EMG BIOFEEDBACK II: THE DOSE—RESPONSE RELATIONSHIP

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SUMMARY

35 clients with anxiety neurosis were trained to reduce frontalis muscle tension over two phases of ten sessions each. They were assessed on psychological and physiological measures, before, during and after the phases. The data analysis indicated that the clients succeeded in lowering frontalis muscle tension levels during the feedback and no-feedback phases of the training sessions. The inter-correlations among the outcome measures indicated that with an increasing amount of control of muscle tension, the clients perceived greater amounts of change in state anxiety and in anxiety symptoms. This implies that EMG biofeedback can effect cognitive changes in clients.

Treatment outcome with EMG biofeedback training may be mediated by two change mechanisms.

The first model of the change mechanism postulates that as a consequence of contingent reinforcement of a physiological response, clients learn control of the response and the appropriate exertion of this control results in a reduction of the symptoms caused by the dysfunctional system. During biofeedback training, clients may also learn to evoke a generalised state of low arousal as well as to alter the levels of the target physiological response (Stoyva, 1977).

The second model is derived from a general model of psychotherapeutic change which emphasizes the impact of performance accomplishments on cognitive processes thought to mediate symptom improvement (Bandura, 1977; Frank, 1974). It postulates that if clients perceive biofeedback training as a credible treatment and perceive themselves as self-efficacious, these cognitive changes can result in new persistent efforts to cope with the symptom related stressors. These efforts can alter the psychological and physiological stress responses which trigger the symptoms. It is possible that biofeedback training, by encouraging clients, to attend to bodily sensations, may heighten awareness of sensations associated with the symptom onset, so that efforts to control the symptom can be initiated at an earlier point. Essentially, it is postulated that symptoms reduce, as a consequence of cognitive and behavioral changes stimulated by contingent success and not as a direct consequence of the clients efforts to control a target physiological response.

These two models of therapeutic change may not be mutually exclusive: different subgroups of clients may follow different paths to improvement or different biofeedback training procedures may activate different change mechanisms (Holroyd et al., 1984).

The authors in the present paper sought to identify the mechanism by which
changes in anxiety responses occurs with increasing amounts of control of frontalis muscle tension.

Material and Methods

Sample:

Clients with anxiety symptoms were referred to the Behaviour therapy and Biofeedback Unit, Department of Clinical Psychology at the National Institute of Mental Health & Neuro Sciences (NIMHANS), from the Psychiatry Out-patient centres of NIMHANS and Victoria Hospital, Bangalore. 36 clients with anxiety neurosis (300.0, ICD-9, 1978) completed the twenty session EMG biofeedback therapy programme. There were 32 males and 4 females with an average age of 28.22±6.25 years. They were literate with 13.08±2.93 years of education. 19 of the clients were married and 17 were unmarried. There were 8 professionals, 16 nonprofessionals, 9 students and 3 unemployed clients. 31 of the clients had prior treatment experience and 5 did not have any prior treatment experience. The mean duration of anxiety neurosis was 5.32±3.14 years, without an associated medical illness or an additional/alternative psychiatric diagnosis.

Assessment measures:

PSYCHOLOGICAL

State—Trait Anxiety Inventory (STAI)—Form Y1 (Spielberger et al., 1993).

Hamilton’s Anxiety Rating Scale (HARS) (Hamilton, 1959; Lader & Marks, 1971).

Symptom Rating Scale (SRS) (Sargunaraj and Kumaraiah, 1989).

PHYSIOLOGICAL

Feedback Myograph—Autogen 1700:

The frontalis placement procedure (Instruction manual, Autogen 1700) was used for the assessment sessions and each of the training sessions.

During each session, the input weighting control was at A, the band-pass selector at 100-200 Hz, the electrode impedance from the two active electrodes was 20,000 ohms or lower and an appropriate scale of sensitivity was chosen for each client. In addition, during each training session the meter averaging time selector was at 50 seconds; the audio feedback mode selector at AN2 (continuous analog tone and feedback response control at 1 sec).

At the pre-, mid- and post-therapy intervals, following a 5 minutes adaptation period, the therapist recorded the resting level at 50 seconds intervals during the 30 minutes session.

