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**COGNITIVE SCIENCE 1**

"The Man Who Mistook His Wife for a Hat"

The effects of brain damage on cognitive functioning in human patients

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**First Written Reference to the "Brain"**

From the Edwin Smith Surgical Papyrus:
Written by an Egyptian field surgeon: 3000-2500BC

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Convolutions of the brain - the author of the papyrus describes these "like those corrugations which form molten copper." The gyri and sulci of the brain.

Meninges (coverings of the brain) - described as the membrane enveloping the brain.

Cerebrospinal fluid - described as the fluid in the interior of the head.

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**Edwin Smith Surgical Papyrus - Case C6:**
(First reported case of aphasia induced by localized brain trauma)

Examination:

If thou examinest a man having a smash in his temple, thou shouldst place thy thumb upon his chin and thy finger the end of his ramus, so that the blood will flow from his two nostrils ...

If thou callest to him, he is speechless and cannot speak.
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The Central Question in Human Neuropsychology:

WHAT IS THE RELATIONSHIP BETWEEN HUMAN BEHAVIOR AND THE BRAIN?

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Where in the brain is_______?

The Central Debate:

Is brain mediation of human functions

- localized to specific cortical regions
  or
- the product of the aggregate functioning of the entire cortex.

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Phrenology: The Strong Localizationist View

1798, Gall and Spurzheim:

Behaviors and traits are localized to specific brain regions

The morphology of the skull reflected this pattern of regionalization

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AFFECTIVE FACULTIES

PROPERTIES
7. Desire to live
  - Ablationlessness
1. Destructiveness
2. Anarthritis
3. Philoprogenitiveness
4. Arbritiveness
5. Embitterness
6. Constrictiveness
7. Conclusiveness
8. Aggressiveness
9. Constructiveness

SENTIMENTS
10. Contentlessness
11. Aggristiveness
12. Self-Spersonn
13. Beneathness
14. Reverence
15. Pervenome
16. Conscientlessness
17. Hope
18. Prognostiveness
19. Idiocy
20. Worthlessness
21. Devotion

INTELLECTUAL FACULTIES

PERCEPTIVE
22. Tactileliness
23. Configuration
24. Size
25. Weight & Resistance
26. Coloring
27. Locality
28. Order
29. Calculation
30. Equivocality
31. Dissimilarity
32. Tone
33. Language
Flourens and the Aggregate Field View

- Strong reaction against phrenology
- Long series of animal brain lesion studies - found no specific associations between site of lesion and behavioral dysfunction
- 1824: published very influential book on aggregate field view

Paul Broca
"Tan": A Case Study of Productive Aphasia (1861)

The Emergence of the Lesion Methodology as a Major Source of Data in the Debate

The Logic:

- Cognitive functions involve specific brain regions
- Those functions will be compromised if that region is damaged.

New Methods, New Ideas

The "Neuron doctrine"
Ramón y Cajal 1883

The "Synapse"
Sherrington 1897
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The Identification of Regional Differences in the Cortical “Cytoarchitecture”
(different parts of the brain have different kinds of neurons)

Brodman’s map of the region differences in the cellular architecture of the human brain – numbers indicate his numbering system (1909).

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MODERN NEUROPSYCHOLOGICAL VIEW

Modified Localizationist View:

New models argue for more, complex and distributed systems of neural mediation that reflect the conjoint activity of multiple brain regions.

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What are the effects of brain damage on cognitive functioning of human patients?

Four examples:
1. Memory Function – Amnesia
2. Language Function – Aphasia
3. Visual-spatial Function – Agnosia
4. Locked-in Syndrome

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The Neurobiology of Memory

What are the brain systems that mediate memory?

