Part 2

NEUROFEEDBACK and BIOFEEDBACK

Chapter Three

INTRODUCTION: NEUROFEEDBACK IN EDUCATION TO ENHANCE INTELLIGENCE

By Jean Millay, Ph.D.

Over the last 20 years the health professionals have proved the benefits of neurofeedback and biofeedback for the prevention or relief of many stress related illnesses. During this same period of time, quietly, without fanfare and with little or no funding, teachers in different parts of the country have brought biofeedback into their classrooms for various reasons. Some have used it for lessons in:

1. Science

- a. To study the electromagnetism of the body
- **b.** To show physical reactions to thoughts

2. Stress management

- a. To demonstrate ways of releasing emotional tension
- 3. Ways to modify a learning disability
 - **a.** Brainwave and/or GSR training can be used to help alleviate (ADHD) Attention Deficient Hyperactive Disorder
- 4. Exploring how food may have an effect on your thinking
 - **a.** How do your brainwaves change when you have used any of the following substances? -- lots of sugar, greasy food, colas, coffee?
 - a. How does your energy level change, and for how long?
 - c. Do you feel that your thinking changes when you are hungry? If so, how?
- 5. Self-discovery (students should keep notes about their own reactions)
- **a.** What changes occur in the electromagnetic signals from my body and/or brain when I think about different ideas?
 - b. Will my hands and feet get warmer if I just think about warm things?
 - **c.** If my heart is beating rapidly, will it slow down when I focus on breathing slower and more evenly?
 - d. Can I learn to stop a headache by relaxing tense muscles?
 - e. Can I learn to increase my ability to focus attention?
 - f. Can I learn to improve my speaking ability with video feedback (VF)?

In each situation, regardless of the stated objective of the class, most students in our various independent studies included statements about enhanced self-esteem as their personal power improved along with their increased knowledge of mind/body interactions.

Methods used for Neurofeedback and Biofeedback measurement

These instruments can be small portable machines, or those attached to computers:

- 1. Galvanic Skin Resistance or Conductance (GSR)
- 2. Skin Temperature (TEMP) ---- [Skin Temperature and GSR are both inexpensive]
- 3. Electrical Activity of Muscles (EMG) ---- [Slightly more expensive]
- **4.** Electrical Activity of Brain (scalp measurements) (**EEG**) --- [*This is complex, however, 10 year olds often learn to use it faster than most teachers*] [*The following forms of biofeedback will be included in Chapter Four*]
- 5. Heart Rate rhythm, entrainment and coherence (HeartMath Freeze Framer™).
- 6. Video Feedback (VF) -----[Video cameras are already available in most schools]
- 7. Different types of BFB to examine personal ways of thinking and body chemistry

DESCRIPTION OF COMMON NEUROFEEDBACK INSTRUMENTS

A) Skin Talk – A simple Galvanic Skin Response machine GSR) tracks emotional responses

by measuring amounts of sweat on your fingertips. Exercise causes sweat, but when the hands are clean and dry, emotional reactions also cause the skin to produce minute amounts of sweat, and this changes the electrical conductance of the skin. A GSR can be purchased so inexpensively that the school, the teacher, or a parent may be able to afford one. GSR-feedback demonstrates the direct relationship between emotions and health.

Exercise -- Each student should keep a record of those thoughts that cause the sound of the GSR to change to a higher or to a lower sound (i.e., thoughts that cause his/her skin to "talk").

B) Skin Temperature – Thermistors that provide biofeedback sounds are quite helpful for

registering minute changes in skin temperature. They are not expensive and often come with the GSR package. Tense muscles will cause the hands and feet to be cold constantly, so the EMG is also useful here, and might be used together with the GSR.

Exercise -- Tape a thermometer to your finger tip and see if you can learn to raise or lower the temperature of your hand. Keep notes of what thoughts help you to do this.



