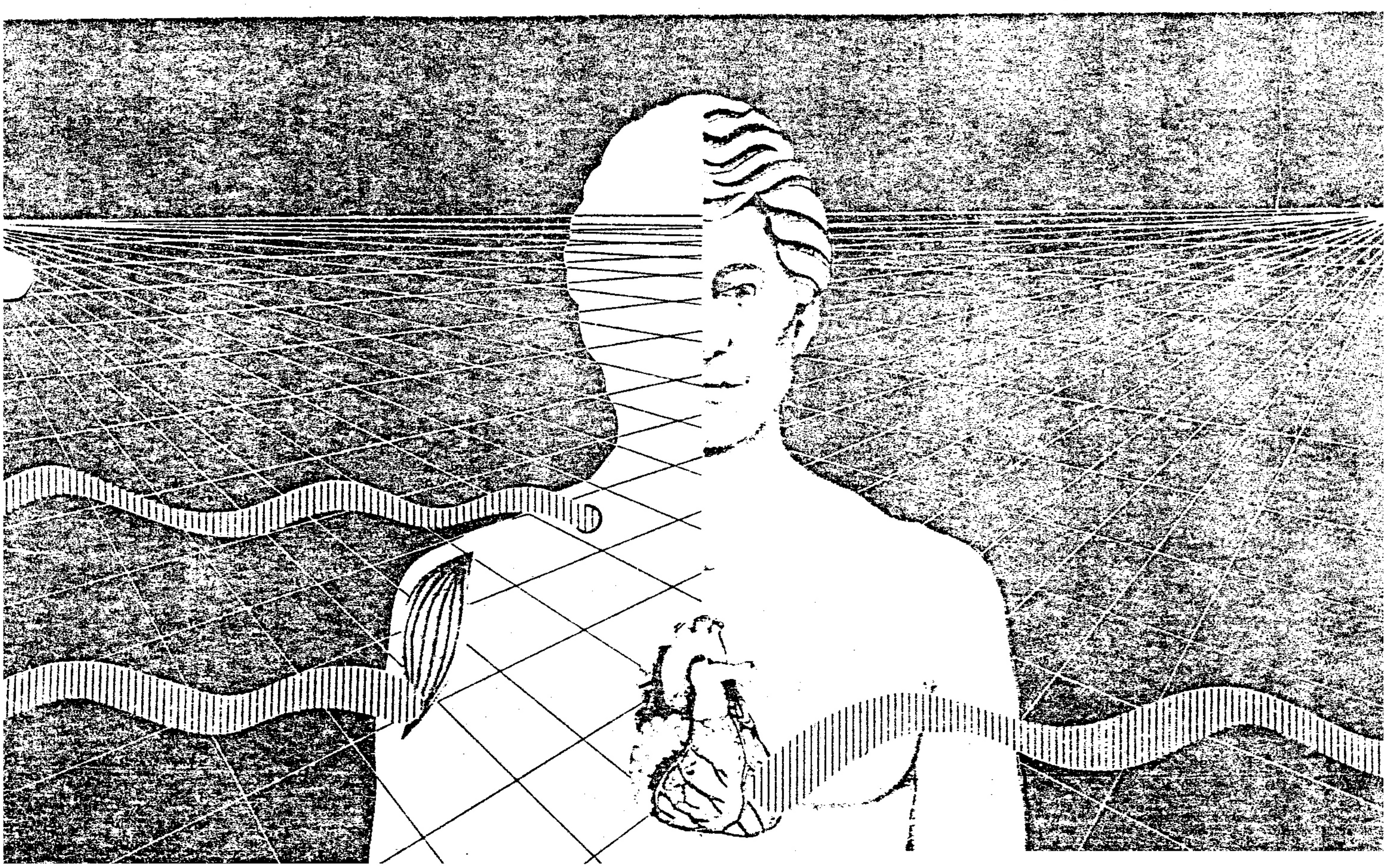
Guide

Biofeedback MicroLab™



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BIOFEEDBACK MICROLAB

GUIDE

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Biofeedback MicroLab is the result of the collaborative effort of many people. Paul Antonucci designed the hardware. Lars Travers designed the software and programmed the Commodore version. Steve Schumacher helped design the software and programmed the Apple version. Lyle Miller, Ph.D., and Bruce Mehler, M.A., of Biobehavioral Associates served as consultants and wrote the Guide. Peter Cochran, Vice President of Human Relations Media, served as editor and project manager for HRM. Adeline Naiman, Director of Software for HRM, assisted throughout. Sandy Kahn prepared the manuscript of the Guide for publication. Jo-Ann Rosiello provided the illustrations.

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CONTENTS

I. ORGANIZATION OF THIS GUIDE

This guide is organized into nine sections. This first section describes how the guide is organized and provides summaries of the contents of the other sections. Section II details possible uses for Biofeedback MicroLab in classroom and home settings. Section III offers an overview of what biofeedback is and of some of its possible applications. Section IV describes the equipment that comes with Biofeedback MicroLab and explains how to set up the hardware. Section V shows how to connect the sensors to the MicroLab Interface and how to attach the sensors to the body.

Section VI explains how to load the software into the computer. It then describes how the software is organized and details the different options that are available. We recommend that you spend some time reading this chapter before going on to the experiments in the later sections.

Sections VII, VIII, and IX are the heart of the guide. Each of these sections provides background material for different types of experiments and explains how to set up, perform, and interpret the experiments. These experiments are highlighted in the Table of Contents of this guide.

In addition, the Biofeedback MicroLab guide includes a glossary of important terms encountered in the guide, and appendices. Appendix A is a Progressive-Muscle-Relaxation Exercise that can be performed individually or by groups. Other appendices focus on troubleshooting, testing the hardware, batteries, care of sensors, electrical safety, using archive disks to store files, and using a cassette player as a feedback "reward."

II. USES AND APPLICATIONS OF THE BIOFEEDBACK MICROLAB

The Biofeedback MicroLab has a variety of potential applications in a number of settings. It is designed to be used in the classroom or in the home by individuals or groups. It is an instructional tool that increases awareness of how our bodies respond to various stimuli and introduces some of the basic ideas and procedures involved in biofeedback.

Biofeedback MicroLab is not intended for use in medical or other clinical settings, or as basic research instrumentation.

Biofeedback MicroLab is a powerful tool and should be used with discretion and care. It provides intimate information as to how an individual responds physiologically to various thoughts, questions, or stimuli. It should not be used as a "lie detector," nor as a means of violating personal privacy.

A. Classroom Uses

The Biofeedback MicroLab provides the student with a window into the workings of mind-body relationships. It is appropriate for any level of education from high school on up.

In biology and health classrooms the program illustrates the nature of the fight-or-flight response in a variety of its subtle combinations. The significance of this response for the survival of the species is obvious. Less obvious is the fact that the reaction that enabled our ancestors to escape danger and to defeat enemies can, in today's world, be a major menace to our health and well-being, and sometimes to our lives.

In the physiology classroom, the Biofeedback MicroLab introduces students to principles of electrophysiology in a simple but substantial manner. Students can explore the electrophysiology of the sweat gland and somatic muscle. They can explore the relationship of respiration to cardiac activity and become aware of the variability of heart rate as a function of mental or physical activity. The question of whether the "autonomic" nervous system responds to voluntary control becomes a means of studying the complexities of the nervous system as it controls physiological functioning.

In the psychology classroom, the Biofeedback MicroLab provides an unparalleled introduction to psychophysiology. It provides students a means of seeing the relationship of psychological processes with physiological activity in a way that is both captivating and informative. Computers make it possible to appreciate these relationships as never before. In addition, learning and conditioning concepts can be demonstrated and explored with ease.

For the pre-medicine student, Biofeedback MicroLab provides insights into the nature of stress-related illness and the subtlety of the stresses that impinge upon us and wreak havoc with our health and well-being. In addition, the pre-medicine student will have an opportunity to develop an understanding of the basic concepts and procedures that make biofeedback a powerful therapeutic tool.

B. Home Uses

The Biofeedback MicroLab provides a means of promoting increased awareness of our bodies. It can be used in learning general stress reduction techniques and, under the direction of a qualified professional, could even be used as a biofeedback home-training device. For those interested in general knowledge about physiological functioning, it provides a window into the body that heretofore has been available only in the most sophisticated research laboratories.

III. ABOUT BIOFEEDBACK

Biofeedback is a scientific technique for learning enhanced self-control over various bodily processes, many of which were once thought to be beyond our ability to consciously control. This exciting technology has grown out of important advances in the fields of psychology, physiology, electronics, and computer science.

Under normal circumstances, we are largely unaware of the subtle internal adjustments our bodies make to meet the demands of our daily activities. These actions take place below the level of conscious awareness either because we have practiced the act so often that we do not have to focus our attention on it and do it by habit, or because our bodies have automatic mechanisms for dealing with demands as they arise. The coordinated tensing and relaxing of muscle groups to pick up a pencil is a highly practiced motor act that we perform smoothly without thinking about it. The increase in heart rate, blood flow, and respiration that take place when we go out running happens automatically in response to increased metabolic demands. These normal patterns of activity can, however, be disrupted by physical injury, disease, or through the strains involved with excessive stress in our lives.

Biofeedback involves the use of sensitive electronic instrumentation to detect subtle changes in muscle tension, heart rate, skin temperature, perspiration, and a variety of other physiological activities. If this information is then displayed or "fed back" to us, we can be made aware of these changing bodily processes. Research has shown that by observing ourselves through this technique of "biofeedback" we can learn to modify these activities in healthy directions that can significantly improve the quality of life. For instance, one can learn through biofeedback training to control the heart so that it doesn't pump any harder or faster than is absolutely necessary. When we are tense and under stress we can learn to slow the heart down so that we reduce the risk of suffering a "stress-related" heart attack. Our chances for healthier and longer lives are increased the more we learn to relax and not overwork our bodies.

Biofeedback techniques are currently being applied in the treatment of a variety of disorders, including tension headache, migraine headache, and high blood pressure. Biofeedback is also used in training stroke and accident victims in regaining control of their bodies.

For most of us, biofeedback can be used as a window into how our bodies respond physiologically to stresses such as a load noise, taking a test, or just thinking about something. This manual and the Biofeedback MicroLab have been designed to introduce the basic ideas, techniques, and procedures involved in biofeedback and to allow the user to explore some of the basic factors that enable us to use biofeedback in learning to modify physiological activity and to gain mastery over our bodies.

IV. SETTING UP

A. Computer Requirements

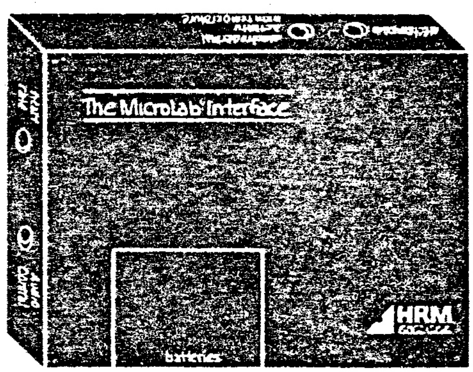
To run Biofeedback MicroLab you need either:

- Apple II+ or IIe computer with at least 64K RAM and one disk drive
- Commodore 64 or 128 computer with disk drive

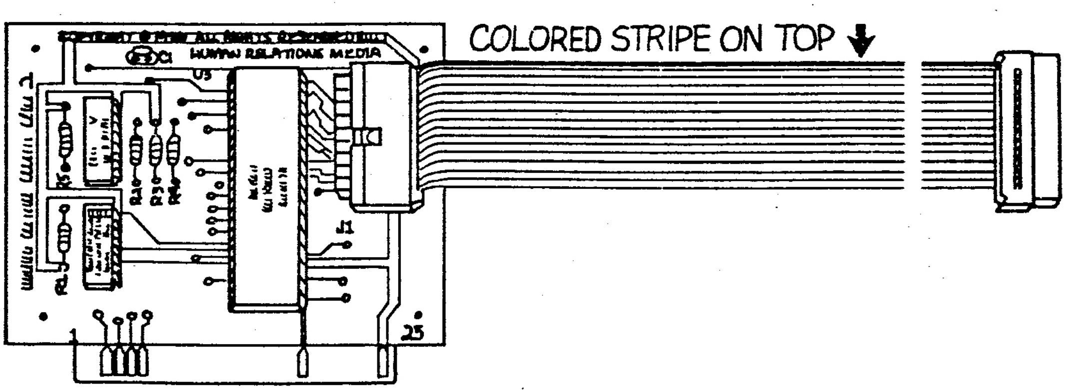
B. Package Contents

The following equipment is provided in the package:

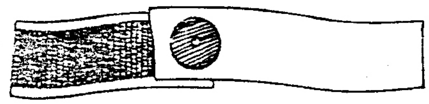
1. Program disk
2. This Guide
3. The MicroLab Interface. Batteries are included but will need to be changed periodically. See Appendix C.



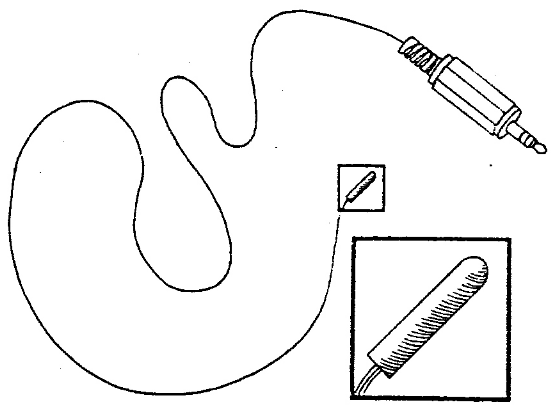
4. Apple interface card and cable (Apple version only). The interface card was probably shipped with the cable already attached. If the ribbon cable has not been attached, you will need to plug one end of it into the card. It is important that the colored stripe on the cable be on top, as illustrated below.



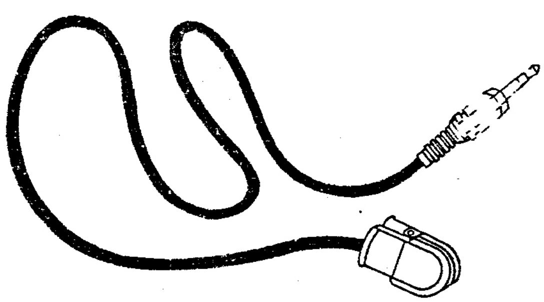
5. Two electrodermal activity (EDA) sensors with snap connectors



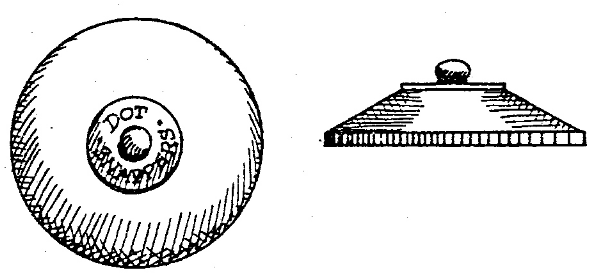
6. Thermistor with cable for measuring skin temperature



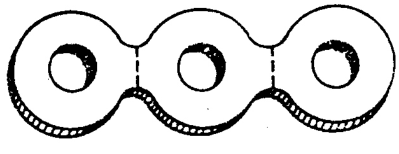
7. Heart-rate sensor with cable



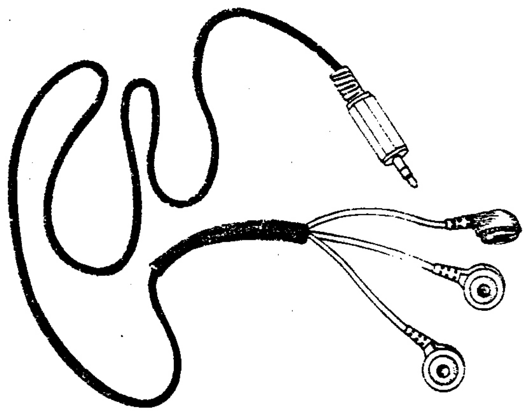
8. Three electromyogram (EMG) sensors with snap connectors



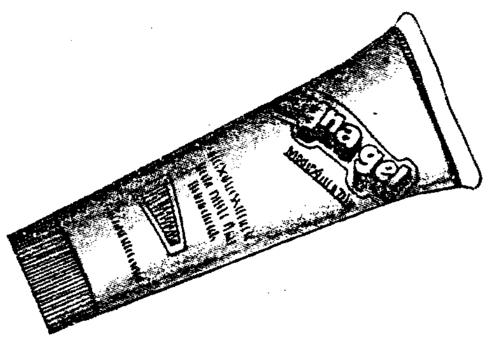
9. Forty adhesive strips for use with EMG sensors



10. Sensor cable with three snap connectors for use with EDA and EMG sensors



11. Tube of electrolyte gel for use with EMG sensors



<u>Testing hardware</u>: All of the equipment included in the <u>Biofeedback MicroLab</u> package has been tested prior to shipment. It is wise, however, to test the hardware again on receipt of the program or when you suspect the program is not functioning properly. Appendix B of this guide details testing procedures.

