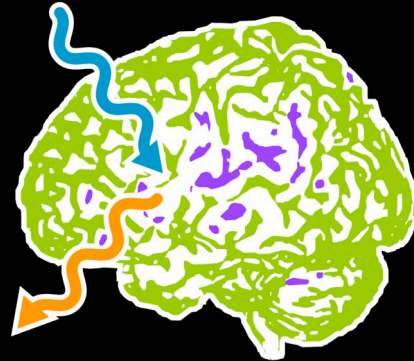

h2 o

Engineering the Brain



Ed Boyden

Assistant Professor • MIT Media Lab
Leader • Neuroengineering and Neuromedia Group

Adapting Humans by Engineering the Matter Mediating the Mind

To treat neurological & psychiatric disorders

1.5 billion sufferers worldwide of disorders such as stroke, depression, addiction, epilepsy, pain, Parkinson's,...

\$1 trillion annual worldwide cost

To augment cognition

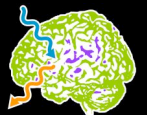
Improve memory, happiness, creativity, intelligence,...

To better understand the human condition

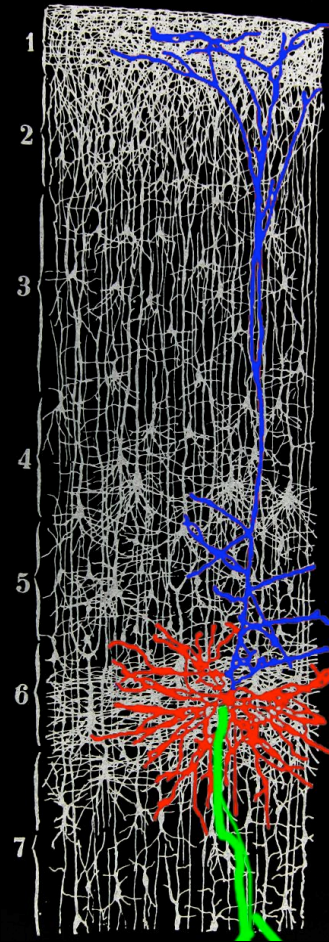
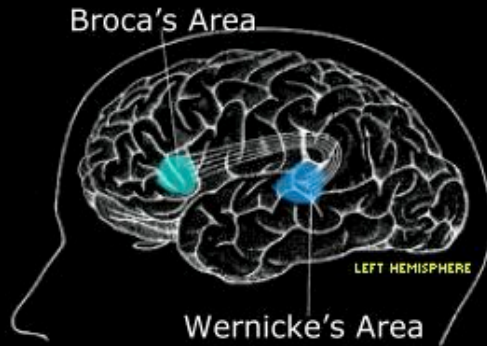
Society, war, economies, cultures...

Subjective experiences

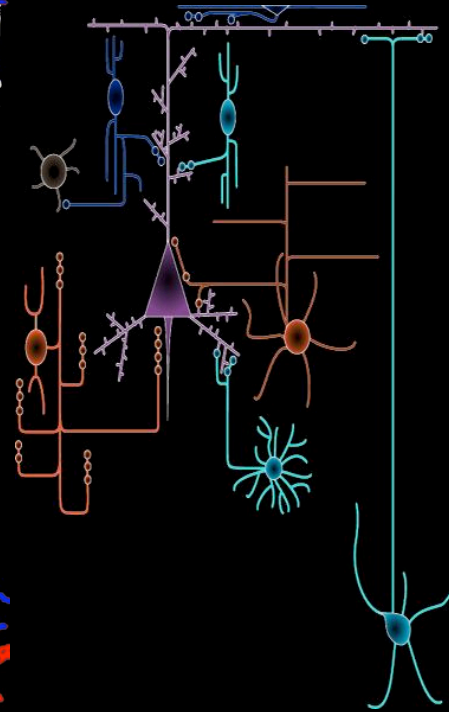
Need new tools... systematic tools...



