LAB 9: MOTOR SYSTEM (Week of November 3)

Lab report is due at the beginning of your lab in the Week of November 17 (Lab 10).

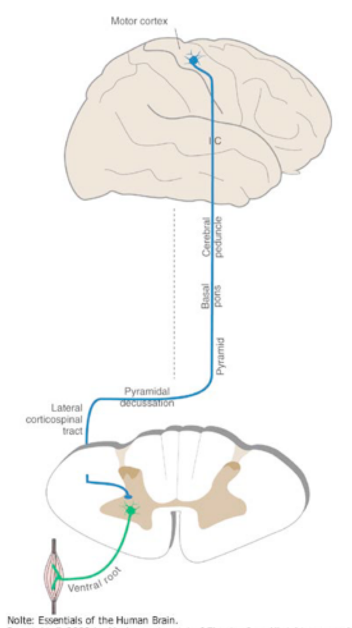
<u>Objectives:</u>
1. Identify and name the structures involved in the production of movement
2. Follow each of the motor pathways from the motor cortex to lower motor neurons
3. Perform activities to better understand the anatomy and physiology of sensory-guided motor behavior and muscle stretch reflex. Recording the stretch reflex using an electrophysiology device will require exposure of your upper arm and calf. Loose-fitting clothes are suggested.

<u>Materials:</u>
1. whole and half human brains
2. dissected human brainstem
3. human spinal cord
4. histological slides of cross sections of the human brain and spinal cord
5. reflex hammer and EMG Spikerbox for testing stretch reflex (one per group)
4. EMG Reaction Timer for measuring reaction time (one per group)
8. iPad (provided; one per group)

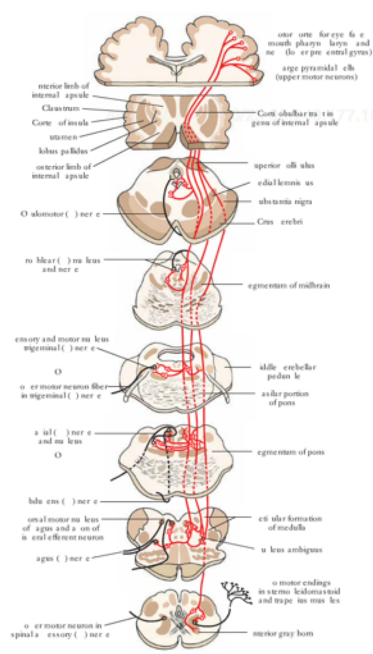
<u>The lab report should include the following (total point for lab report=3.5):</u>
1. Answer the clinical questions (page 66): 1.0 point (0.5 point for each question)
2. Describe the procedures of three different activities: 1.5 point
    a. testing muscle stretch reflexes
    b. electrophysiology of muscle contraction using EMG Spikerbox
    c. measurement of response time using EMG SpikerBox and EMG Reaction Timer
3. Answer the discussion questions for each experiment: 1.0 point

<u>Make sure you also cover the listed structures of human materials. They will be tested in exams.</u>

corticospinal tract



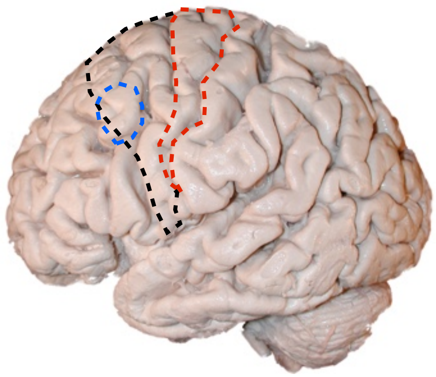
corticobulbar tract

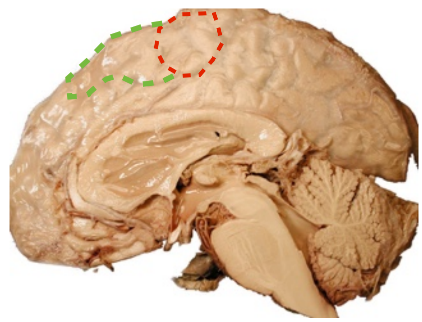


Examination of gross human materials (A-C)
<u>You will be asked to identify the listed structures in exams</u>

<u>A. Identify the following on whole and half human brains</u>
-precentral gyrus including primary motor cortex
-premotor cortex
-frontal eye field
-supplementary motor cortex