What is the effect of lesions to specific brain structures on memory ability?
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**WHAT IS MEMORY?**

**Working memory:**
- Limited capacity
- Information can be held for several minutes with rehearsal
  (e.g. memory system you need when you have to remember a phone number, but have no place to write it down)

**Long-term memory:**
- Very large capacity
- Essentially infinite duration
  (e.g. memory system you need when you are reminiscing with friends, or taking a final exam)

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**Different Kinds of Long-term Memory**

**Declarative Memory:**
- Semantic memory - factual memory, general world knowledge
  (e.g. Tell me what an airplane is)
- Episodic memory - autobiographical memory for events
  To remember you must remember the time and place of the original event
  (e.g. What were you doing when you heard that an airplane hit the WTC?)

**Nondeclarative ("Procedural") Memory:**
- Procedures used by an individual to operate effectively on some task
- Memory for procedures is usually implicit, and skills can be performed automatically
  (e.g. typing, bicycle riding, a classically conditioned response)

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**Types of Amnesia (memory loss)**

**Anteriograde Amnesia:** Amnesia for events occurring after the precipitating event.

**Retrograde Amnesia:** Amnesia for events occurring before the precipitating event.

**Hollywood Amnesia**
- Bump your head → lose your memory
- Bump your head, again → regain your memory

** only happens in Hollywood films

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**The Medial Temporal Lobe:**

The Declarative Memory System

- Damage to these areas usually results in serious anteriograde amnesia - patients are unable to form new declarative memories.
- It can also affect past memories, resulting in retrograde amnesia. However, retrograde amnesia is typically “graded.”
- Non-declarative memory is not affected by injury to this brain area.
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A Classic Case of Anteriograde Amnesia: Patient HM
(Scoville and Milner, 1957)

History:
• Minor seizures beginning age 10; major by age 16
• Severe, persistent seizure condition – could not be controlled with anticonvulsant medication
• By mid-20s, condition was so severe, he was unable to work
• Surgery – age 27. Bilateral, medial temporal lobe resection.

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Areas in Brain Injury in Patient HM

Normal Control  Patient HM

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Patient HM
(Scoville and Milner, 1957)

Evaluation two years post-surgery (April, 1955):
• HM gave date as March, 1953 and age as 27
• HM talked to physician just before entering the examining room, but at exam had no recollection of this and denied he had talked to anyone.
• Memories of past were clear.
• Post-Operative Wechsler IQ = 112
• No deficits in perception, abstract thought, reasoning
• Tests of associative learning, score = 0
• As he progressed through the series of tests, he retained no memory of the earlier tests, and did not recognize them when presented a second time.

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What’s wrong with Patient HM, and what does it tell us about the functions of the Medial Temporal Lobe?

First, what can he do?
• His intellect is normal.
• He can remember the past (prior to his surgery) - that means he has very little “retrograde” amnesia
  ➔ His long term memory is in tact
• He can carry on an excellent, short conversation.
  ➔ His working memory is in tact
• He can learn new skills at normal rate – and retains those skills over long periods of time.
  ➔ His procedural memory is in tact
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BUT HM ....

...doesn’t retain new semantic or episodic information,

and he cannot form new declarative memories.

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What does HM tell us about the Medial Temporal Lobe?

MTL structures are:

✓ Essential for the formation, but not storage of long-term declarative memory
✓ Memory depends on MTL for a short duration
✓ It does not mediate short term memory.

The MTL system is required at the time of learning and during a period thereafter while slowly developing, more permanent memories are established elsewhere.

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APHASIA

The disturbance of language processing caused by dysfunction of specific brain regions. Aphasia is characterized by impaired:

• Comprehension of language
• Production of language
• or both

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Types of Aphasia

Broca’s Wernicke’s
THE TWO MAJOR TYPES OF APHASIA

BROCA’S APHASIA:
Nonfluent/ Production Aphasia

WERNICKE’S APHASIA:
 Fluent/ Receptive Aphasia

MAJOR LEFT HEMISPHERE LANGUAGE AREAS

Broca’s Aphasia

- Good comprehension of language
- Limited word output, mainly content words
- Slow labored speech, short sentences with long labored pauses
- Agrammatical output

BROCA'S APHASIA
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**WERNICKE'S APHASIA**

