REGULATION OF THE FREQUENCY OF PART-WORD REPETITIONS USING ELECTROMYOGRAPHIC FEEDBACK

THESIS

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By

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This study investigated the use of electromyographic feedback in regulating the frequency of part-word repetitions. Two adult stutterers, one female (Subject A) and one male (Subject B) were employed. The frequency of part-word repetitions during baserate, EMG uV raising, and EMG uV lowering conditions was assessed for Subject B. As hypothesized, results indicate that there was a notable decline in the frequency of part-word repetitions during the EMG uV lowering sessions. However, contrary to the second hypothesis, (i.e. that an increase in EMG uV would correspond with an increase in part-word repetitions) there was also a decline in the frequency of part-word repetitions during the EMG raising sessions.

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INTRODUCTION:

REGULATION OF THE FREQUENCY OF PART-WORD REPETITIONS USING ELECTROMYOGRAPHIC FEEDBACK

Learning-theory approaches to the clinical disorder commonly referred to as stuttering have recently begun to make significant progress toward a firmer understanding of the behavior through the scientific application of experimental principles of behavior analysis (Shames and Sherrick, 1963; Goldiamond, 1965; Martin and Siegel, 1966). Unfortunately, most of the researchers have not molecularly defined the specific behaviors at both the verbal and non-verbal levels that they were purporting to manipulate. "Stuttering," "the moment of stuttering," and "the moment of the stuttering block" are terms that are as vacuous as the terms "libido," "personality," and "ego strength."

More importantly; there is a considerable amount of empirical evidence that all of the verbal behaviors and overt nonverbal concomitant behaviors that are so often lumped together and labeled as "stuttering" do not behave in an identical fashion when response contingent stimulation is applied. Therefore, employing a molar definition of stuttering may mask a true description of the various molecular components. The question of whether stuttering behavior acts as an operant, i.e., whether its occurrence acts in accordance with the Law of Effect, is still a moot point, with the data being extremely equivocal. It appears that these inconsistent results may be due to the failure of all the researchers to employ a molecular definition and specify the specific responses that they were stimulating. As Brutten and Shoemaker (1971) have pointed out, the different behaviors that are commonly included in a molar definition of stuttering do not have the same learning histories and thus would not necessarily be equally and similarly affected by the introduction of an independent variable.

Van Riper (1937) found that when individuals were informed that they would later receive a shock for every word that they stuttered on, stuttering increased. Obviously, this study faces problems in that the stimulation was to be deferred. Frick (1951) found that the introduction of response contingent shock increased the frequency of stuttering. Frederick (1955) found the same results in a similar experiment. Timmons (1966) made the verbal stimulus "wrong" contingent upon the moment of stuttering and found no change. Cady and Robbins (1968) observed a reduction in stuttering when either a negative, positive, or neutral verbal stimulus was delivered contingently upon stuttering. Other investigators, such as Martin and Siegel (1966), Flannagan, Goldiamond, and Azrin (1958), and Goldiamond (1965) found changes in the frequency of stuttering in the predicted direction when the response was contingently stimulated.

One may take a headcount, discover that more studies than not have found stuttering to act as an operant, and choose to ignore the contradictory data and lay claim to that position. However, as Sidman (1960) and others have pointed out, when discrepancies among the data appear, one should look for differences in methodology to account for those discrepancies. It appears that the outstanding methodological difference in outcome studies on stuttering behavior is the means by which the dependent variable is defined.

Interestingly, when researchers have employed a molecular definition of stuttering behavior it appears that certain behaviors, such as facial grimaces, eye blinks, voice inflections, air inhalations, and interjections do indeed behave in accordance with the Law of Effect. However, it appears that two specific verbal behaviors, part-word repetitions and prolongations, do not. Thus Webster (1967) found that when behaviors such as head-jaw movements were contingently stimulated with the verbal stimulus wrong there was a decrement in the behavior, but part-word repetitions evidenced no change. Starkweather (1970) found no change in the frequency of the occurrence of part-word repetitions in the presence of response contingent stimulation. Oelschlaeger (1973) found no change in the frequency of the occurrence of part-word repetitions in the face of response contingent positive stimulation. The results of these studies suggest that part-word repetitions should not rightfully be conceptualized as operant behaviors.

Stuttering behavior (i.e. part-word repetitions and prolongations) is conceptualized here as a breakdown in the speech process that occurs as a result of heightened autonomic activity. Certain stimuli are apt to elicit this autonomic activity in various degrees, and the ensuing speech breakdown will likewise be evidenced in corresponding degrees. (The reader will recognize this to be the position outlined in much greater detail by Brutten and Shoemaker, 1967.) Therefore, the most appropriate treatments are believed to be those that attempt to "de-sensitize" the various noxious stimuli, or those that attempt to provide the stutterer with some control over his autonomic functioning.