Photgraphs by Richard Lowenberg and Jean Millay

These three pictures are infrared photographs of Joanne Kamiya as she demonstrates her ability to raise the temperature of her hands just by thinking about warmth things. She had trained herself to do this using a skin temperature biofeedback instrument, and the skill she learned stayed with her long after she no longer needed the instrument. These images were taken in sequence by an infra-red video camera, and copied onto 35 mm film from the video. Kamiya was able to move the "infra-red light" around her body as she intends the flow of her blood to be increased to the tips of her fingers. She held her hands out in front of her the entire time all these pictures were taken. Black is the coldest color, and white is the hottest. The nose is always colder than the rest of the face. **1**) Her fingers start out cold and disappear into the black background. **2**) As she concentrates on warming her hands, her face cools way down. **3**) As the skin temperature of her hands increases by ten degrees, the temperature of her face also increases again.

C) Muscle Activity – An Electromyogram (EMG) is a machine that measures muscle activity.

The electrical signals of tense muscles are stronger than the signals of relaxed muscles. Students can discover for themselves how to relax tight muscles, or how to tighten loose ones after an illness, if an EMG feedback machine is available in the classroom.

Exercise -- Tight muscles in the forehead and neck often cause headaches. When students keep a record of what they do as they learn to relax, they can practice at home without the EMG instrument. This technology can also be used to enhance sports activity.

D) Brainwaves -- Every thought, feeling or emotion is accompanied by electrical signals in our brains. We can learn voluntary control of them with neurofeedback from EEG (Electroencephalogram) equipment. This is generally more expensive than GSR or EMG, because measuring brainwaves requires more complex computer analysis. If brainwave analyzers are available, however, they have the potential to teach students specific ways to focus attention. Brainwave neurofeedback is used in clinics to alleviate milder forms of ADHD.
Exercise -- Discover the differences in your brain's electricity between your thoughts of joy, anger, anxiety, stress, relaxation, or creative insight. It is possible for students to learn how to maintain steady brainwaves in fast or slow frequencies for longer periods of time. This becomes an exercise in learning to increase intelligence. 1) Form a clear intention. 2) Practice extending your ability to sustain a steady focus of attention on that intention. 3) Learn more

Brainwaves are measured in the same way that all electromagnetic frequencies are measured – in cycles per second, using the term **Hertz (Hz)**. All the wiggly lines below represent **EEG** (brainwave) signals as they were measured simultaneously from both right and left sides of the brain. A pair of vertical lines represents 1 second.

= cvcles per second or Hz

Count the top peaks of the top line on the left between one pair of vertical lines. These are **beta rhythms** between **13 Hz to 30 Hz.** This pair of lines is uneven and dissimilar. This electrical activity of the brain can relate to anxiety or to nervous tension. When symmetrical, they can indicate a steady one-pointed focus of attention.

The next two lines are **alpha rhythms** between **13 Hz** and **8 Hz**. They are slower and more even. This electrical activity of the brain can relate to simple relaxation. When both sides are synchronized for a time, they may gradually become a deep meditation.

The last two lines are **theta rhythms**. They range between **8Hz** and **4Hz**. When both sides are very different, they can relate to drowsiness or high emotions. When one synchronizes them for an extended time, one may have an experience of receiving a major insight.

E) Heart Beat – The strongest measurable frequency is the heartbeat. The small "StressEraser"* might work well in a classroom. However, if a HeartMath* computer program is available, it has several fine programs built into it to analyze each moment of heart rate for feedback. This is very useful for learning about the actual variations in the activity of the heart. If not, you can use a stopwatch to count the wrist pulse for some simple experiments. An elaborate combination of heart rate with GSR activity is available in an adventure game called, "The Wild Divine." However, the young students, who play fast moving and violent computer games, may find this boring. The HeartMath program by itself is more direct for self-discovery science.

Exercise -- Check your pulse and record the rate when resting and after exercise. Count the pulse of others in the classroom before and after exercise, and keep a record of their pulse changes to compare and share them. Every heart has it own natural rhythm and variation.

