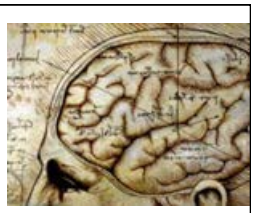
HISTORICAL NOTES

Understanding the mind by looking at what happens when it is damaged



Neuropsychology

- Understanding and assessing the consequences of damage to the brain

***Cognitive* Neuropsychology (CN)**

- Understanding how the mind works *functionally (*not biologically) in all of us by understanding how it breaks down;
- Reasoning backward: How it must have worked before for symptoms to be possible.

Aphasiology – The study of language impairments

- Understanding different type of impairments to:

--understand how language is realized in all of us (aim in common with CN)

-- provide better diagnosis and rehabilitation for people with aphasia

In this first part we will:

- Provide a **brief history of neuropsychology** and how it has influence ideas about the mind and the brain (with a special focus on aphasiology);

HISTORICAL NOTES

It is important to understand to path that science has taken to understand current knowledge. The point of this brief historical review is:

1. Sketch how the field of neuropsychology developed and highlight some of the tensions; Are capacities localised in the brain or globally distributed?
2. Highlight the role played by aphasia studies in the development of ideas of the relation between the mind and the brain;
3. Set the stage for a discussion of methods in neuropsychological research;

Historical roots: The first theories of mind and brain

The Edwin Smith papyrus (around 1700 BC).
Lesions to one side of the brain and motor and visual impairments.

Hittite text (1300 BC) – Possible aphasia of king Mursilis

Hippocratic corpus (400 BC) – The brain and not the hearth is the site of the mind
Insult to the brain may cause limb paralyses and speech impediments.

Valerius Maximus (30 A.D.) - A case of pure alexia?

Renaissance and 17th and 18th century texts
Continues references to brain lesions but...
No distinction between motor impairment and cognitive impairments;
no reference of associations between language and left side of the brain

Is the mind in the brain?: R. Descartes

In the 17th century, the French Philosopher Rene' Descartes put forward the first physiological model of behaviour, claiming that behaviour is realized through pumping of fluid into the muscles.

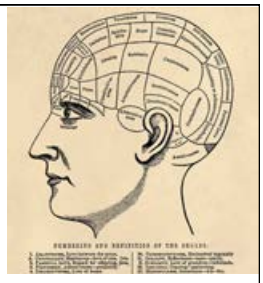
However, the most important part of Descartes philosophy is the separation between the mind and the body (the approach known as **dualism**). The rational soul, was an entity distinct from the body making contact with the body at the pineal gland.

The mechanisms for automatic reaction in response to external events. From Descartes' De Homine (1662)

Local vs global capacities: J. Gall

- Franz Joseph Gall (1790s) – founder of phrenology
- Talented in dissection of the brain
- Fundamental faculties were localised in the brain
- Pressure from the brain determined the shape of the skull
- More developed capacities were larger
- Therefore, abilities could be determined by examining the sizes of bumps on the skull

Phrenology



Principles:

•The Brain is the organ of the mind

•The brain is not a homogenous unity, but an aggregate of mental organs with specific functions

•The cerebral organs are topographically localized

•Other things being equal, the relative size of any particular mental organ is indicative of the power or strength of that organ

•Since the skull ossifies over the brain during infant development, external craniological means could be used to diagnose the internal states of the mental characters

Seat of parental love according to Gall.

A woman who loved children (top) and one who was indifferent to children (bottom).

The woman in the bottom picture was found guilty of infanticide without remorse.

The faculty of parental love (II) is placed in the back of the cerebrum.

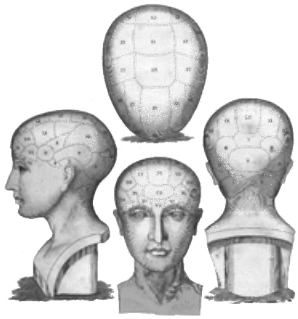
From Prins & Baastianse et al. (2006)

Discuss in groups of three:

- **What are the main tenets of phrenology?**
- **Where did phrenology go wrong?**
- **Why was phrenology influential?**

Phrenology: what was wrong?

