

# INTRODUCTION TO COGNITIVE NEUROPSYCHOLOGY

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# WHAT IS NEUROPSYCHOLOGY?

- *Neuropsychology* is the study of the effects of lesions or dysfunctions of the Central Nervous System (CNS) on cognition and behaviour.
- The regions of interest are the cortex of the two brain hemispheres, the sub-cortical structures (such as thalamus, basal ganglia, hypothalamus, and amygdala) and the main connecting white matter fibres.

# THE AIMS OF NP

- Neuropsychology is useful for both research and clinical purposes:
  1. It explores the functional architecture of the mind and its neural correlates;
  2. It provides patients with a diagnosis and possibly with rehabilitative recommendations.
- No research is possible without a clear understanding of the nature of the deficit.

# LOCALIZATION

- The history of neuropsychology is linked to the changing of concepts of functions' *localization*.
- By *localization* we mean that different parts of the brain are specialized in such a way so as to contribute to behaviour at various levels.
- The most fundamental fact was established in ancient times when the Greeks first determined that the *brain* was the physical *seat* of the mind.
- The one credited with making this basic advance in the *V century B.C.* is *Alcmaeon of Croton*, who came to this conclusion after observing brain damaged patients.

# THE CARDIOCENTRIC VIEW

- The alternative hypothesis held the *heart* to be the organ responsible for sensation and thought.
- This was the accepted view among ancient Egyptian writers and continued to attract adherents in ancient Greece.
- Among them, *Aristotle* (ca 384-322 BC) maintained the *cardiocentric view*, and suggested that the brain served to cool the blood.

# THE THEORY OF THE VENTRICLES

- Among cerebrocentrics, however, the nature of the mind-brain relation was poorly understood.
- In fact, for centuries, the most important anatomical features of the brain were considered to be the *ventricles*.
- Why *ventricles*? Because they contained the *real substance* of the mind, i.e. the *cerebrospinal fluid*.



# LOCALIZATION AND THE VENTRICLES

## Herophilus of Alexandria (ca 335-280 BC)

- placed the mind in the *posterior (fourth) ventricle*.

## Galen (130-200 AD)

- distinguished three basic components of the intellect: *imagination, reason and memory*.
- Although he thought that each function could be affected separately by brain damage, he did not propose to localize them within the ventricular system.

## Nemesius Bishop of Emesia (ca. 390 AD)

- proposed that *perception* + *imagination* were localized in the 2 lateral ventricles (treated as a single, anterior cavity);
- *reason* in the middle ventricle (3°);
- *memory* in the most posterior ventricle (4°).

