Brain and Nervous System
Gleitman *et al*. (2011), Chapter 3, Part 2

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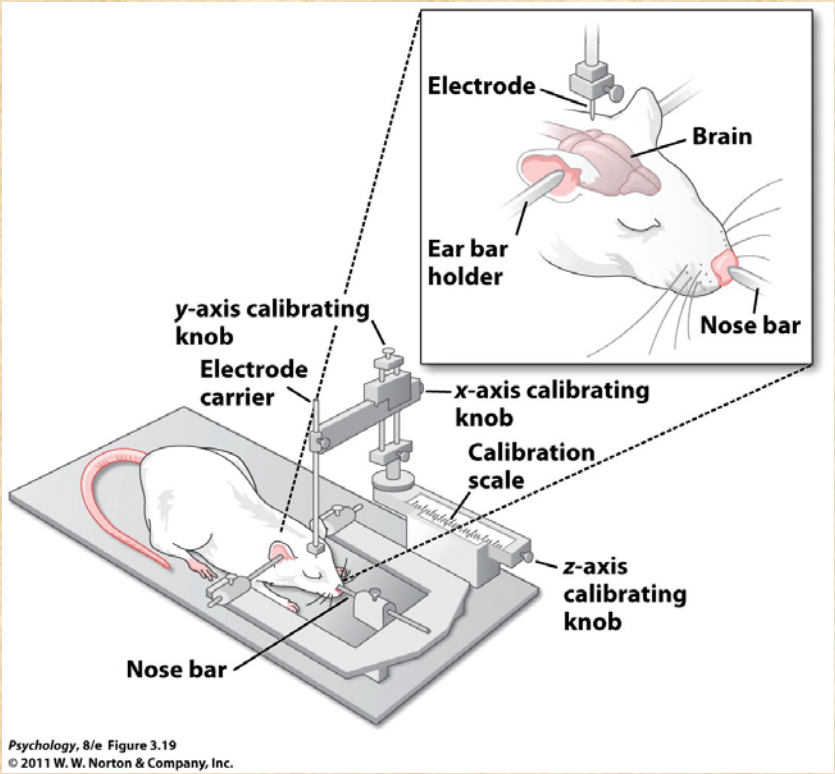
Psych 9A / Psy Beh 11A
January 23, 2014

Studying the Nervous System

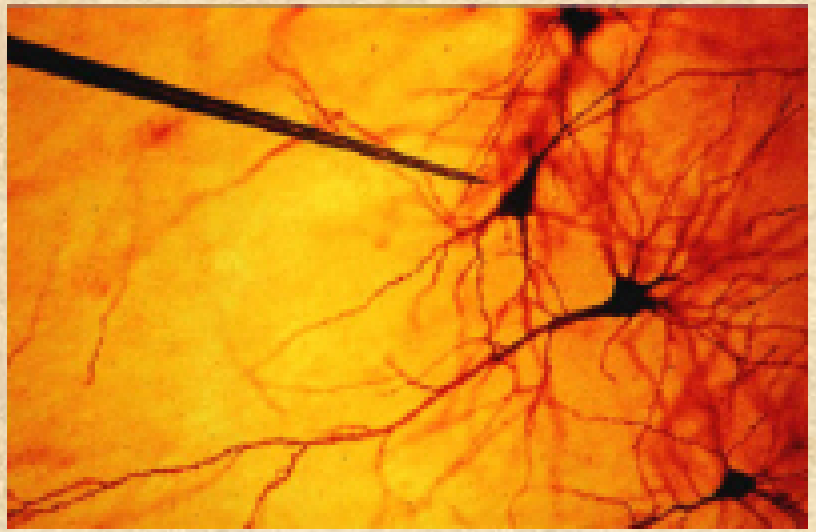
- Some sources of data about the nervous system
  - single-unit recording (from an individual cell)



stereotaxic apparatus

Studying the Nervous System

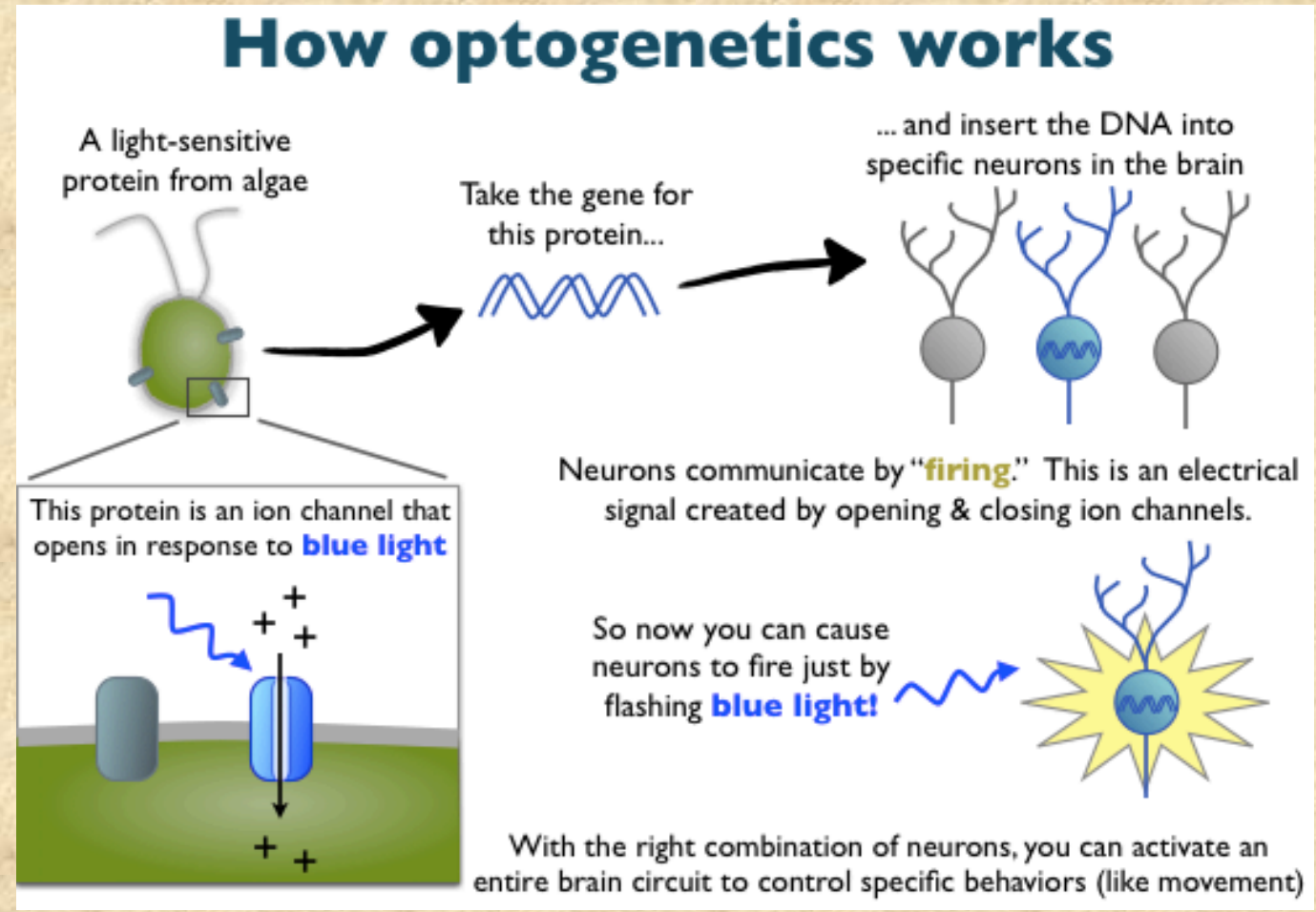
- Some sources of data about the nervous system
  - single-unit recording (from an individual cell) & stimulation



