BIOFEEDBACK AND RATIONAL-EMOTIVE THERAPY IN THE MANAGEMENT OF MIGRAINE HEADACHE

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Twenty-four migraine patients were randomly assigned to one of four conditions: (a) self-monitoring of headache activity (waiting list), (b) frontalis EMG biofeedback, (c) digit temperature biofeedback, and (d) digit temperature biofeedback plus Rational-Emotive Therapy (RET). Bidirectional control over the target physiological response was assessed through a reversal design in each session. Following at least a four-week baseline, the three biofeedback groups received 8 to 10, 30-minute sessions of bidirectional biofeedback training, scheduled twice a week. Subjects in the combined digit temperature biofeedback plus RET group received three 40-minute sessions of RET as an addition to the third, fifth, and seventh biofeedback sessions. Records of daily home practice were kept throughout treatment and three-month followup. Subjects on the waiting list monitored headaches for at least five months, corresponding to "baseline", "treatment", and three-month followup. Digit temperature biofeedback alone and in conjunction with RET did not prove to be more effective than the control conditions. All the EMG subjects reduced headache activity to two-thirds or less of the baseline level by the third month of followup. Bidirectional digit temperature performance did not improve with training, was demonstrated in only 33% of the biofeedback sessions, was not maintained over time, and was unrelated to improvement in headache activity. EMG subjects reported biofeedback performance to be an easier task and met the performance criterion on 85% of the sessions. The frequency of home practice contributed over 55% of the variance in retrospective estimates of headache improvement but was not related to changes in daily records of headache activity.

DESCRIPTORS: migraine, biofeedback, pain management, behavioral medicine, rational-emotive therapy, adults

Migraine headache is a pervasive and painful disorder, affecting from 15% to 29% of the general population (Waters, 1974). The outstanding feature of the migraine syndrome is recurrent episodes of throbbing head pain, commonly unilateral in onset (Dalessio, 1972; Friedman, 1972). In classical migraine, pain is preceded by a period of intracranial vasoconstriction and prodromal visual and sensory

disturbances. Prodromes are absent in the more frequently diagnosed common migraine, although sensory disturbances may or may not accompany the headache itself (Ad Hoc Committee on the Classification of Headache, 1962). In either case, the pain is vascular in origin and varies directly with the degree of passive dilation of the extracranial arteries (Dalessio, 1972). Migraine patients have also been shown to demonstrate chronic, high levels of tension in the muscles of the head and neck (Bakal and Kaganov, 1977; Poźniak-Patewicz, 1976). A variety of immediate antecedents to migraine attacks have been identified, ranging from changes in weather conditions, consumption of foods containing tyramine, food deprivation, changes in sleep patterns, and violent physical

exercise, to stress (Dalessio, 1972; Selby and Lance, 1960). Fifty-four per cent of the migraine attacks recorded over a two-month period by a random sample of 50 classical migraine patients coincided with stressful situations and accompanying reports of anxiety, overwork, anger, resentment, emotional strain, or relief from strain (Henryk-Gutt and Rees, 1973).

The most frequently utilized behavioral treatment in the management of migraine is digit temperature biofeedback. Typically a visual display reflecting moment-to-moment changes in the temperature of the middle finger is available to the subject, who is instructed to warm the hands. The temperature in the finger is directly related to the amount of blood flow or pulse amplitude in the finger (Surwit, Shapiro, and Feld, 1976).

Published reports suggest that digit temperature biofeedback directed at increases in hand temperature is an effective clinical tool. Much of this literature is based on clinical trials with the scientific status of anecdotal case reports (Adler and Adler, 1976; Diamond and Franklin, Note 1; Kentsmith, Strider, Copenhaver, and Jacques, 1976; Mitch, McGrady, and Iannone, 1976; Peper, 1973; Sargent, Green, and Walters, 1972, 1973; Sargent, Walters, and Green, 1973; Weinstock, 1972). However, several articles do report the systematic recording of headache activity under both baseline and posttreatment conditions. In a series of AB designs with extended pretreatment baselines and posttreatment followup, Medina, Diamond, and Franklin (1976) found a combination of frontalis EMG biofeedback and digit temperature biofeedback to lead to a 30% or greater reduction in both headache activity and medication consumption for 13 of 27 patients. Johnson and Turin (1975; Turin and Johnson, 1976), using an ABC design, found training in finger cooling less effective than subsequent training directed at increases in digit temperature (n = 3). Wickramaskera (1973) reported anecdotal evidence of treatment failure for two

subjects receiving frontalis EMG biofeedback, but who were later successfully treated in a systematic case study with digit temperature biofeedback. On the other hand, one investigation found digit temperature biofeedback to be no more effective than EEG alpha feedback or a "self-hypnosis" package combining relaxation and pain control instructions (Andreychuk and Skriver, 1975). No controlled group outcome studies have been reported that show the superiority of digit temperature biofeedback over self-monitoring controls or other biofeedback procedures, such as EMG biofeedback.

