Excerpt from

LABORATORY MANUAL

PRINCIPLES OF PSYCHOLOGY: EXPERIMENTAL FOUNDATIONS

PSYCHOLOGY 122
2001

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Experiment 5

Attention and Brain Activity

Howard Thorsheim

begins on the next page and constitutes pp. 60-73 of the full manual

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Attention and Brain Activity

Howard Thorsheim,

Introduction

Attention

The major concept of the lab is ***attention***. Attention is vital for our survival. Without attention, the rest of the information-processing system is at a disadvantage. Because of the importance of attention in education, athletics, business, advertising, and mental health, researchers around the world are devoting considerable time to better understanding the relationship between attention and brain activity.

Attention is an important stage in the information processing system. The following stages of the information processing system are highlighted in Figure 1:

a. Stimuli from external environment
b. Sensory memory
c. Attention
d. Response-produced stimuli (proprioception; thoughts; images)

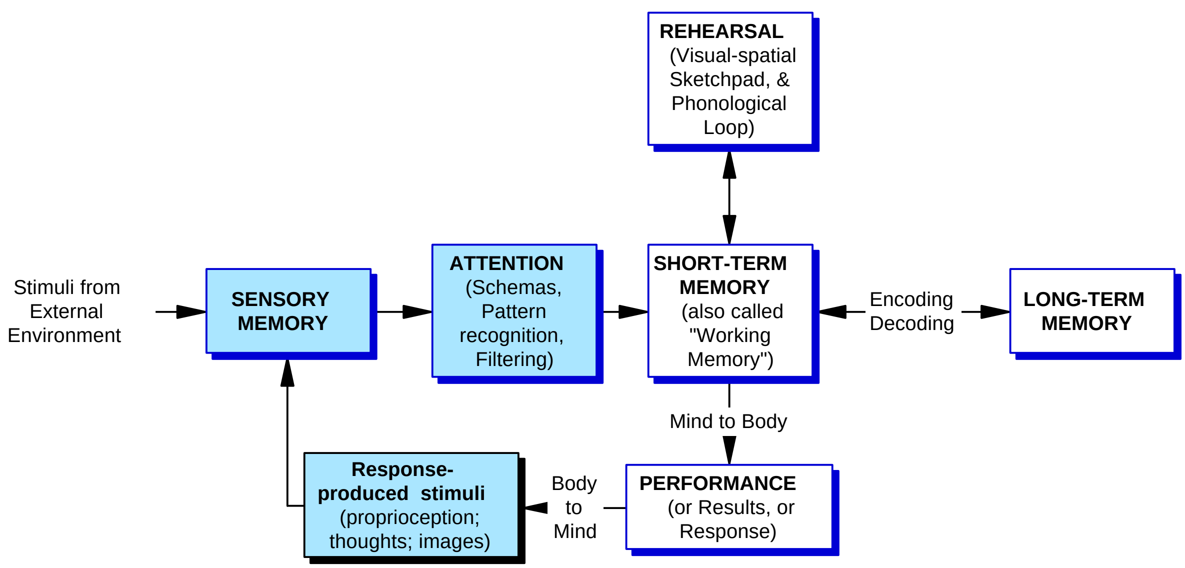


Figure 1. The Information-processing system

The laboratory today will focus on the highlighted boxes in the Information Processing System (Figure 1). The plain, white boxes will not be the focus of today's lab.

Interconnectedness of all Scientific Fields

A major objective of Psychology 122 is to provide a taste of what science is truly about. Science is a way of knowing and <u>learning from experience</u> through making observations in order to discover causes of events. These observations are not just any kind of observations, but rather very careful observations, made with much thought beforehand. These observations may be made in a natural environment; for example, <u>naturalistic observation</u> of play behavior.

Another kind of experience that is <u>planned in advance</u> is called an <u>experiment.</u> In an experiment special care is taken to limit or hold constant variables that could confuse the observations being made—this is called <u>experimental control</u>. Another way scientists speak of these sources of confusion is to call them sources of <u>confounding</u>.

Today's lab is a good example of how all sciences are interrelated. We will draw on several sciences, psychology, biology, chemistry and physics.

<u>Psychology</u>: We will focus on behavior, both physical and mental behavior.

<u>Biology</u>: We will need to know something about the biological structure and function of the brain.