LISTEN TO YOUR SKIN TALK By Marjorie King and Jean Millay

The portable **GSR** (Galvanic Skin Response) is a battery powered, solid-state, device that is extremely sensitive to changes in the electrical resistance of the skin. (It is also called the BSR for Basal Skin Response.) When the two sensors are placed on the fingertips, a small current flows through the skin (less than one thousandth of an ampere). Changes in this current flow are amplified and used to alter the frequency of a tone generator. By monitoring these changes, you can become more aware of how you are affected by various thoughts and events. The flow of the current changes because of minute amounts of sweat that increase or decrease relative to your emotional state. A dry skin is more resistant to the flow of the electrical current, and represents a calmer, less emotional, state of mind.

When you are very nervous, you can feel your hands getting cold, while the sweat runs down under your armpits. Your hands might even shake. In this state, you don't need a GSR biofeedback device to tell you that you are nervous. However, we also have subtle reactions to situations, words, or sounds that are just under our conscious awareness. It is these that are brought to our attention by the use of the GSR. The GSR should not be used to suppress these emotions, since suppressed emotions can become a time bomb in a person's future health situation. The GSR allows us to face the emotions directly and to find a creative, rather than a destructive, outlet for the extra energy emotions provide.

For example, a person may hold a painful memory of an old accident to his arm. When the arm heals, it may not seem to work as easily as before. With the GSR, a student can call up all the emotions of the accident, and allow the tone of the feedback to go as high as possible. The next step is to focus all of the energy of that emotional memory as a mental light and visualize the arm surrounded by the light until the sound of the GSR returns to a normal low tone. This exercise may have to be repeated several times. During this activity, the student learns to maintain a focus of attention on the task. When the student's mind wanders or continues to be caught up in the original emotion, the tone stops descending, and rises again to the high sound. The student can hear the feedback sound and use it to stabilize his focus of attention. Once the emotional mobility with additional exercise. Often healing is enhanced by this process of removing the physiological response to the memory of the accident. It is not appropriate to hide any memories; we can keep them all. The dramas of our own lives can be more interesting than any fiction, and, once we are released from the body tension associated with them, we can be as nonattached to our own dramas as we are to fiction.

When we are young, we live in a world of emotions. Many of us develop our lifelong habits of dealing with them at this time. If our methods are less than stable, our lives are colored by emotional upheavals. The GSR could fill an important role in the classrooms of public schools. Louise Samples, a 5th grade teacher in Santa Clara County, chose to study how her students might benefit with holistic methods of teaching. Since her school was large it had several 5th grade classes. Her class had the same curriculum that the others had, with the addition of guided visualization to enhance memory, cooperative learning projects, relaxation exercises to reduce stress (including the introduction of GSR biofeedback). After final exams were given to all the classes at the end of the term, her students averaged two grade levels higher than the other classes. (See page 51) This was an important study done around 1985, yet the information was not carried on to the other classes at that time.

Now is the time to seek new levels of reality in public education. PSYCHOLOGICAL EXPERIMENTS WITH GALVANIC SKIN RESPONSE

By Buryl Payne, Ph.D.

Buryl Payne earned his Ph.D. in psychology and his M.S. in physics. He developed and marketed the first commercial biofeedback instruments in the 60s, and served on the faculties of Boston University prior to directing a holistic health clinic there. Payne also founded PsychoPhysics Labs, which designs instruments and provides classes in telepathy. His recent book is: "Getting Started in Magnetic Healing."

Be sure your fingers are clean and warm (not hot). Set the Galvanic Skin Response (GSR) instrument at a low tone before you begin each part of each experiment. Allow at least 15 seconds between stimuli; otherwise residual activity from previous stimuli will combine with succeeding ones making it hard to relate cause with effect. You will observe that the GSR effect occurs from one half to two seconds after the application of stimuli. This is not an instrument effect, but a time delay in activation of the nervous system and/or the sweat glands.

PSYCHOLOGICAL EXPERIMENTS -- Suitable for groups of three or more.

(Let each person alternate in the role of subject, experimenter and data recorder.)

Experiment I — Apprehension

Tell the subject to just think silently about what you threaten to do. You promise not to do any of them, because that is not fair. Say that you intend to pinch him/her. Threaten to tell a secret. Say you are thinking of an embarrassing question to ask.

Experiment II — Startle Response

After the subject has been quiet for 30 seconds, make a loud noise, or flash a light.