The stuttering literature is replete with studies reporting on the application of systematic desensitization, or reciprocal inhibition treatment, to stutterers (Rosenthal, 1968; Lanyon, 1969; Webster, 1970; Adams, 1972). Although most of the outcomes have been decidedly favorable, lack of controls and other general methodological pitfalls proliferate the efforts. In addition, reciprocal inhibition therapy has not proven to be effective with all kinds of clients (Wolpe, 1973, p. 140), and no less an authority than Brutten (1967) has stated that: "Clinical experience with these (thirty) stutterers does not permit the proclamation that inhibition therapy has been universally effective. . ." (pp. 8-82).

According to Brutten and Shoemaker (1967) stuttering is the failure of fluent speech that follows stimulus patterns that elicit "conditioned negative emotion." Ostensibly, what Brutten and Shoemaker are referring to as conditioned negative emotion is tantamount to what most authors have labeled "conditioned emotional response" (Estes and Skinner, 1941; Brady and Hunt, 1955). It follows from this theory that in attempting to modify stuttering behavior, one can either somehow eliminate the noxious stimulus situations or eliminate the "negative emotion." The thrust of the present study will be an investigation of the efficacy of the latter course through the employment of biofeedback procedures.

Biofeedback can be conceptualized as the use of monitoring instruments, usually electrical, to detect and amplify internal physiological processes within the body and feed back this information to the individual who is being monitored. In this procedure, the participant is placed in a closed feedback loop whereby information about one or more of his covert physiological processes is made available to him as a visual, auditory, or tactile signal. Gradually, through a process of trial and error and hypothesis testing, the individual evolves strategies for controlling the feedback and concomitantly, the response.

An advantage of biofeedback treatment over reciprocal inhibition therapy is that the relaxation training procedure is broken down into small increments, with at least some degree of success practically insured. As Budzynski and Stoyva (1972) point out, a modest success experienced at the onset of therapy can prove useful as a motivator.

EMG regulation was chosen to be employed here largely owing to the evidence from therapies such as progressive relaxation (Jacobson, 1938) and behavior therapy (Wolpe, 1958) attesting to the therapeutic efficacy of muscle relaxation in anxiety and stress related disorders. There have been numerous reports (e.g. Budzynski and Stoyva, 1972) attesting to the finding that EMG activity, particularly from the frontalis site, is a highly sensitive indicator of anxiety.

As Budzynski and Stoyva point out, a critical assumption is that muscle relaxation affects the autonomic nervous system, and results in a condition in which parasympathetic responses dominate. As such, it is assumed that anxiety has both muscular and autonomic components. There is considerable evidence in support of the above assumptions, that is, when muscle activity is dampened, autonomic activity is dampened (Hess, 1954; Gelhorn, 1964, Germana, 1969).

Cameron (1944) found that the above duality between the muscle and autonomic systems does not exist for all individuals. He observed that for one group of individuals, whom he labeled "autonomic responders," muscle relaxation did not diminish anxiety. If both of the subjects in the present study happened to be "autonomic responders," one would not expect to demonstrate an effect. However, this is an empirical question that will be determined as a prelude to the introduction of biofeedback procedures.

There are numerous reports in the literature attesting to the usefulness of EMG feedback in muscular relaxation (Budzynski and Stoyva, 1969; Green, Walters, Green and Murphy, 1969), tension headaches (Budzynski, Stoyva, and Adler, 1970; Wickramasekera, 1972), chronic anxiety (Raskin et.al., 1973) and subvocalization (Aarons, 1971; McGuigan, 1971). However, one is hardpressed to find published reports of the application of EMG feedback, or any other type of biofeedback, as applied to the treatment of stuttering behavior.

In an unpublished study, Treon, Tamyo and Standley (1972) trained seven stutterers in maintaining both high and low amplitude GSR patterns via visual feedback. Following the completion of successful training, each half hour session was divided into four, three minute experimental sessions as well as pre-and post-neutral sessions. The sequence of the four experimental sessions was systematically varied between attempted low and high GSR feedback while reading. The authors report that while neither the fluency difference between low amplitude attempted and no attempted GSR self-regulation, nor the difference between high amplitude and no attempted self regulation was statistically significant, the fluency difference between the high and low conditions was significant.

