

Computerized Biofeedback and Stress Management

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Editors Note:

In a future issue Dr. Scully will present a construction article on building and programming a simple biofeedback system for a personal computer system.

Stress is killing many of us every year. Ulcers, insomnia, headaches and many allergies are generally accepted as stress-related diseases. Radicals in the medical community say that even cancer is stress-related. Be that as it may, biofeedback stress management training is becoming popular as a medical treatment for stress-related problems. Educational biofeedback stress management training is even more interesting; this training teaches people how to manage stress before it becomes a medical problem. Your microcomputer could become an educational biofeedback instrument.

What Is Biofeedback?

Biofeedback is the measurement of a BIOlogical process and the FEEDing BACK of the results of this measurement to the originals being measured. Looking in a mirror is a biofeedback process in which information about one's facial expression is fed back. Biofeedback training takes place when biofeedback information is used to produce conscious control over the process which is measured and fed back, e.g., when an actor uses a mirror to learn to produce a desired facial expression.

Biofeedback training is usually done to teach awareness and control over body processes of which most of us are not usually aware. These might include the electrical activity of the brain (EEG or electroencephalo-

graphic signals), the electrical activity associated with subtle changes in muscle tension (EMG or electromyographic signals), the electrical resistance of the skin (GSR or galvanic skin response and BSR or basal skin resistance) and changes in the temperature of the fingertips. These body processes are usually selected for training because they are fairly easy to measure and because they reflect stress or relaxation. To a lesser extent, they reflect changes in consciousness.

The relationships between body processes and mood or thought are not the same for everyone. You might say that each of us has a personal "body language." But there are some general relationships which you'll need to understand in order to understand biofeedback stress management training.

Skin Temperature

Cold hands and feet are a common stress response, a result of peripheral vasoconstriction. The "fight or flight response" to stress causes the sympathetic nervous system to contract the smooth muscles lining peripheral blood vessels, reducing blood circulation and thus reducing skin temperature at the extremities. A deeply relaxed person may have a fingertip temperature of 37 C (98 F), while a person under severe stress may have a fingertip temperature several degrees colder than room temperature, perhaps as low as 20 C (68 F). This relationship between stress and fingertip temperature has made biofeedback training in hand-warming a popular modality for clinical stress management training.

Peripheral skin temperature is influenced by a number of variables, of which stress is only one. The

environmental temperature has an obvious influence and most training is done in a constant temperature room with no drafts. A variety of drugs, including tobacco, influence peripheral vasoconstriction. Vigorous exercise increases peripheral circulation and extended immobility decreases it. Even apart from these factors, warm hands do not necessarily imply a state of relaxation, although cold hands are a fairly reliable indicator of the presence of stress. At best, warm hands are an indication of sympathetic nervous system relaxation.

The Electrical Properties of the Skin

Changes in the electrical properties of the skin are caused primarily by changes in sweat gland activity. Your body has two main types of sweat glands: those which respond

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mostly to temperature changes, which are part of your body's thermodynamic system, and those which respond mostly to stress. These glands are not evenly distributed over the skin, and the stress responders which are of interest in biofeedback training are located primarily on the hands and feet.

There are several ways of measuring the electrical properties of the skin, some of which are passive techniques for sensing naturally occurring electrical potentials on the skin

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(EDP or electrodermal potential), while other methods use a sensing current to measure the electrical resistance (BSR or basal skin resistance) or conductance (BSC or basal skin conductance) of the skin.

The baseline levels of these measurements are influenced by many factors including environmental temperature, skin temperature, drug effects, location on the skin and the subject's level of arousal. Short term fluctuations in these measures, as a response to stimulation, are sometimes called GSR or galvanic skin responses. GSR responses may be triggered by sensory stimuli, such as an unexpected sound, touch or flash of light. They may be triggered by arousing ideational stimuli, such as an obscene word, the memory of an unusually pleasant or unpleasant event or the threat of a painful stimulus. They also may be triggered by physical exertion; even holding your breath for a little while will usually produce a large GSR response.

