h2.o

new minds, new bodies, new identities

A One-Day Symposium
May 9, 2007
at MIT's Kresge Auditorium
8:30 am - 4:30 pm

MIT Media Lab

Neural Interfaces

John Donoghue
Brown University,
Providence, RI, USA
NINDS Javits Investigator

CONFLICT OF INTEREST:
Co-founder Cyberkinetics Neurotechnology Systems,Inc.
JD is a consultant, stockholder and director of CKI,
makers of BrainGate technology to be discussed.

Brown University

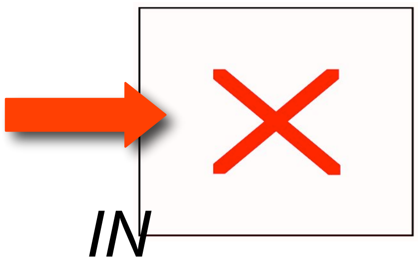
Age of Neurotechnology

•*Neural Interfaces*: Devices coupled to the nervous systems to *diagnose* and *treat* nervous system disorders and to **restore lost function**: paralysis, blindness, deafness…

…..epilepsy, depression…..

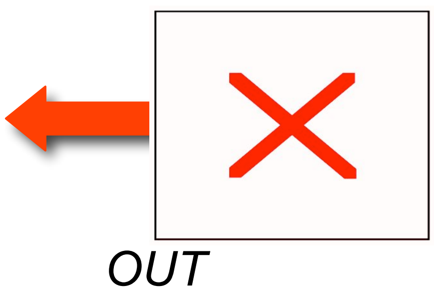
Neurotechnology

Current and Developing Neural Interfaces



Electrical stimulation

- Restore lost sensory function
- Therapy



Sensing

- Restore movement
- Evaluation (diagnosis)

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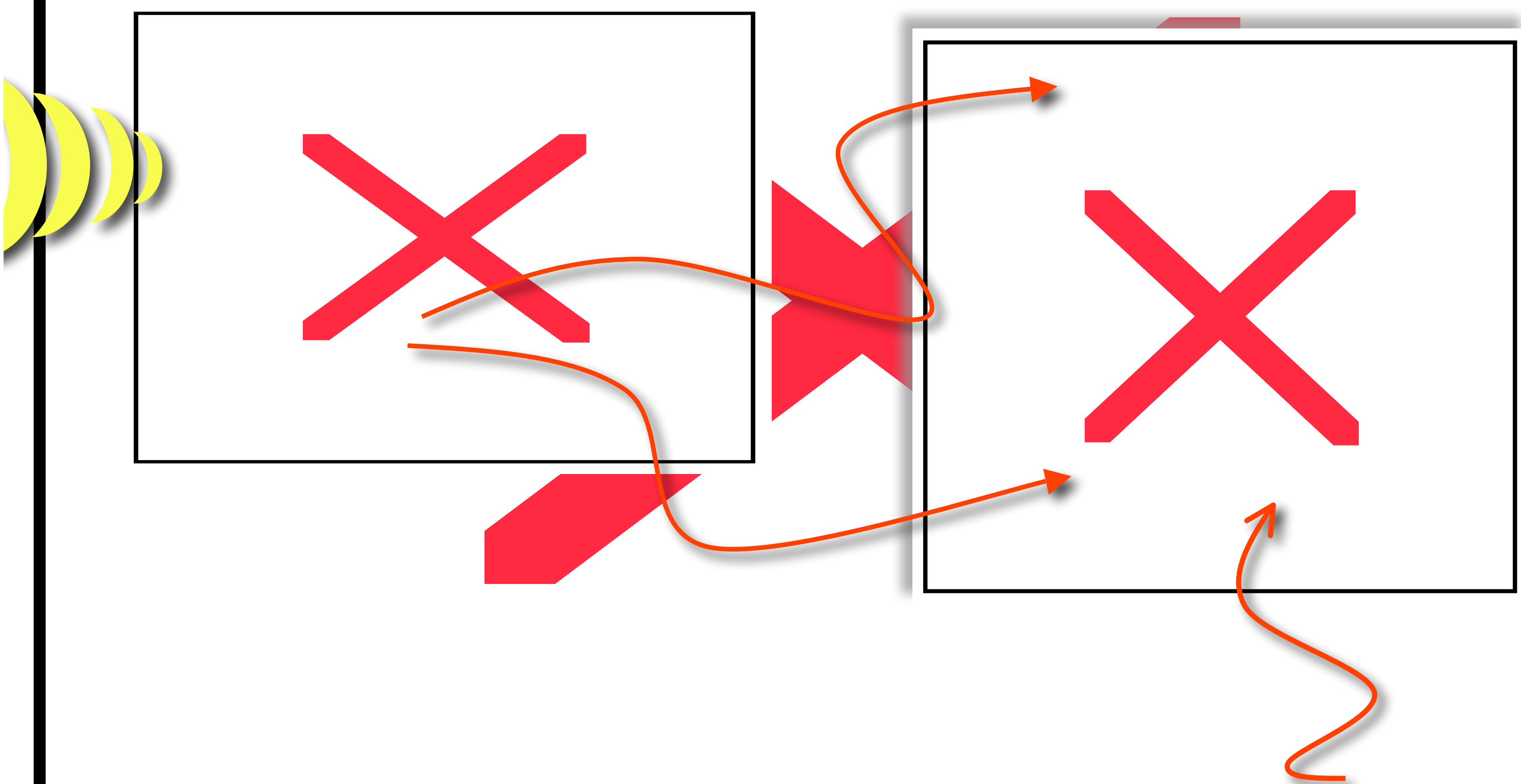