Electrode: recording or stimulating

Studying the Nervous System

- Optogenetics: *single-unit stimulation* using light



Studying the Nervous System

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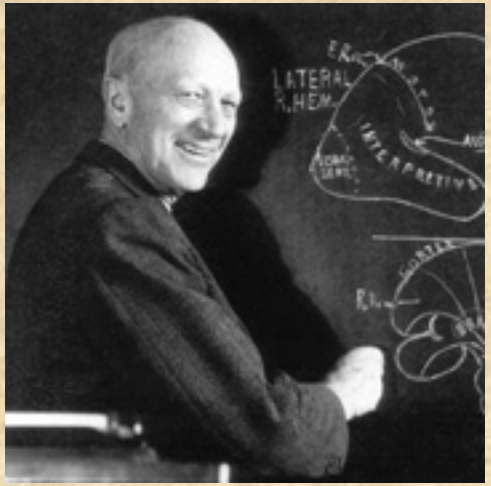
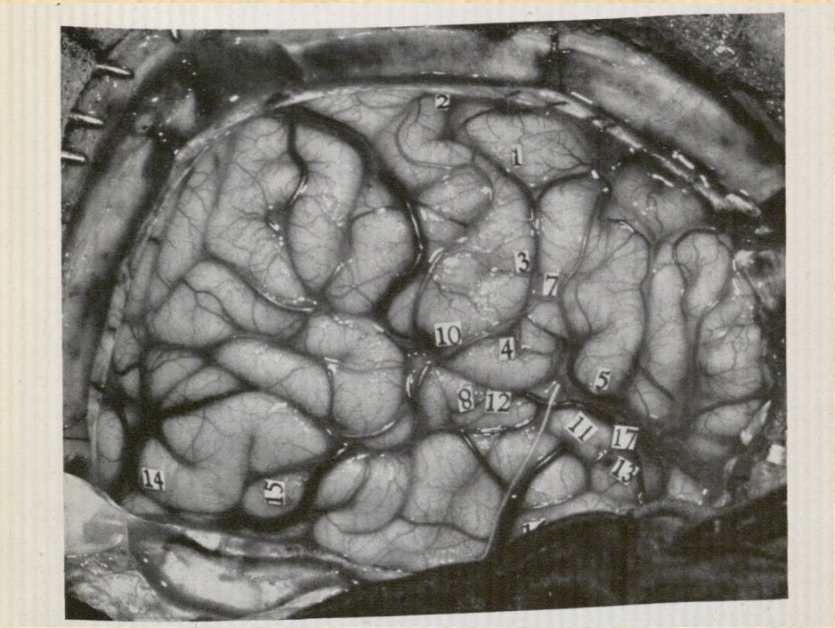
  - single-unit recording (from an individual cell) & stimulation
  - multi-unit stimulation (a number of cells)



Wilder Penfield



Electric stimulation of an alert human's cortex prior to neurosurgery for removal of epileptic foci

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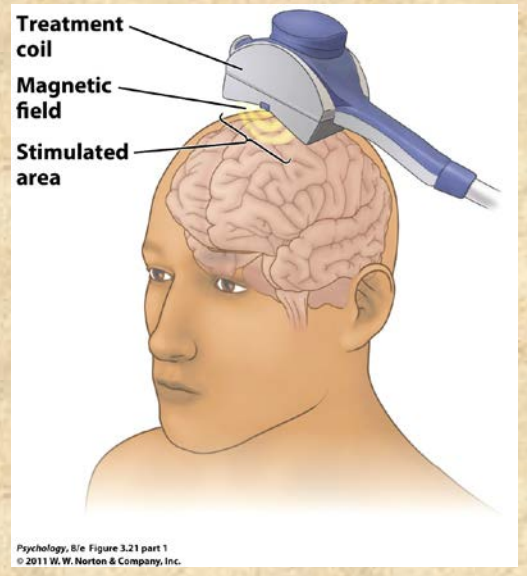

Trans-Cranial Magnetic Stimulation (TMS)

Magnetic pulses disrupt function of underlying cortex and areas to which the underlying cortex is connected

Studying the Nervous System

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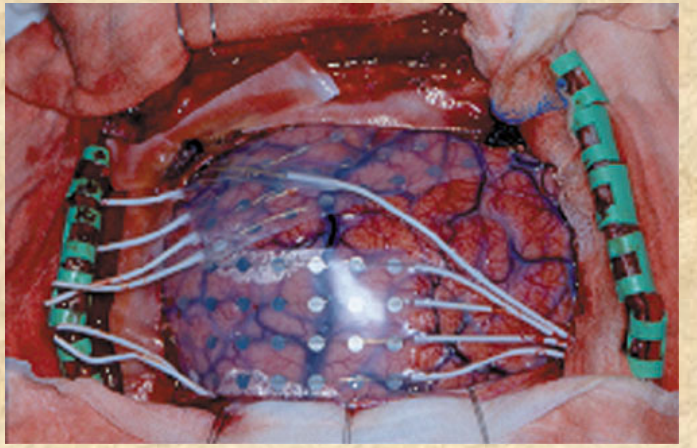
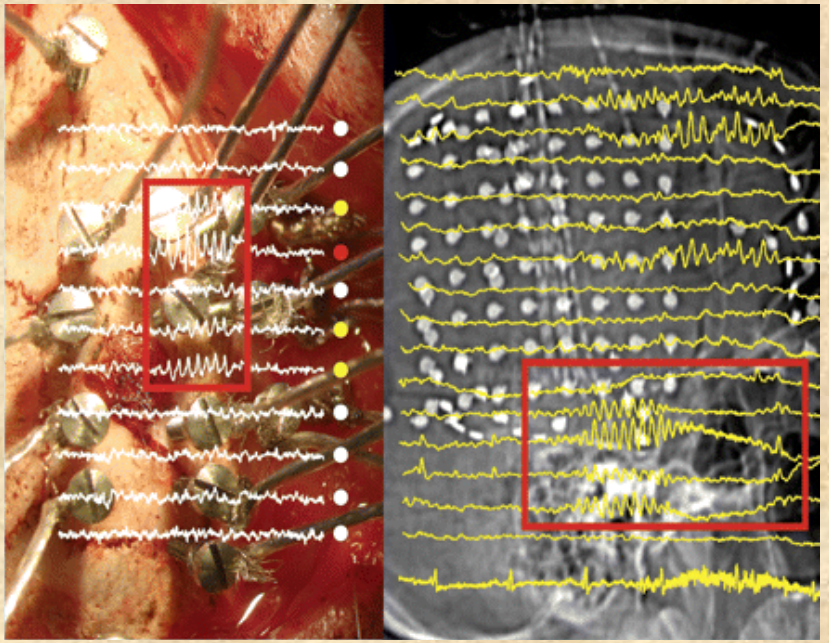
  - multi-unit stimulation (a number of cells)
  - multi-unit recording