**2nd Ventricle**  
Reason

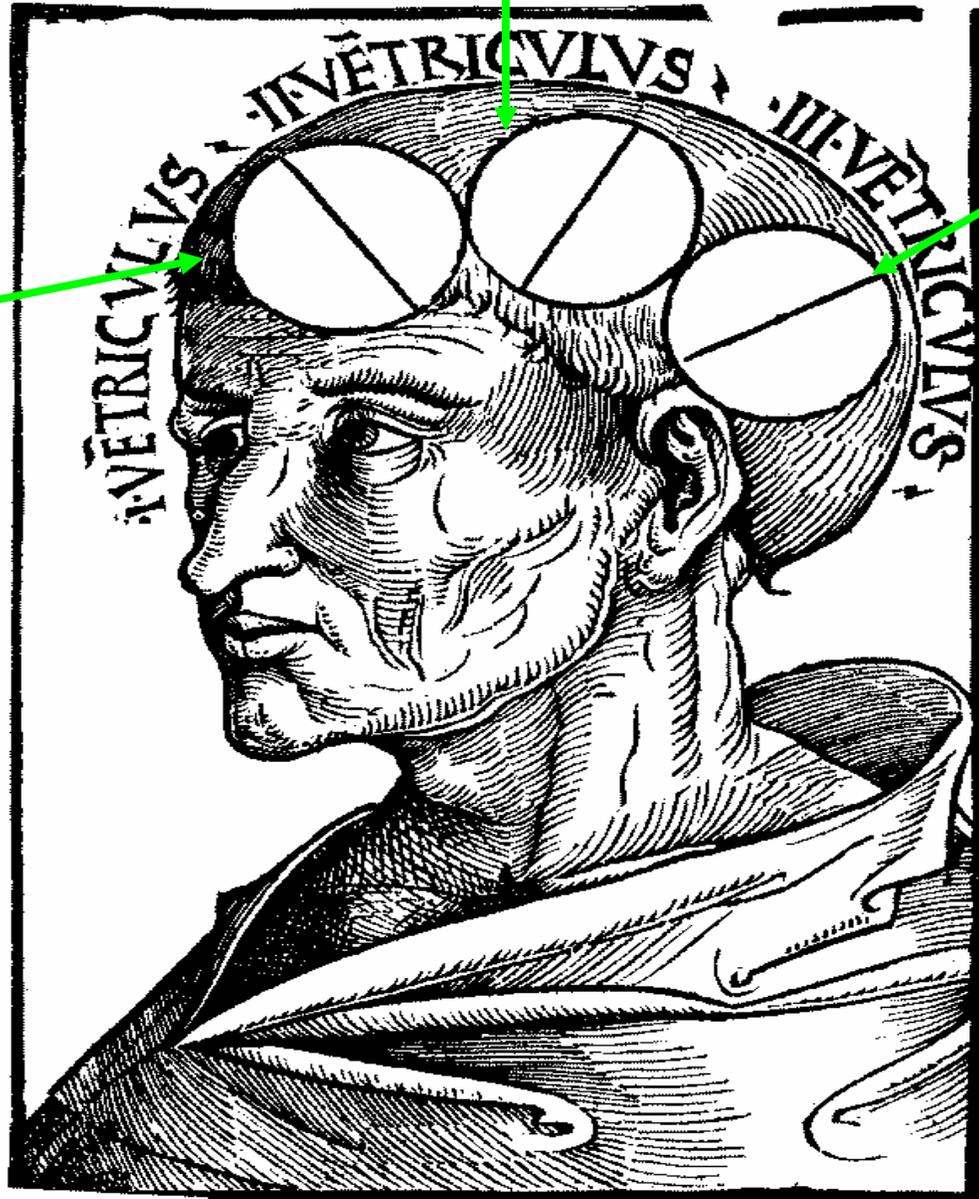
**1st Ventricle**

Perception

Imagination

**3rd Ventricle**

Memory



Albertus Magnus, *Philosophia naturalis*, 1506

## DECLINE OF THE THEORY OF THE VENTRICLES

- After many centuries, the ventricular doctrine slowly started to decline and the forebrain began its rise to prominence as the source of things intellectual.

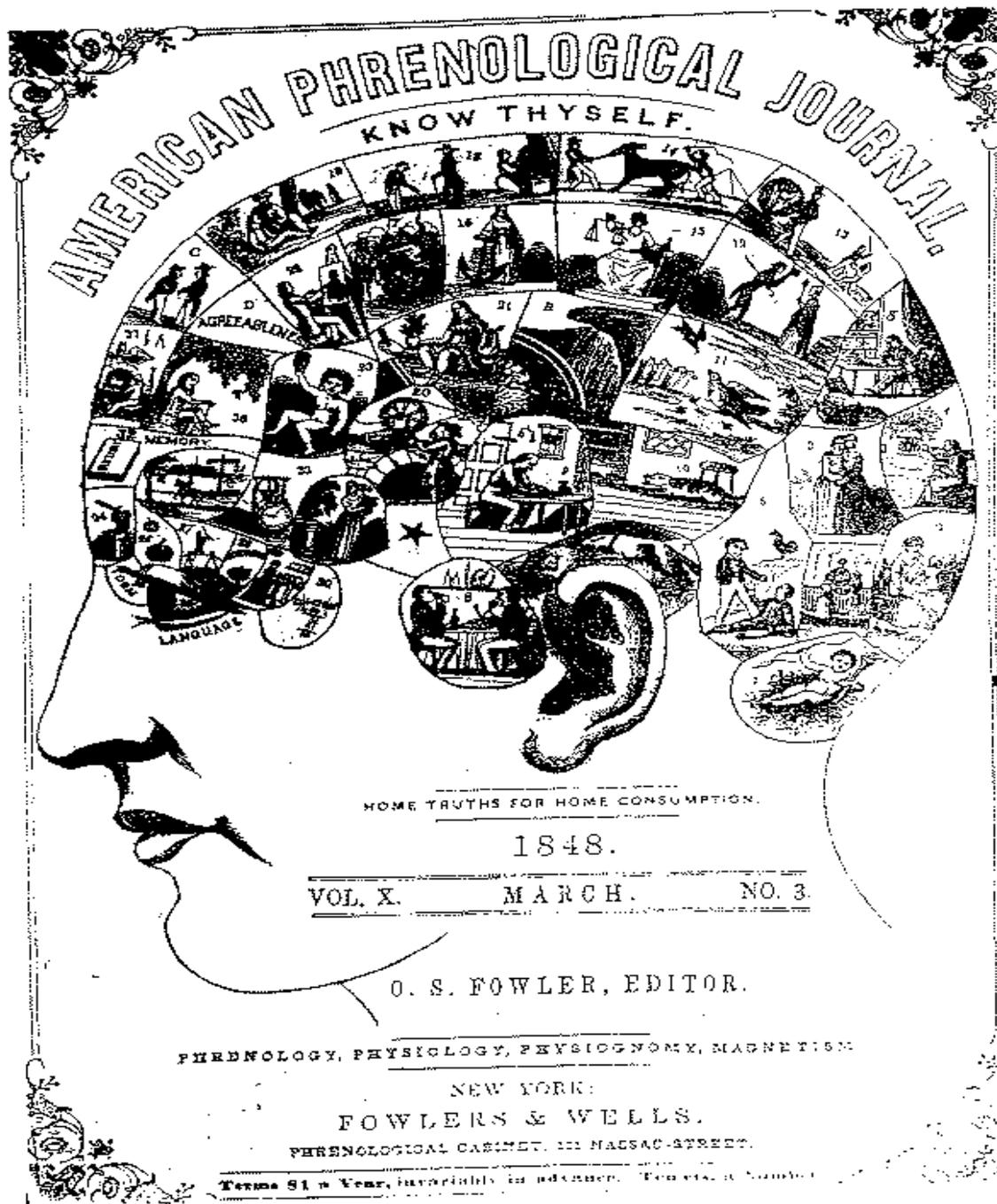
## WHITE MATTER

- After the XVI century, it was accepted that the encephalon was the site of mental functions but the critical structure was held to be the *white matter*, whereas the *gray matter* was considered as the external, protecting layer.
- Schenck (XVI)
- Wepfer (1727, book published posthumously)

