The Temporal Lobes

Readings: KW Ch.15

Anatomy of the Temporal Lobe

- Tissue below the Sylvain Fissure and anterior to the occipital cortex
- Subcortical Temporal Lobe Structures
  - Limbic cortex
  - Amygdala
  - Hippocampal Formation

Subdivisions of the Temporal Cortex

- Lateral surface
  - Auditory areas
    - Brodmann's areas 41, 42, and 22
  - Ventral Stream of Visual Information
    - Inferotemporal cortex or TE
    - Brodmann's areas 20, 21, 37, and 38

Subdivisions of the Temporal Cortex

- Insula
  - Area under Sylvan Fissure
  - Gustatory Cortex
  - Auditory association cortex
- Multimodal Cortex or Polymodal Cortex
  - Area under Superior Temporal Sulcus
  - Receives input from auditory, visual, and somatic regions

Portrait: Living With Temporal Lobe Damage

- H.H.
  - 40 years old, successful lawyer
  - Left wife of 15 years to join a religious group
  - Experienced a seizure and a left temporal lobe tumor was found
  - Tumor removed and H.H. was able to return to his job
  - Left with word-finding difficulties
Subdivisions of the Temporal Cortex

- **Medial Temporal Cortex**
  - Includes the amygdala and adjacent cortex, the hippocampus and surrounding cortex, and the fusiform gyrus

- **TH and TF**
  - Posterior end of the temporal lobe
  - Parahippocampal cortex

Connections of the Temporal Cortex

- Afferent Projections from sensory systems
- Efferent Projections to the parietal and frontal association regions, limbic system, and basal ganglia
- Left and Right Connected Via:
  - Corpus Callosum
  - Anterior Commissure
- Five Distinct Connections

Connections of the Temporal Lobe

- **Hierarchical Sensory Pathway**
  - Incoming Auditory and Visual Information
  - Stimulus Recognition

- **Dorsal Auditory Pathway**
  - From Auditory cortex to Posterior Parietal
  - Detection of spatial location/movement

Connections of the Temporal Lobe

- **Polymodal Pathway**
  - From Auditory and Visual Areas to the Polymodal Cortex
  - Stimulus Categorization

- **Medial Temporal Projection**
  - From Auditory and Visual Areas to the medial temporal lobe, limbic cortex, hippocampal formation, and amygdala
  - Perforant Pathway
  - Long-term Memory
Connections of the Temporal Lobe

- Frontal Lobe Projection
  - Auditory and Visual Cortex to the Frontal Lobe
  - Movement Control
  - Short-term Memory
  - Affect

Theory of Temporal Lobe Function

- Three Basic Sensory Functions
  - Processing auditory input
  - Visual object recognition
  - Long-term storage of information

- Sensory Processes
  - Identification and Categorization of Stimuli
  - Cross-Modal Matching
    - Process of matching visual and auditory information
    - Depends on cortex of the superior temporal sulcus

Theory of Temporal Lobe Function

- Affective Responses
  - Emotional response is associated with a particular stimulus
- Spatial Navigation
  - Hippocampus – Spatial Memory

Superior Temporal Sulcus (STS) and Biological Motion

- Imaging reveals activation in the STS during perception of biological motion
- Biological Motion
  - Movements relevant to a species
  - Allow us to guess others’ intentions
  - Social Cognition or “theory of mind”
- David Perrett and colleagues
  - STS cells are maximally responsive to particular types of biological motion
Visual Processing in the Temporal Lobe

- Hasson and colleagues
  - Used fMRI to monitor cortical activity with viewing a film
  - Findings:
    • Extensive activity in the auditory and visual regions in the temporal lobe, in the STS and cingulate regions
    • Selective activation to precise moment-to-moment film content
    • Regions of the parietal and frontal lobes showed no intersubject coherence

Visual Processing in the Temporal Lobe

- Tanaka and colleagues
  - Cells in area TE require complex features for activation
  - Cells with similar selectivity cluster in vertical columns
  - Specificity of neurons is altered by experience
Are Faces Special?

