JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1978, 11, 215-223 NUMBER 2 (SUMMER 1978)

MODIFICATION OF COMBINED MIGRAINE-MUSCLE CONTRACTION HEADACHES USING BVP AND EMG FEEDBACK[1]

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The effect of blood volume pulse (BVP) and frontalis muscle action potential (EMG) feedback on control of vasoconstriction of the temporal artery and frontalis muscle activity in combined migraine-muscle tension subjects was investigated in a multiple baseline design (across subjects and responses). The data indicated: (a) both subjects obtained an ability to control BVP during BVP feedback and EMG during EMG feedback; (b) there were decreases in frequency of migraine headaches during BVP feedback and decreases in muscle contraction headaches during EMG feedback. The results of this study supported the theoretical explanation of two pain mechanisms involved in combined muscle contraction-migraine headaches as well as the effectiveness of biofeedback procedures that target directly the specific pain mechanism in the elimination of the two types of head pain.

DESCRIPTORS: migraine headaches, biofeedback, muscle contraction headaches, humans

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Research in the area of biofeedback now includes basic research that investigates the utility and limitations of biofeedback in the control of skeletal, visceral, and cortical responses as well as more applied research designed to investigate the utility and limitations of the technique in controlling abnormal psychophysiological responses (Birk, 1973; Blanchard and Young, 1974; Shapiro and Surwit, 1976). Recent biofeedback research has shown increased interest in the modification of psychophysiological responses hypothesized to be the active peripheral mechanisms in eliciting headache activity (Bakal, 1975). The assumed basis for a vascular headache of the migraine type has been unilateral or bilateral dilation of the extracranial arteries of the temporal area. Sustained contraction of the musculature of the cephalic and neck areas is believed to be the basis of the muscle contraction headache. It has also been hypothesized that individuals who have combined headaches of the migraine-muscle contraction variety have two distinct types of headaches, each of which results from separate physiological mechanisms (Dalessio, 1972). Previous research has demonstrated that electromyogram (EMG) feedback to the frontalis muscle can sometimes attentuate or alleviate muscle contraction headaches (Budzynski, Stoyva, Adler, and Mullaney, 1973; Wickramasekera, 1973), while skin temperature training (Sargent, Walters, and Green, 1973) and cephalic vasomotor training (Feuerstein, Adams, and Beiman, 1976; Feuerstein and Adams, 1977; Friar and Beatty, 1976) can be effective in the treatment of vascular headaches.

The present investigation was an attempt to train self-control of the blood volume pulse (BVP) in the temporal artery of the facial area and of the tonic muscle activity of the frontalis muscle in individuals who exhibited headaches of the combined variety. It was hypothesized that decreases in migraine activity would be related to BVP training and that reductions in muscle contraction headaches would be observed as a function of EMG training. The BVP training consisted of teaching the subject to constrict

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the zygomatico-facial branch of the temporal artery and thus mimic the effect of ergotamine tartrate, a vasoconstrictive drug often used to control migraine headaches. The BVP feedback was designed to decrease pulse amplitude and thus produce a physiological response similar to that of individuals who do not experience migraine headaches. The EMG feedback was designed to lower the tonic level of muscle activity to a level characteristic of individuals who do not experience muscle contraction headaches.

METHOD

Subjects

Two females diagnosed as having chronic, recurring headaches of the combined migraine-muscle contraction type served as the subjects. Each was self-referred to the Psychology Clinic for participation in the headache research program. Both subjects were required to undergo a complete neurological and physical examination as a prerequisite for participation in the study.