# RISE OF THE THEORY OF PHRENOLOGY

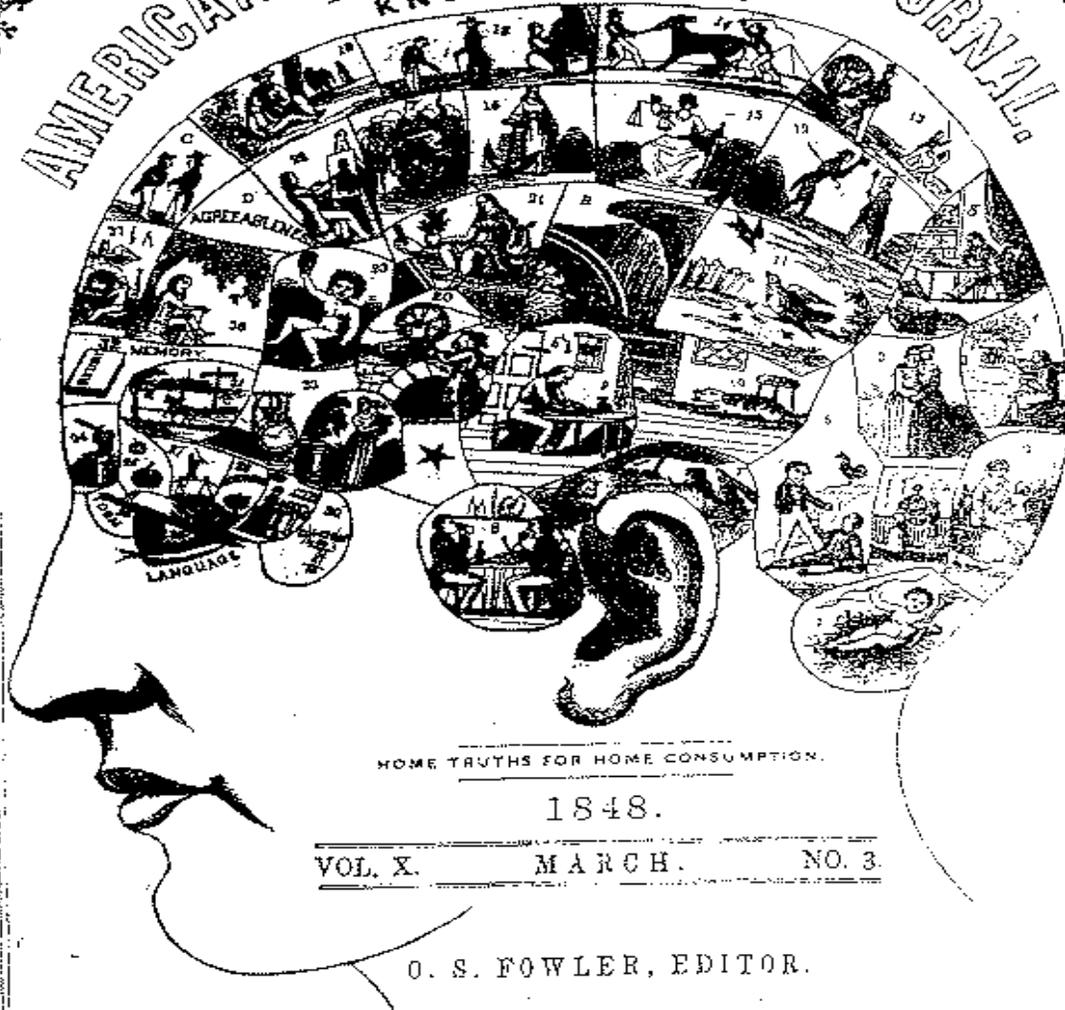
## FRANZ JOSEPH GALL (1757-1828)

- He proposed an explicit theory of the mind-brain relationship whose main ideas are:
  - the mind is made up of 27 distinctive components (*faculties*)
  - these are localized in specific regions (*organs*) of the cerebral cortex
  - the amount of a given faculty determines the size of the organ: the more highly a faculty is developed, the larger the organ.
  - by measuring the skull of an individual, one can infer the dimension of single faculties.



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- The theory of phrenology was dismissed because it could not be proved scientifically:
  - too many faculties which were non-cognitive
  - impossible to find their localization.
- Although the method employed by Gall was far from being satisfactory, the theory had the merit of drawing the attention to the **correlation** between the *cortex (i.e. grey matter)* and *cognitive functions*.
- Importantly, Gall and his followers were convinced that **speech** was housed in the **front** part of the cerebral cortex.

# IS LANGUAGE IN THE FRONTAL LOBES?

JEAN-BAPTISTE BOUILLAUD (1796-1881)

- examined a large number of patients with brain damage and language disorders (collected by others);
- confirmed the localization of speech in the frontal cortex, without distinguishing between left and right hemisphere, in all the cases considered.
- However Luzzatti & Whitaker (2001) demonstrated that Bouillaud's localization was inconsistent with the observation of many patients with injuries to the frontal lobes without aphasia (and patients with aphasia without frontal lesions).

