EMG BIOFEEDBACK APPLICATION WITH BEHAVIOURALLY DISTURBED MENTALLY RETARDED INDIVIDUALS

By

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ABSTRACT

Biofeedback is the use of instrumentation to provide feedback to a client about his/her psychophysiological processes. One type of biofeedback is Electromyographic (EMG) which measures muscular contraction and relaxation. This thesis examines the use of EMG feedback as a therapeutic tool in teaching relaxation to seven mentally retarded individuals from a specialized treatment area for aggressive and self-injurious clients in a provincially-operated institution.

Experiment 1 examined the feasibility of EMG biofeedback relaxation training with a 21 year old profoundly retarded male and a 27 year old severely retarded female. An Auto Clinic 2001 (Colbourn Instruments) biofeedback apparatus was used to monitor EMG activity. Subjects participated in 10 training sessions for each of the following three conditions: (a) contingent biofeedback (music) relaxation training; (b) control on (continuous music); and (c) control off (no music). The results demonstrated more consistent reductions of EMG activity across contingent conditions for both subjects. Contingent biofeedback training also resulted in significantly lower measures for one subject in comparison to one control condition, and two control conditions for the other subject.

Experiment 2 examined the possibility of generalizing the effects of biofeedback training across settings and compared the effects of a proportional-analog stimulus and discrete stimulus. The three subjects were a 21 year old mildly retarded male, a 31 year old severely

retarded male and a 15 year old mildly retarded male. The same equipment was used, with modifications that allowed the production of a proportional-analog stimulus. All subjects were exposed to 25 sessions consisting of the following four conditions: discrete, variable, baseline and control. Music was presented to the clients in the discrete and variable conditions. The results from the final sessions demonstrated that the discrete condition induced more relaxation in all subjects than the three other conditions. An analysis of the pre- and post-training rating scales indicated that 100% of the improvement in the subjects behaviour occurred in the non-control treatment conditions.

Experiment 3 investigated the possible advantage of massed practice EMG biofeedback training with a 26 year old mildly retarded male and a 42 year old moderately retarded male. Subjects were exposed to the same conditions as in Experiment 2 for a total of 26 sessions. Analyses of the one subject's data suggested that both feedback (treatment) conditions induced more relaxation than the baseline condition, but not significantly more than the control condition. Analyses of the other subject's data suggested that the subject only relaxed during the control condition.

In summary, the results of these experiments demonstrated that EMG biofeedback is feasible with mentally retarded clients, and that a descrete condition was the best relaxation technique (Experiment 2). It was also shown that generalization of biofeedback training across settings was not detected, and that massed practice may be more conducive to learning to relax, as opposed to randomizing and inter-mixing several conditions. Several suggestions for future research were also discussed.

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INTRODUCTION

"Biofeedback is a generic term which is applied to a variety of procedures which, in essence, feature the continuous display (or feedback) of information about the status of physiological changes in the body. With such information continuously available, the individual is able to consciously control physiologic functioning which had previously been maintained on an unconscious, or less conscious, level" (Strider & Strider, 1979). Currently, biofeedback technology and clinical application most often encompass: (1) stress management and relaxation; (2) temperature; (3) electromyography; (4) galvanic skin response; (5) electrocardiographic technique; and (6) electroencephalographic measurements (Strider & Strider, 1979).

Biofeedback is also used to assist in the rehabilitation of physically disabled persons, such as cerebral-palsied children. In addition, EMG biofeedback has been used to decrease hyperactivity, to lower the frequency of asthma attacks and tension headaches, and to assist in the rehabilitation of muscles (Blanchard et al., 1974; Coursey, 1975; Finley et al., 1977; Simkins, 1982; Strider & Strider, 1979). Research has also been conducted in the use of EMG biofeedback to decrease the frequency of self-injurious behaviour and aggression (Hughes & Davis, 1980; Schroeder & Peterson, 1977). Other examples of biofeedback's diverse applications include the application of EEG biofeedback to decrease the frequency of epileptic seizures and of vascular headaches (Blanchard et al., 1974; Rudrud and Striefel, 1981). It has also been used to assist in teaching relaxation and to increase visual attention (Conners, 1979; Thorson & Lipscomb, 1982). Temperature biofeedback has been employed in the treatment of Raynaud's disease and migraine headaches (Blanchard et al., 1974).

This thesis will be focusing on the use of electromyography (EMG) biofeedback to teach relaxation. EMG biofeedback measures muscle tension which is a result of the electrical activity in the muscles. Electromyograph biofeedback has been used to treat general anxiety, asthma, tension headaches, and vascular disorders such as hypertension, migraine headaches and Raynaud's disease (Simkins, 1982).

Although EMG biofeedback can be obtained from any muscle, the frontalis (forehead) muscle has been traditionally used to determine an individual's state of relaxation. In EMG biofeedback relaxation studies, muscle activity of the frontalis muscle reflects the tension of facial muscles which is one of the most difficult tensions to dissipate and which has been established as a reliable indicator of overall level of relaxation (Schandler & Grings, 1976; Stoyva & Budzynskii, 1974: cited in Denkowski et al., 1983). However, Simkins (1982) points out that declines in EMG may not occur specifically due to a reduction in frontalis muscle activity, but may occur as part of the subject's habituation to a new environment or of a subject's general non-specific relaxation state.

Although there have been many studies using biofeedback techniques, including EMG biofeedback, there have not been many studies using biofeedback techniques with mentally retarded persons. The following is a brief review of some of the literature involving biofeedback with mentally retarded individuals. Rudrud & Striefel (1981) demonstrated that electroencephalograph (EEG) biofeedback could be used with retarded individuals to decrease some aspects of their seizure activity. All the subjects received feedback when they produced 8-12 Hz activity; however, only two of the three subjects increased production of 8-12 Hz activity as a result of the training procedures. The authors speculated that the most probable explanation for these results was the differing degree of effectiveness of the feedback stimuli used in terms of their function as reinforcers. Although firm conclusions regarding the efficacy of the procedures used could not be drawn, the results of the study suggested potential benefit in conditioning 8-12 Hz occipital activity in retarded individuals with uncontrolled epilepsy.

In another study using EEG feedback, Thorson & Lipscomb (1982) taught 16 moderately retarded adolescents to increase oculomotor activity. In their study occipital alpha density (percentage time in alpha) was used as an index of oculomotor activity. The subjects could learn to decrease their occipital alpha activity by learning to visually attend to a toy train (the oculomotor theory of alpha training). In addition to the reinforcing properties of the train, 8 subjects (experimental group) received a M & M candy each minute that they reduced their average alpha activity by 10% from the previous training session's average. The subjects who received occipital alpha feedback plus a reinforcer (edible) stimulus significantly decreased their alpha density in comparison to the control group. The results of this study demonstrated that the experimental individuals who were presented with contingent feedback produced significant alpha attenuation. In comparison, the control group which did not receive contingent feedback, produced little change in alpha attenuation.

Schroeder et al. (1977) employed EMG biofeedback to aid in the reduction of self-injurious behaviour (SIB) in two severely retarded individuals. Each subject was involved in three daily procedural conditions: (a) contingent restraint for SIB, verbal reinforcement for relaxation, but no biofeedback signal; (b) same as (a) but with the biofeedback signal; (c) same as (a) and (b) but with edible reinforcement in addition to verbal reinforcement for relaxation. Condition (c) also included a break during which therapist, client and observer socialized without any consequences for SIB or relaxation. The results indicate that contingent restraint combined with EMG biofeedback decreased SIB more effectively than contingent restraint alone. The authors also discovered that each client displayed an idiosyncratic pattern of EMG activity immediately prior to performing SIB of different specific topographies. The authors suggested that EMG feedback could possibly be used as an alternative channel of communication, particularly with non-verbal clients. They also indicated that if the idiosyncratic pattern of EMG activity is converted to specific signals, it could be used as a cue by the therapist to prevent the occurrence of SIB.

