Seminar Lab Notes:

General Psychology (PSYC 1101)

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1. Introduction to Labs

Psychophysiology is the study of the interaction of psychological and physiological processes. In other words, it is the study of how cognitions and emotions influence the physical body, and how the physical body influences cognitions and emotions. For example, it is typical to experience a slightly depressed mood when one contracts the common cold. It is likewise not at all uncommon to become sick when overworked and over-stressed. Being sick is truly a psychophysiological (albeit unpleasant) experience. Psychophysiology is thus the investigation of the dialogue between the "mind" and "body", which are really just two different ways of considering the same thing. Yet, how can we measure how the mind-body is functioning?

Research over the past century has demonstrated the utility of several methods of psychophysiological measurement. Although the terms for each method sound technical, understanding the basics of each method it is really just a matter of identifying the parts in the terms:

1. **Electromyography (EMG):** A measure of muscular activity.
2. **Electrooculography (EOG):** A measure of eye movement.
3. **Electroencephalography (EEG):** A measure of brain waves.
4. **Electrocardiography (ECG):** A measure of heart rate.

Each of these methods works because the mind-body constantly creates small electrical fields within its tissues. The heart creates by far the strongest bioelectric field (i.e., a biologically-generated electric field) in the mind-body, with brain in second place. According to the electrical engineering phenomenon of electromagnetic induction, the movement of an electric current through a physical medium creates a magnetic field. Complimentarily, the movement of a magnetic field through a physical medium results in an electrical current. Based on this principle, we can use electrodes attached to various places on the skin to meaningful observe the inner processes of the mind-body.

Working with psychophysiological equipment requires the use of proper laboratory procedures. Essentially, this involves obtaining informed consent and placing electrodes. The purpose of informed consent is to provide an individual with sufficient information so that she can make an informed decision whether to participate. One must obtain informed consent prior to proceeding with the procedure. This is absolutely necessary to the research endeavor. For our purposes, you are asked to sign an informed consent form at the beginning of the semester. Students agreeing to undergo psychophysiological measurement and recording in the labs are also asked to provide verbal consent at the time of measurement. Electrodes function as a bridge between the skin and the acquisition unit by way of leads. The red lead is always positive, the white lead is always negative, and the black lead is always the ground. Yes, I realize this is completely at odds with standard electrical wiring.

We will use a bipolar electrode placement to measure the difference in voltage across the skin regions of interest. The first step in electrode placement is to abrade the electrode sites. This is done with the use of an alcohol swab to remove the skin's natural oil and dead cells so as to facilitate a better connection between the skin and the electrode. Once the electrode is stuck to the skin, the second step is to attach the appropriate lead clip. Third, it is important to check for noise in the system. Any number of situations can cause electrical noise (e.g., hair at an electrode site, leads to close together, nearby electrical or computer equipment, etc.). Fourth, the removal of the electrodes entails unclipping the leads, and then swiftly but gently pealing off the electrodes from the skin. Laboratory gloves must be warn throughout the entire process to prevent contamination of the electrode sites.

2. Electromyography I Lab: Motor Unit Recruitment

Skeletal muscles are muscles that produce physical action in the mind-body by attaching to various points of the skeleton. All muscles work via contraction, a shortening of the muscular tissue. However, contractions in the skeletal muscles are graded. The amount of contraction is dependent upon the encountered workload. Lifting a textbook requires greater contraction of the biceps than lifting a pen. Likewise, walking on the Earth requires a higher degree of contraction of the relevant leg muscles than walking on the Moon. Such contractions are controlled by the brain at a subconscious level. One typically need not consciously think about how to lift an object. One simply lifts the object.

