Course Administration

Unit 4 Exam:
Tuesday 12/11; this room; this time

Email: Dr. Davis immediately (if not sooner) if there is a need to make other arrangements

Posted on Blackboard: sample exam

Exam review session:
Day; Time; Room

Optional cumulative FINAL EXAM
Wednesday, Dec 19TH (this room) 4-5:15 PM
Brain Damage and Neuroplasticity
Types of Brain Damage

Human behavior is the product of brain activity, thus structural damage to the brain will most likely cause disordered behavior.

Brain damage is an injury that causes the destruction or deterioration of brain cells. In the U.S., every year, about 2 million people have some type of brain injury; and about 100,000 die as a result.

Six major causes of brain injury include tumors, vascular disorders (strokes), closed-head injuries, infections, neurotoxins and genetic factors.
A tumor (or neoplasm meaning “new growth”) is a mass of cells that grows independently of the rest of the body.

Tumors may be cancerous (infiltrating: growing diffusely through surrounding tissue), or non-cancerous (encapsulated; growing within a membrane).

Infiltrating tumors are malignant (cancerous) (e.g., gliomas). Cancerous tumors invade/destroy neighboring tissue, and can metastasize (spread from one part of the body to another). Such tumors are difficult to remove.

In contrast, encapsulated tumors are usually benign (i.e., non-cancerous), but cause damage by putting pressure on tissue. Can often be surgically removed.

Symptoms of a brain tumor can be general or specific. General symptoms include headache, seizures, vomiting and nausea.
Cerebrovascular Disorders: Stroke

Stroke: a sudden-onset cerebrovascular event that causes brain damage. Infarct, area of dead tissue; penumbra, area of dysfunctional tissue surrounding infarct.

Two major types of stroke:
- cerebral hemorrhage: bleeding in the brain. Typically caused when an aneurysm (a weakened point in a blood vessel) bursts. Aneurysms may be congenital (present at birth) or result from poison or infection.
- cerebral ischemia: disruption of blood supply due to:
  - thrombosis, blood clot blocking blood flow at site of formation;
  - embolism, clot carried by blood from a large vessel to a small vessel;
  - arteriosclerosis, walls of blood vessel thicken and narrow the channel
Ischemia-induced brain damage has two important properties:

- first, it takes a while to develop. That is, there is little initial damage, but substantial neuron loss can often be detected days later (glutamate theory).
- second, not all parts of the brain are equally susceptible to damage.

The specific symptoms of stroke depend on the area of the brain affected. General symptoms include paralysis and aphasia.

Stroke – there’s treatment if you act FAST.

- F: Face look uneven?
- A: Arm hanging down?
- S: Slurred speech?
- T: Time to call 911 now!
Brain injuries produced by blows that do not penetrate the skull are called closed-head injuries. Damage results from the brain colliding with the skull.

Contusions are injuries that involve damage to the cerebral circulatory system. This damage causes internal bleeding, and a hematoma (a localized collection of clotted blood; a bruise).

Contusions typically occur under the site of impact (coup) and on the side opposite the impact (contrecoup).

Concussion: blow to the head resulting in no contusion, but a disturbance of consciousness. Multiple concussions may result in a dementia referred to as “punch-drunk syndrome.”

Specific symptoms of traumatic brain injury (TBI) depend on the site of impact/contusions. General symptoms include headache, seizures, nausea and vomiting.
Scientists at the University of Rochester have shown that cerebrospinal fluid (CSF) plays an important role in carrying waste products out of the brain. In the so-called glymphatic system, astrocytes use projections known as “end feet” to form a network of conduits around the outsides of arteries and veins in the brain. CSF is pumped along these channels that surround arteries, then washes through brain tissue before collecting in channels around veins and draining from the brain.

Traumatic brain injury can damage this system allowing the buildup of toxic proteins leading to dementia (general decrease in intellect). Deterioration of this system with age may also contribute to Alzheimer’s disease.
Infections of the Brain

An invasion of the brain by microorganisms is a brain infection, and the resulting inflammation is called encephalitis.

