NP taps the Brain
DBS/BCI
prepared for the class of BME2008

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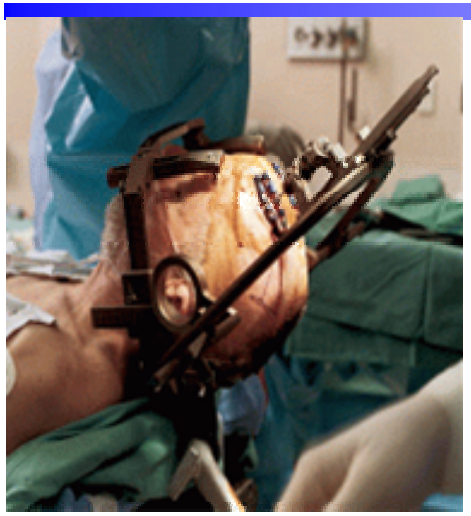
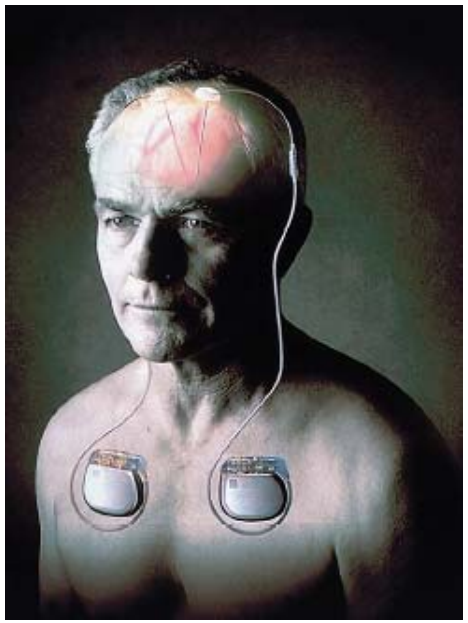
Deep Brain Stimulator
뇌심부 자극기

Deep Brain Stimulation





- Definition
  - 운동장애의 원인이 되는 뇌심부의 **overactive neuron**에 전기자극을 가함으로서 **temporarily disable**시키는 방법
- Advantages over ablative Surgery
  - 환자의 의식이 있는 상태에서 테스트 자극을 가하여 정확한 자극부 위를 찾아냄으로서 수술성공 확률 극대화.
  - 자극 부위를 절제하지 않기 때문에 뇌손상의 위험이 적음.
  - 새로운 치료법이 개발되어도 적용가능.
- 2001년 NIH(美미국국립보건원)의 보고에 따르면 현재 2,000명 이상의 Parkinson's disease 환자들이 시술을 하였으며, 급격하게 그 숫자가 늘어나고 있어 해마다 15,000명에 해당하는 환자들이 시술 후보가 된다고 보고됨.
- FDA(美식약청) Approval
  - In August 1997, DBS for the treatment of tremor in Parkinson's disease using a single implanted electrode.
  - In January 2002, DBS using two implanted electrodes for Parkinson's disease