None of the migraine outcome studies reports an adequate experimental analysis of the digit temperature response. The better analyses are based on the mean deviation in temperature during biofeedback relative to baseline conditions (Turin and Johnson, 1976). However, elevations in digit temperature to an asymptotic level have been demonstrated in the absence of biofeedback and without instructions to modify hand temperature (Packer and Selekman, Note 2). Well controlled within-subject studies of digit temperature self-regulation with normal adults in some cases indicate highly reliable changes under the subject's control (Taub and Emurian, 1973). In other cases, they have provided little evidence for temperature *increases* under the subject's control (Surwit et al., 1976). Control over vasodilation and indirectly over skin temperature has been shown to be particularly difficult for migraine sufferers relative to matched controls (Price and Tursky, 1976).

An alternative approach to the management of migraine focuses on modifying the person's cognitive appraisal of stressful situations. Dalessio (1972) emphasized the importance of "procedures that relieve anxiety and induce relaxation by improving the attitudes, habits and life situation of the patient" (p. 414). Mitchell and White (1976, 1977) demonstrated the effectiveness of a complex package of cognitive reappraisal procedures in reducing the frequency of migraine attacks, relative to controls for self-recording of headache activity, self-

monitoring antecedent stimuli, relaxation train-
ing, and self-desensitization. Rational-Emotive
Therapy (RET) is a system of therapy focusing
on the modification of an individual's maladap-
tive cognitive responses or attitudes (Ellis, 1962,
1971). Although several studies are now avail-
able that suggest the utility of RET with vari-
ous stress related disorders, no controlled in-
vestigations of RET with migraine patients
have been reported (DiGiuseppe and Miller,
1977). However, our own criterion-oriented
pilot research and clinical experience with mi-
graine patients suggested that a relatively brief
exposure to RET would be a useful treatment
adjunct.

The present investigation was designed to
address the following questions: (1) Is digit
temperature biofeedback alone or in combina-
tion with RET more effective in the manage-
ment of migraine than EMG biofeedback or the
self-monitoring of headache activity? (2) What
are some of the differential characteristics of
digit temperature and EMG performance with
this population? (3) What is the relationship
of biofeedback performance and frequency of
home practice to changes in daily records of
headache activity and retrospective estimates
of improvement?

METHOD

Subjects

Twenty-four subjects were selected from a
total of 109 respondents to an article in the
local newspaper, letters to area physicians, and
a newspaper advertisement. The subjects in-
cluded 19 women and five men. They ranged
in age from 20 to 56 yr, with a median of 30.5
and a mean of 33.0. The history of severe head-
aches extended from six months to 37 yr with
a median of 10.2 yr and a mean of 13.8 yr.
Criteria for subject selection included positive
indicators for vascular headaches of the mi-
graine type, self-reports of at least three to

four severe headaches per month lasting from
several hours to several days, and past medical
and headache history. Detailed headache de-
scriptions from each subject were discussed with
a neurologist before the decision to include.
Inclusion was also based on several negative
criteria: no subject was using prophylatic medi-
cation for migraine, taking birth control pills,
practicing any other type of relaxation or medi-
tation procedures, or receiving psychotherapy
immediately before or during the course of
study, or was pregnant.

All 24 subjects reported multiple, pronounced
sensory changes of the type usually associated
with classical migraine and which preceded or
accompanied the headache. Twenty-two re-
ported predominantly unilateral headaches. The
other two participants both reported visual
prodromes, nausea, and other sensory distur-
bances associated with headache. At the time
of initial interview, 22 were using prescription
analgesics. Ten were using vasoconstrictors as
a form of symptomatic treatment. Five subjects
reported previously unsuccessful trials of pro-
phylactic medication, including Inderal, Bel-
lergal, and Sansert. Seven subjects reported
some collateral muscle tension accompanying
the headache.

Each subject was required to deposit $25.00
into a Psychology Department account, with
$15.00 returnable at the conclusion of followup
in exchange for completion of the headache
records. The remaining $10.00 was used to help
defray the cost of supplies. Following the de-
cision to participate, the subject and senior
author signed a written contract describing the
nature of the research, the possibility of and
rationale for assignment to the self-monitoring
condition, the financial agreement, and expecta-
tions of the subject including completion of
data records, practice of the procedures at home
without feedback on a daily basis for the du-
ration of the study once treatment had been
initiated, and an agreement not to initiate any
new treatment for migraine until the conclu-
sion of followup.

Design

Following completion of the four-week base-line, subjects were randomly assigned to one of four conditions (n = 6): (1) a self-monitoring (waiting list) control, (2) a frontalis EMG biofeedback group, (3) a digit temperature biofeedback group, and (4) a combined digit temperature biofeedback plus RET group. Each experimental treatment was crossed with one of two therapists (A. L. and J. R.).[2] A reversal design (Leitenberg, 1973) was employed within each biofeedback session. Following an initial adaptation period of at least 10 min, subjects experienced a 5-min baseline (A), 10 min of biofeedback with instructions either to raise finger temperature (in the case of the digit temperature biofeedback groups) or decrease muscle tension (in the case of the EMG feedback group) (B₁), a 5-min period of continued biofeedback with instructions to move the response in the opposite direction (C), followed by a 10-min return to the B condition (B₂).

Apparatus

All biofeedback sessions took place in a temperature-controlled ($\overline{X} = 73.8°$ F, $SD = 2.0$), semi-darkened room within a laboratory suite in an isolated wing of a classroom building. Sound external to the room was attenuated by a white-noise generator.