Sadly, this study is plagued by some serious methodological pitfalls. The dependent variable, "fluency," was never defined. An inter-rater reliability check was unfortunately omitted as well. In addition, no indication was provided as to whether the subjects were reading the same material or different material throughout the sessions. This is a dimension worth considering with regard to any confounding influence of the "adaptation effect" (Wingate, 1966).

The "adaptation effect" deals with the commonly observed decrement in the frequency of stuttering related behaviors as time elapses within a session as well as between sessions, presumably as the stutterer becomes more accustomed to a given situation. One obvious solution to overcoming the confounding influence of the adaptation effect is to opt for group statistics and employ a no-treatment control group. However, recently Toomey and Sidman (1970) found that when a condition of experimental anxiety was induced in four subjects, the stuttering rate increased (statistically significant) for one subject, decreased (statistically significant) for two, and the stuttering rate of the remaining subject was unaffected. Toomey and Sidman concluded that "group statistical evaluation in stuttering research is likely to hide more than it reveals." Owing to the present state of stuttering research, it is felt that Toomey and

Sidman's point is well taken, and that repeated replications of single subject studies are required to feret out the effects of singular relevant variables. Following Toomey and Sidman's suggestion, a single subject design will be employed in the present study.

Another avenue that is available is to employ spontaneous speech as the vehicle to assess stuttering behavior. The evidence regarding the adaptation effect in spontaneous or self-formulated speech, in contrast to reading, is equivocal (Wingate, 1966). An additional advantage to the researcher in employing spontaneous speech is that it has a firmer base in reality. That is, when one demonstrates a change in stuttering behavior during designated reading, one has not necessarily demonstrated a change in self-formulated speech. Presumably, the latter speech behavior is that which is of prime relevance to the subject. Ryan (1964) has reported very little generalization of conditioned fluency in oral reading to self-formulated speech, and other researchers have reported a similar difficulty.

In a methodologically sounder study (unpublished) than the Treon, Tamyo, and Standley (1972) study that was previously discussed, and probably more germane to the task at hand, Guitar (1974) initially trained three stutterers to reduce muscle action potential (MAP) via auditory EMG feedback at four different muscle sites. After the specified MAP reduction was obtained, this was paired with sentences, with the subjects being instructed to keep MAP levels below threshold during a seven second pre-utterance period. The dependent measures were stuttering frequency in percent syllables stuttered and speech rate in syllables per minute during reading. Reduction was found over all sites, but considerable variability was reported in terms of the most effective muscle locations as well as the amount of generalization to the natural environment that was achieved.

As a result of the demonstrations that stuttering could be regulated through the employment of EMG feedback, a practical treatment was designed and employed for a fourth stutterer. After training the subject to employ EMG feedback to reduce muscle activity just prior to speaking, feedback was withdrawn and the subject had to rely on internalized feedback to reduce muscle activity. Stuttering frequency under two assessment conditions (talking on a telephone and laboratory conversational speech) was reportedly reduced to zero, with five week and nine month follow-up assessment sessions demonstrating that the treatment had maintained.

Unfortunately, Guitar neglected to provide a definition of the first of his two dependent measures, stuttering frequency. In addition, the possibility that the silent pre-utterance period, exclusive of any biofeedback contingencies, was responsible for the reported ensuing decrement in stuttering behavior was not controlled for. Although the present study is of decidedly more limited scope than the Guitar effort, these two just-mentioned methodological shortcomings will be eliminated.

Further justification for the assumption of a covariant relationship between EMG activity and stuttering behavior comes from the work of Shrum (1967). Shrum measured EMG activity over the surface of facial, neck and chest muscles in stutterers. Shrum noted a relationship between increased EMG activity and stuttering behavior, pointing out that stuttering was typically preceeded by an early and sustained rise in EMG amplitude.

Stutterers typically exhibit a variety of concomitant instrumental behaviors, one common one of which is excessive eye-blinking. Although this might be thought to be an artifact when one is taking a reading from the adjunctive frontalis muscle, Lippold (1967) has pointed out that this is not a real problem because the axis of the muscle lead is horizontal whereas the axis of the eyeblink potential is vertical. In any event, any physiological artifact would only serve to decrease the reliability of the feedback process, thus reducing the liklihood of the experimenter demonstrating an effect.

Two hypotheses were formulated: (a) A maintained heightened EMG uV level off of the frontalis muscle would result in an increase in the frequency of part-word repetitions. (b) A maintained lowered EMG uV level would result in a decrease in the frequency of part-word repetitions. It was first necessary to employ a subject to demonstrate the feasibility of the entire procedure, efficacy notwithstanding.