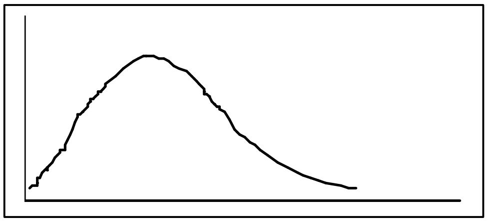
<u>Chemistry</u>: We will need to know about the chemical reactions that result in transmission along nerves, the active and passive flow of ions across the membrane of the nerve axon, which we call the action potential.

<u>Physics</u>: We will need to know about waves (specifically brain waves), how they are described, measured, and the units of measurement used to compare them.

<u>Psycho-physiology vs. Physiological-Psychology</u>

By now you are familiar with the terms independent variable and dependent variable. To review, the independent variable (IV) is the condition the researcher manipulates, changes or observes. The dependent variable (DV) is what the researcher observes, to see what effect on it was caused by or is related to the IV.
The relationship between independent and dependent variables is called a functional relationship. These relationships are shown by plotting the two variables on an X-Y pair of axes of a graph. The independent variable is on the horizontal axis (abscissa), and the dependent variable is on the vertical axis (ordinate), for example:

(Dependent variable
On the Ordinate)



Independent variable on the abscissa

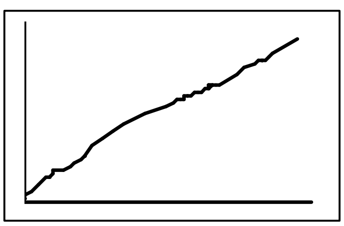
Table 1: Contrast of Psychophysiology and Physiological Psychology

Psycho Physiology		Physiological Psychology	
Independent Variable	Dependent Variable	Independent Variable	Dependent Variable
A **psychological** variable we manipulate, change, or observe. It may be a causal variable	Some kind of **physiological** response related to or caused by the independent variable	A **physiological** variable we manipulate, change, or observe. It may be a causal variable	Some kind of **psychological** response related to or caused by the independent variable
Example: ATTENTION: This is a **psychological** variable	Example: BRAIN WAVE CHANGE. This is a **physiological** variable	Example: BRAIN STIMULATION. This is a **physiological** variable	Example: CHANGE IN ATTENTION. This is a **psychological** variable

In both psychophysiology and physiological psychology, we plot the independent variable on the abscissa, and the dependent variable on the ordinate. What differs is what those independent and dependent variables are. Observe the following two illustrations closely:

<u>Psychophysiology</u>

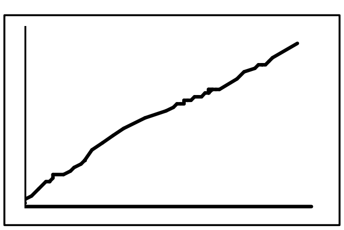
(**Physiological** Dependent variable
On the Ordinate)



Psychological Independent variable on the abscissa

<u>Physiological Psychology</u>

(**Psychological** Dependent variable
On the Ordinate)



Now let us proceed to the dependent variable we will observe today, the electroencephalogram, or brain wave, as it is commonly known.

The Electroencephalogram

The electroencephalogram (EEG) is the record of brain-wave activity. It is recorded easily and nonintrusively from the human brain via gold electrodes placed on the surface of the scalp. As shown in Figure 2, the commonly obtained alpha waves of 8-13 Hz recorded over the occipital lobes**{**xe "occipital lobes"**}** of the brain (when eyes are closed) are reduced in amplitude and increased in frequency when visual stimulation occurs (i.e., when eyes are open).