# IS THE LEFT HEMISPHERE SPECIALIZED FOR LANGUAGE?

Marc Dax (1770-1837)

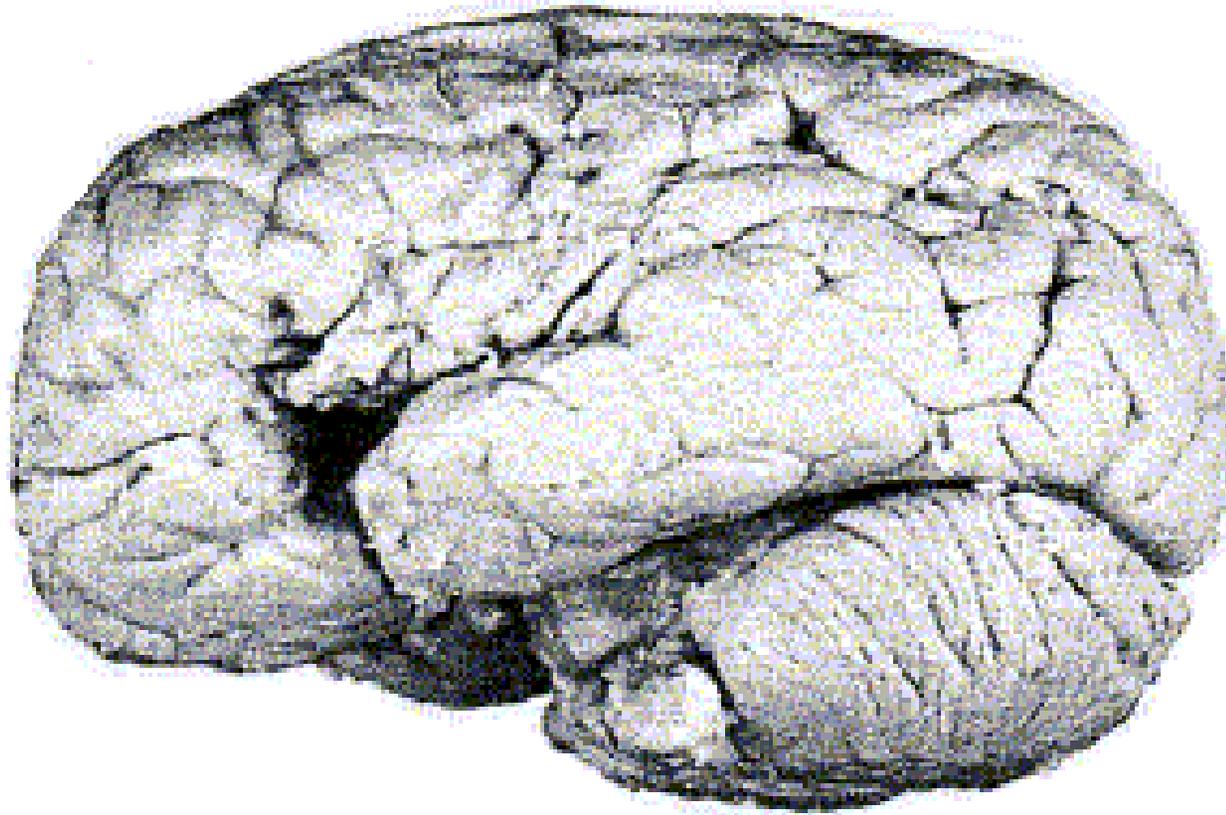
- In 1836, he presented at a conference of medicine in Montpellier, more than 40 cases of patients with left-hemisphere lesions and aphasia, suggesting that language is a lateralized function.
- Dax's report was published by his son only in 1865, after his death.

# PAUL BROCA



- In 1861, he presented his celebrated case of Monsieur Leborgne, nicknamed “*Tan*” because this was his only utterance, along with a few obscenities.
- This 51-yr-old man was a long-term resident in an institution, who had lost his capacity for voluntary language 21 yrs. earlier, and had not been able to use his right arm for 10 yrs.

- **Tan** died soon after Broca saw him and his autopsy revealed a lesion centered in *the foot of the third frontal convolution of the left hemisphere.*