- **The main tenant was completely wrong**
  - Bumps on the skull are not related to the size of brain areas or to mental abilities
- **Aspects of phrenology developed into ideas that have an unhappy history**
  - Dividing people into inferior and superior categories by aspects of their appearance (some of Gall's original observations were made in prisons and asylums)
  - Used to justify inequalities in gender and race



Phrenology: Why was it influential?

- Phrenology was influential, however, because it introduced the idea local brain areas were devoted to specific capacities;
- It was the concept of localization that was influential, not the specifics of Gall's system;
- Note how his principles, if not associated with bumps on the head, would not be out of place today:
  - *The Brain is the organ of the mind*
  - *The brain is not a homogenous unity, but an aggregate of mental organs with specific functions*
  - *The cerebral organs are topographically localized*

The equipotential brain: No localisation of function

- One of the reasons the concept localisation of function fell into doubt was due to the experiments of

  Jean Pierre Flourens

- He developed a method of damaging the brain and then observing the effects of the lesion (rabbits and pigeons – 1825) *note relationship to neuropsychology*

Jean Pierre Flourens

- **Removed cerebral hemispheres**
  - Blocked perception, movement, judgement
  - Concluded: They control higher cognitive functions
- **Removed cerebellum**
  - Disturbed coordination and balance
  - Concluded: Regulates movements
- **Removed brainstem**
  - Caused death
  - Concluded: Regulation of vital functions (e.g. circulation/ respiration)

Failed to isolate memory and cognition – (used large lesions)

Concluded: Cognitive functions are distributed throughout the brain; there is no fine-grained localization as predicted by the phrenologists

The case of language: The return of localization – Dax and Broca

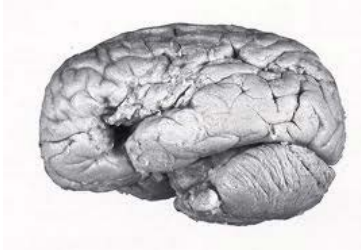
- Marc Dax
- French surgeon
- Language problems are related to disease of the left hemisphere (1836).

- Paul Broca
- French surgeon
- Precocious (graduated medical school at 20)
- Early supporter of evolution
- Massive sideburns (respect!)
- localisation of language (1861)

Broca's patient "Tan"

- Broca heard of a patient with long-term progressive loss of speech (1861)
- At the time he could only say the syllable "tan" (hence his pseudonym
- Today "Tan" would be classified as a global aphasic
- After death, Broca dissected his brain and found a lesion in the left frontal lobe
- Lesion was due to untreated syphilis

Tan's brain still exists →



- In 1863, Broca identified 8 more patients with aphasia and lesions in the left hemisphere; he was caution in his conclusions
- In 1865 identified 12 other patients with speech disturbances and lesions to the left inferior frontal lobe. He concluded: "**We speak with the left hemisphere!"**

Here is Broca's area on an idealised brain >>

Left Hemisphere: The seat of language part 2: Carl Wernicke

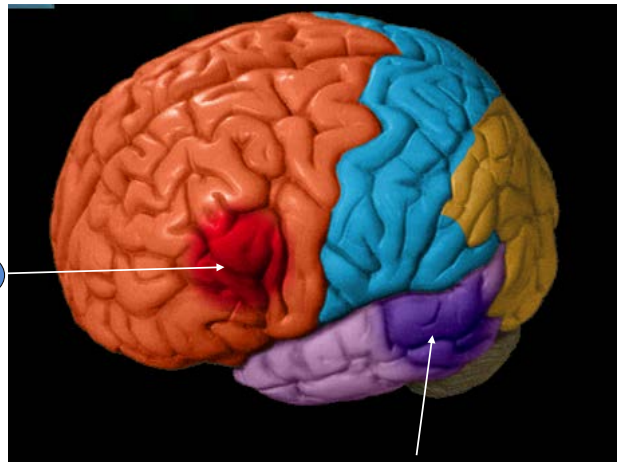
- Broca had (re)discovered an area responsible for speech production. What about language understanding?
- Carl Wernicke -- physician, anatomist, psychiatrist, neuropathologist
- Studied a patient who had very poor language comprehension, along with an intact ability to speak and good hearing
- Dissected the patient's brain after death
- Wernicke found that the patient had a lesion in the left superior temporal lobe (1873)

