MASSACHUSETTS GENERAL HOSPITAL
NEUROSCIENCE

# BrainGate: Clinical Trials Toward Restoring Communication, Mobility, and Independence for People with Paralysis

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# Disclosures

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ALS Association
American Heart Association
Movement Disorder Foundation (Australia)
Cerebral Palsy Alliance Research Foundation
Wyss Center for Bio- and Neuroengineering (wireless device development)

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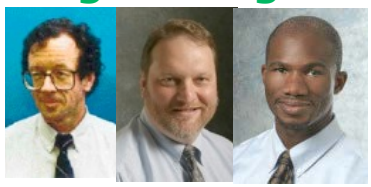
# Inter/multi/cross-disciplinary Research Team

## Engineering



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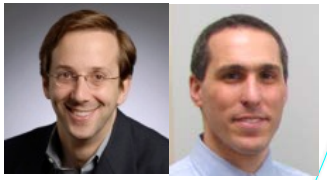
## Systems Engineering

John Simeral

## Neurology



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## Neuroscience

John Donoghue,
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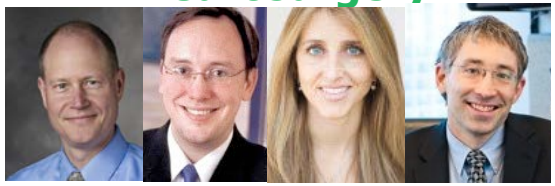
## Program Manager

David Rosler

## Neurosurgery



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Ben Walter
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Frank Willett
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Daniel Young

www.braingate.org

# BrainGate: Simple goals (mission statements)

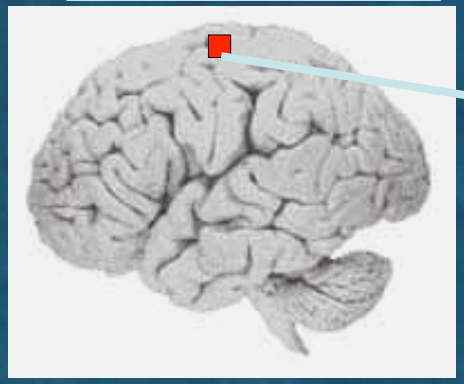
Spinal cord injury/Stroke: You will be able to move again, *tomorrow.*

Brainstem stroke/LIS: You will communicate easily again, *tomorrow*.

ALS: You will *never* lose the ability to communicate.

# BCI / Neural Interface System: Design Concepts

## Neural Sensor



**Movement Intention**

*What signal?*
*What area?*
*What sensor?*

## Decoder

Select the Decoder

$$\mathbf{v}_t = A\mathbf{c}_t$$

Hand motion

Firing rate vector

Understand the Encoding

**Action**

*What technology?*

## (Assistive) Technologies

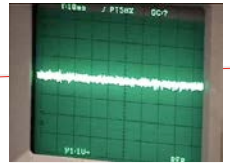
| | |
|---|---|
| Typing | Wheelchairs |
| Internet | Semiautonomous robots |
| Speech | Prosthetic / Robotic limbs |
| SmartHome | Functional Electrical Stimulation |