Electrocorticography
(ECoG)



Neural activity during a seizure (red boxes)

Studying the Nervous System

- Some sources of data about the nervous system
  - single-unit recording (from an individual cell) & stimulation
  - multi-unit stimulation (a number of cells)
  - multi-unit recording
  - brain damage

Impairments caused by brain damage can provide important information on the function of the damaged brain areas.

Result of a stroke: temporal lobe infarction & bleeding

Studying the Nervous System

Phineas Gage suffered severe damage to his left frontal lobe due to the passage of an iron rod through this head.

His behavior and personality were noted to have changed as a result of the accident.

John Harlow on Phineas Gage: The equilibrium or balance, so to speak, between his intellectual faculties and animal propensities, seems to have been destroyed. He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operations, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man. Previous to his injury, although untrained in the schools, he possessed a well-balanced mind, and was looked upon by those who knew him as a shrewd, smart businessman, very energetic and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decidedly that his friends and acquaintances said he was "no longer Gage".

Studying the Nervous System

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  - single-unit recording (from an individual cell) & stimulation
  - multi-unit stimulation (a number of cells)
  - multi-unit recording
  - brain damage

    • Phineas Gage: effects of damage to frontal lobes
    • Hans-Lukas Teuber's studies of occipital lobe damage due to penetrating missile wounds
    • Lesions to temporal lobes cause damage to speech production and perception (early identification of Broca's & Wernicke's areas)

    • There are also a very large number of animal studies where various kinds of lesions are made on purpose. The rationale is like that behind TMS studies: to learn more what an area of the brain does by rendering it non-functional.

Studying the Nervous System

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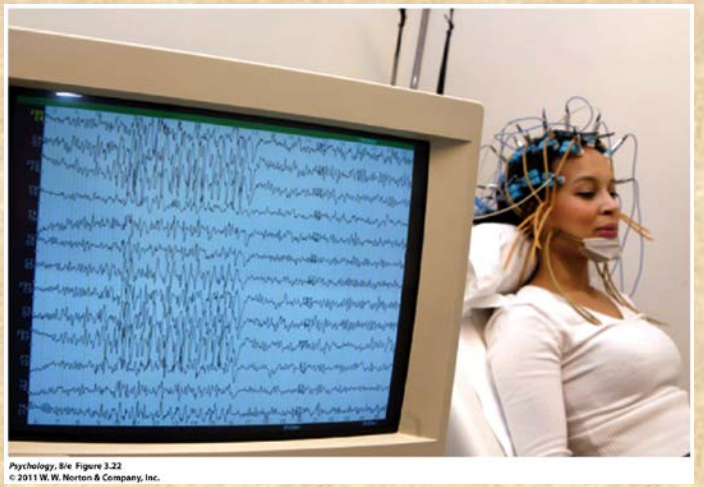
  - single-unit recording (from an individual cell) & stimulation
  - multi-unit stimulation (a number of cells)
  - multi-unit recording
  - brain damage
  - brain imaging

Electroencephalography (EEG)

-measure electric fields at surface of scalp
-moderate spatial localization
-excellent temporal localization (very fast)
-relatively inexpensive, portable, non-invasive



In wide use.
For example, neuromarketing (http://www.sandsresearch.com/)
http://today.msnbc.msn.com/id/26184891/vp/29480666#29480666

