Chapter 2

The Neural Basis of Cognition

Capgras Syndrome

- Alzheimer's patients & others – delusion that significant others are robots or impersonators
- - paranoia
- Two brain systems for facial recognition
- - 'cognitive' – feature analysis, matching to stored info
- - 'emotional' – feeling of familiarity, positive affect
- In Capgras, 1st system okay, damage to 2nd system

Capgras Syndrome - 2

- Neuroimaging shows damage to right temporal lobe (amygdala & connecting circuits)
- Amygdala is emotional evaluator
  - Feelings of familiarity + positive affect
    - Emotional decision making
      - Emotional memories

Capgras Syndrome - 3

- Damage to right prefrontal area
  - schizophrenics have diminished activity in frontal lobes when hallucinating
  - area involved in distinguishing real and imagined events (or plausible vs. implausible events)
  - Schizophrenics can't distinguish hallucinations from reality
  - Alzheimer's patient – generates 'weird' hypotheses about unfamiliar person

How the Brain Works

- Note importance of many areas of the brain working together in recognizing a person
  - Visual processing (occipital lobe)
  - Matching visual input to stored faces
  - Recognizing who the person is (family, friend, neighbour etc.)
  - Recalling person's name (phonological retrieval)
  - Feeling of familiarity
  - Emotional response (like or dislike the person)
  - If person looks different, generate hypothesis why (new glasses or haircut, or space alien)

Sinkman Article

- What explanations have been proposed for Capgras Syndrome?
- What symptoms did the three patients have in common?
- What symptoms exhibited by Sinkman's patients are inconsistent with the explanation of Capgras Syndrome offered by Reisberg?
- What explanation does Sinkman offer?

The Principle Structures of the Brain

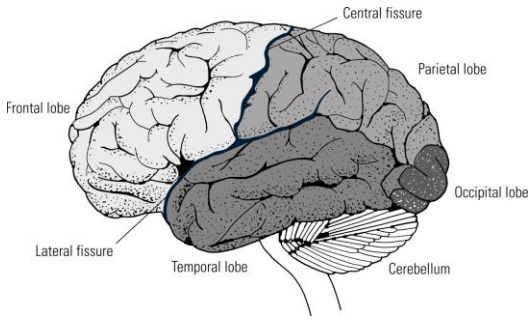
1. Brain Stem
   - Includes hindbrain, midbrain & *diencephalon* (thalamus and hypothalamus)
2. Hindbrain
   - Key life functions – heart rate, respiration rate, posture & balance
   - includes medulla oblongata (continuous with spinal cord), pons (above medulla) & cerebellum
   - *Cerebellum* involved in coordination of movement & balance, motor learning
   - *Reticular System*- Regulates brain's level of alertness – in pons and medulla

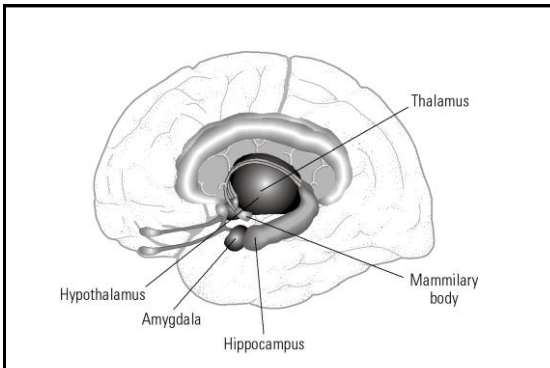
The Principle Structures of the Brain

3. Midbrain (Mesencephalon)
   - above pons, below diencephalon
   - coordinates eye movements
   - relays auditory information to forebrain
   - regulates experience of pain

The Principle Structures of the Brain

4. Forebrain
   - *diencephalon* & *telencephalon* (or *cerebrum)*
   - outer surface is *cortex*
     - hills (convolutions or gyri) & valleys (*sulci*)
   - *longitudinal fissure* separates 2 hemispheres
   - 4 lobes: *frontal*, *parietal*, *occipital* & *temporal*
   - *central (or Sylvian) fissure* separates frontal & parietal lobes





