LAB: Nerve Reflexes

Background:
Nerve impulses follow routes through the nervous system called nerve pathways. Some of the simplest nerve pathways consist of little more than two neurons that communicate across a single synapse. A reflex is a relatively simple motor response that does not involve a large number of interneurons (or association neurons). The simplest version is a mono-synaptic reflex that uses one sensory and one motor neuron (for example, the patellar or knee-jerk reflex). Most reflexes are polysynaptic (involving more than two neurons) and involve the activity of interneurons in the integration center. In these more complicated reflexes, impulses may travel up, down, and transversely in the spinal cord. Since there is synaptic delay in neural transmission at the synapses, the more synapses there are in the reflex pathway, the more time that is required to illicit the reflex.

Reflexes are mediated over simple nerve pathways called reflex arcs. Reflex arcs have five essential components:
1. The **receptor** at the end of a sensory neuron reacts to a **stimulus**.
2. The **sensory neuron** conducts nerve impulses along an **afferent pathway** towards the CNS.
3. The **integration center** consists of one or more synapses in the CNS.
4. A **motor neuron** conducts a nerve impulse along an **efferent pathway** from the integration center to an effector.
5. An **effector** responds to the efferent impulses by contracting (if the effector is a muscle fiber) or secreting a product (if the effector is a gland).

Reflexes can be categorized as either autonomic or somatic. **Autonomic reflexes** are not subject to conscious control, are mediated by the autonomic division of the nervous system, and usually involve the activation of smooth muscle, cardiac muscle, and glands. **Involuntary reflexes** are very fast, traveling in milliseconds. The fastest impulses can reach 320 miles per hour. **Somatic reflexes** involve stimulation of skeletal muscles by the somatic or voluntary division of the nervous system.

Reflex testing is an important diagnostic tool for assessing the condition of the nervous system. Distorted, exaggerated, or reflexes that are absent may indicate degeneration or pathology of portions of the nervous system, often before other signs are apparent. If the spinal cord is damaged, then reflex tests can help determine the area of injury. For example, motor nerves above an injured area may be unaffected, whereas motor nerves at or below the damaged area may be unable to perform the usual reflex activities.

Closed head injuries, such as bleeding in or around the brain, may be diagnosed by reflex testing. The oculomotor nerve stimulates the muscles in and around the eyes. If pressure increases in the cranium (such as from an increase in blood volume due to the brain bleeding), then the pressure exerted on CN III may cause variations in the eye reflex responses.

Objectives:
- Explain the importance of reflex testing in a physical examination.
- Outline the features of a reflex arc and be able to apply this model to specific nerve pathways.
- Demonstrate several nerve reflexes in a human subject.

Materials: Rubber reflex mallet, index card, penlight, metric ruler, meter stick

Procedures/Observations:
This activity demonstrates several reflexes such as stretch reflexes, cutaneous reflexes, and cranial reflexes. Possible abnormal spinal reflex results are: hyperflexia and hypoflexia. **Hyperflexia** is an exaggerated response resulting from damaged or diseased motor areas in the CNS. **Hypoflexia** is an inhibited response resulting from degeneration of nerve pathways, voluntary motor control, and other factors.

**If you are unable to elicit a reflex, stop and consider the following:**
- Are you striking in the correct place? Confirm the location of the tendon by observing and palpating the appropriate region while asking the patient to perform an activity that causes the muscle to shorten, making the attached tendon more apparent.
- Make sure that your mallet strike is falling directly on the tendon. This sometimes provides enough distraction so that the reflex arc is no longer inhibited.
- Make sure that your mallet strike is not too slight or too forceful. If the strike is too slight, the reflex will not be elicited. If the strike is too forceful, the muscle may become fatigued or the patient may tense or resist.
- Make sure that the muscle is uncovered so that you can see any contraction (occasionally the force of the reflex will not be sufficient to cause the limb to move).
- Sometimes your partner is unable to relax, which can inhibit the reflex even when all is neurologically intact. If this occurs during your assessment of lower extremity reflexes, ask the patient to interlock their hands and direct them to pull, while you simultaneously strike the tendon. This sometimes provides enough distraction so that the reflex arc is no longer inhibited.

