The Brain: Biological Basis of Behavior

Part III: Imaging of the Brain

OBJECTIVES/RATIONALE

The latter part of the 20th-century was an important time for neuroimaging and the field of psychology. Advances in technology have enabled scientists to capture images of the brain. The student will compare and contrast the various modes of neuroimaging and determine the advantages and disadvantages of each.

TEKS: 121.26 (c) 1B, 6A, 6B

TAKS ELA 1, 2, 3, 4, 5, 6
Science 2

KEY POINTS

POWER POINT

I. Key Terms
   A. *neuro* – root for brain and/or nervous system
   B. *imaging* – procedure which records a picture or "image" of a body part
   C. *tome* – Greek word that means "slice" sometimes referred to as a "cut" of body tissue
      a. in neuroimaging, *tome* refers to cross-sectional images that demonstrate multiple "slices" of human anatomy
      b. orientation of cross-sectional images depends on the body plane along which the image was recorded
   D. *–graphy* – suffix that means a process of recording (an image)

II. Body Planes – imaginary planes that pass through the body dividing it into sections; these planes provide the orientation for cross-sectional images in neuroimaging
   A. transverse plane – imaginary plane that cuts *across* the body or body part and divides body or its part into upper and lower parts.
   B. sagittal plane – imaginary plane that cuts the body into right and left sections
      a. midsagittal plane (also called median plane) – imaginary plane that cuts body into *equal* right and left halves
   C. coronal plane (also called frontal plane) – imaginary plane that divides the body or its parts into front and back sections

III. Traditional Types of Neuroimaging:
   A. **Skull Radiograph** (takes about 5 to 10 minutes)
      a. description: one-dimensional x-ray of skull
         i. generally requires at least three separate x-ray images from different angles to better determine tissue abnormality
            1. image from the front (AP x-ray)
            2. image from the side (lateral x-ray)
            3. image with head turned 45 degrees (oblique x-ray)
      b. advantages:
         i. relative inexpensive
         ii. fast
         iii. demonstrates bony structures and fractures
      c. disadvantages:

i. radiographic projections are one-dimensional and cannot accurately demonstrate depth and location of lesion
ii. does not image soft-tissue as well as bone

B. **Cerebral Angiography** (takes about 60+ minutes)
   a. description: traditional skull radiographs taken during injection of radiopaque contrast medium ("dye") into the carotid arteries
      i. visualization of blood flow via the carotid arteries to the brain
      ii. helps diagnose patency of vessels, intracranial aneurysms, & tumor masses, which are shown by displacement of normal vessels
   b. disadvantage:
      i. uses bolus of iodine-based dye for visualization of vessels
         1. may produce allergic reaction in some patients
         2. could dislodge vascular plaque and cause a stroke

IV. Neuroimaging of the Late 20th-Century

A. **Computerized Axial Tomography –CAT scan** (also called **CT Scan**) (takes 10 to 30 minutes)
   c. description: involves passing a narrow beam of traditional x-rays through brain of a person lying in a large, donut-shaped x-ray machine called a scanner; provides transverse slices of the head
      i. beam of x-rays sent out by x-ray tube that rotates around patient's head
      ii. whole series of x-rays are taken at every angle around the head and then combined in a computer to reconstruct an image of transaxial slice of the head
   d. advantages:
      i. imaging method of choice for examining skull fractures
      ii. one of the least expensive modalities (other than skull x-rays)
   e. disadvantages:
      i. difficult to see brain tissue, therefore, does not serve as specific test for mental disorders
      ii. sometimes dye (called contrast media) must be given as a shot in a vein to help get a clear picture; some people are allergic to this dye
      iii. underestimation of brain atrophy
      iv. inability to image in sagittal and coronal planes
      v. one CT scan delivers radiation equivalent to many traditional x-rays (this limits the total number of scans that can be performed safely within an individual)

B. **Magnetic Resonance Imaging** (**MRI**) (takes 30 to 90 minutes)
   a. description: uses magnetic fields and radio waves to obtain a mathematically reconstructed image
   b. how it works:
      i. certain nuclei in the body are magnetic (those having odd numbers of protons or neutrons)
      ii. when under the influence of a magnetic field, those nuclei oscillate and reemit radio waves that are picked up by MRI receiver and sent to a computer
      iii. radio waves are then reconstructed by the computer into an image of the brain
   c. advantages:
      i. allows for clear distinctions between cerebrospinal fluid and gray and white matter
      ii. can show minor brain injuries and close-up pictures of base of brain
      iii. intrinsically 3-dimensional, acquiring multiple images in any plane (transverse, sagittal, and/or coronal)

iv. does not involve radiation

d. disadvantages:
   i. noisy (patient ‘s usually given pair of headphones or earplugs
   ii. must lie flat on back inside small “tunnel” of scanner (makes many patients feel claustrophobic)
   iii. must remove all metal objects & jewelry
   iv. tests often take a long time (30 to 90 minutes)
   v. more expensive than CT scans