Each skeletal muscle is composed of thousands of individual muscle fibers. These fibers are actually long, thin muscle cells. Several muscle fibers are innervated by a single motor neuron projecting from the anterior horn of the spinal cord. The motor neuron and its subject muscle fibers together comprise a motor unit. One way the brain increases strength in a muscle is to activate multiple motor units in that muscle. This process is known as motor unit recruitment. There is literally strength in numbers. As an alternative to motor unit recruitment, the brain can increase the frequency of firing of the relevant motor neurons. A quicker rate of firing causes shorter-duration contractions, allowing the muscle fibers to briefly rest between contractions and therefore manifest greater overall stamina. Even when not in active use, the muscles of the mind-body maintain a slight resting tension known as tonus. By periodically activating small numbers of motor units throughout a muscle, the brain maintains that muscle in a constant state of readiness for work.

Once activated, muscle fibers generate their own electrical impulses. We can measure the overall voltage change in the skin across a muscle or group of muscles as an indicator of how much the muscle is working. This process of measuring muscular activity is known as electromyography (EMG). Interestingly, clench strength in the dominant hand tends to be markedly stronger than clench strength in the nondominant hand.

3. Electromyography II Lab: Mechanical Work

Skeletal muscles do work by translating the contraction of muscle fibers into physical action. As dictated by the laws of physics, a group of muscles must exert a force greater than the weight of a given object to lift that object. The amount of force generated to lift an object can be calculated by multiplying the weight of the lifted object by the height the object is lifted. For example, let us suppose a student lifts his textbook with one arm. The textbook weighs 2 kilograms (1 kilogram is approximately equal to 2.2 pounds), and the he lifts it 25 centimeters (1 inch is approximately equal to 2.5 centimeters). Therefore, we can compute the amount of force necessary for the student to have lifted the textbook:

Mechanical Work = (2 kg)(25 cm) = 50 kg.cm

What if the student lifted the textbook twice as high, to 50 cm? We can see that this would require twice the work:

Mechanical Work = (2 kg)(50 cm) = 100 kg.cm

We can thus see that muscular work is graded. The heavier or farther one wishes to move something, the more muscular force is required to do so. In order to move an object of a given weight, the brain actively monitors the necessary required force during the action. If greater force is required, the brain activates additional motor units.

As we all know, however, a muscle cannot contract indefinitely. Eventually the muscle depletes its energy supply of adenosine triphosphate (ATP). The result is increasing fatigue. Fatigue is typically a short-term condition for the muscle. Long-term training of the muscle can result in improved resistance to muscle fatigue. We can nonetheless observe muscle fatigue via electromyography (EMG).

4. Electrooculography Lab

Six muscles control the movement of each eye in its orbit. Four of the muscles, the recti, attach in a direct line to the eyeball: (a) superior rectus, (b) inferior rectus, (c), medial rectus, and (d) lateral rectus. Two other muscles, the obliques, attach at a notable angle to the eyeball. These are known as the superior oblique and the inferior oblique. This collection of six muscles is labeled the extrinsic eye muscles. They are extrinsic because they are outside of the eye. Alternatively, the iris is actually a collection if very small muscles intrinsic to the eye.

The brain controls the contractions of the extrinsic eye muscles via three bilateral cranial nerves. These nerves project directly from the brainstem, whereas most nerves for the body project lower from the spinal cord. The oculomotor nerve (cranial nerve III) controls all but two of the extrinsic eye muscles. The superior oblique is controlled by the trochlear nerve (cranial nerve IV). The lateral rectus is controlled by the abducens nerve (cranial nerve VI). The precise and coordinated movement of the eyes is necessary for many basic tasks, such as visually reading or tracking a moving object. The eyes can focus in nine cardinal directions to accomplish such tasks:

Position	**Right Gaze**		**Straight Gaze**	**Left Gaze**	
	Right Eye	Left Eye	Both Eyes	Right Eye	Left Eye
Upward	Superior Rectus	Inferior Oblique	S.R., I.O.	Inferior Oblique	Superior Rectus
Centered	Lateral Rectus	Medial Rectus	*Central Gaze*	Medial Rectus	Lateral Rectus
Downward	Inferior Rectus	Superior Oblique	I.R., S.O.	Superior Oblique	Inferior Rectus

