The Mind-Machine Interface

1) Electricity is important for brain function, and can be harnessed by machines to create brain-machine interfaces
2) Mechanical retinal implants are restoring vision to the blind
3) It is possible to record from neurons in the brain to control prosthetic limbs (the brain controlling machines)
Can machines control the mind?

- Neurological disorders: Parkinson's Disease
- Current treatments: Deep Brain Stimulation
- Future mechanical advances in treatment

Mark Dow, University of Oregon, Wikimedia
Parkinson's disease

Symptoms:
- Uncontrollable tremor
- Difficulty initiating movement; Shuffling gait
- Rigidity
- Stooped posture and instability
Neurons that move you

Motor Area

Relay Center

Substantia Nigra

Adapted from Mikael Häggström, Wikimedia
What causes Parkinson's disease?

Substantia Nigra: Normal Parkinsonian

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Dopamine neurons

Substantia Nigra: Normal Parkinsonian

Adapted from Mikael Häggström, Wikimedia
Normal brain:

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GO

Relay Center

dopamine

STOP

Substantia Nigra

Motor Area

Relay Center

Dopamine

Substantia Nigra

Adapted from Mikael Häggström, Wikimedia
Parkinsonian brain:

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GO

STOP

Relay Center

Substantia Nigra

Dopamine

Adapted from Mikael Häggström, Wikimedia
Deep brain stimulation: Current Parkinson's disease treatment
Deep brain stimulation:

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Dopamine

Adapted from Mikael Häggström, Wikimedia
Deep brain stimulation: Pre-operation

Video courtesy of Dr. Philip Starr, UCSF
Deep brain stimulation: Post-operation

Benefits:
• It works
• It is reversible and adjustable

Drawbacks:
• Works optimally for ~5-10 years
• Interferes with neurons in an entire brain region

Video courtesy of Dr. Philip Starr, UCSF
Future treatment:
Light-stimulated neurons
Light stimulated brain:

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Dopamine

Substantia Nigra

GO

STOP

Adapted from Mikael Häggström, Wikimedia
Benefits of light stimulation versus deep brain stimulation

1) Can insert channel into specific neurons to make them light responsive, rather than stimulating a whole brain area

2) Potentially smaller, less invasive cable in the brain

3) Know which neurons are being activated and the mechanism behind the treatment, which will hopefully reduce side
Additional technical advances needed before human application

1. Improve the channel opening in response to light
2. Channel lets in all types of positive ions; develop a way to select which ions can pass
Summary: Machines can control how the brain moves the body

- Parkinson's Disease is caused by the death of dopamine neurons in the substantia nigra.
- Symptoms can currently be controlled by Deep Brain Stimulation.
- In the future, light activation of specific neurons in the GO pathway could replace Deep Brain Stimulation.
Summary: The Mind-Machine Interface

1) Electricity is important for brain function, and can be harnessed by machines to create brain-machine interfaces.

2) Mechanical retinal implants are restoring vision to the blind.

3) It is possible to record from neurons in the brain to control prosthetic limbs (the brain controlling machines).

4) Eventually, neurons might be controlled by light as therapy for Parkinson’s disease (machines “controlling” the brain).
Thank you!

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