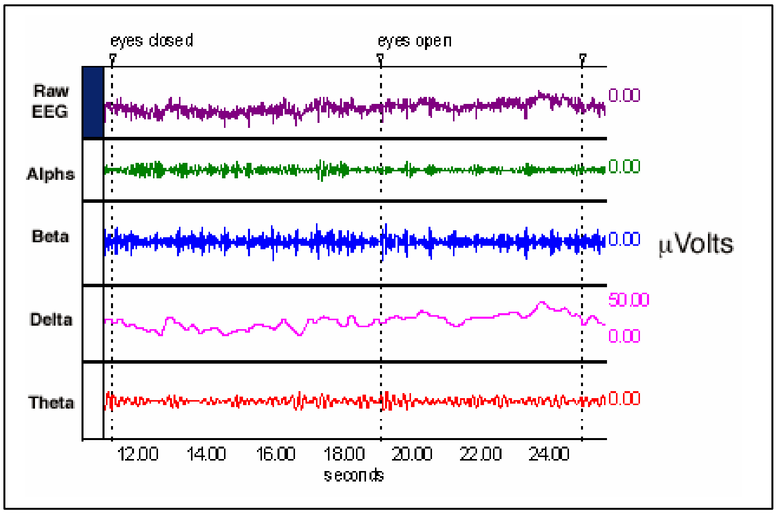


Figure 2. More alpha waves with eyes closed than with eyes open

The alpha rhythm**{**xe "alpha rhythm"**}** is "blocked" when visual stimulation occurs and is replaced by the faster, lower amplitude beta rhythm. A more current term for the same phenomenon is "desynchronization**{**xe "desynchronization"**}**." Alpha blocking**{**xe "alpha blocking"**}** is an increase in frequency**{**xe "frequency"**}** and a decrease in amplitude **{**xe "amplitude "**}**of the alpha rhythm during visual stimulation (i.e., when eyes are open). Visual sensory information achieved by having one's eyes open causes the alpha waves to be "blocked."

You may find it interestingly counterintuitive when you discover that brain <u>attention</u> is represented by <u>small,</u> fast beta waves, whereas <u>inattention</u> is represented by <u>large,</u> but slow, alpha waves. (If this interests you, ask more about it.)

<u>Source of Alpha Waves</u>. The neural activity denoted by the alpha rhythm results from some kind of coordinated electrical activity in the cortex. Ganong **{**xe "Ganong "**}**(1965, p. 128) attributed the source of the rhythmicity

to electrical dipoles (dipoles are like the north and south ends of a magnet) **{**xe "dipoles"**}** formed between dendrites and cell bodies in the cerebral cortex**{**xe "cerebral cortex"**}**. "Current" flows back and forth, in the words of Ganong, through the extracellular fluid that serves as a volume conductor (that is, electrical activity is going on around the neurons as well as inside them). The "current" is a flow of ions that increases and decreases as a result of the activity of excitatory and inhibitory nerve endings that terminate on the dendrites. The activity of these dendrites is increased or decreased by activity in the brainstem ascending reticular activating system**{**xe "ascending reticular activating system"**}** (ARAS**{**xe "ARAS"**}**).

Objectives

- To investigate ways to measure attention by measuring brain activity
- To learn the basic skills of electroencephalography (EEG)
- To identify the difference between alpha and beta brain waves, using criteria of frequency and amplitude
- To understand the difference between paying attention to one's internal thinking (a *rejection task* that involves rejection of external stimuli) and paying attention to external environmental stimuli (an *intake task* that involves intake of external stimuli)
- To understand the Faraday Cage and the BioPac Equipment. (If time is available, you may be able to explore some of the sophisticated digital approaches we use in later courses.)

Issues to investigate

You will compare EEG waveforms under eyes-open and eyes-closed conditions and discuss with your lab partners the evidence you have found for alpha blocking during visual attention. You will be asked to consider how you might test to see if imagery (*internal* visualizing) might reveal itself as similar to or different from direct visual stimulation. You will also be asked to explore the relationship between stimuli in other sensory modalities (hearing, touch, etc.) and "alpha blocking" and to discuss what it might mean if you find evidence for or against your hypotheses.

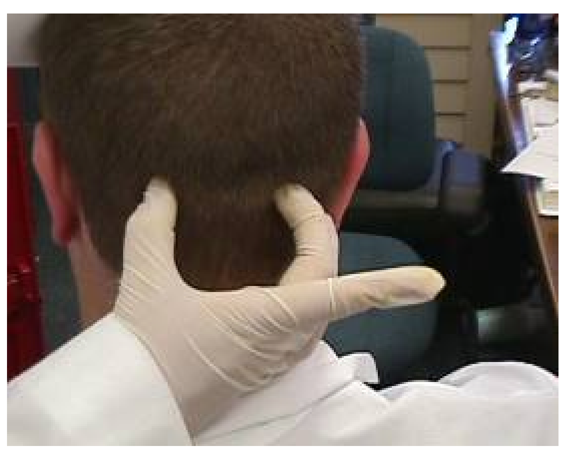



Figure 3. Learning in this investigative laboratory will include the following:

