Hindbrain, Midbrain, Forebrain

Lecture 3
Phrenology
An Early View of Functional Specialization

• In Vienna
  – F.J. Gall (1788-1828)
  – J.K. Spurzheim (1776-1832)

• In Scotland
  – G. Combe (1788-1858)

• In the United States
  – O.S. Fowler (1809-1887)
  – L.N. Fowler (1811-1896)
  – N. Sizer (1812-1897)
19TH-CENTURY HEAD EXAMINATION

According to phrenologists of the period, analysis of the shape and lumps of the skull would reveal a person’s personality and intellect. Below, a contemporary map of localized characteristics.
Brain Lesions

• Brain Insult, Injury, or Disease
  – Broca’s Area
  – Patient H.M.

• Nonhuman Animals
  – Surgery
  – Electrical Current

• Temporary Lesions
  – Cooling
  – Spreading Depression
Electrical and Magnetic Stimulation

• Electrical Stimulation
  – Reticular Formation
    • Lesions (Nauta)
    • Stimulation (Moruzzi & Magoun)

• Transcranial Magnetic Stimulation
  – Striate Cortex of Occipital Lobe
Psychophysiology

• Autonomic Nervous System
  – Electrocardiogram (EKG)
  – Plethysmograph
  – Electrodermal Response (EDR)
    • Skin Conductance/Resistance
  – Electromyogram (EMG)
• Central Nervous system
  – Electroencephalogram (EEG)
  – Event-Related Potentials (ERP)
Brain Imaging

- X-Ray Computed Tomography (CT, CAT)
- Magnetic Resonance Imaging (MRI)
  - Radio Waves
- Positron Emission Tomography (PET)
  - Glucose
- Functional MRI (fMRI)
Identifying Natural Objects From Patterns of fMRI Activity
Kay, Naselaris, Prenger, & Gallant (2008)

Topographical Organization of Visual System
Accuracy of Identification
Kay et al. (2008)

• Chance = 1/120 = 0.8%
• 13 Repeated Trials
  – Subject 1: 92%
    • 1000 Images: 82%
      – Chance = 0.1%
  – Subject 2: 72%
• Single-Trial Performance
  – Subject 1: 51%
  – Subject 2: 32%
Reconstructing Natural Images
Naselaris, Prenger, Kay, Oliver, & Gallant (2009)
The Doctrine of Modularity
Fodor (1983)

- Domain-Specific
- Informational Encapsulation
- Hardwiring
- Innate Specification
- Automaticity
- Characteristic Development
- Characteristic Breakdown
- Fixed Neural Architecture
Functional Specialization
Outside the Brain

• Afferent and Efferent Neurons, Nerves
• Interneurons, Ganglia, Nuclei
• Autonomic Nervous System
  – Sympathetic and Parasympathetic Branches
• Somatic Nervous System
  – Afferent and Efferent Cranial Nerves
  – Afferent and Efferent Tracts in Spinal Nerves
  – Afferent and Efferent Tracts in Spinal Cord
Excitatory and Inhibitory Neurotransmitters

- **Amines**
  - Acetylcholine (Ach)

- **Monoamines**
  - Catecholamines
    - Epinephrine (Adrenaline)
    - Norepinephrine (NA)
    - Dopamine (DA)
  - Serotonin (5-HT)

- **Amino Acids**
  - Glutamate
  - GABA

- **Peptides**
  - Substance P
  - Beta-Endorphin
  - Corticotropin (ACTH)
  - Oxytocin
Neurotransmitters and Brain Disease

• Myasthenia Gravis (Ach)
• Parkinson’s disease (Dopamine, L-DOPA)
• Chorea (Dopamine; Haloperidol)
• Huntington’s Disease
• Gilles de la Tourette’s Syndrome
• Schizophrenia
  – Dopamine Hypothesis, Chlorpromazine
• Affective Disorder
  – Serotonin Hypothesis, SSRIs
Functional Specialization in the Brainstem

- Hindbrain
  - Medulla Oblongata (Myelencephalon)
  - Pons (Metencephalon)

- Midbrain (Mesencephalon)
  - Reticular Formation

- Cerebellum
Coma

- **Loss of Consciousness**
  - Eyes Closed
  - Unresponsive to Stimulation
  - No Sleep-Wake Cycle
  - Spared Vegetative Function

- **Posterior Brain Stem**
  - Reticular Formation
    - Periaqueductal Gray
    - Parabrachial Nucleus
  - Diencephalon (Bilateral)
    - Thalamus, Hypothalamus
Persistent Vegetative State
Jennett & Plum (1972)

- Follows Coma
  - Within 1 month
- Wakefulness Without Consciousness
  - Eyes Open
  - Apparently Vigilant
  - Some reflex functions
  - Normal Sleep Cycle
  - Unresponsive to Stimulation
  - Spared Vegetative Function
- “Minimally Conscious State”
“Locked-In” Syndrome

- Follows Coma
- Largely Immobile
- Limited Responsiveness
  - Vertical Eye Movements
  - Blinking
- Anterior Brain Stem
  - Pons
  - Excludes Reticular Formation
  - Above Trigeminal Nerve (V)
    - Oculomotor Nerve (III)
    - Trochlear Nerve (IV)
Subcortical Structures of the Forebrain

- Limbic System (Lobe)
  - Cingulate Gyrus
  - Parahippocampal Gyrus
  - Hippocampal Formation
    - Amygdala
    - Hippocampus
    - Fornix
    - Mammillary Bodies

- Basal Ganglia
  - Globus Pallidus
  - Caudate Nucleus
  - Putamen

- Diencephalon
  - Thalamus
  - Hypothalamus
Hypothalamus and Eating Behavior
Teitelbaum & Epstein (1962); Teitelbaum (1976)

- Ventromedial Lesions
  - Hyperphagia
- Lateral Lesions
  - Aphagia
- Dual-Center Theory
  - VMH Inhibits Eating
  - LH Disinhibits Eating
Patient H.M.
Bilateral Resection of Hippocampus
Scoville & Milner (1957); Milner, Corkin, & Teuber (1968)

Anterograde Amnesia
The Medial Temporal Lobe Memory System
Squire & Zola-Morgan (1991)
Patient S.
Bilateral Calcification of Amygdala
Adolphs, Tranel, Damasio, & Damasio (1994)
The Triune Brain
MacLean (1970, 1990)

- Neocortex
  - “New Brain”
- Limbic System
  - “Old Mammalian Brain”
    - Amygdala
    - Hypothalamus
    - Hippocampus
- R-Complex
  - “Reptilian Brain”
    - Brain Stem
    - Cerebellum