The first subject was a female laboratory technician, age 34, diagnosed by a screening neurologist as exhibiting combined headaches of the muscle contraction, classic migraine type. The subject reported that the onset of severe headaches coincided with the onset of menses. Muscle contraction headaches were described as a dull pain which appeared first in the forehead and temple area and later spread over the entire head. These headaches occurred three to four times a week. The migraine headaches were usually accompanied by facial paralysis, slurred speech, numbness in the arms and hands, and occasional nausea. Migraine headaches occurred about once a week with an average duration of 18 to 24 hr and necessitated bedrest. The subject used both Wigraine and Cafergot, both strong vasoconstrictive drugs, for the vascular headaches. She was unable to take this medication as frequently as needed to control the vascular headache because of side effects. Aspirin, Emperin, and Darvon compounds were ineffective in relieving the vascular pain. The subject's mother, father, and aunts had all suffered from migraine headaches.

The second subject was a 54-yr-old student at the University of Georgia. She was diagnosed by a screening neurologist as having combined headaches of the muscle contraction, common migraine variety. The onset of headache pain coincided with the onset of menses. Headaches became an increasing problem during her pregnancies. Muscle contraction headaches were described as a dull ache over the entire head. The migraine headaches were described as a severe, unilateral throbbing sensation occasionally accompanied by nausea. Muscle contraction headaches occurred daily, while migraine headaches occurred two to three times a month. The use of vasoconstrictive medications was contraindicated by her medical condition, and Codeine, Fiorinal, and Darvon compounds were only minimally effective in reducing head pain. The subject's mother had also suffered from migraine headaches.

Apparatus

A Grass Model 7 polygraph was used to monitor BVP and EMG activity. The BVP activity was recorded using a Grass reflectant photoelectric transducer positioned over the left zygomatico-facial branch of the temporal artery for both subjects. This placement was selected because both individuals experienced unilateral migraine headaches in the left hemisphere. The transducer had minimal exposure to light before placement, thus reducing the possibility of large voltage changes over time. BVP and EMG outputs from the driver amplifiers were interfaced with a Narco limit indicator and behavioral programming system to control the presentation of a binary auditory feedback signal. The feedback signal for both the BVP and the EMG training sessions consisted of a 1000-Hz tone (40 dB) delivered through a speaker located in the experimental chamber approximately 1 m from the subject. Feedback was administered whenever the subject exceeded the established criterion. Noncriterion responding was defined as an increase in the amplitude of the blood volume pulse. Shifts in blood volume (the dc component of the cephalic vasomotor response) were minimized by interfacing the BVP response with a wide band ac preamplifier with a faster time constant. The BVP feedback was contingent on this latter signal.

A Grass wide band ac preamplifier and integrator were used to record frontalis muscle activity (EMG). The bipolar signal was recorded using Beckman Ag-AgCl surface electrodes and Beckman NaCl electrolyte. Electrode resistance was kept at less than 10,000 ohms by using Bravisol to clean and mildly abrade the forehead area. Alcohol was used further to clean the skin. Electrodes were placed 2.5 cm over the center of each eyebrow and an ear ground was used to attenuate extraneous noise. The integrated muscle action potential from the frontalis muscle controlled the presentation of a binary feedback tone, which was delivered to the subject whenever tonic EMG levels exceeded the preset criterion.

Procedure

Before training, a general rationale for treatment was administered to the subjects. Subjects were then informed that they would receive two types of treatment, the efficiency of which was unknown, and that the investigators were examining which type of feedback might be effective in alleviating head pain. No further information was given to control for client expectancy.

Physiological baseline measures were obtained on each subject during two 20-min pretreatment habituation sessions. During these sessions, the BVP response and integrated EMG activity were monitored while the subject, with eyes closed, reclined on a hospital bed elevated at a 45° angle. These sessions were designed to allow the subject to habituate herself to the experimental setting. All sessions were conducted in an experimental chamber controlled for temperature, light, and sound effects.

Both subjects received 15 BVP and 15 EMG feedback sessions delivered in a counterbalanced sequence across subjects. The multiple baseline design replicated across responses and subjects provided an indication of the effects of BVP and EMG feedback on both the targeted (either EMG or BVP) and the nontargeted responses (either EMG or BVP). This design included an assessment of response generalization (*i.e.,* headache activity) as well as a test for the independence of the BVP and EMG responses. Consequently, the design permitted a determination of the effects of each type of feedback on each type of physiological response and type of headache while controlling for order, placebo, expectancy, and other nonspecific effects.