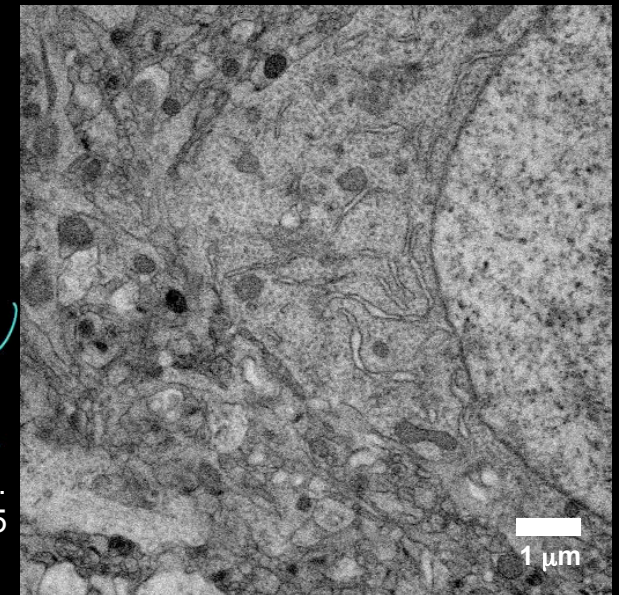
The Brain is Complicated...



Ramon y Cajal
1899



Denk and Horstmann
2004



I. Engineering Devices for Noninvasive Brain Stimulation

Transcranial Magnetic Stimulation (TMS)

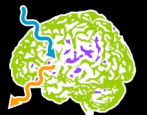
Safe; used in several thousand studies to date in >2 decades

Can activate/silence specific brain circuits it's aimed at

Approved for treating depression in Canada (2002)

Under wide investigation for stroke, schizophrenia, tinnitus,...

Possibilities: improve memory, improve decision-making,...



Towards Wearable Brain Stimulation Devices

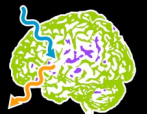
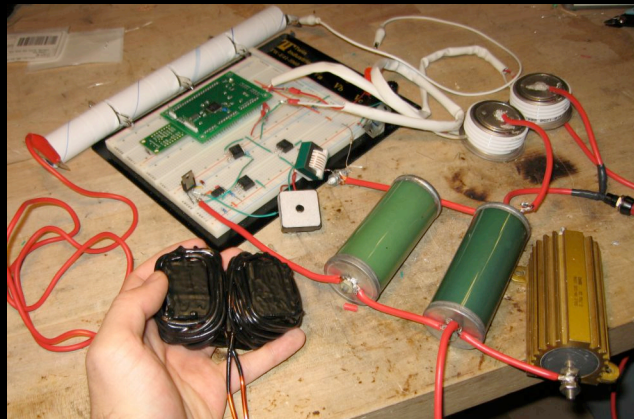
Lithium-ion **batteries** made of nanoscale particulates

Microcontroller-controlled **transformer** to step up the battery power to kilovolt ranges

