Learning as Cognition

- Not Just a Change in Behavior

- Change in *Knowledge* About the World
  - Predict Events
  - Control Events
Cognition

• Basis of Intelligent Behavior
  – Beyond Reflex, Taxis, and Instinct
  – Beyond Conditioned Response
• Acquire Knowledge About World
  – Integrate with Prior Knowledge
  – Store Knowledge in Memory
• Use Knowledge in Action
  – Cope, Achieve
• Language as a Tool
  – Thought, Communication
How Do We Know the World?

• Nativism (Descartes)
  – Innate Knowledge
    • Independent of Sensory Experience

• Empiricism (Locke)
  – Knowledge Acquired Through Experience
  – Reflections on Experience

• Synthesis (Kant)
  – Knowledge Acquired Through Experience
  – Presumes Categories of Thought
Acquiring Knowledge Through Experience

• Sensation
  – Is There Something Out There?
  – How Intense Is It?

• Perception
  – Where Is It?
  – What Is It Doing?
  – What Is It?
    • What Can I Do With It?
    • What Can It Do to Me?
Relations Between Sensation, Perception

- Distal Stimulus
- Proximal Stimulus
- Transduction
- Neural Impulse
- Mental Representation
  - of Distal Stimulus

- Object, Event
- Stimulus Energy
  - Radiated
  - Reflected
- Sensory Receptor
- Transmitted to Cortex
- Object, Event
  - Physical Features
  - Meaning, Implications

How Do We Get From the Stimulus to the Percept?

Back Into Nature
Aristotle’s Five Senses

*De Anima* (4th c. BCE)

- Vision
- Audition
- Olfaction
- Gustation
- Touch
The Sensory Modalities
Sherrington (1906)

**Exteroception**
- Distance Senses
  - Vision
  - Audition
- Chemical Senses
  - Gustation
  - Olfaction
- Skin (Cutaneous) Senses
  - Touch (Tactile)
  - Temperature (Thermal)
  - Pain

**Proprioception**
- Kinesthesia
- Equilibrium (Vestibular)
  - (Skin Senses)
    - Touch
    - Temperature
    - Pain

**Interoception**
Defining the Sensory Modalities

• Proximal Stimulus
• Receptor Organ
• Sensory Tract
• Projection Area
Vision

- **Proximal Stimulus**
  - Electromagnetic Radiation
    - 380-780 Nanometers
  - Retinal Image

- **Receptor Organ**
  - Rods and Cones in Retina

- **Sensory Tract**
  - Optic Nerve (II)
  - Lateral Geniculate Nucleus (Thalamus)

- **Primary Visual Cortex (V1)**
  - Brodmann’s Area 17 (Occipital Lobe)
Details of the Visual System
Audition

• Proximal Stimulus
  – Mechanical Vibration
    • 20-20,000 cycles per second

• Receptor Organ
  – Cochlea
    • Basilar Membrane
    • Hair Cells

• Sensory Tract
  – Vestibulo-Cochlear Nerve (VIII)
    • Auditory Component
  – Medial Geniculate Nucleus (Thalamus)

• Primary Auditory Cortex A1
  – Brodmann’s Area 41 (Temporal Lobe)
Details of the Auditory System
Gustation

- **Proximal Stimulus**
  - Chemical Molecules in Food, Drink
    - Dissolved in Saliva
- **Receptor Organ**
  - Papillae (Taste Buds)
- **Sensory Tract**
  - Glossopharyngeal Nerve (IX)
  - Facial Nerve (VII), Vagus Nerve (X)
- **Primary Gustatory Cortex**
  - Frontal Lobe
    - Anterior Insula, Frontal Operculum
  - Somatosensory Cortex
Olfaction

• Proximal Stimulus
  – Chemical Molecules in Air
    • Dissolved in Mucous

• Receptor Organ
  – Olfactory Epithelium

• Sensory Tract
  – Olfactory Bulb
  – Olfactory Nerve (I)

• Primary Olfactory Cortex
  – Prepyriform Cortex
  – Periamygdaloid Complex
Touch (the Tactile Sense)

• Proximal Stimulus
  – Mechanical Pressure on Skin
• Mechanoreceptors
  – Free Nerve Endings
  – “Basket” Endings, Merkel’s Disks
  – Meissner’s / Pacinian Corpuscles
• Sensory Tract
  – Afferent Tract
    • Spinal, Cranial Nerves
    • Spinal Cord
• Primary Somatosensory Cortex
  – Brodmann’s Areas 1, 2, 3
Temperature (The Thermal Sense)

- Proximal Stimulus
  - Temperature Differential
- Receptor Organ
  - Krause End-Bulbs
  - Ruffini End-Organs
- Sensory Tract
  - Spinal Nerves
  - (Afferent) Cranial Nerves

- Primary Somatosensory Cortex
  - Brodmann’s Areas 1, 2, 3
Cutaneous Pain (Nociception)

- **Proximal Stimulus**
  - Injury/Destruction of Tissue
    - Inflammation
- **Receptor Organs**
  - Free Nerve Endings
    - A-delta fibers, C fibers
- **Sensory Tract**
  - Neospinothalamic Tract
  - Paleospinothalamic Tract
- **Primary Somatosensory Cortex**
  - Brodmann’s Areas 1, 2, 3
The Skin Senses Reviewed
Kinesthesis (Movement, Position)

- **Proximal Stimulus**
  - Activity in Skeletal Musculature
    - Stretching, Contraction, Movement

- **Receptor Organ**
  - Neuromuscular Spindles
  - Neurotendinous (Golgi) Organs
  - Nerve Endings in Joints

- **Sensory Tract**
  - Spinal Nerves
  - (Afferent) Cranial Nerves

- **Primary Somatosensory Cortex**
  - Brodmann’s Areas 1, 2, 3
The Vestibular Sense (Equilibrium)

• **Proximal Stimulus**
  – Gravitational Force on Otoliths

• **Receptor Organ**
  – Hair Cells
    • Vestibular Sac
    • Semicircular Canals

• **Sensory Tract**
  – Vestibulo-Cochlear Nerve (VIII)
    • Vestibular Component
    Projection Area

• **Cerebellum**
How Do We Know the World?

• Distance Senses
  – Vision
  – Audition

• Chemical Senses
  – Gustation
  – Olfaction

• Skin Senses
  – Touch (Tactile)
  – Temperature (Thermal)
  – Pain (Nociception)

• Proprioception
  – Kinesthesia
  – Equilibrium (Vestibular)

Jan Brueghel the Younger, An Allegory of the Five Senses (1625)