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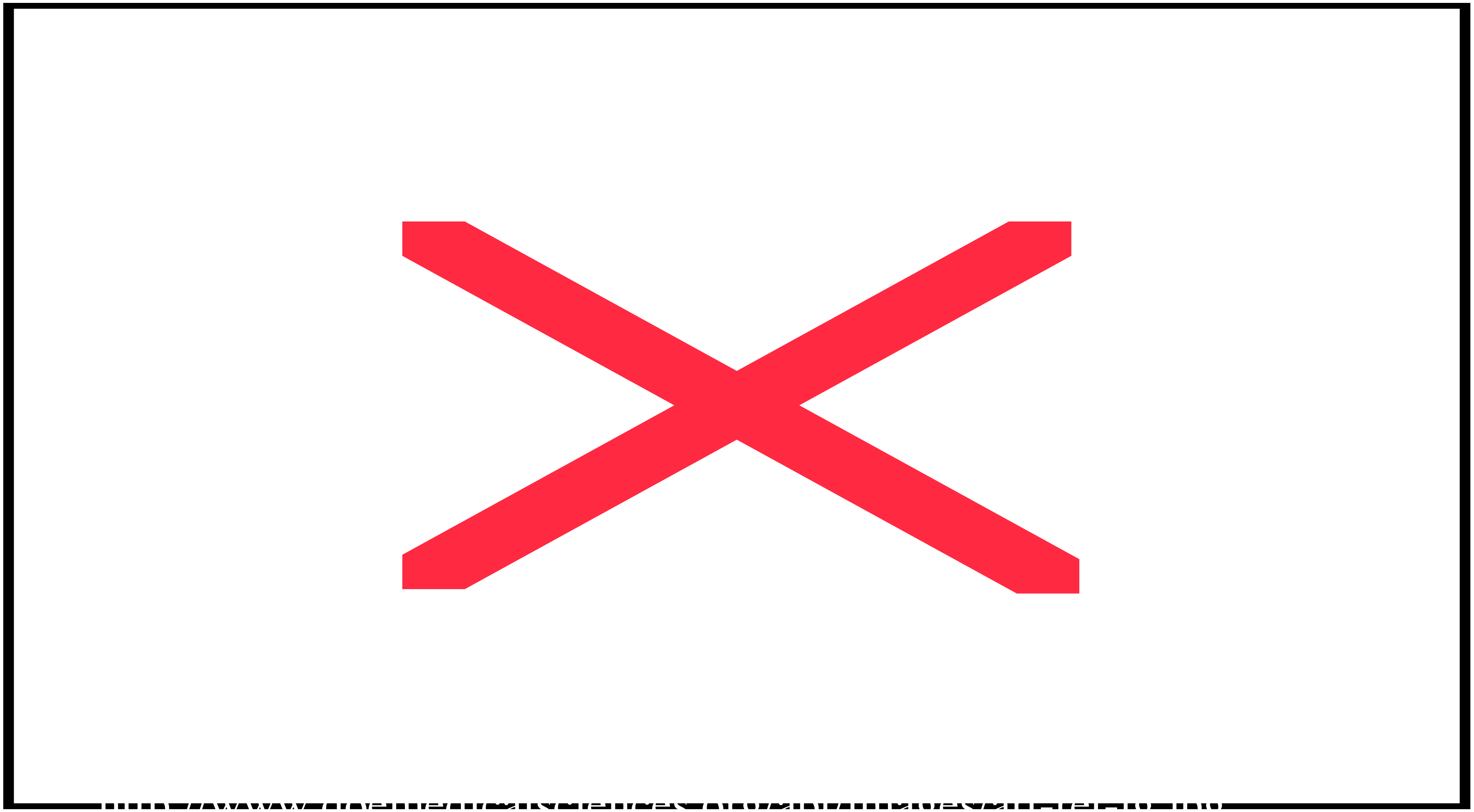
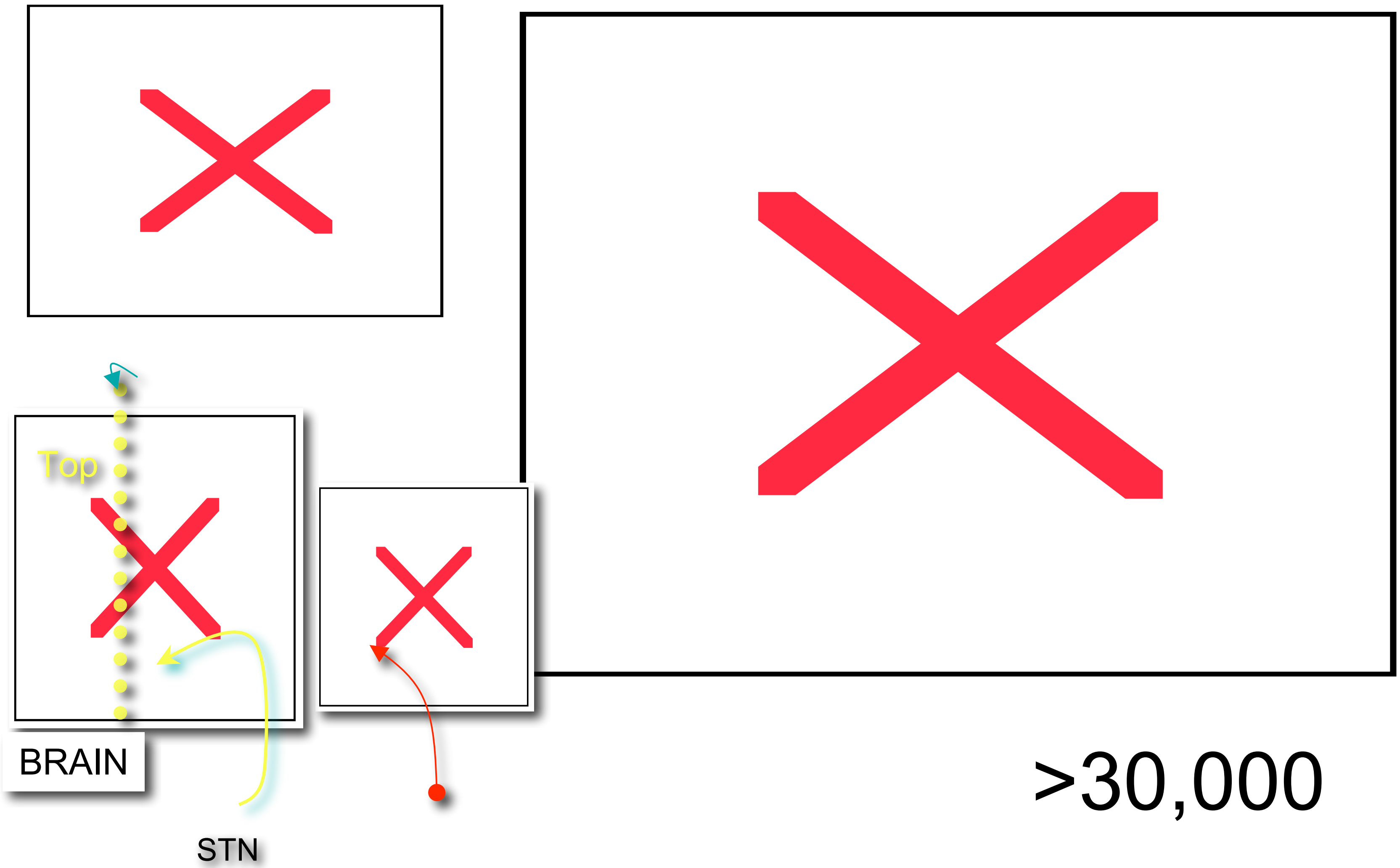
Retinal Vision Implant (N~6)



5

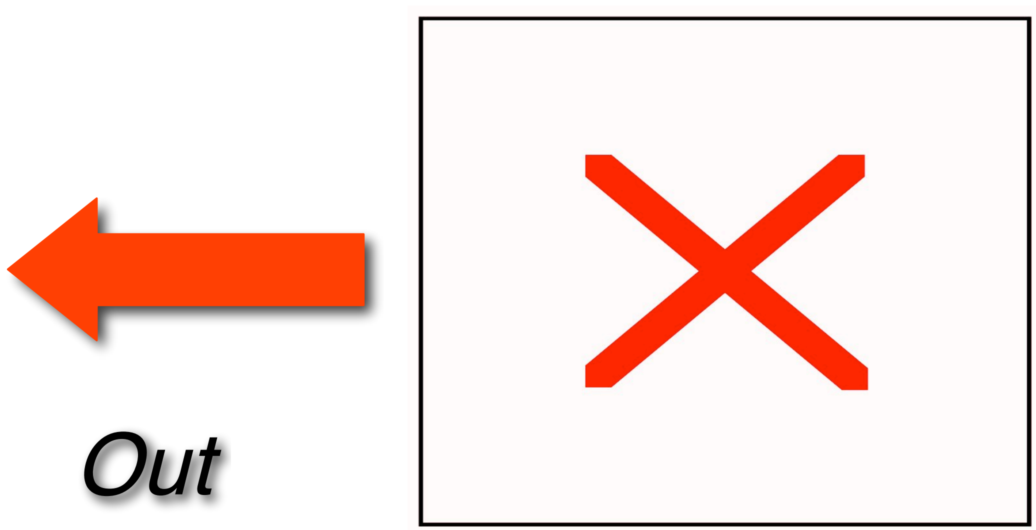
Deep Brain Stimulation (DBS) for Movement Disorders



>30,000

Neurotechnology

Neural Interfaces to ‘read out’ brain electrical signals



Neural Sensing (what's going on in there?)