Finger temperature readings were obtained using a Yellow Springs clinical thermocouple attached with paper surgical tape to the middle phalange of the middle finger of the nondominant hand (Surwit et al., 1976). The thermocouple was connected to a Coulbourn Instruments Temperature Module (Model S71-30) with the sensitivity set at 500 mV/°C. The output from the temperature converter was fed into a BK Precision digital volt meter (Model 280). The three-digit visual display depicted

hundredths of a degree deviations from the initial setting on the Temperature Converter.

EMG recordings were obtained from quarter-inch diameter AgAgCl Narco Bio-Systems recessed electrodes (710-0037) using standard EMG electrode placements and procedures. The electrodes were connected through a shielded cable to a Coulbourn Instruments Hi Gain Bioamplifier/Coupler (S75-01), with the gain set so that a 100-μV signal yielded a 5-V output. The EMG signal was processed through a 90- to 1000-Hz band pass to a Coulbourn Instruments Contour Following Integrator (S76-01). The Root Mean Square (RMS) integration over a 2000-msec period was fed into a second BK Precision digital volt meter. The three-digit visual display was proportional to the absolute RMS integration in microvolts by a factor of 20. That is, a reading of "0.20" on the volt meter would correspond to 4.0 microvolts.

Procedure

Subjects in all treatment conditions recorded daily headache intensity and medication consumption for the duration of the study, using the grid and rating scale developed by Budzynski, Stoyva, Adler, and Mullaney (1973). This instrument requires the subject to rate headache activity for each waking hour as follows: "0" = no headache activity; "1" = low level headache which enters awareness only at times when attention is devoted to it; "2" = headache pain level that can be ignored at times; "3" = painful headache, but you can continue at your job; "4" = very severe headache—concentration difficult, but you can perform tasks of an undemanding nature; "5" = intense, incapacitating headache. Three-by-five daily data cards, with the grid on one side and the scale on the other, were collected at one-week intervals.

Following at least a four-week baseline, the three biofeedback groups were scheduled for eight individual sessions of bidirectional biofeedback training at a frequency of two sessions

[2] Karen Bick, Richard Immers, and Michael Latus served as biofeedback technicians. Each technician worked with one subject in each treatment-by-therapist condition for the duration of the experiment.

per week. Subjects received one followup bio-feedback session three months after the last treatment session. The principal therapist worked with each subject for the first, third, fifth, seventh, and followup sessions. A biofeedback technician operated the equipment on alternate sessions. Subjects were provided with a repetitive mental device ("my hands are warm" or in the case of EMG biofeedback the word "relax") and instructions on how to achieve a "passive attitude". The principal therapist provided coaching (review of instructions, verbal reinforcement and support) on subsequent sessions if the subject were having difficulty. Both finger temperature and EMG levels were manually recorded from all subjects at 60-sec intervals throughout each session. Feedback for the target response consisted of the visual numerical display from the volt meter.

Once treatment was initiated, subjects in the three biofeedback groups were instructed to practise the relaxation procedures at home twice a day for 10 to 20 min at a time. Home practice did not include access to biofeedback equipment. Both the frequency and duration of home practice were recorded throughout treatment and the three-month followup on the headache data card.

For subjects in the digit temperature biofeedback plus RET group, the third, fifth, and seventh sessions were expanded to include RET discussions with the principal therapist. Each RET discussion lasted 30 to 40 min, and occurred at the end of the session. The RET package[3] included socialization to the idea that "what you think influences how you feel", the identification of idiosyncratic cognitions in stressful situations, discrimination between rational and self-defeating thoughts, the generation of rational, alternative points of view to idiosyncratic cognitions, and a review of 11 "rational points of emphasis" (Lazarus, 1971,

pp. 180-182). Subjects were requested to complete written, rational homework analyses, using the "ABCDE" format developed by Ellis (1962, 1971, 1977), where A = the activating or stressful event, B = the cognitive response to the event (self-talk, imagery), C = the emotional/behavioral consequences presumed to result from B, D = the generation of more "rational" or functional self-talk to dispute B, and E = the emotional/behavioral effect attributed to D.

All subjects were informed that we were comparing the effectiveness of alternative biofeedback procedures, each of which we believed had a reasonable expectation of success. Subjects in the self-monitoring (waiting list) condition were told that self-monitoring might favorably affect headache activity. They were also assured that we would provide them the best treatment, as indicated by our data, at the conclusion of the study. Self-monitoring subjects recorded headache activity for at least five months, corresponding to "baseline", "treatment", and three one-month "followup" periods. The senior author spoke with waiting-list subjects by telephone at one-month intervals, answered questions, and emphasized the scientific importance of the self-monitoring condition. All subjects completed the Irrational Beliefs Test (Jones, 1969) at the initial interview, following the final biofeedback session, and at the conclusion of followup.