Each BVP and EMG treatment session consisted of six components: adaptation (5 min), prefeedback baseline (2 min), prefeedback voluntary control (2 min), contingent feedback (20 min), postfeedback baseline (2 min), and postfeedback voluntary control (2 min). Instructions for the session were administered before adaptation. During treatment sessions, subjects were instructed to relax and attempt to make as few movements as possible. A green light signalled the onset of baseline. During voluntary control conditions of both treatment phases, subjects were instructed both to relax the frontalis muscle and to constrict the temporal artery to achieve the same interoceptive and exteroceptive cues normally experienced during feedback phases. Verbal instructions and a red light signalled the onset of the voluntary control condition. The feedback session began at termination of the red light and onset of the auditory binary feedback tone. Both subjects were instructed to try to keep the tone off as much as possible. After a subject began to acquire voluntary control of the targeted response, she was instructed to practise the newly acquired skill for 10 min daily at home, attempting to reproduce the interoceptive and exteroceptive cues she associated with learning the criterion responses in the laboratory. Each of the subjects was also instructed to practise the newly acquired skills whenever she felt that she was going to develop a headache.

The last 2 min of the adaptation phase were used to establish feedback limits. The limits for BVP were established by adjusting a discriminator to give feedback for 50% of the BVP responses. The upper-limit crossings represented increases in the amplitude of the systolic peak. An upper limit on EMG activity was set to provide feedback 50% of the time during EMG training. Limits were established at the beginning of the session and were maintained unless the subject's response changed during the session so that she received feedback over 75% of the time or less than 25% of the time. In such cases, the limit was eased or made more stringent, accordingly.

Each subject completed a modified version of a headache form described by Sargent *et al.* (1973) that included daily ratings of headache type, frequency of each headache type, intensity, degree of disability, duration in hours of each headache, and medication taken. This headache activity was recorded during baseline ($M =$ seven weeks), BVP feedback ($M =$ eight weeks), EMG feedback ($M = 12$ weeks), and followup conditions ($M = 16$ weeks). It should be noted that both subjects could clearly discriminate between migraine and muscle contraction headaches and viewed them as independent responses. The headache forms were collected weekly by the experimenters.

Data Reduction

Each biofeedback session was divided into four components for analysis of the physiological data: prefeedback baseline, prefeedback voluntary control, feedback, and postfeedback voluntary control. The amplitude of the systolic peak of the BVP (expressed in mv) and the level of integrated EMG (expressed in μv) were sampled at 10-sec intervals in the baseline and voluntary control phases and at 60-sec intervals in the feedback phase. Mean levels of the response for each condition were then computed, as shown in the figures.

RESULTS

The level of the physiological data for each phase was compared to the baseline level for that response for each session. This procedure was used because the electrophysiological measures tend to vary across measurement sessions, with changes in electrode placement, with changes in mood state, and other events.

The self-reported headache activity was analyzed by obtaining the mean duration of headache activity over two-week intervals. The data on rated intensity and disability showed similar results and will not be discussed further.

Subject 1

The first subject received BVP training before EMG training. The mean changes in both physiological responses for each phase for every three treatment sessions are presented in Figure 1. An analysis of the figure indicates that during BVP training, the subject showed no consistent pattern in her ability to decrease the BVP responses relative to the baseline across sessions either in the prevoluntary control phase or the feedback stage. However, following the feedback periods she was consistently able to decrease the BVP responses during the postfeedback voluntary control phases. During the EMG training, she demonstrated an initial ability to decrease the BVP response during all phases of the session. However, this ability appeared to deteriorate across sessions. Analysis of the EMG response during BVP training indicates that the subject initially reduced the EMG level relative to baseline in all phases of the session. However, as the sessions progressed and she acquired more control over the targeted BVP response, she deteriorated in her ability to lower the EMG levels. During EMG training, she regained her control of the EMG response and showed a progressive ability to lower the EMG response across sessions. Analysis of the physiological data itself suggests that she slightly reduced the absolute levels of the BVP and EMG baseline response across sessions, but the pattern

