The Parietal Lobes

Readings: KW Ch.14

Portrait: Varieties of Spatial Information

- H.P.: 28 year old accountant
  - Trouble doing simple subtraction problems
  - Trouble reaching for objects
  - Left and right confusion
  - Difficulty reading
  - Tumor in the left parietal lobe

The Parietal Lobes

- Process and integrate somatosensory and visual information
- Anatomy of the Parietal Lobes
  - Anterior border - Central Fissure
  - Ventral border - Sylvan Fissure
  - Dorsally by the cingulate gyrus
  - Posterior border - Parieto-occipital sulcus

Subdivisions of the Parietal Lobes

- Postcentral Gyrus
  - Brodmann’s areas 1, 2, and 3
- Superior Parietal Lobule
  - Brodmann’s areas 5 and 7
- Parietal Operculum
  - Brodmann’s area 43
- Supramarginal Gyrus
  - Brodmann’s area 40
- Angular Gyrus
  - Brodmann’s area 39

Subdivisions of the Parietal Lobes

- Functional zones
  - Anterior zone - 1, 2, 3, and 43
    - Somatosensory cortex
    - Posterior zone - remaining areas
      - Posterior parietal cortex
  - von Economo
    - Posterior parietal areas
      - PE
      - PF
      - PG - Polymodal and asymmetrical - larger in right hemisphere
Subdivisions of the Parietal Lobes

- Visual processing areas
  - Intraparietal sulcus (cIPS)
    - Control of saccadic eye movements
      - Saccade - involuntary abrupt and rapid small movements made by the eyes when changing the fixation point
    - Visual control of grasping
  - Parietal reach regions (PRR)
    - Visually guided grasping movements

Connections of the Parietal Lobes

- Somatosensory strip
  - To area PE - Tactile recognition
  - To motor regions - sensory information about limb position and movement
- Areas PE, PF, and PG (areas 5 and 7 in the monkey)
  - Over 100 inputs and outputs exist
  - 4 Principles of the connections

Connections of the Parietal Lobes

- Area PE is somatosensory
  - Inputs from the somatosensory strip
  - Outputs to primary motor cortex, supplementary motor cortex, premotor regions, and area PF
- Area PF
  - Input from somatosensory, primary motor cortex, premotor cortex, and small visual input through area PG

Connections of the Parietal Lobes

- Area PG
  - Receives complex connections including visual, somesthetic, proprioceptive, auditory, vestibular, oculomotor, and cingulate connections
  - Parieto-temporo-occipital crossroads
  - Part of the Dorsal Stream
  - Close relation between the posterior parietal connections and the prefrontal cortex
A Theory of Parietal Lobe Function

- Anterior zones - process somatic sensations and perceptions
- Posterior zones - integrate information from vision with somatosensory information for movement
- Spatial Map in the Brain?

Use of Spatial Information

- Spatial information can be used:
  - Object recognition
    - Viewer centered object identification
      - Determines the location, location orientation and motion of an object
    - Posterior parietal cortex
  - Guidance of Movement
    - Sensitive to eye movements
    - Posterior parietal cortex
  - Sensorimotor Transformation
    - Neural calculations of the relative position of the body with respect to sensory feedback from movements being made and planned
  - Anderson and colleagues
    - Trained monkeys to touch different areas on a screen while recording cell activity
    - Monkeys were then instructed to plan a movement while cell activity was recorded
    - If the planned movement activity matched actual activity to perform the movement the monkeys were rewarded

Use of Spatial Information

- Spatial Navigation
  - Cognitive spatial map
    - Route knowledge, unconscious knowledge of how to reach a destination
  - Medial parietal region (MPR)
    - Neurons show responses associated with making a specific movement at a specific location
  - Complexity of spatial information

Use of Spatial Information

- Sensorimotor Transformation
- Anderson and colleagues
- Spatial Navigation
- Cognitive spatial map
- Complexity of spatial information

Snapshot: White-Matter Organization and Spatial Cognition

- Mental transformations are carried out by the posterior parietal cortex
- Noted sex difference in the ability to perform mental transformations of objects
  - Men outperform women
  - Thomas Wolbers and colleagues
    - Used MRI to find a tight relation between mental rotation proficiency and white-matter organization near the anterior part of the intraparietal sulcus
Other Aspects of Parietal Function

- Three symptoms of parietal lobe damage do not fit with the visuomotor view of the parietal lobe:
  - Difficulties with arithmetic
  - Difficulties with certain aspects of language
  - Difficulties with movement sequences

- Acalculia
  - Inability to do arithmetic
  - Noted in parietal lobe patients
  - Might result from the spatial properties of addition and subtraction:
    - Two digit number occupy different spaces
    - “Borrowing” during subtraction

Other Aspects of Parietal Function

- Language
  - Words have spatial organization
    - “tap” vs. “pat”

- Movement Sequencing
  - Individual elements of the movement have a spatial organization

Somatosensory Symptoms of Parietal-Lobe Lesions

- Lesions to the postcentral gyrus produce:
  - Abnormally high sensory thresholds
  - Impaired position sense
  - Deficits in stereognosis, or tactile perception
  - Afferent paresis
    - Clumsy finger movements due to lack of feedback about finger position

Somatoperceptual Disorders

- Astereognosis
  - Inability to recognize an object by touch

- Simultaneous Extinction
  - Two stimuli are applied simultaneously to opposite sides of the body
  - A failure to report a stimulus on one side is referred to as extinction

- Blind Touch
  - Cannot feel stimuli, but can report their location
Somatoperceptual Disorders