Biofeedback training in increasing skin resistance (BSR) is used as a deep relaxation technique. Biofeedback training with GSR is used in systematic desensitization, a procedure in which excessive response to specific stimuli can be unlearned. Skin resistance usually increases and the size of GSR responses usually decreases with relaxation. But some people with chronic stress have unusually high BSR and may have unusually large or small GSR responses. The lack of a GSR response to a particular stimulus may indicate that it is not arousing, or that the subject is already under severe stress (and hence not responding), or that the blood sugar level is low (skipping a meal often flattens GSR responses), or that skin temperature is low, etc. Thus GSR responses are often misinterpreted. When carefully interpreted, GSR and BSR feedback have proven to be quite useful.

Muscle Tension

Galvani discovered in the 18th century that electrical impulses could trigger muscle contractions. His discovery stimulated much of the early research in neurophysiology and electricity. By the early 20th century, researchers were studying naturally occurring electrical signals associated with muscle action, and the use of electromyography (EMG) to measure these signals for diagnostic and clinical purposes soon become widespread. These uses of EMG data

focused on traumatic damage to nerves and muscles, or other neurological pathology, and did not involve much exploration of the real relationship between muscle tension and events in consciousness until after WWII.

Although skeletal muscles are generally considered to be under conscious control, excess muscle tension is a common companion of stress. Many people with chronic stress are unaware of their habitual muscle tension until it becomes painful (e.g., in a tension headache) and most such sufferers have little or no conscious control over the troublesome tension.

Some psychologists believe that we hide behind barriers of "muscle armor." Others say that there are knots of muscle tension which correspond to "knots" in consciousness, traumas or problem areas. For varying reasons, EMG biofeedback training has come into wide clinical use as a relaxation technique.

The Electrical Activity of the Brain

Hans Berger is generally credited with having first recorded the human electroencephalogram (EEG), the electrical activity of the brain, by attaching electrodes to the exposed cerebral cortex of patients with head injuries in 1929. Later he measured similar but weaker signals on the scalp. Berger hoped to find an explanation for psychic phenomena in EEG measurements, but was only able to find a vague relationship between events in consciousness and EEG signals.

EEG signals are weak, complex, constantly changing and usually are different when measured at different scalp locations. For some purposes,



they are classified into four broad categories on the basis of their frequency. Signals between 8 and 13 Hz (Hertz or cycles per second) are called alpha waves because they were the first pattern identified by Berger. EEG signals above 13 Hz, usually weaker in amplitude than alpha, are called beta waves and were the second major pattern named by Berger. Signals between 4 and 8 Hz are called theta waves and those below 4 Hz are called delta.

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Alpha waves, which are usually most prominent in the occipital lobes at the back of the head, are often associated with states of relaxation and with a lack of visual attention (the occipital lobes of the brain process visual information), while beta waves are often associated with arousal, activation and visual attention.

Research on the different stages of sleep revealed that brainwaves progressively slow in frequency as sleep approaches and deepens, from beta to alpha, alpha-theta (drowsiness), a mixture of 14 Hz sleep spindles with a low voltage background (the one departure from a smooth decreasing frequency progression), increasing theta, theta-delta and finally delta during deep dreamless sleep. One of the earliest applications of EEG in the study of consciousness was in the study of sleep and dreaming.

Studies of the brainwaves of Zen monks and yogis revealed that these meditators have an unusual and characteristic EEG pattern consisting of unusually high amplitude alpha spreading over the entire scalp during meditation. Although later research has shown that only some forms of meditation produce this characteristic EEG pattern, these findings stimulated interest in the relationship between EEG and altered states of consciousness.

Early EEG biofeedback training was for the enhancement and suppression of occipital alpha waves, and reports of the high alpha state were similar to those of meditators. This stimulated interest in alpha

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training as an aid to relaxation and meditation. Although some clinical biofeedback training is now done for other purposes, e.g., SMR (sensory motor rhythm) training for control of epileptic seizures, most clinical EEG training is presently alpha enhancement and alpha suppression training.

Pitfalls in Do-It-Yourself Biofeedback Training

Biofeedback training can be an educational experience of great value. It can teach useful physiological self-control skills and increased self-awareness. It can help you to discover how much responsibility you can take for how you feel. But it can also be dangerous if you misuse it.