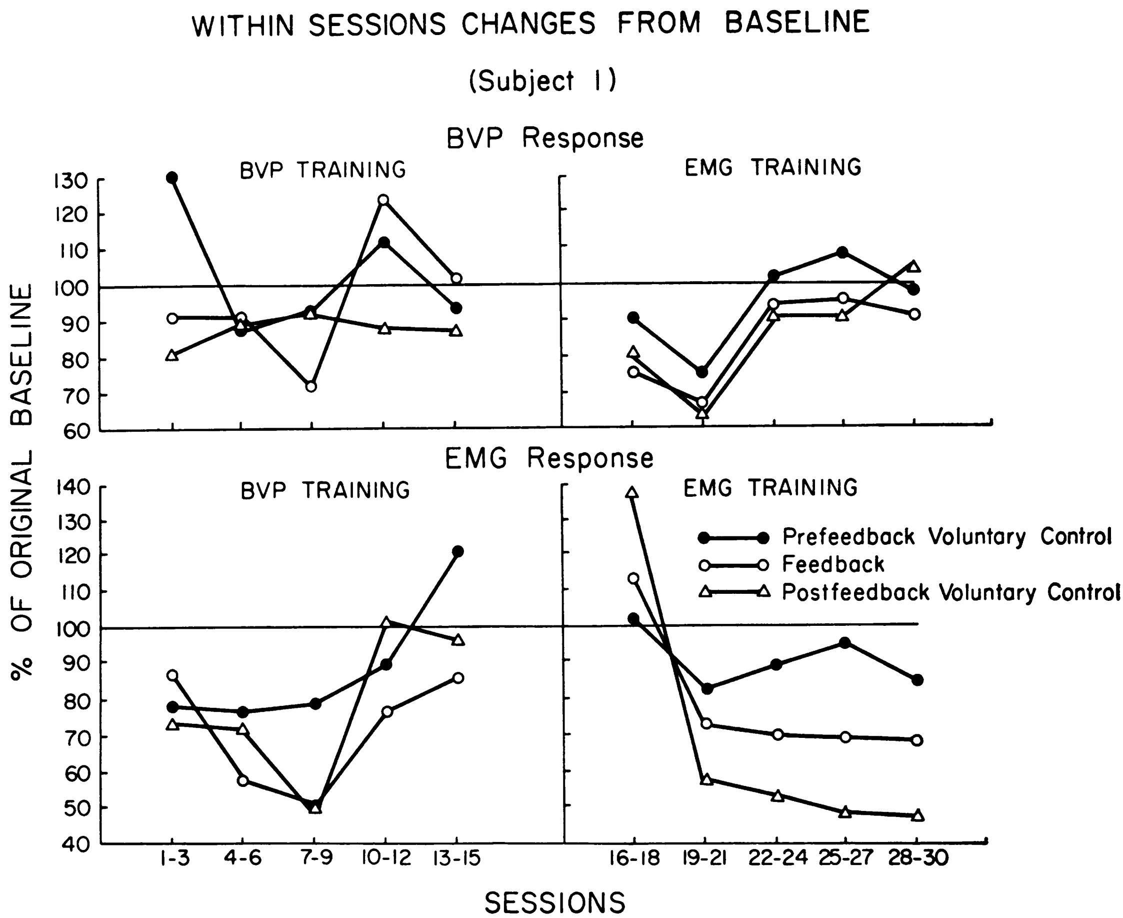

Fig. 1. Changes in physiological responses of Subject 1 as a function of type of feedback.

was somewhat erratic and confounded by possible changes in the position of electrode or transducer placement, the recording apparatus, the physical environment, and other possible uncontrolled sources.