There are two common types of brain infections:

- **bacterial infections** (e.g., syphilis). Often lead to abscesses (pockets of pus). May inflame the meninges, creating meningitis. Treated with penicillin and other antibiotics.
- **viral infections**. Some preferentially attack neural tissues (e.g., rabies), other have no special affinity for it (e.g., mumps and herpes).

Symptoms include headache, fever, confusion, drowsiness and fatigue.
Neurotoxins

Neurotoxins may enter general circulation from the GI tract or lungs, or through the skin.

Toxic psychosis: chronic insanity produced by a neurotoxin (e.g., mercury and lead).

Some older-generation antipsychotic drugs produced motor disorders.

Some neurotoxins are endogenous (e.g., excessive glutamate, antibodies in autoimmune disorders)
Many neuropsychological diseases have a genetic component (e.g., autism, ADHD, schizophrenia, affective disorders, anxiety, dyslexia, and epilepsy). Inherited genetic predispositions are usually associated with recessive genes.

Genetic accident is another major cause of neuropsychological disorders. Down syndrome, which occurs in 0.15% of births, is such a disorder. The genetic accident: an extra chromosome 21 is created during ovulation. The consequences of this duplication include physical and intellectual disabilities.
Neuroplasticity 1: Degeneration

1. Axotomy: The axon of a neuron is cut.
2. Anterograde Degeneration: Then, the distal portion of the damaged neuron degenerates.
3. Retrograde Degeneration: Then, the proximal portion of the damaged neuron may degenerate.
4. Transneuronal Degeneration: Then, neurons that synapsed on the damaged neuron may degenerate (i.e., retrograde transneuronal degeneration) and so too may neurons on which the damaged neuron synapsed (i.e., anterograde transneuronal degeneration).
Neuroplasticity 2: Regeneration

Regeneration does not proceed as successfully in higher vertebrates as in lower order vertebrates: the capacity for accurate axonal growth is lost in maturity.

Regeneration is virtually nonexistent in the CNS of adult mammals and unlikely, but possible, in the PNS.

When an axon degenerates, axon branches grow out from adjacent healthy axons and synapse at the vacated sites (collateral sprouting).
Neuroplasticity 3: Reorganization

Reorganization of primary sensory and motor systems has been observed in laboratory animals following damage to peripheral nerves and cortical areas. Brain-imaging studies indicate that there is continuous competition for cortical space by functional circuits. E.g., auditory and somatosensory input may be processed in formerly visual areas of the brains of blinded humans.

Two mechanisms have been proposed to account for neural reorganization:
- strengthening of existing connections through release of inhibition (quick remapping).
- establishment of new connections (magnitude of effect is large).
Neuroplasticity 4: Recovery of Function

It is difficult to distinguish between true recovery and compensatory changes.

Based on patterns of activity after brain damage, there are three main ways to reduce cognitive dysfunction following an insult:

- block neurodegeneration (apoptosis inhibitors, neurotrophic agonists, glutamate antagonists)
- promote recovery (transplant Schwann cells, embryonic/adult stem cells, olfactory basal cells)
- rehabilitative training (cognitive and physical exercise)
Biopsychology of Brain Damage

Brain damage can cause a variety of physical, cognitive, social, emotional and behavioral effects, and the outcome can range from complete recovery to permanent disability or death. The nature of effects depends on the site(s) of damage:

1. vision; 2. emotion, memory
3. voluntary movement; 4. speech
5. hearing; 6. error-monitoring; 7. taste;
8. smell; 9. touch/pain/temp, body position
10. attention; 11. language comprehension
12. sequencing motor movements
13. intellect, planning, personality, morality
14. motor coordination

In addition to its immediate effects, brain damage increases the long-term risk of developing mental illness:
- schizophrenia (2x);
- depression (1.5x);
- bipolar disorder (1.25x); and
- anxiety disorders (PTSD: 2x)