C. Materials You Need to Supply

You will need to supply the following for some of the measurements:

- isopropyl alcohol
- gauze pads
- paper tape (such as that used for hair setting or by hospitals)

These materials may be obtained from any pharmacy.

D. Optional Additional Equipment

The MicroLab Interface includes an audio-control input that enables you to connect the interface with a cassette player. This feature allows you to use music of your own choosing as feedback. In order to use the audio-control input you will need an adapter and a phono-plug-to-phono-plug cable. See Appendix G for more information and instructions on connecting a cassette player to the MicroLab Interface. Appendix G also describes how this optional feature may be used in biofeedback sessions.

E. Copying the Program Disk

The program disk is not copy-protected, and you may use any standard copy program for the purpose of providing a back-up in case the original is lost or damaged. You are permitted to make only one copy.

F. Installation of the Hardware

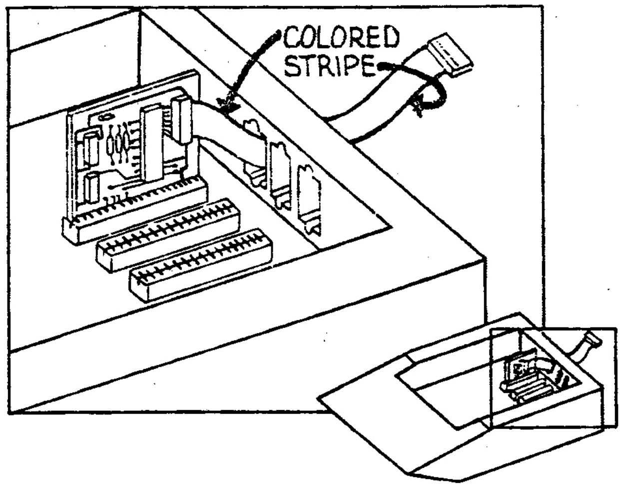
Apple

1. The Apple should be properly attached to the disk drive, monitor, and printer (if available). Turn the computer off, but keep it plugged in to avoid static discharge.

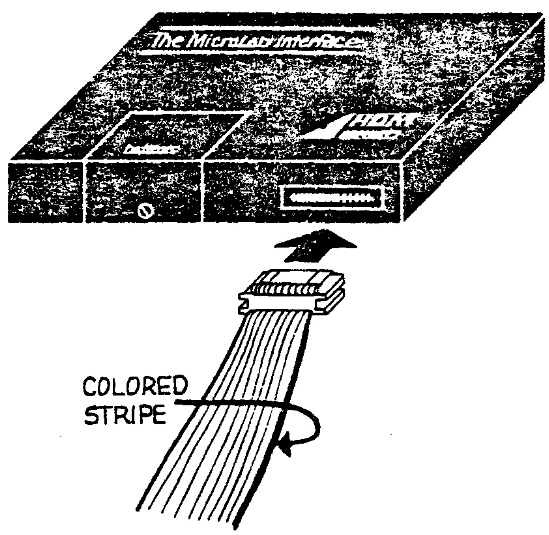
2. Remove the cover from your Apple II series computer.

3. Insert the Apple Interface Card into expansion slot 2, 3, 4, 5, or 7 of your computer (making sure that the cable side of the card is on the right, as shown on the following page). If you are using an Apple IIe and an 80-column Text Card is in the auxiliary slot (AUX. CONNECTOR), the Interface Card will not function in slot 3.

Either remove the 80-column Text Card or put the Interface Card into another slot. Thread the cable through one of the cutouts in back of the computer.



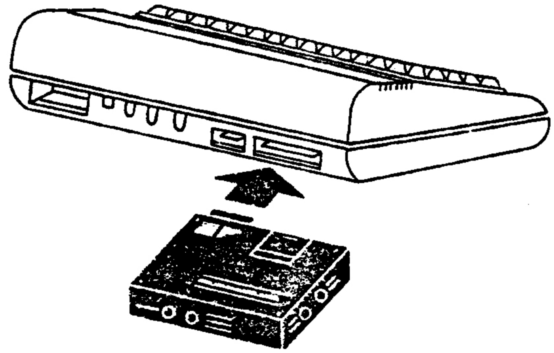
4. Plug the ribbon cable from the Apple Interface Card into the MicroLab Interface. The cable should be plugged in as indicated below. Check carefully to see that the cable is connected correctly <u>before</u> turning the power on.



<u>Commodore</u>

1. The Commodore should be properly attached to the disk drive, monitor, and printer (if available). Turn the computer off, but keep it plugged in to avoid static discharge.

2. Plug the connector protruding from the MicroLab Interface directly into the user port of your Commodore 64 or Commodore 128 computer.

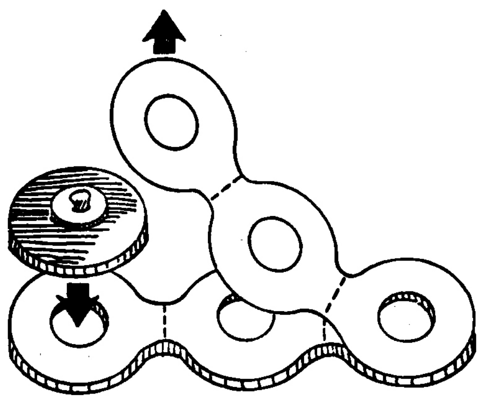


V. CONNECTING SENSORS TO MICROLAB INTERFACE AND ATTACHING SENSORS TO BODY

To minimize the introduction of electrical noise into the MicroLab Interface circuitry and to maximize battery life, connect only the sensors you plan to use. Plugging in the thermistor and the EDA and EMG Electrodes activates portions of the circuitry and drains current from the batteries.

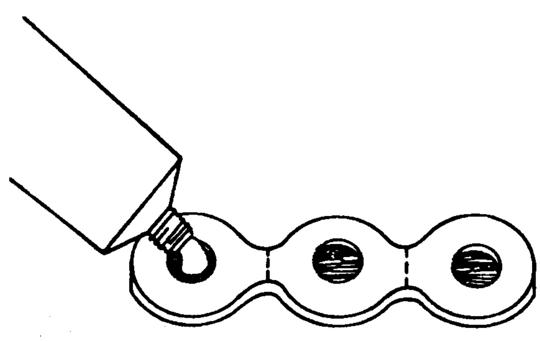
A. Electromyograph:

1. Remove the backing from one side of an adhesive strip and carefully place the three sensors on the strip.



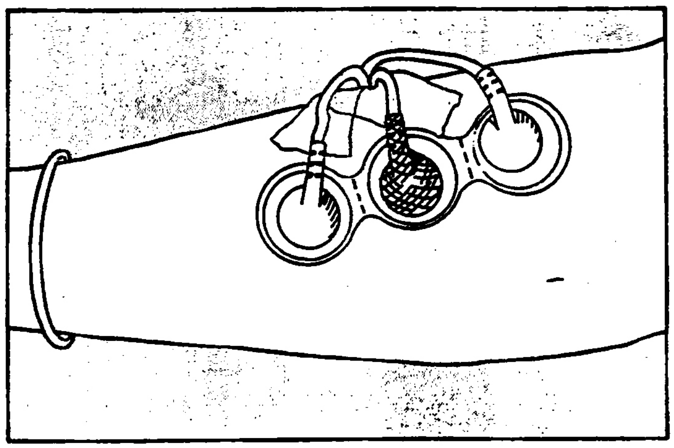
2. Turn the strip over and attach the snap connectors of the sensor cable. The reference electrode (the one with the snap connector with the odd color--usually green) should be in the middle.

3. After the EMG sensors have been attached to an adhesive strip and the snap connectors of the sensor cable have also been attached, turn the adhesive strip over and fill the recessed areas with electrolyte gel.

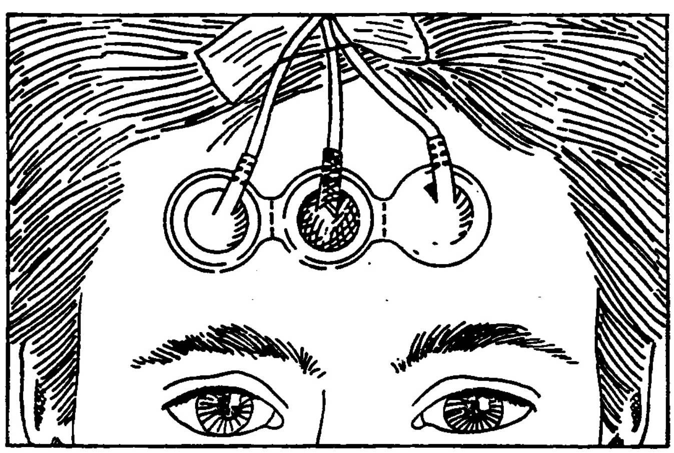


4. Remove the backing on this side of the adhesive strip and apply the sensors to the subject's forearm flexor muscle or forehead.

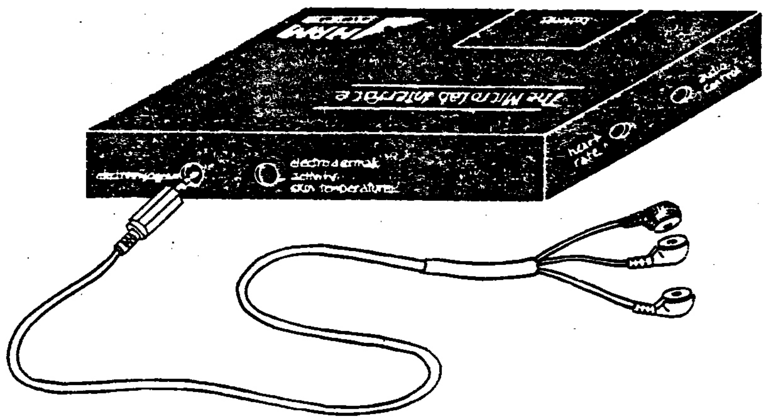
Before applying the sensors to the forearm, have the subject make a fist. Notice how the muscles bunch up on both the top and bottom of the forearm. Unless the top side of the forearm is too hairy, clean this side where the muscles bulge up with alcohol and a gauze pad. If the top side is too hairy, clean the bottom side of the forearm. Attach the EMG sensors as shown in the illustration below. Note in the illustration the placement of the odd-colored sensor (reference or ground sensor) between the two same-colored sensors (active sensors). The sensor cable should then be taped to the arm to reduce movement that might disturb proper measurement.



If you are applying the sensors to the forehead, clean the forehead with alcohol and a gauze pad. Attach the sensors as shown in the illustration below. Note the placement of the odd-colored sensor between the two even-colored sensors. The sensor cable may then be taped to the hair and shoulder to reduce movement.

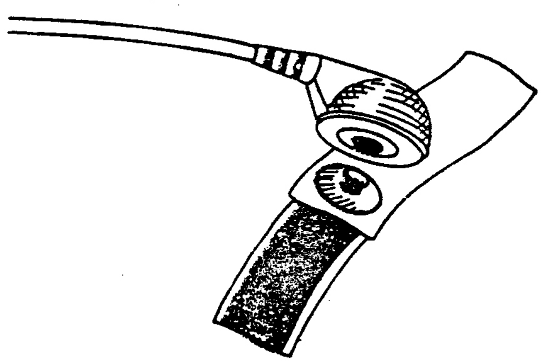


5. Connect the plug on the end of the sensor cable with three snap connectors into the electromyograph input of the MicroLab Interface.

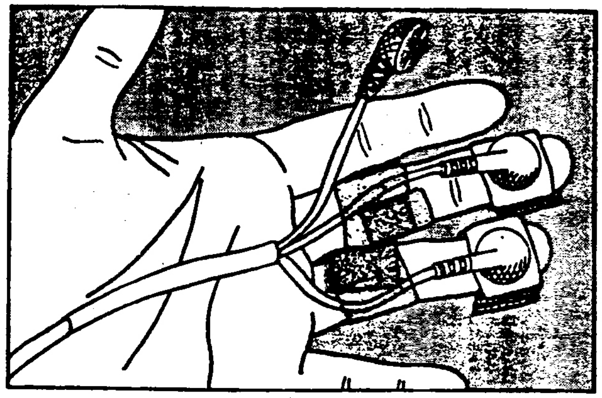


B. <u>Electrodermal Activity</u>:

1. Snap the two same-colored (usually white) snap connectors to the EDA sensors.



2. Attach the EDA sensors with velcro straps to two separate fingers of the subject's non-dominant hand, i.e. the left hand if the subject is right-handed. Note in the illustration on the following page the placement of same-colored sensors with the odd-colored sensor off to the side. Tape is useful for reducing sensor movement that might disturb proper measurement.



3. Connect the plug end of the sensor cable with three snap connectors into the electrodermal activity input on the MicroLab Interface.

C. Skin Temperature

1. Place the temperature sensor on the underside of a finger of the subject's non-dominant hand, i.e., the left hand if the subject is right-handed (figure a). The wire connecting the sensor to the MicroLab Interface should run along the underside of the subject's finger and then run up over the hand where the finger joins the hand. Secure the sensor using paper first-aid tape or paper hair-setting tape (figure b). These kinds of tape are frequently available at your local drugstore. Scotch tape or other types of non-porous tape will cause heat to build up around the sensor and result in inaccurate measurement. Tape should also be used where the cable runs up over the hand. The light velcro bands supplied for attaching the EDA sensors may be used instead of tape for securing the temperature sensor to the finger.

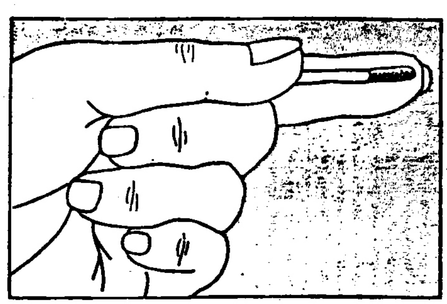


figure a

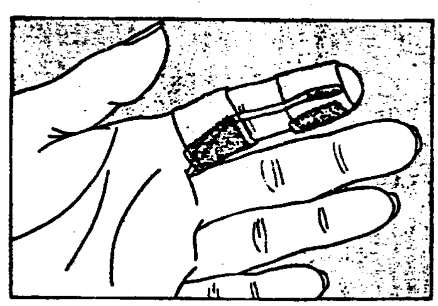


figure b

Check to see that the tip of the temperature sensor is securely attached and in contact with the skin surface. If it is not in good contact with the surface of the skin, you will be measuring changes in room temperature rather than blood flow.

Before attaching the temperature sensor, you can test to see if it is functioning by pressing the sensor between two fingers or by blowing on it to warm it up. If it is functioning properly, the line on the screen should increase. Release the sensor from between your fingers or fan the sensor with a hand to cool it off. The line on the screen should decrease, indicating a drop in temperature. Notice how the thermistor responds slowly to temperature changes.

2. Connect the plug end of the thermistor cable into the electrodermal activity/skin temperature input of the MicroLab Interface.

D. Heart Rate

1. Attach the sensor either to the subject's earlobe (figure a) or to the fleshy part of a finger (figure b). If it is attached to the earlobe, be sure that the light on the clip is on the backside of the earlobe. On the finger, make sure that both the light and sensor are covered.