Medical Problems

Treating your own medical problems with home biofeedback training, without professional guidance, is potentially dangerous. If you decide, for example, that your chronic headaches are due to muscle tension and begin a program of EMG biofeedback training in muscle relaxation, you might delay obtaining professional medical help for a more serious problem, such as a brain tumor. Medical biofeedback training (i.e., training with folks who have medical symptoms) isn't done professionally until a careful medical examination and diagnosis has eliminated the possibility of hidden problems.

If you are taking prescription medication of some kind, especially for diabetes, high blood pressure or some other stress-related problem,

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there's another potential pitfall. If you do successful biofeedback stress management training, learn to relax and generalize these relaxation skills to your everyday life, then it is possible that the maintenance dosage of your prescription medication could become an overdose! In one case, a diabetic patient collapsed in the street from insulin shock after successful biofeedback training. The solution to this problem is simple. Biofeedback training isn't done by folks taking prescription medication

unless the prescribing doctor is willing to become involved. It is necessary to monitor the drug dosage carefully. The patient should be familiar with the early warning signals of drug overdose.

The best advice for those thinking of do-it-yourself medical biofeedback training is **don't**. Such training should be done under professional supervision. Home biofeedback training should be educational biofeedback done by folks who do not have serious medical problems. Many believe that good stress management skills can be valuable as preventative medicine so that problems are less likely to develop later.

Know What you are Training

Another pitfall of do-it-yourself biofeedback training can be training for an undesired response. A poorly designed or improperly operated biofeedback instrument may give you feedback for body processes you don't want to train. For example, most EEF (brainwave) biofeedback instruments will also respond to eye blinks and muscle twitches. A well designed instrument will respond to these with a special signal which indicates that a non-brainwave signal is blocking the accurate measurement of brainwaves. But a less sophisticated instrument or an unsophisticated operator may end up training an eyelid tremor instead of alpha waves!

Electrical Shock Hazard

Most modalities of biofeedback training involve connecting electrodes carefully to your body to get the best possible electrical contact. This is necessary for measuring weak electrophysiological signals. But it can be dangerous too.

Many biofeedback instruments are battery powered. This is a simple way to minimize electrical shock hazard from the power line. Even a battery powered instrument can deliver a nasty shock if it is poorly designed. It is important to look at your circuit design and be sure that the current which can flow through the body is limited to a few microamps, even if part of the instrument fails.

Most computers are power line operated. It is not safe to directly connect your body to a power line operated instrument. Fatal electrical shock could result under some failure conditions. Several people die each year in hospitals from such electrical shocks. The solution to this problem is optical isolation and battery powered physiological data acquisi-

tion circuitry. An optical isolator converts an electrical signal into a beam of light whose brightness varies as the electrical signal varies. This light shines onto a phototransistor which converts the optical signal back into an electrical signal. In this manner, physiological data can get to the computer without hazard. Optical isolation also minimizes another troublesome problem: pick-up of power line hum by sensitive EEG or EMG amplifiers.

What to Train and How to Train It

Different people are quite different in their expression of stress. I respond to stress primarily with cold hands while you might respond mainly with tense muscles while your hands remain warm. Because of these individual differences, it helps to pay attention to picking the right physiological modality for your training.

A major goal of educational biofeedback training is increased self-awareness and understanding. This is another reason for beginning your biofeedback training with a period of introspection. In our culture we rarely give ourselves time to sit down, be quiet and learn what's happening inside. Yet this is a crucial first step in biofeedback learning. Listen to your body for awhile, notice how it responds in different situations. You'll find that your awareness of internal events will grow stronger as biofeedback training progresses.

Generally, it is a good idea to begin your training with the modality in which you show the most tension. But, if you have instruments available for other modalities, it is a good idea to check these from time to time, or better yet, program your computer to record data from these modalities while you train with the chosen one. This will allow you to catch any tendency for tension to shift from one modality to another.

How to Relax?

Although you probably could eventually learn good relaxation skills simply by working with feedback signals from your biofeedback system (learning to increase physiological relaxation by a trial and error process), it is helpful to start out with a toolkit of relaxation techniques. Because of variations in people, you may find one exercise most helpful while I might find another to be best. With biofeedback you will have a chance to check out each one and validate its usefulness for you. I suggest that you try each exercise for at least a week of daily practice before you decide if it is effective for you.

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The mind and body are interwoven. The stresses and tensions of your memories and intentions will create corresponding reactions in your body. The stresses and tensions built up in your body will in turn influence your mind.

