Cogs 143 * Animal Cognition

Lecture 3: PRIMATE BRAINS

See Neuroscience Review on Course Website

Primate Brains **are larger** than other mammals of similar size, Cortex (esp visual) particularly well developed
- See next lecture for discussion of brain size comparisons

Sensory Motor Integration

- **Auditory**: Air vibrations pass into Inner Ear, set up vibrations along neuro-receptors of the **Cochlea**
  - These receptors arrayed from low to high frequency; Hearing range: **0.2-20kHz**
    - Primates make fine discriminations between tones up to ~4kHz
  - **Medulla** in Hindbrain, combines input from 2 ears (**binaural**) to localize source of sound
  - **Inferior Colliculus** in Midbrain, coordinates auditory localization with visual from Superior Colliculus
    - In Primates, (auditory) Inferior Colliculus is somewhat smaller than (visual) Superior Colliculus
  - **MGN** (Medial Geniculate Nucleus of the Thalamus) in Forebrain projects freq & amp maps to …
  - **A1** (Auditory 1) in Cortex, Frequency-by-Amplitude maps, in Dorsal-Medial Temporal Lobe
  - **Higher Auditory Cortex**:
    - Info on Identity of call/caller in Anterior (rostral) Sulcus, adjacent to A1; Connects esp to Frontal lobe
    - Info on Location of call in Posterior (caudal) Sulcus (also "higher" aud cortex), connecting esp to Parietal
    - Auditory system very like typical mammal, less specialized or complex than Vision
      - Altho see notes on Human specializations (language) in "Lateralization" section below

- **Visual:** Principal sensory system;
  - Unlike Audition, no Hindbrain synapses; Most input directly to forebrain, prominent in Cortex
  - Eyes to **LGN** (Lat Genic Nuc of Thalamus) to **V1** of Cortex (rear of Occipital lobe, aka Striate Cortex)
  - In Cortex, topological maps of Retinal surface, **Fovea** (high acuity receptors) greatly MAGNIFIED
  - **Crossover**: Right Visual Field, falls on Left Half of both Retinas, processed by Left Brain (& v-v)
    - e.g. Left **Superior Colliculus** maps primarily right visual field, Right maps primarily left
      - Minimal overlap aids Primates orienting to center of field, e.g. for aiming a reach or jump
  - **Dorsal Pathway** "*Where/How*" Path, V1 to Parietal, for localizing, tracking, interacting w/objects
    - Begins at periphery of Retina, where receptors more sensitive to Motion, broad outline
    - Unlike Ventral Path, some to Midbrain's **Superior Colliculus** (Localization, Blindsight, Co-ord w/Aud)
    - *WHERE:* **MT** (Medial Temporal), adjacent to Parietal, find direction-sensitive Motion Detectors
      - **MST** (Medal Superior Temporal), Optic Flow detectors respond to forward/backward locomotion
      - Disparity Detectors (diff in locus of image on left vs. right eye) in Parietal for depth perception
    - *HOW*: **CIP** (Caudal Intra-Parietal) integrates shape & location of object
      - **AIP** (Anterior Intra-Parietal) How does shape/location of object afford grasping/manipulating
  - **Ventral Pathway** = "*Who/What*" Path, V1 to Temporal Cortex, for identifying objects
    - Begins at **Fovea** with its high concentration of receptors for **detail** discrimination
      - Details preserved in maps up pathway, altho reps become less dependent on Retina's point of view
    - **Color** (esp in Old World primates) via 3 types of "Cone" Receptors that together code each color
    - **IT** (Inferior Temporal Cortex), specialized for object and face recognition
    - **STS** (Superior Temporal Sulcus) cells respond to Biological Motion (e.g. changes in face orientation)

- **Somatosensory**: **"S1"** in Cortex, along Post-Central Gyrus of Parietal Lobe
  - "**Penfield Map**" there shows **face, hands magnified** (indicates greatest innervation, highest acuity)
  - Contributes to high level Visio-Spatial & Visio-Haptic Mapping in Parietal Lobe (see above & below)
    - e.g. Localizing objects/events in immediate and distant space, Hand/eye coord, Object manipulation, etc.

Visio-Haptic (eye-hand) Coordination

- Primary Motor Cortex Map commands motor neurons in Brainstem & Spinal Cord to move body
  - Pre-Central Gyrus in Frontal Lobe, across Central Sulcus from Somatosensory cortex
- **Premotor** Cortex, anterior to Primary Motor, active during "preparation to move" – plans activity
  - **Mirror Cell System:** co-activation of **Premotor (F5)** and **Parietal** Cortex in primates
- Mirror Cell System is activated when Primate sees own, or other's, hands performing familiar task
  - Enables understanding action via translating visual input into motor plan
  - Often goal-dependent: Need to see hand movement and target object
    - May fire at different hand movements accomplishing same goal
  - Probably mediates **imitation** (learn to do by watching)

Some Areas Mediating Social Cognition

Limbic System –also called **Rhinencephalon** ("Nose Brain") since major olfactory input (e.g. Olfactory Bulb)
- In primitive and ancestral mammals, does much of decision making, often smell-mediated
- In Primates, less nose-driven, still critical in evaluating/learning about/reacting to what "matters"
- Olfaction, though declined in importance, can still be *potent*!
  - Complex pathways, include projections to Orbito-Frontal cortex, for social assessments
  - As in other areas, vision has become more important input (e.g. sight of face, visual sexual signals)
- **Anterior Cingulate Cortex (ACC**) – also part of Limbic System, for +/- evaluation
  - Anterior part of Cingulate Gyrus, concerned with Social Assessment (of self and others)
    - e.g. Active in empathy, deception, guilt, embarrassment, etc
  - Also involve in risk assessment (e.g. when to switch responses under uncertainty)
    - Probably implicated in "checking for cheaters", sanction, retaliation etc.
\ - **Amygdala** - In Primates, role in generating and interpreting facial expressions of emotion
  - Damage => inability to produce/judge esp fear, anger, untrustworthiness in faces
  - Part of circuit (w/Orbitofrontal) for "**Theory of Mind**" – postulating what others are thinking, feeling
    - These connections particularly well developed in Humans, but built on basic primate pattern

Related Cortical areas
- **Orbitofrontal Cortex** –Many descending & reciprocal fibers to/from Limbic System
  - Higher primates esp. show increased, mostly inhibitory connections to Limbic System
  - Evaluate, set priorities, delay gratification, suppress (learned) inappropriate behavior, etc.
  - Reciprocal connections with Amygdala probably mediate primate precursors of "Theory of Mind"
- **Frontal Insula (FI**) – Insula = medial surface of Lateral Fissure between Temporal and Frontal lobes
  - Part of pathway between Amygdala and Orbitofrontal
  - Includes sensory projection for Taste, generates disgust/desire re consumables >> social others
  - Some cells involved in spontaneous production & interpretation of emotional expression
    - Implicated in helping produce/read pro-social and anti-social responses
- **Von Economo Neurons (VEN**) – In primates, found **only** in Apes and Humans
  - Unlike more typical Pyramidal cortical cells with widely-branching dendrites, VEN cells have long, unbranched, symmetrical processes (Axon and Dendrite)
  - Large cells, for rapid transmission of minimal local info to other areas
    - Possibly for fast, intuitive judgments of social situations?
  - Found in **ACC & FI** (above)

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