Chaper 1. A Brief History of Cognitive Neuroscience

Cognitive Neuroscience: The Biology of the Mind, 2nd Ed.,
M. S. Gazzaniga, R. B. Ivry, and G. R. Mangun, Norton, 2002.

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Introduction

- What is the field of cognitive neuroscience all about?
- Where did it come from and where is it going?
- The people and ideas that led to the neurocognitive science, which roots in neurology, neuroscience, and cognitive science.

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- The Brain Story
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- Cognitive Neuroscience
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Pondering The Big Questions

Pondering The Big Questions

- Cognitive neuroscience is the science of the psychological, computational, and neuroscientific bases of cognition. This includes *mind, love, thinking, feeling, moving, attending, remembering, communicating, etc.*
- Cognitive neuroscience is not armchair thinking – To understand neurological basis of cognition, we need a laboratory to conduct experimental studies.
- An example – Face perception: special system or general system?

The Brain Story

Localizationist View (1/3)

- Issue: Is the whole brain working in concert or parts of the brain working independently to enable mind?
- Gall: Emphasized the idea that different brain functions are *localized to discrete brain regions* (phrenology).
- Aggregate Field: Flourens challenged the localizationist view – "The faculty of sensation, percept and volition is then *essentially one faculty*."

Gall & his map

Localizationist View (2/3)

- Broca's aphasia (1861) – lost ability to talk
- Wernicke's aphasia (1876) – talk but make little sense

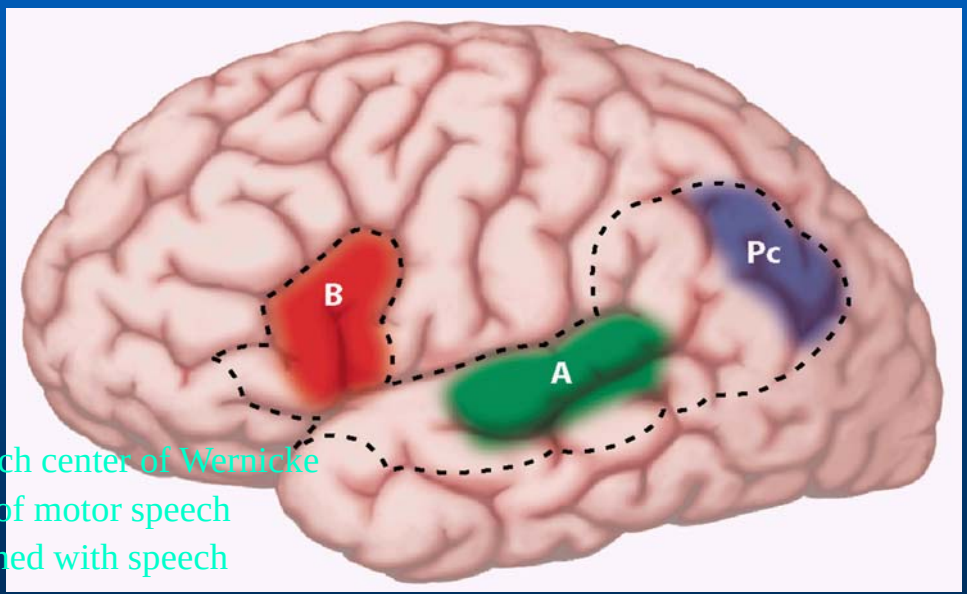


Fig. 1.5:
A: Sensory speech center of Wernicke
B: Broca's area of motor speech
Pc: Area concerned with speech

Localizationist View (3/3)

- Brodmann (1909): Analyzed the cellular organization of the cortex and characterized 52 distinct regions, based on cell structure and arrangement.