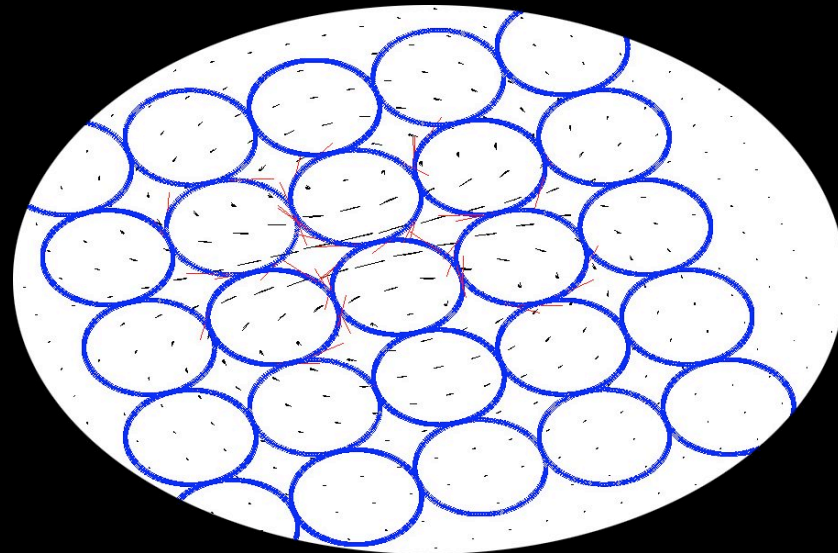
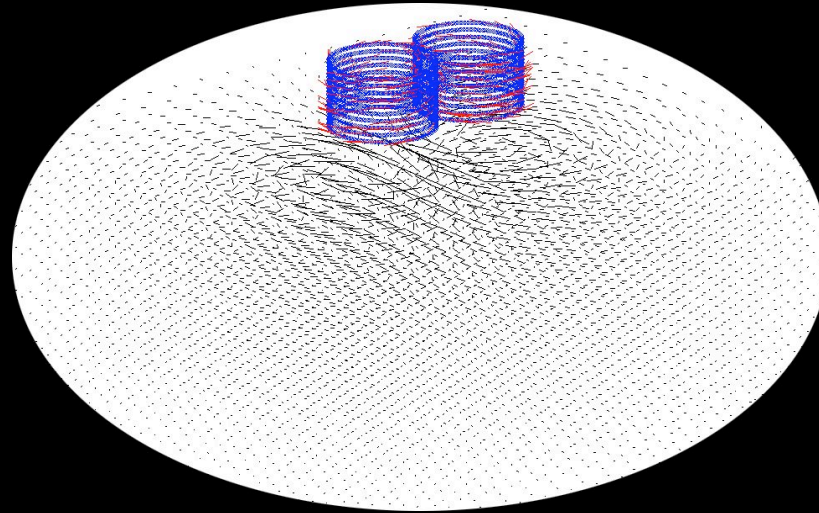
Coil has silicon-steel core to reduce current draw

Recovers **charge** after a pulse using precisely timed active charge gating

Modular design



Towards more Focal, Noninvasive Brain Stimulation



2. Engineering Software for Automated, Customized, Adaptive Therapy

Hypnotherapy for anxiety

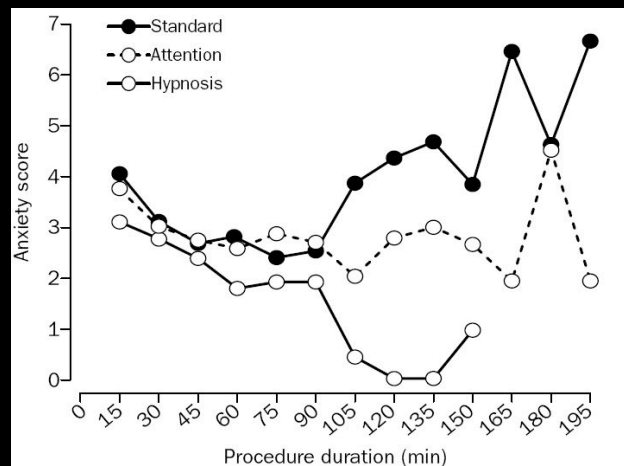


Figure 4: Average anxiety score as a function of procedure-time interval for each group