The self-reported headache activity is presented in Figure 2. The subject experienced a decrease in duration of migraine headaches after four weeks of BVP training, and this decrease was maintained during EMG training and followup. BVP feedback did not appear to have much impact on the duration of muscle contraction headaches. Some change in the duration of muscle contraction headaches was observed after four weeks of EMG training, and after 14 weeks of the training the subject no longer experienced muscle contraction headaches. She reported an increased ability to abort both types of headaches following biofeedback training; however, she felt that the BVP training was more effective in aborting migraine headaches, while the EMG training increased the control of muscle contraction headaches. Anecdotal evidence from the patient about her activities seemed to validate the effectiveness of the training. Before biofeedback training she spent many more hours in bed, was often unable to work around the house, and felt that her headaches were impairing her marriage. After training, she became more active around the house, spent more time with the children, and reported that the marital difficulties seemed to be remedying themselves. No medication for head pain was being taken at followup.

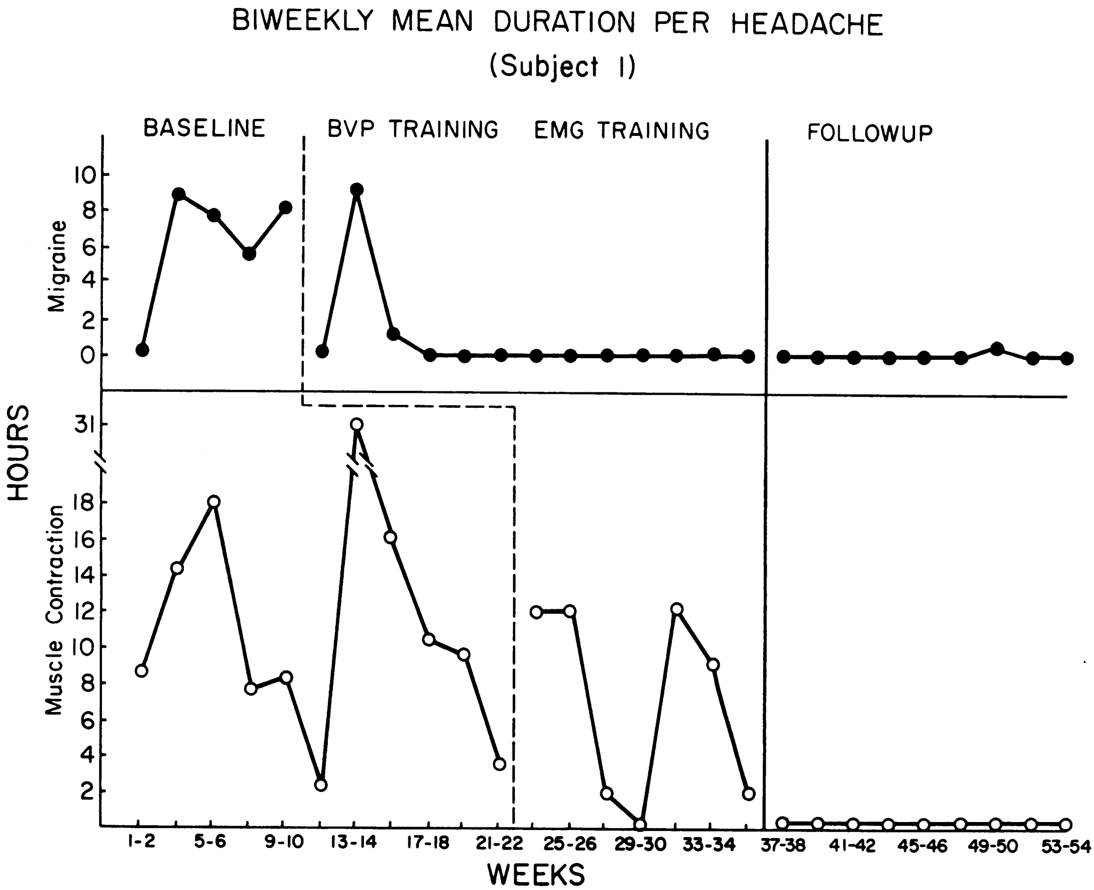

Fig. 2. Migraine and muscle contraction headache activity of Subject 1 during baseline, treatment conditions, and followup.