RESULTS

Daily Headache Record

Each subject's headache data were averaged to obtain a mean headache rating per hour for each period, including baseline, treatment, and three one-month followup periods. This score was computed as $S = \Sigma H_D/24D$, where S = mean daily headache activity, H_D = sum of headache ratings on a given day, and D = number of days in experimental period. Mean daily headache activity was subjected to a four (treatments) by two (therapists) by five (pe-

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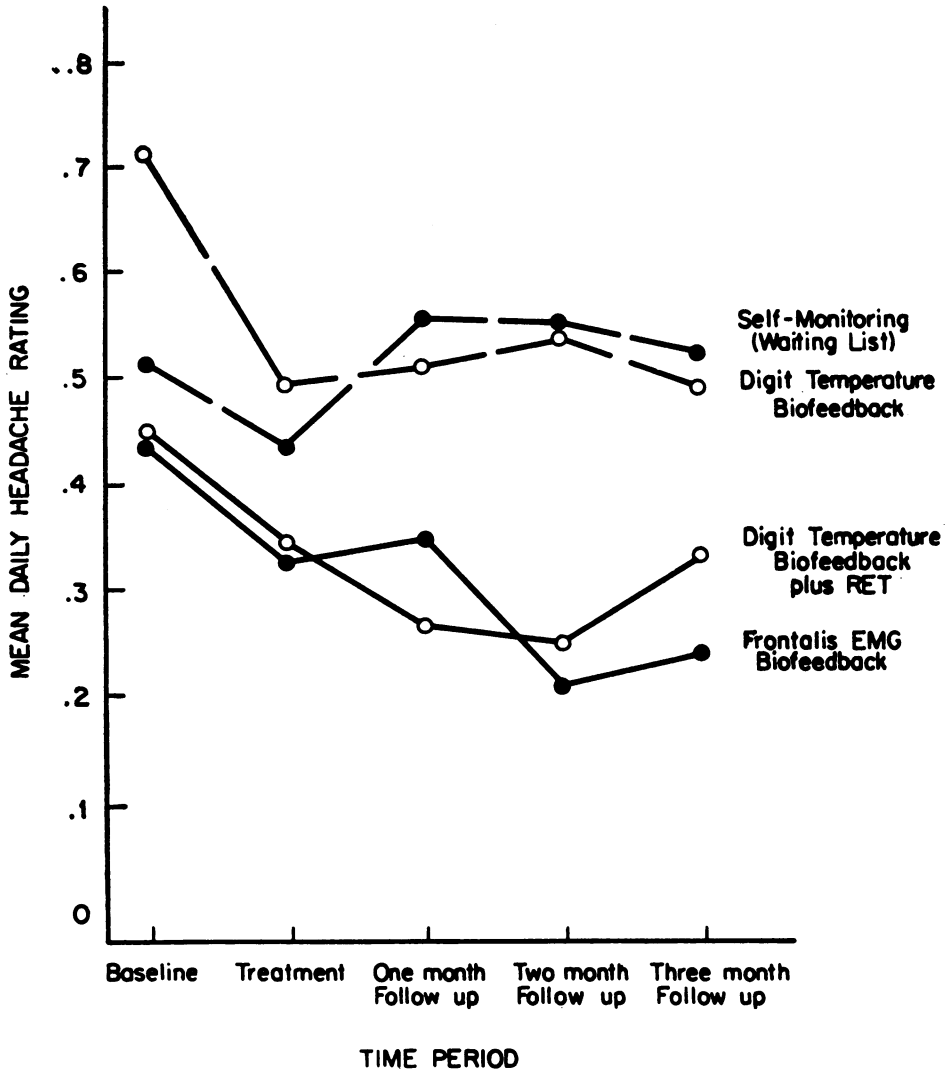[3]Copies of the biofeedback and/or RET manuals are available from the senior author on request.

Fig. 1. Mean daily headache rating for each time period.

riods) repeated measures analysis of variance with subjects nested in treatments and therapists. The analysis revealed a significant period effect $[F\ (4,\ 64) = 4.13;\ p < 0.01]$. As shown in Figure 1, mean daily headache activity ratings decreased over time. However, assignment to the different treatments and therapists did not differentiate between groups.

As Figure 1 indicates, baseline levels of headache activity were somewhat higher in the digit temperature biofeedback group than in the other groups. Consequently, the baseline headache data were subjected to a four (treat-

ments) by two (therapists) analysis of variance. The analysis did not show the groups to be different, but did reveal considerable within-group variance (all F values less than 1.00).

