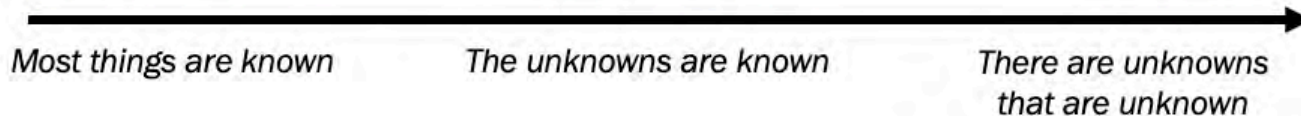


Complicated

The brain



Complex



Most things are known

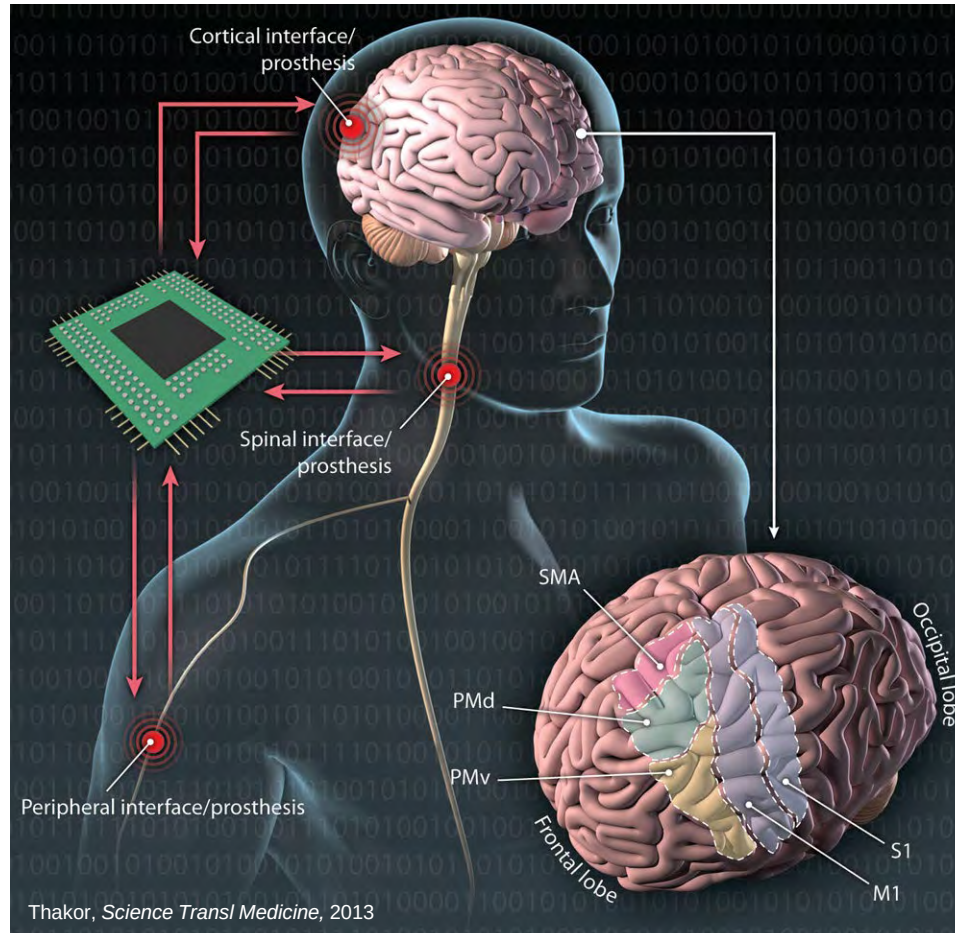
The unknowns are known

*There are unknowns
that are unknown*

The electrical brain, Scientific American, 2006

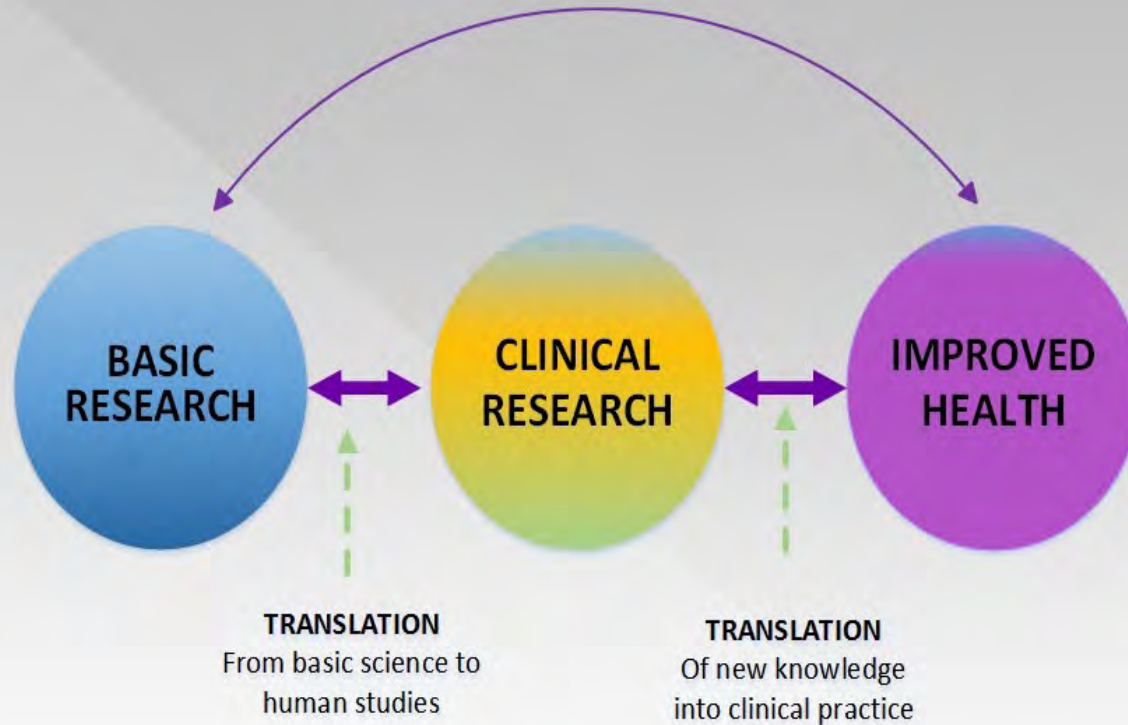


Using a mechanistic understanding of brain processes to guide neuroprosthetics applications





Our philosophy at CNSR



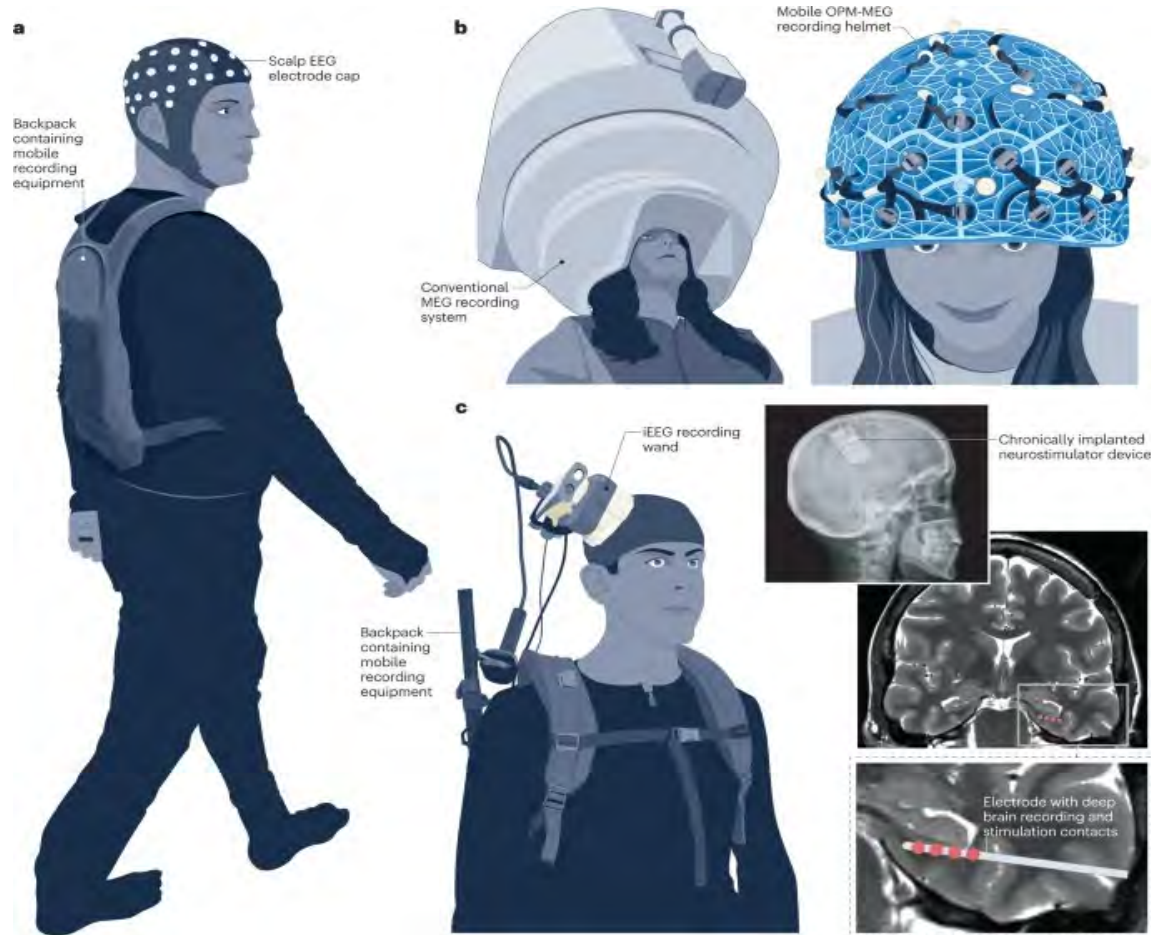
Stroke: loss of neural and behavioral function