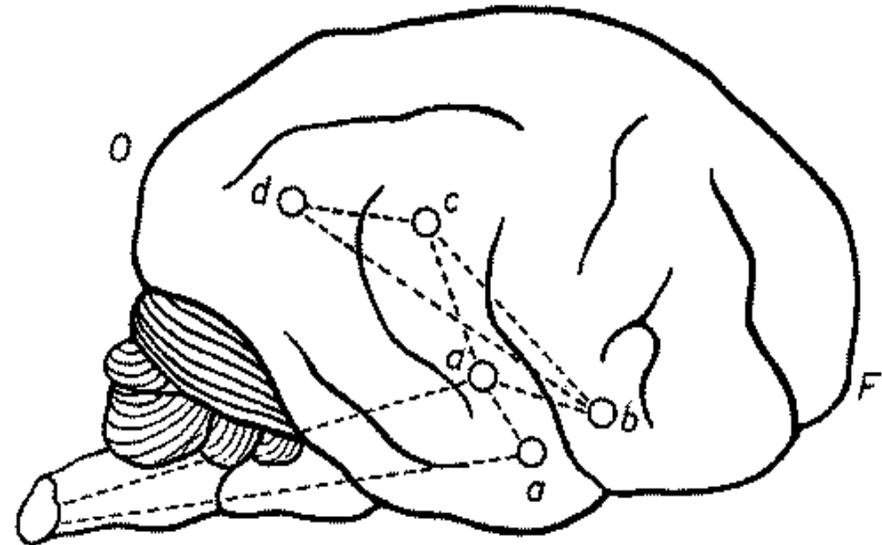
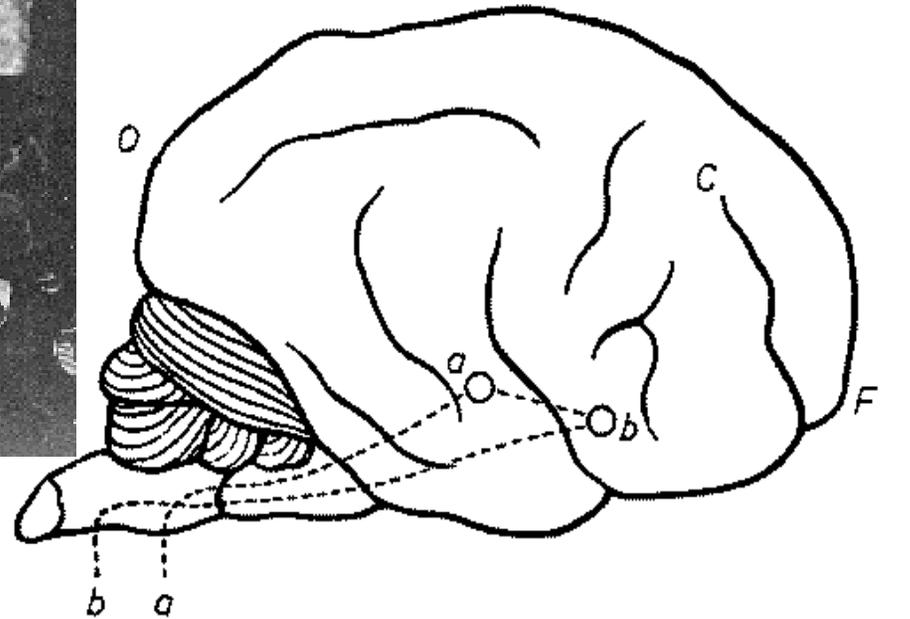
“Tan’s” brain,  
now at the  
Musée  
Dupuytren

- In 1865, Broca suggested that language was a *function lateralized in the left hemisphere.*

# Wernicke

He proposed a general model (1874) of language that could explain a number of different aphasic syndromes by means of lesions to different **centers** and **connections** to centers.

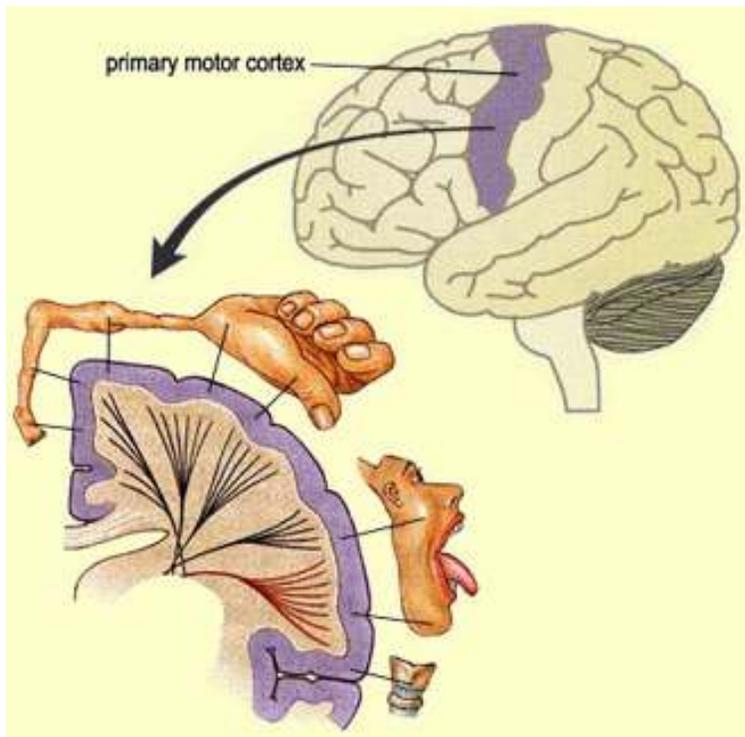
Unlike Gall's model, a relatively small number of basic centers and connections allow one to explain a wide variety of higher functions.