Wernicke: Theory development

- Based on Broca's area and his own discoveries, Wernicke predicted the existence of patients where the connection between areas was disrupted, but both areas were intact
- This would cause a disruption to the ability to repeat words
- Conduction aphasia was later confirmed by Wernicke
  - Problems in repetition tasks
  - Intact comprehension
  - Fluent speech (even if errors are present—contrast with dysfluent patients or patients with anomia, failure to come up with words)

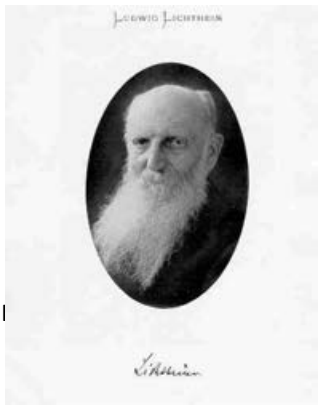
Speech representation on cortex –
Production – Broca / **Comprehension** - Wernicke

Broca's area
at the foot of the
third gyrus of the left
frontal lobe



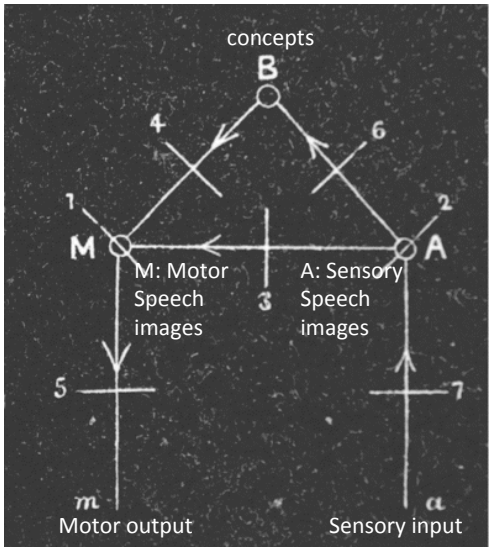
Wernicke's area in the posterior part of the superior temporal lobe

Ludwig Lichtheim – further extensions



- Lichtheim extended Wernicke's predictions
- Produced "Lichtheim's house" diagra
- "Diagram makers": Predict types of aphasia by making diagrams and assessing the consequences of damage to either
  - -- brain centers
  - -- connections between them

Lichtheim's "house"

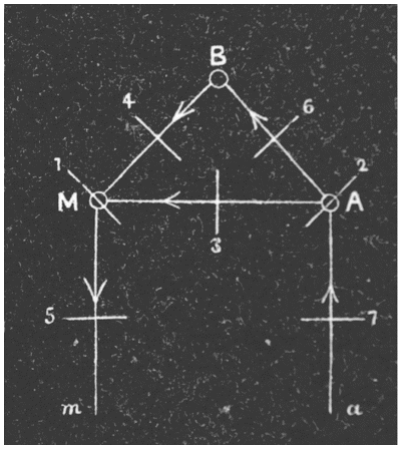


Lichtheim's "house"

- Lesion at A – Wernicke's aphasia
  - Poor comprehension; Poor repetition
- Lesion at M – Broca's aphasia
  - Poor speech; Good comprehension; Poor repetition
- Lesion at 3 – Conduction aphasia

  Poor repetition; Good spontaneous speech
- Lesion at 6 – Transcortical Sensory Aphasia
  - Good repetition; Poor understanding
- Lesion at 4 – Transcortical motor aphasia
  - Good repetition; Good comprehension

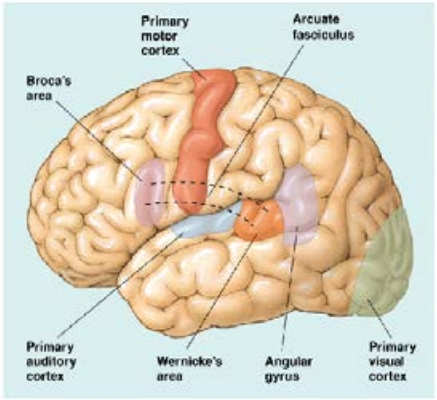
  Poor spontaneous speech
- Lesion at 7 – Pure word deafness
- Lesion at 5 -- Dysarthria