The Principle Structures of the Brain

5. Subcortical structures

- *diencephalon: thalamus* & *hypothalamus*
  - thalamus: relay station for sensory information going to cortex
  - hypothalamus: control of eating, drinking, sex

- *limbic system:*
  - *hippocampus* - memory & learning
  - *amygdala* – emotional evaluator

- *commissures* – bundles of fibres that connect the two hemispheres of the brain
- *corpus callosum* – largest body of fibres connecting the two hemispheres

Neuroimaging Techniques

- CAT scans (computerized axial tomography) – X-rays
- PET scans (positron emission tomography) – measures blood flow in the brain
- MRI (magnetic resonance imagery) – changes in magnetic field
  - fMRI (functional MRI) scans brains of awake people in real time. Measures blood flow and oxygen use.
- ** Any cognitive task requires use of many brain areas. Localization of function is not 100% specific

Neuroimaging – Tong et al. Study

Evidence for functional specialization

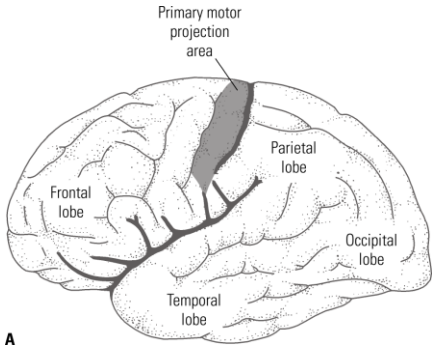
- Activation in *fusiform face area* (FFA) when Ss shown faces
- Activation in *parahippocampal place area* (PPA) when Ss shown houses, landscapes,
- Binocular rivalry – different stimuli to each eye → S sees only one stimulus at a time. Perceptions alternate
- fMRI scans show activation patterns reflect Ss conscious perception

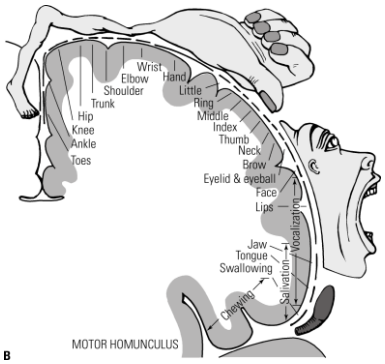
The Primary Motor Projection Areas

Contralateral control: left side of brain controls right side of body
- *Ipsilateral* = same side
- *Contralateral* = opposite side

- In front of central fissure in frontal lobe (See Figure 2.1 in text)

- Areas of brain control movement in specific areas of body (See Figure 2.2 in text)
- Stimulation produces specific movements





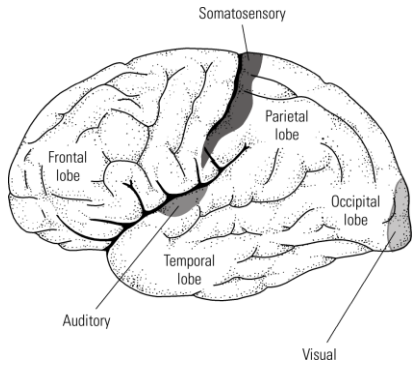
The Primary Sensory Projection Areas

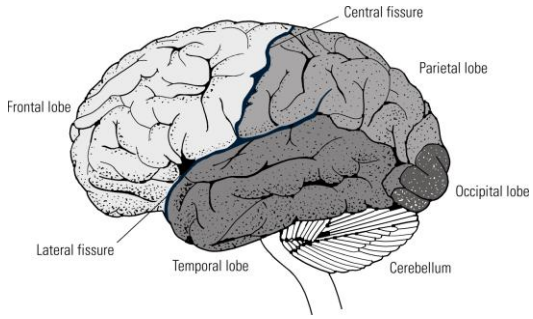
1) Somatosensory – behind central fissure in parietal lobe