Still, the mind and the body relaxes. Relax the body and the mind becomes calm.

Unfortunately, you cannot relax by an act of will. Willful desire and active volition create tension.

Relaxation must be permitted. You must learn to allow yourself to untense. You cannot make yourself relax. You can untense yourself by learning to let yourself be. Such

Men are disturbed not by things, but by the views they take of them.

learning is gradual and the skills involved are largely nonverbal. Mastery of the necessary skills depends, not upon rational understanding, but upon regular practice. However, while the skills associated with active effort require energetic exercise, the skills of relaxation require passive exercise. You must practice, but you should not try too hard. You must learn how not to try at all.

One important goal of this training is to learn to be able to relax quickly, anywhere and in any situation. This skill we call the **LITTLE RELAXATION**. It takes about a second to do it, it's effortless - about as easy as snapping your fingers, and it eventually becomes as automatic as breathing. It is something that you do whenever you decide to do it.

It is important that you set aside some time, on a regular schedule, for deep relaxation every day. A session in which you relax deeply for 10 or 20 minutes is what we'll call the **BIG RELAXATION**.

Relaxing is a little like riding a bicycle; although you may be able to do it, it is difficult to describe how to do it, using only words. That's one reason why biofeedback instruments, which measure body processes associated with relaxation/tension, are very helpful in learning this skill.

There are different ways of looking at biofeedback instruments. One is to think of the instrument as something

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for you to control. Another is to think of the instrument as something magical which will do the task for you. These approaches will keep you from getting all the possible benefits of biofeedback training. The best approach is for you to pay very close attention to how you feel inside and to what you are thinking at times when the biofeedback instrument signals relaxation or tensions. The focus of your attention should be inward. It is absolutely essential for you to practice the **LITTLE RELAXATION** and the **BIG RELAXATION** in between sessions with the biofeedback instruments. You can use the biofeedback sessions as a way of checking out and validating your relaxation skills.

Here are a few things to think about which will help you gain insight into your own stress and relaxation patterns. What situations are you uptight in? How do you feel when you get uptight? Do your hands get cold? Do any muscles get tense? Which ones? What are you thinking about when you get uptight?

A LITTLE RELAXATION exercise...

Take a deep breath and hold it. Raise your shoulders up high and hold them. Clench your fists and tense up all of the rest of your muscles for a few seconds. Then let go, letting your breath out, letting your shoulders drop, go limp all over and smile, saying to yourself: "What

It is never the event, but rather our interpretation of it, that causes our emotional reaction.

a silly thing to do to my body!" If you are in a public place and can't do the complete exercise, at least use the breath.

Some BIG RELAXATION exercises...

1) Imagine that your mind is a lake or a pond and that thoughts and feelings passing through your mind are like ripples and waves on that lake. The mind cannot be stilled by force. If you could reach out with your hands to smooth away the waves and ripples on the lake, you'd just make



more and more waves. But, if you let go and do nothing, the ripples will slowly die away, leaving a calm lake, smooth like a mirror in which the sensory impressions you receive will be reflected without judgment, attachment or analysis.

An exercise to help you do this is to think the words: "the mind cannot..." as you inhale, and think "be stilled by force..." as you exhale. Pay attention to your breathing and repeat these phrases silently with every breath. Without making any special effort you will find that your breathing becomes slower and your mind calmer. This is an example of the use of a mantra, a simple phrase chanted over and over again to alter consciousness.

2) Another simple mantra which helps many people to relax deeply is "let go." Think the word "let" as you inhale and the word "go" as you exhale. As you exhale, feel stresses and tensions draining out of your body along with your breath. It helps if you breathe from your diaphragm, down low, instead of breathing from your chest...

3) Still another popular mantra is "relax deeper." Imagine a pyramid or a triangle. As you inhale, see the word "relax" running from the bottom of the triangle to the top. As you exhale, see the word "deeper" running down the side of the triangle to the bottom, and feel your body grow heavier, warmer and more relaxed as you slide down from the peak of the triangle.

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4) Guided imagery can be very effective for relaxation. One image some folks work with involves imagining that your body is filled with a warm fluid, the way that a balloon is filled with air. Now imagine that a valve has been opened and the fluid slowly drains out, taking all of your tensions and stresses with it, leaving you limp as a rag doll and very deeply relaxed.