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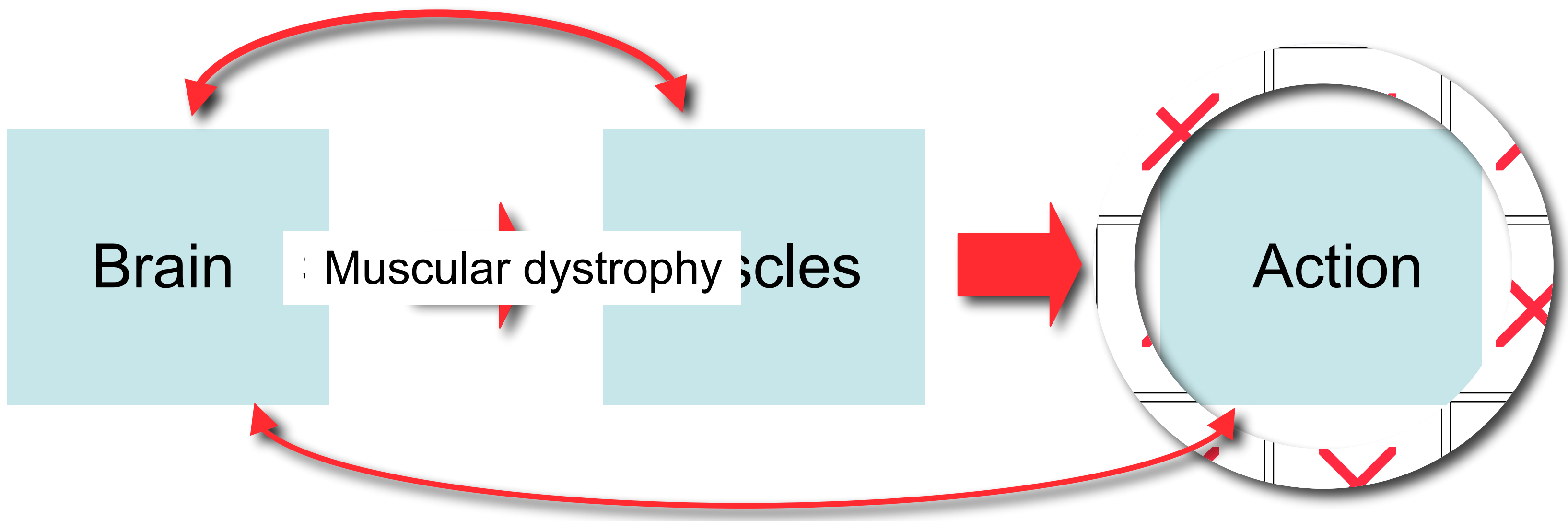
Neural Interface System: *Sensing*

He-man

Movie/game thanks to M.Serruya, A. Caplan, D. Morris

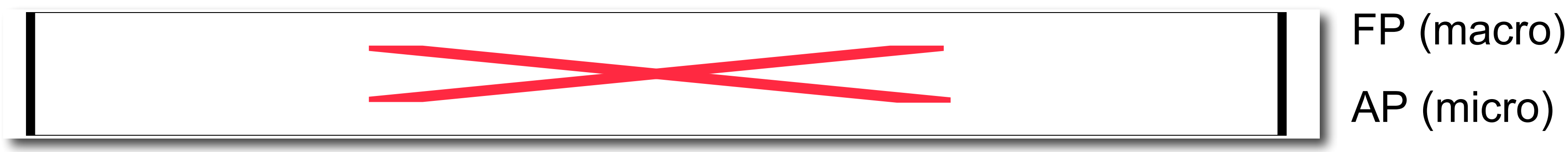
Neural Interface System



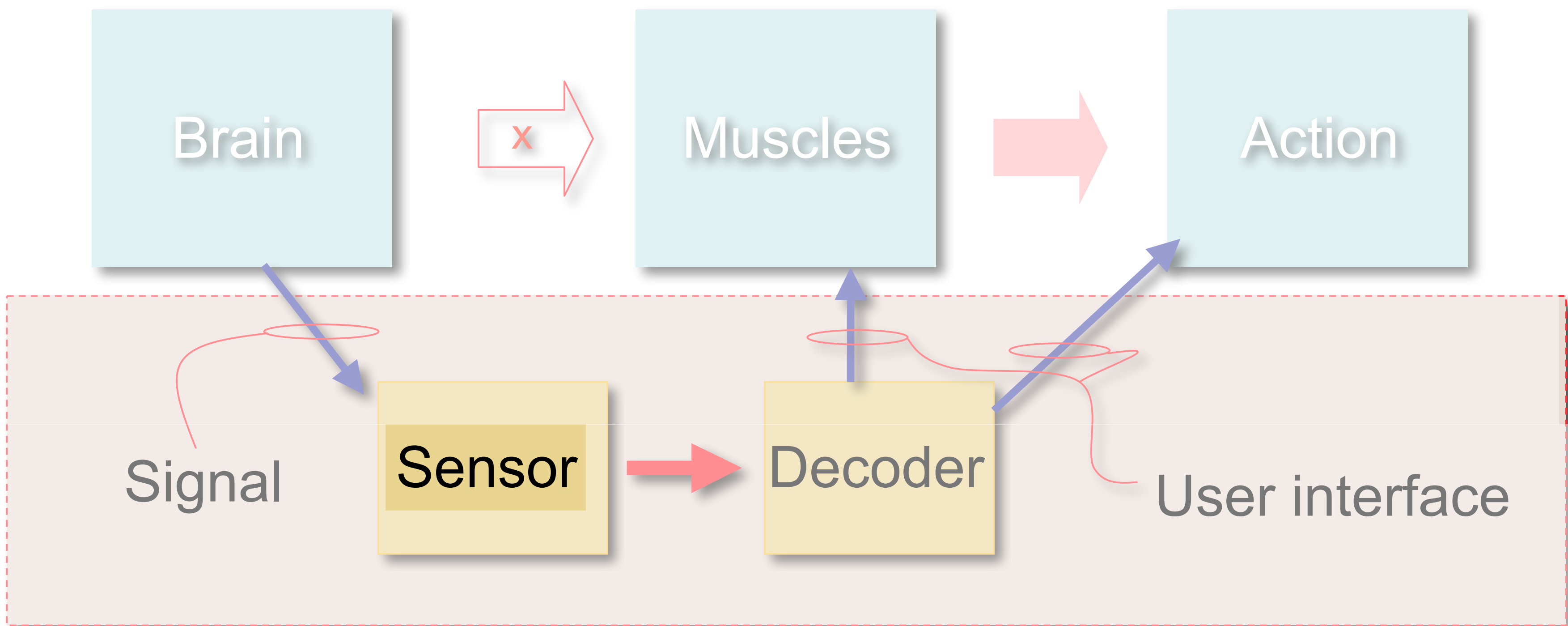
= { Brain Computer Interface (BCI)
Brain Machine Interface (BMI)
Neuromotor Prosthesis (NMP) }

- Computer
- Assistive technology
- Robot
- Artificial Limb
- Muscles

Neural Interface System



Field Potentials (FP, state)
Action Potentials (AP, 'spikes' code)
} Neural electrical potentials



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BrainGate Human Neural Interface System

Cyberkinetics
Neurotechnology Systems, Inc.

IDE pilot trial: 4 tetraplegic humans (2 SCI, 1 Brainstem Stroke, 1 ALS)

- *Sensor Implant*

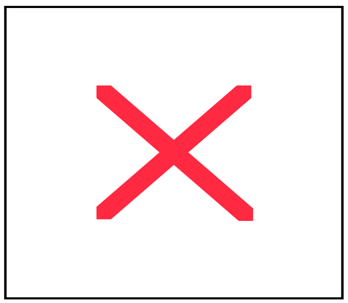
Action Potentials

Amp

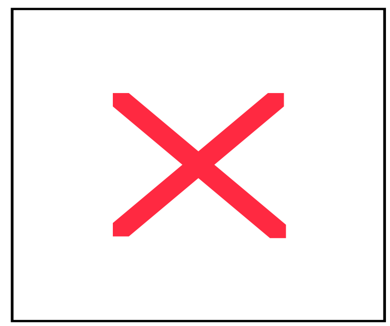
100 microelectrode array
4 x 4 mm 1-1.5 mm long

BrainGate Neural Interface System

- Signals remain in Motor Cortex years after Injury
- Modulated by intention to move the arm (no learning)