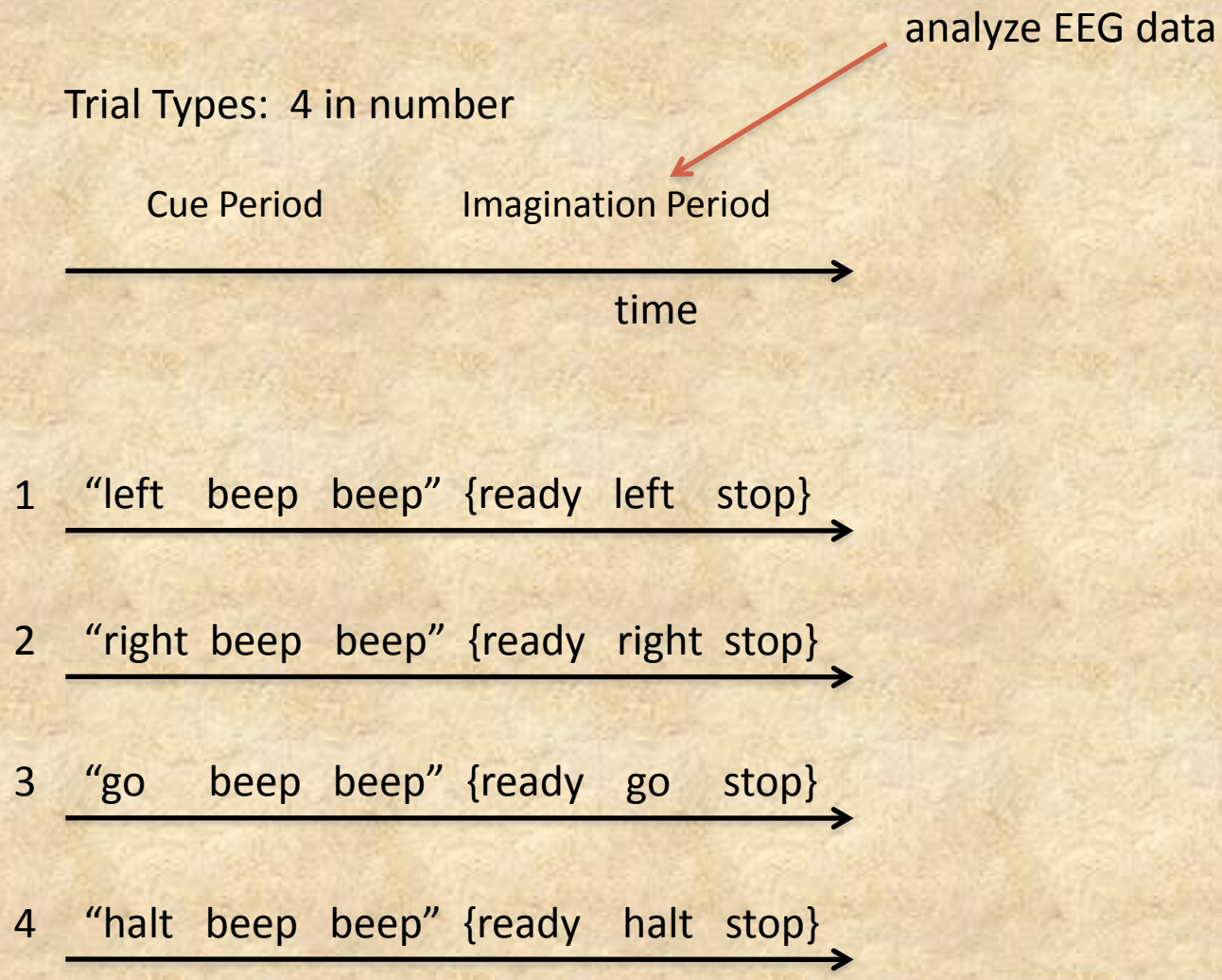
BCI Software for Online Classification

Use EEG to provide streaming features to control systems which direct the activities of various end-applications.

- Mode of operation 1: One conducts training experiments and classifies data from these experiments online. Discriminators based on the experimental data classification are applied to incoming EEG data to generate the streaming features needed by control systems. This mode of operation is best if one does not know in advance which channels and frequencies are informative.

- Mode of operation 2: One can use predefined discriminators, which may be best if
  - one already knows, for a particular subject and application, how control is best achieved, or
  - one prefers that the subject learn to emit pre-specified brain waves.

Sample Experiment for use in controlling Left/Right and Go/Halt in a 3D action game.



A Brain-Computer Interface for Quake 2

Cognitive NeuroSystems Lab
University of California, Irvine
May 20, 2010

Funded by the
Army Research Office

How well can we extract brain signals from EEG when a person is moving around normally?

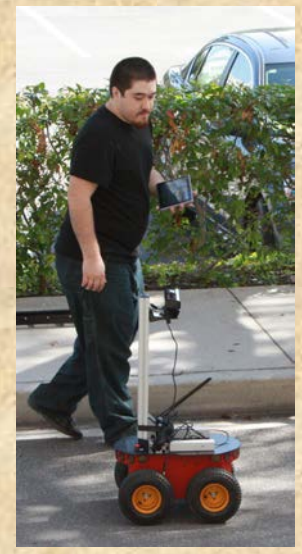
DURIP-funded portable, tetherless EEG systems by ANT

Mobile EEG

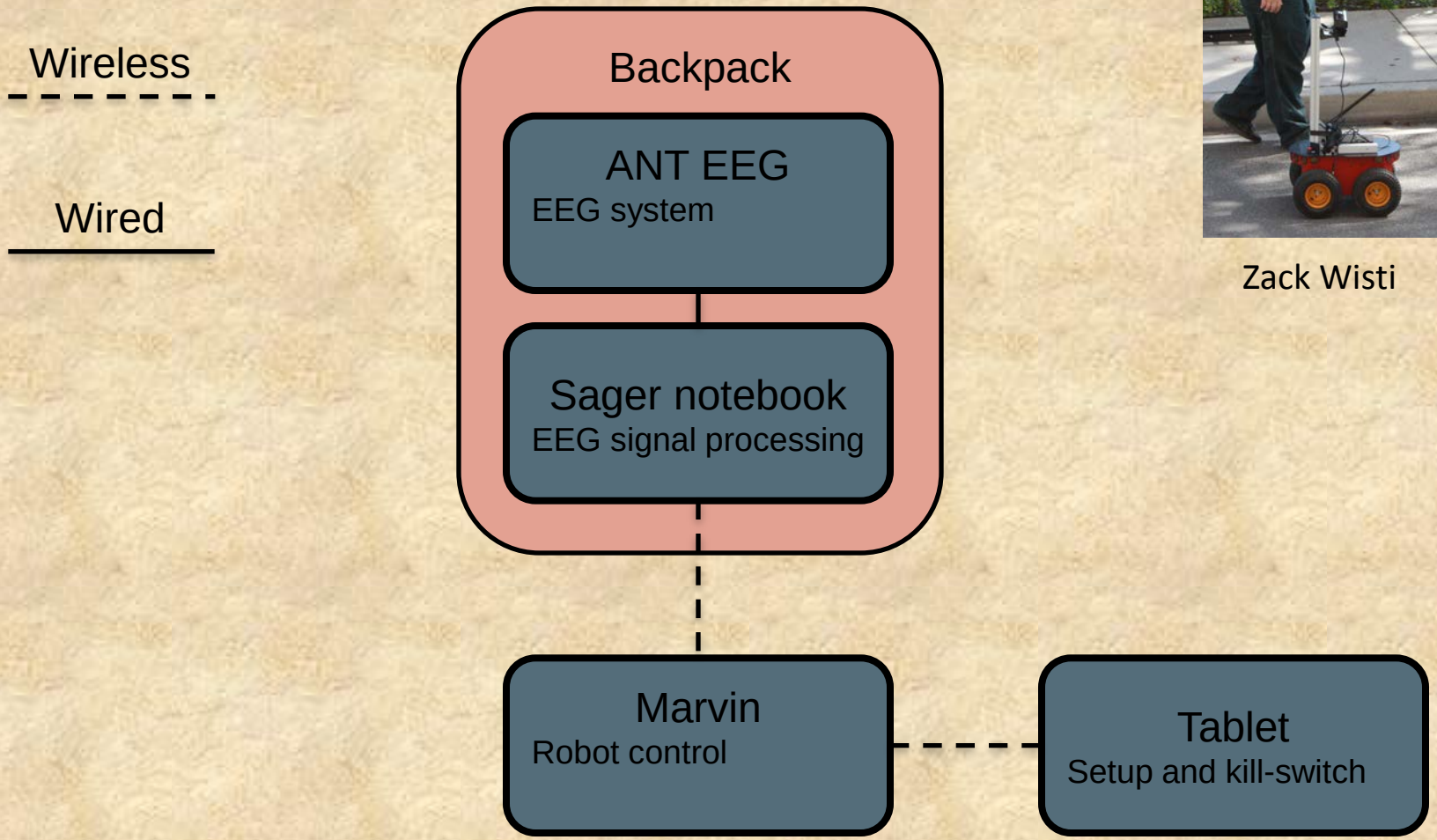
Marvin the Robot

Max speed 2.5 mph
Front and rear sonar, 15 cm – 7m
Onboard Computer
Wireless Connection