Remember that all of the above areas contain neurons that project axons down to the spinal cord. The premotor cortex, frontal eye field and supplementary motor cortex also project to the primary motor area.





primary motor area (included in the precentral gyrus)

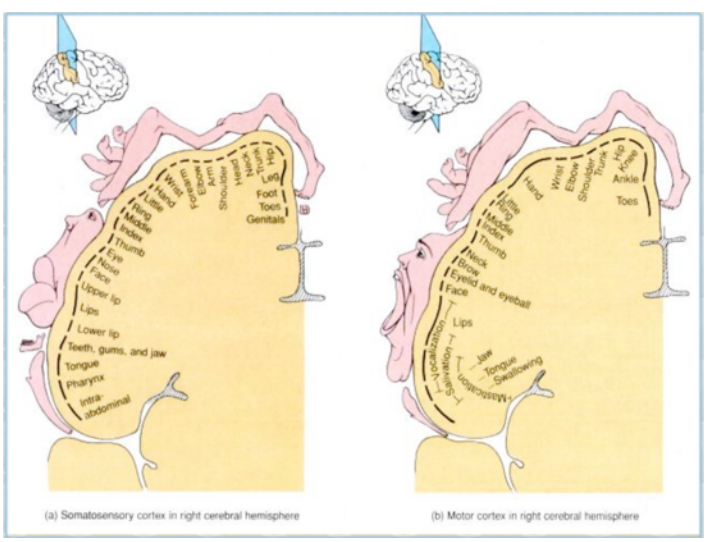
premotor area

frontal eye fields

supplementary motor area

Primary motor area is topographically organized, just like the primary somatosensory area (see homunculus diagram below).

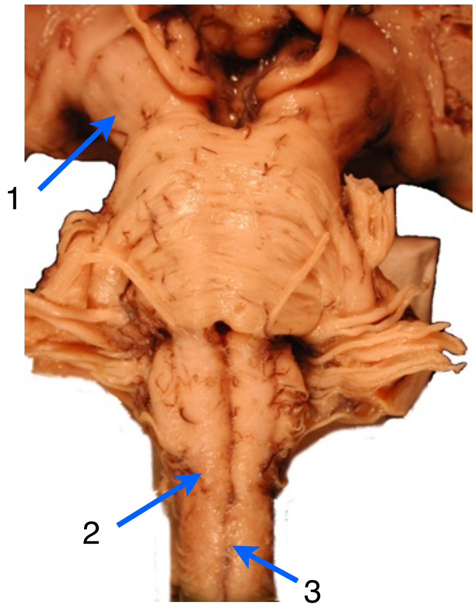
medial/dorsal part: leg, genitalia
lateral/ventral part: face, tongue



sensory homunculus

motor homunculus

B. Identify the following on dissected human brainstem

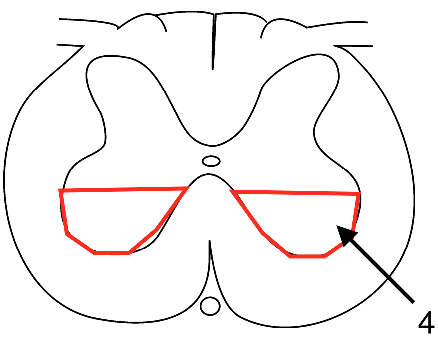


1. cerebral peduncle (midbrain)
2. pyramid (medulla)
3. pyramidal decussation (medulla-spinal cord junction)

Corticospinal tract runs through various structures (and changes its name) as it descends from the cortex to the spinal cord.

-internal capsule, posterior limb (forebrain)
-cerebral peduncle (midbrain)
-pyramidal fascicle (pons)
-pyramid (medulla)
-pyramidal decussation
-lateral funiculus (spinal cord)

C. Human spinal cord



ventral horn (spinal cord)..includes motor neurons

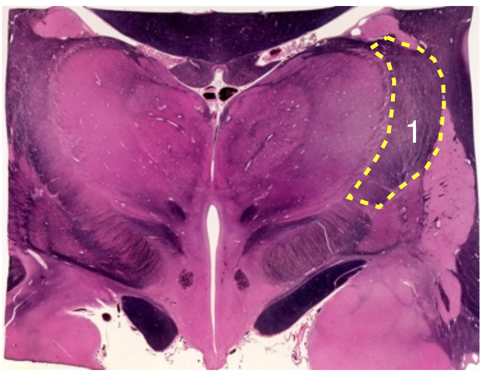
Also identify the ventral roots on gross spinal cord.