Adjunct to Neurorehabilitation / Neural Repair

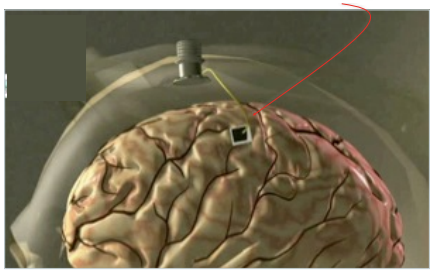
Closed-Loop Neuromodulation

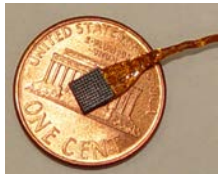
Hochberg and Donoghue (2006), IEEE EMB

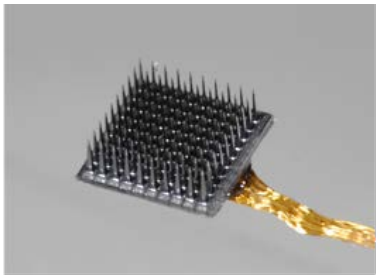
# BrainGate Pilot Clinical Trials



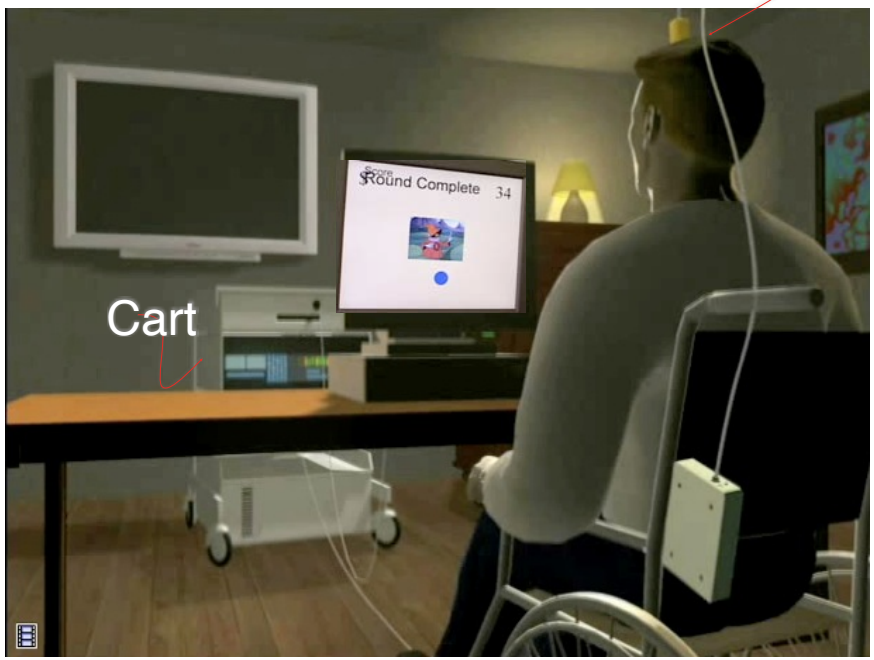
*(spikes, MUA, LFP)*







100 Microelectrode array




*NHP proofs of concept:*

Serruya, M., et al. (2002). Nature 416: 141-142.
Taylor, D.M. et al. (2002). Science 296.
Carmena, J.M., et al. (2003). PLOS 1(2):1-16.
Musallam, S. et al. (2004). Science 305: 258-263.
Santhanam, G., et al. (2006) Nature 442: 195-98.

BrainGate (14)
+ U.Pitt (3)
+ Caltech (5)
+ OSU (1)
+ Hopkins (1)

+ San Sebastian (1)
+ China (1+)
+ Germany (1)
+ Philadelphia (1)

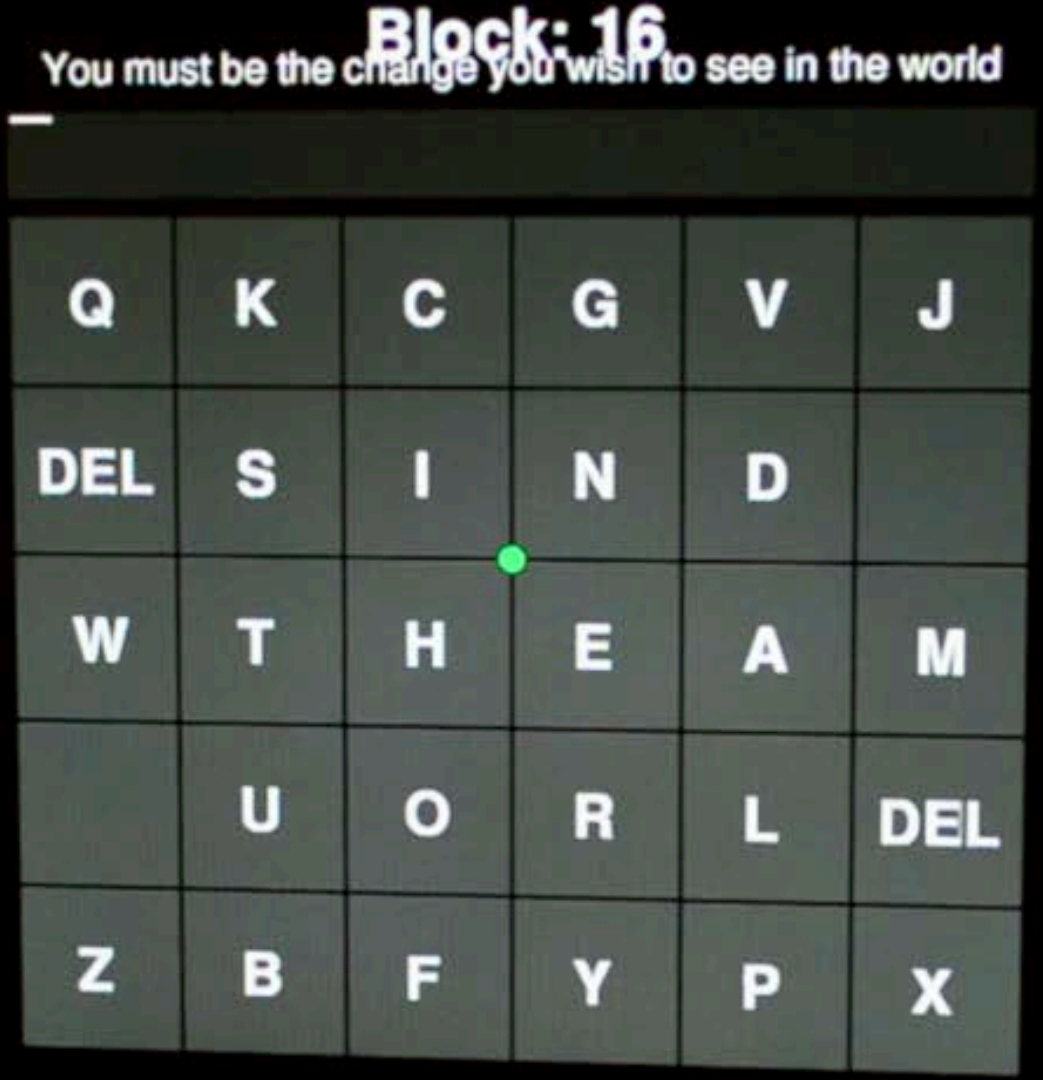
+ Utrecht (2)
+ UCSF (2)
+ Melbourne (2)