Several other analyses were performed on data from the daily headache record, all of which supported the finding of a significant period effect ($p < 0.05$). Again, assignment to the different treatments and therapists did not differentiate between groups. These analyses were based on the following four measures: (1) hours of daily headache activity rated "very severe" (assigned a weight of 4 or 5 on the
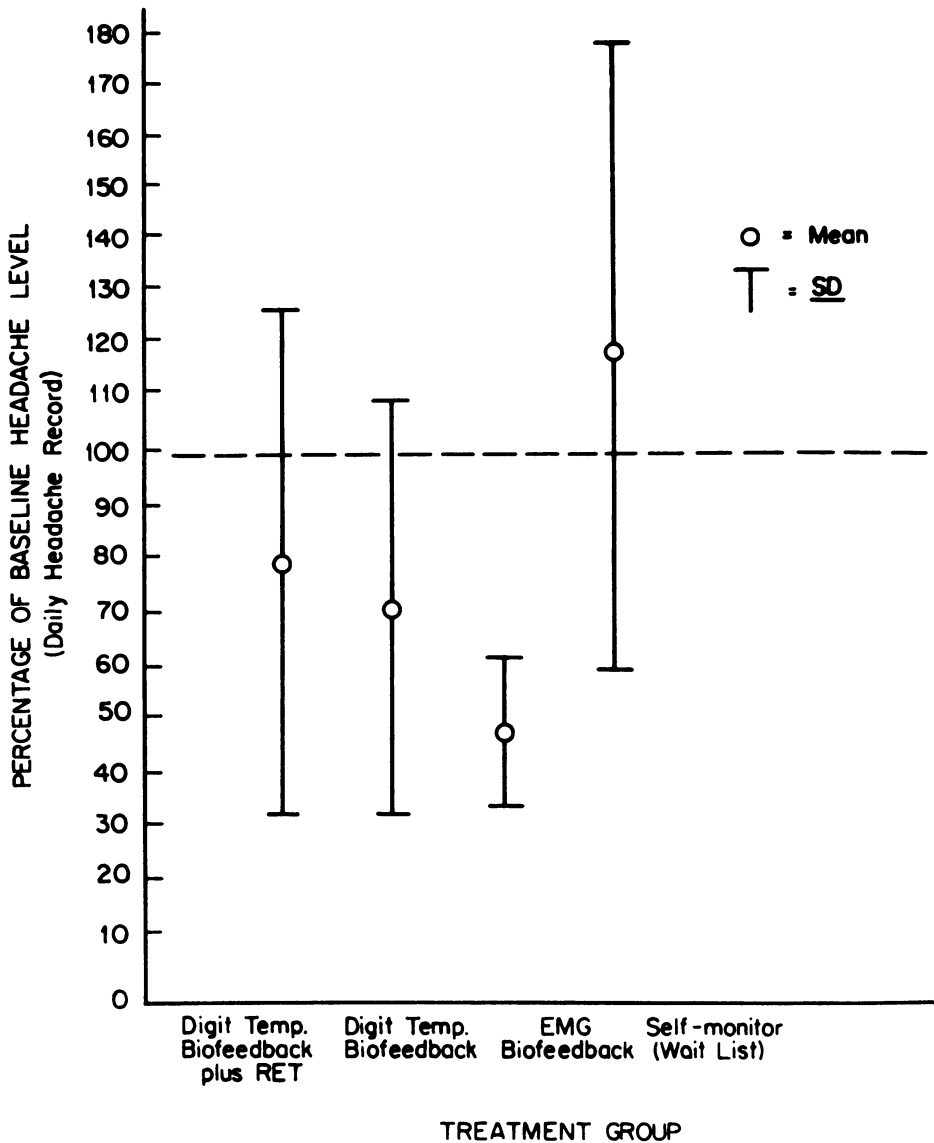
Fig. 2. The percentage of baseline headache level during the third month of followup, based on the daily headache record.

headache scale), (2) hours of daily headache activity rated "painful" (assigned a weight of 3 or above on the scale), (3) total hours of daily headache activity, and (4) the percentage of days in the experimental period with any reported headache activity.

The percentage of baseline headache level during the third month of followup was calculated by dividing the mean daily headache rating for each subject during the final time period by the mean daily headache rating during the baseline period. A four (treatments) by two (therapists) analysis of variance on the percentage data did not show the groups to be different. Figure 2 shows the percentage of baseline headache level during the third month of followup, including the mean and standard deviation, as a function of experimental treatment collapsed across therapists. An analysis testing the homogeneity of variance did not

support the apparent differences in variance between groups.

Using a criterion of clinical improvement of at least a 33% reduction from baseline in mean daily headache rating during the third followup period, 12 of 18 subjects receiving some type of biofeedback training improved, in contrast to only one of the six subjects in the self-monitoring condition. All six of the EMG subjects improved, four of the digit temperature biofeedback subjects improved, and two of the digit temperature biofeedback plus RET subjects improved. Collapsing the three treatment groups together, Fisher's Exact Test showed biofeedback treatment to be superior to self-monitoring alone ($p = 0.048$). Separate Fisher's Exact Tests showed only the EMG treatment to be superior to self-monitoring ($p = 0.0076$).[4] Assignment to different therapists did not differentiate between groups on the basis of clinical improvement.

Retrospective Estimates of Improvement

At the conclusion of the three-month followup, subjects were asked to estimate the percentage of improvement or deterioration in headache activity, by comparing the last month of followup with the original baseline period. The percentage of baseline headache level during the third month of followup was then calculated by subtracting the estimated percentage of improvement from 100, or adding the estimated percentage deterioration to 100. A four (treatments) by two (therapists) analysis of variance revealed both a significant treatment effect [F (3, 16) = 9.05; $p < 0.001$] and a significant treatment by therapist interaction [F (3, 16) = 4.23; $p < 0.05$]. A further analysis of variance did not show the three

biofeedback groups to differ from each other. These retrospective estimates indicated a mean reduction in headache activity of 46% for the three biofeedback groups combined, in contrast to a mean increase in headache activity of 17% reported by subjects on the self-monitoring waiting list.

Using the daily headache record as the more objective measure, a chi square analysis did not show the number of overestimations of headache improvement to be greater than the number of underestimations. The percentage of baseline headache based on daily headache records was related to the percentage of baseline headache measured by retrospective estimate ($r = 0.42$, $p < 0.05$).

