Psychology 125: Clinical Neuropsychology and Assessment
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Syllabus Review

- Course Website:
  - http://courses.ucsd.edu/frose/ps125/
- Grading
  - Exams: 2 midterms, 1 comprehensive final

What are we doing here?

- "If our brains were so simple that we could understand them, we would be so simple that we could not."
  (Anonymous)
- There is no scientific study more vital to man than the study of his own brain. Our entire view of the universe depends on it. --Francis H. C. Crick
What Do You Want to Know?

Introduction

- Psychology
- Behavior
- Neuropsychology
  - Brain-Behavior relationships

Professionals Who Study The Brain

- Psychologist: Study Behavior
- Neuropsychologist: Brain-Behavior relationships
- Neurologist: MD; diagnose and treat disorders of the nervous system
- Neuropsychiatrist: MD; Psychiatrists emphasizing organic aspects of mental disorders
- Neurosurgeon: MD’s specializing in surgery of nervous structures
- Neuroscientist: researchers in biology/related fields; study molecular composition and functioning of NS
Guiding Principles

- The Brain Hypothesis
  - The brain is the source of behavior
- The Neuron Hypothesis
  - The neuron is the unit of brain structure and function

Modern Neuropsychology

- 70’s and beyond
  - Movement from laboratory to clinic
  - International Neuropsychological Society (INS) organized
  - National Academy of Neuropsychology (NAN) founded
    - emphasis on clinical issues
  - Division 40 of the APA
  - Explosion of scientific journals and membership in these organizations

What Makes Neuropsychology Unique?

- Firmly grounded in science
- Data driven
- Objective
- Emphasis on statistical measurement
  - Validity
  - Reliability
  - Standardization
What is a Clinical Neuropsychologist?

- Doctoral level training in clinical psychology
- Ideally, some education in brain behavior relationships
- Internship
  - 1 year
- Postdoctoral Fellowship
  - 2 years

As a neuropsychologist, what types of things would you do?

- Assessment/Diagnosis
- Treatment recommendations
- Rehabilitation
- Research
- Teaching
- Work in diverse settings

Methods of Studying the Brain

“Research into the functional and structural properties of the living human brain is now the most important advancement in the neurosciences.”

-- Bigler, 1996
Neuropsychological Analysis: 
The Lesion Approach

Key Features of the Lesion Approach
- Models of cognitive function are developed, verified, and modified by studying patients with brain lesions
- Lesions may be acquired or developmental
- Learn about normal function through dysfunction
- Emphasis on deficit measurement

Broca’s Area
Photograph of the brain of Paul Broca’s patient called “Tan” (real name was Leborgne)

Pars triangularis and pars opercularis of the inferior frontal gyrus of dominant hemisphere for language

The Case of H.M.

Patient H.M. (coronal section)  Normal brain (coronal section)
Neuropsychological Analysis: The Lesion Approach

- Performance Measures
  - Most studies use behavioral performance measures
  - Choice of appropriate comparison/control groups is critical

Reversible Lesion Methods

- The WADA Technique
  - Injection of barbiturate (typically sodium amytal) into R or L internal carotid artery; temporarily anesthetizes one hemisphere
  - Allows you to test abilities of other hemisphere alone
  - Used, for example, to lateralize language function
  - Hit speech hemisphere, patient can’t speak, respond to questions etc.; no language
  - Major drawback: Highly invasive
Reversible Lesions - TMS/rTMS

- Transcranial magnetic stimulation
- r = repeated
- Most frequently used to examine motor and cognitive processing
- Pulses of magnetic stimulation
- Disrupt ongoing cognitive processing
- Activate simple motor & visual systems

http://neuroscience.berkeley.edu/images/tms.jpg

Reversible Lesions - TMS/rTMS
Intensity matters:
- "Fast rTMS" at frequencies of 10 to 30 Hz, can enhance cortical excitability
- "Slow rTMS" at 1 Hz, can be shown to decrease cortical excitability

Strengths & weaknesses:
- Relatively noninvasive
- Shows some potential in treatment of depression & other neuropsychiatric disorders
- Long term effects unclear
- Strong inter-subject differences- needs to be individualized

Imaging the Brain
Historically:
- Inability to examine the living brain
- In vivo neurosurgical procedures & postmortem examinations immediately after death
Early attempts

Eduard Hitzig (1860s)
- German doctor working at a military hospital
- Working with war-related brain injuries
  - Stimulated exposed brains with wires connected to a battery
  - Discovered that weak electric shocks, when applied to areas of the brain, caused the patients' eyes to move

Early attempts

Wilder Penfield (1940s-1950s)
- Brain surgeon
- Applied electric currents to the surface of patients' brains
- Mapped motor cortex, some somatosensory cortex

CT/CAT Scans

- Computed transaxial tomography (1971)
- First technology to provide a real anatomical image of the brain
- Based on same technology as X-ray
CT scans

- Originally only gross brain features, now more refined features
- X-ray beams pass through the head, detect differences in density of tissue
- Black-and-white shadings reflect structural density
- Bone is white, cerebrospinal fluid dark
- Diagnose strokes, lesions, tumors, vascular malformations

CT/CAT Scans

Enhanced CT:
- Iodine used as contrast
- Injected, absorbed by brain tissue, reveals more contrast of brain structures
- Absorbs x-rays better

Advantages:
- Can see calcium deposits better than MRI
- Faster than MRI

Disadvantages:
- Uses radiation
- Poorer resolution than MRI
- Can see most tissue types better with MRI
CT/CAT Scans

- Created new methods for neuropathological diagnosis and lesion localization
- Role of neuropsychologist was changed

Electrophysiological Methods

- Electroencephalography (EEG)
  - Ongoing electrical activity in large groups of neurons firing synchrony
- EEG and Neuropsychology:
  - ms level timing of neural events
  - Often used as diagnostic tool in hospitals
  - Good temporal resolution
  - Poor spatial resolution

Approximately 4 seconds of data from 15 EEG electrodes recorded during normal waking activity
The ictal activity in the EEG signal recorded during a generalized epileptic seizure.