In another study, Hughes and Davis (1980), decreased the frequency of verbal and physical aggressive responses by reinforcing attempts to relax (utilizing EMG biofeedback) when discriminative stimuli for aggressive behaviour were present. The investigation was conducted in five phases: (1) baseline; (2) EMG biofeedback training; (3) response discrimination training; (4) intervention; and (5) return to baseline. The results indicated that there was a significant decrease in aggressive responses during intervention in comparison to the number of responses that occurred during the initial baseline. The frequency of aggression increased during return to baseline, however, the rate did not return to the level of initial baseline. This demonstrates some generalization of intervention effects. The authors concluded that their treatment effectively reduced physical and verbal aggressive responses in an autistic individual exhibiting such behaviours.

Although there has been much research conducted in the area of biofeedback, very few methodologically sound studies have been conducted. Simkins (1982) has addressed some of the methodological and conceptual problems inherent in many of the biofeedback studies conducted during the last 20 years.

Studies differ in the experimental procedure used and fall into several general categories: (1) single individual case reports and uncontrollable group studies; (2) larger group, controlled comparison studies employing double blind and placebo conditions; and (3) clinical trials using large samples and adequate controls. The type of experimental procedure has a direct effect on the reliability and validity of conclusion regarding treatment effects.

Procedural issues also have an effect on the reliability and validity of conclusions about treatment results. For instance, many biofeedback therapists have an incomplete understanding of how biofeedback works and therefore, they may be unaware of the possible artifacts which can influence the signal or affect the instrument. Simkins (1982) notes that there is a wide range of variability in the technical characteristics of biofeedback equipment. This instrument variation should be taken into consideration when designing an experiment.

Some of the other procedural issues that may invalidate biofeedback studies are response measurement, baselines, subject selection, and the role of instruction. Response measurement can be defined as how the response is observed and reported. There is a need for a standardized response measurement, as these appear to vary greatly from study to study.

With regard to baseline variables, many studies use very brief baselines, and hence the resulting decline in EMG activity may be the consequence of a subject's habituation to a new environment rather than a function of biofeedback effects. Inconsistent results may also be obtained when there are large individual differences in baseline levels of physiological responses.

Subject selection is often inadequately done. The motivational factors and trait anxiety of the subjects should be considered when designing an experiment: Are the subjects volunteers from an academic setting or are they patients seeking relief from a clinical problem? It is not clear what role instructions play in the facilitation of response change. However, Simkins (1982) points out that previous research has demonstrated that brief instructions are not as effective as detailed instructions in reducing muscle tension.

Some of the conceptual issues that Simkins addresses are model inconsistencies, maintenance and generalization effects, placebo effects, and therapist's attitudes. The issue of model inconsistencies brings to our attention the validity of various treatment procedures. For example, there is little evidence that EMG biofeedback using the frontalis muscle to relax will generalize to non-target muscle groups. This lack of generalization demonstrates that sound research is required in order to validate various treatment procedures.

Many studies do not test for generalization, nor do they include a maintenance phase. A clinically sound study should result in the response changes occurring in the subject's natural environment, not just in the laboratory setting. With respect to generalization, all studies should include a post-feedback test. This test would suggest how enduring training effects are in the absence of feedback.

The problem of placebo effects refers to whether or not the treatment is really effective, and if the results are thus contingent upon treatment, or on whether or not the results can be attributed to nonspecific factors. (Miller 1978, cited in Simkins, 1982) discusses how some patients will show improvement regardless of what treatment intervention is used. Simkins (1982) concludes that the placebo effect is not necessarily evil, but that it may be unethical to advocate wide scale use of costly biofeedback techniques instead of cheaper procedures. Simkins (1982) has also pointed out that the therapists' attitudes can potentially inflate placebo reactions or suppress genuine effects.

As stated previously, there have been very few studies using biofeedback that have attempted to adquately address all or some of the above issues. There have been even fewer biofeedback studies conducted with mentally retarded persons as subjects that have examined and corrected the above problems. In this thesis, EMG biofeedback was used to assist a number of mentally retarded clients to relax.[1] I also attempted to address some of the methodological and conceputal problems relating to habituation, non-specific relaxation, placebo or demand effects (Simkins, 1982) that have affected other studies. The feasibility of using biofeedback with a mentally retarded population, while controlling for some common methodological and conceptual problems was also demonstrated in this thesis.

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[1]As part of the admission process of clients to the specialized units, parents give their approval for their children to participate in research projects for clinical and therapeutic treatment. This approval also permits the presentation of research to other professionals.

EXPERIMENT I

The purpose of this experiment was to compare EMG (frontalis muscle) biofeedback relaxation training vis-a-vis control conditions in a within-subjects design to establish the effectiveness of such training in severely and profoundly retarded individuals.

METHOD

Subjects

Two subjects from a specialized treatment area for aggressive and self-injurious clients in a provincially-operated institution for the mentally retarded participated in the experiment.

Subject 1 was a 21 year old male (Jimmy) who was functioning at the profound level of retardation (-5) and untestable for I.Q. level. The subject had self-injurious behaviour, such as headbanging, headslapping, scratching and biting. Jimmy had a limited spoken vocabulary but was able to understand short sentences.

Subject 2 was a 27 year old female (Ruth) who was functioning at the severe level of retardation (-4) with an I.Q. of 26. The subject had been institutionalized for 19 years. She had a history of severe aggressive behaviour, such as hitting, scratching, and kicking others. The subject had a good vocabulary and was able to understand sentences.

Both subjects were ambulatory and did not have any visual or auditory impairments. Neither subject was on any medications at the time of the experiment.

Apparatus

The equipment used was an Auto Clinic 2001 (Colbourn Instruments) biofeedback apparatus equipped with an AC slave relay that activated a portable radio set at approximately 70 dB and tuned to a local, commercial music station. The Auto Clinic 2001 was used to monitor and to feedback to the subject muscle tension levels. The feedback myograph recorded muscle-produced electrical activity through three Ag Cl electrodes (6.5 mm in diameter) placed approximately 1 in. (2.5 cm) above the eyebrows and spaced 1½ in. (3.75 cm) apart on the subject's forehead. The electrodes were attached to the skin with adhesive disks and conductive gel, after the subject's forehead was cleansed with alcohol. The dependent variable (frontalis muscle bioelectric activity) was expressed in microvolt seconds (uv's), a time amplitude integrated measure of the amount of time the bioelectric response exceeded a high cutoff level (0.5 range from 0-10 microvolt sensitivity 250-1000 Hz band). Microvolt seconds were accumulated in four 60-sec. digital read-out bins. The biofeedback was calibrated at different times throughout the study using a non-retarded individual.

Procedure

Each subject participated in 30 weekly sessions. The subjects did not participate in any preliminary practice sessions, however, at the beginning of the first session the therapist explained the procedure to the subjects. Each biofeedback session lasted for 25 minutes including approximately 9 minutes hook-up and clean-up time. During each session each subject was brought to the experimental setting (an office adjacent to their residential areas) and made at ease in a comfortable chair. Ag Cl electrodes were affixed to the forehead with microlyte gel and adhesive collars. At the beginning of each session the subjects were instructed to "sit down and relax." During each session subjects were given the same prompts ("be nice and quiet, sit still"), and comments of encouragement ("you're doing fine, you're being a good boy/girl"). If the subject acted out behaviourally during the session, the therapist would ignore the behaviour if it was not serious. For more serious behaviours the therapist would intervene, and if necessary stop the session. The session would then be done the next day. Each session consisted of four 4 min. trials (total trials/sessions = 16). The subjects were exposed to 10 randomly assigned sessions for each of the following three conditions:

(a) Contingent biofeedback relaxation training, in which uv's below the 0.5 cutoff level activated the radio and provided pop music from a radio station.

(b) Control on condition, during which the radio provided continuous music regardless of the level of uv's activity.

(c) Control off condition, during which no range of uv's resulted in music presentation.

During each session the amount of bioelectric activity expressed in uv's was recorded for all 16 trials. During each session the amount of bioelectric activity expressed in uv's in the digital read-out bins was recorded in the subject's file for all 16 trials.