Experiment III — Proximity or Contact by People

Maintain steady eye contact for at least 30 seconds. Move your hand near your partner's head. As a group experiment you might try asking one person to hold the GSR instrument while others in the group come and stand behind the student. Our reactions may not be evident to the eye, but the GSR clearly shows them.

Experiment IV — Mental Effort

Ask the subject to solve a difficult problem, define a hard word or spell "rhythm" backwards. Set the stopwatch to impose a limited time on the completion of the task.

Experiment V — Effect of Anger and Fear

Ask the subject to think about someone or something that angers him/her. Ask the subject to reflect on a private fear, but not to talk about it. (The GSR will usually respond to the thought.)

More Experiments

Wear a small portable GSR, which usually has an earphone, so that no one else can hear the tone when your skin talks to you. Wear it while watching TV, doing homework, listening to loud or soft music, or having a discussion with the family.

The GSR was once thought to be a good lie detector, but it is not totally accurate for this. However, people may be though to be lying if they are simply distressed at being accused of lying, even though they are innocent. The practice of the deep relaxation techniques might help prevent embarrassing reactions.

Make up a list of emotional words, and read them one at a time to your partner. Make a note of which ones caused a reaction. Can you repeat that word a few times to diminish the reaction?

PHYSIOLOGICAL EXPERIMENTS WITH GALVANIC SKIN RESISTANCE

By Burl Payne, Ph.D.

The following experiments will acquaint you with your own Skin Talk (GSR) and help you understand what happens within your body during various activities. Be sure your fingers are clean and warm (not hot). Set the GSR instrument at a low tone before you begin each part of each experiment. Allow at least 15 seconds between stimuli; otherwise residual activity from previous stimuli will combine with succeeding ones making it hard to relate cause with effect. You will observe that the GSR effect occurs from one half to two seconds after the application of stimuli. This is not an instrument effect, but a time delay in activation of the nervous system and/or the sweat glands.

PHYSIOLOGICAL EXPERIMENTS

Experiment I — Muscle Tension

1) Make a fist, squeezing it tightly for a few seconds, and then tense other muscles of the body. Which muscular tensions produce the largest GSR effects?

Experiment II — Breathing

2) Take a very deep breath and hold it for a few seconds. Take a series of abdominal breaths rapidly, and then sit quietly and breathe normally. Describe any change of tone in each case.

Experiment III — Effect of Pain

3) Pinch your arm. Bite your lip. Gently scratch your skin. Does the tone of the GSR change even before the pain is felt? Are there some areas of your body that are more sensitive than others?

Experiment IV — Effects of Odors and Tastes

5) Smell onions, vinegar, blue cheese, perfume, and flowers. (Inhale gently or you may get a GSR response just from breathing.) Taste pickles, berries, chocolate, and ice cream. Imagine you are eating your favorite food or that you smell something nasty. Which stimuli caused the most response? Was the response to the imagined stimuli as great as the response to real smell and taste?

Experiment V — More than One Person

- 6) Using the remote sensing plates, put one electrode on one person and the other electrode on another person. Ask them to hold the other hands that are not connected to the electrodes to complete the electrical circuit. Have one person take a deep breath, and then ask both of them to relax to bring the tone of the GSR down again.
- 7) Ask each person to hold the hand of another person, until there is a circle of people holding hands, with the first two still connected to the electrodes, but not touching. Notice that the electrical circuit passes through all of them to cause the sound of the GSR. Ask two people on the opposite side of the circle to drop their hands. The sound of the GSR also stops. Then ask two people to gently tap each other's hands. The GSR will respond to the on/off connection of the tapping in the same rhythm. What does this tell us about our electrical connections to each other? (See Appendix B, page 73.)
- 8) Put one GSR on one person's bare foot, and another GSR on his/her partner's bare foot. Ask them to face each other, without touching. Play some slow waltz music (4/4), and ask them to mirror each other's hand movements to the rhythm of the music. Are the tones of each GSR different? Do the tones gradually rise as the dance progresses, or become lower?