# Feasibility Study of the BrainGate Neural Interface System

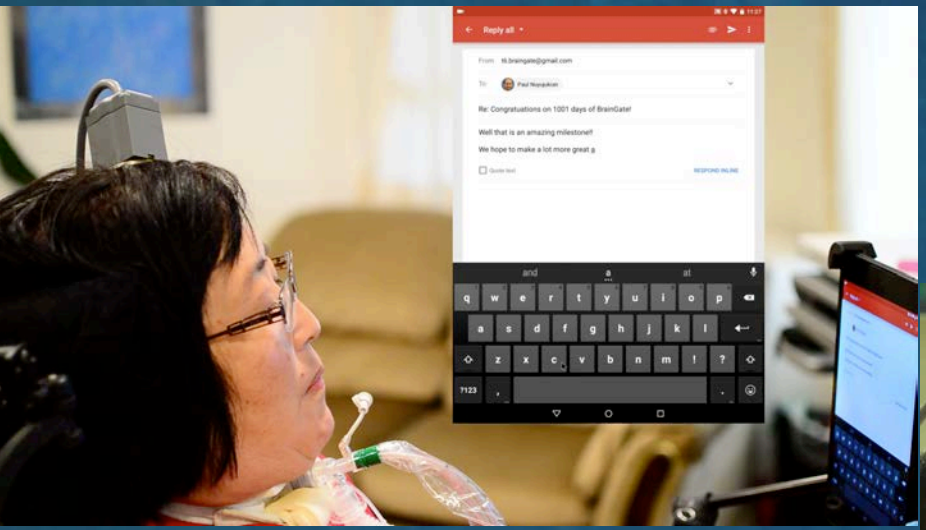
- Participants must have limited use of their hands due to spinal cord injury, stroke, muscular dystrophy, or motor neuron disease (ALS, PMA, adult-onset SMA)
- 18-75 years old; >1 year from injury; able to communicate; otherwise healthy; live within 3 hours of the study site.
- Recording and neural control trials occur in the participant's place of residence.
- **Recruiting:** Boston/Providence, Cleveland, Palo Alto. clinicaltrials.gov/ct2/show/NCT00912041

>39 correct characters per minute, *without* word prediction

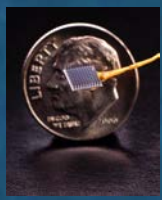
~10x faster than best EEG-BCI for people with paralysis (2017)

