Vision and Audition

Functional Anatomy of Vision

Subdivisions of the Occipital Cortex

- **Primary Visual Cortex (V1)**
  - Laminar organization most distinct of all cortical areas
  - Retinotopic mapping
  - Has more than one distinct function
  - Preserved in V2

- **Striate cortex**
  - Another name for visual cortex due to its striped appearance
Subdivisions of the Occipital Cortex
- Color Vision
  - Primary job of V4, but distributed throughout occipital cortex
  - Plays a role in detection of movement, depth, and position
  - V4 is now thought to process both color and form

What number do you see?
16

What number do you see?
2
Color Blindness

- Color vision deficiency
- Affects a significant proportion of the population
- Overrepresented in males — genetic color blindness is X-linked and thus will tend to affect males more than females
- Caused by a deficiency in the development of one or more sets of retinal cones (red, blue, green)

Connections of the Visual Cortex

- Primary Visual Cortex (V1)
  - Input from LGN
  - Output to all other levels
- Secondary Visual Cortex (V2)
  - Output to all other levels
- After V2
  - Output to the parietal lobe - Dorsal Stream
  - Output to the inferior temporal lobe - Ventral Stream
  - Output to the superior temporal sulcus (STS) - STS Stream

Dorsal vs. Ventral Pathways
Dorsal vs. Ventral Pathways

<table>
<thead>
<tr>
<th>Region</th>
<th>Proposed Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventral Stream Regions</td>
<td></td>
</tr>
<tr>
<td>LO</td>
<td>Lateral occipital</td>
</tr>
<tr>
<td>FFA</td>
<td>Fusiform face area</td>
</tr>
<tr>
<td>EBA</td>
<td>Extrastriate body area</td>
</tr>
<tr>
<td>FBA</td>
<td>Fusiform body area</td>
</tr>
<tr>
<td>STS</td>
<td>Superior temporal sulcus</td>
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<tr>
<td>STSp</td>
<td>Superior temporal sulcus (posterior)</td>
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<tr>
<td>PPR</td>
<td>Parahippocampal place area</td>
</tr>
<tr>
<td>Dorsal Stream Regions</td>
<td></td>
</tr>
<tr>
<td>LIP</td>
<td>Lateral intraparietal sulcus</td>
</tr>
<tr>
<td>AIP</td>
<td>Anterior intraparietal sulcus</td>
</tr>
<tr>
<td>VIP</td>
<td>Ventral intraparietal sulcus</td>
</tr>
<tr>
<td>PRF</td>
<td>Parametral reach region</td>
</tr>
<tr>
<td>eIPS</td>
<td>Intraparietal sulcus</td>
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<tr>
<td></td>
<td>Object analysis</td>
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<tr>
<td></td>
<td>Face analysis</td>
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<td></td>
<td>Body analysis</td>
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<tr>
<td></td>
<td>Body analysis</td>
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<td></td>
<td>Analysis of biological motion</td>
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<td></td>
<td>Moving-body analysis</td>
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<td></td>
<td>Analysis of landmarks</td>
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<td></td>
<td>Voluntary eye movement</td>
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<tr>
<td></td>
<td>Object-directed grasping</td>
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<tr>
<td></td>
<td>Visual motor guidance</td>
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<tr>
<td></td>
<td>Visually guided reach</td>
</tr>
<tr>
<td></td>
<td>Object-directed action</td>
</tr>
</tbody>
</table>

Summary of Visual System Anatomy

Visual field deficits

Figure 3.1: Primary Visual Pathway and Results of Damage at Four Sites

The left-hand diagram illustrates the primary visual pathway, viewed looking down from above the head. Note that the sample visual field is in the diagram represents only the inferior portion of the visual field. The visual pathways from early to lateral geniculate nucleus are colored to represent the visual field information they process. The grey pathways carry information from the left visual field (gray “STOP”), and the black pathways carry information from the right visual field (black “STOP”). The white pathways convey information from both the right and left visual fields. The results of damage at four different sites are illustrated in the three panels to the right of the anatomical drawing. Courtesy of Dr. Andrea Nicholas.
Scotomas - blindspots