LISTEN TO YOUR MUSCLES TALK By Marjorie King and Jean Millay

The **EMG** measures electromyographic signals from muscles, and produces a biofeedback response, such as a sound, a light, or the motion of an indicator needle on a dial, or an action in a computer game. Each fiber in a muscle produces a pulse of electrical energy as it contracts. This is measured in microvolts, and can range from zero to over one hundred microvolts. These pulses are called single muscle unit firings. Surface electrodes placed on the skin over a muscle will pick up these pulses from a large number of muscle units located in the area under the electrodes. When no muscle unit firings occur, the EMG will indicate that every muscle is completely relaxed.

By learning to relax the muscles in your forehead, for example, you can learn to change a habit of holding tension there that may cause headaches. A very large percentage of headaches are caused by muscle tension. Other sources of stress leading to pain are the habits of holding muscle tension in the jaw, neck and shoulders. Biofeedback can be more useful in the relief of muscle tension headaches than the use of medication, which may have harmful side effects. While adults, who have lived with a long-term habit of holding muscle tension, may eventually be led to biofeedback for stress management through a doctor's prescription, young students can learn to avoid developing these habits. This learning can help them become more relaxed and alert during exams. It can also carry them through life with less stress and less stress related illnesses.

In the early days of EMG biofeedback, Tim Scully, Ph.D., coordinated an EMG response program with and old Atari Video Pong Game. An ADHD student become so absorbed in the game trying to get his right eyebrow to beat his left hand at Video Pong, that he learned he could focus his attention. He was able to spend long periods of time playing this game, because it interested him. Gradually, his ability to sustain a focus of attention on the game was transferred to his schoolwork, as well. This discovery has evolved over the years until now neurofeedback is the preferred treatment of ADD / ADHD by certified therapists.

When a student temporarily loses the flexibility of some muscle because of a sports accident at school, s/he may find that the EMG can help establish a communication with the single muscle units that need to be re-activated. Certain muscle activity, which ordinarily is unconscious, can be evoked consciously with the EMG. The student can then learn to practice the necessary flexibility with the feedback tones, and then slowly learn to increase that activity. Researchers over the last thirty years have reported that such learning may shorten the time it takes for healing to take place.

Tense muscles tend to restrict blood flow. People who live with perpetually cold hands and feet might use EMG biofeedback to release the areas where their blood flow is restricted. After that they can voluntarily warm their hands and feet as needed. A person with relaxed muscles may be able to handle their emotions more easily.

EMG definitely has a place in public school programs. Since schools cannot avoid creating learning situations that are often stressful, it should also provide students with a way to relieve the pain caused by stress. Those ten year-olds, who learn to operate computers CDs and cell phones faster than adults do, can also learn to operate simple biofeedback equipment. Learning to relax muscles with biofeedback is a skill that continues after the machines are turned off. It can be a lifelong learning exercise that has many benefits. It can also lead to important improvements in the way health care is practiced in the future.

INSTRUCTIONS FOR LISTENING TO YOUR MUSCLES TALK WITH AN ELECTROMYOGRAPH (EMG)

By Marjorie Beers King, M.S.

M. B. King, M.S., was a lieutenant in the WAVES during WW II. During the cold war race to find better rocket fuels, she worked as a literature chemist for the aerospace industry. She taught science in high school from 1968. The excerpts quoted throughout this book are from papers that she presented at science teacher's conferences from 1972 – 1979. She graduated from Earth School at age 80 in 2002.

Each fiber in a muscle, called a single muscle unit, produces a pulse of electrical energy as it contracts. An EMG uses surface electrodes placed on the skin over a muscle in order to pick up these pulses from a large number of muscle units located in the area under the electrodes. When the muscles are tense, the EMG will indicate the amount of electrical energy related to the level of tension measured. As relaxation gradually takes place, the measurable amount of electrical energy becomes less. When every muscle unit in a muscle is completely relaxed, no muscle unit firings will be detected, and the EMG will be quiet.