Neurological Movement Disorder

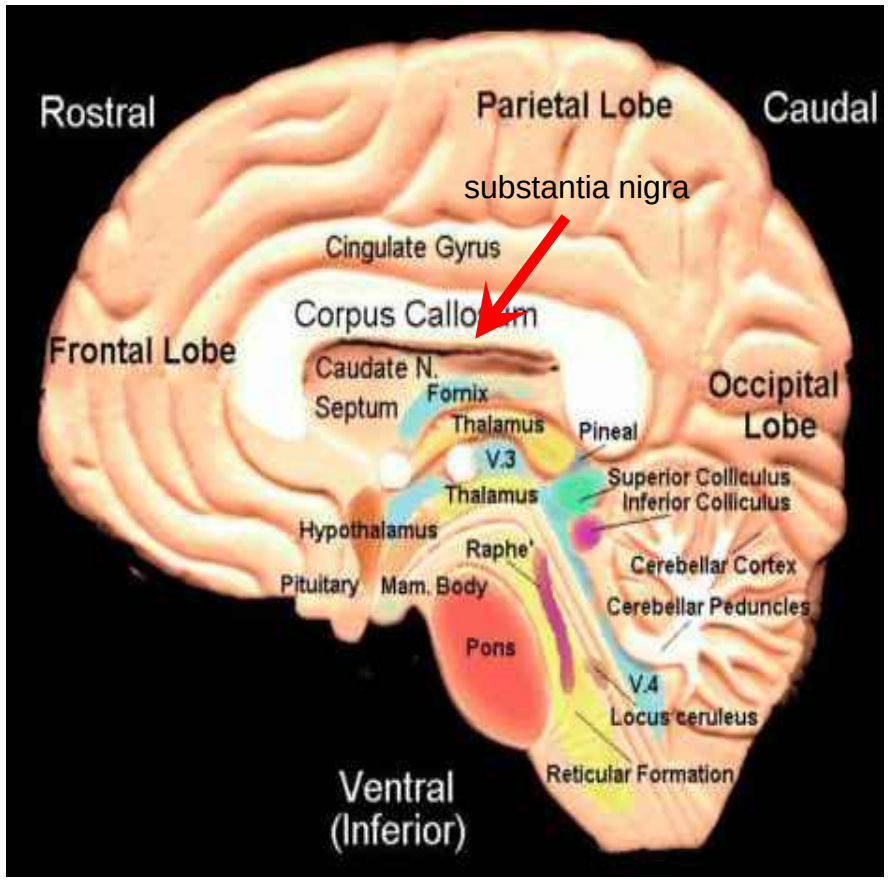
발병 원인

운동기능을 담당하는 뇌심부 구조물**(substantia nigra)** 에 존재하는 억제성 신경세포**(inhibitory neuron)**의 소실로 인하여 연접한 신경망의 **over-activities** 발생

➔ **Movement Disorders** 야기

종류 및 증상

- **Parkinson's Disease**
  - **Tremore at rest state**
  - **lower shaking frequency**
  - **Ceases during purposeful movement**
- **Essential Tremor (본태성 진전)**
  - **Tremore during movement**
  - **Higher shaking frequency**
- **Dyskinesia (이상운동증)**
  - **Power Impairment of voluntary movement**
- **Dystonia (근긴장이상증)**
  - **Disordered tonicity of muscles**



Treatments for Movement Disorders

Ablative Surgery

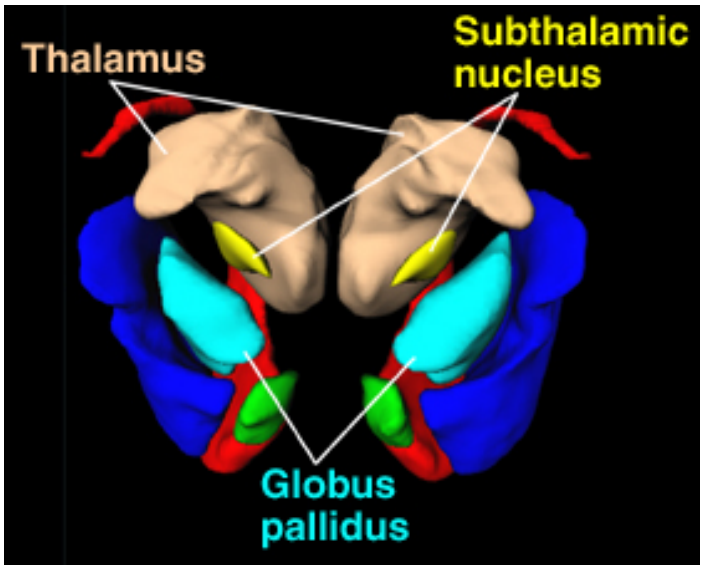
- **Over activities**를 보이는 심뇌부위를 제거함으로서 운동장애를 호전시키는 방법으로 **20**세기 초반부터 연구되어 온 가장 고전적인 방법
- 현재까지도 사용되고 있는 치료법이나, 절제 시 부작용에 의해 주변 뇌의 기능의 손상을 야기할 수 있음.

Drug Medication

- 신경전달물질을 이용한 약물을 투여하여 운동장애를 호전시키는 방법
- 증세가 호전되는 비율이 낮고, 시간의 경과에 따라 효과가 떨어짐.