Lang et al.,
2000

State of suggestibility, attention, and distance from feelings

...[...becoming more and more relaxed and drowsy] +

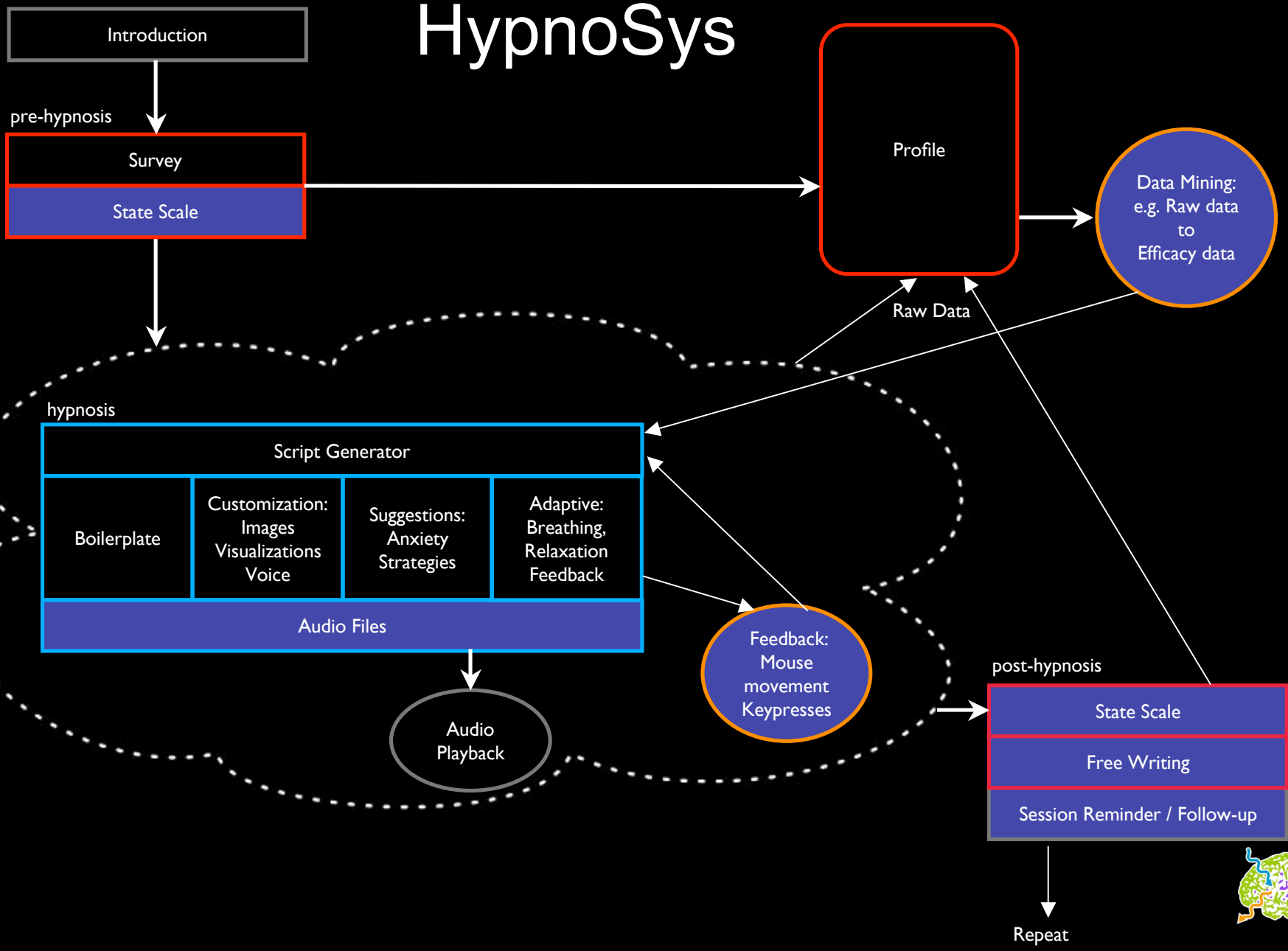
[...three... two... one... zero] +

[...Breathing pleasantly, slowly, drifting deeper and deeper with each breath] +
[REPEAT UNTIL BREATHING RATE CALMED BY 50%] +

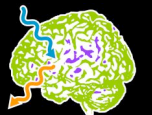
[...Suggestion commitment: As you continue to be deeply relaxed, and to become even more relaxed, you are thinking about your suggestions]...