EEG-Robot System Setup



Zack Wisti

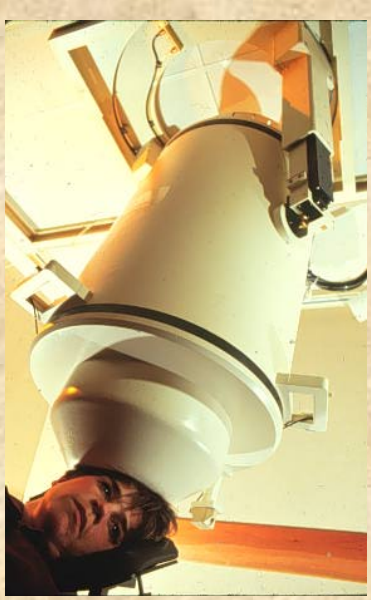


Robot Remote Control Using Mobile EEG

This takes some practice…

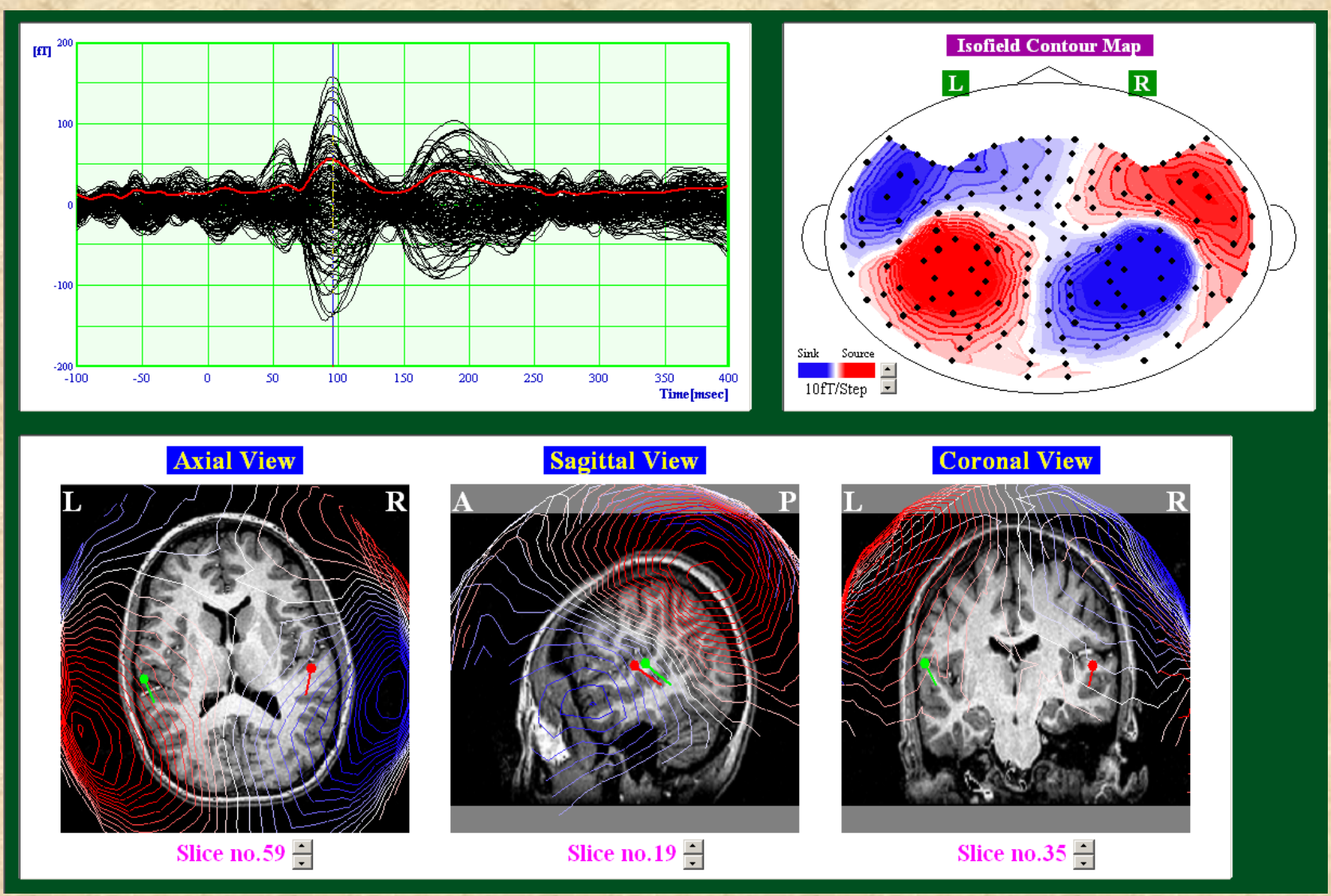
Magnetoencephalography (MEG)

-measure magnetic fields at surface of scalp
-moderate spatial localization
-excellent temporal localization (very fast)
-very expensive and unwieldy, portable, non-invasive
-well-known studies of auditory cortex function



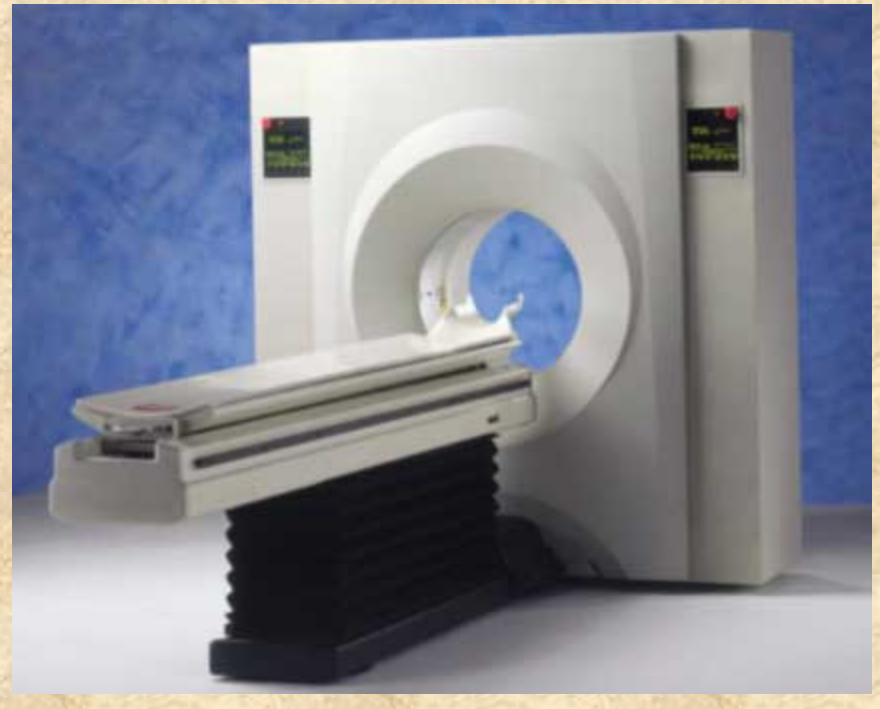
from Henry Yau, http://amath.colorado.edu/courses/4380/2003fall/meg.ppt