Deep Brain Stimulation

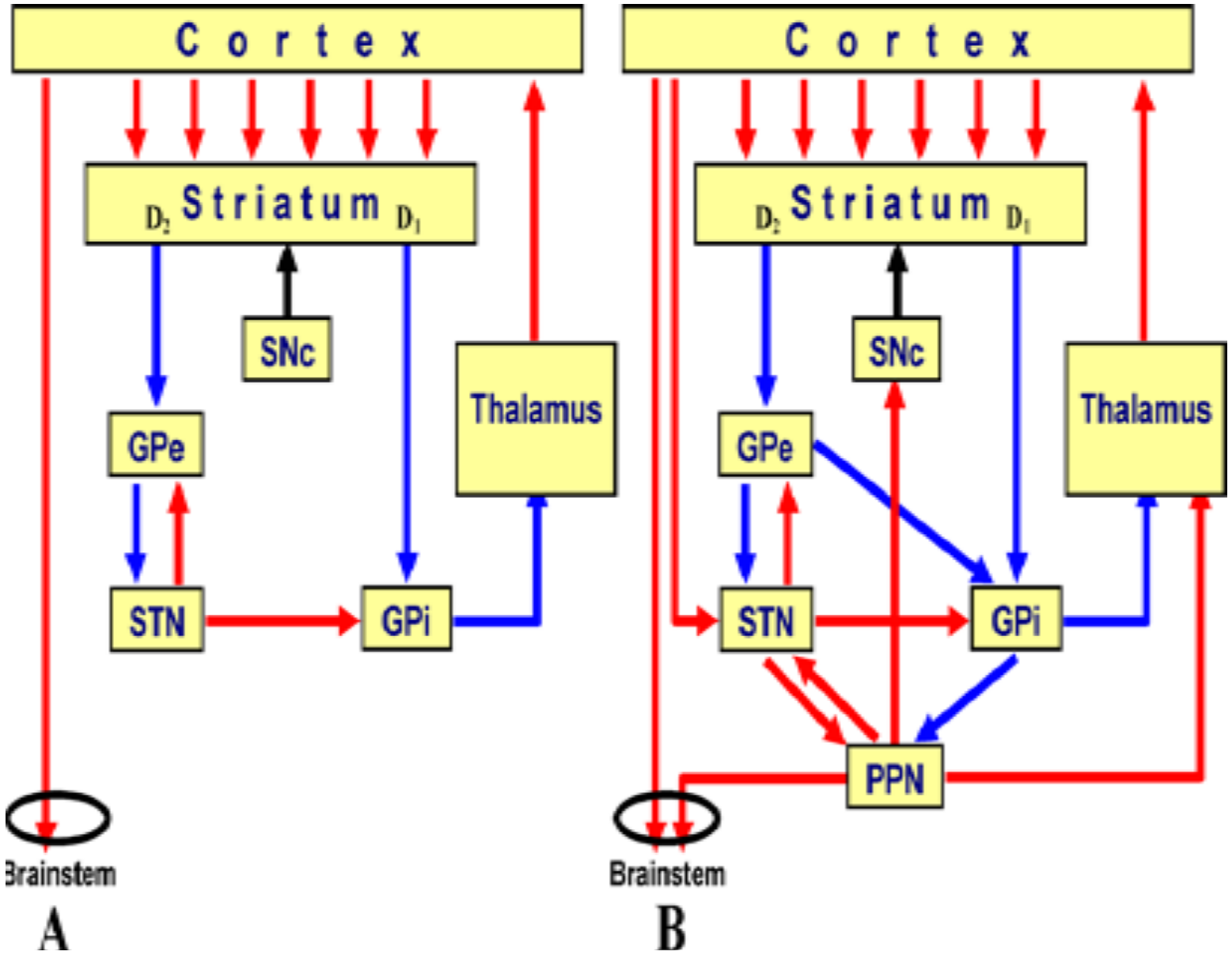
- 병변 부위에 전극을 삽입하여 전류자극을 줌으로서 운동장애를 극적으로 호전시키는 방법
- **Tremor**를 포함한 각종 운동장애에 효과가 있는 것으로 밝혀져 활발히 연구가 진행 중에 있음.