RESULTS

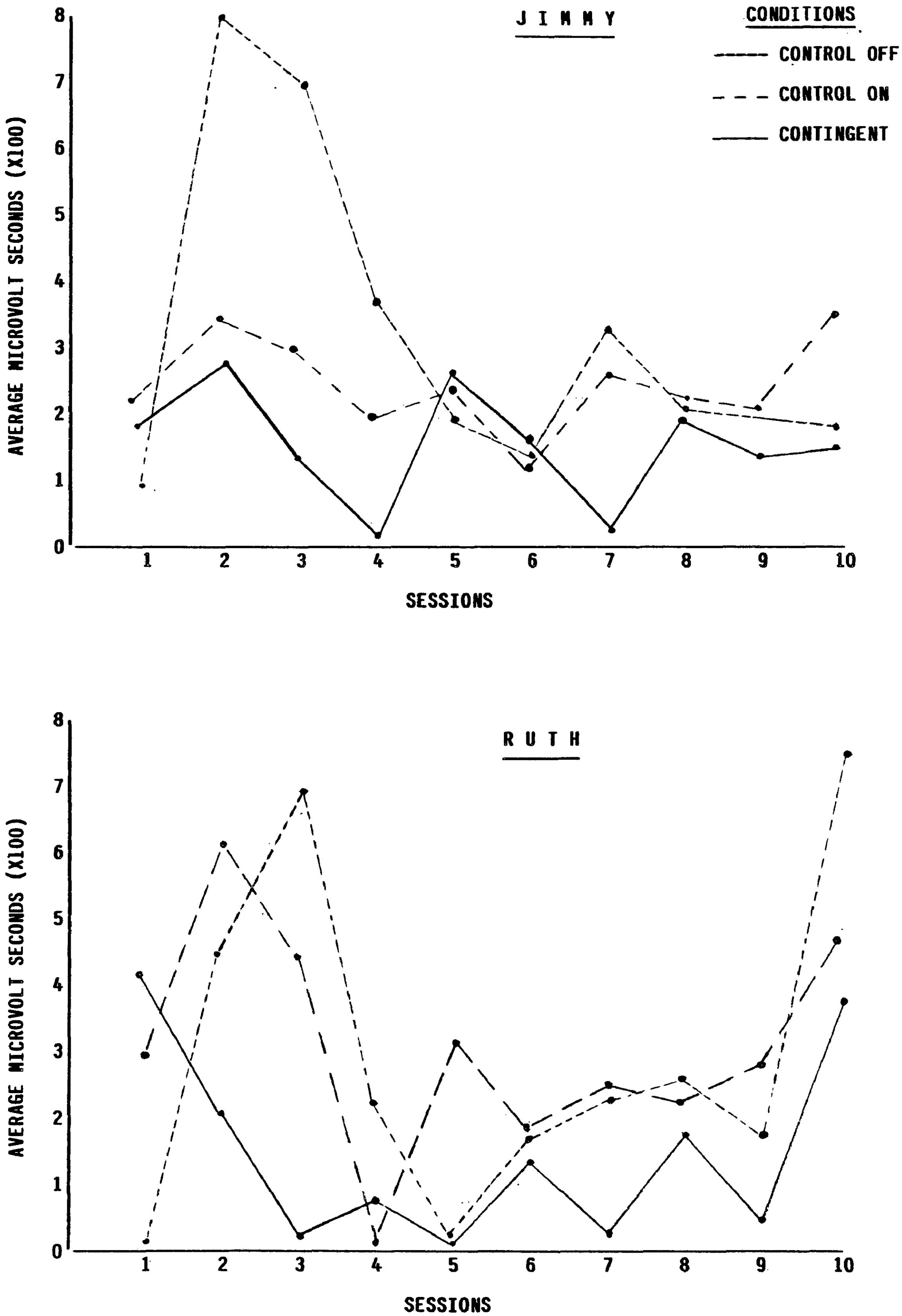
The average frequency of bioelectric activity per session was calculated for all conditions for both subjects and is presented in Figure 1. The results from Jimmy's graph demonstrates that the average uv's per session measures were lowest in 70% of the contingent biofeedback sessions, in comparison to the control on (10%) and control off (20%) conditions. The results shown on Ruth's graph demonstrate that the average uv's per session measures were also lowest in 80% of the contingent biofeedback sessions, in comparison to the control on (10%) and control off (10%) conditions.

A one-way analysis of variance with repeated measures was performed. This analysis did not yield any significant differences between conditions.

The data were then analyzed using a t-test. The t-test analysis of Ruth's data revealed a significant difference, $t(18)=1.43$, $P<.10$ between control off and control on sessions for average uv's and a significant difference, $t(18)=3.257$, $P<.005$ between contingent and control on sessions for the same measure.

The t-test analysis of Jimmy's data revealed a significant difference, $t(18)=2.33$, $P<.025$ between contingent and control off sessions (average uv's); a significant difference, $t(18)=4.095$, $P<.005$

FIGURE 1: AVERAGE EMG LEVEL ACROSS CONDITIONS



between contingent and control on sessions; and a significant difference, $t(18)=1.72$, $P<.100$ between control on and control off sessions (average uv's). Other t-tests were done but they were not significant. Thus, contingent training resulted in significantly lower measures for both subjects in comparison to at least one (Ruth) or both (Jimmy) control conditions.

Analysis of first and last session averages (see Table 1) demonstrates that there were consistent reductions of EMG activity across contingent conditions for both subjects, whereas consistent increases were noted in all other conditions.

Table 1

Average Percentage Change of EMG Activity

Between First and Last Sessions

	Ruth	Jimmy
Contingent	(152.1) - 11%	(221.2) - 9%
Control Off	(334.7) +1307%	(304.9) +80%
Control On	(311.8) + 138%	(254.9) +54%

* **NOTE:** Number in parentheses denotes mean uv's per condition

EXPERIMENT 2

An important difference between the stimulus variable used in Experiment 1 and the feedback stimuli commonly used in the literature is that Experiment 1 used a "discrete" signal whereas other studies (e.g., Russel, et al., 1982; Coursey, 1975) have used "proportional-analog" signals.

A discrete signal is generated only when the subject achieves relaxation at a predetermined fixed level of bioelectric activity. A proportional signal, in turn, begins to be generated as soon as a subject starts to relax and it continues to increase in pitch or along a similar dimension as the subject relaxes more deeply. Due to the broader range of proportional-analog signal, it could be assumed that the therapist would be able to shape a subject's relaxing behaviour more precisely. Hence, one of the main objectives of the present study was to determine if relaxation could be shaped faster, better or easier with a proportional-analog stimulus than with the fixed, discrete stimulus used in Experiment 1.

Few, if any biofeedback studies have attempted to generalize the effects of biofeedback training across settings. It is this generalizability of biofeedback across settings that determines the clinical significance of biofeedback training. In this study, I attempted to determine the generalizability of biofeedback training to other, non-training settings. This was done by correlating specific indices of the subjects' behaviour following each training condition, and comparing the post-training measure from a separate setting with a similar pretraining (control) measure from the same settings.

It was assumed that by incorporating a proportional signal as well as a discrete signal and analyzing the generalizability across settings, the present study would be able to further demonstrate what biofeedback variables are the most salient and most clinically effective for training M.R. clients in signaled biofeedback relaxation.

METHOD

Subjects

Three adult, male clients from a behavioural treatment unit for aggressive and self-injurious clients, located in a provincially-operated institution for mentally retarded individuals, participated in this experiment. The main characteristics of the experimental subjects are shown in Table 2.