HypnoSys



HypnoSys: Live Demo



HypnoSys

Loading ■

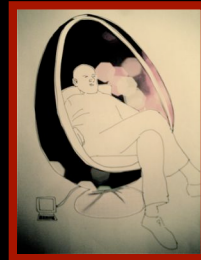
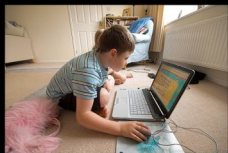


HypnoSys



Next:

- This philosophy of adaptive, customized, therapeutic software may find:
 - Application to other kinds of therapy
 - Deployment on a variety of media

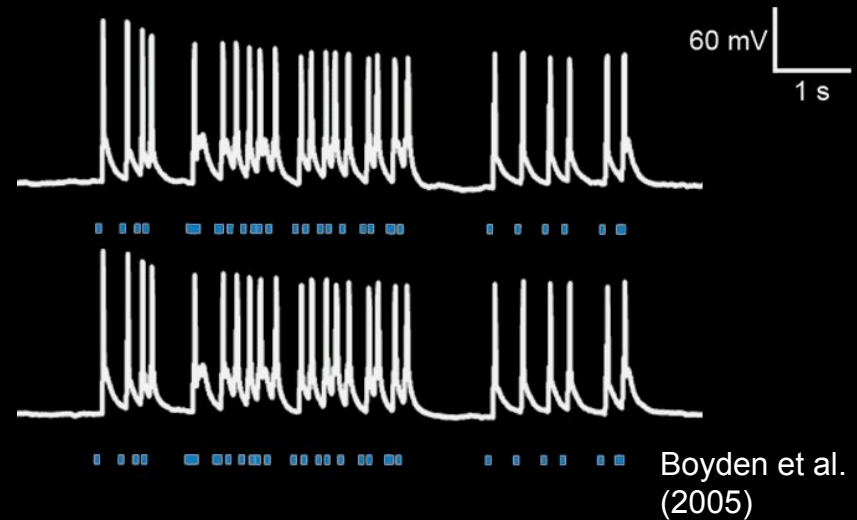
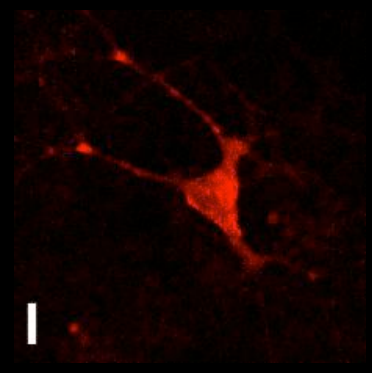
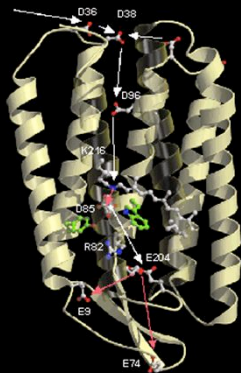


<http://www.flickr.com/photos/danielegaliffa/125095843/>
<http://www.flickr.com/photos/gpennykid/270645364/>
<http://www.flickr.com/photos/kfmush/346217157/>
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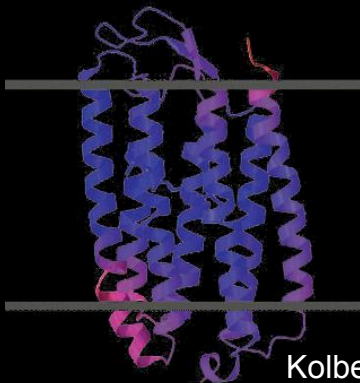