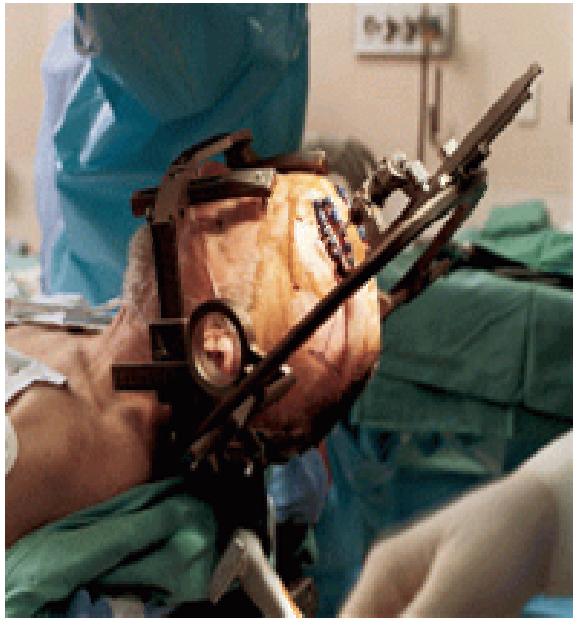
Three Stimulating Targets of DBS

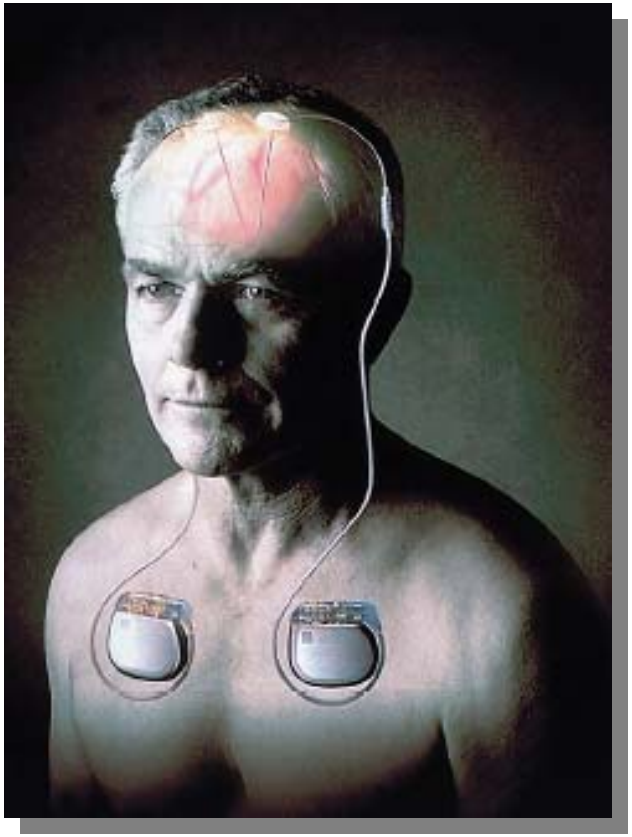
- **Thalamic nucleus (**시상핵**)**
- **Subthalamic nucleus (**시상하핵**)**
- **Globus pallidus (**창백핵**)**

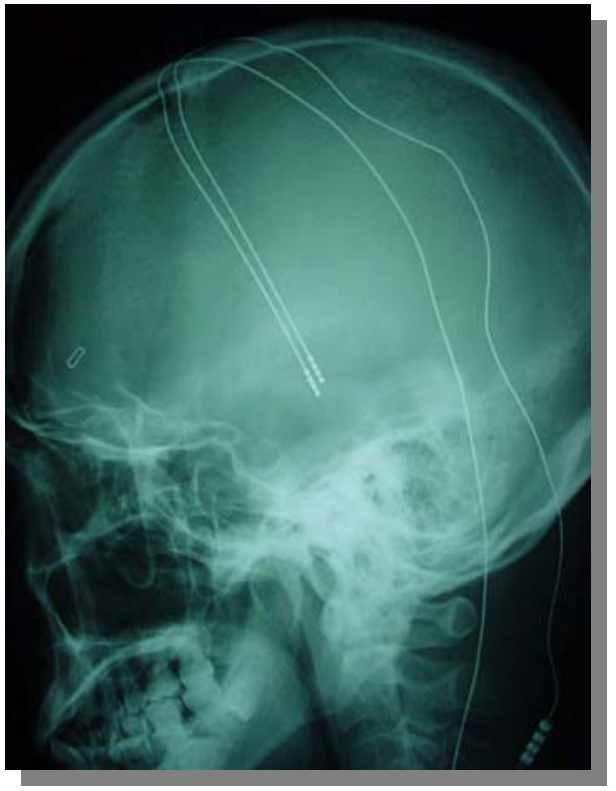
PD – DBS pathway



(DBS; Deep Brain Stimulation)