D. **Positron Emission Tomography** (**PET**) &
Single Photon Emission Computed Tomography (**SPECT**)
   a. description: both are noninvasive imaging techniques that scan radioactive material that was injected into a peripheral vessel of the patient
   b. advantages:
      i. unlike conventional radiography which demonstrates the structure (anatomy) of organs, PET & SPECT are able to measure particular aspects of human physiology (which is determined from scanner’s measurement of neurotransmitter radioactivity)
      ii. unlike other studies that use toxic contrast medium (“dye”) to visualize vessels, the small amount of radioactive pharmaceuticals used in PET & SPECT studies are similar to body’s own biochemical constituents
   c. note that SPECT studies are much more cost effective than PET exams

IV. Clinical Applications of PET & SPECT

A. Alzheimer’s Disease and Dementia
   a. SPECT studies have shown decreased size of hippocampus and metabolic disturbances in early stages of Alzheimer’s

B. Mood Disorders
   a. SPECT & PET studies consistently found reduced global cerebral blood flow—particularly in unipolar patients
      i. decreased activity in prefrontal cortex seen in depressed patients

C. Schizophrenia
   a. PET studies demonstrate a decrease of activity in frontal lobe and an increase of activity in the subcortical regions

D. Anxiety Disorders
   a. panic attacks: PET scans demonstrate area of hyperactivity in right parahippocampal gyrus
   b. general anxiety disorder: PET studies show increase in glucose metabolism in thalamus
   c. obsessive-compulsive disorder: SPECT studies show increased metabolic activity in frontal lobes and basal ganglia

E. Personality and Eating Disorders
   a. bulimia: PET images show cortical asymmetry in metabolic rate for glucose
   b. schizotypal personality disorder: abnormalities found in frontal and temporal lobes

ACTIVITIES

I. Summarize and write a report on one of the following:
http://www.faseb.org/opar/mri/med_mri.html - *Breakthrough in Bioscience—MRI Medical Applications*

http://www.faseb.org/opar/mri/mri.html - *Magnetic Resonance Imaging: From Atomic Physics to Visualization, Understanding and Treatment of Brain Disorders*

II. Tour a neuroradiology facility.

MATERIALS NEEDED

http://www.faseb.org/opar/mri/med_mri.html - site for Activity: *Breakthrough in Bioscience—MRI Medical Applications*

http://www.faseb.org/opar/mri/mri.html - site for Activity: *Magnetic Resonance Imaging: From Atomic Physics to Visualization, Understanding and Treatment of Brain Disorders*

www.films.com - *The Brain: An Inside Look*, Films For the Humanities & Sciences, #DPM5988; 1-800-257-5126

http://www.med.harvard.edu/AANLIB//home.htm/ - interesting site for brain pathology imaging

http://www.nlm.nih.gov/research/visible/getting_data.html - site for the Visible Human Project (creation of digital image of a complete human male and female cadaver in MRI and CT scans

http://www.vh.org/Providers/Dept/InfoByDept.Rad.html - virtual hospital (click on radiology)

http://www.vh.org/Providers/Textbooks/FetalYoungCNS/FetalYoungCNS.html -neuro scans show the story of development and maldevelopment of brain

http://www.sbu.ac.uk/~dirt/museum/museum.html - good site for neuropathology (click on skull icon)

http://www.uke.uni.hamburg.de/institue/imdm/idv/forschung/mumie/index.en.html - fun site--Virtual Mummy; see how CT scans allow researchers to see inside ancient Egyptian mummies. Click on "How the procedure works" and "Examining reconstruction of the mummy's head".

ASSESSMENT

Successful completion of Written Report Rubric.

ACCOMMODATIONS

For reinforcement, the student will view and summarize the key points from the video, *The Brain: An Inside Look.*

For enrichment, the students will participate in an interactive discussion with a neuroradiologist or a special procedure radiographer and view normal and abnormal scans of the brain.

REFLECTIONS

Written Report Rubric

Neuroimaging

Student: _____ **Date:** _____

Topic: _____ **Period:** _____

Scoring criteria	4 Excellent	3 Good	2 Needs Some Improvement	1 Needs Much Improvement	**N/A**
The report has all required parts from introduction to body to conclusion.					
The report is concise but complete.					
The report demonstrates that the writer comprehends addiction and related disorders.					
The report demonstrates accurate spelling, grammar, and punctuation.					
The overall content of the report emphasizes appropriate points.					
The writer shows an understanding of sentence structure, paragraphing, and punctuation.					
The source of the report is clearly and accurately documented.					
The report demonstrates correct use of medical language.					

NOTE: N/A represents a response to the performance, which is "not appropriate."