Medication

Medications were grouped into four categories: (1) vasoconstrictors, such as Cafergot or Ergomar, (2) narcotics, such as Fiorinal or Tylenol with codeine, (3) synthetics, primarily the Darvon group, and (4) minor analgesics such as Aspirin or Tylenol. Within each category, a medication unit was defined as one tablet or capsule containing the least commercially available amount of active ingredients. For example, one medication unit of minor analgesics was equivalent to 325 mg of either acetaminophen or Aspirin. "Extra Strength Tylenol" contains 500 mg of acetaminophen, equivalent to 1.54 medication units in the minor analgesic category. An ordinal analysis was performed on these data to determine whether the mean daily consumption of medication units within each category during the third month of followup increased or decreased relative to medication consumption during baseline. In general, this analysis indicated that medication consumption decreased in all categories for all groups, including the self-monitoring waiting list.

Biofeedback

Performance. Each biofeedback session was classified as a "criterion performance" if it met at least one of the following criteria:

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[4]Any superiority of EMG biofeedback is not attributable to differential pretreatment reports of collateral muscle tension. Following the random assignment to treatment conditions, it was noted that only one of the seven subjects reporting collateral muscle tension was assigned to the EMG biofeedback condition, with the other six equally distributed between the remaining groups.

1. An appropriate pattern of trends in the response, as indicated by the arithmetic sign of the slope coefficient of the linear regression equation for each experimental phase within the session (*e.g.*, positive slope under instructions to "warm hands", negative slope under instructions to "cool hands"), or,

2. Expected changes in level of the response, as indicated by shifts in the mean value for each experimental phase (*e.g.*, under instructions to "warm hands", the mean values were expected to be greater than under instructions to "cool hands").

EMG artifacts, arbitrarily defined as readings at least 14 μV greater than the highest reading for the previous or subsequent minute, were eliminated before the linear regression and mean analyses. Sessions in which the subject was judged to show bidirectional control of the response on the basis of visual inspection also met the linear regression/mean analysis performance criterion. However, it should be noted that the present statistical analysis is responsive to relatively small changes in slope or mean values. Some sessions may meet the statistical criterion but fail reliably to pass visual inspection. Although a linear regression does not always provide the best descriptive model of the trend in the data, it does provide a consistent and available yardstick for comparing time periods within the reversal design. Examples of criterion performances are depicted in Figures 3 and 4.

Rising baselines characterized the digit temperature response. A positive linear slope coefficient described the baseline trend in 125 sessions, compared to only 51 instances of negative slope during baseline [χ^2 (1) = 31.11; $p < 0.001$]. In contrast, rising and falling baselines were more or less equally distributed throughout the set of frontalis EMG recordings, characterizing the linear baseline trend in 75 and 93 sessions respectively. This difference was not significant.

Subjects receiving EMG biofeedback met the performance criterion for the EMG response in 85% of the biofeedback sessions ($SD = 15$, range = 67 to 100). In contrast, subjects in the digit temperature biofeedback alone and digit temperature biofeedback plus RET groups met the performance criterion for the digit temperature response in only 37% and 29% of the sessions respectively ($SD = 15$, range = 8 to 55; $SD = 19$, range = 00 to 55). Although they received no feedback on digit temperature, EMG subjects met the performance criterion for the digit temperature response on 26% of the sessions. Subjects in the two digit temperature biofeedback groups met the performance criterion for monitored EMG (for
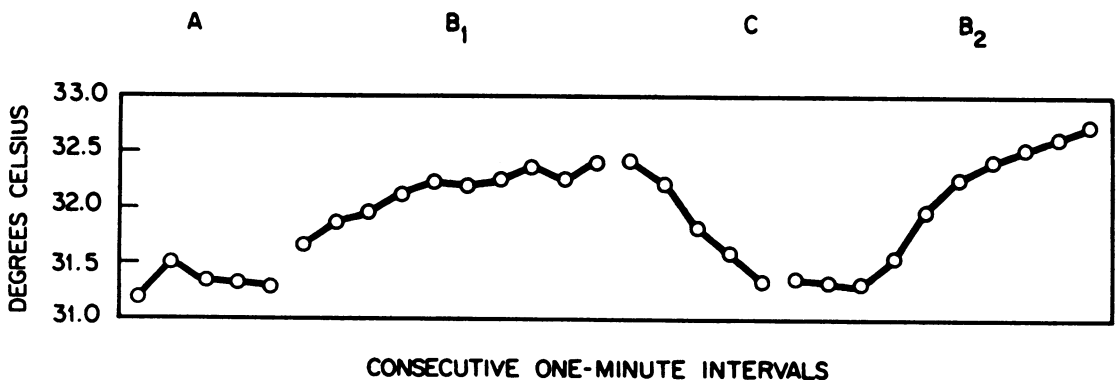