Dave was a 21 year old male, functioning at the mild (-2) level of retardation with an I.Q. of 69. Just prior to the study, Dave had graduated from school. Dave had been institutionalized for over 5

Table 2

SUBJECT INFORMATION

Name	Age[1]	I.Q.	Medication[2]	Years Institutionalized	Major Problem Behaviours[3]	Major Diagnosis
Dave	21	69	None	5	Aggression; tantrum associated self-injurious behaviour.	Mild Retardation
Mark	31	32	200 mg Tegretol t.i.d.[4] 8 mg Haldol h.s. 2 mg Cogentin o.d.	23	Severe aggression; occasional self-injurious behaviour and destruction.	Severe Retardation
Billy	15	56	None	9	Severe aggression	Moderate Retardation

[1] At onset of Experiment 2.

[2] In effect during the course of Experiment 2

[3] Reason for referral to specialized unit.

[4] t.i.d. - three times a day; h.s. - at night; o.d. - once a day (during the morning)

years, and had a history of aggressive behaviour, and tantrum-associated self-injurious behaviour. He was diagnosed as Praeder-Willi Syndrome. Dave had excellent receptive and expressive language skills, although he did stutter on occasion. At the time of the study, he was not on any medications.

Mark was a 31 year old male, functioning at the severe (-4) level of retardation with an I.Q. of 32. He had been institutionalized for 23 years and had a long history of severe aggressive behaviour. Mark also had a history of periodic self-injurious and destructive behaviour when angered. At the time of this study, Mark's prescribed medication was 200 mg Tegretol t.i.d., 8 mg Haldol h.s., and 2 mg Cogentin o.d. Mark was able to understand simple commands and speak using single words, and worked full-time in the Craft Industrial Workshop during weekdays.

Billy was a 15 year old male, functioning at the moderate (-2) level of retardation with an I.Q. of 56. He had been institutionalized for 9 years with a history of severe aggression. At the time of this study, he was on no medications, and was attending school at the Grade 8 level. Billy had well-developed receptive and expressive language skills.

None of the subjects had any major visual or auditory impairments which would have precluded their participation in this study. They were all ambulatory, only Mark had an impaired gait.

Apparatus

The equipment used was an Auto Clinic 2001 (Colbourn Instruments, Lehigh Valley, Pennsylvania) portable biofeedback apparatus; it was equipped with an AC slave relay that activated a portable radio set at approximately 70 dB and tuned to a local, commercial FM pop music station. Prior to Experiment 2 the Auto Clinic 2001 was returned to the factory for recalibration. For this experiment, the apparatus was modified to produce, in addition to discrete (fixed level) signal, a variable (multi-level) signal. The additional threshold control, installed for the variable signal condition, bypassed the stimulus synthesis section of the biofeedback control panel. This enabled the therapist to generate proportional signals (i.e., music presentations that gradually increased in volume as microvolt seconds [uv's] activity gradually decreased below the High cutoff level of 0.5 range), as well as discrete signals (i.e., music presentations were made dependent upon uv's below the pre-specified High cutoff level of 0.5 range).

The Auto Clinic 2001 monitored and fedback to the subjects frontalis muscle tension levels. The feedback myograph recorded muscle-produced electrical activity through three AG Cl electrodes (6.5 mm in diameter) placed approximately 1-in. (2.5 cm) above the eyebrows and spaced 1.5 in. (3.75 cm) apart on a subject's forehead. Electrodes were attached to skin with adhesive disks and conductive gel, after the subject's forehead was cleansed with alcohol. The dependent variable was frontalis muscle bioelectric activity, expressed in uv's, a time-amplitude integrated response measure in the 0-10 uv and 205-1000 Hz band sensitivity range. Microvolt seconds were accumulated in four 60-sec. digital read-out bins.

Experimental Design

A within-subjects design was used in this study. Subjects were each exposed to 7 sessions of a baseline condition in which uv's were recorded, and no feedback was provided. They were then exposed to 6 randomly assigned sessions for each of the three following stimulus variables:

Discrete biofeedback relaxation training condition, in which uv's below a pre-established (0.5) cutoff level resulted in presentation of (radio) music at a pre-established volume.

Variable biofeedback training condition, in which uv's output proportionally affected the volume of the (radio) music (i.e., as the subject became more relaxed, the volume of the music increased).

Control condition, during which uv's activity was recorded but no music was presented.

Mark, Billy, and David participated in 25 sessions each.

Procedure

Sessions were conducted by two therapists. Each therapist usually worked separately and each had an opportunity to work with all clients. Sessions were conducted approximately every other day and lasted about 25 minutes, including 9 minutes preparation and clean-up time. Each session consisted of four bins of one-minute trials repeated four times for a total of 16 trials (16 minutes). During each session the amount of bioelectric activity expressed in uv's in the digital read-out bins was recorded in the subject's file.

The subjects did not participate in any preliminary practice sessions, however, at the beginning of the first session the therapist explained the procedure to the subjects. At the start of a session each individual subject was brought to the experimental setting (a quiet, bright room located on the residential ward) and made at ease in a comfortable, padded chair. Subjects' foreheads were then cleansed with rubbing alcohol and electrodes were affixed to the forehead with microlyte gel and adhesive collars. At the beginning of each session, subjects were instructed to "sit down and relax." During each session the subjects were given the same prompts ("be nice and quiet," and "sit still," or "try to relax,"), and comments of encouragement ("you are doing fine," "you are being good,"). If the subject acted out behaviourally during the session, the therapist would ignore the behaviour if it was not serious. For more serious behaviours the therapist would intervene, and if necessary stop the session. The session would then be done the next day. Before each session the equipment was adjusted according to the experimental condition, as pre-determined by a randomized schedule.

One hour prior to, and one hour after each session, the therapist consulted the residential staff about the subject's general behaviour, making specific inquiries about each client, such as: "Was Billy non-compliant today?", "Was he quiet, talkative, or argumentative?", and so forth. Residential staff were unaware of the experimental condition of any client on any particular day (single blind format). The therapist would then compare the subject's behaviour to the individualized behaviour scales (Appendix A) and determine the categories that were applicable to the subject's general behaviour. This data was not included because pre- and post-behaviour ratings were completed only during the last 32% of the sessions.

RESULTS

Figure 2 shows the average bioelectric activity (uv's) of the final session for each of the four conditions for each subject.[2] For all three subjects, uv's for the discrete condition were the lowest in comparison to each of the other three conditions. This was also demonstrated statistically by T-test analyses of the data.

A one-way analysis of variance with repeated measures was performed. The only significant difference found was for Billy between the control and variable session, $F(5,5)=3.32$, $P<.05$.

T-test analyses of Billy's data revealed significant differences between the following final sessions: discrete and baseline, $t(11)=12.34$, $P<.005$; discrete and variable, $t(10)=5.02$, $P<.005$; variable and baseline, $t(11)=7.39$, $P<.005$; control and variable, $t(10)=3.35$, $P<.005$; control and baseline, $t(11)-17.76$, $P<.005$. These