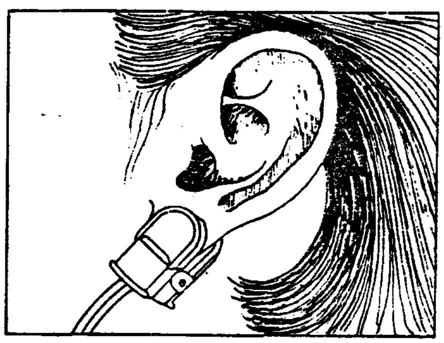


figure a

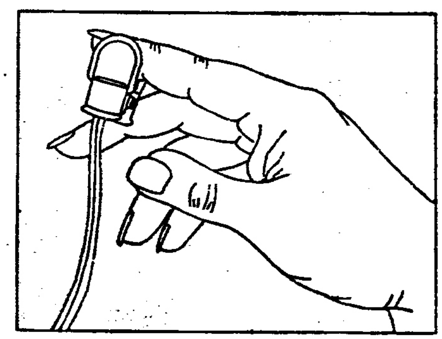


figure b

When recording heart rate, avoid areas of very bright light or flashing lights as these may cause heart rate to be recorded incorrectly. Different earlobe or fingertip areas may work better for different people. If heart rate does not seem to be recording accurately, move the sensor slightly to another area. If your earlobe or fingers are cold, massage them to improve circulation.

2. Connect the plug end of the heart-rate sensor into the heart-rate input on the MicroLab Interface.

VI. GETTING ACQUAINTED WITH THE SOFTWARE

Overview: The software has been designed to make the program as flexible as possible for a variety of uses without also making it unnecessarily complicated. There are many options that allow the user to tailor the program to his or her particular needs. Some may wish to use the program simply to monitor various physiological activities, others to engage in different types of experiments; for example, to see how their bodies react to different types of stress. For still others, the program may provide a tool to help learn how to relax and to alleviate the effects of stress. Part of the power of Biofeedback MicroLab comes from the many options that it provides. You will need to spend some time learning how to use the software to its best advantage. We recommend that--as you read the following section--you actually try out the different options in order to get a better feel for how the program operates.

Loading the Program into the Computer:

1. Apple II+, IIe

   Remove the program disk from its envelope and insert it into the disk drive. Close the door to the disk drive and turn on the computer. The disk drive will make a noise, and the program will begin loading. The red light will stay on as long as the program is loading.

   IMPORTANT:

   a. With an Apple IIe, the 80-column card must be installed in order for the program to function.

   b. The program will not function with any extended memory RAM card. If such a card is present, please remove it before turning on the computer.

2. Commodore 64

   Remove the program disk from its envelope and insert it into the disk drive. Close the door to the disk drive and turn on the drive and then the computer. Type LOAD"*",8 or LOAD"GO",8. Then press RETURN. When the computer prints READY on the screen, type RUN and then press RETURN. The disk drive will make a noise and the program will begin loading. This takes a couple of minutes.

   If you have a Commodore 128, the program will operate in the 64 mode. Follow the instructions in the computer manual.

Getting Started: After you load the program, the title screen will appear and then erase. You will next see the following choices:

NOTE: The calibration routine has been updated. See separate sheet included with this guide

Type of Feedback

1. Electromyogram
2. Electrodermal Activity
3. Heart Rate
4. Skin Temperature

At this point, you tell the computer which type of activity you wish to measure and record. You should have the correct sensor or electrodes connected to the MicroLab Interface (see Sections IV and V).

If you press 2 for Electrodermal Activity or 4 for Skin Temperature, the program will ask you if you want to calibrate the sensors. The calibration procedure enables the program to make these two measurements more accurately. Calibration simply requires removing the sensors from the MicroLab Interface and then reinserting them. If you are measuring skin temperature, the program will also give you the option of displaying temperature in degrees Celsius or degrees Fahrenheit.

Once you have chosen the type of feedback, you will see the Main Menu.

Main Menu

1. Start Monitoring
2. View Results
3. Modify Parameters
4. Access Data Files
5. Change Type of Feedback

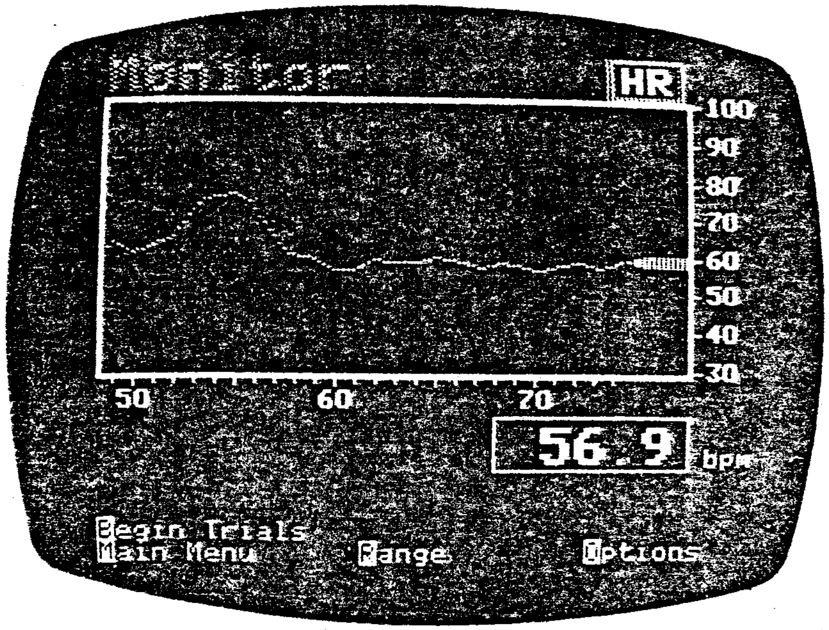
If at this point you wish to go back and change the type of feedback, simply press 5. The program has a CONTROL-X function which takes you out of the program to the Applesoft prompt. This terminates the program.

There are many available options that affect how biofeedback data are recorded and displayed on the screen. Some of these options are included under MODIFY PARAMETERS, and these options will be discussed later in this section. But let's begin by discussing option 1, START MONITORING.

1. <u>Start Monitoring</u>

This option is the heart of the program. By pressing 1 the computer begins to record and display data in the feedback mode that you earlier chose: electromyogram, electrodermal activity, heart rate, or skin temperature.

When you start monitoring you get the screen displayed on the following page. (The screens shown in this guide are from the Apple version of the program.)



The computer is now acting as a kind of scrolling strip chart or graph with a "pen" plotting data. Elapsed time is indicated in seconds at the bottom of the graph.

The word "monitor" simply means that data are being collected. These data are saved in the computer's memory and can later be recalled (see option 2: VIEW RESULTS) or even saved on the program disk (see option 3: ACCESS DATA FILES).

The monitor mode is the simplest way to see the data. The plot you see scrolling across the screen is an instantaneous display and record of your muscle tension, electrodermal activity, heart rate, or skin temperature. The display lets you see how your body is functioning and how it is reacting to different influences in its environment.

Options: There are several ways, however, in which you can alter the way the computer displays and saves the information. For instance, if while in the monitor mode you press O (Options), you will see several options appear on the screen. These options are available even if you don't press O. Pressing O simply provides a reminder of what the key-stroke commands are.

a. Event Marker: Pressing E (Event) leaves an event marker. This option is valuable because it allows you to record the exact moment that something unusual is happening. Event markers also allow you to establish boundaries that divide a session or experiment into distinct segments that can be viewed later (see option 2: VIEW RESULTS).

b. Goal: Pressing G turns a goal on or off while you are in the monitor mode. The goal gives you a target to aim for while practicing biofeedback. Usually the object is to try to lower muscle tension (EMG), electrodermal activity (EDA), or heart rate so that it is below the goal, or to raise skin temperature so that it is above the goal. By modifying our physiological activities in such ways, we are learning to relax by modifying how our bodies respond to stress.

Several important feedback features are activated when the goal is on. If you have chosen to have the sound on (see option 3: MODIFY PARAMETERS), with the goal off there is a steady tone that changes pitch as your heart rate, muscle tension, electrodermal activity, or skin temperature increases or decreases. With the goal on, in the Apple version of the program the nature of the sound feedback changes according to whether you are above or below the goal. In the Commodore version, soothing bell-like chimes occur if you are below the goal for EMG, EDA, or heart rate and above the goal for skin temperature. If you have an adapter and cable, you may also connect a cassette player to the MicroLab Interface. The cassette player will activate when you are appropriately either above or below the goal, so that music of your own choice may be used as a "reward." See Appendix G for more information about this optional feature.

If you press E (for Event Marker) when the goal is on in the monitor mode, you will notice that the graph stops scrolling for an instant, and the goal changes. The goal actually represents the mean or average of the readings taken during the period of time between the event markers. Every time you press E the goal changes according to your readings during the previous period of time.

Note that pressing E causes the axis on the right part of the graph to be rescaled. Although previous data on the screen are erased, they are not "lost." The computer retains the data in its memory and they can be recalled later (see option 2: VIEW RESULTS).

c. New: Pressing N restarts the plotting routine. Be careful not to use this option unless you really want it, because it causes all the data collected up to that point to be erased in the computer's memory.

d. Range: Pressing R while in the monitor mode allows you to see the various options available for adjusting the range or scale of the graph. These options exist even if you do not press R. Pressing R simply provides a reminder of the key-stroke commands.

The Range options allow you to adjust the vertical scale on the right of the scrolling graph. They are important features because they allow you to quickly adjust how the data are plotted and displayed on the screen. For instance, when you start off in the monitor mode you may find that the data are being plotted at the very top or bottom of the graph. You can center the data by simply pressing C. In fact, it usually makes sense to do this when you first start out in the monitor mode.

You may also wish to decrease the range. For example, you may find that the data shows very little up or down variation on the graph. Decreasing the range has the effect of magnifying variations in the data. You can do this by pressing Z (Zoom In), causing the graph to be rescaled. Pressing P (Pull Back) increases the range shown. Pulling back is a useful feature if you find the current range too small to accomodate the data.

Note: Once you enter the trial mode (see below), you cannot re-center the data, but you can continue to zoom in or pull back.

e. Begin Trials: Now let's look at one of the most important features of Biofeedback MicroLab. Breaking a biofeedback session into a series of trials provides a convenient means to adjust the challenge to your performance. The goal that you try to better in each trial is determined by how you did in the previous trial. In each trial, the goal is the mean or average of your performance in the prior trial. For example, if your average heart rate in Trial 1 was 70 beats per minute, 70 becomes the goal you try to better in Trial 2. The average for Trial 2 then becomes the goal for Trial 3, and so on. (The goal for Trial 1 is determined by the baseline, which is described below.)

Before beginning any trials, you should decide how many trials you wish and how long each trial should be. These options can be accessed from the Main Menu (see option 3: MODIFY PARAMETERS).

Once you press B (Begin Trials), the program begins to take baseline data. As we explained above, the average of your performance during the baseline measurement determines the goal for Trial 1. Baselines are important because they provide a benchmark indicating where you started. If you start out at a high level on the type of feedback under observation, it generally takes less control to move to a lower level. In fact, you may show decreased activity merely as a function of time and getting used to the situation. Comparisons between baselines from session to session provide some indication as to the effectiveness of the training.

2. View Results

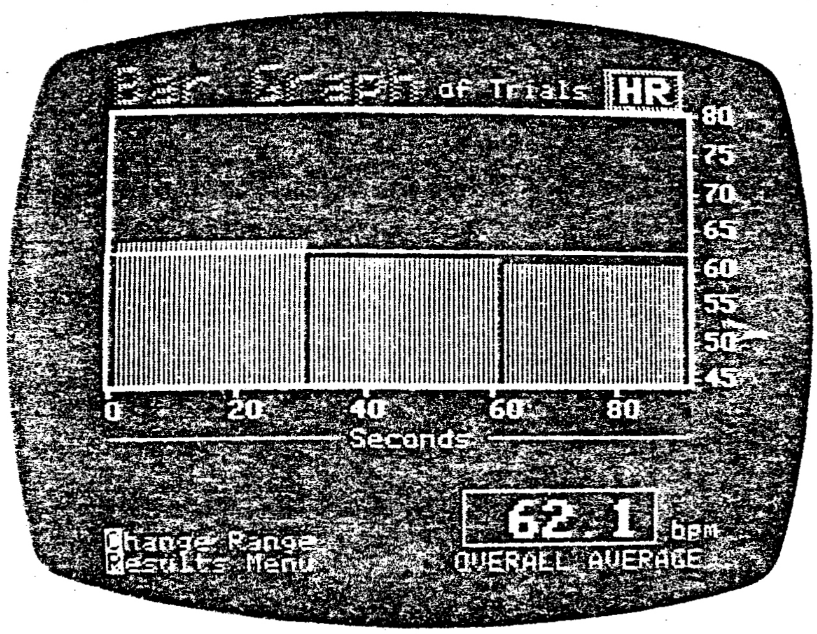
Once you have completed an experiment or series of trials, pressing the space bar will return you to the Main Menu. You can now review a history of what you just did by pressing 2 (VIEW RESULTS), which gives you the following submenu.

Results Menu

1. Bar Graph of Trials (or Events)
2. Table of Trials (or Events)
3. Plot of Data
4. Table of Data
5. Main Menu

Let us now look at the different ways you can examine the results.

a. Bar Graph of Trials: This option displays a bar graph showing the average for the data collected for the baseline and each trial. In the screen shown below, for example, the bar graph shows the means for the baseline, Trial 1, and Trial 2.



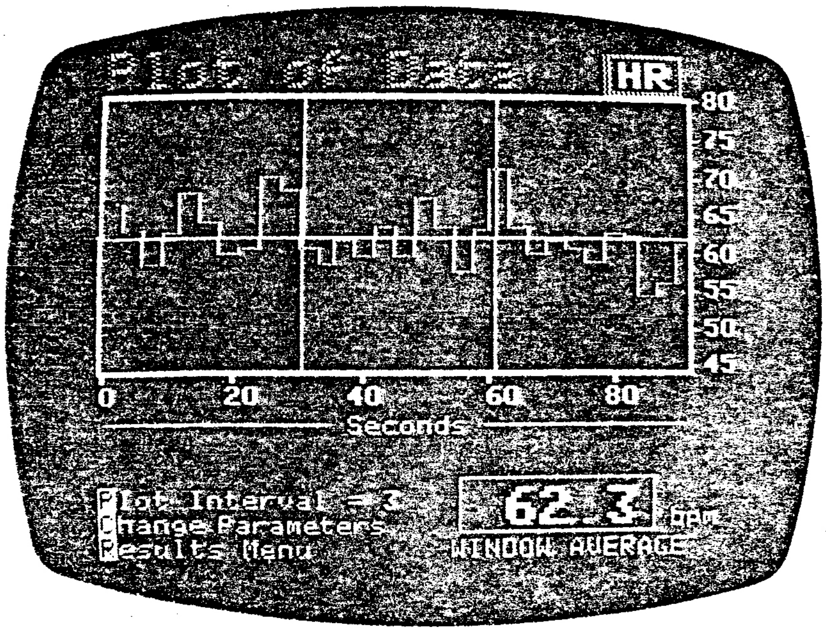
If you were not in the trial mode, the bar graph shows the average for each event. An event is simply a period of time separated by an event marker from other events.

The program permits you to adjust the range of the vertical axis of the bar graph.

Printing the Bar Graph: In the Apple version of the program, pressing Control-P allows you to print the screen if you have the appropriate graphics printer and support hardware. Simply follow the directions that appear on the screen. In the Commodore version, press F7 (Function Key 7) and follow the subsequent directions. The Commodore version works with the MPS 801 printer or with any printer with an interface that emulates the 801.

b. Table of Trials: This option gives you the same data as the bar graph but in tabular form. If you have a printer, you may print the data.

c. Plot of Data: This graph displays the data plotted against time. It shows the average data for intervals of time--called plot intervals--that you determine. In the sample below, the plot interval has been set at 3 seconds. You may change the plot interval by pressing P. The screen also displays the "window average" for all the data displayed.



You may also tailor other ways in which the data are shown by pressing C (Change Parameters). The Plot Parameters menu will then appear.

Plot Parameters

1. Plot Interval
2. Range
3. Plot Window
4. Show Data
5. Results Menu

From the Plot Parameters menu you may also change the plot interval by pressing 1. Pressing 2 allows you to change the range of the vertical axis of the graph. Pressing 3 (Plot Window) allows you to plot data for a specific portion of the biofeedback session. For example, if the session was 240 seconds long, you may wish to see only the data for the period from 45 seconds to 90 seconds. Pressing 4 (Show Data) returns you to the graph. Pressing 5 takes you to the Results Menu.