For each training session, following the 5 minutes adaptation period, the therapist recorded a pre-session baseline value. It was an average of those obtained over the last 50 seconds of the adaptation period. During the 30 minutes feedback phase, values were obtained at 50 seconds intervals. There was a 5 minutes period of no-feedback after the training session. Then the therapist recorded a post-session baseline value which was an average of those obtained over the last 50 seconds of the post-session rest period.

Feedback thermometer—Autogen 2000b:

The digital skin temperature was monitored with a single thermistor taped to the palmar surface of the middle finger of the left hand.

The input was from channel A and the scale of sensitivity was XI. The baseline temperature quantifier was set at the reading for which the needle on the response meter rested at 0.

During each assessment session, after the 5 minutes adaptation period, the therapist recorded the resting level at 50 seconds intervals for 30 minutes.

Feedback dermograph—Autogen 3400:

The electrodermal activity was monitored
from the palmar surface of the second and fourth fingers of the right hand.

The instrument was set with the meter function selector at R 5 (50 seconds) and the response scale selector at XI. An appropriate scale of sensitivity was chosen for each client.

In each assessment session, following the adaptation period, the automatic baseline switch was depressed to reset the response meter to the skin conductance baseline level. The therapist recorded resting levels of skin conductance level and response at 50 seconds intervals for 30 minutes.

Procedure:

*Intake interview*: A client consenting for EMG biofeedback therapy was informed that the entire programme would involve 20, one-hour sessions of EMG biofeedback training with assessments sessions before, during and after therapy to monitor progress. The concepts of tension, reactivity to stress and the consequences of chronic elevated tension were explained to each client through illustrations. It was emphasized that there was a need for the home practice of relaxation and the active use of relaxation skills to overcome situational anxiety.

*EMG biofeedback therapy (Phase I)*: The training protocol for the EMG biofeedback therapy was evolved from the guidelines provided in the Instruction manual for the Autogen 1700 and that provided by Budzynski et al. (1980), Stoyva (1979) as well as from the therapist's clinical experience of working with an independent sample of 12 anxious clients during the pilot phase.

Following the pre-therapy assessment, the first training session was designed to acquaint the client with the capabilities of the feedback myograph, as all the clients were naive regarding biofeedback therapy. The therapist explained that the frontalis muscles were chosen as the site for relaxation training, as the tension level in these muscles served as an indicator of residual muscle tension throughout the head, neck and shoulder regions. The client was informed that the biofeedback instrument was a passive learning device and that its function was to continuously monitor and display muscle tension levels. Further, that the readings on the response meter, the audio and the visual displays would provide additional information as to the presence or absence of muscle tension.

During the initial three feedback sessions, clients learnt to be aware of the occurrence of tension or relaxation. Each client actively experimented with the biofeedback signals and observed what caused the changes in them. During this phase, at the post-session interview most often, clients reported that the physical movements of the upper body musculature (swallowing, movement of the eyebrows, lips or tongue, clenching of the teeth, deep breathing) caused the change in the signals while movements of the limbs produced no change. The absence of physical movements and adopting a passive attitude caused a fall in the meter reading. The therapist provided prompts to those clients who had difficulty in identifying cues signalling tension or its absence. They were encouraged to observe the effect of physical movements, affective imagery intrusive thoughts on the feedback signals.

Over the next seven feedback sessions, each client learnt to control the levels of muscle tension by utilising the threshold function of the instrument. The threshold value was always set at the microvolt reading obtained as the pre-ession baseline. The visual feedback was present both above and below the threshold while the audio feedback was activated only if the muscle tension level exceeded the
Towards the end of the first phase of EMG biofeedback therapy, the meter scale was adjusted to a higher sensitivity level so as to enable each client to learn to reduce muscle tension levels to as low a level as possible.

EMG biofeedback therapy (Phase 2):

Following the mid-therapy assessment, an additional ten sessions were provided, the purpose of which was to facilitate generalisation of tension reduction to situations other than the clinic setting.

Apart from the training sessions at the clinic, the client was asked to commence practice of relaxation at home. The simulation of the training session was to be practised for 15 to 20 minutes at least twice a day preferably before one fell asleep and immediately on awakening in the morning.

On reporting an ability to relax adequately at home, the client was advised to practice relaxation briefly during the daily routine. The client was also encouraged to use relaxation as a coping skill during stressful situations. It was emphasized that clients needed to adopt a relaxed lifestyle.