- Good articulation, normal prosody, rapid speech
- Free use of range of grammatical constructions
- Paraphasias – loss of ability to use words correctly or coherently
- Neologisms – patient coins new words to which special significance is given

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**WERNICKE'S APHASIA**

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**VISUAL AGNOSIA**

The inability to recognize a visual object, in the absence of visual sensory or memory disorders.
Two Types of Visual Agnosia

**APPERCPTIVE:** Difficulty forming a percept.
- There is rudimentary processing of visual information (e.g., light/dark)
- But information cannot be bound together in a meaningful way

**ASSOCIATIVE:** Perceptual information cannot be linked to stored knowledge.
- Patients see objects, but cannot identify them.
- Some patients can read, others cannot.

Brain Areas affected in Patients with Agnosia

<table>
<thead>
<tr>
<th>LEFT HEMISPHERE</th>
<th>RIGHT HEMISPHERE</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="brain-left.png" alt="Brain Diagram" /></td>
<td><img src="brain-right.png" alt="Brain Diagram" /></td>
</tr>
</tbody>
</table>

Locked-in Syndrome

- “Pseudo-coma” in patients who are awake but have no means of communication.
- They cannot talk or move limbs or facial muscles
- The ability to move the eyes vertically and to blink are generally normal
- Lock-in syndrome is due to an infarction or hemorrhage of the brain stem.
Children with Prenatal or Perinatal Stroke

- early occurrence of brain injury
- single brain lesion, in one hemisphere
- IQ within the normal range

MRI STUDY OF A 3.5-YR OLD CHILD WITH PRENATAL LEFT HEMISPHERE INJURY

What happens when adults have strokes in posterior temporal brain areas?

Patient Data:
Adults with strokes to right or left posterior temporal brain areas show different patterns of deficit on simple spatial processing tasks.

MEMORY REPRODUCTION: 30 Second Delay

Left Hemisphere: Segmenting the "Parts"
Right Hemisphere: Configuration of the "Whole"
MODEL HIERARCHICAL FORMS FOR THE MEMORY REPRODUCTION TASK WITH CHILDREN

REPRODUCTION ACCURACY ON THE MEMORY FOR HIERARCHICAL FORMS TASK (5-7 year olds and 9-12 year olds)

Control group performs equally well on global and local
RH – deficit global
LH – deficit local

How do typically developing children do?
Examples from 5-year-old controls
Examples from 6-year-old controls

How do children with early right or left hemisphere stroke do?
3 Children with LEFT Hemisphere Stroke: LOCAL Processing Deficit
Model
(5yr, 1mo)
(6yr, 0mo)
(6yr, 3mo)

3 Children with RIGHT Hemisphere Stroke: GLOBAL Processing Deficit
Model
(5yr, 1mo)
(6yr, 2mo)
(6yr, 11mo)
(8yr, 4mo)
(8yr, 4mo)
(8yr, 11mo)
(9yr, 1mo)
(9yr, 1mo)
(8yr, 7mo)
(9yr, 2mo)
(8yr, 2mo)
FUNCTIONAL MAGNETIC RESONANCE IMAGING (fMRI)

Part-Whole Stimulus

Two tasks:
1. Attend to the WHOLE.
2. Attend to the PARTS.

Adult Brain Activation on the Part-Whole Processing Task

Attend to the Whole: Right > Left

Attend to the Part: Left > Right

Child Brain Activation on the Global-Local Processing Task

A. Immature-Bilateral
B. Mature-Lateralized
Summary of fMRI

In adults, a division of labor is observed: the right hemisphere predominates during configural processing, the left hemisphere during processing of the parts.

This division of labor is not clearly evident for younger children.

Rather, for children the entire system appears to be activated, suggesting a less specialized, perhaps less efficient use of cognitive and neural resources.

Conclusions

Brain development is a dynamic, adaptive process.

The capacity for brain adaptation is evident from the earliest point in development.

Studies of children with focal brain injury illustrate the plasticity of the developing brain, that is the ability to organize differently, to adapt.