5) Autogenic phrases are another form of guided imagery which can be used in much the same way as a mantra. These phrases invite you to picture various relaxing images and are especially effective in hand-warming or other skin temperature training. Repeat... each... phrase... quietly... to... yourself... very... slowly.

I feel quite quiet.

I am beginning to feel quite relaxed.

My feet feel heavy and relaxed.

My ankles, my knees and my hips feel heavy, relaxed and comfortable.

My solar plexus, and the whole central portion of my body, feel relaxed and quiet.

My hands, my arms and my shoulders feel heavy, relaxed and comfortable.

My neck, my jaws and my forehead feel relaxed. They feel comfortable and smooth.

My whole body feels quiet, heavy, comfortable and relaxed.

....repeat....

I am quite relaxed.

My arms and hands are heavy and warm.

I feel quite quiet.

My body is relaxed and my hands are warm, relaxed and warm.

My hands are warm.

Warmth is flowing into my hands, they are warm, warm...

I can feel the warmth flowing down my arms into my hands.

....repeat....

My whole body feels quiet, comfortable and relaxed.

My mind is quiet.

I withdraw my thoughts from the surroundings and I feel serene and still.

My thoughts are turned inward and I am at ease.

Deep within my mind I can visualize and experience myself as relaxed, comfortable and still.

I am alert, but in an easy, quiet, inward-turned way.

My mind is calm and quiet.

I feel an inward quietness.

....repeat....

The relaxation and reverie are now concluded and the whole body is reactivated with a deep breath, and the following phrases:

I feel life and energy flowing through my legs, hips, solar plexus, chest, arms, hands, neck and head... energy that makes me feel light and alive.

Stretch.

5) Imagine yourself in a very safe and pleasant place, perhaps on the beach, lying on the warm sand, listening to the gentle pounding of the surf, and feeling the warm sun on your body. Let the image become very real, until you can smell the suntan oil and feel the sand between your toes. If you like, imagine yourself running along beside the water, running and running until you are so tired that you can't run any longer. You flop down in the warm sand to lie there limp and warm and relaxed, feeling very good.

6) Another good form of guided imagery for relaxation is visualization of the body process you'd like to experience. If you want a muscle to relax, visualize it as limp and resting. If you want to warm your hands, visualize the veins and arteries relaxing and allowing more warm blood to flow, feel your arms become heavy and limp and imagine the blood draining down into your hands (you may sit so that your arms and hands dangle down). Feel your pulsebeat in the tips of your fingers.

This same creative imagination may be used in other areas of your

life. Start thinking and visualizing positively about the things you'd like to do or the things you'd like to have happen. Develop the habit of thinking about, expecting, talking about and visualizing the things you desire, and not the things you fear.

7) Progressive relaxation exercises are a bit more active and are especially good if you are doing EMG training. The idea behind these exercises is to learn how to relax your muscles by learning to sense the dif-

The greatest discovery of my generation is that human beings by changing the inner attitudes of their minds can change the outer aspects of their lives. It is too bad that more people will not accept this tremendous discovery and begin living it.

ferences between relaxation and tension.

Start out by lying down in a comfortable place. Relax. Pause. Now slowly begin tensing the muscles in your toes. Tighter...tighter...feel the tension and hold it...hold it. Now relax and let it go, completely. Notice how your toes feel when they are limp and relaxed. Pause. Now tense up your toes again. Tighter. Hold it and notice how the tension feels. Okay, relax completely. Let go. Notice how this feels, limp and warm and relaxed.

Now tense all the muscles in your feet, not just the toes. Tighter. Hold the tension and feel it, notice it. Pause. Then let go and relax. Notice how this feels.

Continue this exercise slowly from toes to head. Work with all the muscles in your body. You'll probably find that relaxing the muscles in your facial region makes it very easy to cut down on internal dialogue (self-talk). Eventually, after about 20 minutes, you'll come to the stage where you tighten up every muscle in your body and then let go. Just relax and float along for a while before you return to your normal activities. Enjoy the deep relaxation that comes from completing this exercise.

NOTE: Be gentle in tightening your jaw muscles — don't damage your teeth! □