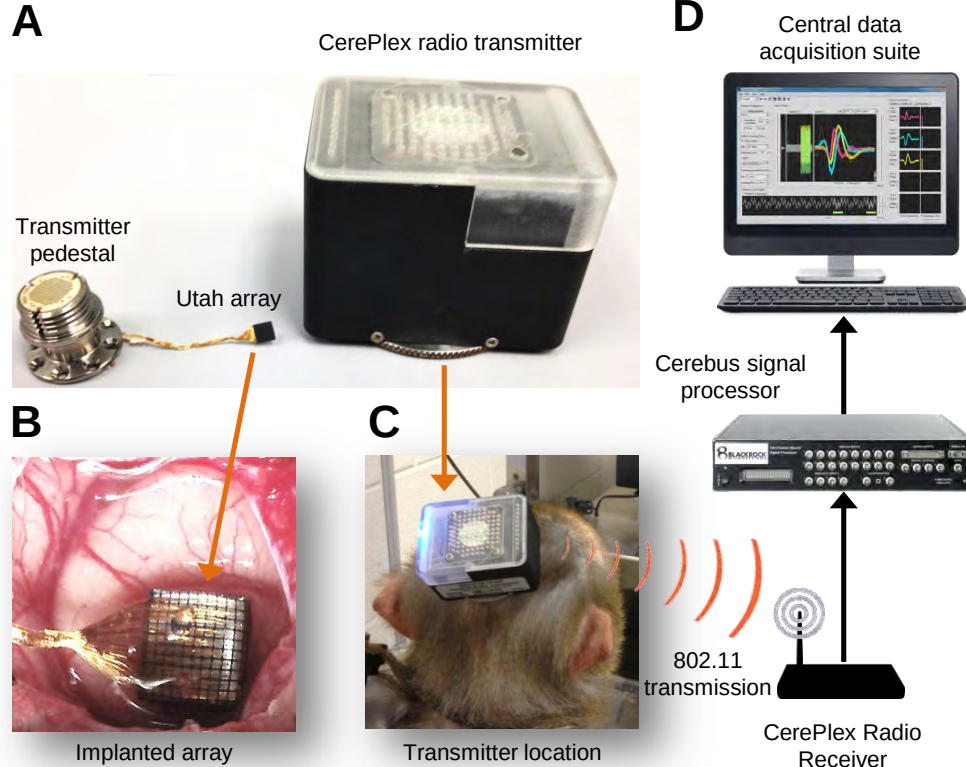
Stroke could impair movement, spatial navigation, memory, decision making