To print the graph, press Control-P if you are using the Apple version of the program, or the F7 (Function 7) key if you are using the Commodore version.

d. Table of Data: This option allows you to see in tabular form the same data shown in the plot. The Plot Parameters menu may be accessed from this table. The table can be printed.

3. Modify Parameters

The MODIFY PARAMETERS option on the Main Menu allows you to custom design certain parameters affecting how the screen appears while running an experiment or session. Pressing 3 on the Main Menu will result in the submenu shown below.

Parameters

1. Feedback Menu
2. Number of Trials
3. Duration of Trial
4. Smoothing Value
5. Main Menu

1. Feedback Menu: The program allows you to specify certain types of feedback during an experiment, giving you additional control over how the program functions. Pressing 1 gives you the following menu.

Feedback Menu

1. Sound is on (off)
2. Arrow is on (off)
3. Parameters Menu

Pressing 1 turns on or off a tone that occurs during a session. This tone varies according to your physiological activity. If you have the goal on, it may also act as a reward if you are below the goal for electromyogram, electrodermal activity, and heart rate and above the goal for skin temperature.

Note: While you are in the monitor or trial modes, you may also turn the sound on or off by pressing S.

Pressing 2 will result in a down arrow being displayed if you are above the goal for electromyogram, electrodermal activity, or heart rate. An up arrow will appear if you are below the goal for skin temperature.

The Commodore version of the program also lets you use phrases for feedback and allows you to customize these phrases.

2. Number of Trials: Allows you to specify the number of trials that will run if you press B (Begin Trials) while in the monitor mode.

3. Duration of Trial: Establishes the duration of each trial.

4. Smoothing Value: The smoothing value is a parameter that affects the visual display of the data. Increasing the smoothing value averages out that data over longer periods of time so that small variations don't appear in the monitor or trial modes. The smoothing value does not affect the Bar Graph or the Plot of Data accessed from the Results Menu.

   For the most part, you will probably not wish to change the smoothing value from what it is originally set at. The feature is most useful in displaying heart rate. Respiration affects heart rate, and if you do not wish to see the variations caused by simply breathing in and out, you will want to have the smoothing value set at about 10 seconds. On the other hand, you might well be interested in the effects of respiration on heart rate. In this case, you will want to set the smoothing value much lower, say two seconds.

5. Main Menu: Returns you to Main Menu.

4. Access Data Files

Biofeedback MicroLab allows you to save the results of an experiment so that it can be recalled later as either a graph or a table. This way you have a permanent record of whatever you do.

After running an experiment, you can press 4 on the Main Menu and then choose to SAVE A DATA FILE. You can save the file to the program disk or to a separate archive disk (see Appendix F). A file name may be a string of letters, symbols, and/or numbers, but it should start with a letter; for example, PHC-1/7/86.

The file operations include a catalog of what files are available on the program disk or archive disk.

At any future time that you wish to recall the data, simply choose the Access Data Files option and then choose to LOAD A DATA FILE. The computer will ask the name of the file you wish to load. You can also choose to delete unwanted files.

Once you have loaded a file, you can then examine its contents by choosing to VIEW RESULTS from the Main Menu.

Important: In order to save an experiment, you must save it immediately after running it. If you turn the computer off before saving the experiment, it will be erased. It will also be erased if you run a new experiment before saving the old one.

VII. PHYSIOLOGICAL REACTIVITY: STRESS AND YOUR BODY

In this section you will be introduced to the basic ideas on how our bodies respond to stress and why this response is necessary when there is danger or the threat of danger. Then there is a description of two experiments you can perform to illustrate the effects of stress on the body.

Background

Automatic vs. Voluntary Reactions

Our bodies function in truly remarkable ways. We can, for the most part, choose whether we want to perform various functions automatically or whether we wish to take detailed voluntary control of them. With some functions, such as walking or talking, we can easily choose whether to run on "automatic pilot" or whether to take pains to walk or talk in certain ways. However, other functions, such as respiration, digestion, circulation, etc., generally run on "automatic pilot" most of the time. Because so many of the internal functions of the body are usually carried out automatically, the part of the nervous system that controls these functions is known as the autonomic nervous system. It is composed of two parts that work together smoothly to manage all the "housekeeping" details that are necessary if the body is to function properly.

One part of the autonomic nervous system, the parasympathetic nervous system, tends to slow things down; the second, the sympathetic nervous system, tends to speed things up. When we are sleeping or relaxing, the parasympathetic system is dominant. When there is danger or the threat of danger, however, the sympathetic system becomes dominant.

The "Fight-or-Flight" Reaction to Danger or the Threat of Danger

The complex physiological reactions that take place when we see a situation as threatening or potentially threatening have been called the "fight-or-flight" reaction. In large part, this automatic reaction consists of increased heart rate, increased respiration, increased blood pressure, increased sweat-gland activity in the palms and soles, increased muscle tension, increased brain-wave frequency, and increased metabolism. The response consists mainly of the activity of the sympathetic nervous system and the endocrine glands (such as the adrenal glands, which secrete adrenaline, noradrenaline, and cortisol). The response makes it possible for the body to automatically mobilize its energy resources to fight or run, to quickly repair any damage that might be incurred, and to more readily reject infections. In confrontations with wild animals or in hand-to-hand combat, the fight-or-flight mechanism is absolutely necessary for survival; in confrontations with the boss, nasty neighbors, parents, teachers, or any charged social interaction, it is far less adaptive. The automatic response mechanism that can save our lives in some situations can hurt or even kill us in others.

Fight-or-Flight and Stress

When we undergo too many of these mobilizing reactions, or they are too extreme, or they are too prolonged, it becomes increasingly difficult for us to relax or to return to a state of lowered sympathetic-nervous-system and endocrine-gland activity. As a consequence, our bodies develop signs of overwork or strain, and we may develop one or more of what have come to be known as "stress-related diseases."

The stress-related diseases are responsible for an estimated 50% of all visits to physicians. The top four causes of death in the United States--accidents, heart attack, strokes, and suicide--are all stress-related. How we manage stress and how our bodies react to it have serious implications, it seems, not only for the quality of life but for life itself.

Stress in General

While stress can be a deadly killer and can make our lives miserable, it is not all bad. It can be a powerful motivator that pushes us to exert ourselves in the pursuit of excellence and to perform heroic deeds. Depending upon how we deal with stress, it can be an exciting friend or a deadly enemy. Managed effectively, stress can be stimulating and energizing. When stress is mismanaged, however, it can lead to tension headache, migraine headache, high blood pressure, stroke, heart attack, ulcers, constipation, diarrhea, hormonal disruptions, failures of the immune system, emotional problems, accidental death, suicide, or any one of a host of other stress-related problems. The objective is not to avoid stress, but to manage it so as to reap the benefits without suffering the consequences.

Controlling Physiological Responses to Stress

Our bodies can pay a heavy price when we automatically react, or overreact, too frequently or to too many situations. We need a chance to rest between fight-or-flight situations just as soldiers at the front are periodically sent to the rear for "rest and relaxation." Too often we forget to relax and refresh ourselves, and, after awhile, some of us forget how to relax at all.

When this happens, we either have to learn how to relax again or suffer the consequences of mismanaged stress. While there is no escaping stress, it is possible to modify the ways we physically respond to stress so as to minimize the impact on our health. Many of our physical responses to stress are very subtle and beyond our awareness. Also, many of them are, under most circumstances, almost automatic; and, for too many of us, they are beyond conscious control. Biofeedback provides a means of not only making us much more aware of our physical responses to stress, but of actually controlling what have been for years regarded as automatic reactions that were beyond our control.

Two Experiments on Physiological Reactions to External and Internal Stimulation

The two experiments detailed below illustrate how our bodies react to stimulation that comes from the outside and stimulation that comes from the inside. The first experiment shows how our bodies respond to a sudden loud noise. Everyone is familiar with the "startle response." When there is a loud, unexpected noise, we mobilize our bodies to pay attention to the noise. It might signal danger, and we must be poised to fight or run if it does. If the noise is repeated, we pay less and less attention to it as it becomes clearer that it doesn't indicate danger.

The second experiment demonstrates the effect of mental activity on our bodies. It takes energy to think, and the body must mobilize resources for thinking. While the brain weighs only 2% of total body weight, it consumes 20% of body energy. Thinking can be very hard work.

EXPERIMENT ONE: YOUR BODY'S REACTION TO NOISE

Goals of the Experiment

This experiment will introduce the idea of using biofeedback equipment to look at subtle physiological responses of which we are not generally aware. You will also see how the body responds to a brief, loud noise as an example of a mild stress reaction.

Background

In this and the next experiment, we will be measuring electrodermal activity (changes in the electrical properties of the skin). This measure of physiological reactivity was first discovered in the last part of the 1800's and has been called the galvanic skin response, or GSR, among other things. You may be familiar with the term GSR because of its popular use in "lie detection" or polygraph work. In recent years an attempt has been made to standardize the terminology associated with this response. In keeping with that attempt we will be using the term electrodermal activity, or EDA, to refer to the measurement of changes in electrodermal reactivity.

EDA will be discussed in more detail in Section IX. For the moment, however, we can think of the EDA as measuring minute changes in perspiration. As you are probably already aware, we tend to sweat when we get nervous or anxious. Increased sweat-gland activity is one indicator of stress. With the aid of the EDA instrumentation, you will be able to detect levels of sweat-gland activity far more sensitively than checking to see if your palms are sweaty.

The EDA instrumentation included in the Biofeedback MicroLab detects changes in sweat-gland activity by passing a very weak electrical current from one of the EDA sensors, through your skin, through the body fluids under the skin, and back out through your skin again to the other EDA sensor. This current comes from a small battery and is of such a low level that it is impossible to feel. When there is little sweat-gland activity, and consequently little perspiration, your skin is dry and the current is conducted very poorly through the skin. When sweat-gland activity increases, the salty water of perspiration increases the skin's electrical conductance, which is what the instrumentation measures. In general, increased stress or any change in arousal leads to increased sweat-gland activity which leads to increased perspiration, increased electrical conductance of the skin, and increasead EDA readings by the Biofeedback MicroLab.

Equipment and Supplies

- EDA sensors
- sensor cable with 3 snap connectors

Procedure

You may wish to review the earlier sections of this manual on setting up the hardware, attaching the sensors, and running the software.

If you are working with a group, one individual should be selected to serve as the subject and another individual should handle the biofeedback equipment and operate the computer.

Have the subject take a seat in a comfortable chair and attach the EDA sensors to the palmar surfaces of two fingers of the subject's non-dominant hand (the left hand if the subject is right-handed and vice versa).

Place the Biofeedback MicroLab software disk in the disk drive and load the program.

Select ELECTRODERMAL ACTIVITY from the "Type of Feedback" menu.

When the Main Menu appears on the screen, press 1 for START MONITORING. This will take you to the monitor mode and the EDA signal should appear on the monitor screen. As you become more familiar with the system, you may want to use some of the other options on the Main Menu to modify the biofeedback program.

When the EDA biofeedback display appears, notice how the line on the screen tends to wander up and down. The up and down movement of the line reflects the changing level of the subject's EDA activity. Up reflects increased arousal or stress. Down reflects decreased arousal or stress. The numbers on the screen indicate the level of EDA activity in micromhos. To check that everything is functioning appropriately, have the subject take a deep breath and hold it for a short time. A deep breath should produce an arousal-like upward movement of the EDA line on the screen.

Allow a few moments for the signal to stabilize somewhat. At this point, you can adjust the display by using the RANGE options (CENTER, ZOOM IN, PULL BACK). If the signal is not near the center of the screen, it is generally a good idea to press C for CENTER. If you do not remember the commands for these options, press R (RANGE) and the options will appear on the screen. Press R again to hide the RANGE options.

When you are ready to begin the formal experiment, have the subject sit back comfortably in his or her chair. Press E (Event Marker) to mark this moment as the start of the baseline period. The baseline is the reference point to which we will compare the subject's later responses. Everyone watching should remain quiet while the baseline for the subject is recorded.

Two to three minutes after starting the baseline recording, someone standing behind the subject should either clap his or her hands sharply or drop a heavy book on the floor. Press the E key to mark this event. You should see a dramatic upward deflection of the EDA line on the screen.

Wait for the EDA signal to return to its previous level. Repeat the loud noise several times at random intervals. Mark each event by pressing the E key.

Press M (Main Menu) to quit the recording session for this subject. From the Main Menu choose option 2: VIEW RESULTS. From the Results Menu select option 3: PLOT OF RESULTS. A graph of EDA activity will appear on the screen with event markers for every time you pressed the E key. The event markers will indicate when you started the formal experiment, the baseline period, and each of the loud noises.

If you have a printer available, you may wish to make a hard copy of your results.

If you wish to save the data from the session on disk, return to the Main Menu. Select ACCESS DATA FILES by pressing 3. When the FILE OPERATIONS menu appears, press 3 for SAVE A DATA FILE and follow the directions that appear on screen.

Repeat the experiment with several other subjects.

EXPERIMENT TWO: YOUR BODY'S REACTION TO MENTAL TASKS

Goals of the Experiment

This experiment will show that your body responds to internal as well as external stimulation.

Background

In Experiment One an unexpected loud noise was used as an example of an external stressor. The loud sound of a book hitting the floor or the sound of someone clapping sharply was a strong physical event that exerted pressure on the subject's eardrum. The pressure on the subject's eardrum was converted into a neural event that travelled along the nervous system to the brain. The subject did not have to think about this kind of stimulation for it to cause him or her to jump slightly and to cause an EDA response. Both reactions were automatic, reflexive responses to unexpected physical stimulation. We can think of this reaction as a "what was that?" reaction. Scientists call this an <u>orienting response</u>.

Our bodies also respond to internal stimulation. They respond in order for us to be able to think. They also respond to what we think and how we feel about what we think. As we indicated before, it takes energy to think, and the body must mobilize its resources to provide that energy. Just as important in this kind of experiment, however, is the threat that we may be made to look foolish in front of our peers. This threat can generate a lot of stress. When we are thinking hard or have strong feelings about what we are thinking, our level of EDA activity is generally higher than when we are relaxing quietly.

This experiment will demonstrate a relationship between mental events and physiological events. We will be using EDA again to illustrate this relationship.

Equipment and Supplies

- EDA sensors
- sensor cable with 3 snap connectors
- A mental task must be prepared for this experiment. Arithmetic problems, spelling, or any question and answer task will do. The harder the problems and the greater the possible embarrassment, the greater the degree of EDA response. A list of six to ten items should be sufficient for the one-minute testing period.

Procedure

If you are working in a group, select one individual to handle the biofeedback instrumentation and to operate the computer.

Have the subject take a seat in a comfortable chair and attach the EDA sensors to the palmar surfaces of two fingers of the subject's non-dominant hand (the left hand if the subject is right-handed and vice versa).

Place the Biofeedback MicroLab disk in the disk drive and load the program.

Select ELECTRODERMAL ACTIVITY from the "Type of Feedback" menu.

When the Main Menu appears on the screen, press 1 for START MONITORING. This will take you to the monitor mode and the EDA signal should appear on the monitor screen. As you become more familiar with the system, you may want to use some of the other options on the Main Menu to modify the biofeedback programs.

When the EDA biofeedback display appears, notice how the line on the screen tends to wander up and down. The up and down movement of the line reflects the changing level of the subject's EDA activity. Up reflects increased arousal or stress. Down reflects decreased arousal or stress. To check that everything is functioning appropriately, have the subject take a deep breath and hold it for a short time. A deep breath should produce an arousal-like upward movement of the EDA line on the screen.

Allow a few moments for the signal to stabilize somewhat. At this point, you can adjust the display by using RANGE options (CENTER, ZOOM IN, PULL BACK). If the signal is not near the center of the screen, it is generally a good idea to press C for CENTER. If you do not remember the commands for these options, press R (RANGE) and the options will appear on the screen.

When you are ready to begin the formal experiment, have the subject sit back comfortably. Press the E key to mark this as the start of the baseline period. The baseline is the reference point to which we will compare the subject's later responses. Everyone watching should remain quiet while the baseline for the subject is recorded.