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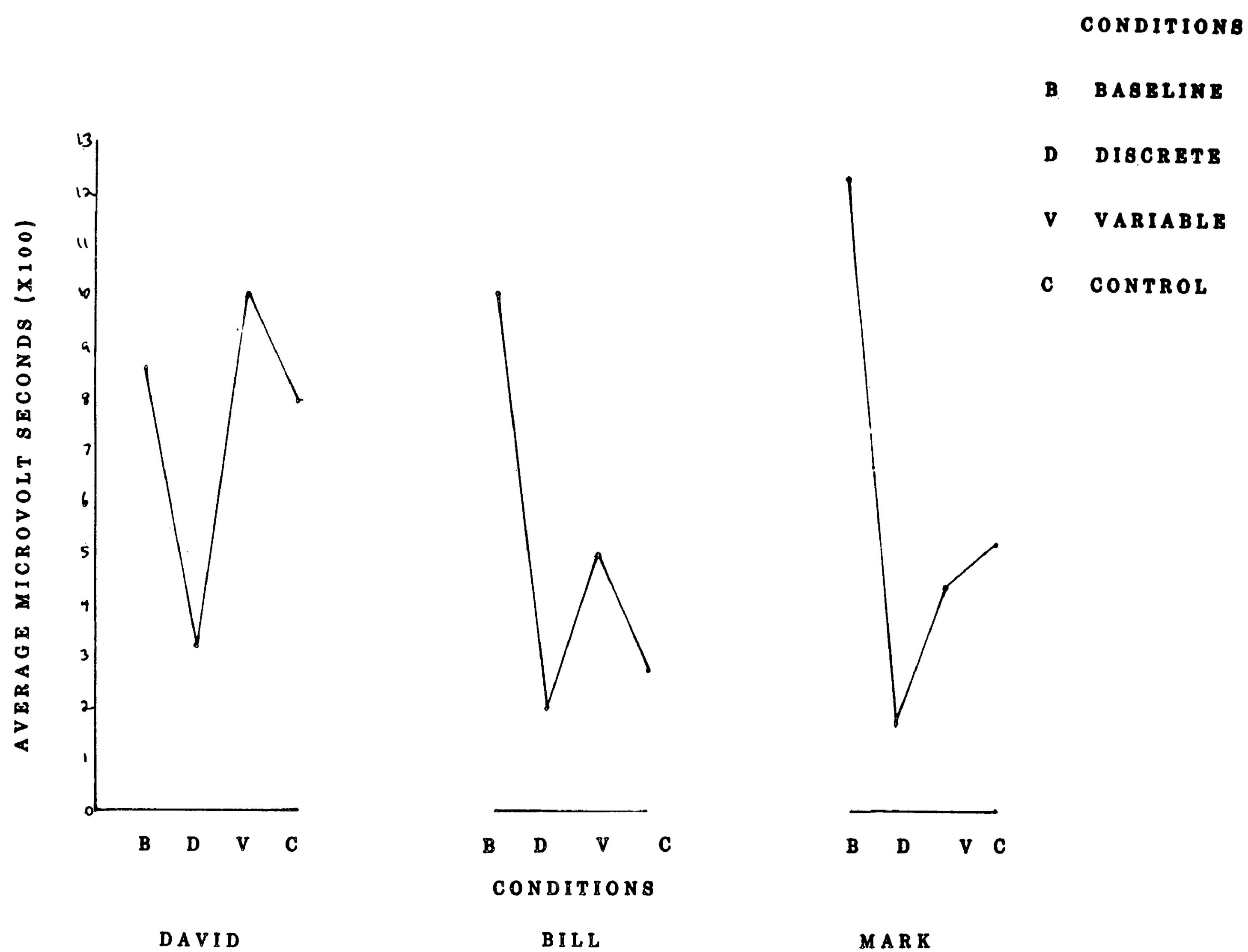
[2] More so than in Experiment 1, the results of Experiment 2 were marked by much intrasubject variability, and hence the decision to focus primarily on the final session of each condition. Statistical analysis of all sessions combined were also conducted (see Figure 4).

FIGURE 2: AVERAGE EMG LEVEL OF FINAL SESSIONS FOR ALL FOUR CONDITIONS



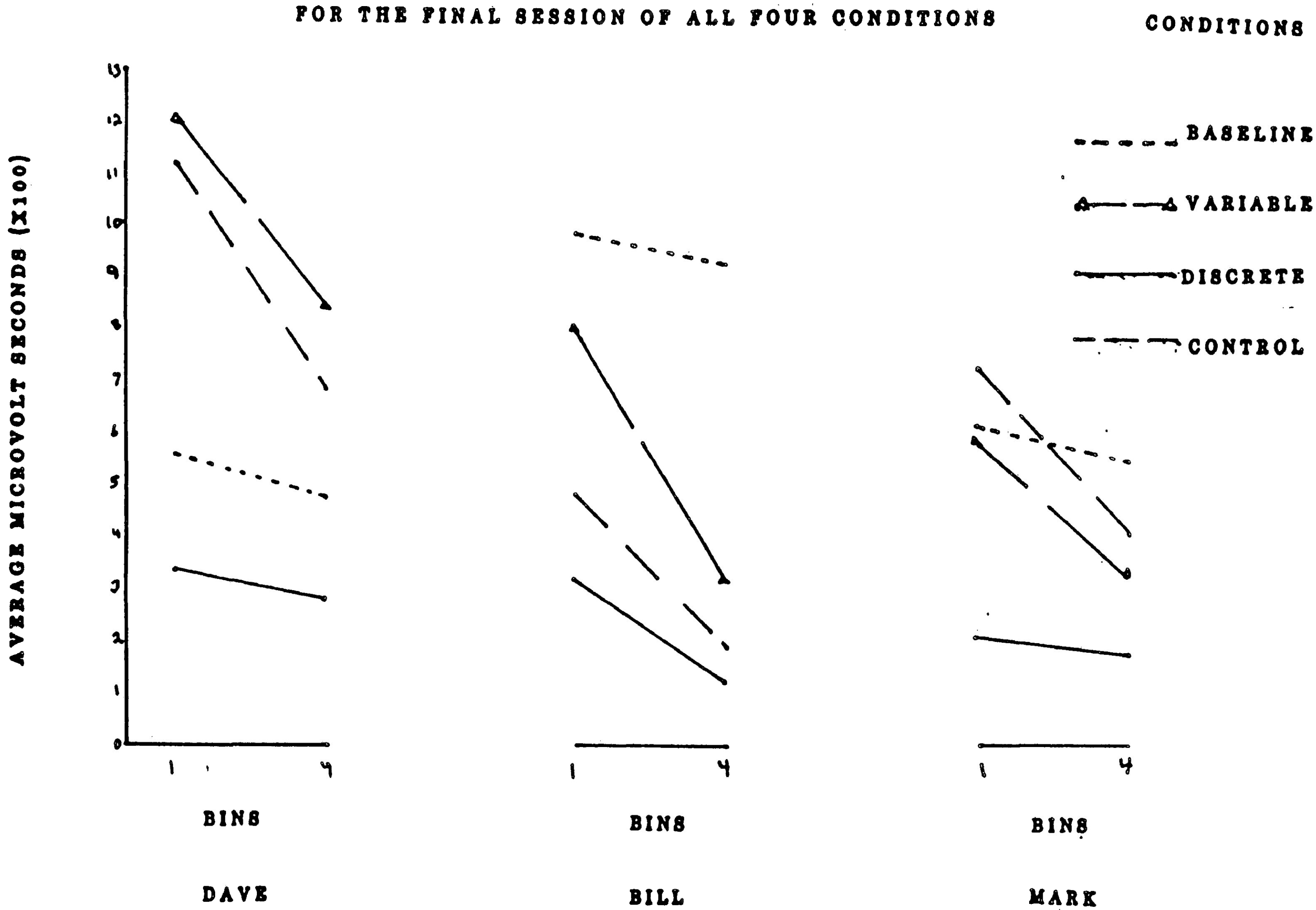
results suggest that the discrete condition induced more relaxation than the other three conditions. The results also show that the control condition also induced more relaxation relative to the baseline and variable conditions.

The t-test analyses of Mark's data revealed significant differences between the final sessions of the discrete and the other three conditions: baseline: $t(11)=6.33$, $P<.005$; variable: $t(10)=6.33$, $P<.005$; control: $t(10)=8.29$, $P<.005$. There were also significant differences between the final sessions: variable and control, $t(10)=2.11$, $P\leq.050$; variable and baseline, $t(11)=42.99$, $P<.005$; control and baseline, $t(11)=38.29$, $P<.005$. The analysis of Mark's data suggest that Mark was most relaxed during the discrete condition followed by the variable condition. The condition also intended to induce more relaxation than the baseline condition.

The t-test analyses of Dave's data revealed significant differences between the final sessions of the discrete and the other three conditions: baseline, $t(11)=6.69$, $P<.005$; variable, $t(10)=19.27$, $P<.005$; control, $t(10)=4.17$, $P<.005$; control and variable, $t(10)=5.85$, $P<.005$. These data suggest that the discrete condition clearly induced more relaxation than the other conditions. The analyses also suggest that the control and baseline conditions induced more relaxation than the variable condition.