- Humans spend most of their time looking at faces
- Special face processing pathway
  - Different aspects of facial perception are analyzed in the core visual areas in the temporal part of the ventral stream
  - The right temporal lobe has a more important role in facial processing
  - The Split Faces Test

Auditory Processing in the Temporal Lobe

- Speech perception
  - Speech sounds come from three restricted ranges of frequencies, known as formants
  - Speech sounds vary from one context to another, yet all are perceived as being the same
  - Speech sounds change very rapidly in relation to one another
Auditory Processing in the Temporal Lobe

• Music Perception
  – Relies on relation between elements
  – Loudness: magnitude of a sensation as judged by a given person
  – Timbre: distinctive characteristic of a sound
  – Pitch: position of a sound in a musical scale as judged by the listener

• Music Perception
  – Patients with temporal lobe injuries illustrate that the left temporal lobe plays a major role in temporal grouping for rhythm, whereas the right hemisphere plays a role in meter
  – Right temporal lobe special function in extracting pitch from sound regardless if the sound is speech or music
    • Prosody - "tone of voice" or pitch in speech

Auditory Processing in the Temporal Lobe

• Music Perception
  – Schneider and colleagues
    • Musicians have a larger volume of gray and white matter in Heschl's gyrus
    • Fundamental pitch listener's - leftward asymmetry
    • Spectral-pitch listeners - rightward asymmetry

Asymmetry of Temporal Lobe Function

• Left temporal lobe
  – Verbal memory
  – Speech processing

• Right temporal lobe
  – Nonverbal memory
  – Musical processing
  – Facial processing

Symptoms of Temporal-Lobe Lesions

• Auditory Disturbance
• Disorders of Music Perception
• Disturbance of selection of visual and auditory input
• Impaired organization and categorization
• Inability to use contextual information
• Long-term memory problems
• Altered personality and affective behavior
• Altered sexual behavior
Auditory hallucinations are the most common symptom of schizophrenia. Patients hear fully formed verbal passages that may be hostile or paranoid. Verbal hallucinations activate primary auditory cortex, Broca’s area, and the speech zone in the posterior temporal cortex.

Disorders of Auditory and Speech Perception

- Cortical Deafness
  - Absence of neural activity in the auditory regions
- Auditory Hallucinations
- Impaired auditory processing
  - Have trouble discriminating speech sounds
- Speech Disorders
  - Wernicke’s Aphasia
    - Disturbed recognition of words

Disorders of Auditory and Speech Perception

- Disorders of Music Perception
  - Right posterior temporal gyrus damage affects rhythm discrimination
  - Meter discrimination affected by anterior damage to either right or left temporal lobe
  - Congenital Amusia
    - Tone deaf

Disorders of Visual Perception

- Patients with temporal lobe damage are impaired at object recognition, complex pattern recognition
- Right temporal lobe lesions lead to abnormal face perception and biological motion recognition
Disturbance of Selection of Visual and Auditory Input

- Selective attention to auditory input is impaired in patients with temporal lobe damage and can be tested with dichotic listening
- Damage to the left temporal lobe impairs recall of visual stimuli in the right visual field
- Damage to the right temporal lobe impairs recall of visual stimuli in both visual fields

Organization and Categorization

- Left temporal lobe lobectomies lead to impairment in the ability to categorize words or pictures of objects
- Posterior lesions lead to a difficulty in recognizing specific word categories

Using Contextual Information

- Stimuli can be interpreted in different ways depending on the context
  - Example: Fall - the season or a tumble

Memory

- Anterograde Amnesia
  - Amnesia for events after bilateral removal of the medial temporal lobes
- Inferotemporal Cortex
  - Conscious recall of information
- Left temporal lobe
  - Verbal memory
- Right temporal lobe
  - Impaired recall of nonverbal material
Affect and Personality

- Stimulation of anterior and medial temporal cortex produces feelings of fear
- Temporal lobe personality
  - Personality that overemphasizes trivia and petty details of life
  - Pedantic speech
  - Egocentricity
  - Perseveration
  - Paranoia
  - Preoccupation with religion
  - Proneness to aggression

Changes in Sexual Behavior

- Release of sexual behavior seen after bilateral temporal damage

Clinical Neuropsychological Assessment of Temporal-Lobe Damage

- Tests do not assess all possible temporal-lobe symptoms

<table>
<thead>
<tr>
<th>Function</th>
<th>Test</th>
<th>Basic Reference</th>
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<tbody>
<tr>
<td>Auditory processing capacity</td>
<td>Dichotic words and melodies</td>
<td>Spokes et al., 1970</td>
</tr>
<tr>
<td>Visual processing capacity</td>
<td>McGill Picture Anomalies</td>
<td>Misner, 1978</td>
</tr>
<tr>
<td>Verbal memory</td>
<td>Revised Webster Memory Scale, logical stories and paired associates</td>
<td>Misner, 1975</td>
</tr>
<tr>
<td>Numerical memory</td>
<td>Rey Complex Figure</td>
<td>Taylor, 1969</td>
</tr>
<tr>
<td>Language</td>
<td>Tokens</td>
<td>de Renzi and Faglioni, 1978</td>
</tr>
</tbody>
</table>