Since the front of the eye maintains a positive voltage relative to the back of the eye, we can measure ocular behavior via an electrooculogram (EOG). EOG allows us to specifically observe a number of conscious phenomena related to eye movement. Voluntary movement of the eyes provides for visual fixation on a target, which ensures that the incoming visual stimuli remain focused on the fovea of each eye. Fixation is the ability to intentionally orient the eyes toward a target in the environment. For example, the EOG of an individual tracking a pendulum as it swings back and forth should demonstrate a roughly sinusoidal waveform. However, other voluntary fixation requires saccades. Saccadic movement involves the use of jerky, lateral ocular shifts in gaze. This can be demonstrated during reading.

As opposed to such voluntary and conscious processes, there also exists the necessity of microsaccades. Microsaccadic movements are automatic, subconscious, and generally imperceptible attempts to maintain visual fixation by refreshing the stimuli received at the foveae. They can be demonstrated via EOG when an individual is required to fixate for more than a few seconds on a stationary target. In the absence of such induced ocular movement, the neurons of the occipital lobes cease to respond to an otherwise stationary target.

5. Electroencephalography I Lab: Brain Rhythms

The adult human brain is estimated to contain approximately 100 billion neurons, and another 1 trillion supportive glia. For our purposes, we are most interested in neural processes in the cortex. Also known as the cerebral cortex or cranium, this "outer bark" of the brain is the site of all higher functioning. It is split into two hemispheres, known as the right and left hemispheres. Each hemisphere is further divided into four lobes.

The frontal lobes control voluntary motor behavior. They also mediate higher-order thought; the prefrontal cortices are especially implicated in cognitive ability. The parietal lobes process sensory and somatic information. This includes the cutaneous (i.e., skin) senses, as well as the somatic senses (e.g., kinesthesia). The temporal lobes process auditory information from the ears. Finally, the occipital lobes process visual information from the eyes.

Electrical activity is constantly present throughout the brain. Regardless of the level of organismic arousal, the brain remains active. Thus, what changes is not whether the brain is active at any given point day or night, but the ways in which it remains active. We can measure the workings of the brain via electroencephalography (EEG). Specifically, we can observe the workings of the cortex, which lies atop the deeper structures of the brain and thus prohibits ours ability to easily observe those structures. The EEG has been used for scientific and clinic purposes for over a century.

The EEG records five periodic rhythms from the cortex: (a) alpha, (b) beta, (c) delta, (d) theta, and (e) gamma. These rhythms are said to be periodic because they occur in repeated intervals. Brain rhythms are identified via wave frequency (in hertz) and amplitude (in microvolts):

Rhythm	Frequency (Hz)	Amplitude (μV)
Alpha	8-13	20-200
Beta	13-30	5-10
Delta	1-5	20-200
Theta	4-8	10
Gamma	30-90	5-10

Please note two things. First, the amplitude ranges in the table are for the clinical setting, and may be greater than those we observe in the classroom. Second, the waveforms are listed in their typical order of presentation from wakefulness, to sleep, to deep relaxation.

Alpha rhythms are typical during a relaxed, inattentive state and indicate a high level of neural synchrony. In other words, the many areas of the cortex are working together in a functionally unified matrix. Alpha rhythms are most strongly observed in the occipital and parietal lobes. They also change based on attentional task, typically decreasing with eyes open and focused on an external stimulus. Beta rhythms occur during both waking activity and rapid eye movement (REM) sleep. Beta rhythms are of lower amplitude than alpha rhythms. This indicates that the relative positive and negative voltages across the cortex are becoming more balanced. It does not indicate lower actual activity; the cortex is actually now in a higher state of arousal and manifests the beginnings of desynchronization (i.e., alpha block). Thus, we might expect such a waveform during a state of effortful attentiveness.

