Introduction to Neuropsychology

Clinical Neuroscience

- Emerging field – application of neuroscience to mental health
- In this course you will become more familiar with neuroanatomy, neurochemistry, and neurophysiology.
- Our goal is translating this information so that it will have practical applications to your practice as a therapist.

Neuropsychology

- Subfield of the neurosciences
- Study of the relation between human brain function and behavior
- Draws from many disciplines
- Professional organizations
  - APA Division 40, Clinical Neuropsychology http://www.div40.org/
  - National Academy of Neuropsychology (NAN) http://nanonline.org/
  - The International Neuropsychological Society (INS) http://www.the-ins.org/
Definition of Clinical Neuropsychologist

- A professional psychologist who applies principles of assessment and intervention based upon the scientific study of human behavior as it relates to normal and abnormal functioning of the central nervous system.
- A doctoral-level psychology provider who has demonstrated competence in the application of such principles for human welfare following:
  - A. Successful completion of systematic didactic and experiential training in neuropsychology and neuroscience at a regionally accredited university;
  - B. Two or more years of appropriate supervised training applying neuropsychological services in a clinical setting;
  - C. Licensing and certification to provide psychological services to the public by laws or the state or province in which he or she practices;
  - D. Review by one's peers as a test of these competencies.

Historical View of Neuropsychology

- Neuropsychology is strongly influenced by 2 traditional foci of experimental and theoretical investigations:
  1. The brain hypothesis: the brain is the source of behavior
  2. The neuron hypothesis: the unit of brain structure and function is the neuron

The Brain versus the Heart

- Alcmaeon of Croton – located mental processes in the brain (the brain hypothesis)
- Empedocles of Acragas – located mental processes in the heart (the cardiac hypothesis)
- The relative merits of these two hypotheses were debated from the next 2000 years.
Descartes: The Mind-Body Problem

- Introduced idea of a singular soul – called the mind.
- Described the mind as non-material and separate from the body (dualism).
- Proposed body is like a machine (responding mechanically and reflexively to influences), but the mind decides what movements the machine makes.
- Beginning of the mind-body problem: How can a nonmaterial mind produce movements in a material body?

- Laws of physics at the root of the problem:
  - For the mind to affect the body it would have to expend energy – thus adding new energy to the material world.
  - The creation of new energy violates a fundamental law of physics.
  - Thus dualists, have a problem explaining how the mind (immortal) and the body (material) interact.
- Monists – avoid the problem by stating the mind and body are two words for the same thing (includes most neuropsychologists).

Darwin and Materialism

- By mid-19th century- emergence of materialism, the idea that rational behavior can be fully explained by the workings of the nervous system.
- Rooted in work of Darwin & Wallace-evolutionary theory that all living things are related.
- All living things have a common ancestor: brains of all animals are related.
- Leads to belief that human behavior is also a product of the brain.
Localization of Brain Function

- Thomas Willis (1621 – 1675)
  - Medical physiologists – used clinical observations and scientific methods to study the nervous system
  - Used dissection to learn functions of some of brain structures

Localization of Brain Function

- Gall and Phrenology
  - First general theory to present the idea that different parts of the brain had different functions
  - Did make a number of important discoveries in neuroanatomy
  - Theory of brain function called localization of function
    - Related individual differences to prominent features of head and skull
    - Bump = well-developed cortical gyrus and greater ability
    - Depression = underdeveloped gyrus and reduced ability
Recovery of Function: Pierre Flourens

- Pierre Flourens (1794-1867): Developed method of controlled laboratory experiments
- Removed parts of animal brain to study changes produced in their behavior and how they recovered from the loss of brain tissue.
- He varied the location from which he removed tissue in order to search for different functions.
- Saw that animals eventually recovered to the point where they seemed normal
- Led him to refute idea that different areas of the cortex had specialized functions – argued cortex worked as a whole