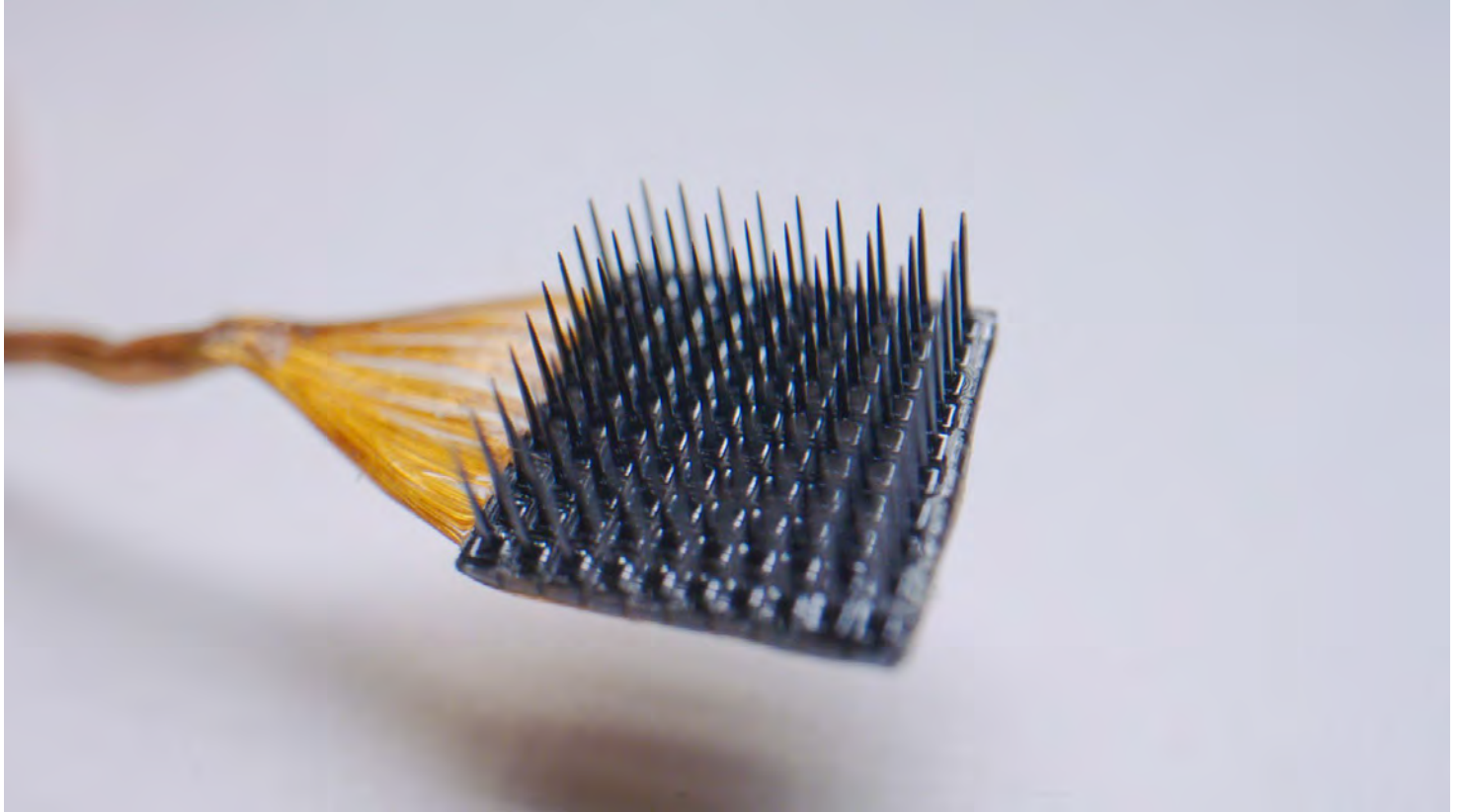


Wireless brain monitoring in freely moving humans



Configuration of a high-fidelity signal transmission wireless telemetry

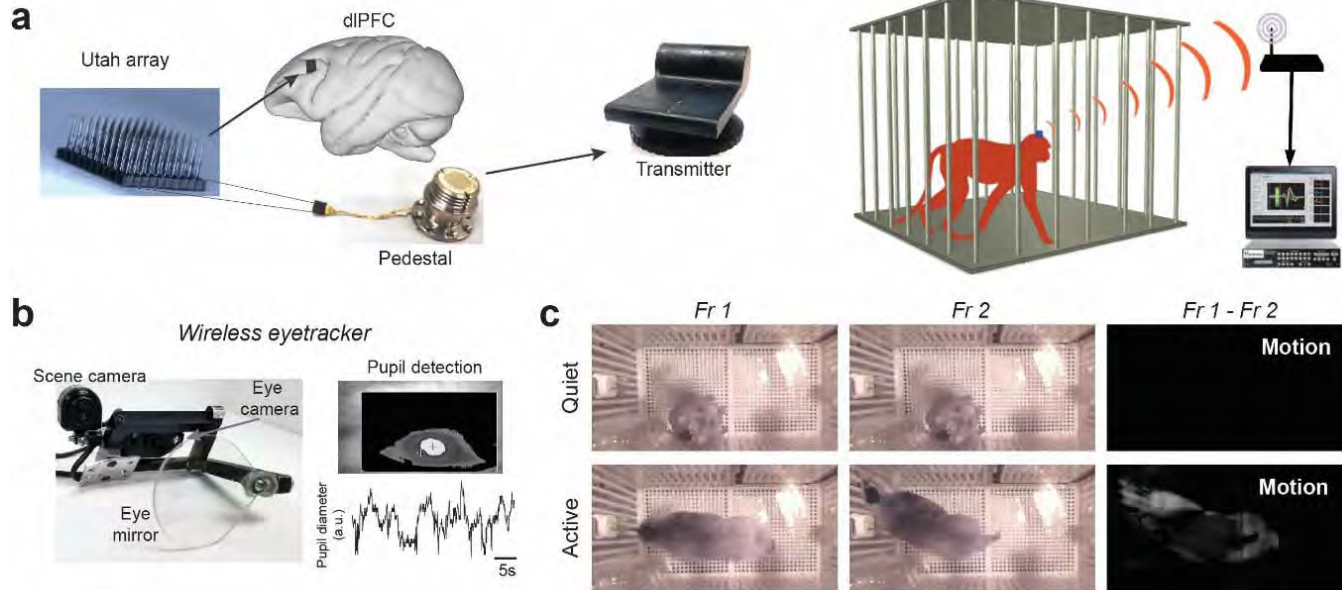




Freely moving macaques exploring their environment



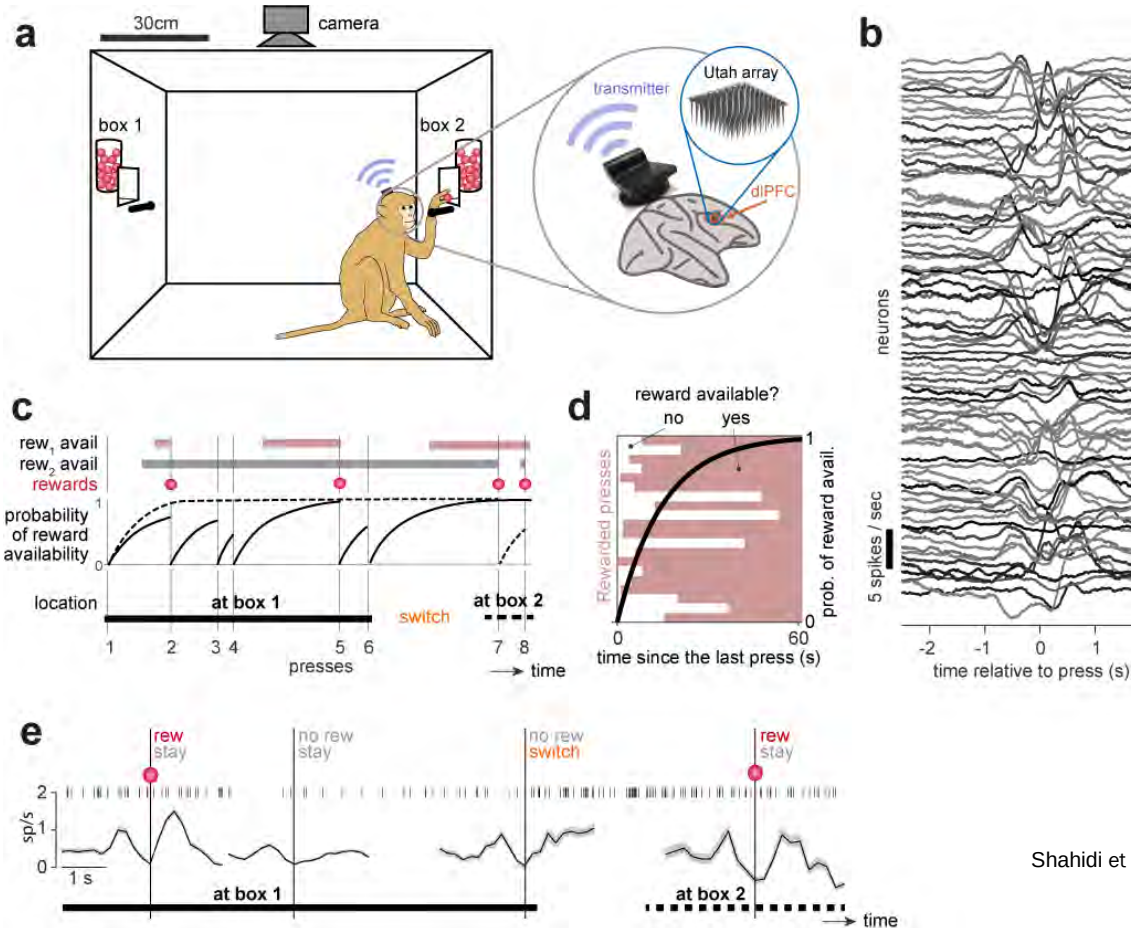
Russell Milton



Population coding of strategic variables during foraging in freely-moving macaques



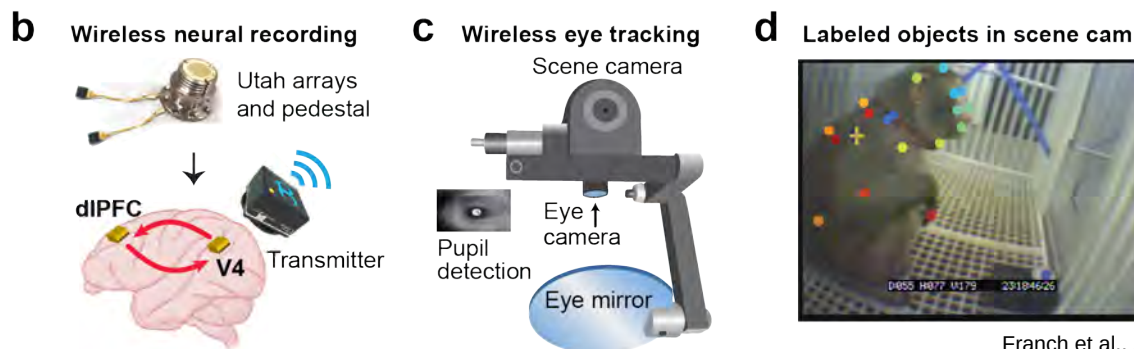
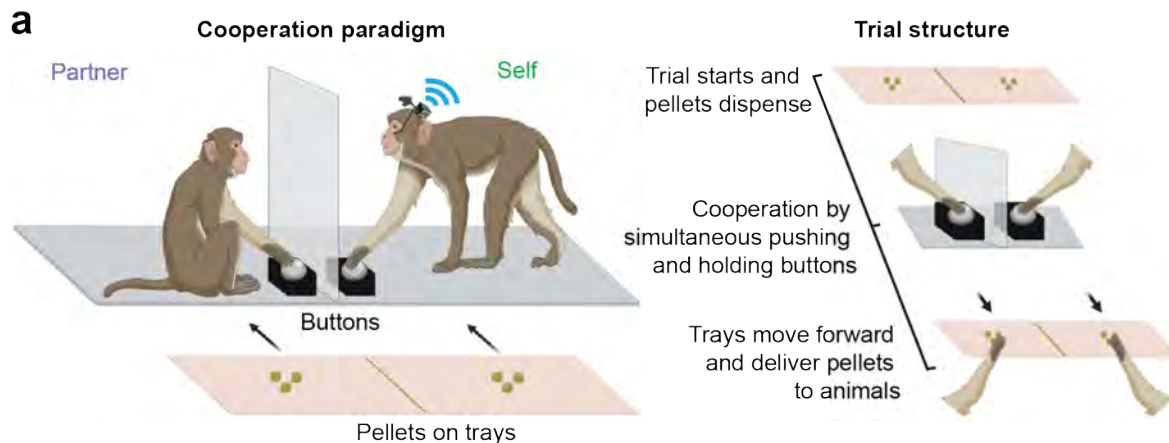
Neda Shahidi



Wireless recording of behavioral, oculomotor, and neural events during social interactions

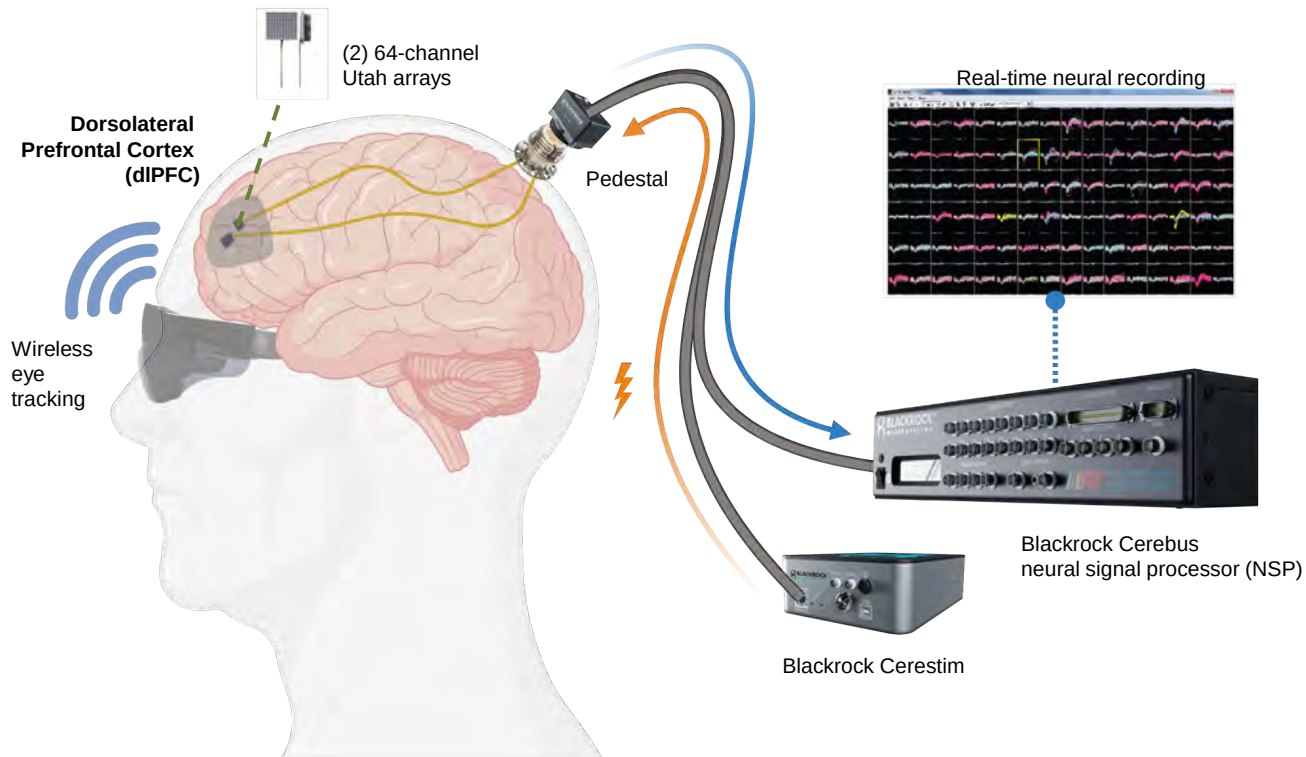


Melissa Franch



Franch et al., *Nature*, 2024

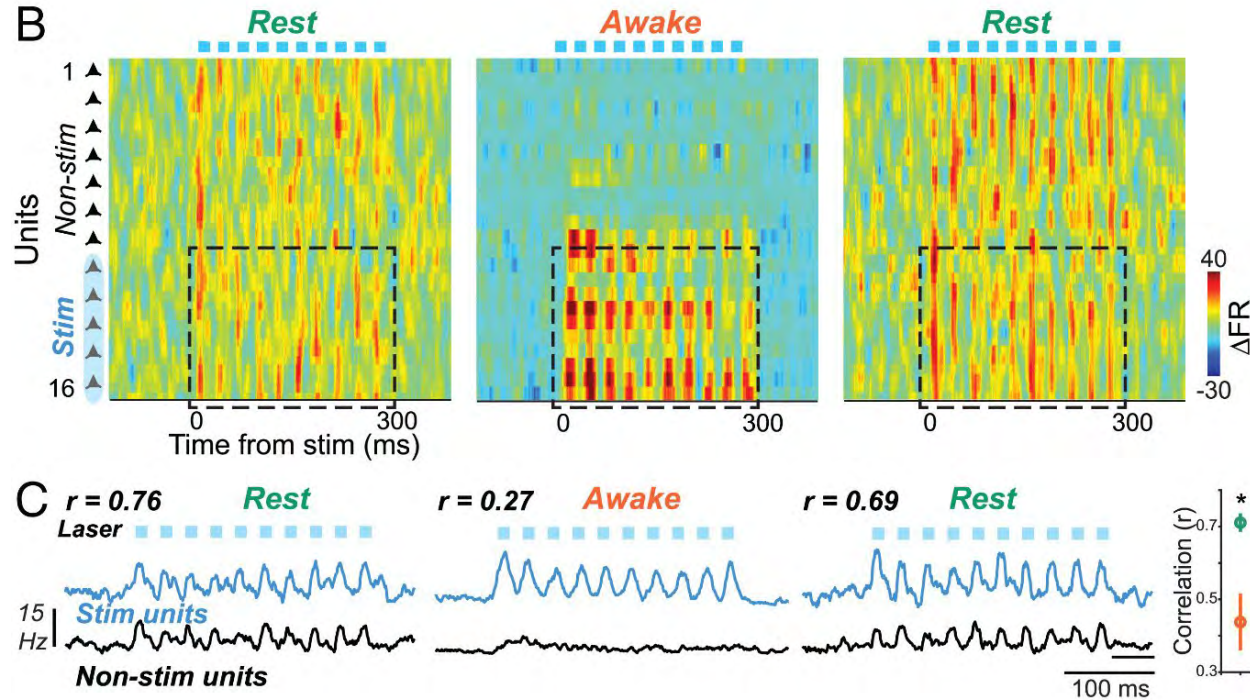
Restore motor function using targeted electrical stimulation to induce plasticity