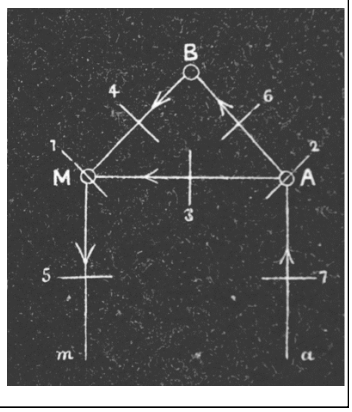
Led to the Wernicke-Geshwind Model

Associated language components and brain structures

► Seven Components of the Wernicke-Geshwind Model



Considered too simple today



Discuss in groups of three:

- **Why where Broca and Wernicke important?**
- **Do you remember where Broca's are and Wernicke's areas are?**
- **Why were the model of Wernicke's and Lichtheim's influential?**

The legacy of the diagram-makers

We still think of cognition as consisting of different cognitive faculties of module which communicate with each other creating cognitive networks.

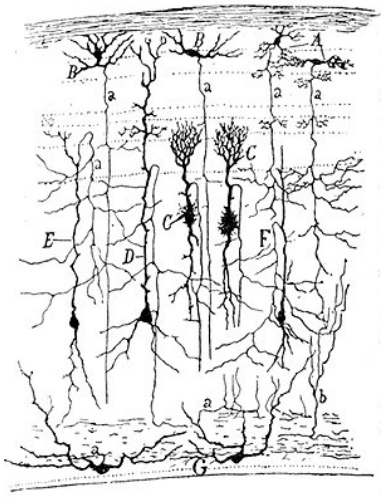
We still interpret aphasia symptoms as arising from damage to one or more of these cognitive modules.

Other contributions to the localist approach

Santiago Ramon y Cajal, Spanish histologist, 1888 – discovered that the brain is made up by a network of brain cells and that the distribution of cells is different in different parts of the brain.

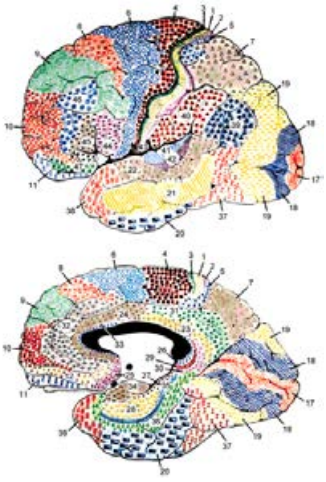
He used the staining technique discovered by Golgi.

He was strongly opposed to the idea that the nervous system is made up a network of continuous elements, as it was supported by Golgi himself.

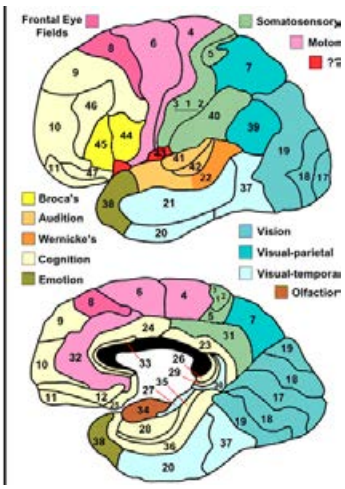


Korbinian Brodmann, German anatomist, 1909 - numbered 50 brain areas varying in appearance.

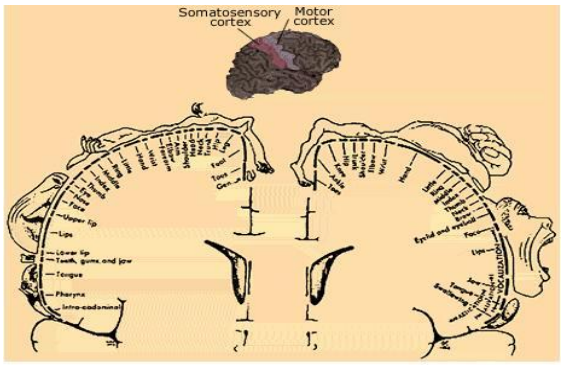
Original Brodman map



Outlines with functional attribution



Wilder Penfield, Canadian neurosurgeon, 1960s - electrical stimulation of human brains.