# Localizing motor functions

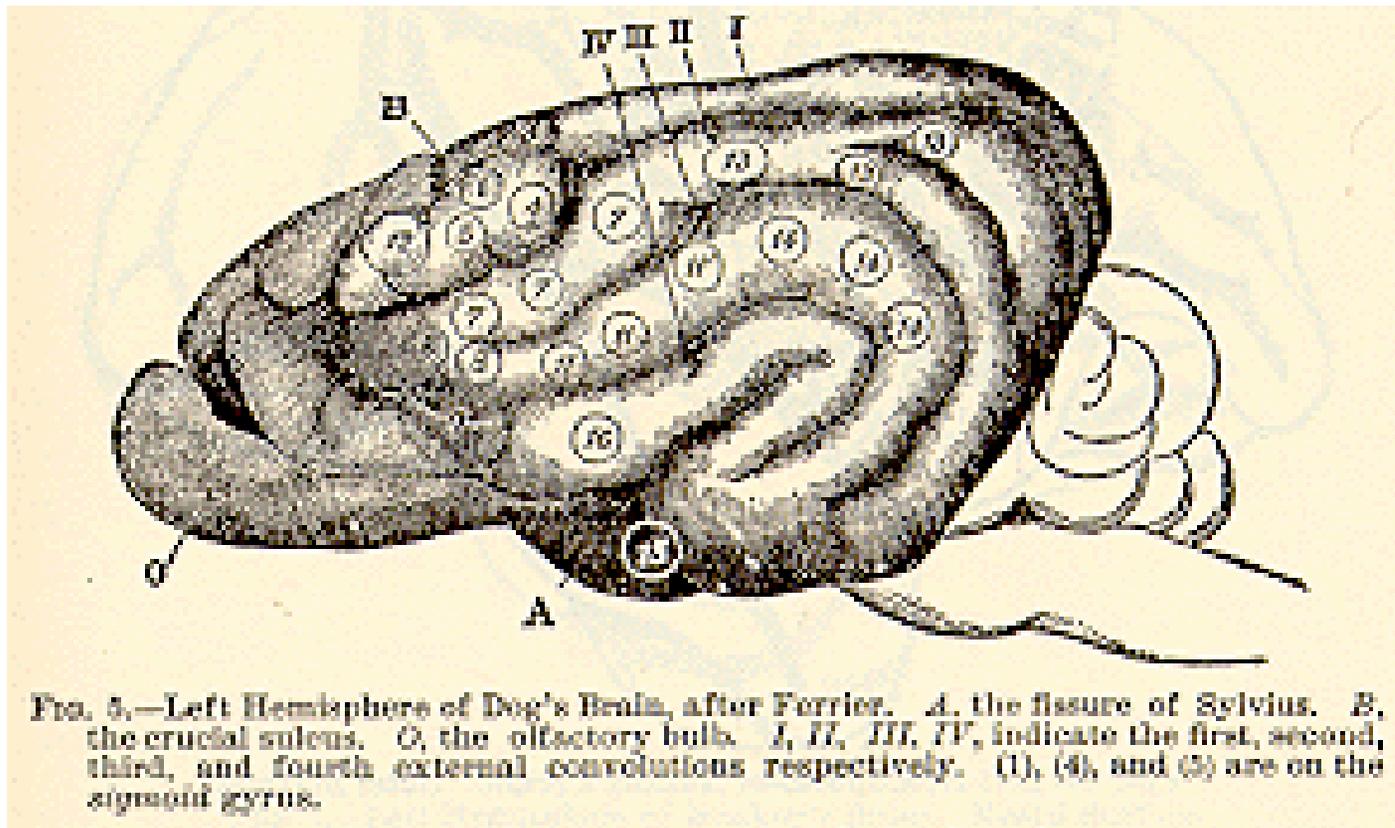


- Fritsch & Hitzig (1870) found that, depending on what part of the dog's cortex they stimulated electrically, a different part of the body contracted.
- They also found that if they destroyed this same small area of the cortex, the corresponding part of the body became paralyzed.
- They thus established that every part of the body has a particular region of the primary motor cortex that controls its movement.
- Body parts that can make the finest movements take up much more space than others (Penfield, in man).





- David Ferrier (1843-1928) performed electric stimulation on the monkey brain.