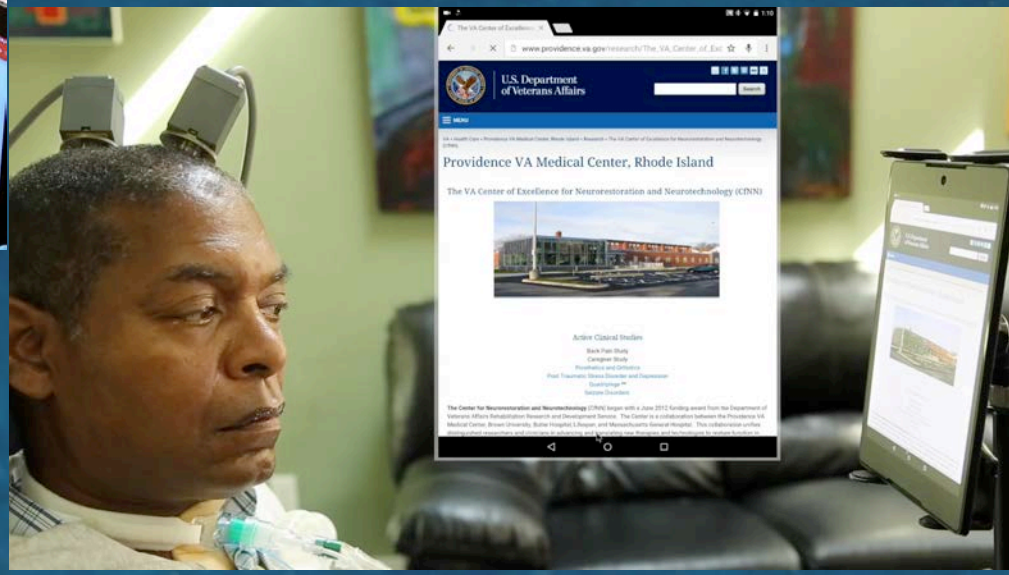


# BrainGate-enabled tablet computer control by people with ALS



Nuyujukian, Albites-Sanabria, *et al, PLOS ONE* 2018






VA, NIDCD, NINDS

Restoration of reaching and grasping movements through brain-controlled muscle stimulation in a person with tetraplegia
Ajiboye, *et al.*, Lancet 2017

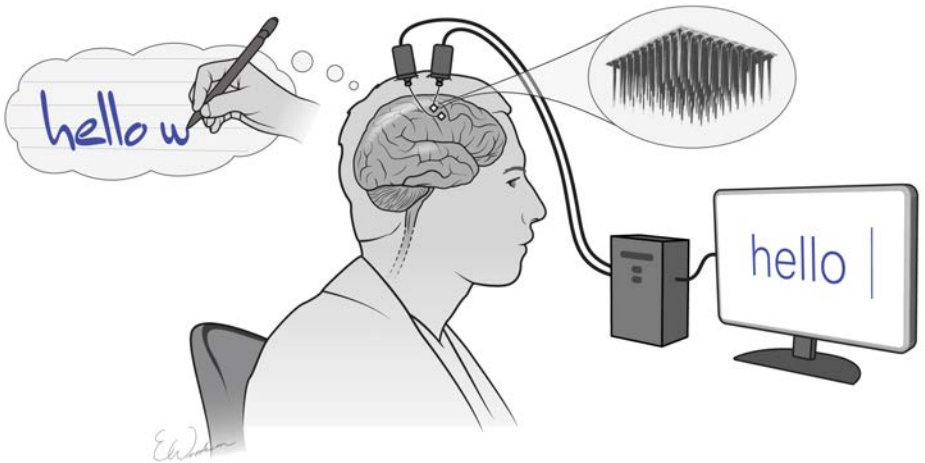
# Functional Self-Feeding Task

BrainGate Pilot Clinical Trial, Participant T8
Trial Day 392


Caution: Investigational device. Limited by federal law to investigational use.

