Cognitive Neuroscience

• **Why is it exciting?**
  – Open up the “black boxes” of flowcharts
  – Investigate the link between minds and brains

• **Modularity at multiple levels**
  – Modules: spatially localized parts of the brain that are specialized for a specific function
  – Link to phrenologists
  – Neural-level modules
  – Lobe-level modules (large brain areas)
  – Hemisphere-level modules
Phrenology: the most important Faculties
Neural Level Organization

- Neurons, axons, dendrites, synapses, thresholds
  - Excitation and inhibition
  - The brain is a parallel, not serial, device
    - 10 msec/neuron, face recognition in 250 msec
    - Over 10 billion neurons in the brain, each with about 5000 connections
    - Many neurons sending messages simultaneously

- Feature detectors, complex, and hypercomplex cells

- Coarse coding
  - Nervous system is more sensitive because neurons have overlapping (“sloppy”) receptive fields

- Topographic maps
  - Visual map
  - Sensory map
  - Motor map
Hyper-complex cells

Super-releaser - an artificial stimulus that causes more responding than the natural stimulus

FIG. 6. Examples of shapes used to stimulate a group TE unit apparently having very complex trigger features. The stimuli are arranged from left to right in order of increasing ability to drive the neuron from none (1) or little (2 and 3) to maximum (6).
“Whoa! That was a good one! Try it, Hobbs—just poke his brain right where my finger is.”
Receptive Field = spatial area that a neuron will respond to

Coarse Coding

Fine Coding

3 inches

4 inches

5 inches
The Frontal Lobe

- **Planning and reasoning**
  - Perseveration and mimicking if lesioned

- **Broca’s area for speech production**
  - Halted but contentful speech if lesioned
  - Important for using the syntactical rules of language

- **Inhibition**
  - Phineus Gage’s moodiness and impulsiveness

- **Motor map**
Figure 5.7
Stimulation mapping of six language-related functions at nine sites on the cortex of a 30-year-old female, bilingual in English and Greek. Each site stimulated is represented by a rectangle, and symbols within the rectangle represent significant errors evoked at that site. Abbreviations: N, naming in English; G, naming in Greek; R, reading; VI, short-term verbal memory, with stimulation during input to memory; VS, memory with stimulation during presumed time of storage; VO, memory with stimulation at time of retrieval; P, phoneme identification; M, mimicry of sequences of orofacial movements; A, site of speech arrest; F, site of evoked facial movement and sensation. (From Ojemann 1983.)
The Temporal Lobe

• **Memories (often for sounds)**
  – Penfield’s direct electrical stimulation experiments
  – H.M.’s anterograde amnesia - can’t create new memories

• **Wernicke’s area for speech comprehension**
  – “Word salad” if lesioned: fluent but contentless

• **“What” visual system**

The Parietal Lobe

• **Association cortex**
  – Links visual information to its meaning
  – If lesioned, patients may not be able to integrate parts together

• **“Where” visual system**
Two cortical pathways for vision

Dorsal Pathway in Parietal lobe = “Where” = locates objects in space

Ventral Pathway in Temporal lobe = “What” = identifies objects
Figure 2. Behavioral tasks sensitive to cortical visual lesions in monkeys. (A) Object discrimination. Bilateral removal of area TE in inferior temporal cortex produces severe impairment on object discrimination. A simple version of such a discrimination is a one-trial object-recognition task based on the principle of non-matching to sample, in which monkeys are first familiarized with one object of a pair in a central location (familiarization trial not shown) and are then rewarded in the choice test for selecting the unfamiliar object. (B) Landmark discrimination. Bilateral removal of posterior parietal cortex produces severe impairment on landmark discrimination. On this task, monkeys are rewarded for choosing the covered foodwell closer to a tall cylinder, the 'landmark', which is positioned randomly from trial to trial closer to the left cover or closer to the right cover, the two covers being otherwise identical.
Double dissociation Logic
Two tasks (A and B) and two groups of subjects
One group does better on Task A
The other group does better on Task B
Good evidence for two distinct modules
The Occipital Lobe

