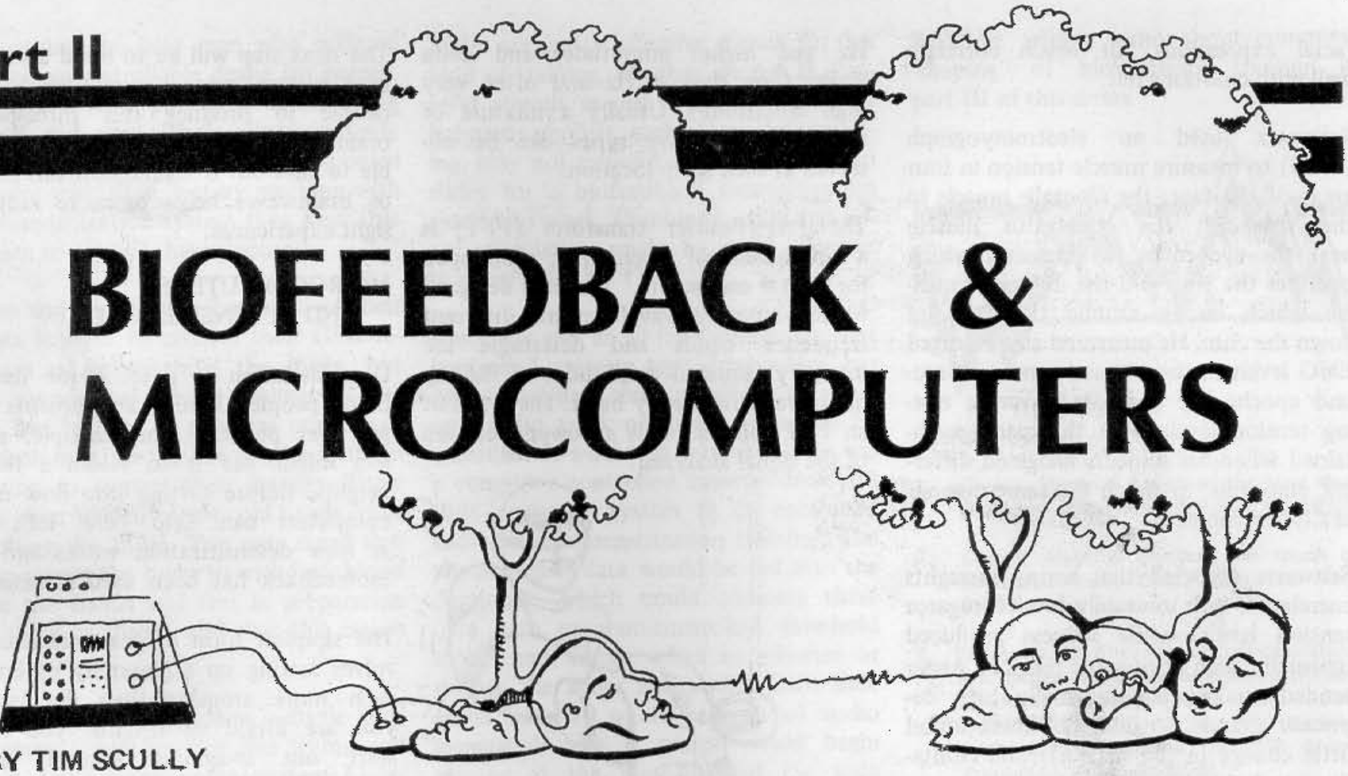
Part II

BIOFEEDBACK & MICROCOMPUTERS



BY TIM SCULLY

Although this series is titled 'Biofeedback and Microcomputers', so far we've mostly discussed the use of microcomputers for physiological data analysis. We'll get to computerized biofeedback soon, but it will be worthwhile to also talk a little more about physiological data analysis by computer: it may be the key to decoding the body's language and opening up new modes of intra- and inter-personal communications and new possibilities for exploring inner space,

SENTICS: EMOTIONS IN A FINGERTIP

Manfred Clynes,[1] a musician and biocybernetic researcher, has approached the problem of decoding the body's language from a unique direction. He asked experimental subjects, at a signal from his computer, to express various emotions by movements of one fingertip, while his computer recorded the fingertip's responses. A strain gauge was used to convert variations in fingertip pressure into a varying electrical signal which an A/D converter communicated to the computer.

The computer collected samples of data from the strain gauge at regular intervals. If one recording of these repeated samples of strain gauge data were graphed by the computer, the result would be a picture of fingertip pressure as it varies with time. As in the brainwave experiments described in the last installment, several recordings were made for each emotion, and the resulting patterns were averaged together. This averaging process smoothed out random variations in fingertip pressure and produced a pattern typical of one emotion for the person whose fingertip was tested.

The results of this process were a set of curves of fingertip pressure versus time for emotions such as love, hate, joy and sadness. The purpose of Clynes' experiment was to see if the body has a universal language for expressing emotions, a language independent of cultural and linguistic differences. Clynes traveled extensively and tested subjects from many different cultures: he found that the patterns of fingertip pressure for these emotions were distinctive and cross-cultural.