# Handwriting decoding from motor cortex (Participant T5; C4 AIS-C)

HHMI, Nature





Willett, Avansino, Hochberg, Henderson, Shenoy, Nature 2021

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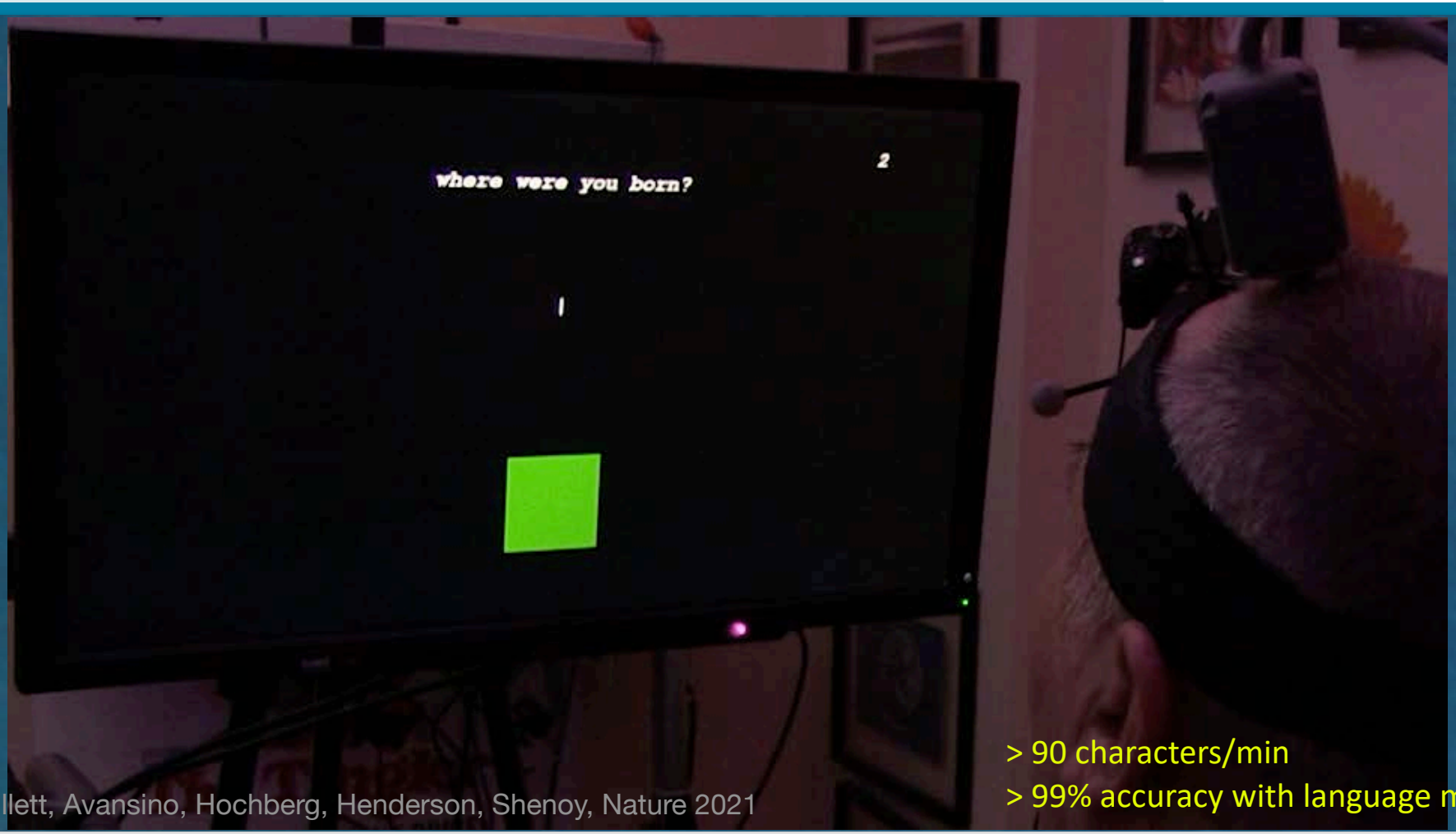
# Brain-to-text handwriting by a person with tetraplegia




> 90 characters/min
> 99% accuracy with language model

Willett, Avansino, Hochberg, Henderson, Shenoy, Nature 2021

# First-in-human: Broadband intracortical wireless recording


Simeral et al, IEEE TBME 2021

# BrainGate/BCI Opportunities in Neurorehabilitation

- ✓ Neuroengineering and Neuroscience: intuitive, lasts a decade+, invisible, 24/7, seamless control of multiple effectors, available
- ✓ Communication: tablet control, handwriting, speech
- ✓ Restoring mobility: assistive robotics, FES
- ✓ SCI and stroke *rehabilitation*
- ✓ Closed-loop neuromod for movement & mood disorders, epilepsy
- ✓ Expanded populations

# Thank you!

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