FIGURE 3: AVERAGE EMG LEVEL FOR THE FIRST AND LAST BINS

FOR THE FINAL SESSION OF ALL FOUR CONDITIONS

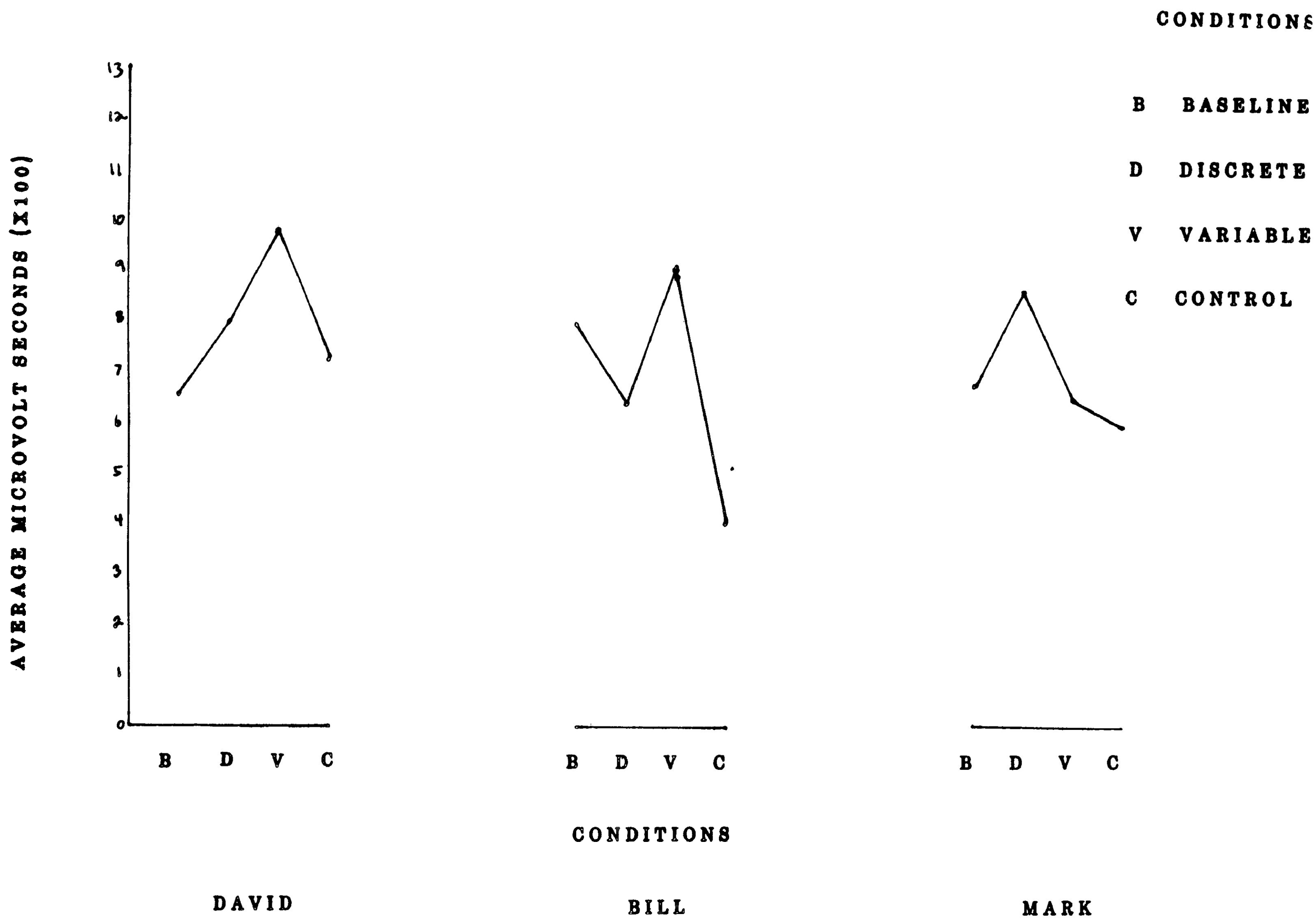


In summary, the discrete condition induced more relaxation than the other three conditions for all the subjects. For Dave and Bill, the control condition (which was identical to the baseline condition), appeared to induce more relaxation than the variable or baseline conditions. Other t-tests were done but they were not significant.

To determine if there were consistent reductions of bioelectric activity across conditions, the average uv's for the first and the last (fourth) bins for the final session of each of the four conditions for each subject were inspected. The data shown in Figure 3 demonstrates that the average uv's were always lower in the fourth bin in each condition for all subjects. Figure 3 also shows that the discrete condition had the lowest frequency of average uv's. Thus, it appears by the last session the discrete condition was the most effective condition for relaxation, and that across conditions subjects were more relaxed in the fourth bin relative to the first bin.

The average bioelectric activity (uv's) for the average of all sessions for each of the four conditions was calculated (see Figure 4). For two of the subjects, the uv's for the control condition were the lowest in comparison to the uv's for any of the other three conditions. For the other subject the uv's for the baseline condition were the lowest in comparison to the uv's for each of the other three conditions.

FIGURE 4: AVERAGE EMG LEVEL FOR ALL SESSIONS OF ALL FOUR CONDITIONS



T-test analyses of the data provided the following results. For Billy, the following conditions proved to be significantly different: discrete and variable, $t=2.77$, $P<.025$; control and baseline, $t=6.88$, $P<.005$; control and variable, $t=3.07$, $P<.025$. Thus, Billy was most relaxed during the control condition, followed by the discrete condition. T-test analyses of Mark's data did not reveal any significant differences. T-test analyses of Dave's data revealed significant differences between the following sessions: baseline and variable, $t=4.06$, $P<.005$; discrete and variable, $t=2.30$, $P<.050$; control and variable, $t=3.17$, $P<.025$. These results suggest that the baseline condition induced more relaxation, and was followed very closely by the control and discrete conditions.

In summary, the above analyses revealed that the discrete condition had a lower overall average of uv's than the variable condition for David and Billy. For Billy and Mark, the control condition provided the lowest average uv's. And for David, the baseline condition provided the lowest uv's. Overall the above data provided mixed results.

EXPERIMENT 3

Experiment 1 demonstrated the contingent feedback with a discrete stimulus assisted clients to relax more effectively than the two non-contingent control conditions. Although the experimental design of randomizing the three conditions in Experiment 1 assisted the clients in learning to discriminate between conditions, this design differs markedly from those typically employed in other studies. In such studies subjects have been exposed to a single training condition for an extended period of time (e.g., subjects in Finley et al.'s, 1977, study were exposed to six weeks of frontal EMG pre-electrophysiologic behaviour modification "EBM," followed by six weeks of no training, and finally by four weeks of EMG EBM).

Exposure to only one training variable at a time hence might result in better acquisition of relaxation training due to the massed practice effect. Wrightsman and Sanford (1975) define massed practice as "concentrated practice without rest or intervening activity." In order to investigate the possible advantage of massed practice, the present experiment presented one training condition at a time before another condition was introduced. This was done by exposing the subjects to seven sessions of the baseline condition, followed by seven sessions of the variable conditions, five sessions of the control condition, and seven sessions of the discrete condition.

METHOD

Subjects

Two adult, male clients from a behavioural treatment unit for aggressive and self-injurious clients, located within a provincially-operated institution for mentally retarded individuals, participated in this experiment. The main characteristics of the experimental subjects are shown in Table 4.

Steven[3] was a 26 year old male, functioning at the mild (-2) level of retardation with an I.Q. of 65. Steven had been institutionalized for just over 8 years in various facilities and had a history of very severe explosive and violently aggressive behaviour, as well as a history of tantrum-associated self-injurious incidents. During the course of Experiment 3, Steven received 200 mg Tegretol t.i.d., on a daily basis. He also attended a Behaviour Modification Rehabilitation Workshop two hours a day, and had good receptive and expressive language skills.

Nelson was a 42 year old male, functioning at the severe (-4) level of retardation with an I.Q. of 33. He had been institutionalized for 35 years and had a history of dangerous aggression. At the time of

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[3]Not his real name.