Left picture: Measuring to place EEG electrodes at the O1 and O2 Occipital positions on participant's scalp.
Right picture: Approximate location for O1 and O2 electrode placement

Terms

60-Hertz Noise	Action Potential	Alpha waves
Artifact	Attention	Beta waves
Calibration curve	Confounding	Delta waves
Electroencephalogram	Experiment	Experimental Control
Faraday Cage	Hertz (Hz)	Impedance
Informed consent	Microvolt	Mu
Naturalistic Observation	Occipital lobes	Sensory memory
Ten-twenty system	Theta waves	Variables (Dependent and Independent)
Volt	< "less than"	~ "approximately"

Some key definitions

Alpha and beta electroencephalogram waves are distinguished by two independent criteria:

(a) Frequency (alpha waves are 8-13 Hz; beta waves are 13-30 Hz)
(b) Amplitude (alpha waves are 20-100 microvolts; beta waves are <20 microvolts).

**Note: Hz stands for Hertz, the unit of measure for "cycles per second."

- Beta waves{xe "Beta waves"} (14-30 Hz; <20 microvolts) are associated with alert wakefulness and cognitive processing. You are likely producing beta waves now as you are reading. Rapid-eye-movement (REM) sleep is also associated with similar low-amplitude, irregular activity.
- Alpha waves{xe "Alpha waves"} (8-13 Hz, 20-60 microvolts) are associated with relaxation, meditation, and drowsiness. Zen Buddhist monks, when meditating, produce alpha waves.
- Theta waves{xe "Theta waves"} (4-7 Hz, ~20-100 microvolts) are associated with sleep states, as well as being implicated in creative processing and problem solving.
- Delta waves{xe "Delta waves"} (.5-3.5 Hz, 20-200 microvolts) are associated with deep sleep. Some research indicates that humans need to spend time in deep sleep when certain restorative processes of the body occur.

Method

Participants

Lab participants will work in two-person teams. One person will be the participant, while the other person will be engaged in conducting the investigations and recording observations. Both members of the two-person team will share their observations, notes, and data with each other.

Materials

Faraday Cage
BioPac Equipment
Grass Instruments EC5 gold electrodes (see Figure 4)
Grass Instruments impedance meter (see Figure 5)
Alcohol-acetone Prep Pads
Rubber gloves (Latex-free gloves are an option)

Figure 4. (Left) Recording electrode; reference electrode

Figure 5. (Right) Impedance meter; (Grass Instruments model F-EZM5)

Figure 6. (Left) Cleansing the area before placing electrodes.

Figure 7. (Right) Pressing the electrodes in place on scalp to ensure good contact.

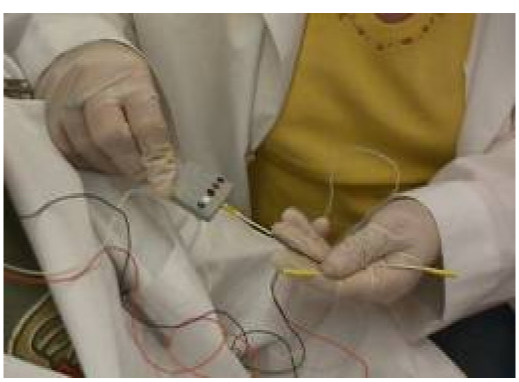


Figure 8. (Left) Placing the electrodes in the Safe Sockets.

Figure 9. (Right) Washing the paste from the electrodes. (Note: When washing ear clip sensors, only remove one at a time to keep the clip from being lost.)

Hints for obtaining optimal data:

1) Good electrode contact is essential to minimize "noise" and increase signal amplitude.
2) The subject should try relaxation techniques, such as concentrating on breathing slowly or relaxing muscles.
3) The subject should remain still, and especially, keep facial muscles still.
4) During the "eyes open" segment, subject should not blink.

Logging your Work:

Good research practice includes keeping track of every time you use your equipment. Find the lab log in the top drawer of your workstation. Find the next blank log sheet and write down today's date, your names as researchers, and what you will be doing. For example, "we will be doing the 'attention and brain behavior' labs." Then, during your labs make notes on the log page how the labs went for you, difficulties you figured out how to overcome, tips you might have for others, any problems with the equipment, etc.