Wait two or three minutes to establish a baseline. You may then commence the testing condition. Press the E key to mark the beginning of the test period. The test questions should be read aloud to the subject and the subject should answer out loud. Read questions and obtain answers for one minute. At the end of the test period, press the E key to mark the end of the test period.

Allow two or three minutes for a recovery period. Press M (Main Menu) to end the experiment. From the Main Menu choose Option 2: VIEW RESULTS. From the Results Menu choose Option 3: PLOT OF RESULTS. The event markers on the resulting graph will indicate the start of the formal experiment, the baseline period, the test period, and the recovery period.

If you have a printer available, you may wish to make a hard copy of your results.

If you wish to save the data from the session on disk, return to the Main Menu. Select ACCESS DATA FILES by pressing 3. When the FILE OPERATIONS menu appears, press 3 for SAVE A DATA FILE and follow the directions that appear on screen.

Repeat the experiment with several other subjects or by using other mental tasks. Does answering silently, or on paper, produce a larger or smaller response than answering out loud? Does the magnitude of the response get bigger with more difficult questions?

Discussion of Experiments One and Two

We have seen in these two experiments that our bodies react automatically and reflexively to stimulation that comes from the inside as well as stimulation that comes from the outside. Stress does not have to come from the outside to affect us. The demand imposed by just a few simple mental tasks results in almost as much EDA activity as is caused by a startling noise. For some of us the threat of being embarrassed in front of our peers results in an even bigger response. In fact, most of the stress that we experience in our everyday lives can be traced to how we think about, interpret, and feel about events around us rather than to direct, unpleasant physical stimulation. As a consequence, psychologists and other professionals who specialize in the study of stress have found that stress can be managed most effectively by learning to master our attitudes about something that causes stress as well as our automatic and reflexive physiological responses to it.

As you review the graphs from these two experiments, notice that it takes time to recover from the physiological effects of such stimulation. When we don't have time to recover from these effects, stress begins to pile up and create significant problems for us.

Remember that EDA is not the only measure of the body's response to stress and that the sweat gland is only one of the many physiological elements that are involved in our complex reactions to stress. Heart rate, blood flow, and muscle tension were also responding to the stimulation involved in these two experiments. Other sections of this manual explore these other measures of our reactions to stress and how to control them.

Note: Some people may find that the readings of their skin's electrical conductance are low--2 micromhos or less. This conductance can be increased by applying a small amount of electrolyte gel to each of the sensors. Use of a small amount of gel will also increase absolute accuracy. Be sure to clean the sensors after use.

VIII. THE RELATIONSHIP BETWEEN RELAXATION AND BIOFEEDBACK

Background

Biofeedback is an effective tool that can be used to help us gain control over our bodies and become self-regulating in terms of some of our physiological functions. Biofeedback facilitates our learning new motor skills. Learning to control our heart rate, skin temperature, muscle tension, sweat-gland activity, and a host of other bodily functions is essentially motor-skill learning. Just as we can learn to type, play the piano, tap dance, or hit a baseball, we can learn to regulate our bodies so that we are better able to modulate levels of physical activity.

The key to motor learning is feedback. The dancer's mirror, for instance, is a feedback device that facilitates learning the motor skills involved in dancing. The key to fine-tuning such motor skills is knowing how to relax specific muscles at specific times. The relaxed dancer is smooth and graceful; the tense dancer is awkward and clumsy. Similarly, biofeedback provides a mirror that reflects how relaxed we really are. With practice and good feedback, almost anyone can learn to relax at will and reduce the tensions of modern living.

Feedback From Our Own Bodies

We can generally tell when we are very tense or very relaxed just by the ways our bodies feel. Too often, though, we do not pay much attention to our bodies until the strain of unrelieved tension forces us to seek some sort of relief. Tension has a way of creeping up on us so that being tense becomes a habit, and we don't recognize how tense we really are until it is too late. Extreme tension is not the real problem. The real problem is the way the subtle low-level tensions to which we become accustomed pile up to the point where they become a health hazard. Becoming more aware of our own bodies, recognizing these low levels of tension, and relaxing before tension piles up are essential in the prevention of strain. Biofeedback helps develop this capacity; but, in the end, the feedback that comes from our own bodies is most important.

EXPERIMENT THREE: OBSERVING MUSCLE TENSION DURING REST AND ACTIVE RELAXATION

Goals of the Experiment

This experiment will introduce the idea of voluntary control over levels of muscle tension in the body and demonstrate the effect of exercise on muscle tension.

Background

The Electromyograph, or EMG, is the workhorse of biofeedback. It is the most commonly used type of biofeedback for a number of reasons. First of all, it is easier for most of us to gain control over the voluntary muscles of the skeletal musculature than over the "involuntary" muscles of the blood vessels or the heart. Secondly, EMG provides an easy introduction to using biofeedback to gain control over your body. Thirdly, it provides a tool for gaining immediate relief from such stress-related physical symptoms as tension headache, low back pain, and the painful jaw condition known as temporo mandibular joint pain (TMJ) that arises from clenching our jaws too tightly.

Muscles are necessary for movement. Two different sets of muscles are involved in almost all motor activity. These are called agonists (muscles that move a body part in the direction we want it to go) and antagonists (muscles that return the body part to where it started). Agonists and antagonists must work smoothly together if we are to function effectively. If antagonist muscles are too tense, agonist muscles have to work even harder to overcome this antagonistic tension. Isometric exercises in which muscles are tensed without any body movement is an example of balanced tension between agonists and antagonists. Such balanced tension is non-productive hard work that is useful only for building muscle strength and tone. Too much chronic muscle tension often leads to muscle spasm and pain.

Nerves tell muscles when to contract and create tension. When nerves are quiet, muscles quit contracting and are less tense. Nerves communicate with muscles through electrochemical impulses that are called electrical potentials. When nerves tell muscles to contract, there are more of these electrical potentials than when the nerves are quiet and the muscles are relaxed. The EMG amplifies these electrical potentials from the muscles and essentially adds them together (or integrates them). EMG puts out a signal that reflects the overall level of tension of a given muscle or set of muscles.

Too often we get into the habit of carrying too much tension in our muscles. We get so used to carrying this tension that we don't even know we are doing it. EMG biofeedback lets us know how much tension we are carrying in given muscles and provides a means of monitoring our efforts to reduce this tension through active relaxation.

Equipment and Supplies

- EMG sensors
- adhesive strips
- electrolyte gel
- isopropyl alcohol
- gauze pads

Procedure

You may wish to review the sections of this manual on setting up the hardware, attaching the sensors, and running the software.

If you are working with a group, one individual should be selected to serve as the subject, and another individual should be selected to handle the biofeedback equipment and to operate the computer.

Have the subject take a seat in a comfortable chair and make a fist with the right hand. Notice how the muscles bunch up on both the top and bottom of the forearm. Unless the top side of the forearm is too hairy, clean the top side of the forearm where the muscles bulge up with alcohol and a gauze pad. If the top side of the forearm is too hairy, clean the bottom side of the forearm. Place a small amount of electrolyte gel in each of the three holes of the adhesive sensor assembly. Attach the EMG sensors to the part of the forearm that you have selected and cleaned. See Section V of this guide for more information on how to attach the EMG sensors.

Place the Biofeedback MicroLab disk in the disk drive and turn the computer on.

Select ELECTROMYOGRAM (EMG) from the TYPE OF FEEDBACK menu by pressing 1.

When the Main Menu appears on the screen, press 1 for START MONITORING. This will take you to the monitor mode and the EMG signal should appear on the monitor screen. As you become more familiar with the system, you may want to use some of the other options on the Main Menu to modify the biofeedback programs.

When the EMG biofeedback display appears, notice how the line on the screen tends to wander up and down. The up and down movement of the line reflects the changing levels of the subject's EMG activity. Up reflects increased muscle tension. Down reflects decreased muscle tension. The numbers that appear on the screen indicate the level of muscle tension in microvolts. To check that everything is functioning appropriately, have the subject make a fist and hold it for a short time. Making a fist should produce an upward movement of the EMG line on the screen, and the microvolt level should show a marked increase.

Allow a few moments for the signal to stabilize somewhat. At this point, you will probably want to adjust the display by choosing one of the RANGE options (CENTER, ZOOM IN, PULL BACK). These options can be made visible by pressing R. If the signal is not near the center of the display, it is generally a good idea to press C for CENTER.

When you are ready to begin the formal experiment, have the subject sit back comfortably in his or her chair. Press E (Event Marker) to mark this moment as the start of the baseline period. The baseline is the reference point to which we will compare the subject's later responses. Everyone watching should remain quiet while the baseline for the subject is recorded.

After two minutes, instruct the subject to make a tight fist and hold it for one minute. Mark this event by pressing E. Notice the dramatic increase in the EMG level.

After one minute, instruct the subject to relax the fist. Mark the event by pressing E.

Make note of the time it takes the EMG to return to its previous level. Press E when it does.

Instruct the subject to consciously let the muscles in the forearm relax even more deeply. Mark the event by pressing E. Note how much lower the EMG level sinks with active relaxation following tensing.

Repeat this procedure several times marking each event by pressing the E key.

Press M (Main Menu) to quit the recording session for this subject. From the Main Menu, choose option 2: VIEW RESULTS. Select option 3: PLOT OF DATA. A graph of EMG activity will appear on the screen with event markers for every time you pressed the E key. The event markers will indicate when you started the formal experiment, the baseline period, and each of the contractions and relaxations of the forearm. If your computer has a printer, you may wish to print out a hard copy of the results to compare with the results of other subjects.

Repeat the experiment with several other subjects.

Discussion of Experiment Three

In Experiment Three we saw how the EMG lets us see the actual level of muscle tension in a given muscle or set of muscles. We also saw that tensing a muscle results in a lower level of resting activity than before the muscle was tensed. In general, a relaxed muscle should have a tension level of less than two microvolts and should be able to return to a resting level of tension within one minute after releasing a strong contraction.

Did any of the subjects show spiky little increases in EMG level while they were "relaxed?" Muscle spasms show up as spikes in the EMG and are indicative of fatigued, out-of-shape muscles. Repetition of Experiment Three will help eliminate them.

Were any of the subjects already so relaxed that they went below the level of the instrumentation? Obviously, this can happen, and when it does the subject should be congratulated for being in touch with his or her body and being able to self-regulate naturally with the feedback from his or her own body.

IX. EXPLORING BIOFEEDBACK

Background

In Experiments One, Two, and Three we used the Biofeedback MicroLab instrumentation to monitor various forms of physiological activity. In each of these situations, you were asked to simply observe the reactions of your body in response to a loud noise, while engaging in mental tasks, and while experimenting with a relaxation exercise. In the following experiments, you will be exploring how this information is utilized to create a biofeedback loop. In a biofeedback loop, physiological activity is detected, amplified, and displayed. As a part of this loop, you attend to the display, attempt to intentionally alter or direct the physiological activity being measured, and then observe the results of that attempt. This process of observing, acting, observing the result, and then modifying your actions based on the result observed is what biofeedback is all about.

A key concept in biofeedback is the idea of "passive" control. If you are attempting to lower the level of muscle tension in your forearm, you are unlikely to have much success if you attempt to actively "force" your muscles to relax. Rather, you gain control by passively allowing your muscles to "let go" of tension.

Developing this kind of control is not a skill you can rush. In any biofeedback task, you need to give yourself time to learn how to "listen" carefully to your body. When you notice your EMG suddenly rising, try not to focus on the idea of having to bring it right back down. Instead, try to observe what your body feels like at that moment in time. You may notice a slight pulling sensation in the muscle or become aware that your mind is occupied with thoughts about what you have to do in the next hour rather than with thoughts of relaxing. As you become aware of such events, it becomes easier to ease back and to begin to let go of them.

If at anytime you find yourself becoming over anxious while working with a biofeedback task, take a break. Disconnect the sensors, take a few deep breaths, and walk away. Remember, you are in control at all times.

The procedure section for Experiment Four will cover, in detail, the steps for using the Biofeedback MicroLab as a biofeedback instrument. This section will also introduce more of the concepts and terminology used in biofeedback work. You may wish to refer back to this section if you find the abbreviated procedure sections in Experiments Five, Six, and Seven too brief.

EXPERIMENT FOUR: EXPLORING MUSCLE-TENSION BIOFEEDBACK

Goal of the Experiment

To introduce concepts and issues involving muscle-tension (electromyographic or EMG) biofeedback.

Background

As we noted in Experiment Three, EMG is the workhorse of biofeedback. (You may wish to refer to the background material for Experiment Three.) The more voluntary skeletal musculature is easier to control than the "involuntary" muscles associated with the autonomic nervous system. For this reason, much of biofeedback training starts with a few sessions of EMG training no matter what type of feedback might be used later on. Starting with EMG makes it much easier for the individual to grasp the basic ideas involved with biofeedback and to achieve some measure of success before proceeding with more difficult types of feedback.

In doing EMG biofeedback, it is good practice to begin with muscles that are fairly easy to control. When you find that you can maintain a low level of muscle tension at one muscle site, you are ready to move on to a more difficult muscle. In doing biofeedback for general relaxation training, the muscles of the forearm are usually a good starting point. For example, we used the forearm flexor muscles in Experiment Three. If your EMG readings tended to be around two microvolts or higher at the end of Experiment Three, you may wish to continue with the forearm flexor muscles in this experiment. If your readings were generally less than two microvolts in Experiment Three, you may wish to move on to the muscles of the face using a frontal placement (see Section V). Initially, the facial muscles are generally more difficult than the muscles of the forearm to work with.

How long you choose to work with EMG will depend on a number of factors. If you are using the Biofeedback MicroLab as part of a group, each individual who takes part should be given a minimum of five to ten minutes of biofeedback time. In clinical work, biofeedback sessions typically run 20 to 30 minutes. Most people begin to tire after 30 minutes, and continuing longer than 30 minutes for single sessions is generally not advisable. Trying to learn a new skill takes a lot of mental effort, even if the skill is learning to relax more effectively.

Equipment and Supplies

- EMG sensors
- adhesive attachment strips for EMG sensors
- electrolyte gel
- isopropyl (rubbing) alcohol (not supplied)
- gauze pads (not supplied)
- tape for securing sensor cable (not supplied)

Procedure

If you have a cassette player and the necessary adapters, you may wish to use music as a reward during the biofeedback learning trials. Refer to Appendix G.

Following the directions on attaching sensors (Section V of this guide), attach the EMG sensors to the site with which you have decided to work--either forearm flexor or frontal placement. Plug the EMG probe into the EMG input on the MicroLab Interface. Place the Biofeedback MicroLab software disk into the disk drive and load the program.

When the TYPE OF FEEDBACK menu appears on the screen, select ELECTROMYOGRAM (EMG) by pressing the number 1 on the keyboard.

You should now be at the Main Menu. Press 3 (MODIFY PARAMETERS). Choose the number of trials you wish to perform and the duration of each trial. From the PARAMETERS menu you should also decide what types of feedback you wish to have during the biofeedback sessions. Press 1 for FEEDBACK MENU and then decide whether or not you wish to have sound and what other forms of feedback you wish. Note: If you are using a cassette player, the sound option should be "off."

Return to the Main Menu and press 1 to START MONITORING. This should take you to the monitor mode and the EMG signal should appear on the screen.

Sit back in your chair and find a comfortable position with your hands resting in your lap, palms up. Allow a few moments for the signal to stabilize. At this point, you or an individual assisting you can adjust the display by using the RANGE options (CENTER, ZOOM IN, PULL BACK). If the signal is not near the center of the screen, it is generally a good idea to press C for CENTER. If you do not remember the commands for these options, press R (RANGE) and the options will appear on the screen. Press R again to hide the RANGE options.

To begin the biofeedback session, press B for BEGIN TRIALS. The initial trial is called the baseline and is used as a reference point for the training trials that follow. At the end of the baseline, the mean (average) of the data collected becomes the goal for Trial 1. This procedure will be repeated at the end of each trial, with the average value of that trial becoming the goal for the next trial. Sit back and relax comfortably during the baseline.