Subject 2

The second subject received EMG training before BVP training. Mean changes in both physiological responses for each phase for every three treatment sessions in both treatment conditions are presented in Figure 3. An examination of the figure indicates that during EMG training, the subject demonstrated a progressive decline in her ability to reduce the BVP response in all phases of the session. However, during BVP training she demonstrated a progressive ability to decrease the BVP response, the greatest change occurring during the postfeedback voluntary control phases. During EMG training, the subject consistently lowered the EMG level relative to the baseline level in each phase during all sessions. Again, the ability to decrease the response during the postfeedback voluntary control phase was the greatest. This reduction continued to a lesser extent during the BVP training. Subject 2 also demonstrated a slight tendency to reduce the baseline level of the EMG and BVP activity across sessions. However, this response pattern was again highly erratic.

The self-reported headache activity is presented in Figure 4. After EMG training was instituted, the mean duration of muscle contraction headaches was markedly reduced. This trend continued throughout the BVP training and during followup. Migraine headaches were not reduced by the EMG training and actually seemed to have increased in severity when they

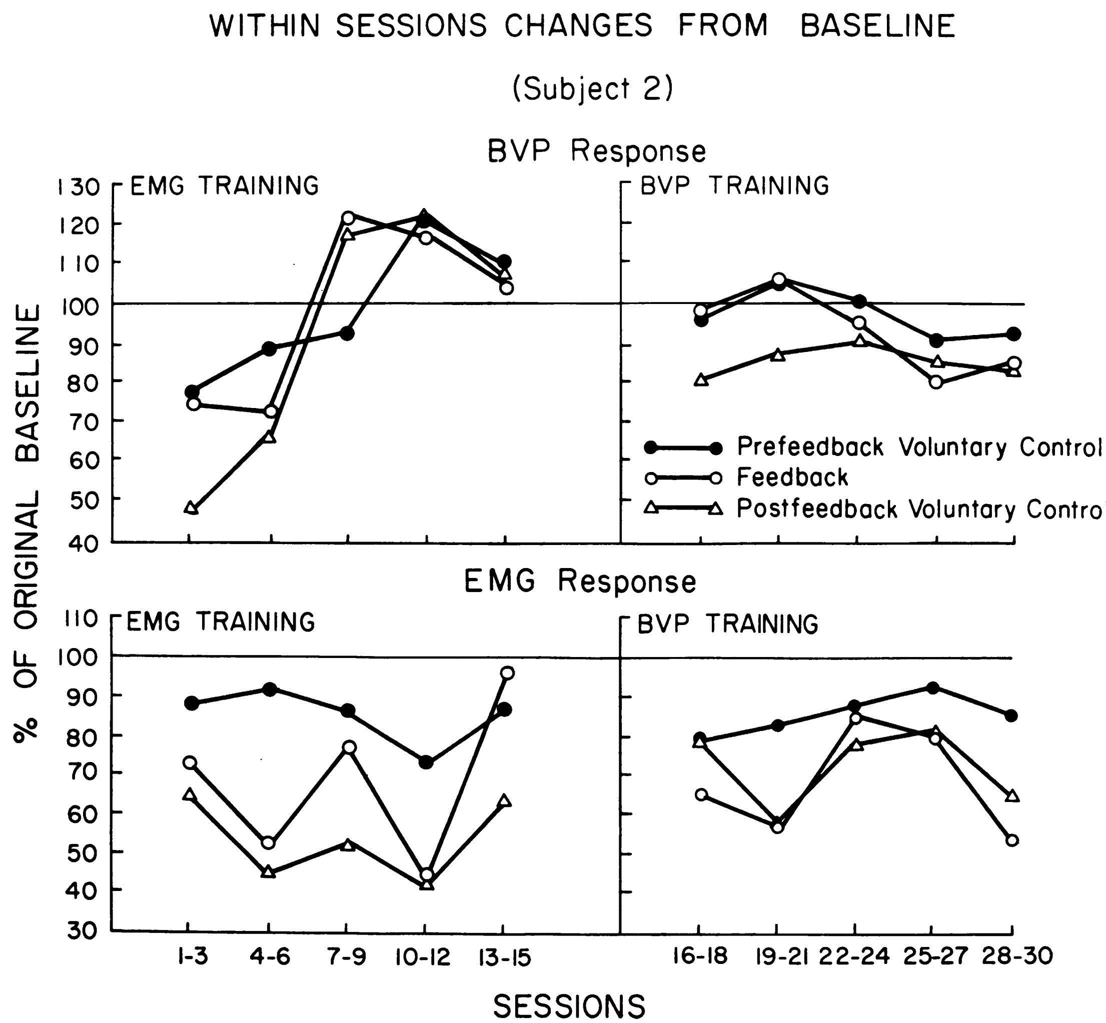

Fig. 3. Changes in physiological responses of Subject 2 as a function of type of feedback.

occurred. No migraine headaches occurred after BVP training was instituted, and the reduction in headache frequency and duration continued throughout followup. Subject 2 also reported to the investigators that she considered EMG feedback to be more effective in ameliorating muscle contraction headaches, while BVP feedback appeared to reduce migraine headache. Anecdotal evidence reported by Subject 2 supported the impact of treatment in reducing the degree to which headaches interfered with her life. During the previous two terms of university study she had not been able to complete her required coursework. However, during treatment she completed the unfinished courses, as well as the courses she was taking, and decided that, during the following term, she would take two courses she had previously avoided. The use of medication for head pain was eliminated.

DISCUSSION

These results suggest that biofeedback procedures can be effective in teaching individuals to constrict the temporal artery and to lower tonic levels of EMG in the frontalis muscle on instruction. There appears to be an acquisition of voluntary control of the target response across