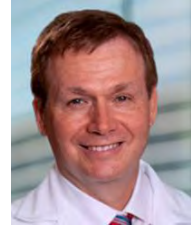
Propagation of electrical signals depends on brain state



Natasha Kharas



Electrical stimulation to induce plasticity and facilitate recovery



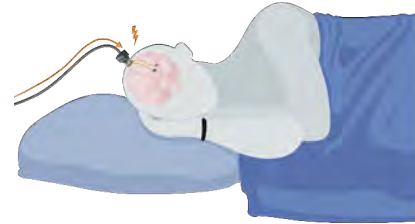
Gavin Britz, Methodist



Active Wakefulness



Quiet Wakefulness

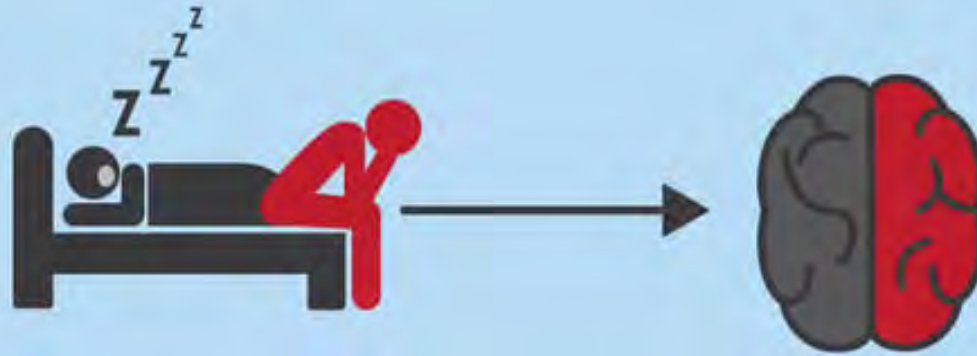


Sleep

***Over 40 million Americans suffer from chronic
sleep dysfunction***

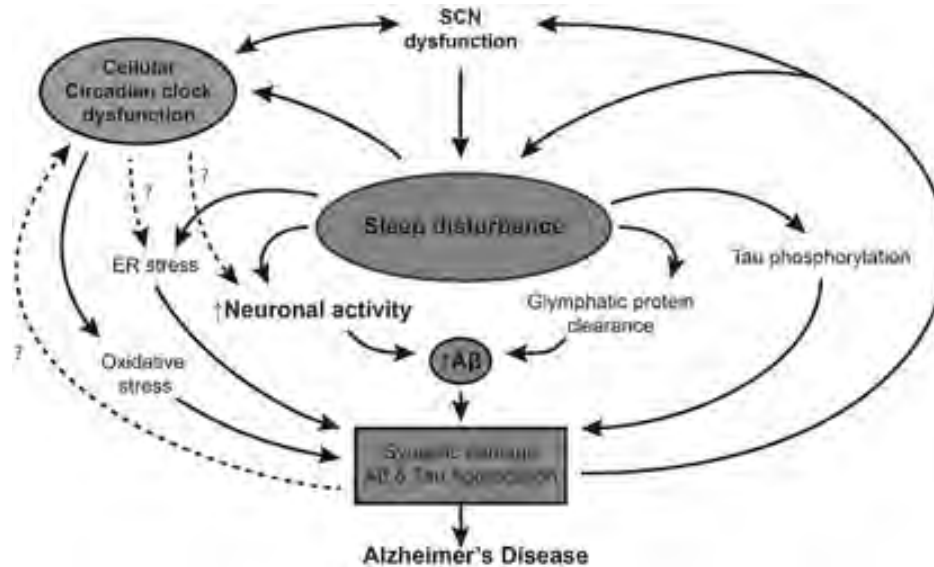


Sleep deprivation severely impairs brain function and may cause dementia

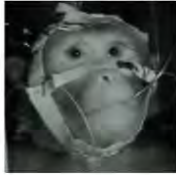


sleep deprivation
causes acute brain malfunction

Sleep deprivation directly influences metabolic clearance and neural activity to damage individual synapses



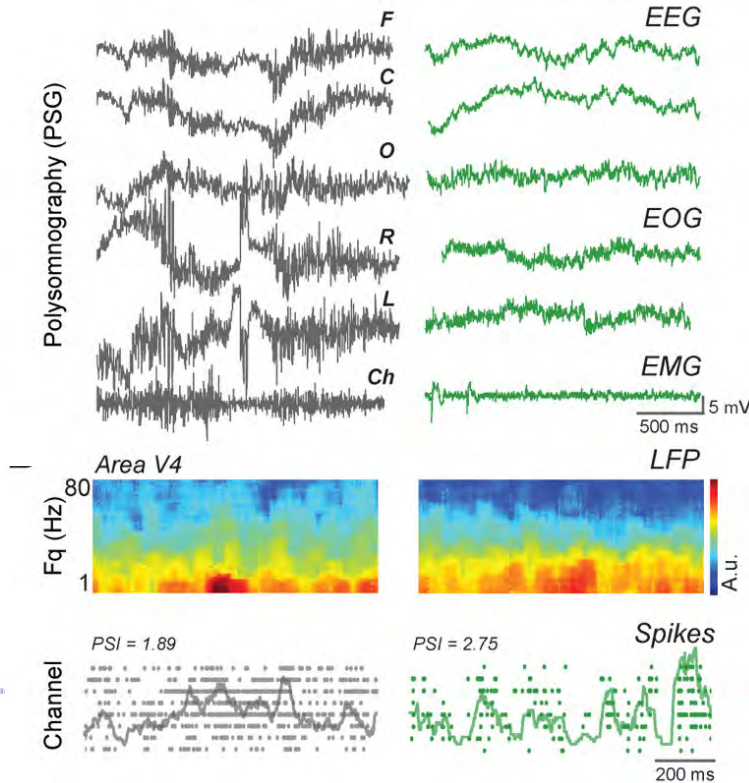
No sleep



Sleep



Examine the beneficial effects of sleep on neural and cognitive performance



NREM sleep improves behavioral performance



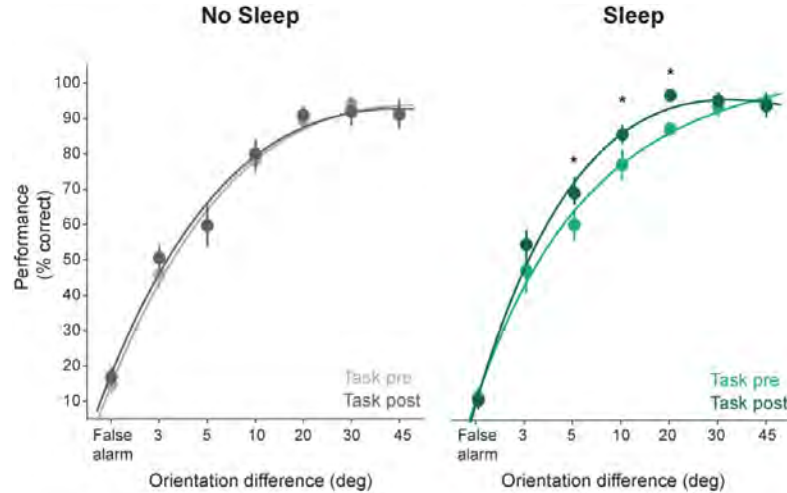
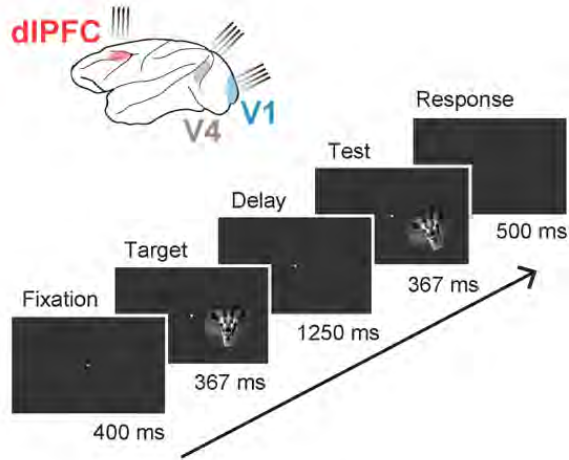
Natasha Kharas, MD/PhD

Experimental Paradigm

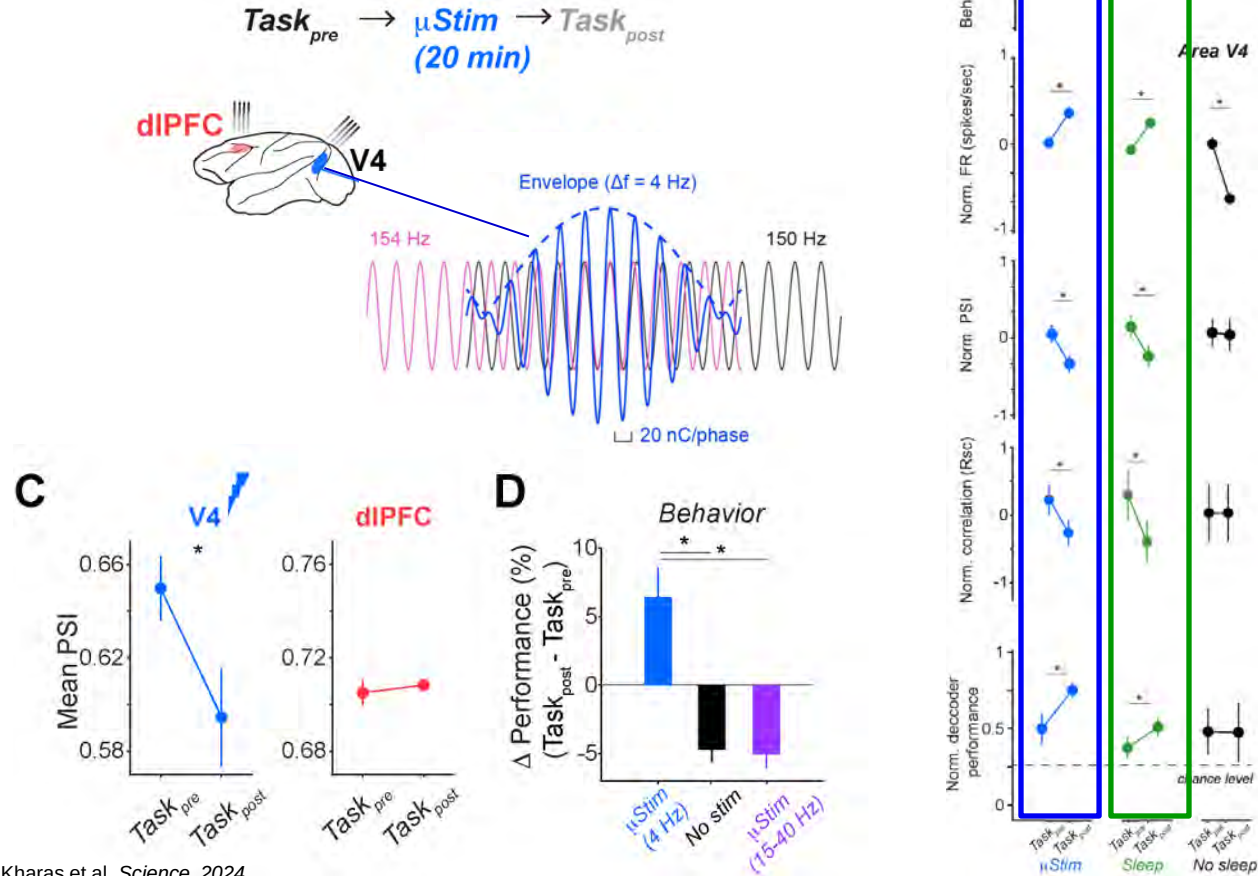
$Task_{pre} \rightarrow \text{Sleep} \rightarrow Task_{post}$