Clynes called these patterns 'essentic forms', and he reported that the essentic form for anger is the same for Mexican, Japanese, American and Balinese fingertips: a brief sharp pulse of pressure. The pattern for love is universally a gentle curve.

In more recent research,[2] Clynes has collected fingertip responses to musical works by different composers and has once again found patterns of response typical of each composer. He even found that the essentic forms were similar for different subjects and between different works by the same composer.

To explore essentic patterns with your computer, you need to be able to communicate fingertip pressure data to it. A strain gauge will do the job, but may be a little expensive. A material called 'Dynacon A' (Dynacon Industries, 14 Bisset Drive, West Milford, N.J. 07480) might do the same job with less cost. In any case, a simple 8 bit A/D converter (now under $10!) will suffice to complete the interface to your computer. If I can get it together, a future article may give an exact circuit diagram and a program for producing essentic forms with a Poly video system.

A MIRROR FOR EMOTIONS

Gary Schwartz,[3] working at Harvard University, has done some very interesting work in uncovering patterns of muscle tension in the facial region which are related to emotions. He learned that there are patterns of muscle tension which are too subtle to produce visible facial expressions but which correlate well with emotions felt.

Schwartz used an electromyograph (EMG) to measure muscle tension in four areas of the face: the frontalis muscle in the forehead, the corrugator muscle near the eyebrows, the masseter which operates the jaws and the depressor muscle which circles around the lips and down the chin. He measured and averaged EMG levels in these muscles over 30 second epochs. He compared average resting tension levels with the readings obtained when his subjects imagined different emotions, in much the same manner as Clynes' subjects.

Schwartz reported that happy thoughts correlated with unusually low corrugator tension levels, while sadness produced unusually high corrugator tension. Anger tended to produce unusually high depressor muscle tension. Schwartz found little change in the masseter and frontalis muscles for these three emotions, so it appears that a two channel EMG system may be enough to identify them.

Can you imagine a two channel EMG system interfaced to your computer with a graphic display showing the facial expression that corresponds to your hidden emotions? Such a mirror for emotions is under development for use in counseling, and a future article may describe the hardware and software for it in more detail. The system will use Aquarius Electronics EMG amplifiers and S-100 compatible interface, along with a Poly video card.

INSIGHT: GETTING A BRAINWAVE

Norman Don [4] used a computer to search for brainwave patterns that might identify moments of insight. To understand his experiment, it will help to review a bit of the history of electroencephalography (the measurement of brainwaves). When Hans Berger first recorded human brainwaves in 1929, he attempted to classify and categorize the constantly changing waveforms which he observed. He used amplitude and frequency differences to establish rough categories for types of brainwaves. The use of amplitude and frequency domain features to classify brainwaves is still popular, and you may have heard of alpha waves (8-13 Hz and fairly high amplitude), beta waves (13-30 Hz and low amplitude), theta waves (4-8 Hz and higher amplitude) and delta waves (less than 4 Hz and often very high amplitude). Usually a mixture of different brainwave types can be observed at each scalp location.

The fast Fourier transform (FFT) is a mathematical technique, developed for digital computers,[5] which is designed to decompose a waveform into different frequency bands and determine the intensity (squared amplitude) of the signal in each frequency band. The result of an FFT calculation is a power spectrum of the signal analyzed.

Don used FFT to analyze a single channel of brainwaves in his research. His subjects were graduate students in psychology who were practicing an introspective technique called 'focusing' while tape recording a running commentary of events in consciousness along with their EEG data. Each subject reviewed his tape recorded commentary of his session and identified those times, if any, during which insight or 'ah-ha' experiences took place. Don then used a computer to do FFT analysis of the tape recorded EEG data. He broke the long tape into short time segments called epochs, each 2.56 seconds long, and instructed his computer to calculate in FFT power spectrum for each epoch. A typical session consisted of 1024 epochs.

Don wanted to test his hypothesis that insight experiences would be correlated with unusually high peaks in the alpha band and in its two subharmonics in theta and delta. He wrote a computer program to sort out those which matched this general pattern – he was right: the insight experience did happen during these epochs. The next step will be to build a biofeedback system, using a computer, to train people to produce this three-peaked brainwave pattern. Then it will be possible to find out if training for this pattern of brainwaves helps promote more insight experiences.

MICROCOMPUTERS AND DESENSITIZATION

Desensitization is a technique used to help people lessen attachments and get over phobias. For example, a person might use it to lessen a fear of heights. Before getting into how microcomputers can help here, let's look at how desensitization works and how biofeedback has been used in doing it.

The simplest form of desensitization involves setting up a hierarchy of images, each more arousing than the last. If you are afraid of heights, you might start out imagining yourself safely in your favorite chair in your living room, then walking outdoors and up a few steps onto a low platform with a railing, then imagine removing the railing and then begin raising the platform up slowly. If imagining this series of images is all you did, the result would probably be just discomfort or even fear. The trick to desensitization is to stop as soon as fear or discomfort is felt, and back up to an earlier, less threatening image until you can relax again. Then try moving forward to more arousing images until fear begins again. If this process is continued, you find that it is possible to make more and more progress through the series of images as you practice more. You are becoming desensitized to images of heights.