3. Ultraprecise Engineering of Neural Computation via Optical Neural Control

Channelrhodopsin-2



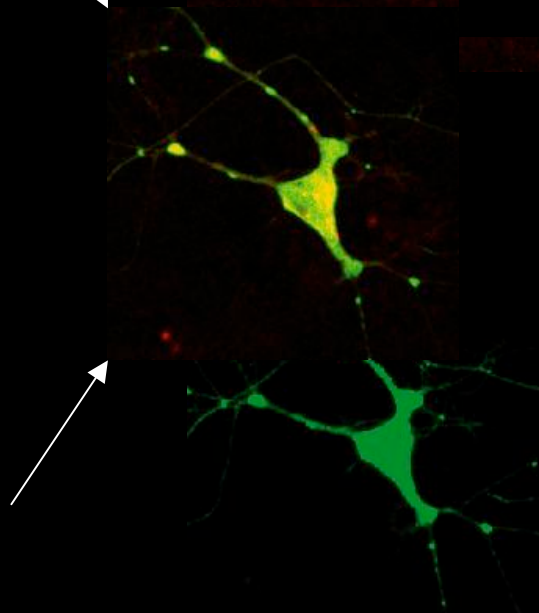
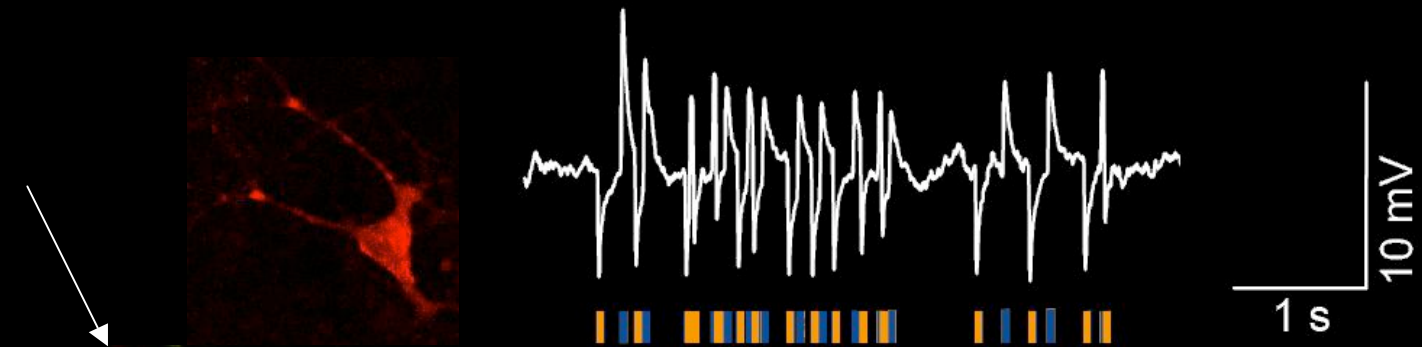
Halorhodopsin



Kolbe et al.,
(2000)