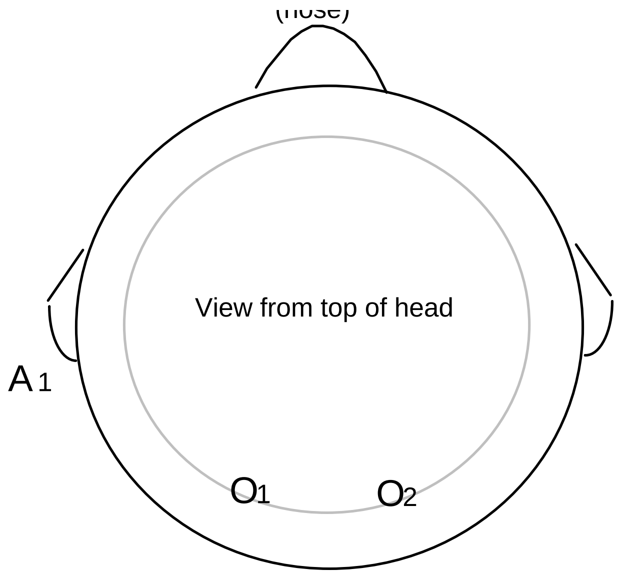
Procedure

1. Bring your lab notebook, handout for the lab and citation skeleton (which will be collected at the beginning of the period) to the lab. All other belongings (coats, backpacks, heavy sweaters, etc.) should be stored in another room. (To be specified)

2. Use of laboratory coats is mandatory in the psychophysiology lab to protect your clothing against electrode paste and Cetylcide disinfectant. Select a white lab coat for the lab. There are four sizes: small, medium, large, extra large. The smallest are to the left on the pegs in the Observation Room. The mediums should be in the middle, the largest to the right.

3. Form teams of two persons. Each team will have an electrode kit to share containing two recording electrodes per person and one reference electrode.

4. When lab starts, your preceptor will introduce you to the Faraday Cage, a "specialized instrument" used to make electronic measurements that are free of electronic noise from car ignitions, motors, static, or other such sources.



a. Please read the booklet "Story of the Faraday Cage." This information will be on the Lab Final. We will not be using the Faraday Cage for lab today because our measurements will not require such sensitive recording. It is important to know that, like many psychophysiological labs in the world, our psychology department has a Faraday Cage. Whereas often such cages look like "cages" and are somewhat austere in appearance, ours is specially designed to look like a "screen porch" to reduce participant anxiety.

b. The “radio test” should be done by every student. While standing near the Faraday Cage, put on the radio earphones and listen to the AM station. Then go inside the Cage. (The signal from the broadcast station has been stopped by the Faraday Cage.)

CT **Why is there no sound from the station?**

5. The instructor will demonstrate the procedure for placing electrodes on the scalp for electroencephalograph bipolar readings, using the international scientific 10-20 system. (This activity is preceded by going through an “informed consent” process.) Take notes so you can repeat the process on your own.

Figure 10. International (10-20) system for Electrode placement for EEG (you will be placing electrodes at O_1, O_2, and A_1)

6. Turn the computer ON.

7. Make sure the BioPac MP30 unit is OFF; that is, no green lights are on in the front of the MP30 box.

8. Plug the equipment in as follows, making sure the labels face up

BSL 3 Electrode Lead Electrode for Safe Socket (SS1LA) goes to Channel 1

9. Turn the MP30 Data Acquisition Unit ON. The switch to turn the unit on is located on the back left corner.

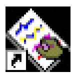
10. Have the subject assume a relaxing position.

11. Clean electrode loci on the scalp and ear lobe (VERY important for good results!)

12. Place electrodes with electrode paste in the cup, and cover electrode with gauze.

13. Check impedance to see that it is less than 10,000 ohms (VERY important for good results!)

14. Connect electrodes to the BSL 3 Lead Electrode for Safe Sockets (SS1lA)

15. Start the  Biopac Student Lab. 3.6.6.lnk program.

16. Choose **Lesson 3 (LO3-EEG-1).**

17. Type in your file name. Click **OK.**

18. Review Fig. 10 to ensure the electrodes leads are properly placed, and that the electrode assembly is plugged into Channel 1.

19. Click on **Calibrate**. An error message will appear if the BioPac accessories are not plugged into the proper channels.