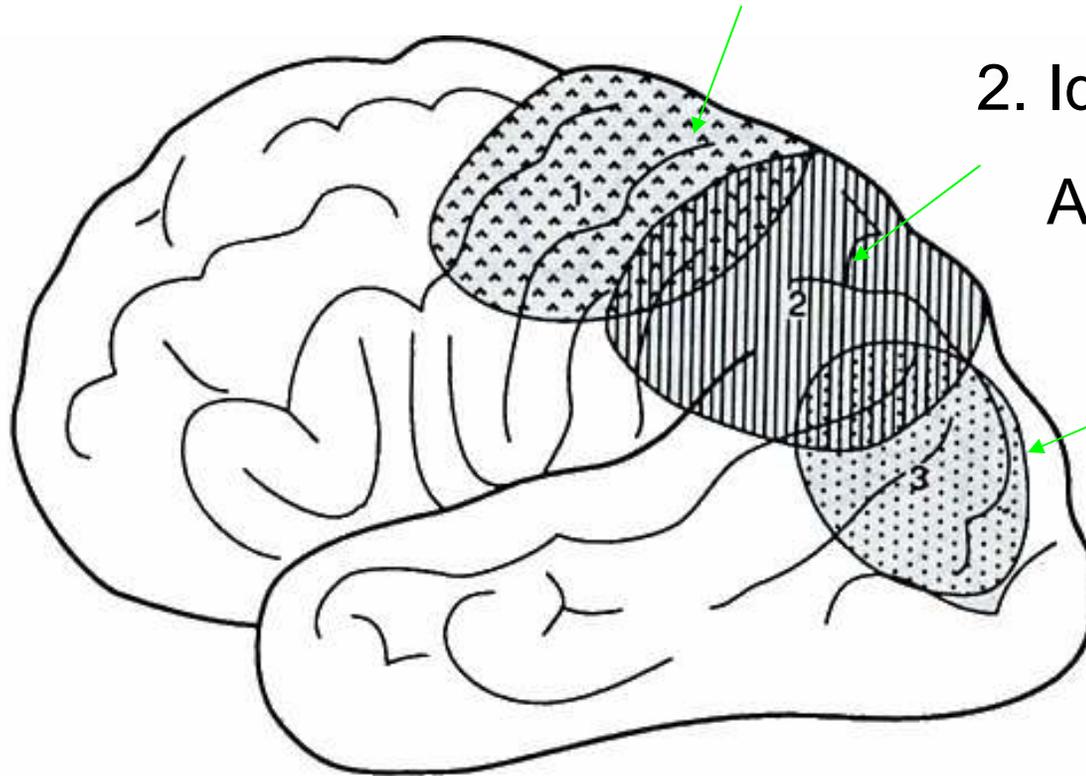


# APRAXIA: LIEPMANN (1920)

1. Motor Apraxia

2. Ideomotor  
Apraxia

3. Ideational  
Apraxia



# PSYCHIC BLINDNESS

- **Munk** ablated bilaterally the occipital lobes of dogs and monkeys (1878, 1881).
- The ablation produced an impairment of the animals' ability *to recognize objects*, although they were still able to navigate in the environment.
- These findings established an association between *vision* and *occipital cortex*.

# *Seelenblindheit* or *Soul-blindness*

- Lissauer (1890) described the case of a patient with a lesion of the left temporo-occipital junction, who was not able to identify familiar objects though he could copy drawings and was not confused.
- He suggested a distinction between an *apperceptive* and an *associative* deficit, a clinical dichotomy still in use today.
- The term *agnosia* was introduced by Sigmund Freud (1891).