2) Visual – in occipital lobe

3) Auditory – upper part of temporal lobe adjacent to Sylvian fissure or lateral fissure

- Each area provides a map: (1) map of body, (2) map of visual space, (3) map of frequencies





The Primary Sensory Projection Areas

1) Somatosensory map – body parts represented according to sensitivity to touch, not actual size

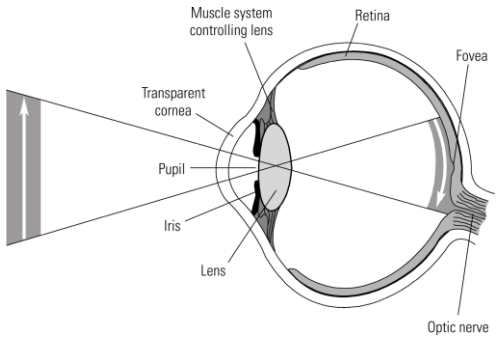
2) Visual – left visual field processed in right hemisphere, right visual field in left hemisphere
   - each eye represented in both hemispheres

3) Auditory – left ear projects to right hemisphere and right ear to left.

- Contralateral connections

Association Areas

- *nonprimary motor areas* – initiation and coordination of movements
- *nonprimary sensory areas* – interpretation of sensory info & cross-modal integration
- deficits:
  - *Apraxias* – initiation of voluntary movement
    - frontal lobe
  - *Aphasias* – language disorders
    - Broca's area → expressive disorder
    - Wernicke's area → receptive disorder
    - Angular and supramarginal gyri – dyslexia, discalculia, disconnection syndrome
  - Neglect – usuallyright parietal lobe damage
  - *Agnosias* – inability to identify stimuli
    - modality specific - occipital (visual), temporal (auditory)
  - Frontal lobe damage – disorders of planning & strategy implementation, inhibition of responses, Capgras Syndrome



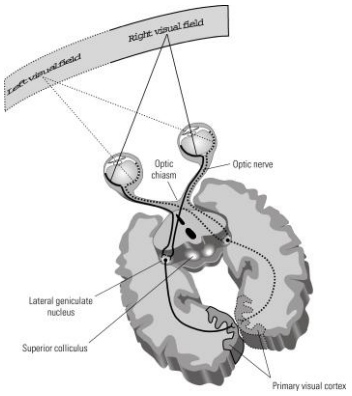
The Visual System

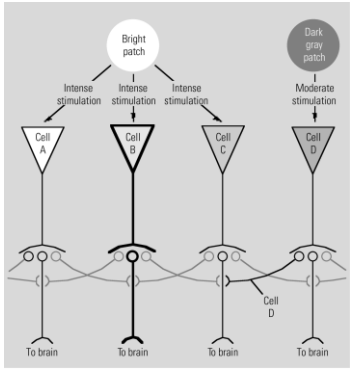
Parts of the Eye

- Cornea, iris, lens, retina, fovea
- Photoreceptors:
  - Rods - dim light, no colour vision, in peripheral vision
  - Cones - colour vision, in foveal vision, higher acuity than rods → fine detail

Optic Nerve

- Rods & cones → *bipolar cells* → *ganglion cells* = optic nerve
- Optic nerve → *lateral geniculate nucleus* (LGN) in thalamus → occipital lobe

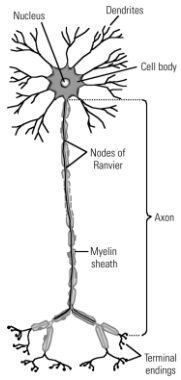




The Visual System

Lateral Inhibition

- Lateral Inhibition
  - Observed at many levels in visual system
  - Retinal cells A, B, & C stimulated by light, adjacent cell D not stimulated.
  - Cells A. B, & C strongly inhibit all adjacent cells. Cell D inhibits Cell C weakly .
  - Cell C inhibited strongly by B & weakly by D.
  - Cell B inhibited strongly by both A & B. More total inhibition for B than C. ▲Cell C more active than Cell B.
  - → cells on edge of stimulation are more active than cells in middle of stimulation and less active then cells not being stimulated.
    - *Edge enhancement*