After each demonstration below, refer to your laboratory answer sheet. Record your observations and answer all questions within the procedure.
PART A – Stretch Reflexes

Stretch reflexes are those that result from the stimulation of stretch receptors. Here, reflex arcs will be tested that are initiated by stretch receptors within the muscle. Some of these will produce a quite noticeable contraction; others will only display a slight rippling or dimpling of the muscle.

1. Patellar tendon reflex
The patellar tendon reflex, or knee-jerk reflex, is a monosynaptic stretch reflex that assesses the nervous tissue between (and including) the L2 and L4 segments. It can be elicited by sharply tapping the patellar ligament (just below the knee) with the base of a reflex mallet. Have your partner sit on a table with his/her legs dangling above the floor. Tap the knee sharply. Repeat with the other limb. Switch roles.

a. What did you observe happen?
b. What muscles are used to produce this movement?

Test the effect of mental concentration on the patellar reflex by having the subject read a book that blocks their vision of their leg. Repeat with the other limb.

c. Is the response greater or lesser than above? Explain your observations.

Test the effect of fatigue on the patellar reflex by having the subject exercise by doing jumping jacks for 1 minute. Observe the reflex in both limbs.

d. Describe the effect of exercise below. Explain your observations.

2. Achilles reflex
The Achilles reflex (calcaneal reflex or ankle-jerk reflex) is a stretch reflex that assesses the nervous tissue between (and including) the first two sacral segments. It can be elicited by sharply tapping the calcaneal tendon (just above the ankle) with the base of a reflex mallet (no shoes or socks). Repeat with the other limb. Be sure that the calf if exposed so that you can see the muscle contract.

a. What movement was observed?

3. Biceps reflex
The biceps reflex is a spinal reflex that involves nerves C5 and C6. Have your partner sit with his/her elbow flexed at about 90° and palm facing downwards. Put your thumb on the biceps (brachii) tendon at the inside angle of the elbow and press gently. Tap your thumb with a reflex mallet. If correctly done, the biceps will twitch but not contract strongly. Now switch roles.

a. Describe the movement of the arm.
4. **Triceps reflex**
The triceps reflex is another stretch reflex. The triceps reflex is mediated by the C6 and C7 nerve roots, predominantly by C7. Have your partner sit on the table. Supporting your partner’s arm with the elbow flexed at a 90° angle, sharply tap the posterior surface of the upper arm approximately 2 inches above the **olecranon** (bony “tip” of the elbow). Switch roles. If you are having difficulty eliciting a response, have the subject lie on their back on the desk with the elbow bent, so that the arm lies loosely across the abdomen. Strike the triceps tendon approximately 2 inches above the elbow. If no response, try striking to either side of the first site.

   a. The olecranon is a part of which bone?
   b. Describe the movement of the arm.

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**PART B – Cutaneous Reflexes**
Cutaneous reflexes are those that result from the stimulation of cutaneous (skin) receptors.

1. **Plantar reflex**
The plantar reflex is elicited by cutaneous receptors of the foot rather than deep receptors in muscles or tendons. In a normal individual, stimulation causes flexion of the big toe and the others toes flex and draw together. This requires uninterrupted conduction of impulses along the pyramidal motor tracts. Damage anywhere along these pathways produces **Babinski’s Sign** to this stimulation where the big toe extends and the other toes fan laterally. Babinski’s sign is normal in infants whose neural control is not yet fully formed (nerves have not fully myelinated).

   Have the subject lie on their back with knees slightly bent and thigh rotated so that the lateral side of the foot is resting on the table. Draw the handle of reflex mallet along the lateral border of the subject's sole, starting at the heel and continuing toward the big toe (across the ball of the foot).

   a. What movement was observed?

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**PART C – Cranial Reflexes**
Cranial reflexes are a type of reflex mediated by the brain.

**Pupillary reflexes** are centered in the brainstem and involve cranial nerves and autonomic reflex centers. In a dimly lit room, the subject should look out toward a wall until his/her eyes dilate. Observe for any irregularities or asymmetry.

   a. Measure the approximate pupillary size with a metric ruler. Be very careful near the subject’s eyes.