Control

$Task_{pre} \rightarrow \text{No Sleep} \rightarrow Task_{post}$



Delta-band electrical stimulation during wakefulness emulates the beneficial effects of sleep



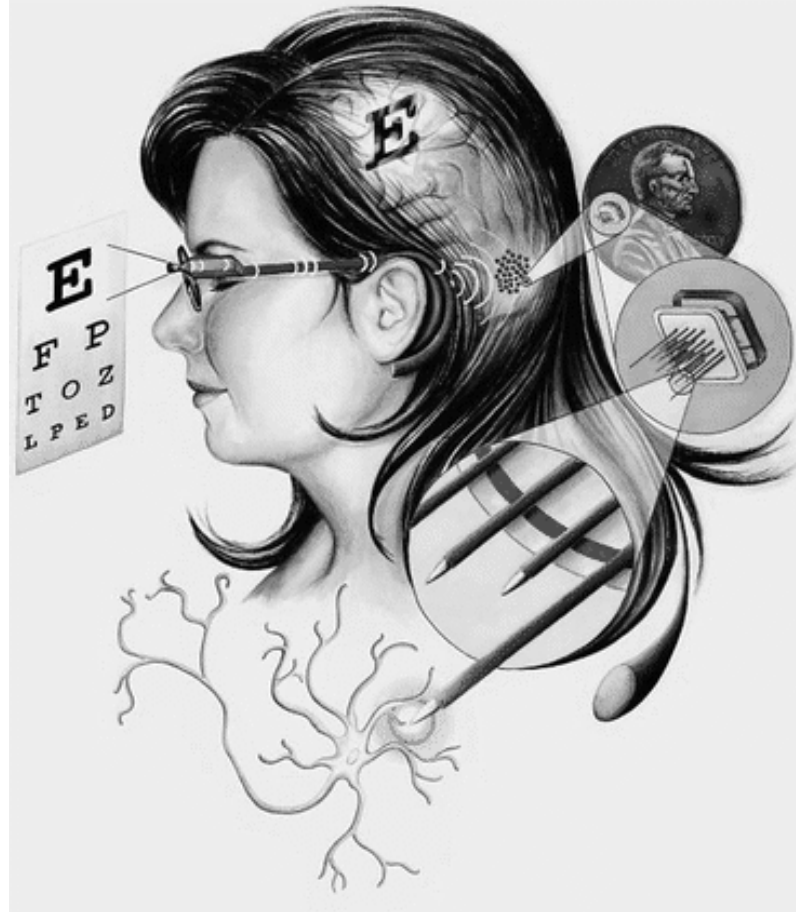
***Area-specific non-invasive delta-band
electrical stimulation during wakefulness to
emulate the beneficial effects of sleep***



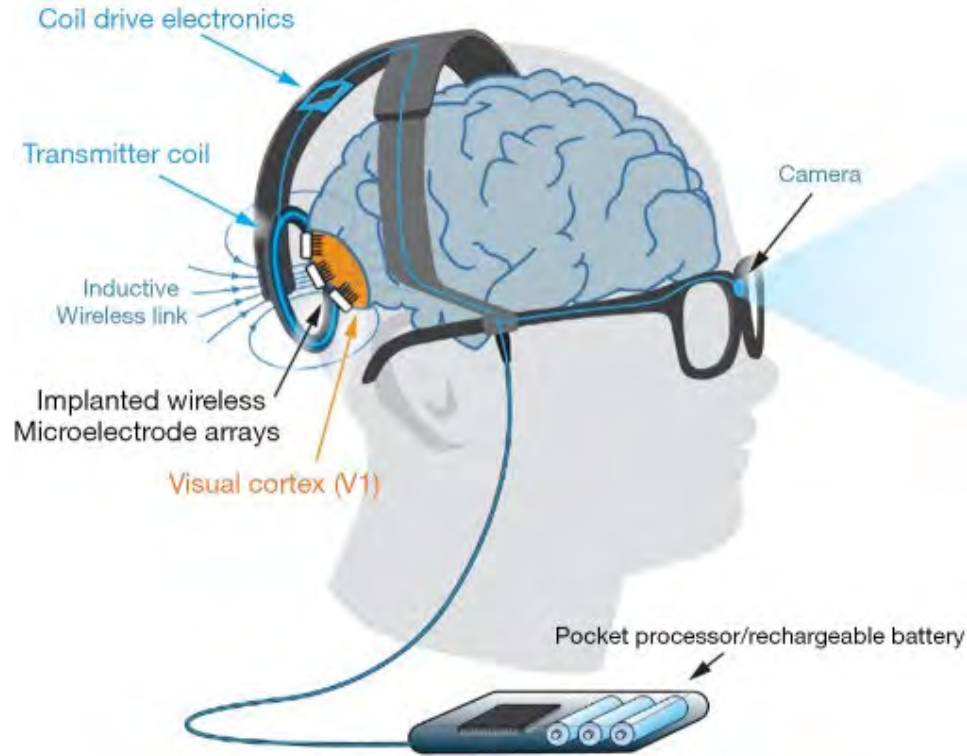
Blindness can have multiple causes



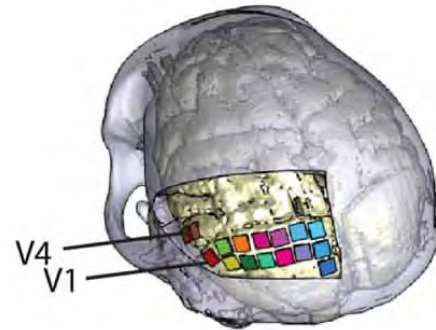
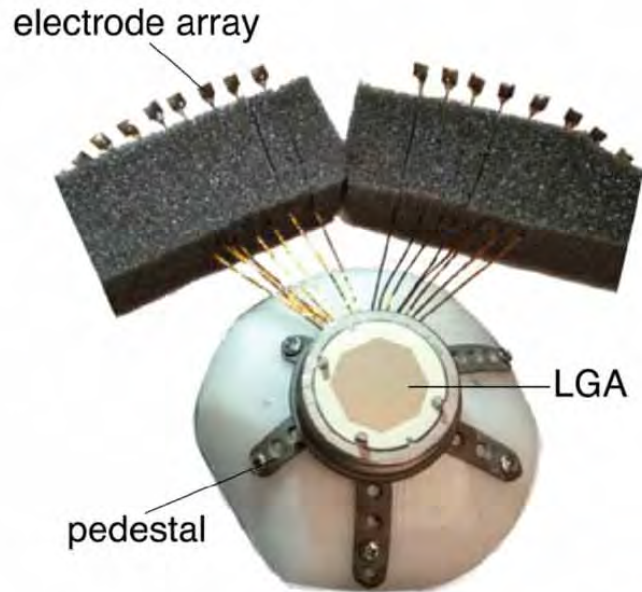
Visual cortical prosthesis to restore vision