MEG Study: Mental imagery (Tian & Poeppel, 2011)



Positron Emission Tomography (PET)

-feed the subject radioactive glucose, which is then taken up into active brain areas and can be imaged



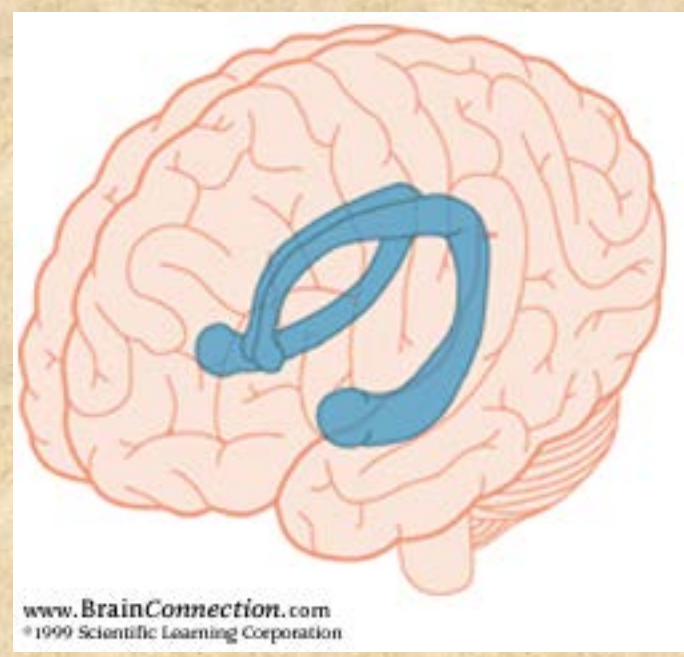
from http://www.radiologyinfo.org/content/petomography.htm

Maguire's PET Study (1997)

Neurons in the hippocampus are likely to be very active in maintaining a representation of the environment's layout

"Place cells" – in rats, these cells fire when the rat is in a particular place.

In humans, high hippocampus activation when navigating their environment.



Hippocampus - blue

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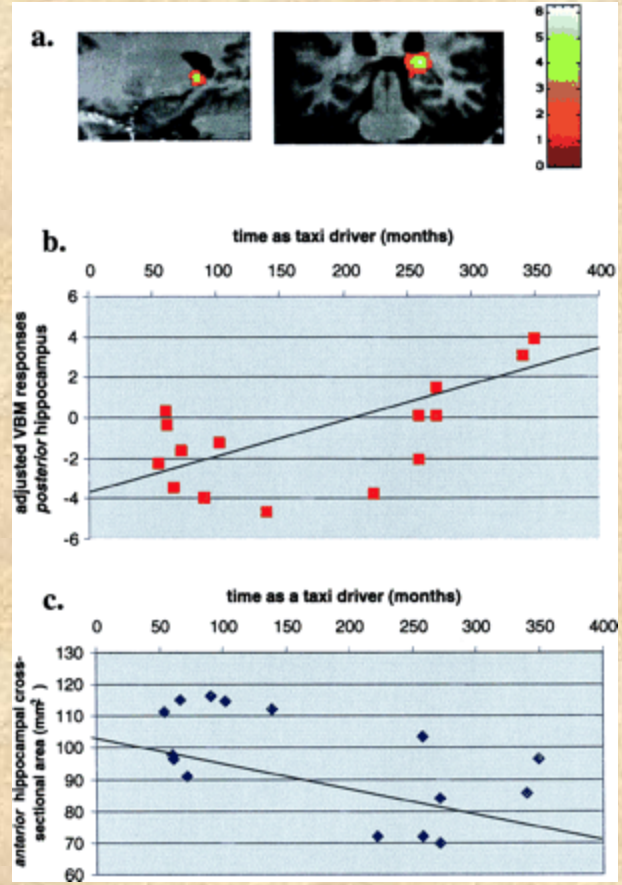
Eleanor Maguire & the London taxi-drivers

1) greater *posterior* hippocampus volume among the drivers than among normals

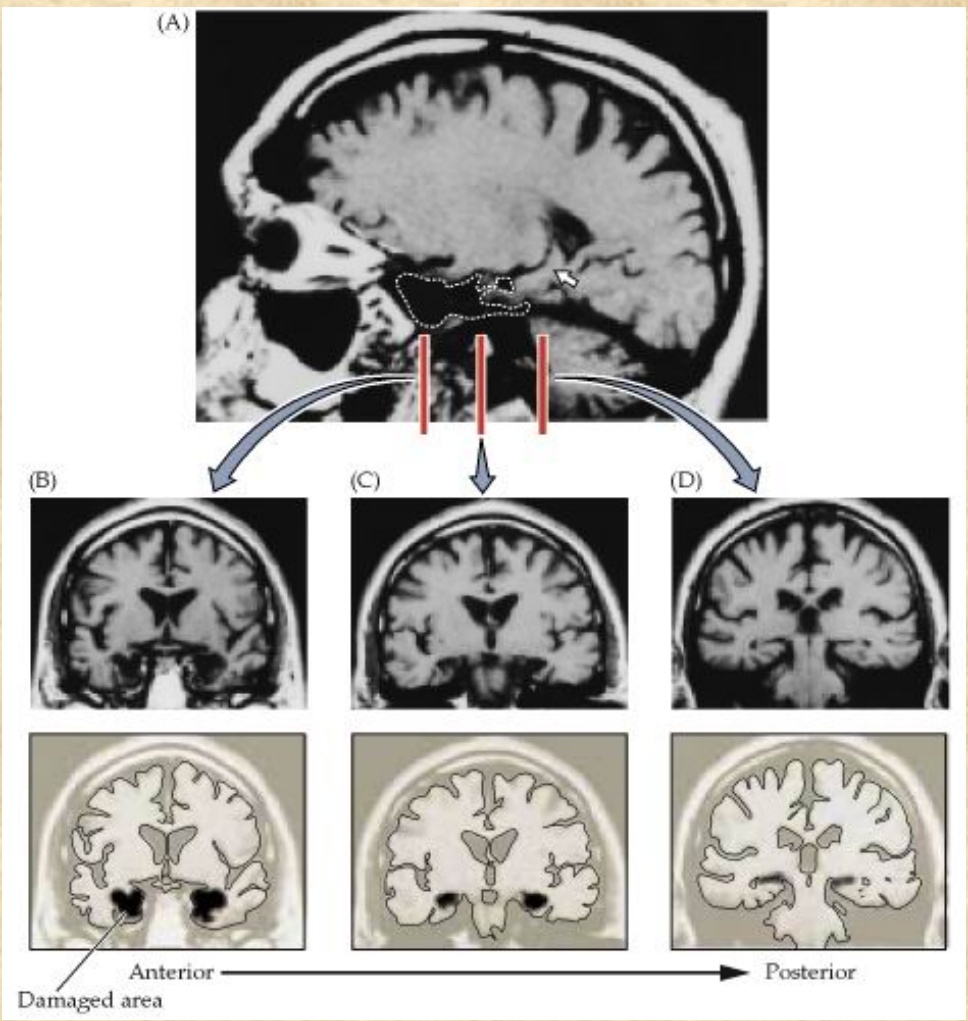
2) the longer the taxi-driver has spent driving the taxi, the greater the posterior hippocampal activation as determined by PET scan



MRI – magnetic resonance imaging

Structural MRI scans provide a wealth of anatomical information.