20. If no error message, click on **OK**

21. **Check** your calibration data. If yours is similar to Figure 11, proceed to Data Recording. If your data differ from Figure 11, **Redo Calibration.**

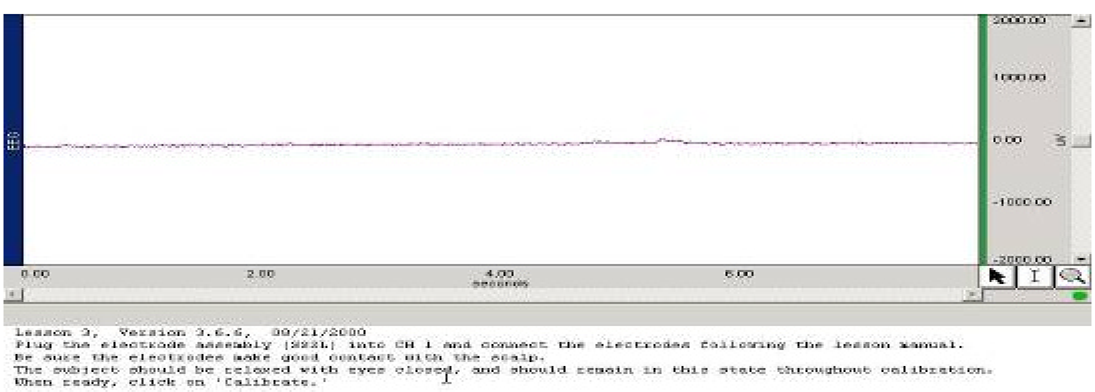


Figure 11. Typical calibration wave from the BioPac Student Lab program.

22. You will be shown some typical signals, and a volunteer participant will be asked to demonstrate what the lab teams will do. Follow these steps carefully:
    a. Prepare for the recording.
.   b. Click on Record.
        The director should instruct the subject to remain relaxed but, as directed, open and close their eyes. The director should also insert markers when the eyes close, open, close, etc.
    c. The participant should spend at least 10 seconds in each condition (10 sec eyes closed, 10sec eyes open, etc)
        ** Be sure to insert marker, the F9 key, for each event during the study. Also type a brief explanation of what the marker stands for so you will remember it, and refer to it later.
    d. Have the participant:
        -close and open eyes (to show alpha to beta transition)
        -grit teeth (to show electromyogram muscle action potential "artifacts" from jaw muscle motor neurons.
        -move head to show "sensor pops"
        -close eyes (so that alpha appears) and visualize an image
        -determine the kinds of stimuli you would like to investigate (e.g., auditory, olfactory, imagery, and touch) and hypothesize whether or not you would see "attention" revealed in the brain wave. ("Attention" = alpha changing to <u>alpha with beta components mixed in</u>, even when the eyes are closed.)

23. Click on stop only when you have completed investigating **ALL** conditions. You will learn how to operate the "record / stop" buttons, as well as waveform horizontal, waveform vertical, zoom, zoom previous, and F9.
24. Review data using the above keys. Click redo if your data do not look right.

25. Click on the frequency buttons in the following sequence;
    a. Beta
    b. Alpha
    c. Theta
    d. Delta

26. Review the data on the screen

27. Partners will rotate, testing one participant at a time, and collect their data. When each participant's data have been recorded, print the graph following these steps:
  a. File menu
  b. Print and then print graph
  c. Click ok.

Print out part of the EEG recordings, trim to fit, and paste them into your lab notebook using rubber cement.

The following points should be labeled:

Alpha and beta waves
Artifacts (and what they are)
Eyes open and closed
Any mental tasks you asked participant to do

CT	**If brain waves relate to your level of attention, what might various brain-wave rhythms mean for learning? Or for remembering?**

28. Clean up your participant, and clean up the electrodes, using hot water and a Toothbrush (go back and review what caption of figure 9 said about how to prevent losing ear clips); then disinfect the sensors by dipping them in Cetylcide for 6 seconds; then rinse them in hot water, allowing the sensors to air dry. (Show your electrodes to your preceptor when you come back to check that there is NO residual of electrode paste. If there is, you must go back and reclean them).

29. Please remember at all times to keep your workstation **Neat**. At all times, put all scrap in the trash receptacle. Ask your preceptor any procedural questions as you are hooking up your participants. Watch for and correct any deviations from correct procedure that you notice.