Integrated electronics to transduce light stimuli to electrical impulses

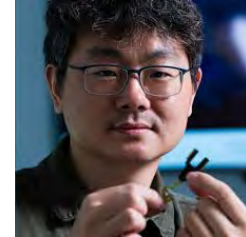


Electrical stimulation using chronic Utah arrays implanted in visual cortex



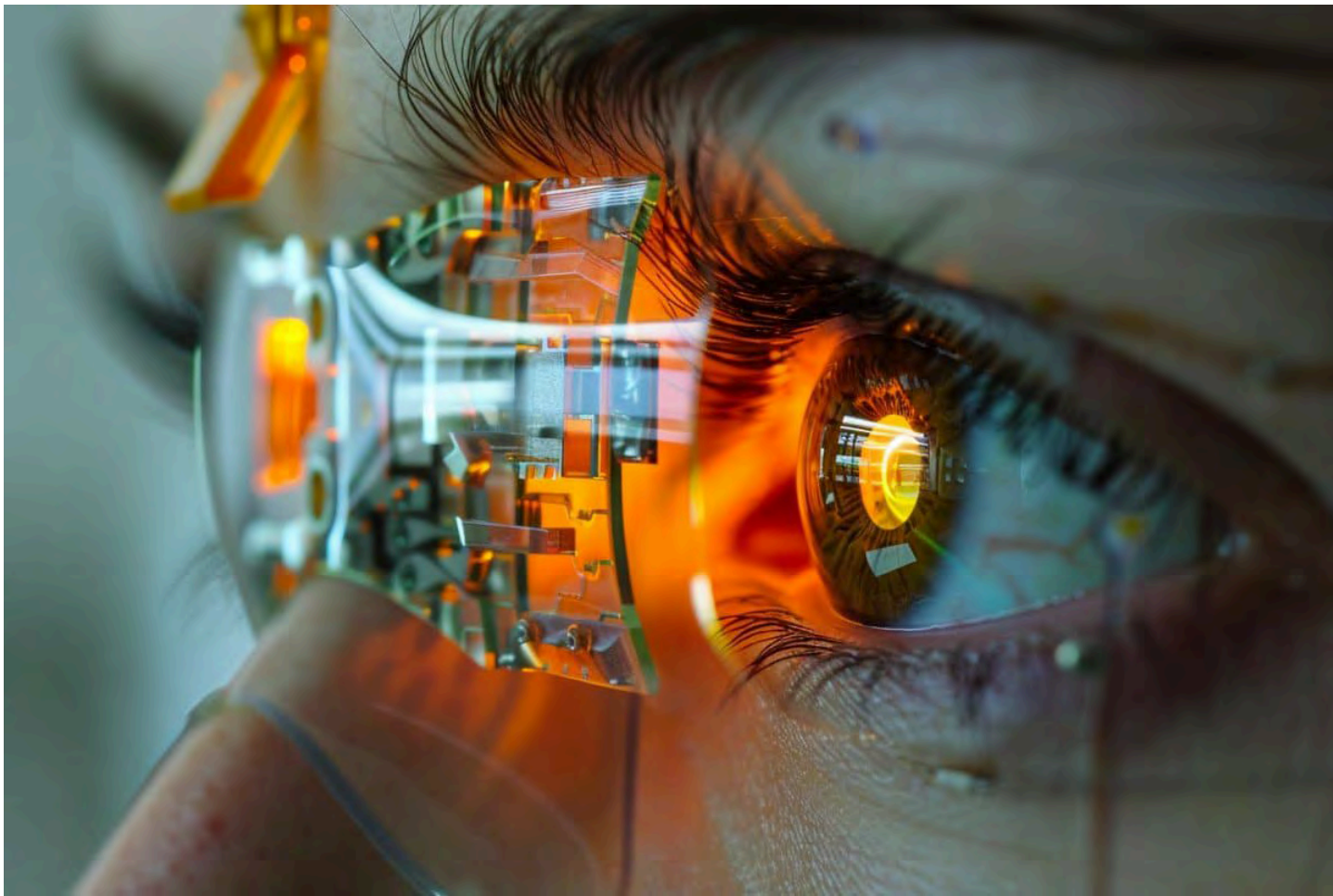
Chen et al., *J Neural Eng*, 2023

Nanoprobes: arrays of ultraflexible electrodes

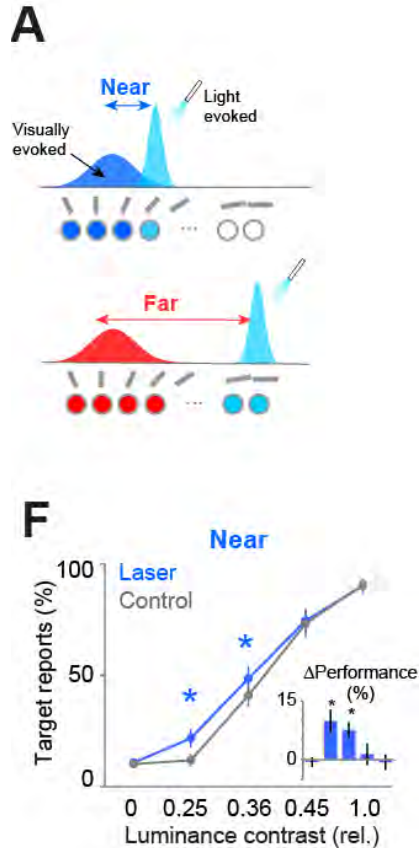


Chong Xie, Rice

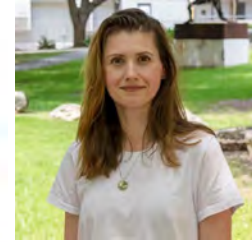
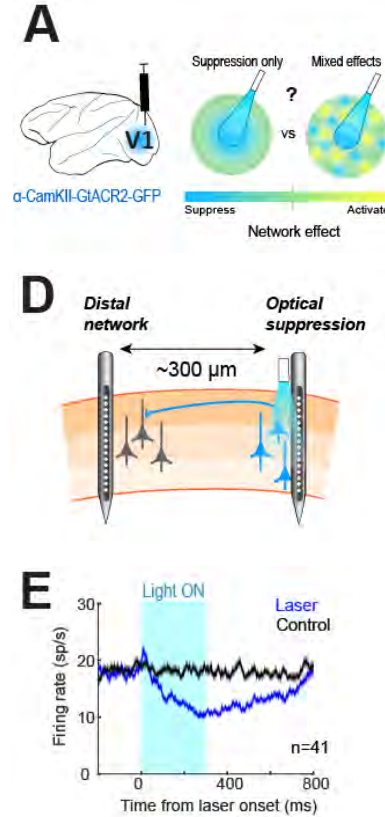
Stimulating implanted electrodes in visual cortex with weak electrical currents generates tiny points of light known as 'phosphenes'



Cortical activation



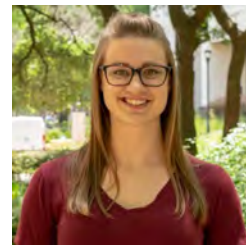
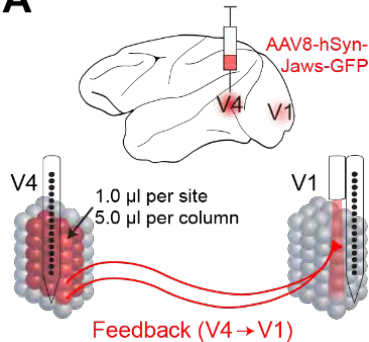
Cortical suppression



Ariana Andrei

Suppressing **feedback** signals to visual cortex abolishes **attentional** modulation