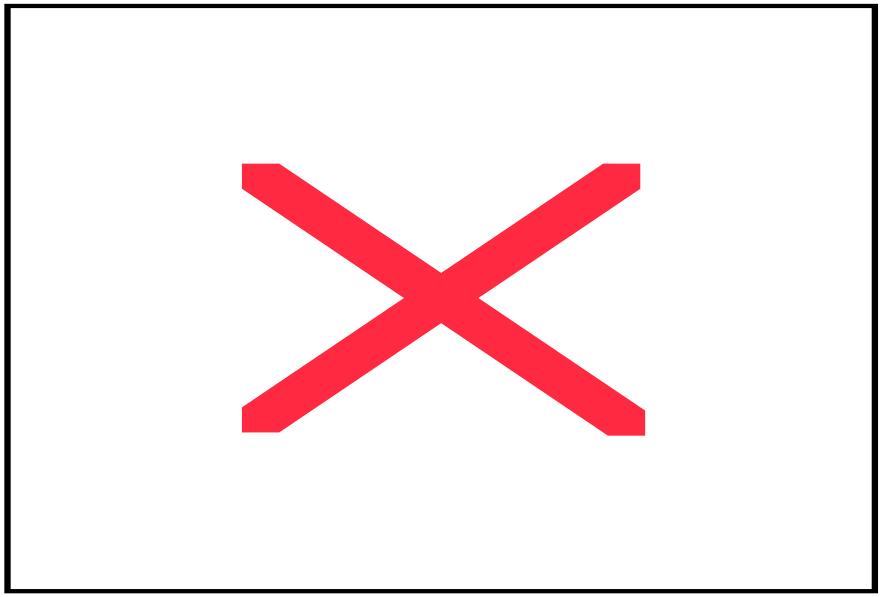
SPIKE



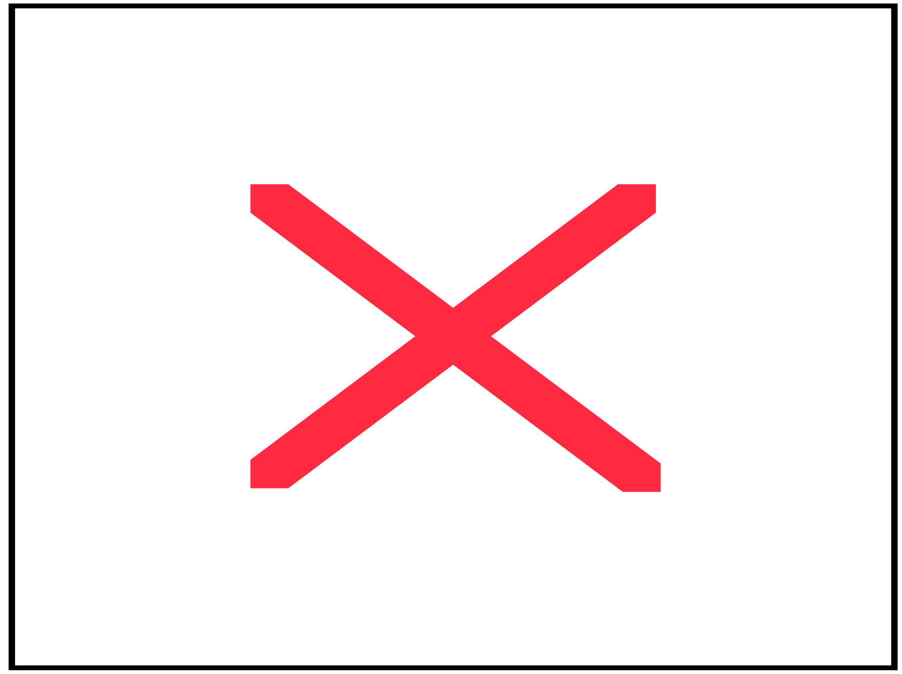
RATE METER

BrainGate User Interface: Functionality

Cyberkinetics
Neurotechnology Systems, Inc.



Early Test of Control
S1 Spinal Cord
1 year post injury



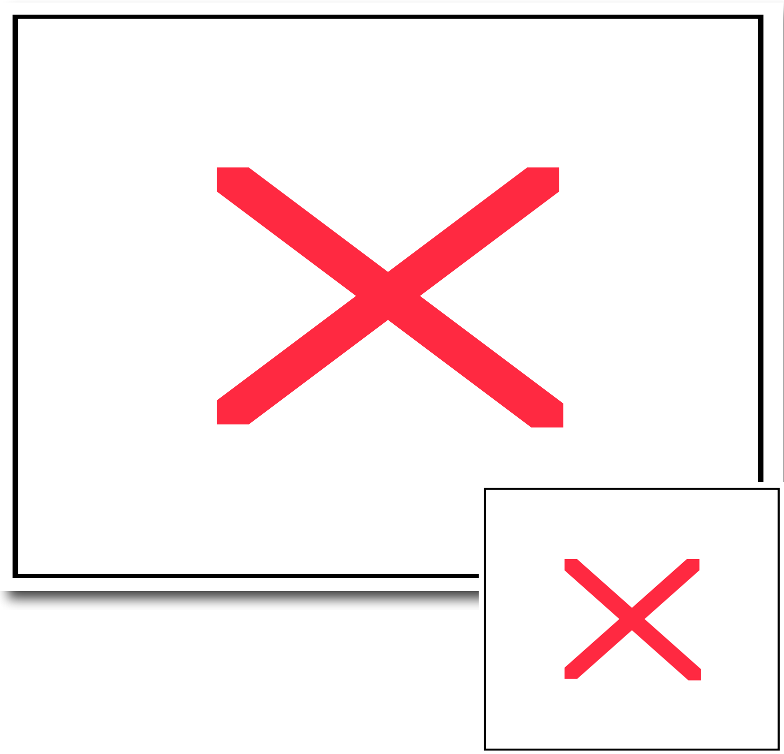
Control Now:
Point and click decoding
Black, Kim, Simeral et al., Brown U.
S3 > 9 years post stroke

See: Hochberg et al., (2006)
Nature, 442, 164-171 (13 July 2006)

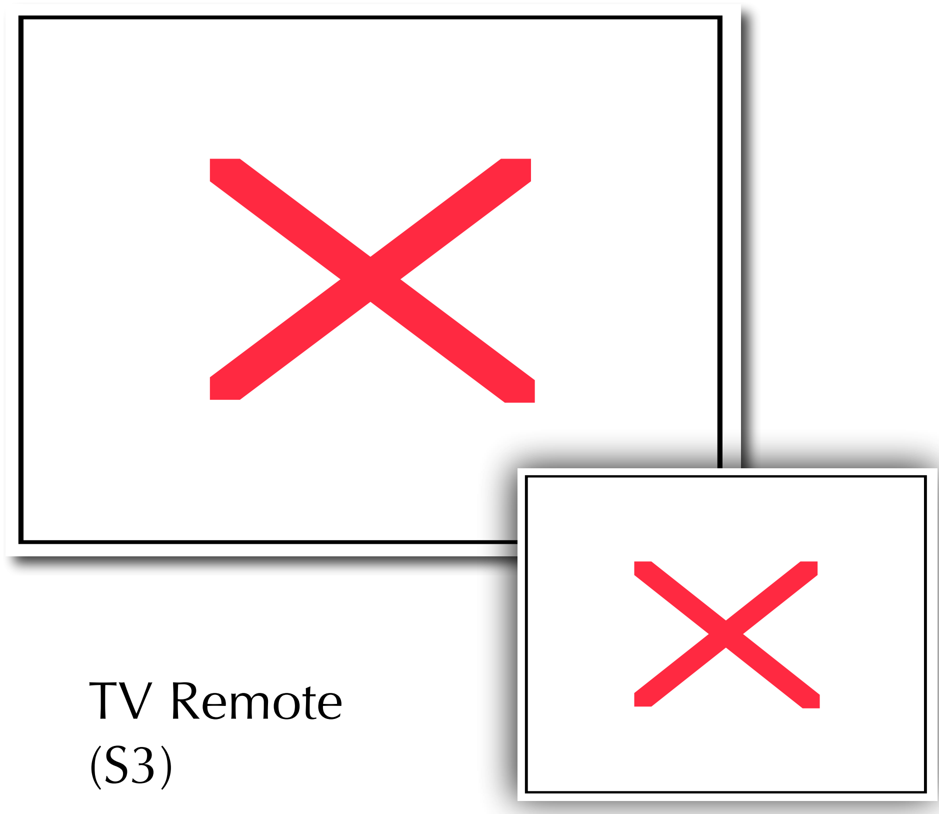
Nature Neural Interface WEBSITE:
http://www.nature.com/nature/journal/v442/n7099/index

User Interface: Demonstrations

Cyberkinetics Neurotechnology Systems, Inc.