DBS Video

Medtronic Inc. Activa® Tremor Control Therapy

Applications

1. **Parkinson’s disease**
2. **pain**
3. **Clinical Depression**
4. **Tourettte syncrome (Tic disorder)**
5. **OCD (obsessive-compulsive disorder)**
6. **Epilepsy**

The Brain-Computer-Interface

1. BCI is basically chronic, multi-channel, neural recording from Brain
2. Reliable Neural Interface (electrode array) is required.
3. Signal Processing is heavily involved to process, sort the multi-channel data and apply them to the actuator.
4. Working groups:
    1. Donoghue group at Brown Univ.
    2. Andersen group at Caltech.
    3. Schwartz group at Pittsburgh
    4. Nicoleidus at Duke
    5. Shin at Hanlim Univ.(all above invasive BCI)
    6. Wolpaw group at Wadsworth Center (non-invasive BCI)
    7. And more world-wide

BCI- Brown Group

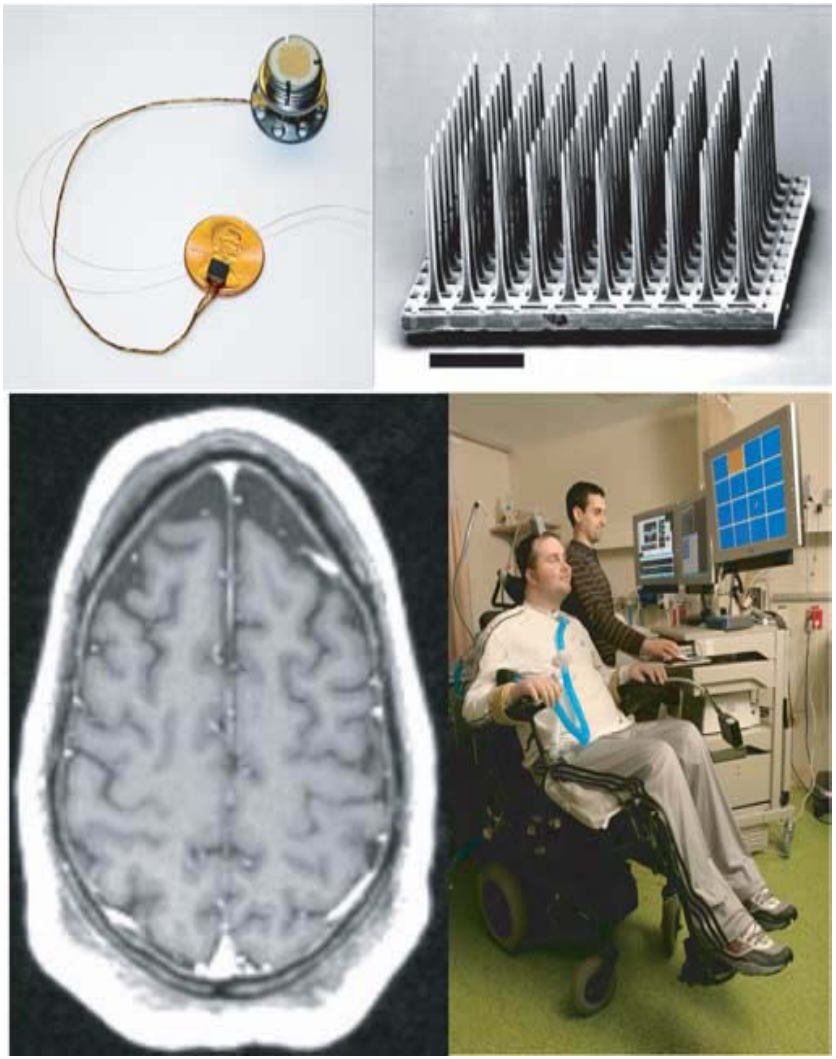


Figure 1 | Intracortical sensor and placement, participant 1. a, The BrainGate sensor (arrowhead), resting on a US penny, connected by a 13-pin ribbon cable to the percutaneous Ti pedestal (arrow), which is secured to the skull. Neural signals are recorded while the pedestal is connected