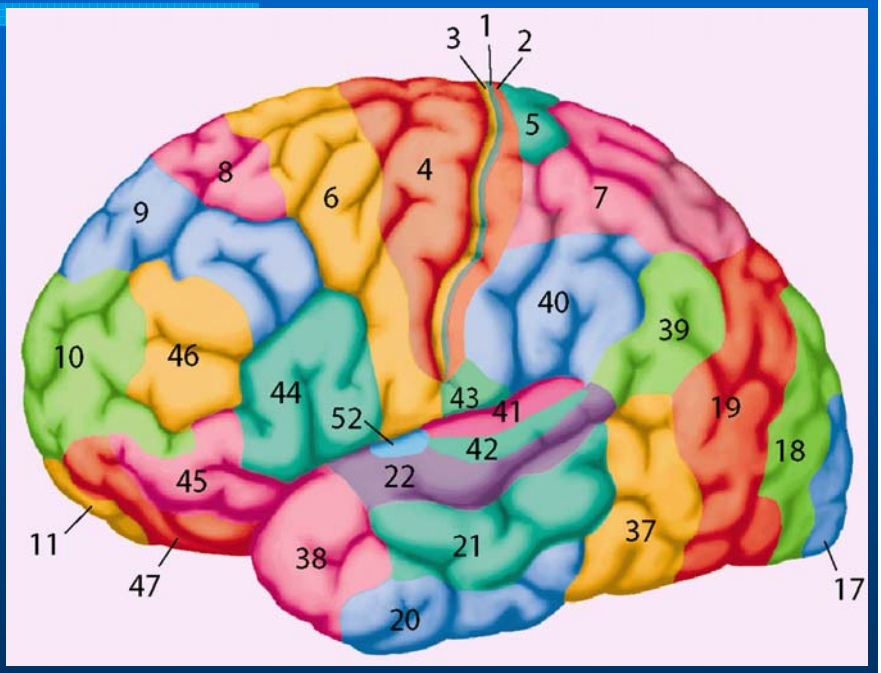
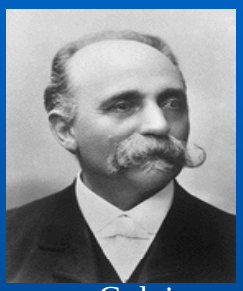


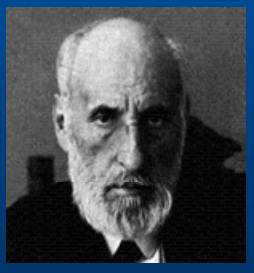
Fig. 1.7: The 52 distinct areas described by Brodmann (1909)

Neuron Doctrine

- Golgi (1843-1926): Firstly developed full visualization of single neurons with silver stain. Golgi had believed that the whole brain was a *cyncytium*, or a continuous mass of tissue that shared a common cytoplasm.
- Cajal (1852-1934): Extended identified not only the unitary nature of neurons but also their transmission of electrical information in only one direction, from the dendrites down to the axonal tip.
- Golgi continued to believe that neurons were a single unit, whereas Cajal saw each neuron as the independent unit.



Golgi



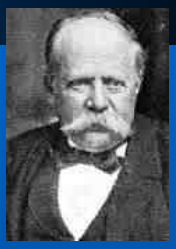
Cajal

The Twentieth Century

Localizationists vs. Holists (1/3)

- *Behaviors are constellations of independent activities, not a single whole unit.*
- One has to distinguish between evidence for localization of *symptoms* and the idea of localization of *function*.
- The mistake of early localizationists is that they tried to map behaviors and perceptions into single locations in the cortex.
- *Any particular behavior or perception is produced by many areas, located in various parts of the brain.*
- *Any given complex ability is not accomplished by a single part of the brain. But simple processes that are recruited to exercise such abilities are localized.*

Localizationists vs. Holists (2/3)



Goltz

- Goltz: removed large parts of a dog's cortex, but the dog was remarkably functional.
- von Monakow & Head
  - *Diaschisis*: damage to one part of the brain can create problems for another – demonstrated time and time again
  - Head saw the whole brain as a dynamic system, and believed lesioned brain were like a new system.
- Karl Lashley pointed out that lesions made throughout the brain did not appear to created problems of learning or performing a task.

Localizationists vs. Holists (3/3)

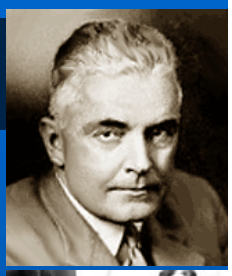
- Starting in the 1930s, Clinton Woolsey, Philip Bard, and others began to discover motor and sensory "maps" in the brain.
- In the 1970s and 1980s, we learned that multiple maps exist in each sensory modality.
- We now know there are very localized areas in the brain, such as the middle temporal area which is highly specialized for the processing of visual motion information.
- In short, neuroscience is continuing to reveal the startling complexity and specialization of the cerebral cortex.