- **Agnosias**
  - Asomatognosia
    - Loss of knowledge or sense of one’s own body
  - Anosognosia
    - Unawareness or denial of illness
    - Anosodiaphoria
      - Indifference to illness
      - Asymbolia for pain
      - Absence of normal reactions to pain
    - Finger Agnosia
      - Unable to point to the fingers or show them to the examiner

Symptoms of Posterior Parietal Lobe Damage

- **Balint’s Syndrome**
  - Can’t fixate on a visual stimulus
  - Neglect of objects
  - Optic Ataxia
- **Contralateral Neglect**
  - Neglect for visual, auditory, and somesthetic stimulation on one side of the body or space
  - During recovery patients go through alesthesias, begin to respond to the neglected stimuli as if they were on the other side of the body or space, and then simultaneous extinction

Symptoms of Posterior Parietal Lobe Damage

- **Contralateral Neglect**
  - Lesion most often in the right inferior parietal lobe
    - Right intraparietal sulcus and the right angular gyrus
  - Occasionally noted after lesions to the frontal lobe and cingulate cortex
  - Defective sensation or perception
  - Defective attention or orientation
Symptoms of Posterior Parietal Lobe Damage

• Object Recognition
  – After right parietal lobe lesions patients are poor at recognizing objects in unfamiliar views

Symptoms of Posterior Parietal Lobe Damage

• Gerstmann Syndrome
  – Finger agnosia
  – Right-Left Confusion
  – Agraphia
  – Acalculia
  – Results from a left parietal lobe lesion

Other Left Parietal Symptoms

• Disturbed Language Function

• Apraxia
  – Movement disorder in which the loss of movement is not caused by weakness, inability to move, abnormal muscle tone, intellectual deterioration, poor comprehension, or other disorders of movement

Other Left Parietal Symptoms

• Dyscalculia
  – Difficulties with arithmetic

• Poor recall

• Inability to discriminate left from right

• Right hemianopia

Apraxia and the Parietal Lobe

• Ideomotor Apraxia
  – Cannot copy serial movements
  – More likely to be associated with left parietal lesions

• Constructional Apraxia
  – Cannot copy pictures, build puzzles, or copy a series of facial movements
  – Associated with right and left parietal lesions
Symptoms of Posterior Parietal Lobe Damage

- Deficits in drawing appear after damage to the right parietal lobe
- Spatial Attention
  - Function of the parietal lobe to selectively attend to different stimuli
  - Disengagement
    - Shifting attention from one stimulus to the next

Disorders of Spatial Cognition

- Mental rotation requires:
  - Mental imaging of the stimulus
  - Manipulation of the image
- Left hemisphere deficit may result from the inability to generate the image
- Right hemisphere deficit may result from the inability to manipulate the image
- Inability to use topographic information is associated with right hemisphere damage

Left and Right Parietal Lobes Compared

- Clear asymmetry, but some overlap
- Overlap may be due to preferred cognitive mode of individuals

Table 14.1 Effects of left- and right-parietal-lobe lesions compared

<table>
<thead>
<tr>
<th></th>
<th>PERCENTAGE OF SUBJECTS WITH DEFICIT*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left (%)</td>
</tr>
<tr>
<td>Unilateral neglect</td>
<td>13</td>
</tr>
<tr>
<td>Dressing disability</td>
<td>13</td>
</tr>
<tr>
<td>Cube counting</td>
<td>0</td>
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<tr>
<td>Paper cutting</td>
<td>0</td>
</tr>
<tr>
<td>Topographical loss</td>
<td>13</td>
</tr>
<tr>
<td>Right–left discrimination</td>
<td>63</td>
</tr>
<tr>
<td>Weigl’s Sorting Test</td>
<td>83</td>
</tr>
</tbody>
</table>

*Note the small but significant overlap in symptoms at left and right lesions.
Source: Based on data presented by MfFau and Zangard, 1960.
Major Symptoms and their Assessment

<table>
<thead>
<tr>
<th>Table 14.2 Summary of major symptoms of parietal-lobe damage</th>
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<tbody>
<tr>
<td><strong>Symptom</strong></td>
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<tr>
<td>Disorders of tactile function</td>
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<tr>
<td>Tactile agnosia</td>
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<tr>
<td>Delays in eye movement</td>
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<tr>
<td>Misreading</td>
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<tr>
<td>Manipulation of objects</td>
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<tr>
<td>Apraxia</td>
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<tr>
<td>Constructional apraxia</td>
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<tr>
<td>Agraphia</td>
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<tr>
<td>Injured cross-modal matching</td>
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<tr>
<td>Contralateral neglect</td>
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<tr>
<td>Injured spatial representation</td>
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<tr>
<td>Disorders of body image</td>
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<tr>
<td>Right-left confusion</td>
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<tr>
<td>Disorders of spatial ability</td>
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<tr>
<td>Disorders of drawing</td>
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*Note: *superscript values.

Clinical Neuropsychological Assessment

<table>
<thead>
<tr>
<th>Table 14.3 Standardized clinical neuropsychological tests for parietal-lobe damage</th>
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<tbody>
<tr>
<td><strong>Function</strong></td>
</tr>
<tr>
<td>Sensory discrimination</td>
</tr>
<tr>
<td>Tactile form recognition</td>
</tr>
<tr>
<td>Contralateral neglect</td>
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<tr>
<td>Visual perception</td>
</tr>
<tr>
<td>Spatial relations</td>
</tr>
<tr>
<td>Language</td>
</tr>
<tr>
<td>Reading comprehension</td>
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<tr>
<td>Apraxia</td>
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</tbody>
</table>

*Note: *These standardized tests have been validated on large samples of patients with known localized brain damage.