• Primary visual area
• Visual topographic map is located here

The Limbic Lobe

• In the center of the cortex
  • Most primitive cortical region
• Emotional regulation
• Feeding, fighting, mating

Organizational Sensibility of Brain Regions

• Primitive regulation in middle
• Planning and motor cortex together
• Motor cortex close to sensory cortex
• Language understanding close to hearing
PET (Positron Emission Tomography) study showing large-scale modularity
Agnosia

• Disorder whereby people cannot identify objects or see what the meaning of a visual object is

• Description of Disorder
  – Low-level vision is fine
    • Patients can describe and reproduce visual objects
    • Patient is not blind
  – Normal recognition of objects if not presented visually
    • Patient does not have aphasia (problems with language)
  – Occipital, temporal, and parietal lobes are involved
  – Mistake object for visually similar objects

• Specific brain modules for specific kinds of objects
  – Prosopagnosia - difficulty recognizing faces
  – Alexia - difficulty recognizing words
  – Some evidence for Zooagnosia and vegetagnosia too
Table 1. Results of literature review for possible combinations of impaired and spared recognition of faces, common objects, and printed words

<table>
<thead>
<tr>
<th>Impaired and spared classes of stimuli</th>
<th>Number of cases</th>
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<tbody>
<tr>
<td>Impaired: faces; spared: common objects, words</td>
<td>27</td>
</tr>
<tr>
<td>Impaired: faces, common objects; spared: words</td>
<td>15</td>
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<tr>
<td>Impaired: faces, common objects, words</td>
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<td>Impaired: words; spared: faces, common objects</td>
<td>Not included in search</td>
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<td>Impaired: common objects, words; spared: faces</td>
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<tr>
<td>Impaired: common objects; spared: faces, words</td>
<td>1?</td>
</tr>
<tr>
<td>Impaired: faces, words; spared: common objects</td>
<td>1?</td>
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</tbody>
</table>
Wholistic analysis

Analysis by parts
Hemispheric Asymmetries

- Hemispheric specialization in the pop culture
- Scientific evidence for specialization
  - Left hemisphere is typically language dominant
    - Wada test: anaesthetize one entire hemisphere
    - Strokes and electrical stimulation
  - Split-brain patients
    - Remove corpus collosum
    - Cross-over of visual pathways and chimeric stimuli
    - Different verbal and pointing responses
    - Different preferences and desires
  - Local and global processing
- Modularity revisited
  - The benefits of modularity: speed, efficiency, and encapsulation
  - Reconciliation with Lashley’s equipotentiality thesis
<table>
<thead>
<tr>
<th>Dichotomies</th>
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<tbody>
<tr>
<td>Convergent</td>
<td>Divergent</td>
</tr>
<tr>
<td>Intellectual</td>
<td>Intuitive</td>
</tr>
<tr>
<td>Deductive</td>
<td>Imaginative</td>
</tr>
<tr>
<td>Rational</td>
<td>Metaphorical</td>
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<tr>
<td>Vertical</td>
<td>Horizontal</td>
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<tr>
<td>Discrete</td>
<td>Continuous</td>
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<tr>
<td>Abstract</td>
<td>Concrete</td>
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<td>Realistic</td>
<td>Impulsive</td>
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<td>Directed</td>
<td>Free</td>
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<td>Existential</td>
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<td>Explicit</td>
<td>Tacit</td>
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<tr>
<td>Objective</td>
<td>Subjective</td>
</tr>
<tr>
<td>Successive</td>
<td>Simultaneous</td>
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</table>
“Whom did you see?”

“It was the child.”

“Point to the person you saw.”
<table>
<thead>
<tr>
<th>Target</th>
<th>Right hemisphere damage</th>
<th>Left hemisphere damage</th>
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</thead>
<tbody>
<tr>
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<td><img src="image2" alt="Right hemisphere damage" /></td>
<td><img src="image3" alt="Left hemisphere damage" /></td>
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<tr>
<td>Left hemisphere intact</td>
<td></td>
<td>Right hemisphere intact</td>
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</table>
Figure 4-14

Drawings copied by a patient with contralateral neglect.
From F. E. Bloom and A. Lazerson. *Brain, Mind, and Behavior;*