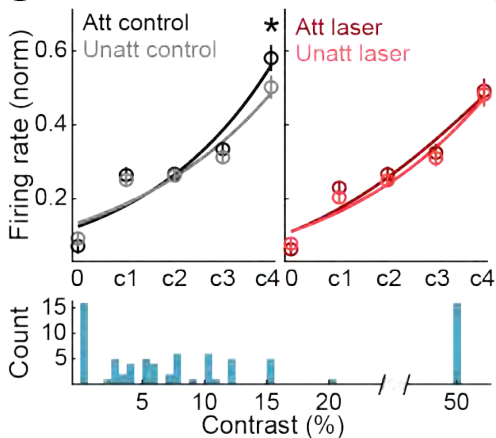
A



Sam Debes

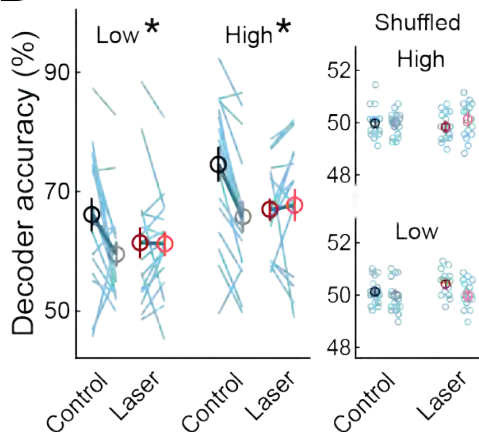
C

Single neurons

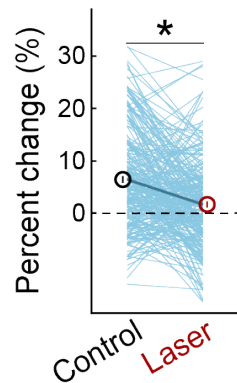


D

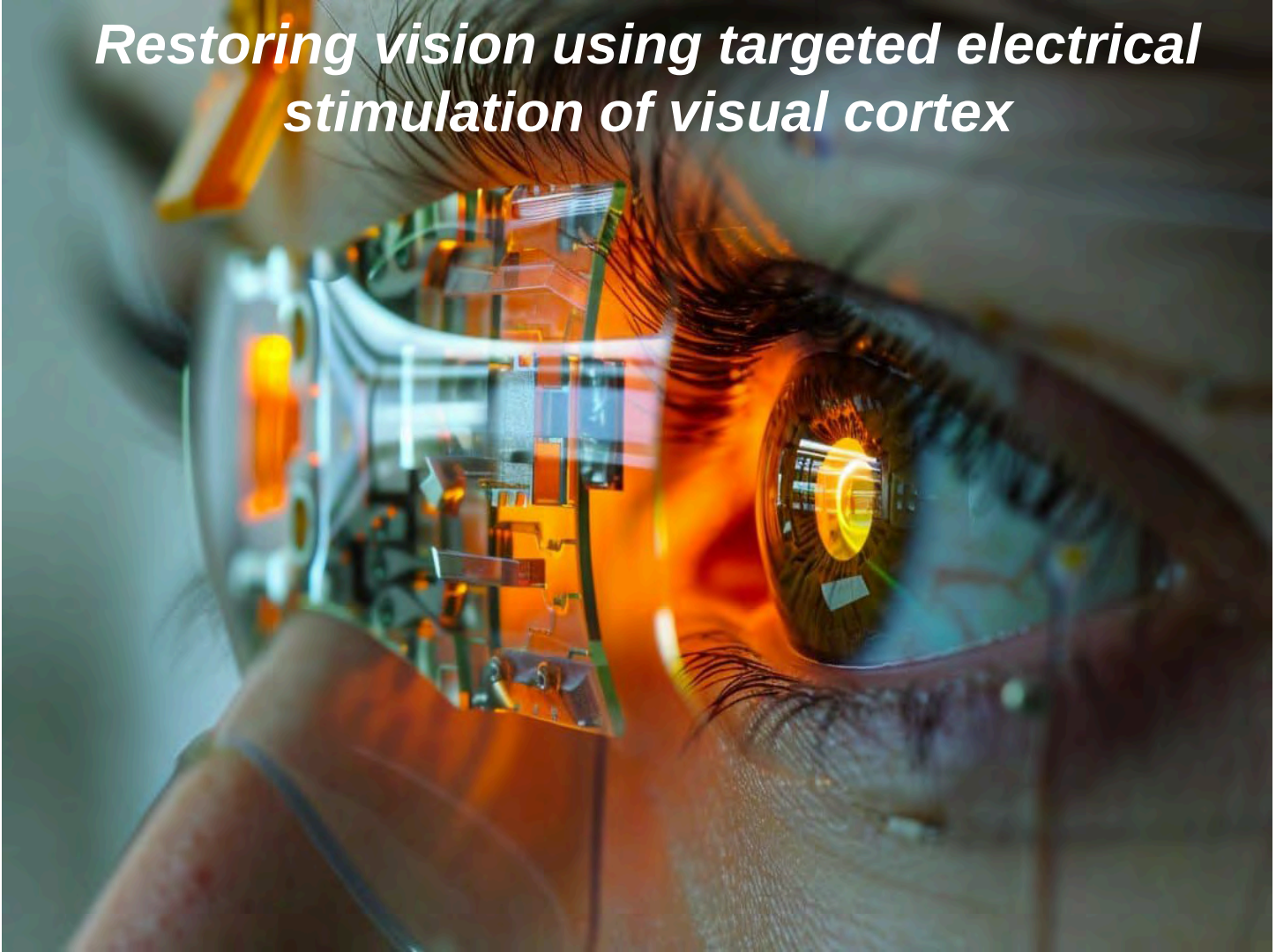
Populations



Att modulation



*Restoring vision using targeted electrical
stimulation of visual cortex*



Lab members

- Madison Shyer, Ph.D. Student
- Mitchell Slapik, Ph.D. Student
- **Ariana Andrei**, Postdoctoral Fellow
- Doris Mikulek, Research Associate
- Grace Neblett, Research Associate
- Xiaoke Niu, Ph.D. Student
- **Natasha Kharas**, M.D./Ph.D. Student
- **Melissa Franch**, Ph.D. Student
- Sorin Pojoga, Postdoctoral Fellow
- **Mircea Chelaru**, Research Scientist
- Sunny Nigam, Postdoctoral Fellow
- Anton Banta, Postdoctoral Fellow
- Alexandra McConnell, Ph.D. Student
- Sergey Egranov, M.S. Student
- Jaewhon Kim, Ph.D. Student
- Josh Bledsoe, Ph.D. Student
- **Arun Parajuli**, Research Engineer

Collaborators

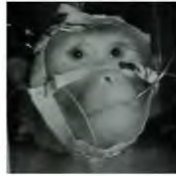
- **Neda Shahidi**, Univ. of Gottingen
- **Kresimir Josic**, Univ. of Houston
- Klaus Obermayer, Tech. Univ. Berlin
- **Gavin Britz**, Houston Methodist
- **Xaq Pitkow**, Carnegie Mellon Univ.
- **Behnaam Aazhang**, Rice Univ.
- Jacob Robinson, Rice Univ.
- Jerzy Szablowski, Rice Univ.
- Tony Wright, UT Houston
- John Spudich, UT Houston



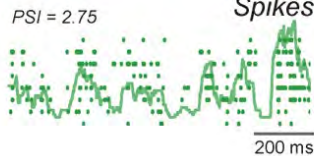
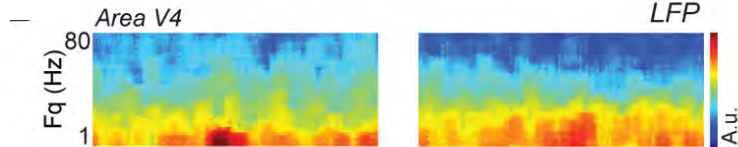
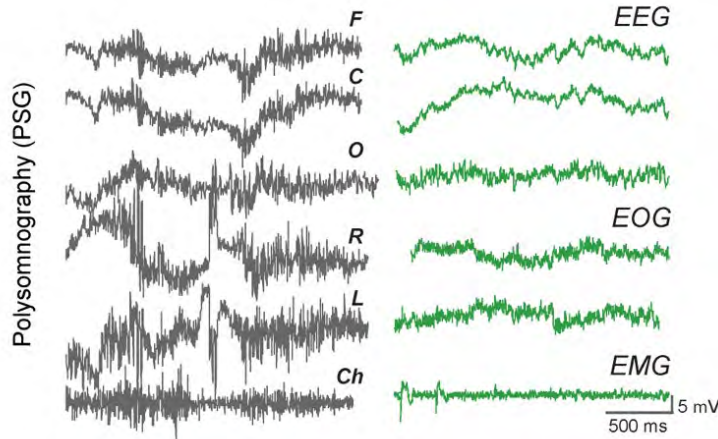
Funding

- NIH BRAIN Initiative
- NIH Director's Pioneer Award
- NIH EUREKA Award
- NEI, NIMH, NINDS
- Pew Scholars Award
- James S. McDonnell Foundation
- STAR Award (UT System)
- Endowment funds (Houston Methodist)

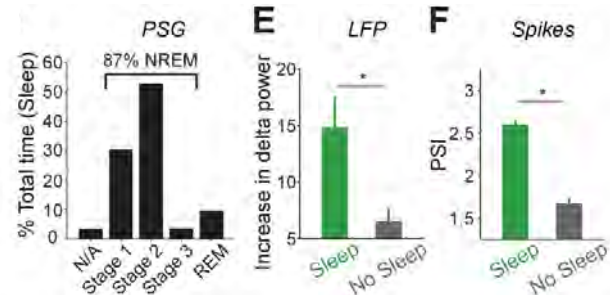
No sleep



Sleep



Why does sleep improve cognitive performance?



NREM sleep improves behavioral performance



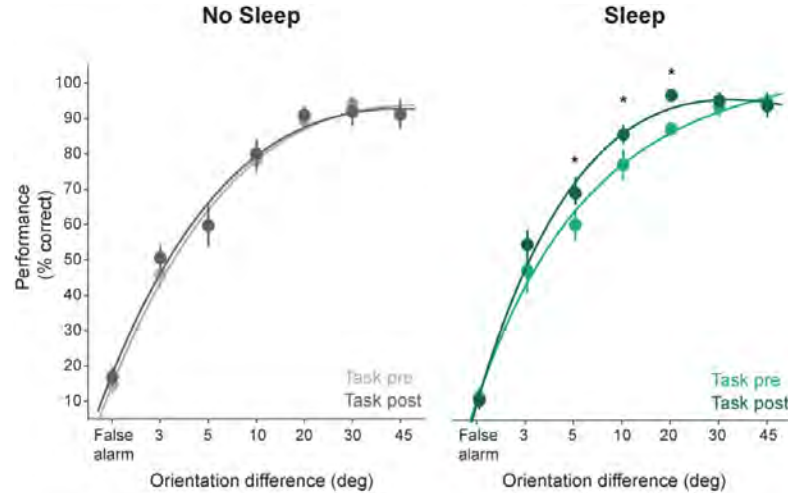
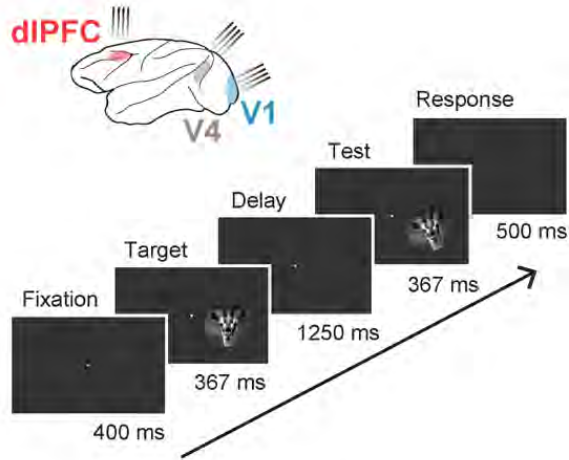
Natasha Kharas, MD/PhD

Experimental Paradigm

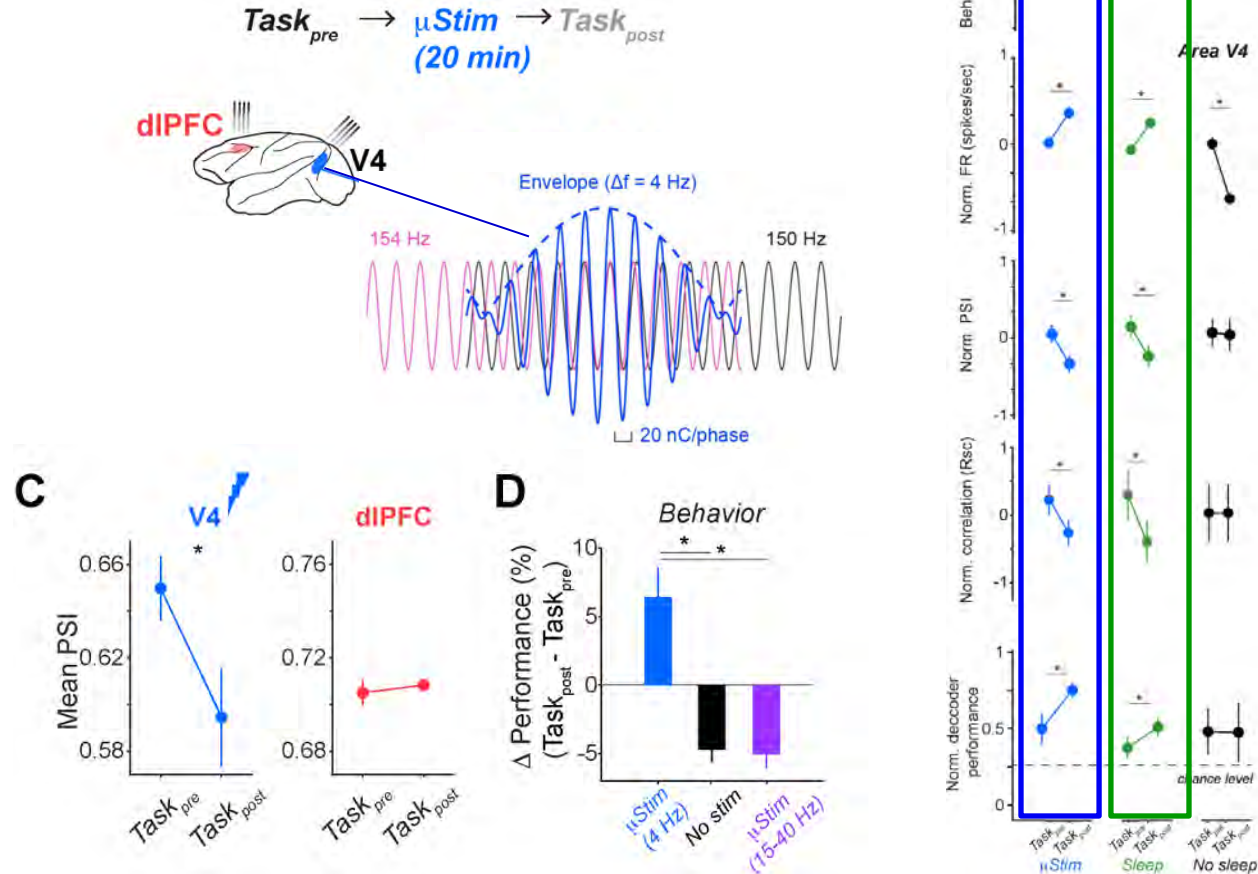
$Task_{pre} \rightarrow \text{Sleep} \rightarrow Task_{post}$