MINIMUM BASIC OPERATING INSTRUCTIONS:

- **1.** Clean the skin area over the muscle with rubbing alcohol. Beginners might start with the forearm muscles, because they are close to the surface and free of hair.
- **2.** Prepare the electrode according to the instructions that come with the particular EMG unit that you are using.
- 3. Place a small daub of electrode cream on the electrodes.
- **4.** Put the two positive electrodes about 4" apart over the desired skin area on the forearm, or forehead. The third electrode (or ground electrode) can be placed somewhere near them.
- 5. Adjust the sensitivity control for 35 microvolts full-scale sensitivity.
- 6. Turn the on/off function switch clockwise to the tone position.
- 7. Adjust the volume control for a comfortable audio level.

GENERAL EXPERIMENTS:

- **1.** Tense the muscle and then relax, it. Notice how the sound changes.
- 2. Tense other muscles, not being measured. Relax.
- **3.** Relax enough to get the tone to turn off (it will be silent when the meter reading drops below 20%).
- **4.** Turn the sensitivity control up (clockwise) and again relax until the tone goes off. When the sensitivity is turned all the way up to 3 microvolts, and the tone turns off, then you are relaxed enough to do the following:
- **5.** If your machine has a function switch that allows you to listen to the clicking sound of individual muscle units firing, explore those sounds.
- 6. Try to fire one muscle unit at a time make it beat a rhythm.
- **7.** Some instruments are connected to computer programs. If you have one of these practice muscle control of any program that can be controlled by the EMG.

The following experiments will acquaint you with the range of frequencies of your muscles (as measured by the EMG), and help you to understand what happens within your body during various activities. Muscles are measured in microvolts, and can range from zero to over one hundred microvolts. When you learn to ride a bike, or eventually

drive a car with the tension of the muscles in your forehead at 10 microvolts, instead of 40 microvolts, you will be less tired when you get back.

Experiment I -- Forehead Muscles

Carefully attach the electrodes to your forehead, and test the machine to make sure that it is measuring the muscle activity correctly. Ask your partner to write down the microvolts of your muscle activity before you begin this experiment. The name of the game here is to read each line one at a time and measure the results. If necessary, print out each line of this poem on a separate card, so you will be sure to read them separately. After you read the first line, your partner can enter the number of microvolts on a chart. Then your partner can then present the next one to you, recording the information before she gives you the card with the next line on it. Repeat the process until you have read all the lines that you can see. Compare the differences as listed on the chart. If you have to squint to read the last lines, please make a note of that, because forehead muscle tension is automatically increased.

How I think is what I see.
Focus defines "reality."
Beyond the things I choose to see,
are other realms of "reality."
Since each one chooses differently,
who should explain "reality?"
When forehead muscles are uptight,
You may have trouble reading right.
If this small print you cannot read,
Glasses may not be your need.
Relax you eyes, relax your brain
There's more than seeing here to gain.
Poem by Jean Millay

Experiment II – Jaw Muscles

Place one of the electrodes along your jaw and the other one on the side of your neck. Record the microvolts of muscle activity before you begin.

- 1) Eat a marshmallow, a few nuts, an ice cream cone, a raw carrot.
- 2) Speak softly, and then louder, and then shout.
- 3) Think of things you don't like.
- 4) Think of someone who is often angry, and how you feel about that.
- 5) Relax your jaw -- teeth slightly apart. Relax as much as you can.
- 6) Record the microvolts of muscle activity and compare this with the first measurement you took at the beginning.

Experiment III – Neck and Shoulders

Place one of the electrodes on the side of your neck and the other one on the top of your shoulder.

Record the microvolts of muscle activity before you begin.

- Tense and then relax your shoulders. Notice that when you tense a muscle very tightly, and then relax it, the microvolt level drops lower than it was before you started. This can be a good way to begin to relax a tight muscle. Get it to move in any direction. Then just intend it to relax, and breathe into the muscle as it relaxes.
- 2) Take a deep breath and drop your shoulders. Some people don't even notice that they often hold their shoulders up to their ears. This creates a great deal of muscle tension, and probably accounts for some headaches.
- 3) Record the microvolts of muscle activity and compare this with the first measurement you took at the beginning

Experiment IV -- Arms and Legs

First place the electrodes on the forearm for these experiments, and then after you have finished this set of exercises, you can place the electrodes on the thigh or on the calf of the leg. These exercises can be used for either arms or legs.