Histological slides of cross sections of human brainstem and spinal cord
<u>You will be asked to identify the listed structures on exams</u>

The corticobulbar tract is composed of the axonal fibers of cranial nerve motor neurons (in the motor cortex). "Bulb" is an archaic term for the medulla (or medulla + pons).

These axons accompany the corticospinal tract until they reach the level of the nuclei in which they terminate.

Unlike the corticospinal tract, the corticobulbar tracts project bilaterally (with some exception; see the schematic in page 66).



Slide 21-22

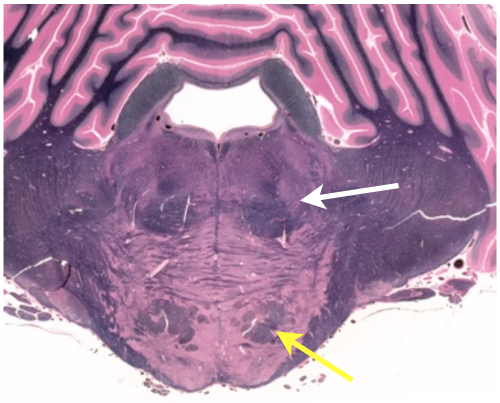
internal capsule, posterior limb (forebrain)

Internal capsule is shared by many other axon bundles including sensory axon bundles from the thalamus to the cortex.

Slide 18

cerebral peduncle (midbrain)

Note that only the middle third of the cerebral peduncle (red) includes the corticospinal tract.



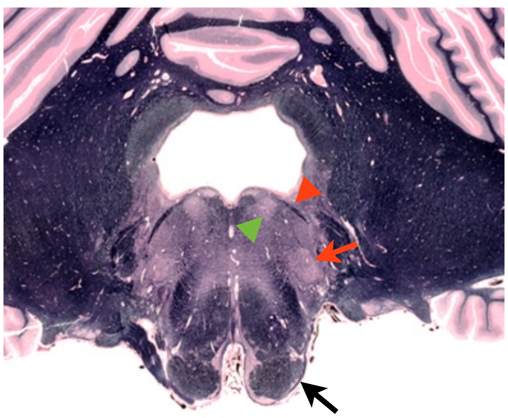
Slide 12

pyramidal fascicle (pons)...yellow arrow

The pons contains two types of fascicles: 1) pontine fascicle, which are the axons of pontine neurons that run medial to lateral, decussating to the contralateral side, arriving at the cerebellum via the middle cerebellar peduncle, and 2) the pyramidal fascicles, which are axons of the corticospinal and corticobulbar tracts that run rostral to caudal.

trigeminal motor nucleus (pons)...white arrow

Axons of neurons in the trigeminal motor nucleus innervate jaw muscles.



Slide 11

facial nucleus (pons)...red arrow

Axons of neurons in the facial nucleus innervate muscles of the face. The axons from this nucleus (red arrowhead) loop around the abducens nucleus (green arrowhead) and leave the brainstem at the ventral surface.

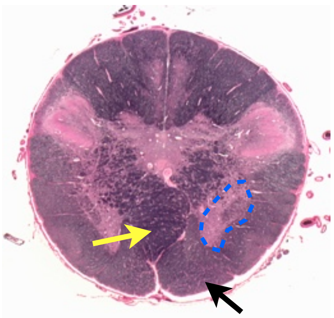
pyramid...black arrow (also observed in the gross material)

Slide 8

hypoglossal nucleus (medulla)...arrowhead

Axons of neurons in the hypoglossal nucleus innervate the tongue muscles.

pyramid...arrow



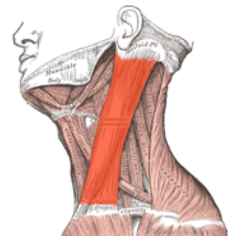
Slide 3

Slide 3 shows a section of a cross section of lower medulla very close to the spinal cord

spinal accessory nucleus...blue dots

Axons of neurons in the spinal accessory nucleus innervate muscles on the shoulder and neck; trapezius and sternocleidomastoid.

