New diagnostic tools

Studying human brain <u>Structural (static)</u> Histology X-ray Computed tomography (CT or CAT) Magnetic Resonance Imaging (MRI)

Functional (active): particular task at particular times

PET fMRI MEG EEG

Structural investigation

Histological Analyses

Figure 2.3 Golgi-stained neurons. (Source: Hubel, 1988, p. 126.)



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Direct manipulation and staining of tissue -cellular and molecular analyses -can only be done post-mortem



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Radioisotope injection and tracking

Color visualization

enzyme reaction: immunohistochemistry fluorescent protein expression





Fluorescent protein expression



The researchers inserted into mice a construct targeted (Cre/Lox system) to the central nervous system, with genes coding for 4 fluorescent protein emmiting 'primary' colours (red, yellow, cyan and orange) organized so that, randomly, only one of the genes are expressed per insertion. Depending on the number and 'color' of insertions (combinatorial expression), distinct cells will show distinct hues. Colours show how cells intertwine.

The research is showing the brain as we have never seen it before. This technique **will allow neurobiologist to track changes in the neural circuitry up to the individual cell level**; it could be also used to monitor the effects of therapies on the neural wiring, and more generally to (more precisely and easily) track tissue organisation changes in model organisms.

X-rays

Brain has little difference in the density Angiograms (혈관조영술) detect blood vessel problems by chemical injection



http://www.mghradrounds.org/index.php?src=gendocs&link=2008_march

Computerized axial tomography (CAT)

Amplification of X-ray signal using a sensor connected to a computer Series of x-ray images

- -Scan living brain
- -localization of brain tissue problems
- -Low resolution
- -Exposure to radiation



Magnetic Resonance Imaging (MRI)



Use electromagnetic fields to image atom (hydrogen) density

- -Scan living brain
- -High resolution
- -Expensive





CT scan of a patient who has had a left middle cerebral artery stroke. The arrow indicates the location of the stroke. MRI



MRI of a patient who has had a stroke of the left hemisphere of the brain. The arrow indicates the area that was affected.

Functional investigation

Positron Emission Tomography (PET)

Box 7.3B A PET image. (Source: Posner and Raichle, 1994, p. 65.)



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Detect decay of injected radioactive substance (oxygen or glucose)

-unstable isotope emits positrons which collide with electrons in other

molecules and ultimately emits high energy gamma rays

- -Scan metabolic/chemical changes in living brain (tens of seconds)
- -Can be mapped onto MRI
- -Low resolution

-Exposure to radioactive substance (labeled 2-fluorodeoxy-glucose, $t_{1/2}=2h$)

Functional MRI (fMRI)



Use electromagnetic fields to image hemoglobin

-Detect metabolic needs of living brain (50-100 ms): neural activity

-High resolution

-Very expensive

fMRI for studying of mental activities



An fMRI of the brain. Green areas were active while subjects remembered information presented visually. Red areas were active while they remembered information presented aurally. Yellow areas were active for both types. <u>http://stanmed.stanford.edu/2005fall/brain-main.html</u>

Magnetic resonance spectroscopy (MSR)

Detect molecular and metabolic changes



Magnetic resonance spectroscopy imaging of a patient with Baló's concentric sclerosis, 12 days after onset of symptoms. (A) Single-voxel spectroscopy of the lesion (TR/TE = 2,000/35 ms) shows an elevated lactate doublet peak and a mildly decreased *N*-acetylaspartate peak, compared with the contralateral side (**B**; TR/TE = 2,000/35 ms). Abbreviations: Cho, choline; Cre, creatinine; Lac, lactate; NAA, *N*-acetylaspartate; ppm, parts per million; TE, echo time; TR, repetition time. Nature Clinical Practice Neurology (2007) 3, 349-354

Optical imaging techniques (Near Infrared Imaging)

Noninvasive functional mapping of the human cortex

Detecting changes in blood hemoglobin concentrations associated with neural activity NIRS is much more portable than fMRI machines, even wireless instrumentation is available However, NIRS cannot fully replace fMRI because it can only be used to scan cortical tissue



Magnetoencephalography (MEG)

Measure magnetic fields produced by electrical activity in the brain

-high temporal resolution (1 ms)-low spatial resolution (2 mm)



http://www.horizons-2000.org/2.%20Ideas%20and%20Meaning/Topics/NeuroPsychology.htm



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Magnetoencephalography (n = 16) was used to measure the activation elicited at different times after spoken action words could be uniquely recognized. Note the slight upward movement of the inferior central source for the face/armrelated word and the delayed appearance of the superior central source for the leg-related word. These activation time courses might reflect the movement of neuronal activity in distributed neuronal assemblies that represent and process words with different action-related meanings. *Nature Reviews Neuroscience* 6, 576-582 (July 2005)





Electrophysiological Recording from Songbird Auditory Forebrain

http://www.ploscompbiol.org/article/slideshow.action?uri=info:doi/10.1371/journal.pcbi.0020161&imageU RI=info:doi/10.1371/journal.pcbi.0020161.g001#





http://naranja.umh.es/~np/index.php?option=com_content&task=view&id=14&Itemid=29



Cyborg

A cybernetic organism (i.e., an organism that has both artificial and natural systems).



Cyborg Steven Hawking

http://igargoyle.com/archives/2006/04/steven_hawkings.html







뇌공학의 현재와 미래: 뇌를 바꾼 공학 공학을 바꾼 뇌 (임창환)

BCI (Brain Computer Interface)

BCI Technology

Brain Computer Interface Connects brain with computer.





braingate technology

fMRI dreaming recording

Mind reading: No Lie MRI

Brain implant technology

Brain stimulation therapy

Neurofeedback technology:

braingate technology: https://www.youtube.com/watch?v=QRt8QCx3BCo



fMRI dreaming recording:

Presented clip



Clip reconstructed from brain activity



http://dana.org/Briefing_Papers/fMRI__Not_a_Mind_Reader_(Yet_)/ https://sploid.gizmodo.com/incredible-experiment-opens-door-todreams-and-memories-1553746627

No Lie MRI



http://www.noliemri.com/

Brain implant technology: https://www.youtube.com/watch?v=PVFSIbZz_NE

Deep brain stimulation





1.5 mm Mind over matter Scientists hope Microexperiments electrode allowing array monkeys to will measure brain control a activity while paralyzed patients computer Motor 7 imagine physical cursor through cortex movements. A brain activity computer will then could be be programmed applied to to recognize the paralyzed patterns and humans. perform functions, such as moving a computer cursor. SOURCE: Cyberkinetics

Dan DeLorenzo+AP

Brain stimulation therapy: http://news.joins.com/article/22111361

TMS (transcranial magnetic stimulation) therapy



remote brain control: https://www.youtube.com/watch?v=SBhx_tGWmZY



Neurofeedback technology: https://www.youtube.com/watch?v=ebd86jSG2Dc



What is Neurofeedback ?



BrainTrainUK