For example, these brain scans show damage to the hippocampus and neighbor structures in a patient suffering from anterograde amnesia.



Functional Magnetic Resonance Imaging (fMRI)

-measures local blood flow in brain

-spatial resolution on order of 1 mm: good

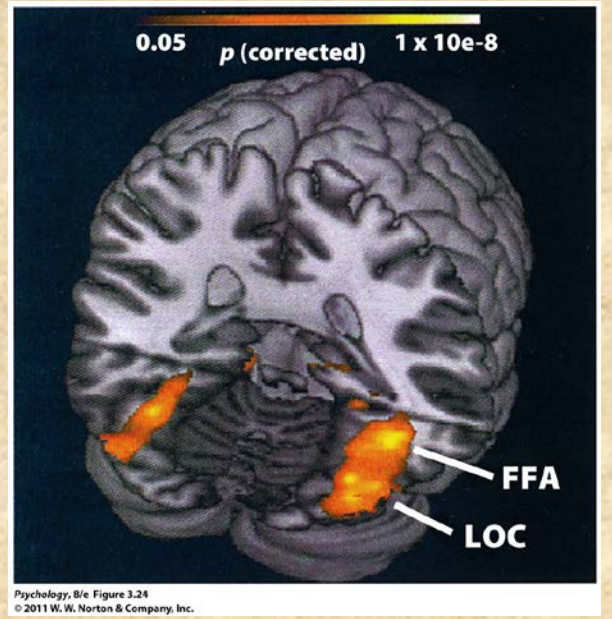
-temporal resolution on the order of seconds: not so hot

-non-invasive (other than the strong magnetic field)

-unwieldy

-many nice neuroscientific results in the past 2 decades

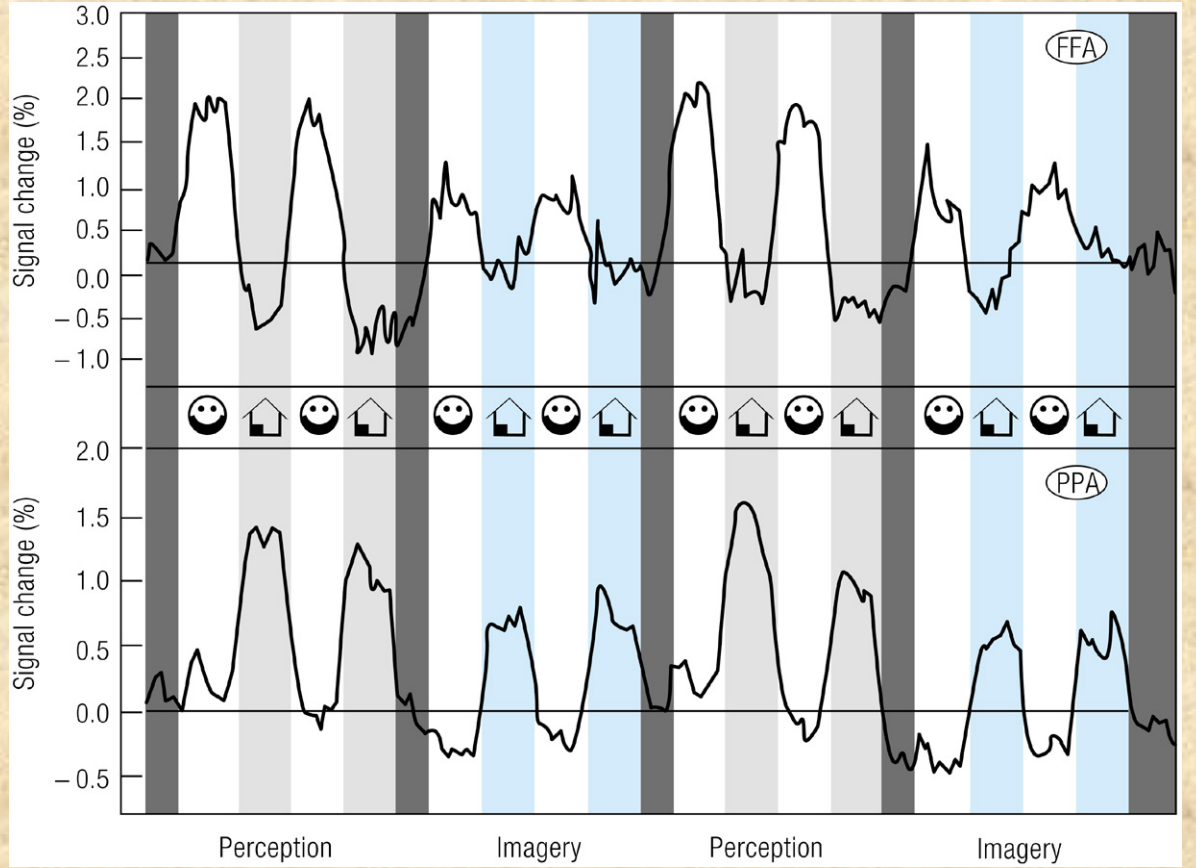
from the Howard Hughes Medical Institute, http://www.hhmi.org/senses/e110.html