**Electrophysiological Methods**

- Event-Related Potentials (ERPs) (“evoked potentials”)
- Time-locked response to a specific stimulus
- Reveal changes in extent and timing of brain response to stimulus
- Provide excellent temporal resolution of neural processes

**Responses to faces & objects**

ERP:
- Responses to categories of stimuli are averaged across many presentations
- Components emerge
Electrophysiological Methods

Advantages:
- Non-invasive
- Does not require behavioral responses
  - Passive viewing of stimuli
  - Continuous EEG of ‘normal’ interactions

This ERP shows electrophysiological responses to different conditions of the stroop task (Larson, 2004)

Imaging of Brain Metabolism

- Positron Emission Tomography (PET)
  - Radioactive tracer labels blood glucose; scan brain for radioactivity
  - Active brain areas metabolize more glucose
  - PET and neuropsychology
    - Localize areas of activity under different cognitive tasks
PET - Positron Emission Tomography

**Advantages:**
- Measures function
- Any task

**Disadvantages:**
- Radioactive (limit exposure)
- Poor resolution
- One task
- Expensive

PET imaging illustrating the finding that practice decreases the brain activity required for a task.

[Image: PET imaging illustrating the finding that practice decreases the brain activity required for a task.

http://www.bsos.umd.edu/hesp/hesp300nbr/BRAIN&LANG.HTM]
PET - Positron Emission Tomography

Major finding using PET in clinical setting:
- Suppressed metabolic activity in neurological patients
- History of head trauma, stroke, tumors
- Even when structural imaging showed intact brain anatomy
- PET may be more sensitive in detecting pathology not clear

Brain Development

1 month 3 months 6 months 12 months

MRI - Magnetic Resonance Imaging
Magnetic Imaging Procedures

- Magnetic Resonance Imaging (MRI)
  - Magnetic field aligns hydrogen atoms in brain
  - Radio frequency pulse "knocks" atoms out of alignment
  - Atoms 'spin back' into place
  - This 'spin back' generates measurable magnetic field

MRI components

- Magnet coil (1.5 T, 3T, 7T)
- Radio Frequency (RF) coil
- Gradient Coil

MRI - Magnetic Resonance Imaging

- Image brain structure
- Advantages:
  - Good spatial resolution
  - Can see different tissues
  - No radiation → safe
- Disadvantages:
  - Can't have metal
  - Can't see calcium well
  - Takes longer than CT
CT vs. MRI - stroke

CT

MRI

http://www.theuniversityhospital.com/stroke/inhospital.htm

Magnetic Imaging Procedures

- Functional MRI (fMRI)
  - Oxygenated blood has slightly different magnetic properties that special-sequence MRI scans can detect
  - Provides excellent spatial resolution
  - Other advantages over PET: No radiation exposure, and better resolution

This image shows different brain region activation for the processing of emotional distractors (blue) and attentional targets (red) (Yamasaki et al., 2002)

fMRI

- Measures blood flow using MRI
- Advantages:
  - Safe
  - Good resolution
  - Multiple tasks at once
- Disadvantages:
  - Poor timing
  - Estimates "brain activity" from blood flow
  - Task inside scanner
Magnetic Imaging Procedures

- What's going on in this brain?

In this case, people are viewing objects and faces. Red = face-specific activation. Blue = object-specific activation.

Contributions from fMRI

Contributions of fMRI
## Contributions from neuroimaging

**Vegetative State**
- Least understood but ethically charged medical condition
- Unique disorder:
  - Patient emerges from coma
  - Appears to be awake
  - No signs of awareness
- Diagnosis depends crucially on there being no reproducible evidence of purposeful behavior in response to external stimulation.

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**“Islands” of preserved brain function in small percentage of some patients**
- "On this basis, we hypothesized that this technique also may provide a means for detecting conscious awareness in patients who are assumed to be vegetative yet retain cognitive abilities that have evaded detection using standard clinical methods."


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**23-year-old woman; severe brain trauma following traffic accident**
- Clinical assessment: diagnosis of vegetative state
- fMRI used to assess her neural responses to stimuli
  - Language stimuli
  - Stimuli to assess ‘conscious awareness’

Contributions from neuroimaging

Language Stimuli
- Sentences
- Emphasized specific words
- Superior and middle temporal gyri response in sagittal (left) and coronal (right) planes

Contributions from neuroimaging
To assess conscious awareness
- Patient given spoken instructions on two tasks:
  1. Imagine playing tennis
  2. Imagine walking through the rooms of your house

Contributions from neuroimaging
Observed the same activity in patient and healthy control group in both tasks!

SMA = supplementary motor area; PMC = lateral premotor cortex; PPC = posterior parietal cortex; PPA = parahippocampal gyrus
Contributions from neuroimaging

Authors of the study concluded that despite fulfilling clinical criteria for diagnosis of vegetative state, patient could still:

- Understand spoken commands
- Respond to commands through brain activity (but not speech or movement)
- Her decision to cooperate reflected intention & conscious awareness of herself and her surroundings

Take home message...

Neuroimaging techniques have created huge advances in:

- Diagnostic techniques for locating/characterizing the nature of neurological damage
- Research techniques for understanding brain structure and brain functioning

They *compliment* behavioral assessment, but should not replace it.