Delta and theta rhythms suggest deepening sleep in most individuals. They demonstrate increasing neural decoherence. Orthogonal to tightly coupled alpha rhythms, delta and theta rhythms make clear how the different areas of the cortex essentially cease communicating with one another in a meaningful way. Perhaps this is why dreams can be so wonky. Finally, gamma rhythms are synchronized waveforms expected during such activities and deep relaxation and meditation.

6. Electroencephalography II Lab:
Alpha Rhythms in the Occipital Lobe

Brain rhythms vary with the state of the mind-body. The alpha rhythm is the typical neural waveform in an adult during a relaxed, inattentive state. It is relatively easy to monitor due to its generally high frequency and amplitude. This is especially true over the occipital lobe, where alpha rhythms tend to be quite strong. Essentially, we can use observations of the alpha rhythm as a very approximate measure of relaxation.

A rather simple way to alter the alpha rhythm is to manipulate the breath. As realized millennia ago by practitioners of Ayurvedic medicine, the breath has a direct link to general mind-body arousal. For example, hyperventilation results in the excessive removal of carbon dioxide from the blood supply. This results in a deficit of carbon dioxide from the cerebrospinal fluid, which then becomes overly alkaline. The brain responds with a general increase in electrical activity, which can be observed through the alpha rhythm.

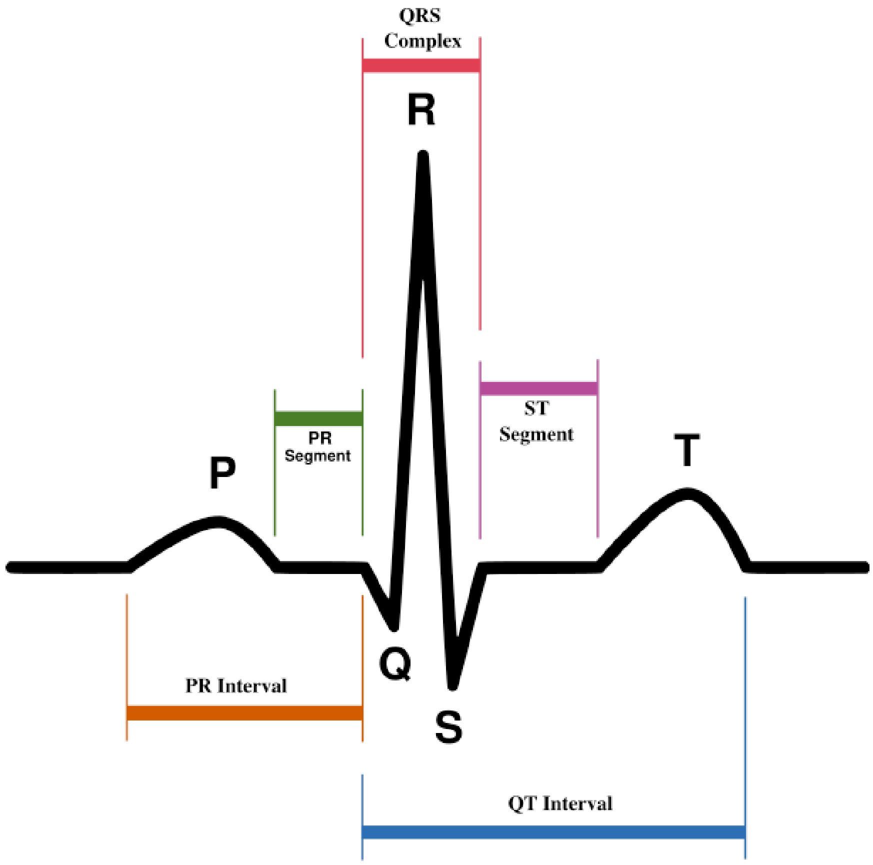
7. Electrocardiography Lab

The human heart manifests four chambers that facilitate the pumping of blood throughout the mind-body. Blood is received from the veins by the right and left atria, and pumped to the arteries by the right and left ventricles. The right heart and left heart maintain completely separate blood flows. The right heart receives blood from the systemic veins and sends it to the lungs for oxygenation via the pulmonary artery. The left heart receives blood via the pulmonary veins from the lungs and sends it throughout the rest of the mind-body by way of the aorta.