fMRI localization of activity to LOC and FFA during a face-inspection task

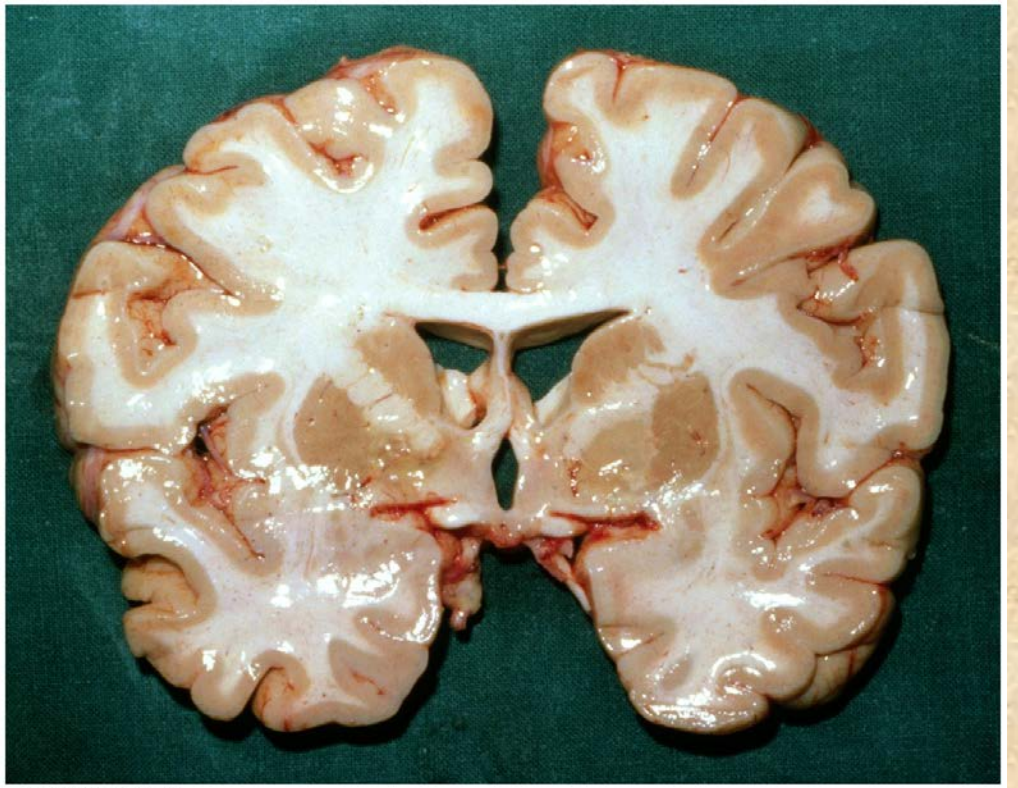
O’Craven & Kanwisher – fMRI Study of Faces & Places (2000)

- with fusiform face area (FFA) and parahippocampal place area (PPA) the regions of interest
- subject alternates between either viewing faces/scenes or imagining faces/scenes
- FFA and PPA modulated by imagery in manner similar to actual stimuli



Diffusion Tensor Imaging (DTI) – a form of MRI

- measures ability of water molecules to diffuse (move) in different directions
- in the brain, their ability to move depends primarily on the orientation of axons making up white matter; water moves best along the length of the axon
- non-invasive measurement of white matter (axon) anatomy in living humans



Psychology, 8/e Figure 3.8

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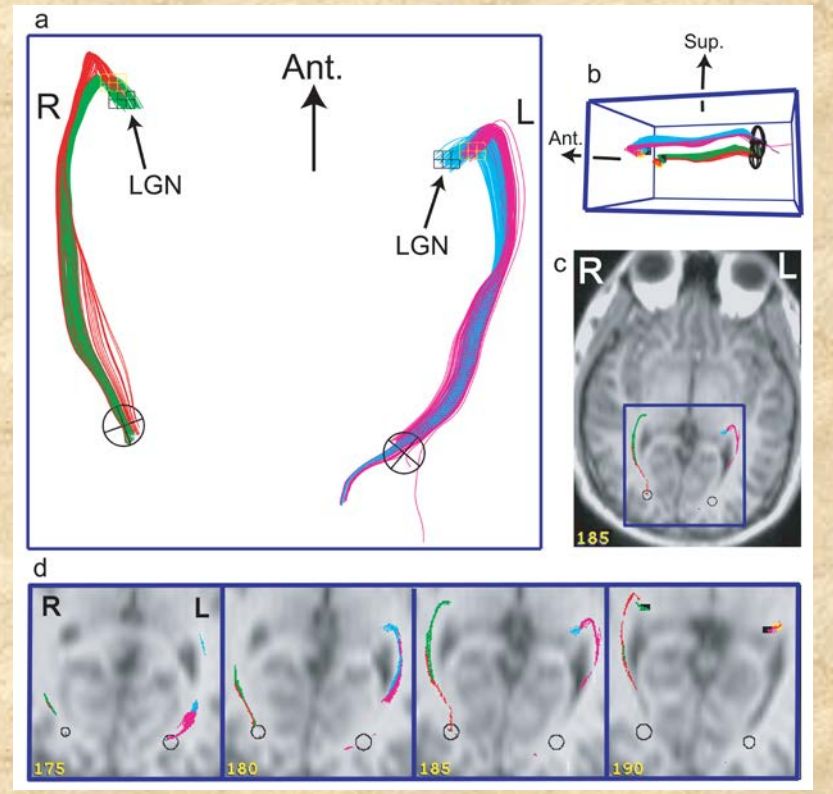
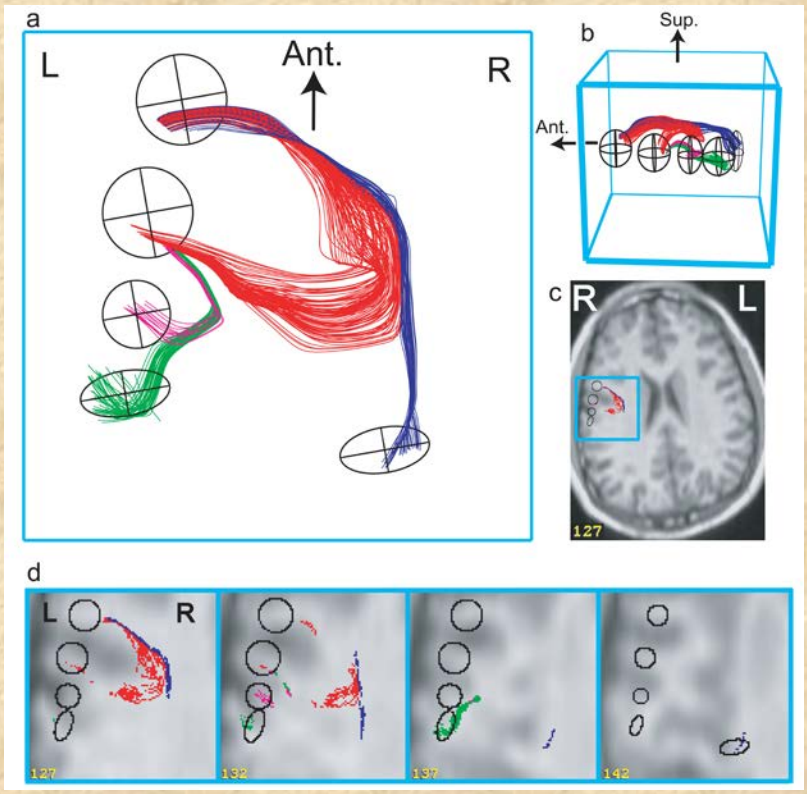
Conturo *et al*., 1999



geniculo-calcarine tracts



parietal association fibers