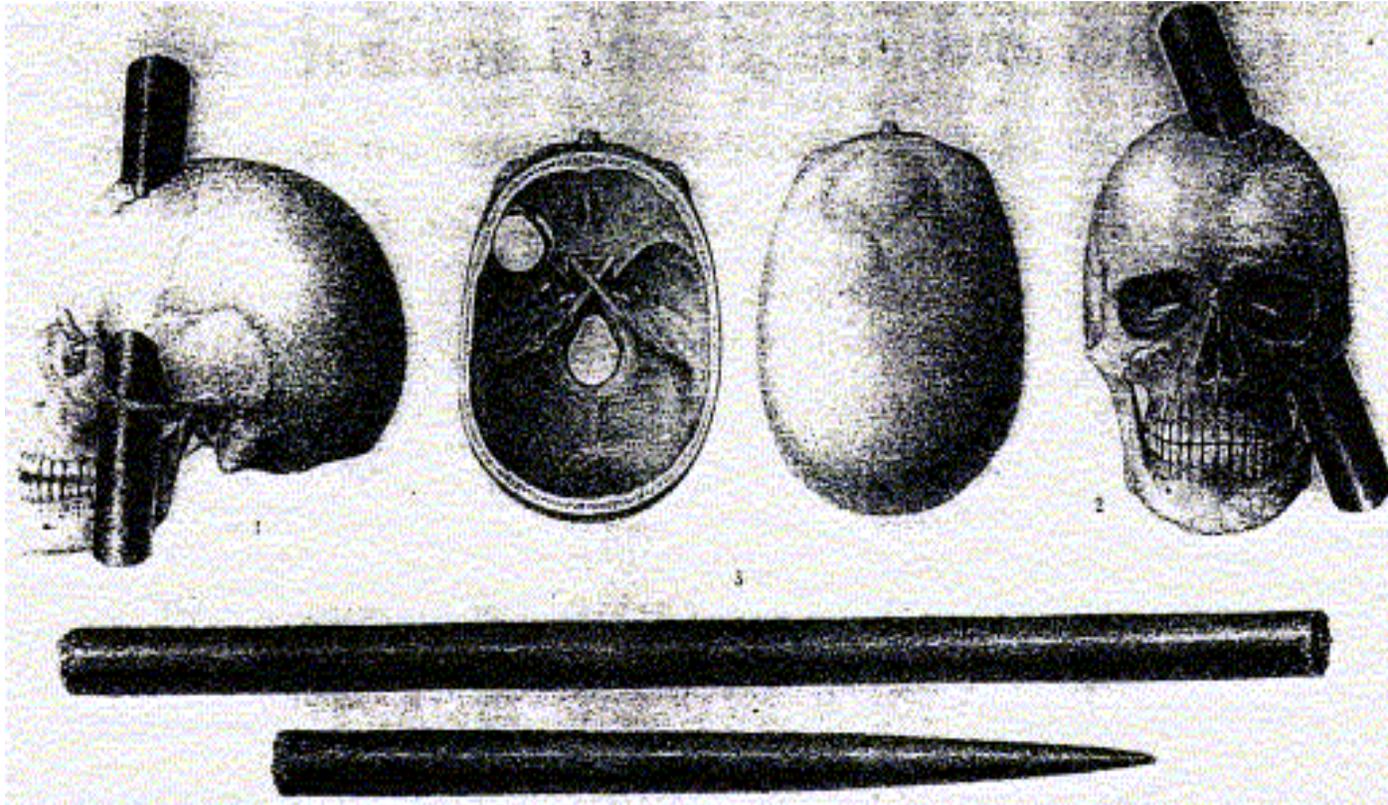


# THE RIGHT HEMISPHERE

- The first to recognize that the **right hemisphere** might have specialized functions of its own was **Hughlings Jackson (1876)**.
- Based on the clinical observation of a single patient, he argued that whilst the left hemisphere might be “dominant” for language, the right hemisphere was critical for visuo-perceptual abilities.

# INTELLECT & FRONTAL LOBES

- Damage to prefrontal cortex leads to more complex phenomena.
- The first description of the consequences of lesion to these regions in man is that of **Phineas Gage**, given by Harlow in **1848**.
- Gage was a rail-road foreman who accidentally dropped his tamping iron on a rock, igniting some blasting powder.
- The explosion caused the iron to shoot through the left side of Gage's jaw and up through the front of his cranium.



Harlow (1868)

# CLINICAL REMARKS

*“He was no longer Gage”*

- Gage’s recovery over the next few months after the accident was far better than anyone expected.
- However, it was clear that his personality and intellect had been altered:
  - he now exhibited poor judgment, impulsivity, and lack of restraint;
  - he had become childish.
- This was the beginning of the association between frontal lobes and more abstract intellectual functions.

## LIMITS OF TRADITIONAL NP

- With a few exceptions, individual patients were poorly described.
- They often suffered from multiple deficits.
- Patients were grouped into *syndromes* because they shared symptoms (patients with Broca's aphasia, Wernicke's aphasia, etc.).
- The psychological concepts and tests available were inadequate.
- The techniques were too few.

# DIAGRAMS

- Traditional neuropsychologists made a great use of diagrams between 1870 and 1910.
- These diagrams were used to explain different forms of language disorder in terms of damage either to the centres themselves or to the pathways connecting them.
- The best known is that put forward by Lichtheim (1885).

# Lichtheim's Model

A = centre of auditory  
*representations of words*

B = centre of auditory  
*representations of words*

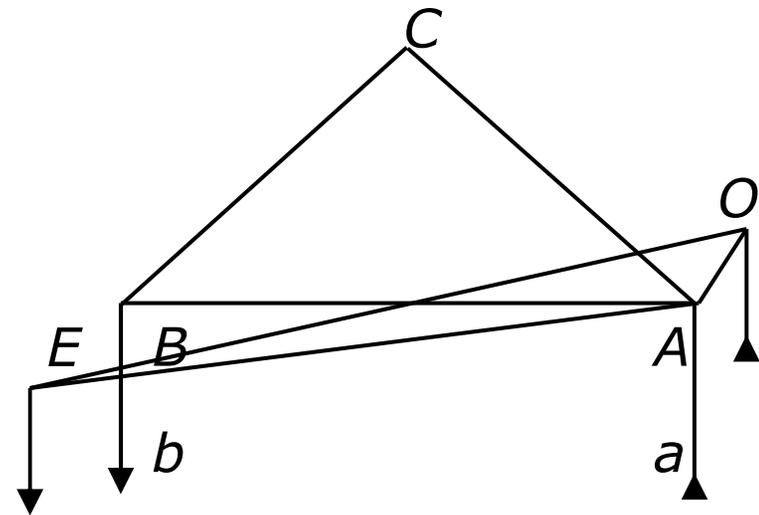
a = *auditory analysis*

b = *articulatory programming*

C = *conceptual knowledge*

O = *visual engrams (reading)*

E = *hand motor engrams (spelling)*



# LIMITS OF DIAGRAMS

- They were only of real use in interpreting disorders that affected comprehension, production, repetition of single words.
- They had little to say about:
  - disorders affecting, for example, grammatical processes involved in sentence construction;
  - or about how the centres might actually work.
- They were constrained only by neuropsychological evidence and often changed to fit new patterns.
- Diagrams were super-imposed upon the left cerebral hemisphere of the brain:
  - they incorporated both a cognitive theory of what centres and connections are, and where they were located.

# COGNITIVE NEUROPSYCHOLOGY

- A revolution occurred when patient-based neuropsychology and cognitive psychology eventually came together.
- The main tenet of cognitive psychology is that mental activity (i.e. cognition) is information processing.
- By varying stimuli and instructions to the subjects, and by measuring their responses, cognitive psychologists make inferences about the information processing that intervenes between stimulus and response (*the black box*).

# COGNITIVE NEUROPSYCHOLOGISTS

- seek to explain the patterns of impaired and intact cognitive performance seen in brain-injured patients in terms of damage to one or more of the components of a theory of normal cognitive functioning
- and, on the other hand, to draw conclusions about normal, intact cognitive processes from observed disorders.