Control

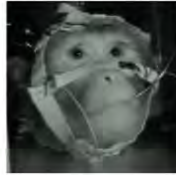
$Task_{pre} \rightarrow \text{No Sleep} \rightarrow Task_{post}$



Delta-band electrical stimulation during wakefulness emulates the beneficial effects of sleep



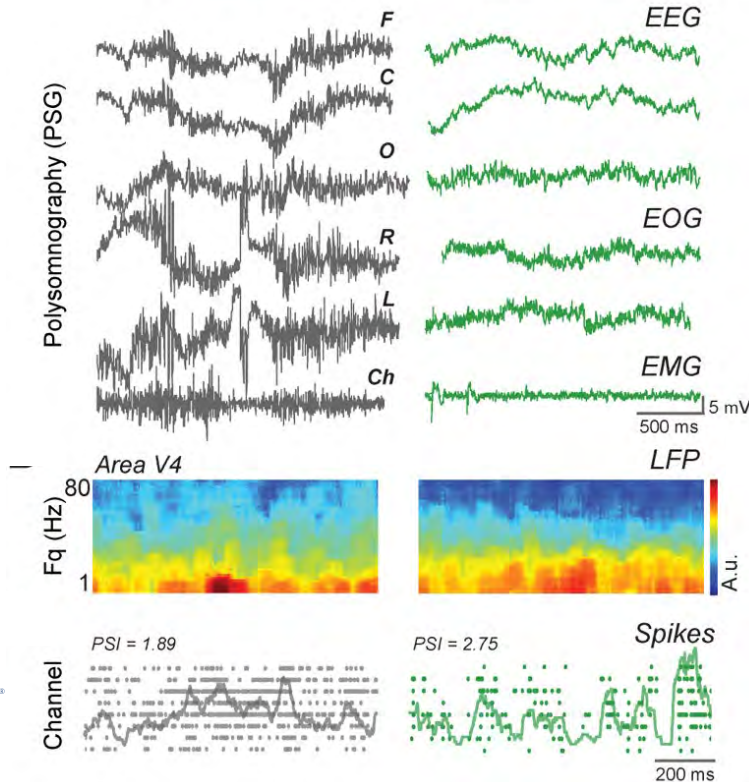
No sleep



Sleep



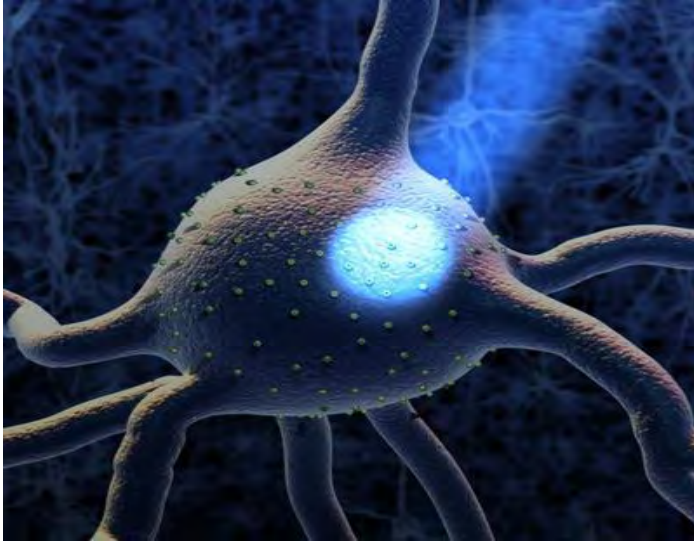
Restore brain function in humans by non- invasive electrical stimulation



Loss of mobility due to spinal cord injury



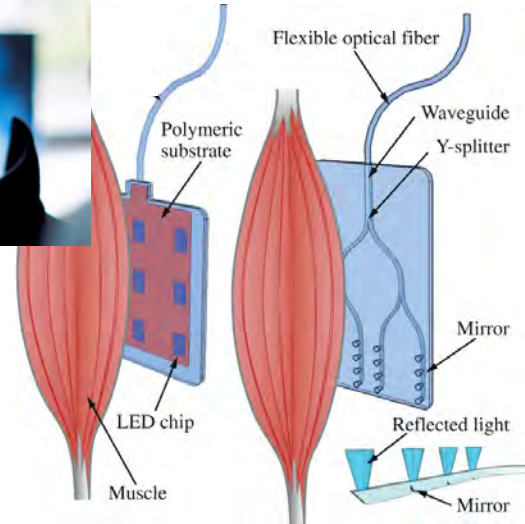
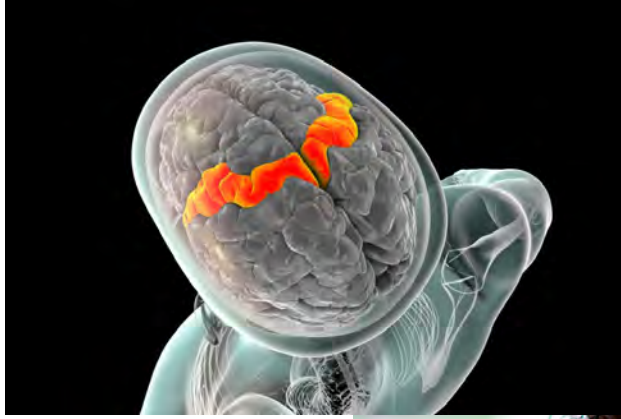
***Using light to
optogenetically activate
neurons***



***Optogenetic activation of
muscle neurons***



Closed-loop optogenetic control of muscle activity using motor cortex



Houston Methodist Update

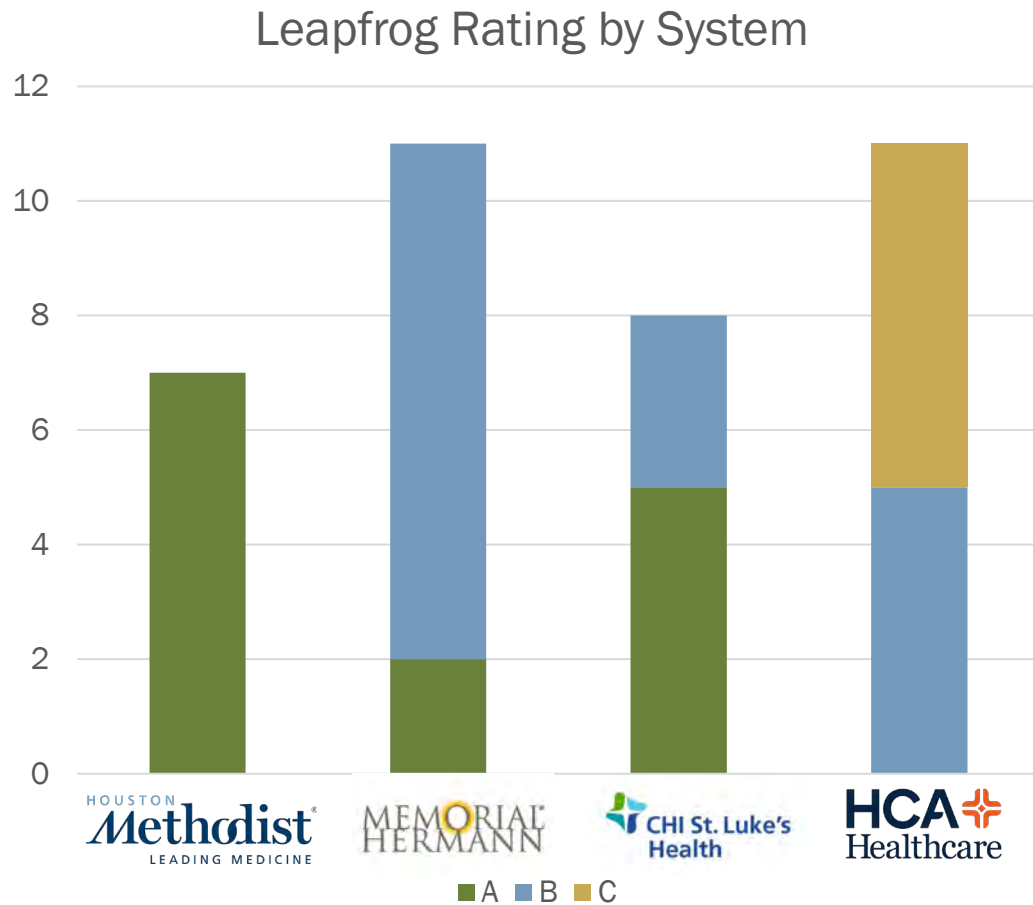
Marc L. Boom, MD

September 10, 2025

Leapfrog Hospital Safety Grade Trend

	Spring '12	Fall '12	Spring '13	Fall '13	Spring '14	Fall '14	Spring '15	Fall '15	Spring '16	Fall '16	Spring '17	Fall '17	Spring '18	Fall '18	Spring '19	Fall '19	Spring '20	Fall '20	Spring '21	Fall '21	Spring '22	Fall '22	Spring '23	Fall '23	Spring '24	Fall '24	SPRING '25
HMH	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
HMB	B	A	A	A	A	A	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
HMCL	B	B	A	A	C	C	C	C	C	C	B	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A
HMSL	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
HMTW																A	A	A	A	A	A	A	A	A	A	A	A
HMWB	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
HMW			A	B	B	A	A	A	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Leapfrog Houston Comparison



Excellence in Patient Care & Safety

Houston Methodist Hospital is recognized by *U.S. News & World Report* as

NO. 1 IN TEXAS and TOP-RANKED IN THE NATION

33

Years ranking in at least one specialty

7

Consecutive years on the Honor Roll

14

Years as the best hospital in Texas



Nationally Ranked in 10 Specialties



#19↑



#10↓



#7



#19↓



#14↑



#15↓



#10↑



#24↓



#8**



#27↓

Network Hospitals Nationally Ranked in 3 Specialties

Willowbrook



#45

The Woodlands



#47



#47**

Centennial Tower Topping Out



THANK YOU FOR ATTENDING OUR **TOWN HALL CONVERSATION**

For more information about Neurosurgery and Neurorestoration at Houston Methodist, please contact **foundation@houstonmethodist.org**

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