Blindsight - A clinical case study

- Patient TN
- Two successive strokes knocked out V1 in both his left and right hemispheres. Complete cortical blindness.
- Yet TN could still navigate his environment without his cane!
- TN was examined by Lawrence Weiskrantz at Oxford University, who coined the term “blindsight”

Blindsight - Patient TN
Blindsight - detecting emotion

- Lesions to V1 produce cortical blindness in the visual field
- Although individuals cannot name the object in the lesioned portion of the visual field, they can react to it unconsciously
- Perhaps evidence for a more primitive form of vision?

Neural basis for unconscious vision?

- Signals from the retina go to the primary visual cortex via the lateral geniculate nucleus in the thalamus and ultimately to higher areas for conscious processing.
- There are also basal ganglia connections to areas such as the amygdala and superior colliculus in the medulla, which do not access consciousness.

Visual Agnosia

- Object Agnosia
  - Apperceptive Agnosia
    - Deficit in the ability to develop a percept of the structure of an object or objects
    - Results from bilateral damage to the lateral parts of the occipital lobes
  - Associative Agnosia
    - Can perceive objects, but cannot identify them
    - Results from lesions to the anterior temporal lobes
## Auditory Processing

<table>
<thead>
<tr>
<th>Physical dimension</th>
<th>Perceptual dimension</th>
</tr>
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<tbody>
<tr>
<td>Frequency</td>
<td>Pitch</td>
</tr>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Amplitude (intensity)</td>
<td>Loudness</td>
</tr>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Soft</td>
</tr>
<tr>
<td>Complexity</td>
<td>Timbre</td>
</tr>
<tr>
<td></td>
<td>Simple</td>
</tr>
<tr>
<td></td>
<td>Complex</td>
</tr>
</tbody>
</table>
Pathways to the Auditory Cortex

- **Auditory nerve** (cranial nerve VIII)
  Carries auditory information from the ear to the CNS.

- **Cochlear nucleus**
  First neurons in the medulla that receive neural messages from auditory receptors via the auditory nerve.

- **Superior olivary nucleus**
  Receives neural messages from the cochlear nuclei.

- **Inferior colliculus**
  Receives information from both the cochlear nucleus and the superior olivary nucleus.

Pathways to the Auditory Cortex

- **Medial geniculate nucleus (MGN)**
  Thalamic neurons receiving signals from the inferior colliculus.

- **Primary auditory cortex (A1)**
  The area of the temporal lobe that receives auditory input from the thalamus.

- **Secondary auditory cortex**
  The area of the temporal lobe surrounding the primary auditory cortex, where pitch, loudness, and timbre are perceived and specific sounds are recognized.

Hearing loss

- **Cortical deafness**
  - damage to primary auditory cortex
  - inability to perceive sounds despite intact ears

- **Auditory Verbal Agnosia - AVA**
  (pure word deafness)
  - damage to posterior superior temporal lobes
  - inability to perceive words (cannot distinguish phonemes)
  - can still speak, read, write, and hear sounds

  Note:
  AVA is one component of Wernicke's aphasia
  We will discuss this more when we talk about Language disorders
Musical Disorders

- **Amusia**
  - An inability to recognize or reproduce music. Cannot perform fine pitch discrimination
  - **Congenital**: "tin ear" or tone deafness (4% of population)
  - **Acquired**: due to organic brain damage
  - Implicates the posterior superior temporal gyrus

- **Perfect (Absolute) Pitch**
  - Ability to identify or recreate musical notes
  - More common in those with Williams Syndrome or Autism
  - More common in congenitally blind individuals

Auditory Hallucinations

- Auditory hallucinations are the most common symptom of schizophrenia
- Verbal hallucinations activate primary auditory cortex, Broca's area, and Wernicke's area.