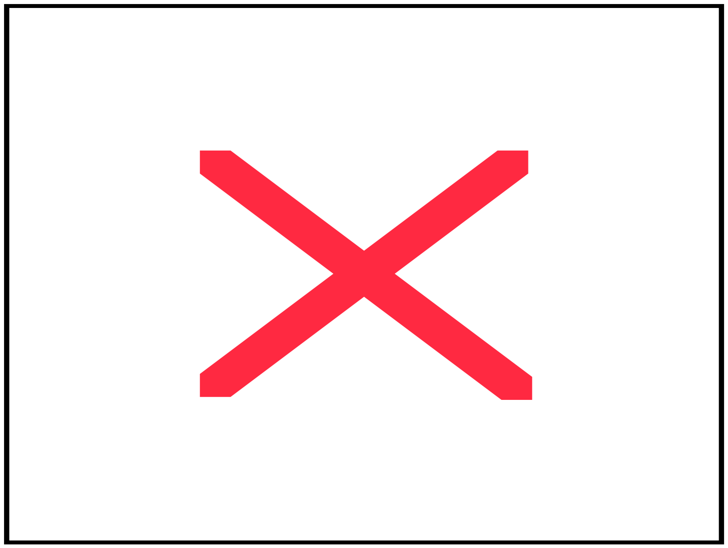


Point and Click Typing

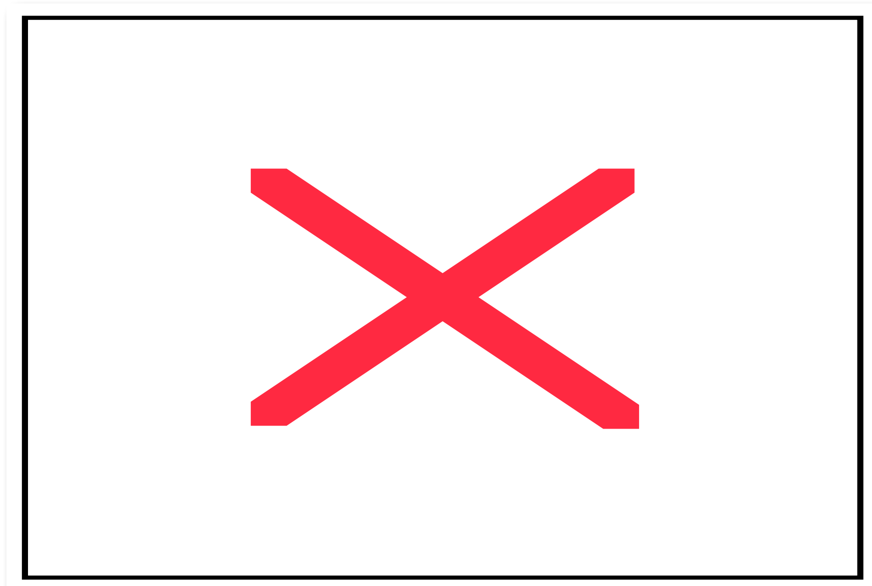


TV Remote (S3)

User Interface: Physical Devices

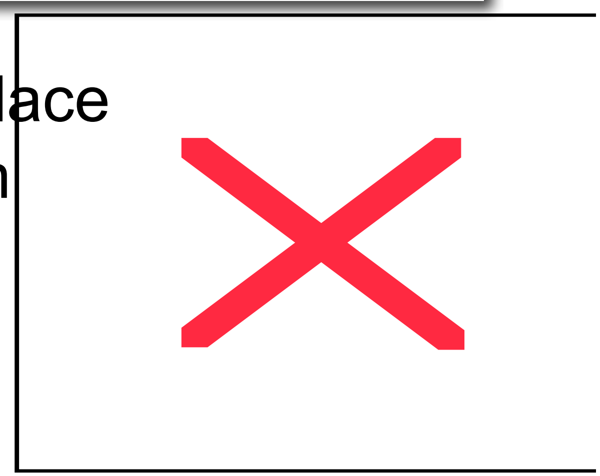


Robotic Hand
(S1 >1 year after SCI injruy)



Pick and Place
Robot Arm

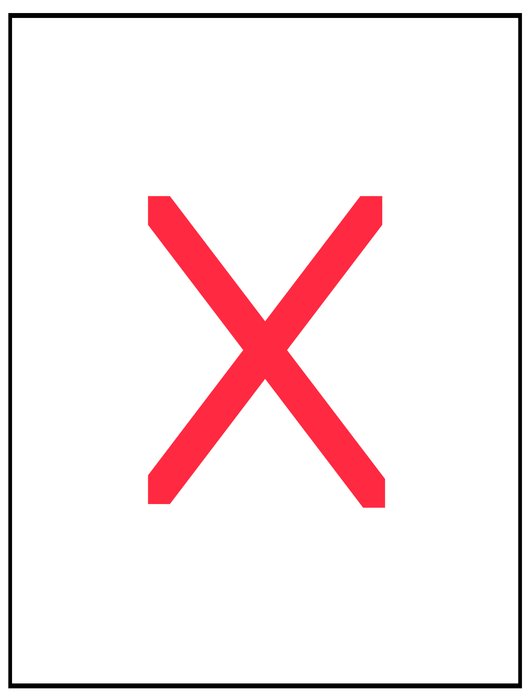
S1



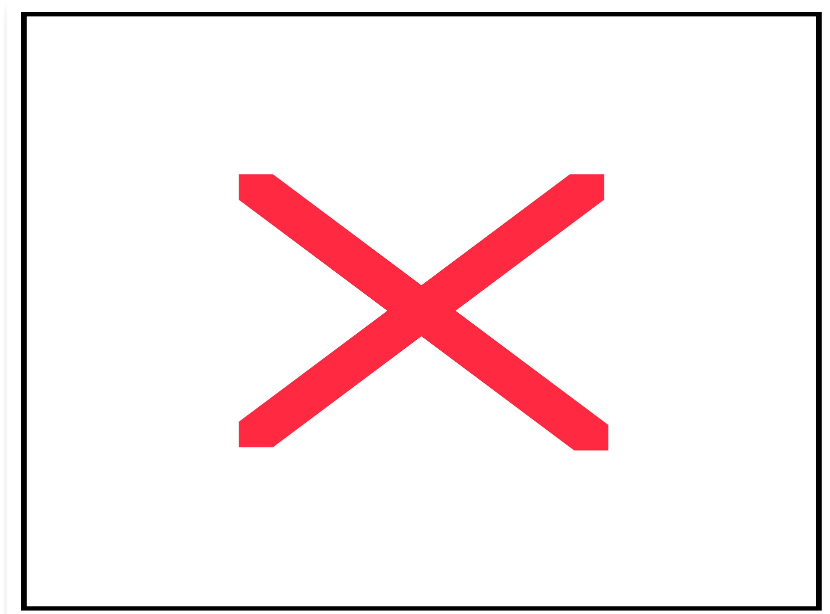
Motorized Prosthetic hand courtesy of Liberating Technologies , Inc.
Computer Interface courtesy of RollTalk, Inc.