Fig. 3. Example of a criterion performance for a subject receiving digit temperature biofeedback. A = baseline; B_1, B_2 = biofeedback with instructions to "warm hands"; C = biofeedback with instructions to "cool hands".
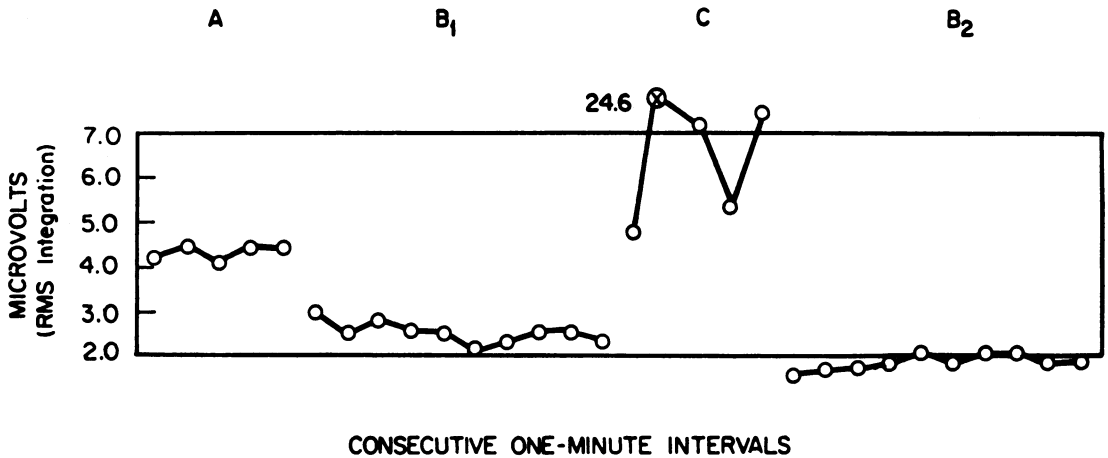
Fig. 4. Example of a criterion performance for a subject receiving frontalis EMG biofeedback. A = base-line; B_1, B_2, = biofeedback with instructions to "lower muscle tension"; C = biofeedback with instructions to "increase muscle tension".

which they received no biofeedback) more frequently than for digit temperature, a mean of 38% and 41% of the sessions. These data were subjected to a three (groups) by two (therapists) by two (responses) related measures analysis of variance. Analysis revealed significant effects attributable to response measures [F (1, 12) = 17.49; $p < 0.01$] and a significant treatment by measures interaction [F (2, 12) = 9.29; $p < 0.01$]. Therapist related effects were not significant.

Improvement over time. Due to the low percentage of criterion performances in the early digit temperature biofeedback sessions, we decided to increase the number of training sessions from eight to 10 in hope of improving performance. To determine whether the frequency of criterion performances for the group increased with training, the first nine biofeedback sessions for subjects receiving digit temperature biofeedback were divided into thirds. A chi square analysis of the distribution of criterion performances over these three periods did not show them to be different. Subjects receiving EMG biofeedback were limited to the originally scheduled eight sessions. A similar analysis of the distribution of EMG control performances over the first and last four sessions showed the distributions to differ only by one performance.

Response maintenance. The point biserial correlations between performance at followup (dichotomous variable) and the percentage of criterion performances during treatment (continuous variable) were 0.33 [t (16) = 1.36; n.s.] for the digit temperature response, and 0.49 [t (16) = 2.23, $p < 0.05$] for the frontalis EMG response. Only two of 12 subjects in the digit temperature biofeedback conditions met the performance criterion during both the last scheduled treatment session and the followup session. In contrast, all six of the EMG subjects met the criterion during both the last treatment session and at followup.

Ease of learning. When interviewed at the conclusion of followup, subjects were asked: "Did you find the biofeedback task a difficult or an easy one to learn?" All six of the EMG biofeedback subjects rated the task as "easy". In contrast, only four of the 12 subjects receiving digit temperature biofeedback reported the task to be easy. Fisher's Exact Test showed this difference in response distributions to be significant ($p = 0.0113$). Reported ease of learning was not related to actual performance in the biofeedback sessions.

Relationship of performance to headache improvement. There was no evidence for any relationship between criterion performance dur-

ing the biofeedback sessions and headache improvement. Product-moment correlations relating digit temperature, EMG, and target response performance to percentage change in headache activity, as measured by the daily headache record during training and the third month of followup, were not significant. Similar correlations between physiological performance and retrospective estimates of headache improvement were not significant. Also, when converted to t scores, none of the point biserial correlations between followup biofeedback performance and the percentage change measures of headache during the last month of record keeping reached significance.

Home Practice

The mean frequency of reported home practice remained relatively stable from treatment through followup at 1.05 times per day ($SD = 0.47$). The mean duration of reported home practice was 16.51 min ($SD = 7.23$). Home practice was not related to improvement in headache activity, as measured by the daily headache record. However, both the frequency and duration of home practice during the third month of followup were related to retrospective estimates of improvement [r (18) = 0.75, p < 0.001; r (18) = 0.55, p < 0.01]. Subjects who practiced the procedure more frequently and for longer periods of time estimated more improvement in headache activity.

Rational-Emotive Therapy

Both principal therapists followed the RET manual closely. Each subject brought at least two written homework reports for discussion by the third RET session. Emphasis was placed on reviewing homework reports, reinforcing examples of rational thinking, and offering alternative points of view to self-defeating cognitions. The review of the 11 "rational points of emphasis" (Lazarus, 1971) was abridged in two cases due to the pressure of time. Although the RET treatment was identified as the "most helpful" aspect of the entire treatment package

by five of the six subjects in the digit temperature biofeedback plus RET group, there was no evidence for a differential effect of RET in modifying "irrational beliefs". A four (groups) by two (therapists) by three (periods) repeated measures analysis of variance on total scores on the Irrational Beliefs Test revealed a significant period effect [F (2, 32) = 4.96; $p < 0.05$], reflecting a decrease in test scores over time for all four experimental conditions. Assignment to the different treatments and therapists did not differentiate between groups. An analysis of variance applied to baseline test scores did not show the groups to be different.