pyramid (black arrow)
pyramidal decussation (yellow arrow)
(both structures were observed in the gross material)

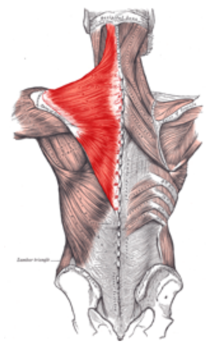


sternocleidomastoid muscle

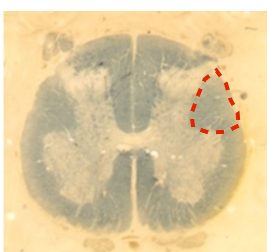
Note: how to discriminate the pyramidal decussation from the sensory decussation

Slide 4

The sensory decussation (blue arrow) is within the medulla (**slide 4**), slightly rostral to the pyramidal decussation. At this level, you can see both gracile (1) and cuneate (2) nuclei, the source of axons that cross at the sensory decussation (see the difference in slide 3).



trapezius muscle



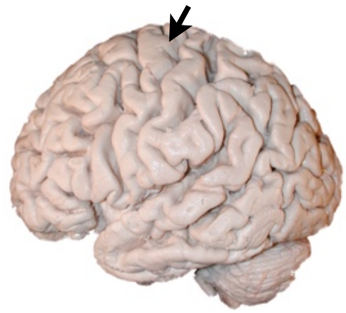
Slide 54

lateral funiculus (dorsal part) in the spinal cord...red dots

In the spinal cord (after the pyramidal decussation), the corticospinal tract runs in the dorsal part of the lateral funiculus.

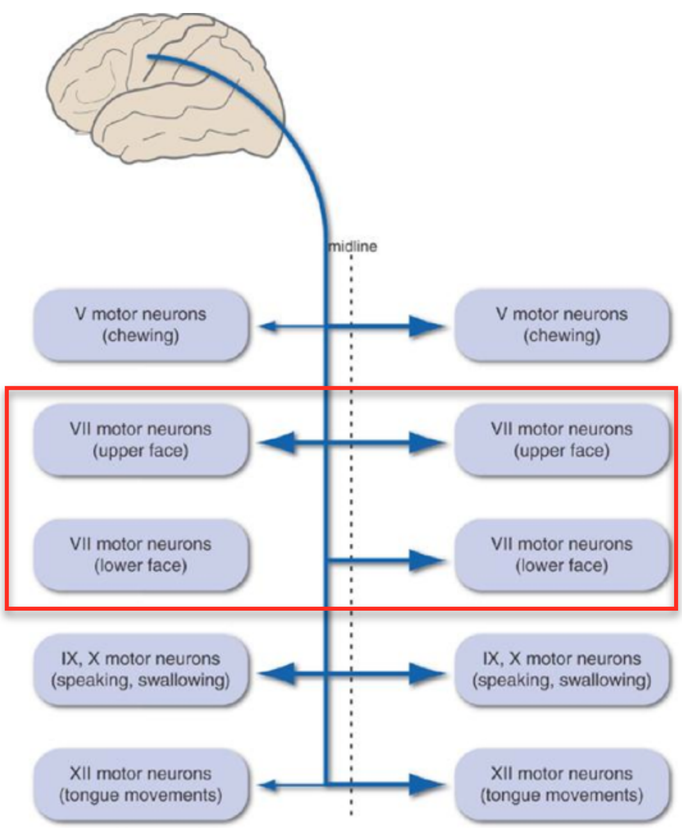
Clinical questions:

1. Which parts of your body will have weakness if you suffer from a stroke that affects the following location on the left side of the cortex?



2. As you saw in Dr. McLoon's lecture (see the diagram to the left below), the lower face and the upper face have a difference in the laterality of innervation from the cortex. The facial nucleus innervating the **lower** face is largely controlled by <u>contralateral</u> motor cortex, whereas the facial nucleus innervating the **upper** face is <u>bilaterally</u> controlled by the motor cortex. Axons of motor neurons in the facial nucleus project to the ipsilateral muscles without crossing at the midline. How are the motor functions of the facial muscles affected in the following situations? Justify your answers.