Beginning with Trial 1, the object for each trial will be to allow the EMG signal to drop below the goal. In other words, you will be trying to lower your level of muscle tension below the mean level of the baseline or previous trial. You will notice that the computer will display your EMG signal in one color when your signal is above the goal and in another color when your signal is below the goal. Depending on whether you have chosen sound as an option, a special tone will occur when you are below the goal. If you have chosen it as an option, a down arrow will appear if you are above the goal. In the Commodore version of the program, phrases of your own choosing can also appear; and they will vary according to whether you are above or below the goal. When the goal line is used in this manner in biofeedback work, it is referred to as a threshold.

If you have a cassette player attached to the MicroLab Interface, turn the player on now. When your EMG signal is above the goal, the music will be turned off. It will be turned on again as a reward when your EMG signal drops below the goal.

As you work with the biofeedback trials that follow, keep in mind the comments made in the introduction to this section. In initial biofeedback work, it is not particularly important whether your signal increases or decreases. What is important is that you begin to become more aware of how your body feels and what your mental state is when the signal is high versus when it is lower. Increased awareness of your body is the first step toward control. As this increased awareness comes, you can begin to use it in a more directed fashion to obtain a specific goal, such as lowering your EMG level.

Most people find that they tend to tense up slightly during their first few trials. If your EMG signal has gone up, ease back and don't try to force your body to relax. Give yourself time.

You may need to adjust the display screen using the RANGE options. If the EMG signal tends to go outside the bounds of the display screen, press P to PULL BACK and widen the range. If the signals show very little variation, press Z to ZOOM IN and magnify the display range. If you continue pressing P or Z, the display range will increase or decrease incrementally with each keypress. If you need to be reminded of these commands, simply press R (RANGE)and the RANGE commands will appear on the screen.

At the end of the trials the computer will display a prompt asking you to press the space bar to continue. Pressing the space bar will return you to the Main Menu. Press number 2 for VIEW RESULTS. You should now be at the RESULTS MENU. Pressing number 1 will take you to a bar graph showing the mean EMG value for each trial. Pressing number 2 will give you the trial means in tabular form. Pressing 3 will let you see the data plotted against time. Pressing 4 will let you see the same data in tabular form. (For more information on manipulating the display of the data, review the information on the RESULTS MENU in Section VI of this guide.) The most direct summary of your session will be obtained by pressing 1 for BAR GRAPH OF TRIALS. Take a look at the results of your biofeedback session. How did you do?

If you have a printer available, you may wish to print the results of your session.

If you wish to save the data from your session on disk, return to the Main Menu. Select the ACCESS DATA FILES option by pressing 3. When the FILE OPERATIONS menu appears, press 3 for SAVE A DATA FILE and follow the directions that appear on the screen.

If you are working in a group and another individual wishes to explore EMG biofeedback, return to the Main Menu and repeat the procedure above.

If you are finished with the <u>Biofeedback MicroLab</u> for the day, remember to clean the EMG sensors (see Appendix D: Care of Sensors).

Discussion of Experiment Four

As we mentioned before, the EMG is the workhorse of biofeedback. It is the easiest of the different types of feedback to master and is often used to introduce biofeedback techniques and strategies for self-regulation of bodily processes.

In many instances, control of specific muscles is the primary goal of biofeedback with clinical instrumentation. Where the symptom is tension headache, biofeedback from the frontalis (forehead), masseter (jaw), and ortrapezius (upper back) muscles can provide relief depending upon the nature and pattern of pain experienced. Low back pain is often associated with spasms in the paraspinal (parallel to the spine) muscles, and EMG biofeedback is often a preferred treatment for these muscle spasms. Temporo-mandibular joint pain is very often the consequence of high levels of muscle tension in the masseters or jaw muscles. Again, EMG biofeedback is a preferred method of treatment.

The goal in clinical biofeedback is to reduce the level of muscle tension and to eliminate muscle spasms, if present, in the muscle that is causing the problem. The criteria for a successful outcome in EMG biofeedback will vary somewhat depending on the instrumentation used and the muscle involved. However, the criteria that have generally proven most useful for the Biofeedback MicroLab in determining satisfactory learning with EMG biofeedback from most muscles include a smooth return to below a one-microvolt level in less than 30 seconds after maximal muscle contraction.

EXPERIMENT FIVE: EXPLORING HEART-RATE BIOFEEDBACK

Goal of Experiment

To introduce concepts and issues involving heart-rate biofeedback

Background

The circulation of blood is a primary necessity for life. The blood stream carries oxygen and nutrients to the cells of the body, carries waste products away, maintains the body's fluid balance, carries hormones to target organs, serves as a medium for the immune system and distributes heat throughout the body according to need. The cardiovascular system, consisting of the heart and the blood vessels, is responsible for maintaining adequate circulation according to the varying demands that are placed upon the body. It is a closed hydraulic system through which blood is pumped under pressure (blood pressure). The pump, of course, is the heart.

The cardiovascular system is regulated by a complex system of reflexes that control the pressure in the system, how much blood is pumped with each stroke of the heart (stroke volume), and how rapidly the heart beats. The performance of the heart is measured by cardiac output which depends on both stroke volume and heart rate. At a heart rate of 72 beats per minute and a stroke volume of 70 milliliters of blood, cardiac output is about five liters of blood per minute. As demand increases, both heart rate and stroke volume increase to meet the cells' need for oxygen. At a moderate level of demand, cardiac output is about three times the "resting" output. At maximum levels of demand, the heart pumps about 20 liters of blood per minute.

Because the heart is only a certain size, and can hold only a certain amount of blood at any given time, stroke volume reaches a plateau much sooner than heart rate. The heart must beat faster in order for it to go beyond a certain level of cardiac output. There is a complex system of reflexes that controls heart rate to prevent the heart from getting out of control and from overworking itself. When pressure gets too high in the arteries, this system slows the heart down and essentially "fine tunes" heart rate to real or anticipated demands.

The heart rate of a relaxed individual is somewhere between 55 and 65 beats per minute. An out-of-shape, tense person has a heart rate of somewhere between 75 to 85 beats per minute or higher. The difference between being relaxed and aerobically fit, and being out-of-shape could mean as much as 28,000 extra heartbeats per day or over 10,000,000 extra beats per year. By exercising to become aerobically fit, learning to relax, and gaining control of heart rate we can make things easier on our hearts, live longer, and enhance the quality of life.

The complex system that controls heart rate involves three major factors. The first of these is the myogenic rate or the rate at which the heart beats without the influence of the nervous system. The second is the influence of the sympathetic nervous system which serves to speed the heart up in response to immediate or anticipated physical needs. And the third is the influence of the parasympathetic nervous system which slows the heart down. Most of the time, heart rate is determined automatically by these three interacting factors.

To an important degree, heart rate is dependent on aerobic fitness. However, heart rate is also highly dependent upon our level of physical tension and our psychological state. Tense, anxious individuals will have higher rates--no matter how aerobically-fit they are--than if they were relaxed and at ease.

Voluntary control of heart rate has been a fact of life in many Eastern cultures for centuries. Biofeedback is now making it possible for heart-rate control to become a fact of life in Western culture. Given appropriate feedback, most of us can develop our own techniques for increasing or decreasing heart rate. Once we gain control with feedback devices, we can become attuned to our own bodies and control our heart rates without feedback devices.

In clinical settings, heart-rate biofeedback has been helpful in treating tachycardias (heart beating too fast), bradycardias (heart beating too slow), and arhythmias (irregular heart rates caused by extra or skipped heart beats). Biofeedback has also been helpful in training for sports such as target shooting where it is important to minimize the effect of a heart beat on performance.

The heart-rate sensor in Biofeedback MicroLab is a photoelectric plethysmograph (PPG) that attaches to the user's earlobe or finger. The probe includes a light and light sensor and measures heart rate by detecting variations in the amount of light transmitted through tissues when blood surges through the earlobe's or finger's capillaries.

Equipment and Supplies

- heart rate sensor

Procedure

If you have a cassette player and the necessary adapters, you may wish to use music as a reward during the biofeedback learning trials. Refer to Appendix G.

Attach the heart-rate sensor to either an earlobe or finger following the directions for attaching sensors (Section V). Plug the heart-rate sensor into the heart-rate input on the MicroLab Interface. Place the Biofeedback MicroLab software disk into the disk drive and load the program.

When the TYPE OF FEEDBACK menu appears on the screen, select HEART RATE (HR) by pressing 3 on the keyboard.

You should now be at the Main Menu. Press 3 to MODIFY PARAMETERS. From the PARAMETERS menu, choose the number of trials you wish to perform and the duration of each trial. You should also decide what types of feedback you wish to have during the biofeedback sessions. Press 1 for FEEDBACK MENU and then decide whether or not you wish to have sound and/or some of the other feedback options. Note: If you are using a cassette player, the sound option should be "off."

Return to the Main Menu and press 1 to START MONITORING. This should take you to the monitor mode and the heart-rate display should appear on the screen.

Sit back in your chair and find a comfortable position with your hands resting in your lap. Allow a few moments for the signal to stabilize. At this point, you or an individual assisting you can adjust the display by using the RANGE options (CENTER, ZOOM IN, PULL BACK). If the signal is not near the center of the screen, it is generally a good idea to press C for CENTER.

To begin the biofeedback session, press B for BEGIN TRIALS. Sit back and relax comfortably during the baseline. Refer to the instructions for Experiment Four if you need additional help at this point.

As you recall from Experiment Four, at the end of each trial the mean value for that trial is calculated and it becomes the goal for the next trial. The object for each trial will be to allow your heart rate to drop below the goal.

As you work with the biofeedback trials that follow, keep in mind the comments made in the introduction to Exploring Biofeedback. In initial biofeedback work, it is not particularly important whether your signal increases or decreases. What is important is that you begin to become more aware of how your body feels and what your mental state is when the signal is high versus when it is lower. Increased awareness of your body is the first step toward control. As this increased awareness comes, you can begin to use it in a more directed fashion to obtain a specific goal, such as lowering your heart rate.

During the session, you may need to adjust the display screen using the RANGE options.

When the trials have ended, the computer will then display a prompt asking you to press the space bar to continue. Pressing the space bar will return you to the Main Menu. Now press 2 for VIEW RESULTS.

You should now be at the RESULTS MENU. Press number for the BAR GRAPH OF TRIALS option and take a look at the results of your biofeedback session. How did you do?

If you have a printer, you may wish to print a copy of the results.

If you wish to save the data from your session on disk, return to the Main Menu. Select the ACCESS DATA FILES option by pressing 3. When the FILE OPERATIONS menu appears, press 3 for SAVE A DATA FILE and follow the directions that appear on the screen.

If you are working in a group and another individual wishes to explore heart-rate biofeedback, return to the Main Menu and repeat the procedure above.

If you are finished with the <u>Biofeedback MicroLab</u> for the day, remember to put all the supplies away.

<u>Discussion of Experiment Five</u>

Heart-rate biofeedback provides a means of developing at least some level of voluntary control over the cardiovascular system. As biofeedback progresses, many individuals become aware of how fast and how hard their hearts are beating at a given point in time and are able to bring the rate and force of the heart under control. Although there are no systematic data available, it seems almost a given that reducing unnecessary workloads on the heart should increase and prolong cardiac efficiency. There is little question, though, that reduction in the rate and force of the heart's action can reduce blood pressure and the threat of stroke.

Through biofeedback, many individuals become aware not only of their cardiovascular state but also of the environmental influences that trigger increased heart rate. This second level of awareness makes it possible for these individuals to modify their reactions to these influences so that stress has less of an effect on their cardiovascular systems.

One of the beneficial effects of heart-rate biofeedback is that it helps to uncouple the cardiovascular system from the effects of respiratory activity. As you were going through the biofeedback program, did you notice an effect of breathing on heart rate? Your heart rate may have increased when you breathed in and decreased when you breathed out. If this happened, you are probably a "chest breather." "Chest breathers" tend to breathe with their rib cages rather than with their diaphragms and thereby create pressure on the heart. The heart varies in rate depending upon the pressures exerted by the rib cage. This can become problematic when we breathe deeply or rapidly because the heart responds to direct pressure rather than to circulatory needs.

One way to differentiate between breathing with your diaphragm and breathing with your rib cage is to lie on the floor, placing one hand so that the little finger is on your navel and the thumb is on your breastbone. Try to breathe so that only the little finger moves up and down (breathing with your diaphragm) and then try to breathe so that only the thumb moves (breathing with your rib cage). Practice diaphragmatic breathing.

EXPERIMENT SIX: EXPLORING SKIN-TEMPERATURE BIOFEEDBACK

Goal of Experiment

To introduce concepts and issues involving skin-temperature biofeedback

Background

Following EMG, temperature training is the most frequently used form of biofeedback. With clinical biofeedback instrumentation, temperature training may be applied as a specific intervention in the treatment of cardiovascular disorders. Examples include essential hypertension, migraine headaches, and Raynaud's syndrome, a condition characterized by painfully cold hands and feet. Temperature training is also frequently utilized as a measure of general relaxation.

Skin temperature is used in biofeedback as an indirect measure of blood flow. Blood is warmed in the core of the body and then distributes heat to the skin as it circulates. As blood flow is increased in a region of the body, say your hands, the heat from the increased blood flow will tend to lead to an increase in temperature in that region. As blood flow decreases, the skin temperature in that region will tend to decrease. Thus, increases and decreases in skin temperature tend to reflect changes in circulation.

Control of vascular activity is primarily mediated by the sympathetic branch of the autonomic nervous system. Our blood vessels are surrounded by smooth muscle fibers. Decreased activity in the sympathetic nervous system causes these fibers to relax, increasing the diameter of our blood vessels, and increasing the flow of blood to a given area of the body. In turn, increased activity in the sympathetic nervous system causes these fibers to contract, reducing the diameter of our blood vessels, and reducing the flow of blood to a given area of our body.

Decreased blood flow may be triggered as a response to cold. Blood is redirected away from the surface of the skin to conserve heat. In the aroused state of the fight-or-flight response, blood flow is directed from the surface of the skin and from the gut and bowel and to the muscles and the brain so that we are prepared to respond to the situation both with our mind and our muscles. While decreased blood flow to the skin is only one aspect of the total physiological reaction pattern that occurs with activation of the general sympathetic nervous system, skin temperature is sometimes used as a general indicator of sympathetic nervous system activity.

Equipment and Supplies

- temperature sensor
- paper tape (not provided)

Procedure

If you have a cassette player and the necessary adaptors, you may wish to use music as a reward during the biofeedback learning trials. Refer to Appendix G.

Attach the temperature sensor to the underside of the middle finger of either hand following the directions in Section V of this guide. Plug the temperature probe into the EDA/TEMP input on the MicroLab Interface. Place the Biofeedback MicroLab software disk into the disk drive and load the program.

When the TYPE OF FEEDBACK menu appears on the screen, select SKIN TEMPERATURE (ST) by pressing the number 4.

You will be asked if you wish to calibrate the temperature circuit. If you are using the Biofeedback MicroLab for the first time today, it would be a good idea to select the calibration option by pressing the Y key on the keyboard and to follow the calibration instructions that appear on the screen. If you have already calibrated the temperature circuit, press the N key.

You should now be at the Main Menu. Press 4 to MODIFY PARAMETERS. Choose the number of trials you wish to perform and the duration of each trial. You should also decide what types of feedback you wish to have during the biofeedback sessions. Press 1 for FEEDBACK MENU and then decide whether or not you wish to have sound and/or some of the other feedback options. Note: If you are using a cassette player, the sound option should be "off."

Return to the Main Menu and press 1 to START MONITORING. This should take you to the monitor mode and the temperature signal should appear on the screen.

Sit back in your chair and find a comfortable position with your hands resting in your lap, palms up. Allow a few moments for the signal to stabilize. At this point, you or an individual assisting you can adjust the display by using the RANGE options. If the signal is not near the center of the screen, it is generally a good idea to press C for CENTER.

To begin the biofeedback session, press B for BEGIN TRIALS. Sit back and relax comfortably during the baseline. Refer to the instructions for Experiment Four if you need additional help at this point.

As you recall from Experiment Four, at the end of each trial the mean value for that trial is calculated, and it becomes the goal or threshold value for the next trial.

Note that the direction of the goal for temperature training differs from that for EMG, Heart Rate, and EDA. In temperature training, the goal is to increase your skin temperature. In other words, you will be aiming to have the temperature signal go up on the screen as opposed to down. Note also that skin temperature is the slowest changing of all the physiological measures available with the Biofeedback MicroLab.