Table 3

SUBJECT INFORMATION

Name	Age[1]	I.Q.	Medication[2]	Years Institutionalized	Major Problem Behaviours[3]	Major Diagnosis
Steven	26	65	200 mg Tegretol t.i.d.[4]	8	Severe explosive aggression, tantrum associated self-injurious behaviour.	Mild retardation, Schizophrenia.
Nelson	42	33	300 mg Tegretol o.d. 10 mg Haldol b.i.d.	35	Dangerous aggression	Severe Retardation.

1 At onset of Experiment 3.

2 In effect during the course of Experiment 3.

3 Reason for referral to specialized treatment unit.

4 t.i.d. - three times per day; o.d. - once a day (during the morning); b.i.d. - twice a day.

he study, Nelson was prescribed 300 mg Tegretol o.d., and 10 mg Haldol b.i.d. He also worked full-time in a Greenhouse, and was able to speak using short, simple sentences, with good receptive language skills.

Both subjects did not have any major visual or auditory impairments which would have precluded their participation in this experiment. They were both ambulatory, although Nelson had an impaired gait.

Apparatus

The same equipment used in Experiment 2 served in this study.

Experimental Design

A within-subjects design was used. Subjects were exposed to seven sessions of a baseline condition in which microvolt seconds (uv's) were recorded and no biofeedback was provided. They were then exposed to similar stimulus conditions as described in Experiment 2, in the following order: seven sessions variable biofeedback training condition, in which uv's output proportionally affected the volume of the (radio) music; five sessions control condition in which uv's were recorded and no music was presented; followed by seven sessions discrete biofeedback training condition in which uv's below a pre-established (0.5) cutoff level resulted in presentation of (radio) music at a pre-established volume, for a total of 26 sessions. The order of the variable and discrete conditions was randomly pre-determined.

Procedure

The same procedure used in Experiment 2 was used here. That is, the subjects were seated in a chair; their foreheads were cleansed, electrodes were affixed, the subjects were prompted to relax and the equipment was adjusted.

RESULTS

The average bioelectric activity (uv's) per session (four 60 sec. periods) was calculated for all conditions for both subjects, as described below.

Nelson's data (Figure 5) demonstrated a variable baseline from session to session (mean = 785 uv's). During the experimental conditions the mean uv's obtained from lowest to highest, were: 492 corresponding to the discrete condition; 587 corresponding to the variable condition; and 601 corresponding to the control condition.

FIGURE 5: AVERAGE EMG LEVEL ACROSS CONDITIONS

NELSON

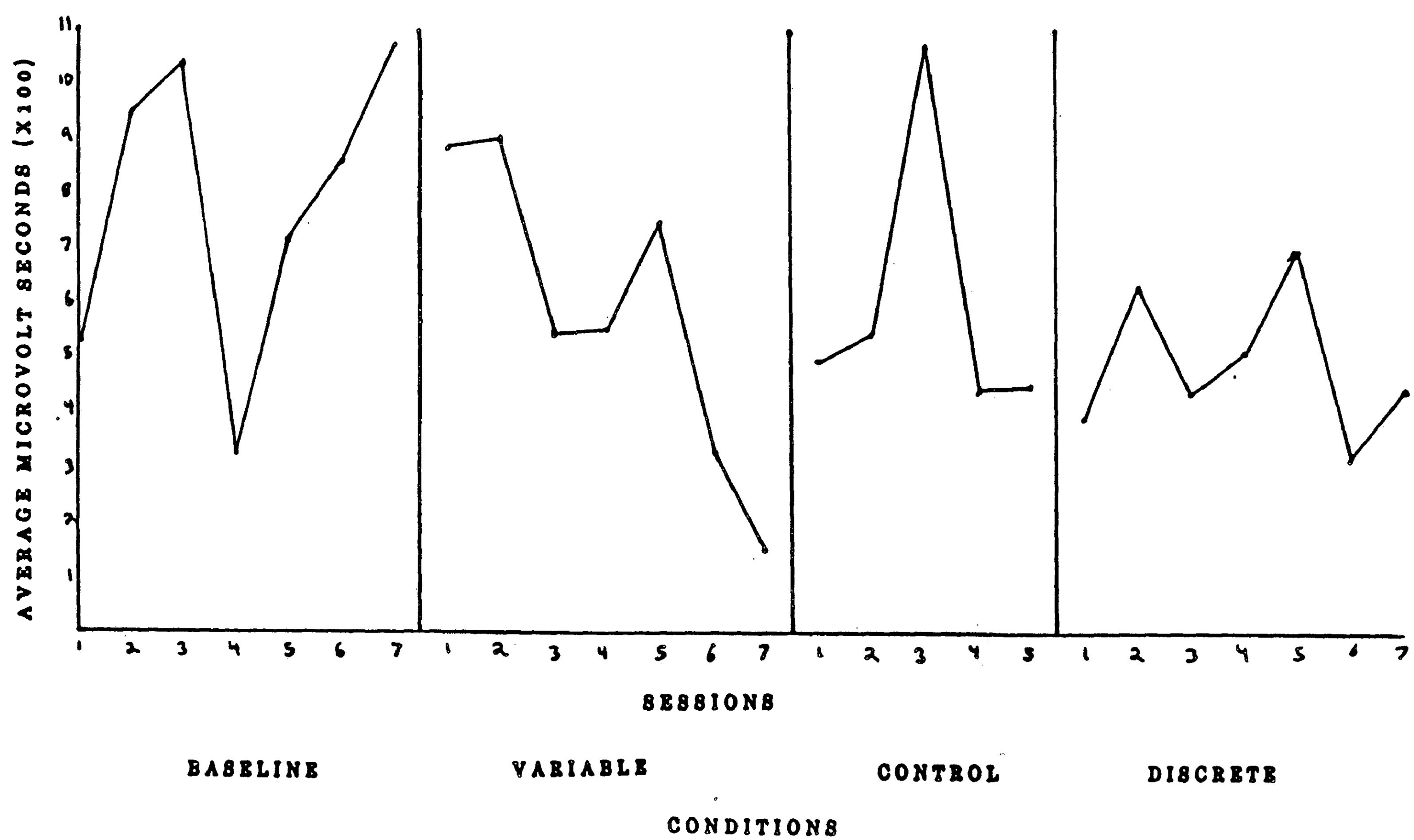
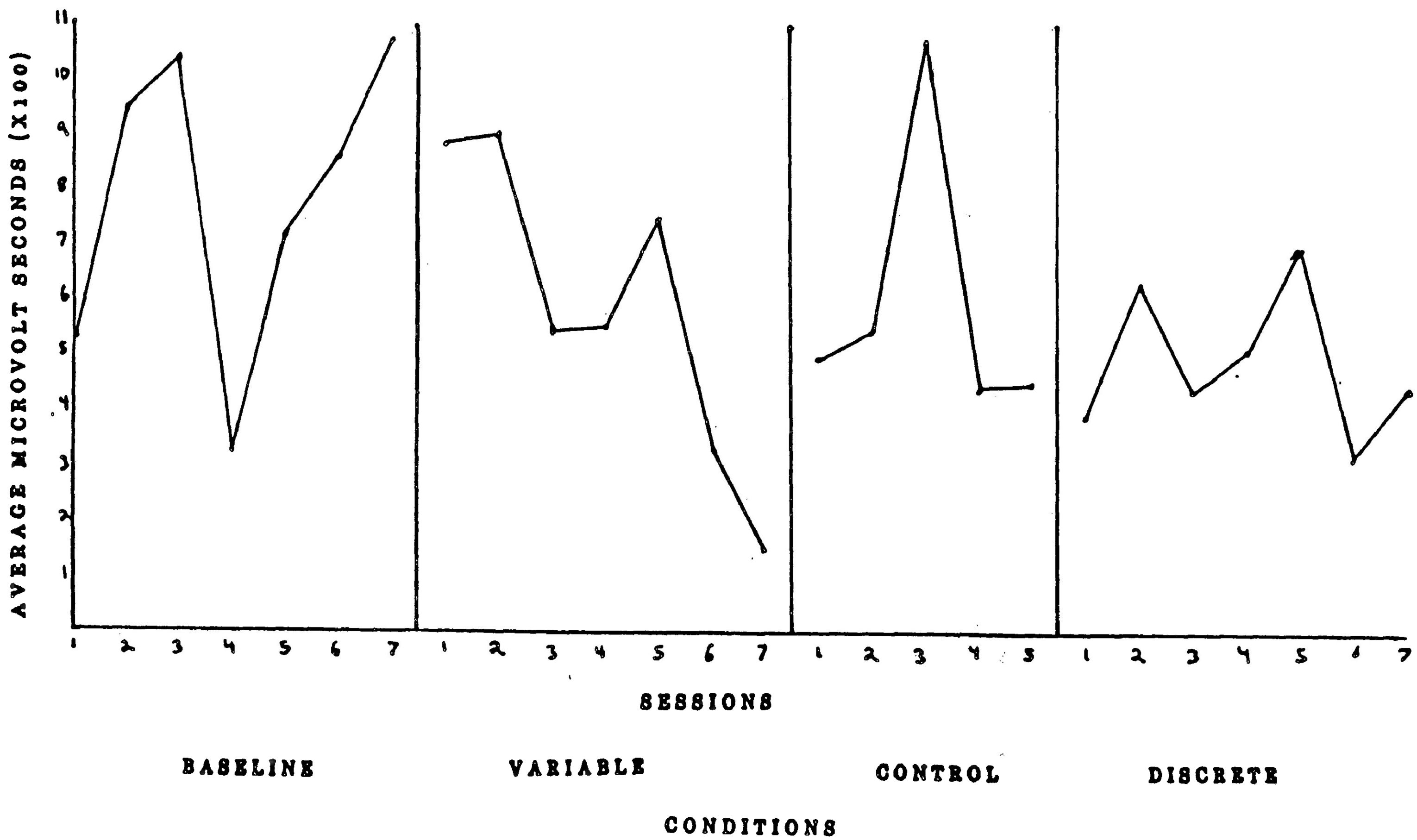


