Methods of Visualizing the Living Human Brain

- Contrast X-rays
- Computerized Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Positron Emission Tomography (PET)
- Functional MRI
- Magnetoencephalography (MEG)

Contrast X-rays

- Substance that absorbs X-rays is introduced into the structure of interest to make it stand out
- Cerebral angiography: dye injected into carotid artery – reveals displacement or enlargement of blood vessels
Computerized Tomography (CT)

- Uses a computer to combine many individual X-rays to produce a three-dimensional picture of the brain
- Not particularly high-resolution

A series of CT scans from a patient with a lesion in the right occipital-parietal area (scan5)
Magnetic Resonance Imaging (MRI)

- MRI passes strong magnetic field through head, causing certain molecules (hydrogen) to spin with a particular orientation.
- Advantages:
  - Does not expose the brain to X-ray like CT scan
  - Better anatomical resolution than CT
- Disadvantages?? $$$

Positron Emission Tomography (PET)

- Provides images of brain activity, rather than structure
- Inject radioactive 2-deoxyglucose (2-DG) into patient’s carotid artery
- 2-DG is taken up into active neurons.
- PET measures the level of radioactivity of cells in brain regions
PET scans of a human brain (horizontal sections).

Functional MRI

- fMRI detects the regional changes in blood oxygenation due to activity-related changes in blood flow:
  - More active neurons
  - --> more blood flow
  - --> more O2

Advantages over PET:
- Nothing injected
- Provides structural and functional info
- Better resolution
Magnetoencephalography (MEG)

- Measures brain activity in terms of changes in magnetic fields measured on the surface of the scalp.
Methods of Visualizing the Living Human Brain

Neurobiology of Meditation

The Measurement of Regional Cerebral Blood Flow During the Complex Cognitive Task of Meditation: a Preliminary SPECT Study.

A. Newberg and colleagues Psychiatry Research, 2001 (106) 113-122.

From T. Hernandez
Neurobiology of Meditation

Hypothesis: Given that meditation has been shown to...
✓ lower heart rate
✓ decrease oxygen consumption by 17%
✓ increase theta brain waves (theta=wave pattern right before sleep but not during sleep), also associated with imagery, creativity)
......then there should be alterations in brain function associated with the meditative state.

From T. Hernandez

Neurobiology of Meditation

Methods:
Measure blood flow using SPECT (single photon emission computed tomography) before and during meditative state.

n=8 highly experienced Tibetan Buddhist mediators

Within-subject control: subject serves as own control

From T. Hernandez
Neurobiology of Meditation

What is SPECT?  
Subject injected with a radiolabeled tracer. The pattern with which this tracer accumulates in the brain is measured.

Advantages? Can use commercially available tracers; tracers more stable (compared to PET)

Disadvantages? Low anatomical resolution (compared to PET, fMRI); injection of tracer

Results: INCREASED prefrontal activation seen with meditation. Prefrontal cortex important for focusing attention and concentration.

From A. Newberg, 2001
**Results:** DECREASED parietal activation seen with meditation. *Parietal lobe important for our sense of orientation in space and time.*

**Baseline**

**Meditation**

From A. Newberg, 2001

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**Neurobiology of Acupuncture**

Acupuncture: a traditional Chinese healing art used as adjunct therapy for

- Chemotherapy-associated nausea
- Post-surgical dental pain
- Drug addiction
- Stroke rehabilitation

Mechanisms underlying acupuncture’s effects are being investigated.

From T. Hernandez
Goal of a study by R. Gollub and colleagues at Massachusetts General Hospital and Harvard:

*Use fMRI to identify what brain structures are activated by acupuncture “needling” in healthy subjects.*

**Methods** Scan brain (with fMRI) before, during and after acupuncture needling AND compare this with tactile stimulation (no needle) over same region.

**Results**

<table>
<thead>
<tr>
<th>Region Affected</th>
<th>ACUP</th>
<th>Level of Activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>somatosensory cortex</td>
<td>increased</td>
<td></td>
</tr>
<tr>
<td>thalamus</td>
<td>decreased</td>
<td></td>
</tr>
<tr>
<td>hippocampus</td>
<td>decreased</td>
<td></td>
</tr>
<tr>
<td>amygdala</td>
<td>decreased</td>
<td></td>
</tr>
<tr>
<td>nucleus accumbens</td>
<td>decreased</td>
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</tbody>
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From T. Hernandez
Neurobiology of Acupuncture

Where is somatosensory cortex? Where is nucleus accumbens?

Neurobiology of Acupuncture

Can the level of activation in certain regions help explain acupuncture’s therapeutic effects?

**Region Affected and Why**

**ACUP**
- somatosensory cortex increased
  - somatosensation of the needle being inserted
- thalamus and hippocampus decreased
  - perception of pain
- amygdala and nucleus accumbens decreased
  - craving sensation associated with cocaine use

**CTRL**
- somatosensory cortex increased
  - somatosensation of tactile stimulation (touch)

From T. Hernandez