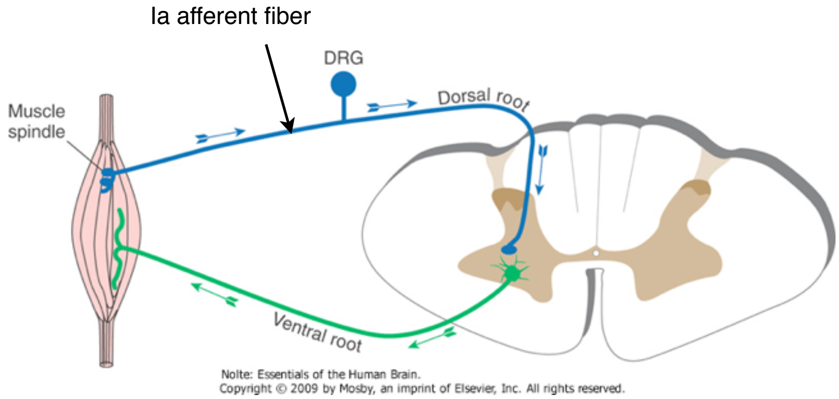
a) a lesion in the left internal capsule involving fibers going to the facial nucleus
b) a left facial nerve lesion ("Bell's palsy")



Activities to understand the integration of sensory and motor pathways

1) <u>Testing muscle stretch reflex</u>

This is a test of monosynaptic reflex involving the sensory neurons and motor neurons.



You can elicit this type of reflex in many parts of your body. These tests are clinically used to evaluate the location of lesions. For example, lesions of descending motor system **above** the lower motor neurons (either in the ventral horn of the spinal cord or cranial motor nuclei) will generate exaggerated reflex (hyper-reflexia). Lesions in the motor neurons or their axons will cause reduced reflex (hypo-reflexia). Examples of reflexes that are clinically useful are:

1) jaw jerk: afferent=trigeminal nerve, efferent=trigeminal nerve (from trigeminal motor nucleus)..note that this nerve contains both afferent and efferent axons
http://www.youtube.com/watch?v=UESIyXicsc0

2) upper extremities (biceps, triceps, brachioradialis)
http://www.youtube.com/watch?v=2sm4ynlzEi8

3) lower extremities (ankle and knee jerks)
http://www.youtube.com/watch?v=3PILgkVKlAg

Take turns with your group members testing each other's reflex. Among the reflexes above, the ones in the lower extremities will be easier to elicit, but you can try other ones if you wish. You can test:

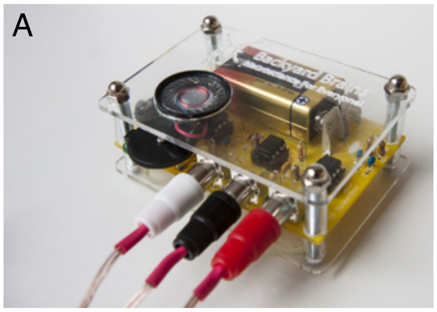
For the knee jerk (patellar reflex), the latency will be about 30ms. The lack of a reflex may indicate a lesion that involves one or more of the components of the reflex arc. Some healthy people show weak or no reflex. You can increase a reflex by the following maneuver:

Jendrassik maneuver: the person forcefully contracts a muscle of the forearm or the jaws while the examiner tries to evoke a reflex in the lower extremities. This may be due to the descending (corticospinal) signals that increase the excitability of the reflex center.

2) Electrophysiology of muscle contraction using EMG Spikerbox

We will then “hear” and “see” muscle contractions using a electrophysiological device (electromyogram; EMG). Each group of students will be provided with a recording box (EMG SpikerBox; Fig.A) (from Backyard Brains). The box contains an amplifier and a speaker to make the electrical activity audible. An output port is available for laptop, tablet or smartphone recording. We provide an iPad for each group so you can visualize the muscle contraction.

A



B

smartphone cable

C

EMG electrode cables

D

muscle electrodes

A. Recording from muscles that move your fingers

[Procedure] watch the video: https://backyardbrains.com/experiments/muscleAP

1. Connect the EMG SpikerBox to the iPad using a green “smartphone cable” (Fig.B). **Be careful: each end of the cable needs to be connected to the right device**
    a. iPad is connected to the end labeled as “Smartphone”.
    b. EMG SpikerBox is connected to the end labeled as “SpikerBox”. There are two cable connectors on EMG SpikerBox. Use the one that is closer to the battery.
2. Connect three EMG electrode cables to the box (make sure the color matches; Fig,A.C)
3. Connect the other end of each cable to:
    a. white (ground): your fingers or any other body parts (if you have a ring, you can attach the clip to it)
    b. black and red: muscle electrodes (Fig.D)
4. Launch Backyard Brain App from the iPad.
5. Turn on the EMG SpikerBox (rotate the black dial all the way).
6. Make sure that the background noise is minimum without movement of fingers (Fig.E). A nearby electronic device connected to an AC adaptor will cause a noisy background activity.