As you work with the biofeedback trials that follow, keep in mind the comments made in the introduction to this section. In initial biofeedback work, it is not particularly important whether your signal increases or decreases. What is important is that you begin to become more aware of how your body feels and what your mental state is when the signal is high versus when it is lower. Increased awareness of your body is the first step toward control. As this increased awareness comes, you can begin to use it in a more directed fashion to obtain a specific goal, such as raising your temperature level.

You may adjust the display screen using the RANGE options. If the signal shows very little variation, press Z to ZOOM IN and magnify the display range.

When the trials are over, the computer will then display a prompt asking you to press the space bar to continue. Pressing the space bar will return you to the Main Menu.

Press number 2 for VIEW RESULTS. You should now be at the RESULTS menu. Press number 1 for the BAR GRAPH OF TRIALS option and take a look at the results of your biofeedback session. How did you do?

If you have a printer available, you may wish to make a copy of your results.

If you wish to save the data from your session on disk, return to the Main Menu. Select the ACCESS DATA FILES option by pressing 3. When the FILE OPERATIONS menu appears, press 3 for SAVE A DATA FILE and follow the directions that appear on the screen.

If you are working in a group and another individual wishes to explore temperature biofeedback, return to the Main Menu and repeat the procedure above.

If you are finished with the Biofeedback MicroLab for the day, remember to put all the supplies away.

Discussion of Experiment Six

As we mentioned in the procedure section, temperature biofeedback is generally more difficult to master than EMG biofeedback. Why do you suppose that is? One factor to consider is the nature of the response we are trying to train. If you think about it, you had a great deal of experience with consciously controlling your muscle activity before you ever saw an EMG biofeedback device. However, how much time had you spent trying to consciously control the smooth muscles surrounding your blood vessels before you tried temperature biofeedback? Developing conscious control of our cardiovascular activitiy is a new and more subtle skill than controlling skeletal muscle activity.

Temperature training is also difficult due to the nature of the measure. It takes time for changes in blood flow to actually influence the temperature at the skin surface, and thermistors take a fairly long time to adjust to changes in temperature. One of the basic principles of biofeedback training is to return accurate information about physiological changes to the biofeedback subject as rapidly as possible. The situation is further complicated by the fact that the time lag between a change in vascular activity and the appearance of a temperature change at the surface of the skin can vary greatly depending on a number of complex physiological factors. These considerations are why we refer to skin temperature as an indirect measure of vascular activity.

Clinical-grade biofeedback instrumentation has been developed that measures blood-flow changes more accurately than thermistors. However, thermistors are much less expensive, and temperature measurement still has a major role to play in biofeedback.

EXPERIMENT SEVEN: EXPLORING ELECTRODERMAL BIOFEEDBACK

Goal of Experiment

To introduce concepts and issues relating to electrodermal biofeedback

Background

EDA was introduced in Experiments One and Two (Section VII). As you recall, changes in the EDA signal largely reflect activity of the body's sweat glands. EDA is generally used in one of two ways in biofeedback work. The first is as a direct treatment for individuals who have difficulty with excessively sweaty palms. Some individuals have such overactive sweat glands that sweat literally drips off their fingertips. This condition is known as hyperhydrosis. EDA biofeedback training can be used to help these individuals learn to decrease the level of sweating from their palms.

As you might guess, hyperhydrosis is a fairly rare condition. EDA biofeedback is more frequently used as an aid to help people learn how to maintain a lowered state of arousal of the sympathetic nervous system. Most people find that their EDA signal is elevated when their mind is overactive or if they are feeling anxious. They find that they have to clear their minds or think calm thoughts to lower the EDA signal. The changing EDA signal thus serves as an external indicator of how well they are succeeding at this task. As they gradually become more successful at lowering their EDA level with a biofeedback instrument, they generally become more confident in their ability to remain calm or to relax in the face of anxiety-arousing situations in their everyday lives.

As we observed in Experiments One and Two, the EDA signal is reactive to even the slightest startle stimulus from the outside world. It is also reactive to passing thoughts about how well we are performing a given task, such as doing arithmetic problems. It may even be reactive to our being concerned about how we are doing at lowering our EDA signal during a biofeedback session.

Equipment and Supplies

- EDA sensors

Procedure

If you have a cassette player and the necessary adaptors, you may wish to use music as a reward during the biofeedback learning trials. Refer to Appendix G.

Attach the EDA sensors to the middle fingers of either hand. Plug the EDA probe into the EDA/TEMP input of the MicroLab Interface. Place the Biofeedback MicroLab software disk into the disk drive and load the program.

When the TYPE OF FEEDBACK menu appears on the screen, select ELECTRODERMAL ACTIVITY (EDA) by pressing 2.

You will be asked if you wish to calibrate the EDA circuit. If you are using the Biofeedback MicroLab for the first time today, it would be a good idea to select the calibration option by pressing the Y key on the keyboard and to follow the calibration instructions that appear on the screen. If you have already calibrated the EDA circuit, press the N key.

You should now be at the Main Menu. Press 4 to MODIFY PARAMETERS. Choose the number of trials you wish to perform and the duration of each trial. You should also decide what types of feedback you wish to have during the biofeedback sessions. Press 1 for FEEDBACK MENU and then decide whether or not you wish to have sound and/or some of the other feedback options. Note: If you are using a cassette player, the sound option should be "off."

Return to the Main Menu and press 1 to START MONITORING. This should take you to the monitor mode, and the EDA signal should appear on the screen.

Sit back in your chair and find a comfortable positon with your hands resting in your lap, palms up. Allow a f moments for the signal to stabilize. At this point or an individual assisting you can adjust the display by using the RANGE options. If the signal is not near the center of the screen, it is generally a good idea to press C for CENTER.

To begin the biofeedback session, press B for BEGIN TRIALS. Sit back and relax comfortably during the baseline. Refer to the instructions for Experiment Four if you need additional help at this point.

As you recall from Experiment Four, at the end of each trial the mean value for that trial is calculated, and it becomes the threshold value for the next trial. The object for each trial will be to allow your EDA signal to drop below the goal or threshold. In other words, you will be trying to lower your level of electrodermal activity below the mean level of the previous trial.

As you work with the biofeedback trials that follow, keep in mind the comments made in the introduction to this section. In initial biofeedback work, it is not particularly important whether your signal increases or decreases. What is important is that you begin to become more aware of how your body feels and what your mental state is when the signal is high versus when it is lower. Increased awareness of your body is the first step toward control. As this increased awareness comes, you can begin to use it in a more directed fashion to obtain a specific goal, such as lowering your EDA level.

When the trials end, the computer will then ask you to press the space bar to continue. Pressing the space bar will return you to the Main Menu. Press number 2 for VIEW RESULTS.

You should now be at the RESULTS MENU Press number 1 for the BAR GRAPH OF TRIALS option and take a look at the results of your biofeedback session. How did you do?

If you have a printer available, you may wish to print a hard copy of your results.

If you wish to save the data from your session on disk, return to the Main Menu. Select the ACCESS DATA FILES option by pressing 3. When the FILE OPERATIONS menu appears, press 3 for SAVE A DATA FILE and follow the directions that appear on the screen.

If you are working in a group and another individual wishes to explore EDA biofeedback, return to the Main Menu and repeat the procedure above.

If you are finished with the Biofeedback MicroLab for the day, remember to put all the supplies away.

Discussion of the Experiment Seven

EDA is very sensitive to a large number of internal and external stimuli. For this reason, it has been extensively used in psychological research as a measure of sympathetic arousal. EDA is somewhat difficult to control because of its sensitivity, but with continued biofeedback practice such voluntary control over this highly volatile autonomic response is possible.

As we indicated before, EDA biofeedback is often employed to simply lower the general level of sympathetic arousal. Lowering the general level of sympathetic arousal makes us feel much calmer and often makes it easier for us to think clearly. EDA biofeedback has been frequently used to reduce anxiety and to promote deep levels of relaxation.

Reductions in the general level of sympathetic arousal have an effect on every organ system involved in the fight-or-flight response. EDA biofeedback training may thus have effects on skin temperature, heart rate, blood pressure, muscle-tension levels, and feelings of anxiety. While these are general rather than specific effects, they can have a profound impact on general physical and psychological health.

Note: Some people may find that the readings of their skin's electrical conductance are low--2 micromhos or less. This conductance can be increased by applying a small amount of electrolyte gel to each of the sensors. Use of a small amount of gel will also increase absolute accuracy. Be sure to clean the sensors after use.

Appendix A

A PROGRESSIVE-MUSCLE-RELAXATION EXERCISE

The following relaxation exercise can be tape recorded for individual use. If it is being used in a group setting, it can be read in a slow-paced, soothing manner for best effect. The entire exercise should take about ten to fifteen minutes.

A word of caution before starting: PMR is a very powerful technique that can be unpleasant for some individals. While unpleasant experiences happen only occasionally, you should advise anyone participating in the exercise to inform you immediately if he or she is experiencing strange sensations or feels uncomfortable. Those who wish not to participate should be excused. Those who feel uncomfortable but wish to continue may do so with some modifications of the procedure. The major modification advised in these cases is that the individuals keep their eyes open in order to stay in touch with their surroundings.

PMR Instructions

Seat yourself in a comfortable chair or lie down on a couch, bed, or the floor. If you are lying down, you may want to place a rolled-up towel or something similar under the small of your back to make yourself more comfortable.

Let your whole body relax gradually and let your body get very heavy. Just feel your body sinking down as it gets heavier and heavier. Breathing through your nose, start taking slow, deep, easy breaths.

Now close your eyes and start getting in touch with your body. Feel the cool air coming in as you breathe in and the warm air going out as you breathe out. Feel the pressure of your back on the chair or floor. If you concentrate, you may even be able to feel your clothing on your skin. As you concentrate, you may be able to feel a pulse in your fingertips, and you may even be able to feel your heart beating.

Keeping the rest of your body completely relaxed, now make a tight fist with each hand. Make the muscles in your hands and arms tight and tense. Notice the difference between being tense...and relaxed. Now slowly let that tension drain out as you relax those tense, tight muscles in your hands and arms. Again, notice the difference between being tense...and relaxed. Let your hands and arms continue to relax and become very heavy. You may feel your hands getting warmer, and you may feel a pulse beating in your fingertips. You may also feel your arms getting heavier and heavier as they relax deeper and deeper.

Keeping the rest of your body completely relaxed, press the backs of your legs against the floor (or push your feet down against the floor if you are seated) and make the muscles in your legs tight and tense. Compare the tight, tense muscles in your legs with the relaxed muscles in the rest of your body. Now slowly release that tension and let your legs, thighs, and calves relax very deeply. Again, notice the difference between being relaxed and tense. Let your legs get very heavy as they relax deeper and deeper.

Keeping the rest of your body completely relaxed, tighten the muscles in your abdomen. Again, feel the difference between being tense...and relaxed. Now let all that tension drain out and let your abdomen relax and your whole body start to get even heavier.

Keeping the rest of your body completely relaxed, tighten the muscles in your buttocks. Feel the difference between being relaxed and tense. Now gradually release that tension and let yourself relax deeper and deeper.

Keeping the rest of your body completely relaxed, press the back of your head against the floor (or the back of your chair) and make the muscles in your upper back and neck tight and tense. Again, notice the difference between being tense...and relaxed. Now let that tension drain out and let the muscles relax. Let your head get heavier, and let it sink down into the floor (or back of your chair). Again, notice the difference between being tense...and relaxed.

Keeping the rest of your body completely relaxed, clench your teeth. Feel the tension in your jaw muscles and in the muscles at your temples. Now slowly let that tension drain out and let those muscles really relax.

Keeping the rest of your body completely relaxed, now press with the tip of your tongue against the roof of your mouth. Feel the tension on your tongue and on the muscles under your chin. Now gradually let that tension drain out and let your tongue fall to the floor of your mouth. As your tongue relaxes, you'll notice that it seems to get thicker and wider. It seems to get bigger and bigger until it almost fills your mouth.

With the rest of your body completely relaxed and just using the muscles in your eyelids, shut your eyes very tightly. Feel the tension on your eyelids. Now gradually let that tension drain out and let your eyelids relax. As they relax more deeply, you may even be able to feel the weight of your eyelids on your eyes.

With the rest of your body remaining relaxed and keeping your eyes closed, raise your eyebrows as high as you can. Feel the pull on all those little muscles in your scalp. Now gradually let that tension drain out and feel all those little muscles in your scalp relax.

The rest of your body is relaxing very deeply now. Let it stay relaxed. Just using the muscles in your forehead, knit your brows and get real tension on those forehead muscles. Now let the tension drain away, and let those forehead muscles relax very deeply.

Now your body is completely relaxed. Just lie there and enjoy that feeling of deep relaxation. Let your body just sink down as it gets heavier and heavier. You may feel as though your body is heavy, but you're light. You may even feel as though you're floating right up out of your body just like a feather on a current of air.

As you lie there and relax, imagine, as vividly as you can, that you're lying on a nice warm beach. You can feel the warm sand on your back, the backs of your arms, and the backs of your legs. You can feel the warm sun on your body. There's a cool breeze blowing in from the ocean, and you can smell the salt sea air. You can hear the sound of the waves as they wash up on the shore. Every once in awhile, you can hear a seabird. Overhead, there are soft, white fluffy clouds floating across a bright blue sky. You're very peaceful, relaxed, and warm, and you feel very comfortable and secure.

Continue to let yourself relax and just let yourself float right up and out of your body just like a feather on a current of air. Just floating up...and up...aimlessly and weightlessly...just floating. And now you begin to drift...just drifting...aimlessly and weightlessly. After awhile, you begin to drift slowly downward. Drifting down...and down...and down...until finally you land just like a feather on a pile of feathers.

Debriefing

Debriefing is an important aspect of the total process of becoming more aware of our bodies. If the exercise has been conducted with a group, group members can share their subjective experiences with other group members. Discussions of how various muscle groups felt, of any emotional reactions, and of the various sensations experienced at different times during the exercise are the kinds of topics that are often discussed.

Where only one person is involved, other than an instructor, the instructor conducting the relaxation exercise should go over the individual's experiences with him or her to help consolidate the learning that took place.

Appendix B

TESTING THE HARDWARE AND TROUBLESHOOTING

The MicroLab Interface and all the Biofeedback MicroLab sensors have been tested prior to shipment. You may, however, wish to test the hardware on receipt of the package or when you suspect that signals are erroneous. Below is a description of how to test the sensors and MicroLab Interface circuitry for accuracy.

1. EMG: Try running an EMG experiment with the sensor cable attached to the MicroLab Interface but the leads left unconnected. Readings should be over 15 microvolts, due to pickup of random electrical noise in the environment. If these results are obtained, it is unlikely that there is a problem with the MicroLab Interface.

   If the readings you receive when performing an experiment seem erroneous, you may be having problems with your EMG sensors. Attaching EMG sensors to the body is a skill that takes some time to perfect. Most faulty EMG readings are due to improper sensor contact, or to a bit of conducting electrolyte gel that gets onto the skin under the adhesive strip, or to inadequate skin preparation. Sensors may also become aged, especially if they are not cleaned properly after using (see Appendix D). If your sensors appear discolored or corroded, we suggest you order replacements from HRM.

2. Electrodermal Activity (EDA): Try running in the EDA mode with the cable plugged into the MicroLab Interface and the EDA sensors attached to the fingers. Readings from one individual to the next may vary widely but should be over 2 micromhos. Some people may find that the readings of their skin's conductance are low--2 micromhos or less. This may be partly due to low conductance in the sensor-to-skin contact. This conductance can be increased by applying a small amount of electrolyte gel to each of the sensors. Even with electrolyte gel there will be occasional individuals whose conductance is so low that there will be no readings. Be sure to clean the sensors after use.

3. Skin Temperature: Place the thermistor in cool water (around 60 degrees F) and then in warm water (around 100 degrees F) and see if the readings change. The thermistor is accurate to plus or minus 2 degrees F over skin-temperature range (about 75 to 98 degrees F). The thermistor should not be exposed to temperatures below 32 degrees F or above 140 degrees F.