One simple form of biofeedback desensitization was developed by Byron Allen and Ken Lebow[6]: a slide projector controlled by galvanic skin response (GSR). You may recall from our last article that a GSR is a brief drop in the electrical resistance of your skin. Byron and Ken's projector advanced to a new slide at regular intervals as long as no GSR response happened. But if a GSR occurred, indicating autonomic nervous system arousal, then the projector would stop advancing and back up to earlier slides. Once the GSR was over, the projector would resume advancing.

Byron and Ken worked at Lompoc Federal Correctional Institution and used their system to help men who suffered from an uncontrollable desire for heroin. Their slides were photos of heroin being bought and used. Their clients initially showed uncontrollable GSR responses to every such slide, but by working with the desensitization system they were able to learn to control this response.

Byron and Ken found that some of their clients learned to control their GSR responses while watching the slides, but still experienced strong feelings. These men had learned to suppress one physiological response to the images without learning to control their feelings. These same men tended to get cold hands while watching the slides. You may recall that stress causes the body to withdraw blood from the hands and feet in preparation for 'fight or flight', and that this causes cold hands.

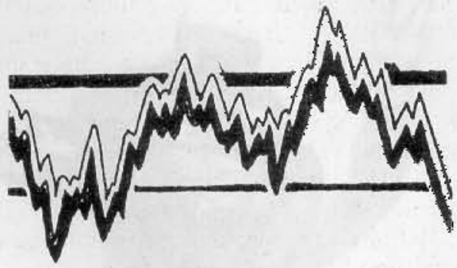
Aquarius Electronics now sells a slide projector controller just like Byron and Ken's. After designing that system, I later built an improved system which used both skin temperature and GSR to control the slide projector. Slides advanced at regular intervals only if hands were warm and no GSR response was detected. Cold hands would cause the projector to stop advancing and 'freeze' until the hands warmed up again. A GSR response caused the projector to back up three slides and then stop. This system worked out well in a pilot study early this year with outpatients in the chemical dependence program at Gladman Memorial Hospital in Oakland, California.

Slides are pretty effective stimuli for this kind of training, but they are not as powerful stimuli as real life situations. Mild habits or phobias, such as cigarette smoking, may not respond strongly enough to slides for a biofeedback desensitization system to work. Combined audio and visual stimulation might be more effective in many cases.

I recently saw an ad for a microcomputer controlled cassette tape drive which has one digital data track parallel with a second audio track on which voice can be recorded. It would be very simple to use a computer controlled cassette deck and slide projector system to do combined audio-visual desensitization training. The physiological data would be fed into the computer, which could compare these data with program-controlled threshold values and decide when to advance or reverse the slides and audio. Each slide could have 10 or 15 seconds of audio associated with it which would begin playing at the same instant the slide appears on the screen.

Even without the audio feature, a computer-controlled desensitization system makes a lot of sense. The computer can be programmed to 'shape' the task so that it is not too difficult at first and so it isn't too easy as learning progresses. This is done by readjusting the thresholds which control the slide projector. The computer can also easily readjust the time each slide is displayed and it can keep good records of training purposes.

We'll be talking more about computer 'shaping' of biofeedback training in part III of this series.



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5. Cooley, J., Lewis, P., & Welch, P. The fast Fourier transform and its application to time series analysis. In K. Enslein, A. Ralston & H. Wilf *Statistical Methods for Digital Computers* (Vol 3 of Mathematical Methods for Digital Computers) Wiley, New York (1977).

6. Lebow, K. & Allen, B. *Finding a Cure for Treatment*, Lompoc FCI DAP Program (1974).

CORRECTIONS FOR OUR SEPT-OCT ISSUE

- Utter Chaos provided the photographs in the PET article on pages 22, 26, and 27 of the Sept-Oct issue.

- In the article 'Computer Networking' by Larry Tesler, the next to last paragraph on page 17 should read as follows:

  Let us look at each of these cases. After packet 3 is lost, retransmission (packet 3R) restores order. After ack 4 is lost, retransmission causes D to receive a duplicate packet (packet 4R), which it must acknowledge (ack 4R) so that S will not continue to retransmit indefinitely. After ack 5 is delayed, not only does D receive a duplicate packet (packet 5R), but S receives a duplicate ack (ack 5R), which it simply ignores.

TRS-80

Radio Shack is now a real computer company – you can tell because they're delivering their systems late. We still hope to have a system for review in time for the January-February press deadline. Meanwhile, a few bits of information: delivery of systems began August 15; it's confidential just how many systems have been delivered. Both the 4K and 16K systems may be ordered with a 6 – 8 week delivery time. The first TRS-80s were scheduled to reach Radio Shack Stores in October, to inaugurate the opening of the first Tandy Computer Store in Fort Worth.