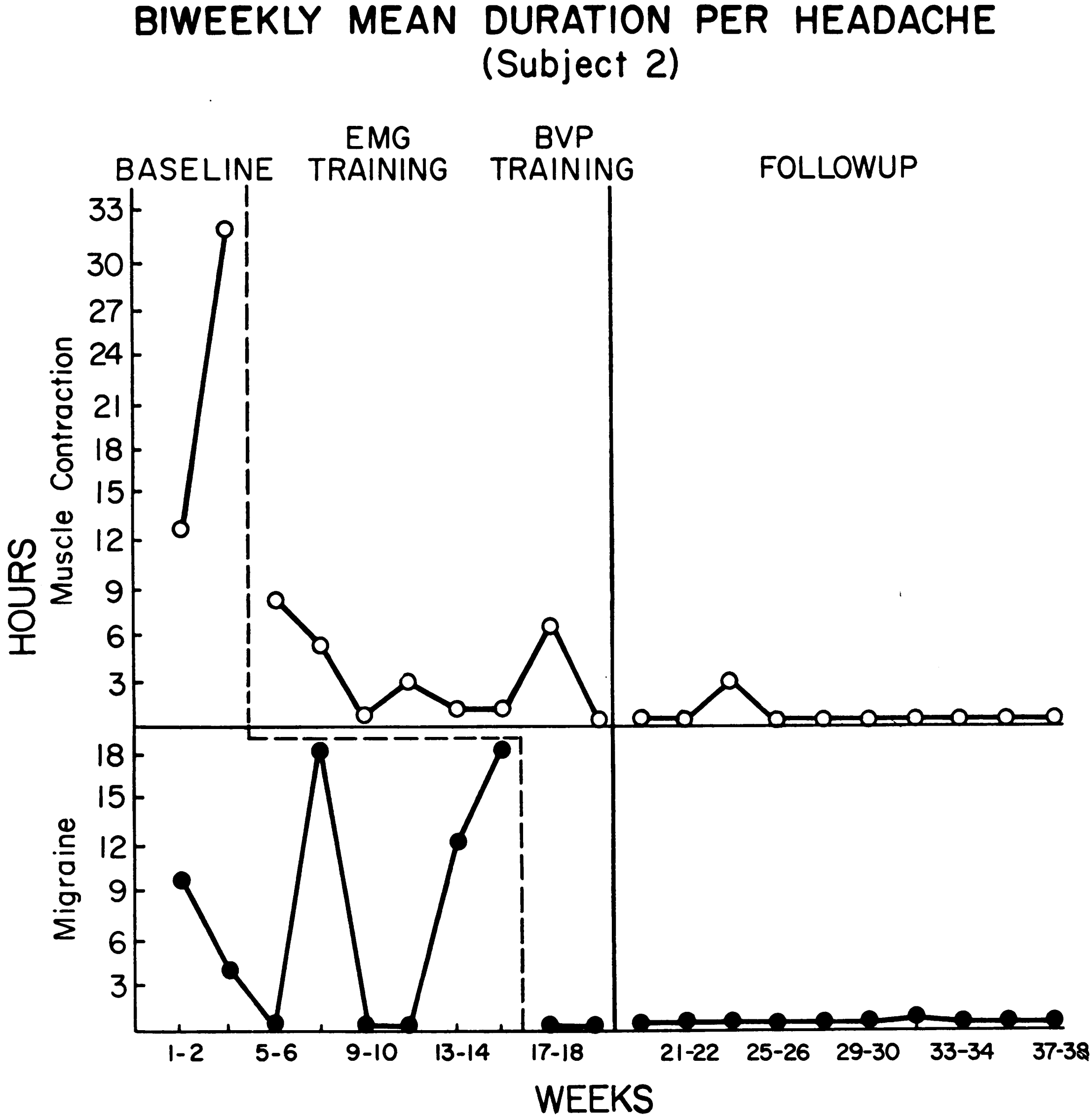

Fig. 4. Migraine and muscle contraction headache activity of Subject 2 during baseline, treatment conditions, and followup.

sessions. Furthermore, these procedures appear helpful in eliminating or reducing headache activity. The two physiological responses were independent, and the control of the nontargeted response did not occur unless control of that response had been taught in previous sessions.

The ability to control a response voluntarily was significantly affected by the feedback experience. This fact is particularly important since voluntary control of a physiological response is necessary if the effects of treatment are to generalize from the analogue situation to control of headache activity. Brener (1973) suggested that the voluntary control component should be the primary criterion for biofeedback effectiveness.

In both subjects, it was shown that control of the physiological response assumed to be the relevant pain mechanism for each type of headache was temporally associated with a reduction in that type of head pain. The reduction in targetted headache activity occurred only during training phases for that particular pain mechanism. Once training was completed for a particular pain mechanism, control was maintained during subsequent treatment and followup phases. Further support for this conclusion is that neither subject is now taking any medication for the control of head pain. These data support the validity of these peripheral pain mechanisms as the primary sources of migraine and muscle contraction headaches, and thus as targets for treatment.

Replicational research is needed to verify further the effectiveness of BVP and EMG training in the modification of combined migraine and muscle contraction headaches and to verify further the hypothetical model of the relevant pain mechanisms involved in these types of headache activity.

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Received 4 April 1977.
(*Final Acceptance 28 September 1977.*)