4. Heart Rate: Compare the heart-rate readings obtained with the sensor with those you get by simply counting pulses. Erroneous readings may result if you jiggle the sensor. If the signal seems erratic, you may also need to adjust the location of the sensor on the finger or earlobe. If your finger or earlobe is cold, massage it to improve circulation.

Appendix C

BATTERIES

After 35 to 100 hours of operation, depending on the type of battery used, the batteries will get weak, and a message to that effect will appear on the computer monitor. Running experiments with low batteries will affect the accuracy of EMG, EDA, and skin-temperature readings and will also increase the level of "noise," or electrical interference, in the system. However, there is no electrical danger in running the program with low batteries.

Replacing Batteries: Disconnect all cables from the MicroLab Interface. Remove the screw from the battery compartment of the case, and replace the worn batteries with new ones. Always replace both batteries at the same time, as it is important for proper circuit operation that both batteries provide equal voltages.

Below are approximations for the operating lives of different types of batteries when used with *Biofeedback MicroLab*.

Regular batteries.............. 35 hours
Extra-life batteries........... 75 hours
Alkaline batteries............. 80 hours

Use of the batteries with *Biofeedback MicroLab* is a low-drainage application, and more expensive alkaline batteries do not provide a significant advantage over extra-life or heavy-duty batteries. Actual battery lifetimes will depend on temperature, signal level, number of hours of daily usage, and the capacity of the particular battery.

Appendix D

CARE OF SENSORS

All the sensors included with the Biofeedback MicroLab have been designed with durability in mind. However, improper or careless usage will reduce their accuracy and useful lifetime.

The tip of the temperature sensor contains a thermistor encased in glass and coated with a plastic material. While this sensor is quite durable, be careful about dropping it on the floor where it might be stepped on. Similar care should be taken with the heart-rate sensor.

After each use of the EMG sensors, the adhesive strips should be removed and the electrolyte gel cleaned from the individual sensor cups. The gel may be wiped off with a soft tissue or cotton swab. The sensor cups should then be wiped off a second time with a moist tissue or swab to remove any remaining gel. Try to avoid scratching the surface of the sensor, for scratches may reduce the quality of future measurements.

The EMG sensors should always be cleaned shortly after using them so that the electrolyte gel does not dry on their surface. In the event that the gel is inadvertently allowed to dry, it may be removed using the following procedure. Unsnap the individual sensors from the sensor cable and place them in a small container of warm water to soak for a few minutes. Do not emerse the sensor cable in water as this may lead to corrosion. Once the gel has softened slightly, the sensors may be removed and rinsed under a water faucet. A soft bristled toothbrush may be used to lightly scrub out any remaining gel.

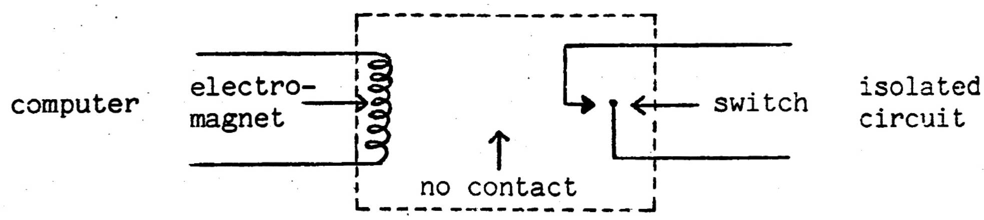
When removing any of the sensors from the MicroLab Interface, do not pull by the lead wires. Pulling by a wire will cause a strain on the internal connections and can result in a break in the wire. Nonvisible breaks or shorts in the lead wires are one of the most common types of equipment failures in biofeedback work.

Appendix E

ELECTRICAL SAFETY

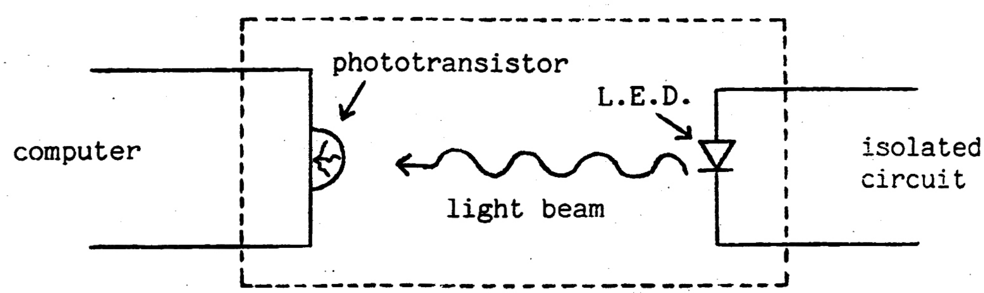
To protect against the possibility of shock, the portions of the MicroLab-Interface circuit that connect to the EDA, EMG, and skin temperature sensors are electrically isolated; that is, there is no electrical contact between the circuitry of the computer and the circuitry that touches your skin. The isolated portions of the circuitry are powered by two nine-volt batteries and, when activated, draw six milliamps of current from the batteries.

The communication between the computer and the isolated portions of the circuit is via optical isolators and a relay. The relay consists of a magnetically operated switch and a nearby electromagnet. The computer runs a current through the electromagnet to turn on the switch, connecting battery power to the isolated portions of the circuit.



Relay

The optical isolators consist of light-emitting diodes (L.E.D.'s) and phototransistors. The L.E.D.'s are turned on by the isolated portions of the circuitry at a rate which indicates signal amplitude, and the phototransistors (photodetectors) are monitored by the computer.



Optical Isolator

Should the subject of an experiment accidentally touch the 117-volt power line, the isolated portion of the circuitry provides no return path to ground. This is true even if you ground your computer chassis, because there is no ground connection to the isolated portions of the circuit.

Should your computer accidentally be connected to the 117-volt power line, the circuitry in the Biofeedback MicroLab will not provide a path for the power-line voltage to reach a subject.

If your MicroLab Interface becomes damaged, you should return it to HRM for inspection and a complete safety check.

Appendix F

USING ARCHIVE DISKS

Saving Data Files to an Archive Disk

It is very simple to save data files to a separate archive disk. When you wish to save a file, simply remove the program disk and insert an initialized disk with enough space to store the file. This should be done just before executing the "save" command on the File Operations menu. After inserting the archive disk and saving the file, you may continue with the program without reinserting the program disk.

Retrieving Data Files from an Archive Disk

If you wish to retrieve a data file from an archive disk at a later date, simply remove the program disk and insert the archive disk immediately before executing the "load" command. At this point you may proceed with the program without reinserting the program disk.

Creating an Initialized Disk

To create an initialized disk for the Apple II, use your Apple System Master program after consulting the DOS (Disk Operating System) manual. For the Commodore 64, consult your Commodore disk drive user's manual.

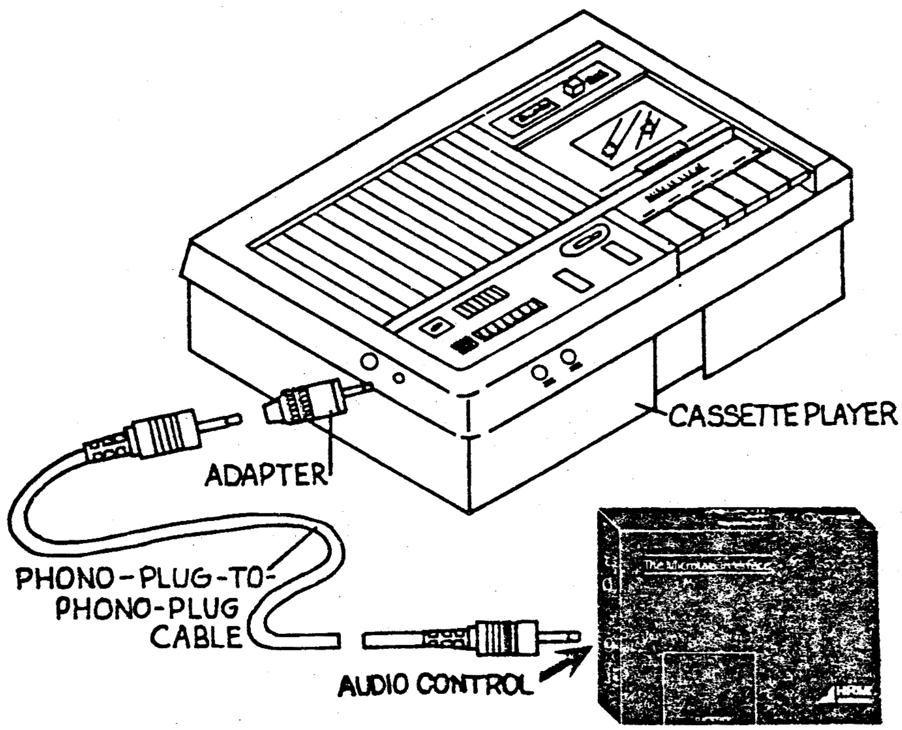
Appendix G

USING A CASSETTE PLAYER

The MicroLab Interface inncludes an audio-control output jack that permits you to connect the interface with a cassette player. This feature allows you to use relaxing music of your own choosing during biofeedback sessions involving goals.

The audio-control output jack is connected to a small relay. The relay is normally open ("off"). It is closed (turned "on") by the biofeedback program when your muscle tension, heart rate, or electrodermal activity goes below the goal or when skin temperature goes above it.

To connect the audio-control output of the MicroLab Interface to a cassette player, plug a 3/32" to 1/8" adapter (such as Radio Shack catalog number 274-327) into the "remote" input of your cassette player. Then connect a 1/8" phono-plug-to-phono-plug cable (such as Radio Shack catalog number 42-2420) from the audio-control output to the adapter on your cassette player.



The audio control is not connected to ground or any other part of the circuitry and may be used for other purposes (for example, turning on a small light) as long as its current, voltage, and power ratings are not exceeded (5VA max, 50 Vdc or PEAK AC at no more than 100 ma, or up to 500 ma at no more than 10 volts).

Appendix H

ADDITIONAL APPLE PRINTING INFORMATION

Printing Graphs: As explained on pages 21 and 23, if you have the appropriate graphics interface and printer it is possible to print either the bar graph or the plot of data by pressing CONTROL-P and following the on-screen directions. Below are additional instructions for those who wish them.

Suggested interfaces include Orange Micro's Grappler Card and Apricorn's Apple Graphics Card. Compatible printers should be dot-matrix graphic printers.

Most printers will be installed in slot #1, but you can change the location by typing a number other than 1. If the printer card is not in the slot specified, the program will stop or "hang" instead of printing. With most graphic printing cards, the printer commands offered, [CONTROL-I] [G] [D] [R] [RETURN], will print a large graph lengthwise down the paper. Changing the commands to [CONTROL-I] [G] [RETURN] will print a small graph across the page. Check your printer manual to make sure these commands apply to your printer.

To save the graph to another initialized disk to be printed later, specify slot #6 rather than #1 as the location of the printer. The graph will be saved as a 34-sector binary file with the name that you select for it. This may be used to print it later with some graphics printing software such as Roger Wagner's Printographer or Beagle Bros.' Triple Dump.

GLOSSARY

automatic reaction

An action that occurs without conscious thought; a reflex.

autonomic nervous system (ANS)

A division of the nervous system which regulates the activity of the heart, blood vessels, glands, and viscera (stomach and intestines). Activity of the ANS was once thought to be totally reflexive or automatic in nature. Biofeedback has demonstrated that learned influence over the ANS is possible.

baseline

An initial measurement of physiological activity taken at the start of a biofeedback training session. This measurement is used as a reference point for an individual's later performance.

biofeedback

A process of providing an individual with ongoing information about a current physiological activity or biological function such as heart rate or muscle tension.

calibration

Adjustment of an instrument at the start of a recording session to insure that values are recorded accurately and correspond to meaningful units of measurement; the skin temperature probe and EDA sensor used in Biofeedback MicroLab have automatic calibration routines.

cardiac output

The volume of blood pumped from the heart during a cardiac cycle (a heart beat).

cardiovascular activity

The activity of the heart and/or blood vessels.

electrodermal activity (EDA)

A measure of various electrical properties of the skin. A primary component influencing the electrical characteristics of the skin is the level of sweat-gland activity. An older term referring to a change in electrodermal activity is galvanic skin response or GSR.

electromyography (EMG)

The measurement of changes in muscle tension by recording changes in electrical potential in the vicinity of a muscle.

electrophysiology

The measurement of physiological events that involve changes in the electrochemical properties of the body. Such events include muscle contraction and sweat-gland activity.

fight-or-flight response

A mobilization of bodily resources in preparation for action, such as fighting or fleeing.

galvanic skin response (GSR)

See electrodermal activity.

goal

A level of physiological activity that an individual tries to attain during a biofeedback trial. For example, an individual may start with a baseline reading of 3 microvolts of muscle tension from a given muscle and may attempt to drop his or her muscle-tension level to below 2 microvolts. A level of 2 microvolts would be the goal in this example.

heart rate

A measure of the speed with which the heart beats; generally expressed as the number of beats occurring per minute.

myogenic heart rate

The rate at which the heart beats independent of any influence from either the parasympathetic or sympathetic nervous systems; approximately 48 beats per minute in a normal individual.

orienting response

A specific pattern of reactions that occurs in response to novel stimuli. Included among these reactions are a general increase in muscle tone, an increase in electrodermal activity (EDA), a brief slowing of heart rate, decreased blood flow to the body's periphery (arms and legs), increased blood flow to the head. Sometimes referred to as a startle response.

sympathetic nervous system (SNS)

A subdivision of the autonomic nervous system generally associated with active control of arousal-related functions as they occur in the fight-or-flight response. SNS usually induces effects opposite to those of the parasympathetic nervous sytem. For example, increased SNS activity causes a speeding of heart rate, whereas increased PNS activity causes a slowing of heart rate.

threshold value

The goal level for a given biofeedback trial.

trial

Biofeedback training sessions are generally divided up into periods or segments of time called trials. A goal is frequently established for each trial and then adjusted for the next trial based on an individual's performance.

vascular activity

Referring to the activity of the blood vessels; i.e., vasoconstriction or vasodilatation.

vasoconstriction:

Tightening of the muscles of the blood vessels. Results in a decrease in blood flow.

vasodilatation

Relaxing of the muscles of the blood vessels. Results in an increase in blood flow.

voluntary reaction

An action that occurs through intentional or conscious thought.

HRM software
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BIOFEEDBACK MICROLAB
Apple version

Errata

Page 9 (top) - (3) Do not remove the 80-column card.
(Disregard the first sentence on page 9.)

Page 16 - Loading the Program into the Computer

1.b. The program will function with an extended memory 80-column card in the auxiliary slot. It only fails to operate if there is an additional memory card in another slot.

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UPDATE - Calibration (Apple)

Since the guide to Biofeedback MicroLab was printed, we have improved the calibration routine for electrodermal activity and skin temperature. Skin temperature readings should be accurate to within about ½ degree Celsius. We have already calibrated the hardware and the calibration constants have been saved to the program disk. You will not need to recalibrate unless you suspect your measurements are inaccurate. If you do wish to recalibrate at any time, we are now supplying a yellow calibration plug for this purpose. Simply follow the directions below:

To Calibrate

First make a copy of the master disk, which is not copy-protected. Keep the master in a safe place and use only the copy. If for some reason the copy is damaged, you can always make another copy from the master.

1) Choose either skin temperature or electrodermal activity from the Type of Feedback Menu.

2) When the screen asks you if you want to calibrate, press Y.

3) After a fifteen-second warmup period, the program will record the first set of calibration data. (If there is a sensor plugged into the MicroLab Interface, the program will ask you to remove the sensor.)

   Note: Sometimes an "UNSTABLE" message appears for a few seconds. If this message persists, preventing calibration, notify HRM and we will repair or replace your interface.

4) The program will now ask you to insert the yellow calibration plug into the skin temperature/electrodermal activity jack of the MicroLab Interface. It will then record a second set of calibration data.

5) Finally, the program will ask you if you want to save the calibration data to the program disk. If you do, press Y.

Once you've saved the calibration data, you will not need to calibrate again unless you suspect your readings are inaccurate, or if the batteries get low or you change the batteries. If at any time you wish to test the calibration, plug in the calibration plug into the skin temperature jack and run the program. Your readings should be between 24.5°C to 25.5°C.

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