Neural Interface System: Advances Towards a Fully Implantable Device

Today

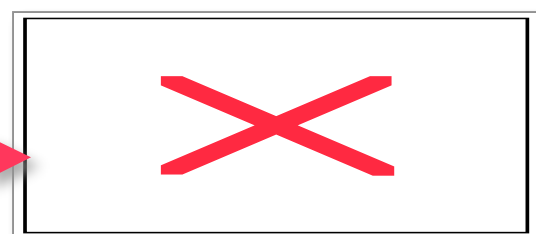


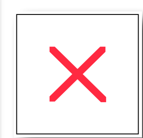
Next Steps



Wireless/ Fully implanted/ Automated

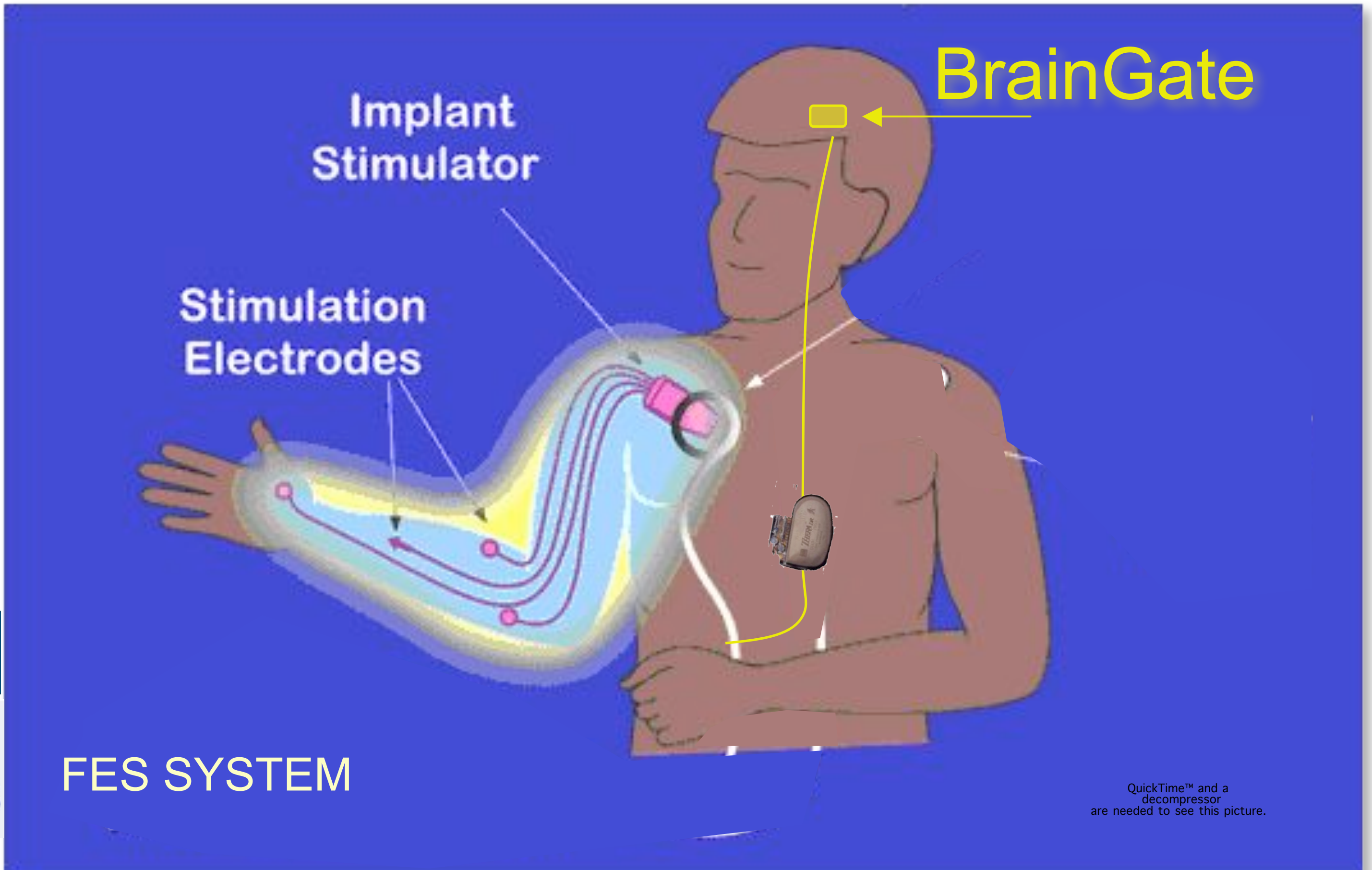
Implantable neural sensor
Prototype (Nurmikko/Brown University)





Next Steps: Moving Paralyzed Limbs

Coupling Functional Electrical Stimulation (FES) and BrainGate



NICHD/NCMRR

Kirsch / Peckham Case Western/ Cleveland FES Center

http://feswww.fes.cwru.edu/

From: Chadwick, Cornwell. Taylor, Branner, Caplan Peterson S3

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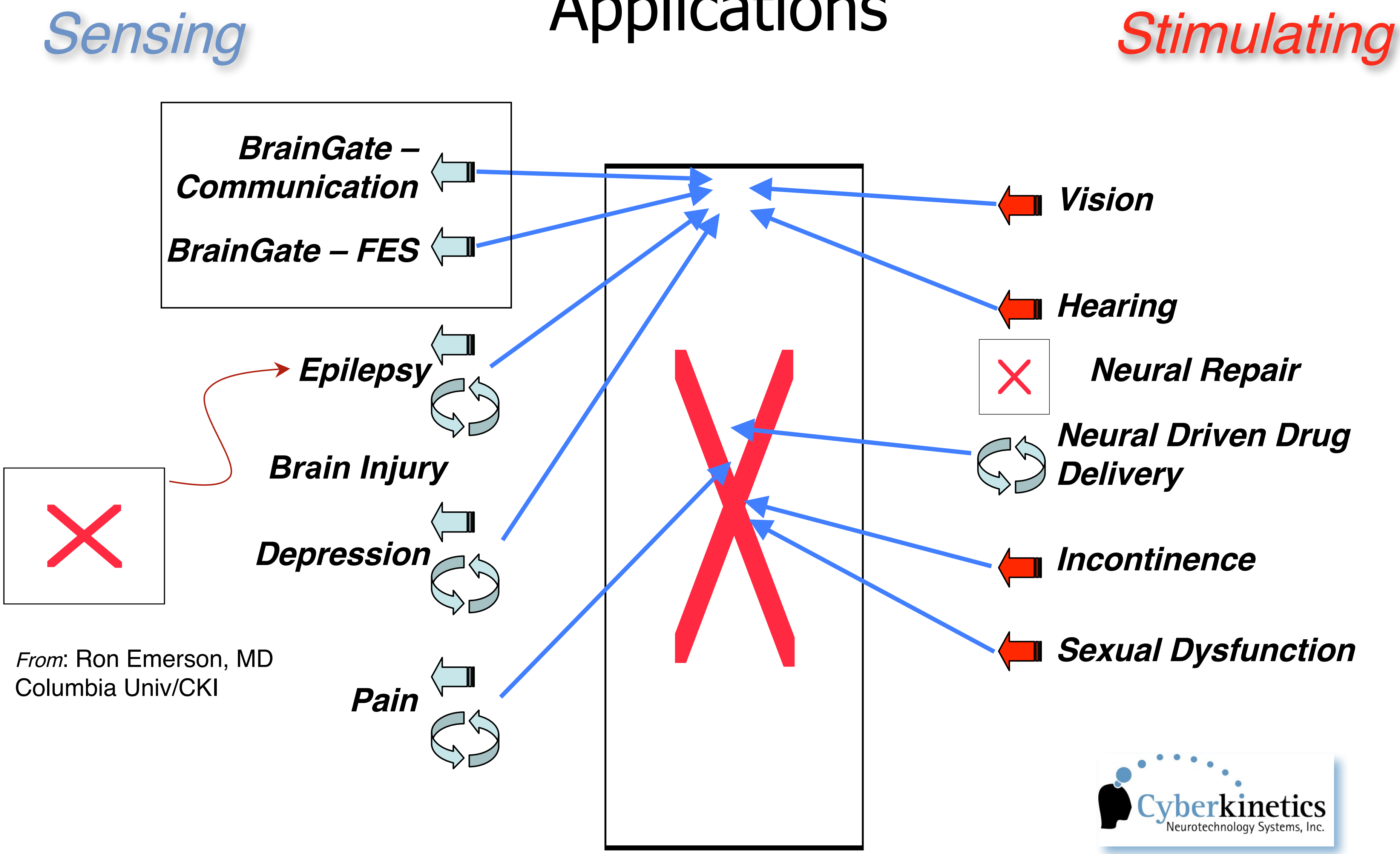
'Smart' Neural Interface Platform: Applications



From: Ron Emerson, MD
Columbia Univ/CKI

Cyberkinetics Neurotechnology Systems, Inc.