E

7. Move your muscle left and right. Do you see muscle activity on the screen?

[Caution] Batteries die very quickly in SpikerBox. If you do not see a response, ask instructors to change batteries and see if it fixes the problem.

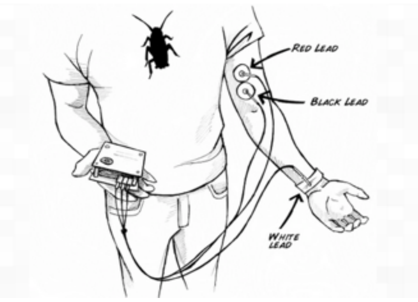
8. How about moving your fingers up and down. Do you see similar response? If not, why?
9. See if you can position the electrodes to optimize the activity of the muscle under study. Which side is more optimal?

B. Recording from your biceps muscle

Use the EMG electrode pads (Fig.F) to record from larger muscles. Setup the recording arrangement for testing the biceps muscle as illustrated on the left, using the EMG electrode pads. Before applying these pads, use the alcohol swabs to clean the skin, then apply a small amount of electrode paste to insure good contact. Grounding the subject is also important for good fidelity recordings. Turn the sound up by moving the dial on the box. You can also test different muscles and see which is easy to record from.

F

G



C. Testing ankle jerk using EMG SpikerBox

H

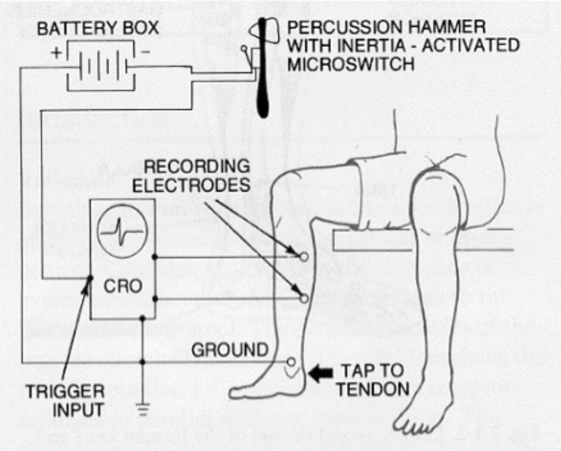


Fig. 7.4-3. Arrangement for recording from the gastrocnemius muscle. Striking the Achilles tendon with the percussion hammer elicits the stretch reflex and starts the oscilloscope sweep. The electrical activity of the muscle is displayed on the oscilloscope. It is important to use differential amplification and shielded cables.

Use the EMG SpikerBox to record stretch reflexes.

1.Connect the leads from your EMG SpikerBox as before.

2.Connect the two recording electrodes over the gastrocnemius (calf) muscle and connect the ground electrode as indicated in Fig.H. It is best to use EMG electrode pads to make these connections.

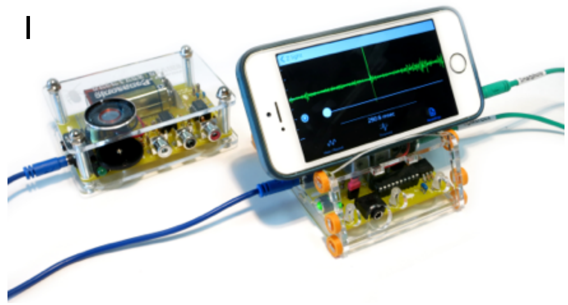
3.Use the reflex hammer to tap the Achilles heel. Do you see a reflex contraction of the muscle in your recording device?

4.You can record other types of stretch reflexes you tested in p.67. Which reflex is the easiest to record in the SpikerBox?

3) Measurement of response time using EMG SpikerBox and EMG Reaction Timer

In this experiment, you will test sensory guided motor control by using a combination of two devices, EMG Reaction Timer (for generating visual and/or auditory stimuli) and EMG SpikerBox (for recording). You will measure the time it takes to respond to visual or auditory stimuli and move your muscles. You will determine if the reaction time differs between different stimuli.

