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.

Pondering The Big Questions
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- 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?

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: Flourrens challenged the localizationist view – “The faculty of sensation, percept and volition is then essentially one faculty.”

The Brain Story

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

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.

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: 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.

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)

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

Behaviorism and Cognitivism (2/2)

- **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.

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

The Sudden Rise of Brain Imaging

- 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.

Biological Consideration

- 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.

Brain Imaging Methods

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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
- Locationization
- 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?