to the remainder of the BrainGate system (seen in d). b, Scanning electron micrograph of the 100-electrode sensor, 96 of which are available for neural recording. Individual electrodes are 1-mm long and spaced 400 mm apart, in a 10 £ 10 grid. c, Pre-operative axial T1-weighted MRI of the brain of participant 1. The arm/hand 'knob' of the right precentral gyrus (red arrow) corresponds to the approximate location of the sensor implant site. A scaled projection of the 4 £ 4-mm array onto the precentral knob is outlined in red. d, The first participant in the BrainGate trial (MN). He is sitting in a wheelchair, mechanically ventilated through a tracheostomy. The grey box (arrow) connected to the percutaneous pedestal contains amplifier and signal conditioning hardware; cabling brings the amplified neural signals to computers sitting beside the participant. He is looking at the monitor, directing the neural cursor towards the orange square in this 16-target 'grid' task. A technician appears (A.H.C.) behind the participant

BCI- chronic neural recordings

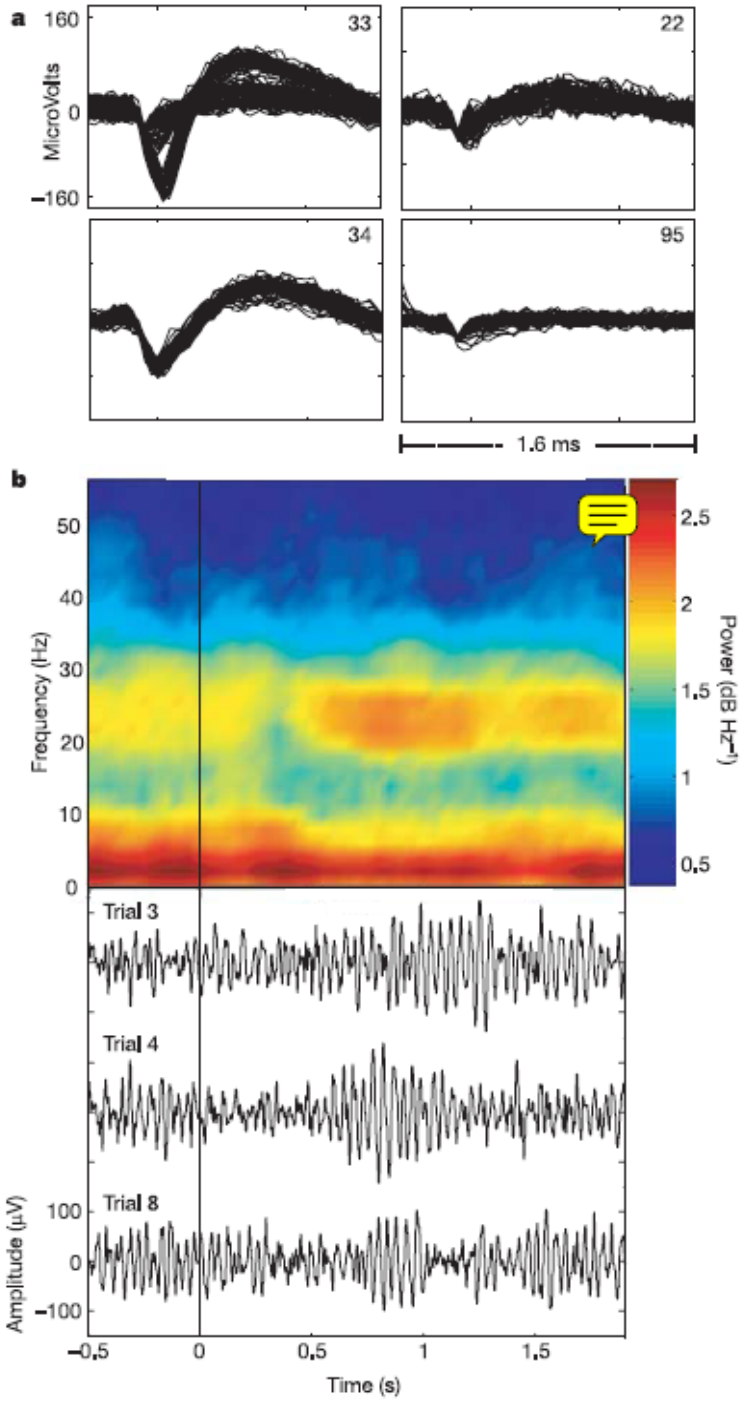
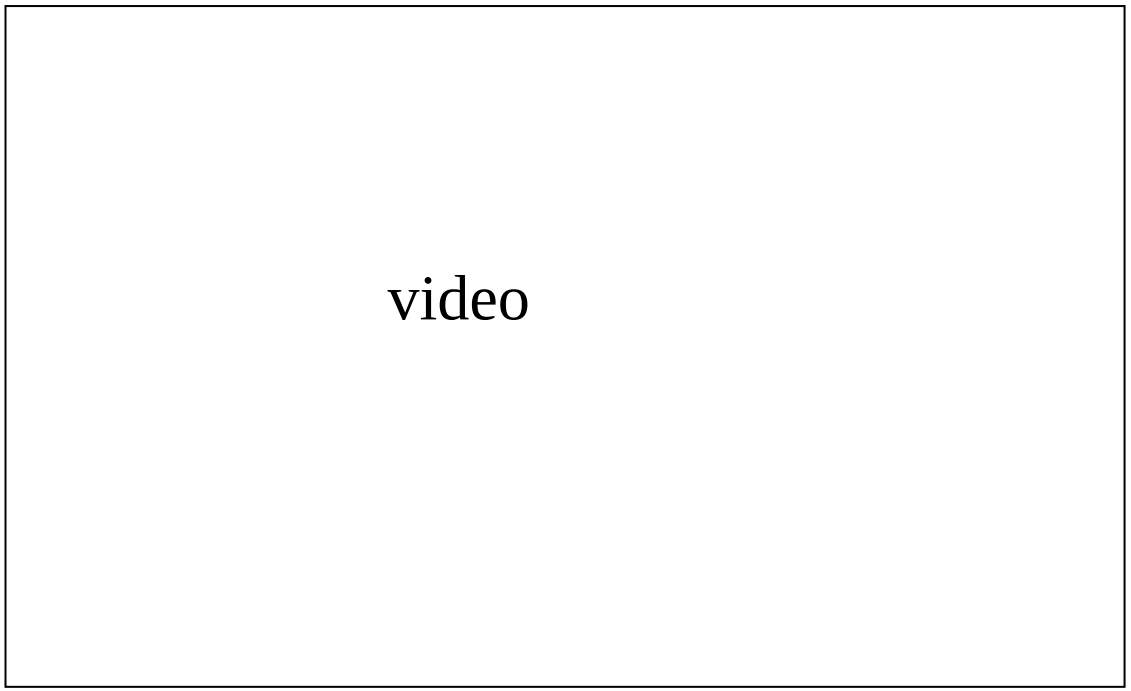