Neurons

Parts of a Neuron

- Cell Body
- Axons – send signals to other neurons
  - Signal is all or nothing. Cell "fires" or not.
  - If cell fires, tips of the axon branches release neurotransmitters
- Synapse – gap between axon and dendrite
  - Neurotransmitters taken up by dendrite of second neuron
- Dendrites – receive stimulation from other neurons

Neurons - 2

Dendrites – receive stimulation from other neurons

- Neurotransmitter → changes in *postsynaptic* membrane → activation of second neuron
- Activation level varies in size. If activation reaches *threshold*, the cell fires.
  - Signal is all or nothing
  - Frequency of firing varies depending on input
- Input (excitatory & inhibitory) from many connecting neurons determine whether a neuron fires or not.

- Single-cell recording – record firing rate of individual neurons in response to various stimuli.
- Receptive Field – size and shape of area in visual world to which cell responds.

Receptive Fields

Center-surround Cells

- increase firing in response to "dots" of light in specific locations in visual field
- Light in center of receptive field has one effect (increasing or decreasing firing) and light is surround has opposite effect
- Light over entire receptive field has no effect
- found in LGN & projections of LGN in cortex (Area V1)

Receptive Fields - 2

Edge & Line Detectors: cells that respond to lines or edges of a particular orientation.

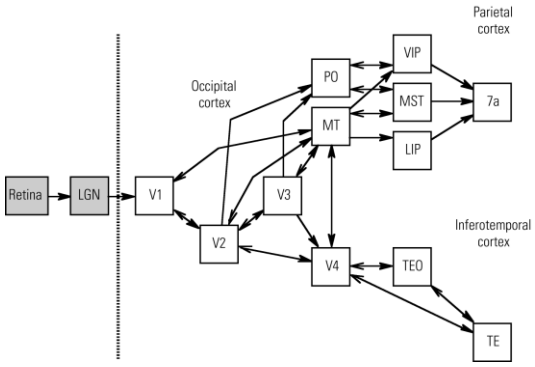
- different cells respond to different orientations.

Movement Detectors – respond when line or edge moves in certain direction

Angle Detectors – respond to angle of particular size

Parallel Processing

- Different layers in V1 & different areas of visual cortex have different jobs.
- Parallel processing →Mutual influence between different processes
  - → fast processing
- Parvocellular cells – in LGN. – specialized for spatial analysis & form.
- Magnocellular cells – in LGN. – specialized for motion detection & depth perception



Parallel Processing

"What" System: occipital →temporal
- object identification
- damage → visual agnosia

"Where System: occipital→parietal
- location information, guides action
- damage → difficulty reaching

Colour System – can have selective loss of colour perception

Akinetopsia – loss of movement perception
world appears as series of static movements

Putting the Information Together

Binding Problem – How integrate information from different brain areas?

1)Spatial position- adjacent cells in visual system usually relate to adjacent spatial positions in visual field.

Spatial position is 'tracked' - adjacent cells in brain respond to adjacent areas of visual field

Spatial location provides a frame of reference for binding various attributes.

Putting the Information Together - 2

2) Neural synchrony

- Suppose vertical line moving to left
- Line detectors, orientation detectors & motion detectors all fire at certain rates depending on 'strength' of stimulus
- If firing is synchronized → pattern (line), orientation & movement all ascribed to same 'object'
- Synchronized firing observed when animal is attending to specific stimulus

Putting the Information Together - 3

3) Attention

- Conjunction errors – error in binding features – occurs when memory is overloaded
- Treisman – 'pop out' effect
  - Need attention to perceive combination of features
- Red triangle in set of blue triangles easy to see; red triangle in set of blue triangles & red circles difficult to see.