DISCUSSION

Digit temperature biofeedback alone or in combination with RET did not prove to be more effective in the management of migraine than EMG biofeedback training or self-monitoring of headache activity. In some analyses, the three biofeedback groups were more effective than self-monitoring alone, but not different from each other. Retrospective estimates at followup indicated a mean reduction in headache activity of 46% relative to baseline for the three biofeedback groups combined, in contrast to a mean increase of 17% reported by subjects on the self-monitoring waiting list. Two-thirds of the subjects receiving some form of biofeedback also reached a clinical criterion of a 33% or greater reduction in headache activity as measured by the more objective daily headache record during the last month of followup relative to baseline. These figures compare favorably with some previous reports. Medina, Diamond, and Franklin (1976) reported that 48% of their subjects achieved a 30% reduction in both headache activity and medication consumption. In a followup of the early Menninger work, Solbach and Sargent (1977) reported that 74% of subjects completing biofeedback training achieved a 25% or greater reduction in headache activity.

On other analyses, the EMG biofeedback treatment was actually superior to the digit temperature conditions. Further statistical analysis based on the clinical criterion showed only the EMG group to be superior to self-monitoring: all six of the EMG subjects passed the clinical criterion of improvement. On the other hand, when daily headache records were examined with the statistical analysis appropriate to the complete experimental design over the five experimental periods, the biofeedback groups were not found to differ from the self-monitoring condition. Daily records of headache activity reflected a great deal of within-subject variation.

In contrast to previous clinical reports of a quick and facile acquisition of the digit temperature response (Medina *et al.,* 1976; Taub, 1977; Wickramaskera, 1973), the present study found evidence for bidirectional performance in only one-third of the digit temperature biofeedback sessions. These results are consistent, however, with the data reported in well-controlled studies with both normal subjects and migraineurs (Packer and Selekman, Note 1; Price and Tursky, 1976; Surwit *et al.,* 1976). Without adequate within-subject designs for the analysis of the response, previous clinical reports may have mistaken the normal rise in digit temperature during baseline periods as evidence of the ability to control finger temperature, if the trend continued through the feedback condition. In the present experiment, a linear finger-warming trend during baseline was identified in 71% of the sessions.

It is conceivable that a greater number of biofeedback sessions are necessary for an adequate test of both the ability to learn bidirectional response performance and the clinical effectiveness of the procedure. However, the number of sessions in the present experiment is within the range reported by some other investigators (Andreychuk and Skriver, 1975; Johnson and Turin, 1975; Medina *et al.,* 1976, Mongtomery and Ehrisman, 1976). Also, digit temperature performance for the group as a whole did not improve with training, a finding consistent with the previous report by Surwit and his colleagues (1976). It should further be noted that the percentage of criterion performances during the biofeedback sessions was not related to changes in headache activity. Kewman (1978) also found no relationship between a "learning criterion" for finger temperature and reductions in migraine activity. Although the frequency of home practice did contribute over 55% of the variance in retrospective estimates of headache improvement, it was not related to changes on the more objective daily headache record.

A number of weaknesses in the present experimental design merit discussion. The limited number of RET sessions does not constitute an adequate test of this treatment. The additional time spent with RET subjects would cause interpretive problems had the results been positive. Differences in the number of treatment sessions between the EMG and digit temperature treatments further confound the design, and would pose additional interpretive problems if the digit temperature treatments had proved superior. On the other hand, had it been possible to train digit temperature subjects to a criterion of successful performance, the EMG and digit temperature treatments might be more adequately compared. As it was, those subjects who performed moderately well on the digit temperature task did not maintain criterion performance at followup. The design does not permit a separate analysis of the contribution of relaxation instructions and biofeedback. The self-monitoring waiting list was not presented as a treatment procedure on the same par as the biofeedback procedures. The reversal design demanding bidirectional movement of the physiological response during the feedback sessions creates a very different protocol than the hand-warming treatment utilized in previous studies, and may have contributed to the negative results on both treatment outcome and biofeedback performance. Continued training in finger-cooling without subsequent warming

instructions may actually increase migraine activity for some individuals (Johnson and Turin, 1975; Kewman, 1978). In the present experiment, however, digit cooling was presented only as a brief experimental phase within the biofeedback sessions, and was not a part of the home practice instructions.

The theoretical rationale for the use of digit temperature biofeedback in managing vascular headache remains both speculative and poorly explicated (Taub, 1977). Future clinical research on the finger temperature technique should continue to subject this response to experimental analysis, explore the conditions under which performance may be enhanced, and assess the relationship of performance to headache activity. Future clinical researchers interested in the nonpharmaceutical treatment of migraine may be advised to examine other biofeedback loci more directly related to the source of head pain, such as the extracranial artery (Friar and Beatty, 1976), as well as other treatment strategies relying on a multimodal package of cognitive and behavior therapeutic techniques (Mitchell and Mitchell, 1971; Mitchell and White, 1976, 1977).

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