Figure 2 | Electrical recordings from a sample of four electrodes. **a**, Discriminated neural activity at electrodes 33, 34, 22, 95 ($n = 80$ superimposed action potentials for each unit). On electrode 33, two neuronal units could be reliably discriminated with peak to peak amplitudes of 206 and 56 μv, respectively. For electrode 34, a single unit is displayed. Electrode 22 illustrates a low-amplitude discriminated signal. Electrode 95 shows triggered noise. Data are from trial day 90 (90 days after array placement). **b**, Local field potentials during neural cursor control. In the bottom panel, three traces of electrical recording (bandpass: 10–100 Hz) from one electrode are shown 0.5 s before and 1.9 s after the go cue instructing MN to move the cursor from the centre position to a target at the top of the screen. In the top panel, a Thomson multi-taper time frequency analysis on each trial data segment was performed. This was done by sliding a 0.3-s window every 0.05 s, using a spectral resolution of 10 Hz. These power spectrograms were averaged across 20 trials to create the resulting pseudocolour power spectral density (PSD) plot. The diagram is aligned such that each point in the PSD plot corresponds to a time window 150 ms before and after an LFP. In the 20–30-Hz band, a decrease in power is seen approximately 300 ms after the go cue, followed by an increase in power from 550–1,200 ms after the go cue, which can also be appreciated in the raw, single trial data below.

BCI- Brown Group- Supplemental Movies

http://www.nature.com/nature/journal/v442/n7099/suppinfo/nature04970.html



Engineers and Doctors in Neural Prosthesis

1. **Helping partners in this heavily technology dependent medical field.**
2. **Doctor find applications**
3. **Engineers provide solutions**
4. **It is expected that most application needs will be met with proper solutions given time.**
5. **Ingenious Solutions, such as novel neural interface or design for low cost availability, can still revolutionize the field.**