The clients were made aware of the progress made in therapy at every post-session interview the therapist acquainted each client with their performance during the training phase as well as the muscle tension levels obtained at the pre- and post-session phases.

Following the post-therapy assessment, the clients were advised to continue the home practice for relaxation and to return to the clinic a month later.

Results

Training Sessions

The values obtained during the 1st, 5th, 10th, 15th and 20th training sessions were averaged for each of these sessions for a particular client and across clients to provide group mean values for each occasion.

![Fig 1 Average EMG values (± SEM) during therapy sessions.](image)

Fig. 1 indicates the group mean values (± SEM) during therapy sessions.

A test of the significance of mean differences indicated that from session 1 to 5, $t=7.10$ (p < .01), from session 5 to 10, $t=2.63$ (p < .05), from session 10 to 15, $t=0.40$ (NS) and from session 15 to 20, $t=1.40$ (NS). A trend analysis yielded a $F$ ratio = $85.37$ (p < .01) indicating a linear decrease in muscle tension levels across the 20 sessions with the decline being significant between sessions 1 and 10.

The pre- and post-session baseline values of each client for the 1st, 5th, 10th, 15th and 20th sessions were averaged across clients to provide group mean values.

The repeated measures analysis of variance (ANOVA-R) (Winer, 1971) yielded an $F$ (9,315) = 11.17, p < .01. Further the test for linearity was significant ($F=78.98$, p < .01).
Fig. 2 illustrates the progressive decline in the initial EMG value across the sessions as well as the clients' ability to maintain these lowered levels in the absence of feedback.

**Relationship among outcome measures:**

The scores of each client on the assessment measures were converted into percent change scores using the formula:

\[
\text{Percent Change Score} = \left( \frac{\text{Pre-therapy score} - \text{Mid/Post-therapy Scores}}{\text{Maximum Score}} \right) \times 100
\]

Angular transformations (Fisher and Yates, 1963) were then performed on each value prior to computing intercorrelations using Pearson's product-moment method (Garrett, 1981).

As indicated in Tables I and II, there is a significant positive relationship between the therapist's rating and state anxiety scores. There is a significant negative relationship between the

**Table I—Intercorrelations among the mid-therapy assessment change scores**

|       | STAI-YI | HARS | SRS | EMG | TEMP |
|-------|---------|------|-----|-----|------|
| HARS  | .3607*  |
| SRS   | .1757   |
| EMG   | .0432   |
| TEMP  | -.1756  |
| SCL   | -.0863  |

*p < .05

**Table II—Intercorrelations among the post-therapy assessment change scores**

|       | STAI-YI | HARS | SRS | EMG | TEMP |
|-------|---------|------|-----|-----|------|
| HARS  | -.0654  |
| SRS   | .0189   |
| EMG   | -.1494  |
| TEMP  | .0962   |
| SCL   | .0396   |

*p < .05
anxiety symptoms and skin conductance values.

Discussion

The training effect discernible over 20 sessions is in accordance with the consensus in the literature that provision of an analog feedback signal results in effective reductions in muscle tension (Qualls & Sheehan, 1981).

The maximum decrease is seen over the initial 10 sessions. A similar length of training is reported by Lavallee et al. (1977) to effect muscle tension reduction in anxious clients.

Besides acquisition of feedback control, clients demonstrate an ability to maintain low tension levels during the post-training session intervals. Self-control of the response is evident in the final session where clients have low pre-session baselines and are able to maintain level during the 5 minutes interval after the termination of the feedback signals.

The greater amount of control over muscle tension has had an impact on state anxiety, on the therapist's rating of anxiety and on the self-report of anxiety symptoms. The associated increase in skin conductance level can be attributed to the demands of the biofeedback task. This component of sympathetic arousal is responsive to tasks requiring concentrated attention (Gatchel et al., 1978).

The lack of an unitary change among the physiological variables indicates an absence of generalised reduction in arousal. Instead the impact of EMG biofeedback on the psychological variables implies that cognitive changes accompany decreases in frontalis muscle tension.

Though the differential pattern of change in anxiety responses implies that the subsystems are loosely linked (Lang, 1985; Kunick, 1984), the cognitive—somatic distinction requires validation in future research.

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