Localization of Language

- Discovery that launched the science of neuropsychology!
- Began with Jean Baptiste Bouillaud and his son-in-law, Ernest Auburtin: as early as 1825 argued that speech controlled by left hemisphere
- Auburtin in 1861 presented patient who lost ability to speak due to pressure on frontal lobe
  - Promised: to examine autopsy and “renounce” his ideas if the frontal lobes were not compromised
- Paul Broca invited Auburtin to examine his patient, Monsieur Leborgne, who’s brain at autopsy revealed lesion in region now known as Broca’s area.
Strict localizationists argued:
- A behavior is controlled by a specific brain area
- Destroying the area selectively destroys the behavior

Wernicke was 1st notable scientist to dissent – he saw aphasic patients that differed from Broca’s
- Damage in first temporal gyrus
- No contralateral paralysis
- Patients spoke, but made no sense
- Could hear, but no understand or repeat what was said to them

Wernicke found that the temporal lobe is also involved in language.
- Disproved the strict localizationists view that language was localized only to part of the frontal lobe.
- He also provided the 1st model for how language is organized in the left hemisphere.
Disconnection

- Idea of disconnection: although different regions have different functions, they are interdependent – to work they must communicate.
- Important idea – predicts that complex behaviors are built up – assembly-line fashion – as information collected by sensory systems enters the brain and travels through different structures before resulting in an overt response.

Electrophysical Confirmation of Localization

- New technique to study the brain – placing a thin insulated wire, an electrode, onto or into the cortex, and passing a small electrical current through the uninsulated tip of the wire, thus exciting the tissue near the electrode tip.
- Fritsch & Hitzing – showed that stimulating the cortex produced movement
  - Stimulation of parts of frontal lobe elicited movement of particular body parts – suggest the cortex possess topographic representations of different parts of the body
Hierarchical Organization of the Brain

Fritsch & Hitzig concluded that that the cortical area involved was necessary and sufficient for producing the movement.

Goltz in 1892 tested this idea: he argued that if the neocortex has a function, then removal of the cortex should lead to a loss of that function.

Removal of cortex did not appear to completely eliminate any function, though it reduced all functions to some extent.

Hierarchical Organization of the Brain

This contradiction was resolved by hierarchical organization concept of brain function (John Hughlings-Jackson -1835-1911).

Nervous system is organized in a functional hierarchy with each successively higher level controlling more complex aspects of behavior, but doing so through the lower levels.

Hierarchical Organization of the Brain

He suggested that diseases or damage that affect the highest levels would produce dissolution (opposite of evolution): the animals would still have the repertoire of behavior but at a simpler level (like animals who have not evolved the missing brain structure).

We now recognize that that functions are localized in one sense but are also distributed over wide areas of the brain in another sense.
The Neuron Hypothesis

- The nervous system is composed of discrete, autonomous units or neurons, than can interact but are not physically connected.
- Next, we will discuss how the neuron hypothesis led to a number of ideas that are central to neuropsychology.

The Neuron

- Earliest anatomists found the substructure of the nervous system to resemble a goo (gelatinous white substance).
- Able to see more when learned to dehydrate brain tissue and view thin slices
- Use of microscope in 1700 – 1800s helped increase understanding
- Biggest advance was staining – stains applied to tissue slices allowed different structures to be distinguished

Golgi and Neural Histology

- Italian anatomist, Camillo Golgi, in 1875, injected tissue with silver nitrate
- A few entire cells became encrusted with silver – allowing entire neuron to be visualized for the first time
- Could see it was a very intricate system
- Which lead to the next debate .... How did the nervous system work? Was it a net of physically connected fibers or a collection of separate units?
Golgi vs. Cajal

- Golgi argued that axons were interconnected forming an axonic net.
- Cajal argued the cells were separate – in his examinations he never saw connections from cell to cell.

Further History

- We’ve established foundations for the brain hypothesis and the neuron hypothesis; two ideas that have strongly influenced neuropsychology.
- See text for discovery of the synapse, realization of chemical communication between cells, and understanding of the action potential.
- Also interesting is the history of neurological approaches to mental illness.
  - See NPR story on transorbital lobotomy