Cardiac muscle tissue is known as the myocardium, and creates a myogenic heartbeat. In other words, the heart creates its own beating rhythm. This rhythm is measured in beats per minute (BPM). Although this rhythm is both directly and indirectly influenced by the brain via nervous and humoral pathways respectively, the heart actually beats on its own as long as it receives an adequate supply of oxygen. A myocardial infarction, or heart attack, can occur as a result of a clot in one of the arteries feeding the myocardium itself.

The coordination of the heartbeat is the result of a network of electrically conductive nodes and pathways throughout the myocardium. Nestled in the top of the right atrium sits the sinoatrial (SA) node which sets the actual rate of firing for the heart at any given moment. The SA node is consequently known as the cardiac pacemaker. The signal from the SA node is conducted through the right atrium by the internodal pathway, and through the left atrium via the interatrial pathway. The result is the simultaneous contraction of both atria, which pump blood to their respecting ventricles. Residing at the junction of the right atrium and right ventricle, the atrioventricular (AV) node receives the signal from the SA node. The AV node then relays the signal to beat to both the right and left ventricles via the right and left branches of the AV bundle. However, the AV node does so after a brief delay that allows the atria sufficient time to contract and relax. Finally, the Purkinje fiber network, which resides at the end of AV bundle branches, triggers both the right and left ventricles to contract. It is the left ventricle that does most of the physical work, since its blood supply is sent throughout the remainder of the mind-body.

We can measure the heart beat, essentially a complete cardiac cycle, via an electrocardiogram (ECG). The ECG is also known as the EKG for its original German name of *elektrokardiogramm*. The pattern of an ECG is comprised of a number of wave components: (a) baseline, (b) P wave, (c) QRS complex, and (d) T wave. The baseline (i.e., isoelectric line) is the straight line that exists between beats on the ECG pattern. The P wave results from depolarization of the atria. The QRS complex results from ventricular depolarization. This indicates the initiation of the ventricular contraction. Due to the electrical strength of the ventricular depolarization, the atrial repolarization is masked. The T wave results from the repolarization of the ventricles and indicates the beginning of their relaxation:



(Released into the public domain on Wikipedia by Anthony Atkielski.)

The ECG pattern also maintains two features in addition to the wave components of the actual heart beat. An interval contains at least one wave and a straight line. For example, the PR interval indicates the time the signal originally triggered from the SA node requires to pass through the AV node and then trigger the ventricles. A segment is a straight line that represents the time between the cessation of one wave and the initiation of another wave. For example, the ST segment represents the delay between ventricular excitation and ventricular relaxation.

8. Relaxation Lab

One of the most amazing abilities of the mind-body, in my opinion, is its ability to heal itself when provided the opportunity to do so. The relaxation response is a feature of the result of the parasympathetic nervous system, one of the two branches of the autonomic nervous system (ANS). When an individual becomes nervous or upset, the result is activation of the sympathetic nervous system (the other branch of the ANS). Although this can be very adaptive in the short term, long-term sympathetic arousal places the individual at risk to develop chronic stress and its many psychological and physical sequelae. Conversely, activation of the parasympathetic nervous system promotes health and healing.

It is actually quite simple to learn basic relaxation techniques that will remain with you throughout your life if you choose to practice them on occasion. Biofeedback training is based on the premise that we maintain an innate ability to directly alter what are typically subconscious physiological processes through the use of intention. For example, children can be taught to race small cars on an electrical track by changing their brain waves. For our purposes, it is sufficient to observe how even a few minutes of intentional relaxation can alter basic psychophysiological functioning. Electromyography (EMG) is often used to monitor the parasympathetic response (i.e., relaxation) because it is so sensitive to slight changes in muscular tonus.