Plus: Unprecedented access to normal/abnormal human brain function at the neuron level

NICHD/NCMRR

Interdisciplinary Research Team

Brain Science

Computer Science

Michael Black

Phil Kim

Frank Wood

Engineering/Physics

Arto Nurmikko

Bill Patterson
YK Song
Chris Bull

Leigh Hochberg
MGH/Brown/VA

Donoghue Lab

Matt Fellows
Wilson Truccolo
Selim Suner
Carlos Vargas
Ammar Shaikhouni
John Simeral
Beth Travers
Loretta Reis
Al Rydberg
Leigh Hochberg

Misha Serruya
Abe Caplan
Maryam Saleh
Dan Morris

Neuroscience

Cyberkinetics
Neurotechnology Systems, Inc.

business

Misha Serruya
Abe Caplan
Maryam Saleh
Dan Morris.Almut Branner, CKI
Pis Jon Mukand, Leigh Hochberg
R. Chen (RIC), R. Penn (Chicago)

Neurosurgery

Gerhard Friehs

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Thank You

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MIT Media Lab

A One-Day Symposium
May 9, 2007
at MIT's Kresge Auditorium
8:30 am - 4:30 pm

Age of Neurotechnology

IN (Stimulation)

OUT (Sensing)

- Cochlear Implants >50,000
- Deep Brain Stimulators > 30,000
- Retinal Vision Prosthesis ~6

www.ucpnyc.org

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http://www.medtronic.com/corporate/l

Donoghue Abstract Hot Topics AAN

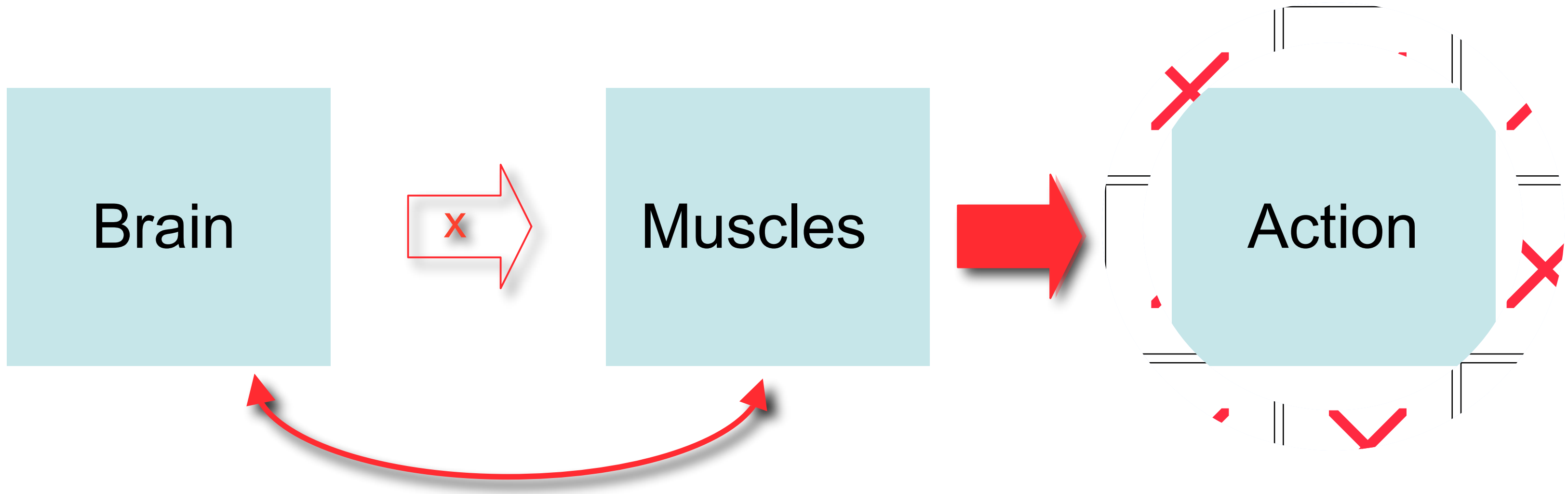
Developments in Neural Interfaces to Restore Lost Functions in Tetraplegia.

John P. Donoghue, Ph.D.
Department of Neuroscience Brown University, Cyberkinetics Neurotechnology Systems, Inc.

Neurotechnology is an emerging field that is beginning to provide a range of new devices to treat nervous system disorders. Tens of thousands of humans have already received neural interface technologies that stimulate the nervous system to treat symptoms of disorders such as epilepsy and Parkinson's disease. Neural interface systems that *sense* neural signals are in early stages of development, but promise to provide a means to restore independence, communication, and potentially movement. Spinal cord injury, stroke and other paralyzing conditions, as well as motor neuron disorders such as ALS, prevent movement intentions from being realized. In these disorders, a neural interface system can provide a physical means to restore a new communication link from the brain to the body or to assistive technologies. Early-stage clinical trials of a pilot human neural interface system, called BrainGate (Cyberkinetics Neurotechnology Systems, Inc.), indicate that individuals with paralysis can use neural activity from the arm area of motor cortex as a control signal to operate a range of assistive technologies. The system is based upon a 4 x 4 mm intracortically implanted array of 100 microelectrodes that detects neural activity patterns. Signal processors located outside the body derive movement intent from the neural patterns to generate a command signal. This command signal can then be used to operate a range of assitive technologies, including a computer, robotic hand or a powered wheelchair. Studies to date have included four individuals with tetraplegia. Despite their inability to move, we found that neural activity in the motor cortex modulated with imagined actions in all participants, even though they had different, long-standing forms of CNS impairment. Participants were able to control cursors in point-to-point movements and operate a robotic arm and hand, but not as well as an able bodied person. Recent advances in decoding have demonstrated the ability to provide point and click control signals that may be effective command signals for a variety of prosthesis applications. By combining the neural sensor with muscle functional electrical stimulation it may be possible to reanimate muscles, returning them to voluntary control via physical connections. These early-stage developments suggest that neural interface systems have to potential to significantly modify the lives of individuals with paralysis from neurodegenerative diseases or CNS damage. The multi-electrode sensor itself also appears to provide a sensitive means to monitor neural function that could be useful in a range of other neurological conditions such as epilepsy or brain trauma.

Conflict of Interest: John Donoghue is a shareholder, director and Chief Scientific Officer of Cyberkinetics.

Neural Interface Systems: Advances- Muscle Control



Neuromotor prosthesis (NMP)

Where we are: Neurotechnology for Paralysis

- *Neural Interface Systems* (external and intracranial) hold great promise to help those with paralysis;

- Very active research area (signals (AP,FP); decoding, technology)