I



Each group of three students will have one complete set of devices. Take turns within the group so that everyone will have her/his reaction times measured. Each experiment needs one subject (who responds to stimuli) and at least one tester (who generates stimuli using the EMG Reaction Timer).

[Procedure] watch the video: https://backyardbrains.com/experiments/EMGReactionTimer

1. Connect EMG SpikerBox and EMG Reaction Timer using a blue cable.

1. Connect EMG Reaction Timer to the iPad using a green cable. Now the three devices are connected in tandem (SpikerBox→Reaction Timer→iPad) (Fig.I).

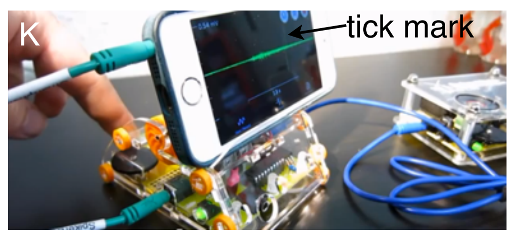
2. Turn on Reaction Timer and SpikerBox (all the way up).

3. Turn off all the functions (“light”, “tone” and “random”) of the Reaction Timer (Fig.J).

4. Press either of the white buttons and make sure that “tick marks” appear on the monitor (Fig.K). These tick marks indicate the timing of the stimulus.

5. The subject is now connected to the SpikerBox. Try the forearm muscles first using EMG electrode pads (Fig.L).

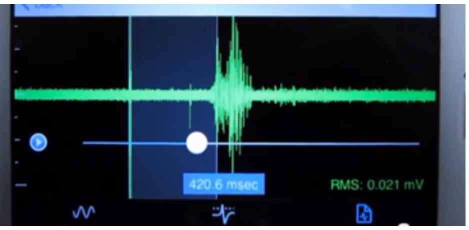
6. Turn on the “light” function of Reaction Timer (Fig.J) and press a white button (left button=yellow light; right button=red light). The subject will flex the muscle as quickly as possible in response to the light stimulus. Do you see a tick mark at the stimulus and EMG signals as you contract your muscles? You can zoom in and out (both horizontally and vertically) using your fingers on the iPad.



7. After a few tests, begin to record the data by pressing the red round button at the upper right corner of the App window of iPad. You can either use the same color of light all the time, or randomly choose the colors and let the subject respond to only one color (you can test both methods and compare the reaction time). After at least 20 stimuli/responses, tap the top, red part of the App window to stop the recording.

8. On the App, tap “Recording” to show a list of your recordings. You can **rename** each recording for your convenience. Tap the “Play” button to **play back the recording**. Pause the playback when you find a tick mark and a robust EMG signal. Using your fingertip, swipe from the tick mark to the first noticeable EMG signal to measure the reaction time (Fig.M). **Measure the reaction time** for 10 responses and record the results in the table in the next page.

M



9. Turn on the “tone” function of Reaction Timer (Fig.J) and turn off the “light” function. Repeat the experiment (steps 7-8) in response to tones. Different buttons now produce tones of different frequencies. You can either use the same tone throughout the experiments, or use random combination of the two different tones and let the subject respond to only one type of tone.

10.Calculate the mean reaction time for each stimulus and compare between:

a. different stimuli (light vs tone vs both light and tone)..every groups should do this

b. different subjects...every group should do this

If you are interested, you can also try different types of comparisons. For example...

a. single color of light vs random color of light

b. single tone vs random tone

c. different muscle group (you could try to tap your thumb and index finger, for example)

11. Delete all the recording from the iPad at the end of the lab. **You can touch “Share” button to email the files to yourself for later analysis just in case.**

In the lab report, include the following discussion in addition to the experimental procedures and results.

a. What explains the difference in reaction time between tone and light stimuli?

b. If you noticed a difference in reaction time between different subjects (to the same stimuli), what would explain that?

muscle:	**student:**			**student:**			**student:**		
Reaction time (msec)	**Audio**	**Visual**	**Both**	**Audio**	**Visual**	**Both**	**Audio**	**Visual**	**Both**
Trial 1									
Trial 2									
Trial 3									
Trial 4									
Trial 5									
Trial 6									
Trial 7									
Trial 8									
Trial 9									
Trial 10									
Average Reaction time									