   The experimenter should place an index card on the bridge of the subject’s nose to separate each eye’s field of vision. Then the experimenter should bring a flashlight from the side to within 5 to 7 cm of the subject’s face. Shine the light from the penlight flashlight into the left eye. As soon as the pupil responds remove the light. The response of **both** eyes should be observed.

   b. What is the pupillary response?
   c. What is the advantage of this response?
   d. Which division of the autonomic nervous system was active during the pupillary reflex?
PART D – Reaction Time of Acquired (Learned) Reflexes

1. Get a meter stick. Hold the meter stick near the end (highest number) and let it hang down. Have your partner put his or her hand at the bottom of the meter stick and have them ready to grab the meter stick. They should not be touching it. Tell your partner that you will drop the meter stick sometime within the next 5 seconds and that they are supposed to catch the meter stick between their thumb and index finger as fast as they can after it is dropped. Record the level (centimeters) at which they catch the meter stick in Data Table 2. Test the same person 5 times … vary the time of dropping the ruler within the 5 second time period so the other person cannot guess when you will drop the ruler! Convert the mean distance into a reaction time (See formula below). Must SHOW WORK.

Use the following formula to calculate reaction time.

\[ t = \sqrt{\frac{2y}{g}} \]

In the formula: \( t \) = time (in seconds); \( y \) = distance (in cm); \( g = 980 \text{ cm/sec}^2 \) (acceleration due to gravity).

2. Repeat the above experiment; but this time say a simple word each time you release the meter stick. Select a specific word as the signal to catch the ruler. On all other words the subject is to let the meter stick pass through his/her fingers. Omit trials in which the subject totally misses the ruler. Record the distances in Data Table 2 and convert the mean distance to a reaction time. Must SHOW WORK.

3. Repeat the test again to investigate the subject's response to word association. As you drop the meter stick say the word, for example "cold". The subject should respond with a word that he or she associates with the stimulus word, for example "hot" while catching the meter stick. Record the distances and the number of times the subject misses the meter stick in Data Table 2. Convert the mean distance to a reaction time. Must SHOW WORK.

a. Note any discrepancies or variations in your responses and offer explanations.
PART E – Put in Order
Put these components of the reflex arc in the order in which nerve signals pass through them.

- Association neuron
- Effector
- Motor Neuron
- Receptor
- Sensory neuron

PART F – Fill in the Blanks
Complete each statement with the correct term.

1. Afferent neurons are ___ neurons.
2. Efferent neurons are ___ neurons.
3. How many synapses are crossed in a reflex arc? ___
4. The ventral root of spinal nerves contains ___ neurons, whereas the dorsal root contains ___ neurons.
5. The test that you performed that involves stimulation of both ascending and descending spinal cord tracts is ___.
6. Interneurons are located within the ___.
7. The patellar reflex assesses the nervous tissue between (and including) the ___ segments.
8. In the triceps reflex demonstration, the triceps muscle was the effector. One or more ___ receptors were stimulated in the tendon.
9. When suddenly illuminated with a penlight, the pupil of the eye normally ___ (dilates/constricts).
10. ___ reflexes result from the stimulation of sensory receptors in the skin.

PART G – LET’S REVIEW
Organization of the Nervous System

1. Consists of the brain and spinal cord
2. Composed of nerves arising from the brain and spinal cord
3. PNS subdivision that transmits incoming info from the sensory organs to the CNS
4. Produces the “fight or flight” response
5. Subdivision that carries info from the CNS to skeletal muscle
6. Subdivision of efferent division that transmits info to smooth muscle, cardiac muscle, and glands
7. Consists of all outgoing motor pathways
8. Coordinates the body’s normal resting activities

A. Efferent division
B. Autonomic Nervous System
C. Central Nervous System
D. Afferent Nervous System
E. Sympathetic division
F. Peripheral Nervous System
G. Somatic Nervous System
H. Parasympathetic division
Reflex Arc
Using the terms provided, label the following illustration of a reflex arc.

Dendrite  Cell Body  Interneuron  Gray matter  Sensory neuron axon
Synapse  White matter  Spinal nerve  Motor neuron axon

1. Describe the sequence of events that occurs from the time the patellar tendon is stretched to the time the leg is extended.

2. Suppose a person has spinal cord damage at the cervical level. Would this stop the knee-jerk reflex? How would it affect the plantar reflex? Explain.

PART H – Applying What You Know

Did You Know?
In the adult human body, there are 46 miles of nerves!