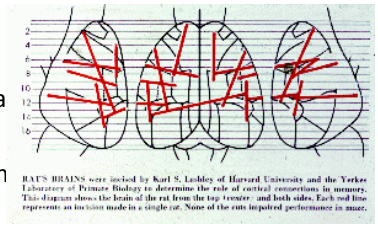
These famous brain maps by Wilder Penfield show that each part of the body is represented on two strips of the brain's cerebral cortex, the somatosensory cortex (left), which receives sensations of touch, and the motor cortex (right), which controls movements. Fingers, mouth, and other sensitive areas take up most space on both maps. Penfield called these cross sections the "sensory homunculus" and the "motor homunculus."

Brain - John Belliveau, NMR Center, Massachusetts General Hospital. Homunculus - Reprinted Simon and Schuster, Inc. from *The Cerebral Cortex of Man* by Wilder Penfield and Theodore Rasmussen ©1950 Macmillan Publishing Co.; renewed ©1978 Theodore Rasmussen.

Return of the Equipotential Brain

Karl Lashley

- Trained in the behaviourist tradition
- Learning/memory are fundamental topics; wanted to localize memory
- Published "Search for Engram" – 1951
- Taught rats in a maze, looked for where the memory of the maze was located by making lesions.
- If he found the memory, damaging it should disrupt learning
- No one area had a critical effect. More dama more disruption
- Conclusion: Functions are distributed over th whole brain



RAT'S BRAINS were incised by Karl S. Lashley of Harvard University and the Yerkes Laboratory of Primate Biology to determine the role of cortical connections in memory. This diagram shows the brain of the rat from the top (center) and both sides. Each red line represents an incision made in a single rat. None of the cuts impaired performance in maze.

Lashley's conclusions

- **Equipotentiality** – all areas have similar potential. If one area is damaged, another takes over
- **Mass action** – Rate, efficacy and accuracy of learning is determined by the total amount of cortex – more damage → worse performance

Lashley – what went wrong?

- Lashley's view of memory (that specific memories are distributed over large areas of the brain) is not the current view
- What went wrong?
- Complex task (maze learning) – based on a complex set of cognitive capacities.
- Damage to different areas impaired *different* cognitive capacities that influenced the task.
- Overall performance deteriorated because overall performance was based on the sum of all the capacities, not on just one capacity.
- He made cortical lesions. Some of the most important structures for memory (giving dramatic lesion results in humans) are at the border between the cortex and the subcortex (e.g. hippocampus -- amnesic patients)

Amnesia

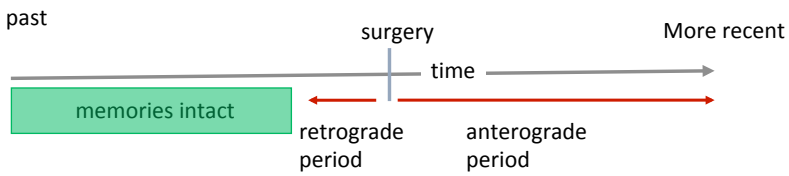
- There is much more that could be said about amnesia and the neuropsychology of memory that we will not cover here
- The point for today is that what Lashley was looking for does, in fact, exist in some form
- The critical structures are deep in the brain on the boundary between cortical and subcortical regions
- The medial temporal lobe structures, however, are not involved in all types of memory, however (STM not affected)
- And, once consolidated, storage is distributed
- Global/local distinction is not "winner take all" for local

Evidence against equipotentiality in memory

- Amnesia – patient HM (Scoville and Milner, 1957)
  - surgery for intractable epilepsy
  - eliminated parts of the medial temporal lobe
    including the hippocampus and entorhinal cortex
  - result: dense amnesia
  - HM was unable to form new long-term memories of events or learn new facts/words

