"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

Cerebrospinal fluid - described as the fluid in the interior of the head.
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.
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…[and]… If thou callest to him, he is speechless and cannot speak.

The Central Question in Human Neuropsychology:
WHAT IS THE RELATIONSHIP BETWEEN HUMAN BEHAVIOR AND THE BRAIN?

Where in the brain is______?
The Central Debate:
Is brain mediation of human functions
- localized to specific cortical regions
- the product of the aggregate functioning of the entire cortex.
**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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**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
The Identification of Regional Differences in the Cortical "Cytoarchitecture" (different parts of the brain have different kinds of neurons)

Brodman’s (1909) Cortical Areas Functional Attributions of Brodman’s Areas

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

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

Three examples and a question:

1. Memory Function – Amnesia
2. Language Function – Aphasia
3. Visual-spatial Function – Agnosia
4. What if damage occurs very early in development? – Effects of Perinatal Stoke
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?

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)

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)
Types of Amnesia (memory loss)

Anterograde 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

The Medial Temporal Lobe: The Declarative Memory System

- Damage to these areas usually results in serious anterograde 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.

A Classic Case of Anterograde 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.
Areas in Brain Injury in Patient HM

Normal Control  Patient HM

MMN = medial mamillary nucleus  lc = lateral colliculus
A = amygdala  PM = parahippocampal
H = hippocampus  GC = collateral sulcus

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 is 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.

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
BUT HM ....

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

and he cannot form new declarative memories.

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.

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
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
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
VISUAL AGNOSIA

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

Two Types of Visual Agnosia

APPERCEPTIVE: 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
- Several different subtypes

ASSOCIATIVE: Perceptual information cannot be linked to stored knowledge.
- Patients see objects, but cannot identify them visually - deficit is modality specific.
- Some patients can read, others cannot.
- Some patients have specific deficits of color identification, or face identification (prosopagnosia)

Brain Areas affected in Patients with Agnosia

ASSOCIATIVE AGNOSIA (can be unilateral)
APPERCEPTIVE AGNOSIA
WHAT HAPPENS WHEN BRAIN INJURY OCCURS EARLY IN LIFE?

THE EFFECTS OF PERINATAL STROKE ON COGNITIVE DEVELOPMENT

Language Development in Children with Perinatal Stroke
1. Lesion occurrence before the end of the first month of life.
2. Single, unilateral focal lesion.
3. Identification on the basis of at least one neuroimaging procedure.
4. Normal or corrected to normal vision and audition.

Children with Pre- or Perinatal Focal Brain Injury (PL): Four Questions

Is there evidence of specific deficits following early focal brain injury?

Are associations between lesion site and functional deficit like those found in adult lesion populations?

Is the pattern of deficit persistent over time?

Do patterns of behavioral deficit change over time?

LANGUAGE ACQUISITION: Early Milestones

Early Vocabulary Development: Comprehension

Early Vocabulary Development: Production

Early Grammatical Development: Production

Discourse Production in School-age Children
VOCABULARY COMPREHENSION

LEFT POSTERIOR TEMPORAL LESIONS
RIGHT HEMISPHERE LESIONS

NO COMPREHENSION DEFICITS
COMPREHENSION DEFICITS

Vocabulary Production

LEFT POSTERIOR TEMPORAL LESIONS

VOCABULARY PRODUCTION DEFICITS

Grammar Production: MLU

LEFT POSTERIOR TEMPORAL LESIONS
LEFT FRONTAL + LEFT POSTERIOR TEMPORAL

GRAMMAR PRODUCTION DEFICITS

MORE SERIOUS GRAMMAR PRODUCTION DEFICITS
Narrative Production In School-age Children

Frog, where are you? (Mercer Mayer, 1969)

Can be used to assess:
• Vocabulary
• Grammar
• Narrative structure
• Narrative coherence

Discourse Production: Age 7

ALL CHILDREN WITHIN NORMAL RANGE ON:
• All measures of vocabulary (by age 5)
• All measures of grammar
• No differences across lesion subgroups

Discourse Production: Age 7

Delays observed in the use of complex language.

DISCOURSE: SUMMARY

BY AGE 7, ALL CHILDREN WITH FL:
DEMONSTRATE MASTERY OF LANGUAGE BASICS

HOWEVER:
DISCOURSE IS SIMPLIFIED
LANGUAGE USE IS FUNCTIONAL, BUT IMPOVERISHED

They know the complex structures of their language, but tend not to use them in discourse.

A CASE STUDY

Large left perinatal lesion
Delayed language acquisition
No productive language at age 3
By age 6, tested within the normal range on standardized measures
Frog, where are you?
(Mercer Mayer, 1969)
HOW DOES THE BRAIN COMPENSATE FOR EXTENSIVE EARLY DAMAGE TO THE BRAIN?

"THE COW IS PUSHING THE ELEPHANT"

QUESTION: WHO IS DOING THE PUSHING?
The Development of Visuospatial Processing in Children with Perinatal Stroke
VISUOSPATIAL PROCESSING

Segmentation of the parts

Integratation of parts into a whole

LEFT HEMISPHERE

RIGHT HEMISPHERE

Performance of Adult Stroke Patients on Memory for Hierarchical Forms

Stimulus  Right Damage  Left Damage

MODEL HIERARCHICAL FORMS FOR THE MEMORY REPRODUCTION TASK

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

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

3 Children with RH Injury: GLOBAL Processing Deficit

3 Children with LH Injury: LOCAL Processing Deficit

Functional Activation in a Part-Whole Processing Task

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