FIGURE 6: AVERAGE EMG LEVEL ACROSS CONDITIONS

NELSON



Steven's results (Figure 6) demonstrated a relatively stable baseline across most sessions (mean = 687 uv's), except for sessions six and seven in which the average bioelectric activity (uv's) climbed to very high levels. The mean uv's for the variable, control and discrete conditions were 632, 436, and 527 uv's, indicating the relaxation (lowest uv reading) was best obtained in the control condition followed by the discrete condition and, less effectively, by the variable condition.

A one-way analysis of variance with repeated measures was performed. This analysis did not yield any significant differences between conditions.

Two-tailed t-tests of the above data indicated that Nelson's results revealed significant differences only between discrete and baseline, and variable and baseline conditions (discrete: $t(12)=3.03$, $P<.025$; variable: $t(12)=2.05$, $P<.050$) suggesting that both feedback (treatment) conditions induced more relaxation than the baseline condition, but not significantly more than the control condition, nor different between themselves.

T-test analyses of Steven's data revealed a significant difference only between the control and the variable conditions ($t(10)=3.39$, $P<.01$), suggesting that Steven only relaxed during the control condition. Other t-tests were done but they were not significant.

DISCUSSION

The results of Experiment 1 demonstrated that contingent EMG feedback was more effective in decreasing frontalis muscle tension in two severely/profoundly retarded individuals than noncontingent EMG feedback. The design of the experiment clearly allows the conclusion that relaxation effects were not attributable to non-specific variables such as music-induced or setting-induced effects, nor to generalized relaxation or habituation variables, or to the effect of boredom or demand characteristics.

Although the sample size of Experiment 1 was far too limited to draw generalizable conclusions concerning the effects of EMG feedback in severely/profoundly retarded individuals, the experiment clearly suggests that EMG feedback may be applicable with such individuals, and that such applications may control extraneous non-specific variables with a methodologically sound experimental design.

The results of Experiment 2 demonstrated that the discrete condition provided the lowest level of bioelectric activity (uv's) in the final training sessions. This result indicates that, in the long run, the discrete condition was a superior relaxation technique, vis-a-vis the other three conditions. Analysis of the bioelectric activity in the first and fourth bins for the final session of all four conditions indicated that uv's were lower in the fourth bin in all subjects, relative to the first bin. This result suggests that there was a habituation effect across conditions, although it was not as strong or statistically significant as that shown by the discrete feedback condition.

Analysis of the average bioelectric activity across all session in Experiment 2 were not clear. For two subjects, the control condition resulted in the lowest average uv's, whereas the third subject, the lowest average uv's occurred in the pre-experimental baseline condition. This overall analysis would suggest that the discrete and variable conditions were apparently not very effective in training relaxation. However, it must be pointed out that intrasubject variability in this study was high, and hence average bioelectric activity may have not been the most representative measure.

The effects of the stimulus variable conditions were clearer in Experiment 3 in which conditions were not randomized. In this experiment, the variable condition resulted in a lower level of EMG (uv's) than baseline. However, for both subjects the lowest level of uv's occurred in the discrete condition. (For one subject the discrete condition resulted in the lowest overall level of uv's; in the other subject, the discrete condition was the lowest only in comparison to the variable condition).

Overall, these results suggest that most subjects learned to relax more deeply when exposed to the discrete training condition. The results from Experiments 2 and 3 do not support the notion that a variable signal would be more advantageous than a discrete signal, as surmised from Russell et al.'s 1982, and Coursey's 1975 studies. There are several explanations for these contrasting results. One specific possibility involves the modification of my biofeedback equipment for the variable condition: The threshold for the proportional-analog signal was found post-facto to be higher than the threshold for the discrete signal. In other words, the proportional stimulus (music) was initially produced at a low volume below the threshold of the discrete stimulus (music) but, when relaxation was attained, the volume of the music for the proportional condition was lower than the volume of the music for the discrete condition.

Another possible explanation is that mentally retarded individuals require more "fine tuning" of the stimulus signal than the present equipment could provide. In other words, the subjects could have learned to relax better when exposed to the proportional signal if the equipment had been adjusted more accurately thus enabling the therapist better control over the stimulus signal (music).

The results of Experiment 3 support in some measure the hypothesis that presenting one condition at a time may be more conducive to learning to relax, as opposed to using randomized and inter-mixed conditions. I also feel that the possibility of a therapist effect can be eliminated in Experiments 2 and 3, as there did not appear to be any significant differences in the results regardless of which therapist conducted the session. Likewise, there appears to be no evidence that conducting these experiments (2 and 3) on the ward (unit), as opposed to in a separate location (office area, Experiment 1), had any negative effect on relaxation training.

In closing, Roberts (1985) feels too many clinicians continue to believe what they want to believe about the clinical efficacy of biofeedback, regardless of the findings from experimental research. He feels that there is little relationship between research findings in the area of biofeedback and the clinical use of biofeedback.

With respect to my research, it did not provide the results that I had hoped for. However, it is hoped that this thesis did contribute to this area of research.

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Appendix A

BEHAVIOUR SCALES

Client	Behaviour Scale
Billy	5: aggression; bed restraint 4: teasing, touching, poking, continual body jerks 3: frequent body jerks; asking a lot of questions; testing staff 2: normal conversation; not excited 1: lying on bed; quietly watching television without jerking or talking; working quietly on his own
Mark	5: aggressive; major destruction; confinement timeout 4: non-compliance; gestural threats; minor destruction; crying, complaining that he is sick 3: initiating a conversation; aggravating others 2: watching television; occasional comment; working effectively in workshop 1: sitting on bed; quiet
David	5: aggressive; destruction; confinement timeout 4: argumentative; swearing 3: non-compliance; calling staff names; stubborn; pestering 2: helpful, normal conversation; doing chores 1: sitting doing homework; withdrawn; quiet