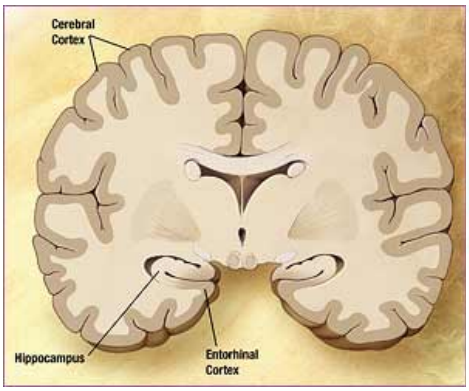
Patient HM

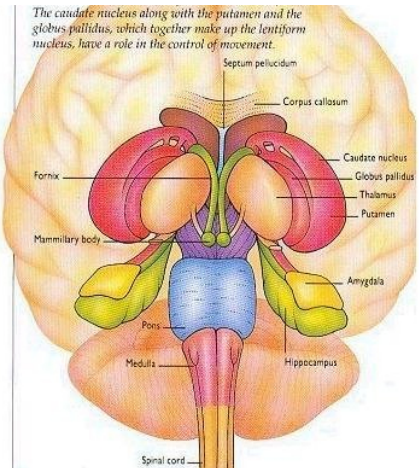
- no <u>new</u> memories after the surgery (anterograde amnesia) and for a <u>short period before</u> the surgery (retrograde amnesia)



- Why before the surgery?
- Retrograde period seems to be due to *consolidation* – a period when memories for events that have already happened are not yet permanently established in the cortex

HM's lesion -- hippocampus





- Note why Lashley's lesions may have largely spared the hippocampus

A reconciliation

Aleksandr Luria, Soviet Neurologist - A Complex function is realized through the interaction of a number of simple functions - Simple functions, but not complex functions can be localized.

In aphasia a **globalist** approach in the 1950s was followed by a return to a **localization** approach in the early 1970s (see lecture 3).

BUT

Local/Global tension still exists

Local

- Many capacities have important localised centres
- Brain damage can lead to very specific impairments
- Human capacities can be varied – ability in one domain does not guarantee ability in another domain
- Emphasizes specificity of brain areas
- Consequences of local view: Human capacities are multidimensional. Measuring one capacity does not give information about others

Global

- Left/right hemisphere areas have similar functions in parallel regions which means functions are distributed over the hemispheres
- "Higher" functions are less localised
- This viewpoint emphasizes distributed information
- This viewpoint emphasizes importance of networks
- Consequences of the global view: Human capacities have some degree of unidimensionality – see IQ – people are higher/lower ability

Aspects of both local and global views are present in current views of brain function

Summary

We have discussed

- Early view of the relationship between the mind and the body
- The birth of modern views with language studies
- The tension between localization vs distributed/global approaches.

Test your acquired knowledge!!

1 **Where is Broca's area localized in the brain?**

2 **Where is Wernicke's area localized in the brain?**

3 **Gall believed that:**
- a Language is localized in the left hemisphere;
- b Language is localized in the frontal lobe;
- c You can assess how good one is at language by feeling the bumps on his/her head;
- d You can b how good one is at language by measuring his/her electromagnetic field;
- e B and C

4 **What is the main difference between Wernicke's and Lichtheim's model?**
- a Lichtheim's model included more components and connections;
- b Lichtheim's model wanted to be an anatomical model;
- c Lichtheim's model included a semantic component;
- d Both a and c
- e Both a and b

5 **Broca enunciated his famous dictum in:**

a 1765

b 1866

c 1965

References

- Prins, R. & Bastiaanse, R. (2006). History of Aphasia. The early history of aphasiology: From the Egyptian surgeons (c 1700 BC) to Broca (1961). *Aphasiology*, *20*, *8*, 762-791.
- Rapp, B. (2001). *The handbook of cognitive neuropsychology: What deficits reveal about the human mind*. Philadelphia, Pa.; Hove: Psychology Press. Chapter 12, Spoken word production.
- Ellis, A.W., & Young, A.W. (1989). *Human Cognitive Neuropsychology*. Hove: Lawrence Erlbaum Associates. Chapters 1