30. Remember to log all observations in your lab notebooks. Do not depend on your memory. This information is important and will be helpful in your lab write-ups. Note correct procedures, as well as incorrect procedures. In research, we learn when procedures don't work out as we had planned and when we notice new details about procedures.
  a) Discuss how many physiograph samples you believe you need to record in order to achieve reliable samples.
  b) Measure frequencies and amplitudes during each sample, and compute the mean frequency and mean amplitude for the eyes-open and eyes-closed conditions. Enter the data in your lab notebook.
  c) As time allows, explore other options for quantifying your data.

Reminder about Lab Logs

Take out the lab log once again and add any comments you can about how the equipment or software worked, or anything else about the BioPac workstation. Be sure to note any problems with the equipment. (Review the earlier part of this lab write-up to see what kinds of things to enter in the log)

Discussion Questions

Topic 1: Training brain waves
What would be some consequences if you were able to control your own brain waves? How might you be able to train yourself to have certain kinds of brain rhythms?

Topic 2: Brain waves--An internal clock?
Might the brain wave serve as the "tick-tock" of your internal clock that keeps track of time when performing music, playing a sport, or waiting for a friend? Why do you suppose time seems to fly when you're having a good time? What might your brain waves be doing?

Topic 3: Brain waves and learning
If brain waves relate to your level of attention, what difference might various brain-wave rhythms make for learning? Or for remembering?

Topic 4: Brain waves and business
Might performance efficiency be improved if people could know what their brain waves were doing? How might the attention-getting value of ads be predicted in advance, using brain waves?

Topic 5: Biofeedback
How could people know what their brain-wave patterns are? How could that be useful to them?

Topic 6: Stress
Stress is a major killer of people during their adult lives. What have you learned in this lab that could help people keep self-control by knowing when they are stressed or relaxed?

Topic 7: EEG and treatment of ADHD
How might what you have learned in this lab be used to diagnose and treat people who are suffering from attention deficit and hyperactivity disorders?

References

Required Lab Reading

Andreassi, J. L. (1995). The EEG and behavior: Sensation, attention, perception, conditioning, and sleep. In J. L. Andreassi (Ed.) *Psychophysiology: Human behavior and physiological responses* (pp. 50-54). Hillsdale, NJ: Erlbaum.

Suggested Readings (Also on reserve in the Library)

Greene, W. A. (1994). Biofeedback. In *Encyclopedia of Psychology* (Vol. 3, pp. 164-166). New York: Wiley. [This is the best article to read first for a broad understanding of biofeedback and the operant conditioning of one's own brain waves, as well as self-control and other physiological events inside one's body.]

Jasper, H. (1958). The ten-twenty system of the international federation.

Electroencephalography and Clinical Neurophysiology, 10, 371-375. [This classic article explains the world-famous way of systematizing the placement of sensors.]

Petersen, I., Herberts, P., Kadefors, R., Persson, J., Ragnarson, K., & Tengroth, B. (1981). The measurement, evaluation, and importance of electroencephalography in arduous industrial work. In L. Lennart (Ed.*), Society, stress, and disease: Vol. 4. Working life* (pp. 145-161). Oxford: Oxford University Press. [Applications of scientific findings are important, as shown by this article in which brain waves are used to study performance in the workplace.]

Triesman, M., Cook, N., Naish, P. L. N., & MacCrone, J. K. (1994). The internal clock: Electroencephalographic evidence for oscillatory processes underlying time perception. *The Quarterly Journal of Experimental Psychology*, *47A(2*), 241-289. [This is the best recent article discussing the idea of how brain waves may be involved in helping us keep track of time. The "internal clock" that allows us to keep track of time is a key to many kinds of human performance, including musical and esthetic performances. In searching for the basis of this "internal clock," brain waves have been identified as likely candidates for the "tick-tock" of the clock.]

Web links

EEG Biofeedback

http://www.eegspectrum.com/

[Good example of a commercial use of EEG biofeedback, plus lots of links to a number of other sources]

International Journal of Psychophysiology

http://www.hhpub.com/journals/jop

[Take a look at the hot topics and current research in the area of psychophysiology.]

The Psychophysiology WWW Directory

http://www.gsu.edu/%7Epsyejv/psyphy.html

[A great directory of links to sites concerning worldwide research and findings in the field of psychophysiology.]