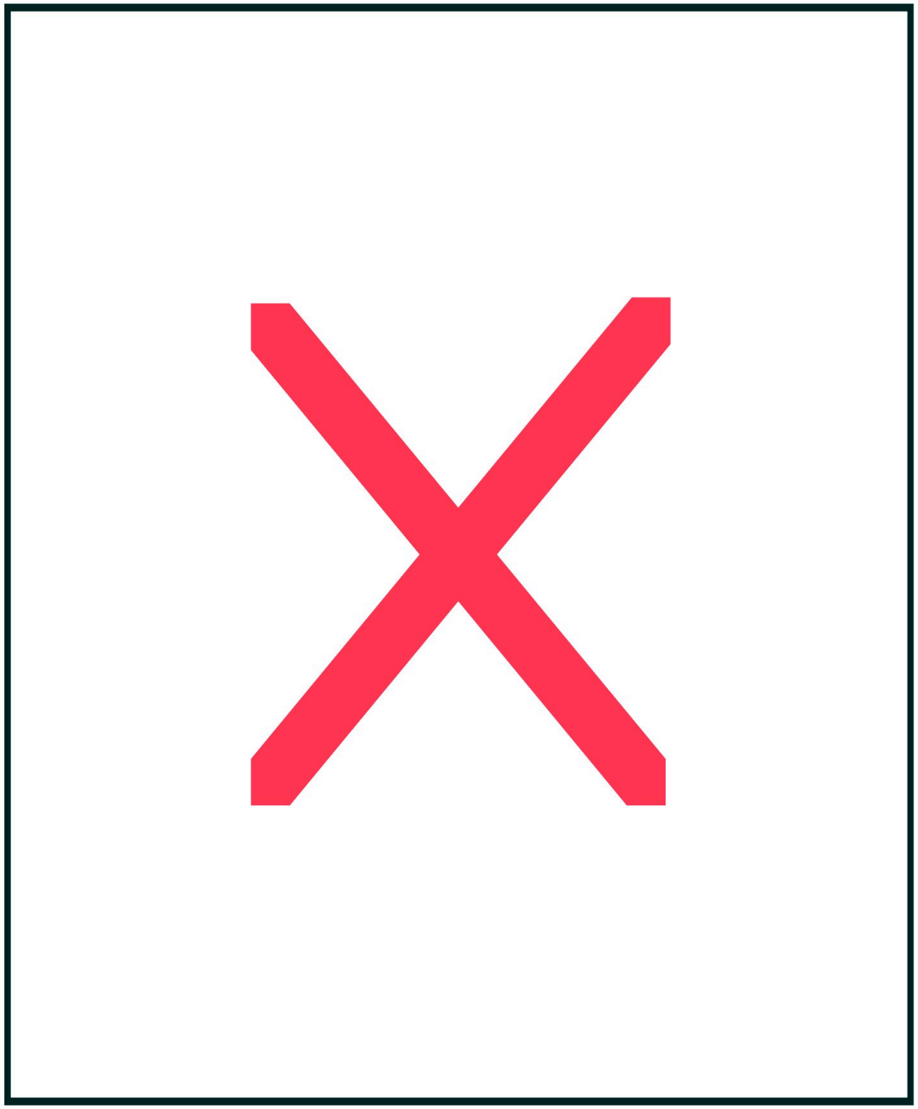
- Human Pilot trials. Initial proof of concept that intracortical interfaces function years after injury in
    - Spinal Cord Injury (2)
    - Brainstem Stroke (1)
    - ALS (1)

- Control includes computer interfaces, physical devices

- Potential to reanimate limb muscle

- Challenges include: engineering fully implantable, automated systems; efforts underway.

- New window on brain function and disease via implanted chronic sensor



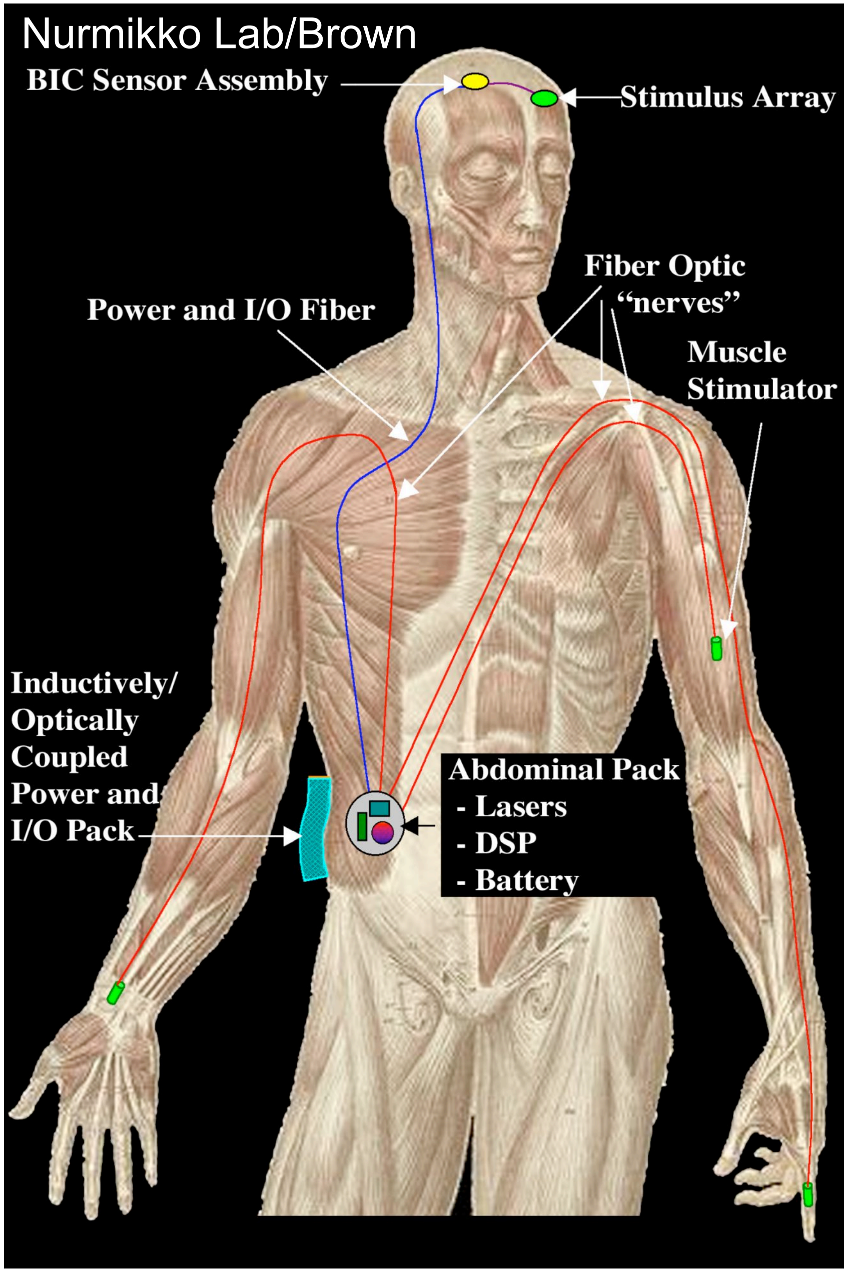
May 9, 2007

For further details:

S37.004 Wednesday, May 2, 2007 ***4:30 PM***

Leigh R. Hochberg
Cortical Control of Assistive Devices by Persons with Tetraplegia

Neuroprosthetic System: Vision



Restore

Rehabilitate

Replace

Platform Presentation:

S37.004 Wednesday, May 2, 2007 ***4:30 PM***

Leigh R. Hochberg, MD PhD
Cortical Control of Assistive Devices by Persons with Tetraplegia

Nature WEBSITE:
http://www.nature.com/nature/journal/v442/n7099/index.html

The Need for Neural Interface Systems

spinal cord injury

cerebral palsy

cerebellar disorders

locked-in syndrome

stroke

spinal muscular atrophies

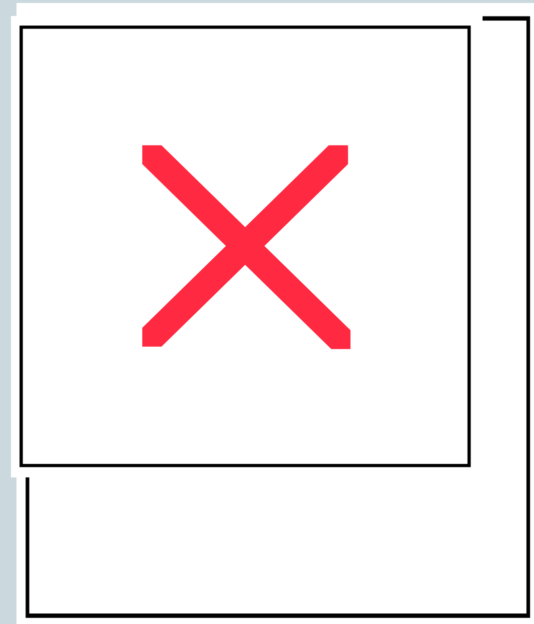
ALS

muscular dystrophy

limb loss

multiple sclerosis

- *Many neurological disorders disrupt the ability to* ***move*** *or* ***communicate****, but leave cognition intact*
- *100,000s affect worldwide*
- *Current assistive technology is limited*



Think x→ Act