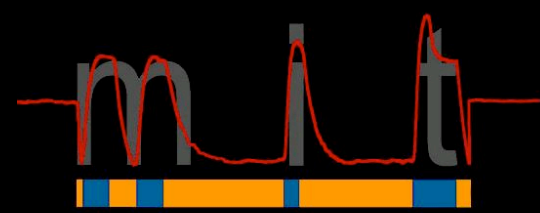


Towards Fixing Neural Circuits with Bi-Directional Optical Control



wednesday, march 28, 2007
MIT massachusetts institute of technology

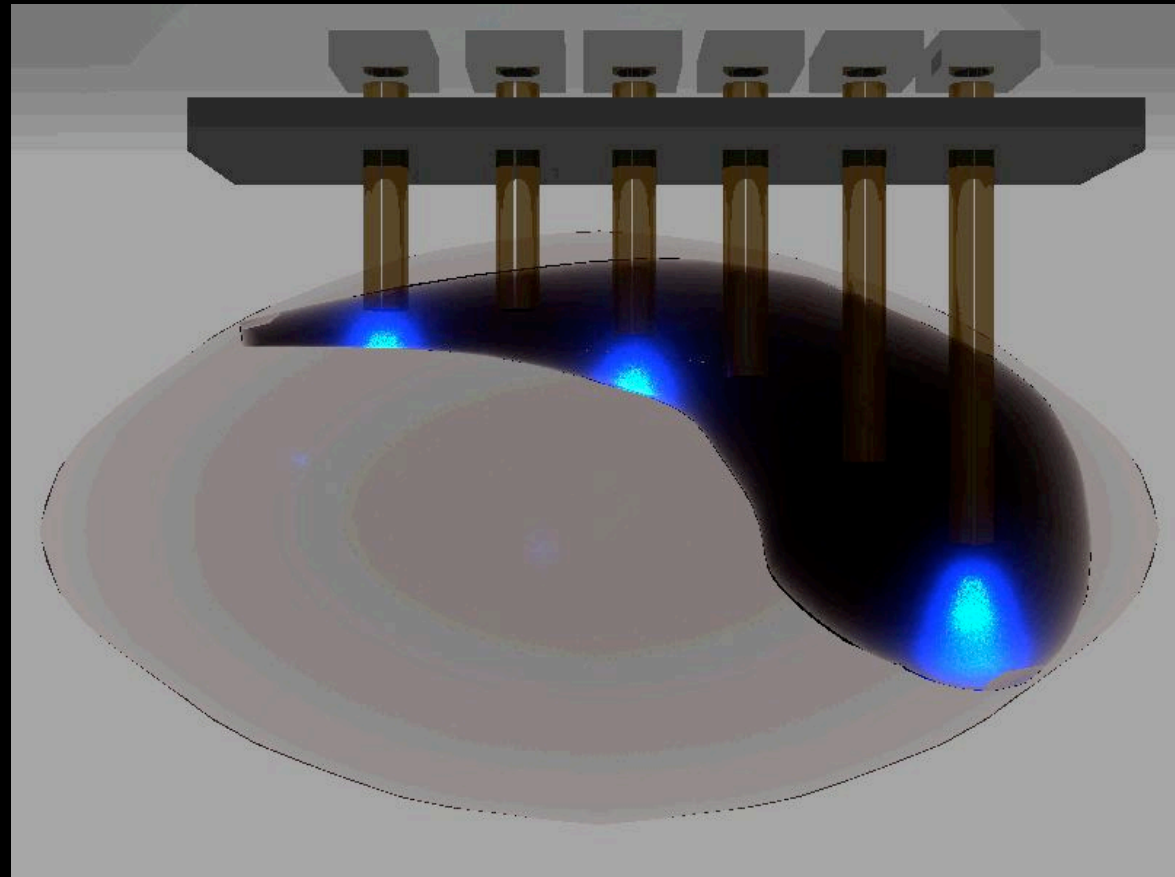
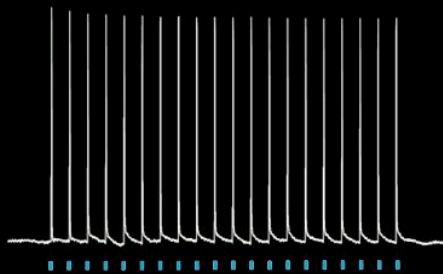
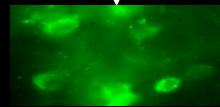
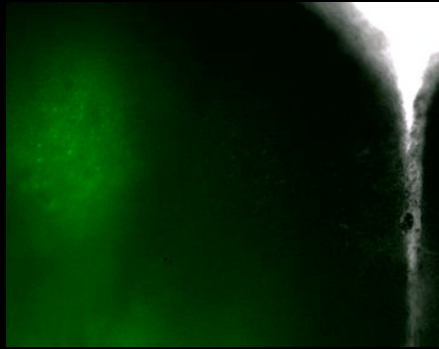
spotlight **MIT helps shed light on epilepsy, Parkinson's**
pulsing light silences overactive neurons



massachusetts institute of technology 77 massachusetts avenue cambridge, ma 02139-4307 tel 617.253.1000 tty 617.258.9344

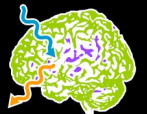


Optical Neural Control Prosthetics



Next:

- **Prosthetic designs**
 - Blindness: if you lose your photoreceptors, just make remaining neurons in the retina light-sensitive
 - Deafness: targeted cochlear implants
 - Fiber arrays: epilepsy, Parkinson's,...
- **Biological testing**
 - Continue safety and efficacy tests



Lab Members:

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Zack Anderson
Barbara Barry
Jake Bernstein
Laureen Chapman
Malamo Countouris
Gabriel Fouasnon
Giovanni Franzesi
Xue Han
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Emily Ko
Nadeem Mazen
Ekavali Mishra
Azadeh Moini
John Moore
Bo Morgan
Xiaofeng Qian

Jessica Schirmer

Jon Spaulding

(+ 6 UROPS joining this summer !)

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