- 1) Explore different ways to raise or lower the level of microvolts of muscle activity.
- 2) Be gentle with yourself as you begin. Don't overdo the process of creating tension. The main idea is to learn how to relax as needed.
- 3) If you are interested in athletics, your coach may help you with suggestions. Many professional athletes have known and used biofeedback for years.

Sometimes, after illness or accident, a person needs to practice tension rather than relaxation. The whole idea of this **"Self-Discovery Model of Biofeedback Training"** is to find your own individual way to feel comfortable in your body, which encourages a healthy attitude about your own life.

LISTEN TO YOUR BRAINWAVES TALK By Marjorie King and Jean Millay

A **brainwave analyzer** measures the electrical activity of the neurons of the brain (page 27). This activity changes with types of thought, though each person's brainwave patterns are as unique as each person's handwriting. Nevertheless, similar mental activities seem to occur in certain frequencies categories, though some thought patterns display a unique mix of different frequencies from right to left. The list below is only a guide to start. It is much oversimplified.

The standard frequency categories are as follows:

Below 4Hz = Delta — Related to deep sleep — may also indicate brain damage 4Hz to 8Hz = Theta — Related to emotions, and to transcendental experiences 8Hz to 13Hz = Alpha — Related to simple relaxation and also to meditation 13Hz to 30Hz = Beta — Related to attention, focused activity, or nervous tension Above 30Hz = Those frequencies observed beyond beta are called Gamma

Eleanor Criswell, Ph.D., introduced biofeedback in her classes at UCSC (Sonoma State) in 1973. Millay's classes at the community college began in 1974. We both used the Aquarius Electronics brainwave analyzers designed by Tim Scully, Ph.D. Students rapidly learned how to use them with no difficulty. There were two forms of feedback: sound for alpha / theta when the eyes were closed, and lights, sounds, and dials for beta / alpha / theta when the eyes were open.

Millay's community college students learned to produce alpha rhythms from both sides of the cerebral cortex at the same time, using two brainwave analyzers, Millay's eight channel Stereo Brainwave Biofeedback Light Sculpture, along with Scully's phase comparator so both analyzer signals could then be compared for frequency similarities and their phase relationships. A low AUM tone was provided when both signals were in alpha and a harmonic tone was added to that when the alpha rhythms where also in phase or in a slowly varying phase angle. While this equipment was more complex to operate, and a trainer was needed in the beginning to show students how to hook up, the results were appreciated by the participants, since a deeper level of meditation could be experienced. Any internal dialog at all would turn the tone off. Often as we are attempting to meditate our minds will wander, and the internal dialog begins before we notice it. However, the tones of the phase comparator stop instantly whenever the mind wanders, reminding us that our intention to meditate had drifted. The students who learned to produce a steady alpha rhythm found that they could relax more easily. For some exercises, students needed to work in pairs so that one could take notes while the other practiced eyes-closed alpha / theta.

A most interesting result of brainwave biofeedback is the help it provides to students from age 10 to adult who have a mild to moderate form of ADHD and ADD. Typically, their initial baseline would show a wavering dial, since their brainwaves tend to move rapidly from beta, alpha, theta, alpha, beta, etc. For them it is important to focus eyes-open attention on something of interest, so that the feedback for their beta waves increases in percent time. In the past, creative engineers connected a toy train to the beta rhythms so the train would go forward only when the student produced a steady focus of attention in the beta frequency category. That worked. This training is now done clinically in many places. Steve Wall, Ph.D., president of the Biofeedback Research Institute in Cotati, CA, has developed an elaborate and aesthetic computer sound and visuals that can also print out charts of overall activity for multiple feedback modalities when his client's session has ended. Wall's complex system requires a trainer to operate it for the student or client.