The Psychological Story

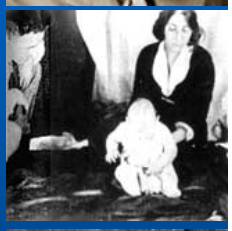
Empiricism and Associationism

- **Empiricism**: "All knowledge comes from sensory experience." – Simple ideas' interaction and association becomes complex ideas and concepts
- **Associationism**: Complex processes like memory could be measured and analyzed in terms of the association of ideas – absorbed into behaviorism
- Edward L. Thorndike: Behavioral response can be produced by reward.

Behaviorism and Cognitivism (1/2)



Watson

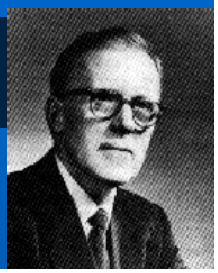


- **Behaviorism**: 'Learning can be controlled by stimulus and response.'
- Watson: "(can) turn any baby into anything."
- *Gestalt psychology*: showed some human behaviors exist only as a function of built-in properties of the brain, not learned.
- **Cognitivism**: From 1950s, psychologists began to think in terms of cognition, not just behavior. The processing stages and cognitive activity could be analyzed with respect to their interlinked components.

Miller

- George A. Miller – rejected the idea that psychology should just study behavior, rather it should incorporate cognition.

Behaviorism and Cognitivism (2/2)



Hebb & his learning rule

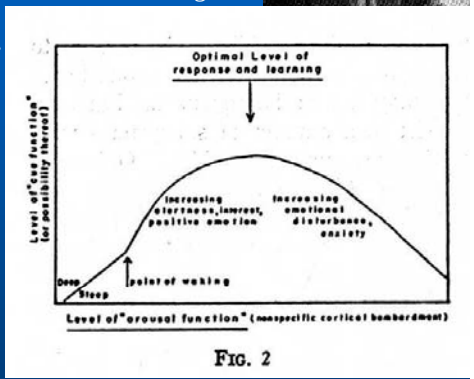


FIG. 2

- **Chomsky**: the complexity of language is built into the brain, runs on rules and principles (a grammar) that are universal.
- **Simon & Newell**: simulated cognitive processes.
- **Hebb**: neuropsychological theory of cell assemblies, which suggested that any set of neurons can learn anything.
- The field gradually moves toward the importance of built-in and universal neural structures, as well as the laws of simple association for learning.

Simon (L) & Newell

Chomsky

Cognitive Neuroscience

Beginning of Cognitive Neuroscience

- *Neuroscience*: beginning to build models of how single cells interact to produce percepts.
- *Psychology*: no longer taking behaviorism seriously as a viable way to explain complex cognition.
- *Language*: since Chomsky, it became clear that grammar is an instinct, whereas the lexicon is learned.

David Marr

- Made a major effort to bridge the gap between brain mechanisms and perception.
- Neural computation can be understood at multiple levels by analysis.
  - *Computation*: what is computed
  - *Algorithm*: how the computation is accomplished
  - *Implementation*: the biology of nervous systems

Biological Consideration

- However, Marr's distinction between the algorithms and implementation mechanisms has been vague.
- Any computational theory must be constrained by how the brain actually works.
- Neural network research
  - Scientists build models of how the brain might work,
  - and limit how their models function by including information from neurphysiology and neuroanatomy.

The Sudden Rise of Brain Imaging

Brain Imaging Methods

- PET (*positron emission tomography*): blood flow and metabolism could be measured.
  - Subtracting one brain scan acquired during a particular behavioral state from another scan made during a different behavioral state. This allowed researchers to isolate relevant brain regions.
- fMRI (*magnetic resonance imaging*, functional MRI): the blood flow (the blood oxygen level dependent, or BOLD) could be tracked.
- More details on neuroimaging in Ch. 4.

Summary

- Brain science gave us:
  - The Brain is made up of discrete units – neurons.
  - Neuron's function, interaction led to some behaviors.
- The debate on localizationist approach to brain function and area
- Beginning to consider seriously the built-in brain function, not learned function from 1950s
- In this book, how the brain does enable mind would be explored, with whole concern for brain's work – not how the mind might work or how it could work.

Key Terms

- Aggregate field
- Associationism
- Behaviorism
- Cytoarchitectonics
- Diaschisis
- Empiricism
- Holism
- Locationzation
- Neuron doctrine
- Phrenology
- Rationalism
- Syncytium

Thought Questions

- Can there be a study of how the mind works without studying the brain?
- Will modern brain imaging experiments become the new phrenology?
- What do cognitive psychologists mean by the term representation? What do neuroscientists mean by the term?
- Can you imagine how the brain might be imaged in the future?