FLASHING LIGHTS IN BRAINWAVE FREQUENCIES (Strobe Lights are not to be used with anyone who might be subject to epilepsy)

Many students have already experienced strobe lights at concerts for a whole evening without any problems. However, most students see the dots of light right away, so the length of time of exposure can be very short. Most commercial strobe lights are very bright and the light is off longer than it is on. I find these difficult to use. I have had the most success with this flashing light experiment using an old variable speed 8 mm or 16 mm film projector. Here the light is on more than it is off, and it is a much softer light with a lower light level. As the rate of projection is turned down from its normal 25 fps (flashes per second) or 18 fps on old silent ones, different types of images appear on the closed eyes of the student. Millay studied over a hundred drawings by students over a few years time. Since the light frequencies are in the same range as the brain's electricity, the results suggest that we may be looking at the rods and cones projected onto the eyelids. We may be **looking at** what we are **seeing with**.

The drawings below are typical illustrations from that study:

PERCEPTION AND TINY DOTS OF LIGHT

1) When The Eye Sees Dots of Light -

Ask all the class members, who volunteer to participate, to draw whatever they see at different frequencies of flashing lights. Share them with the class. Every one of us is different, and some may also see images from memory over the top of these dots and draw them as well. Whatever the student sees and draws is part of the dynamic of his/her own seeing and expression. What is important about what we learn from each other is about how we each "think" differently. Encourage enjoyment of the difference.

2) Computer Images –

Find the resolution of your own computer if you have one. Computer images are also created out of tiny dots of colored light. The number of dots per square inch is called the resolution. When Apple computers were first created, the dots were 1/8" -- very crude.

3) Dots of color in paint and printing - The teacher may want to show prints that are reproductions of paintings by famous post-impressionists. The best example is the work of George Serat who believed that color is mixed in the eye. He used little dots of paint to create large paintings. Lithograph printing of these paintings blends the colors needed by printing dots of different colors together. If possible, plan a field trip to a print shop.

- A) A student may bring in any newspaper comic page in color or print to show the class with a microscope how the dots fit together to form the total image.
- **B)** A student may want to paint a picture with dots of paint as a project.
- c) The set of colors on the <u>right are the basic primary colors of paint</u>. When these are mixed together, most other colors are available. For example, Cyan and Magenta (Primary Red) make various shades between Violet, Purple to Blue-Violet.



D) The set of colors on the <u>left are the basic primary colors of light</u>. When a light shines through a red-orange jel onto a wall where another light shines through a green jel, the mix will create a yellow color. (Refer to the projects listed on Page 15, and Appendix D.)

THE FREQUENCIES OF SOUND AND ITS RESONANCE WITH BRAINWAVES

- 1) Sound is not part of the frequencies from the sun, because it travels through air. It is much slower than the frequencies of Electromagnetism. When you see lightning in the distance, notice how long before the sound reaches you. This can give you an idea about how far away the lightning is. If you see it very close to you, you hear the sound right away, but if you see the lightning twenty miles away, you might have to count to twenty very slowly before you hear that wonderful rumbling sound.
- 2) However, sound resonates with human brainwaves and heart rhythms, which is the essence of musical rhythms. Define the words "resonance," "rhythm," "entrainment." For music that can entrain brainwaves into deep relaxation, contact: <u>www.hemi-sync.com</u> <u>www.brainsync.com</u>, or <u>www.stevenhalpern.com</u>
 - 3) Most popular songs are in 4/4 rhythms. Think of different types of music and how the different ones make you feel when you listen. Prepare a project with <u>short</u> selections of recorded music of marches, waltzes, rap, soft rock 'n' roll, jazz, Blue Grass banjo, Bolero by Ravel, the end of the chorus from Beethoven's 9th Symphony. Encourage openness to new rhythms. Ask the class to express their feelings as you play each one.
 - 4) Chinese, African, Japanese, Middle Eastern, Scottish bagpipe, Latin and North Indian Classical Music. All have their own unique musical rhythms. Students from any of these cultures may know these rhythms well, and may be willing to share them with the class.
 - **5)** A CD may be available to demonstrate the complex rhythms of 5,7,9, 13, and 19. Zakir Hussain and his famous father Alla Rakha could play all of these rhythms. Their recordings of them are available at: <u>www.momentrecords.com</u> and <u>www.aamc.com</u>