Method

Subjects

Two subjects were employed in this study. Subject A was a female college graduate, age 29, and Subject B was a male graduate student, age 23. Subject A reported that she had been subject to speech disfluencies for approximately 20 years and Subject B reported that he had had speech related difficulties for approximately 15 years. Both subjects were referred by acquaintances of theirs who had responded to an advertisement in the North Texas State University campus newspaper (see Appendix D) requesting participation of stutterers in a faculty-supported research project. The subjects were offered no pay for their services and it was indicated that this study was a research, rather than treatment effort. However, it was suggested that participation in the study might prove to be a valuable learning experience, and if it was desired, treatment would be provided following completion of the study. One applicant who responded was rejected because the disfluent speech behaviors that he emitted did not include part-word repetitions.

Apparatus

The BFT EMG 401 system (Bio-Feedback Technology, Inc., Garden Grove, California) and a Farral Instruments "Behavior Modifier" Mark II were employed. The BFT EMG 401 system provided instrumentation for muscle tension detection, information feedback, and data collection. The BFT system consisted of two instruments: the feedback myograph (BFT EMG 401) and the data recorder (BFT Time-Period Integrator 215). The feedback myograph sensed muscle-produced electrical activity through three silver/silver chloride electrodes [.25 inches (6.5 mm) in diameter] which were placed 4 inches (10 cm) apart over each eye, the ground electrode between them centered above the nose. The EMG 401 greatly amplified the detected signal providing both auditory and visual feedback to the participant, and an electrical signal to be recorded by the Time-Period Integrator. Auditory feedback via speakers was provided to the participants such that a tone would vary in pitch in direct proportion to the degree of forehead muscle tension present. The lower the pitch of the tone, the lower the EMG level of muscle tension present. The pitch of the tone would decrease in proportion to the decrease in forehead muscle tension (Budzynski and Stoyva, 1969). Likewise, a meter that provided visual feedback to the participants varied in direct proportion to the amount of muscle tension present. The feedback myograph was powered by low voltage rechargeable batteries and was electrically shielded for effective research use in normal office settings.

The BFT Time-Period Integrator 215 received the amplified EMG 401 signal, integrated it over a selected time period (10 to 120 seconds), and then provided a digital readout in microvolts RMS. The BFT Time-Period Integrator had a noise threshold feature which allowed both the detection of internal equipment "noise," and the cancellation of the effect of that "noise" on the EMG uV readings. The BFT Time-Period Integrator 215 was 125 volts AC powered, and for optimal safety the participant was electrically isolated by optical-isolation circuitry. Cassette tape recorders were used to provide pseudo-feedback when called for and to record the subjects' verbal behavior. A recliner chair was used to allow the participants to relax in a comfortable position.

Materials

Subjects were provided with a list of topics (see Appendix A) that they were free to refer to in the event that they could not think of anything to spontaneously discuss. A Biofeedback Participant Release Form concerning informed consent was signed by both participants prior to investigating the use of the EMG 401 system (see Appendix B).

The subjects were also required to sign a release form related to the use of faradic shock via the Farral Instruments "Behavior Modifier" shock apparatus, stating therein that they were presently not and never had been treated for any medical disorder which would render the use of faradic shock prohibitive (see Appendix C).

Procedure

Both participants in the study were first provided with an explanation concerning the function and safety of the equipment being employed. A Biofeedback Participant Release Form and a Faradic Shock Release Form were then discussed and then signed by both subjects. The EMG noise threshold calibration was made. The participant's forehead was prepared for electrode contact by scrubbing the skin lightly with an abrasive cleaner (Bravisol) and swabbing it with alchohol. Three electrodes treated with electrode cream were placed one inch (24mm) over the participant's eyebrows. The two active electrodes were placed approximately 4 inches (10 cm) apart over each eye, the ground electrode between them and centered above the nose. The subject was seated in a comfortable recliner chair situated away from electrical and ground sources as a general safety precaution, and facing the experimenter. The subjects were requested to touch a ground screw on the EMG unit so that their body static electricity might be discharged and thereby prevent damage to the equipment's sensitive input circuits. Electrode resistance was then checked to insure that both electrodes were below 20,000 ohms and approximately similar in resistance (Leaf and Gaarder, 1971). The subjects were informed that social interaction with the experimenter prior to each session was to be held to the bare minimum.

The participants were at all times seated in a dimly lit airconditioned room facing the experimenter. Both subjects were initially connected to the Farral Instruments "Behavior Modifier" shock apparatus via the forearm and to the EMG 401 system via the frontalis muscle cite. Baserate on the EMG uV levels was taken for five 10 second intervals. The subjects were told that they would receive one shock for one second duration at an intensity of 3 microvolts at a rate of 14 pulses per second for each of the next four 10 second intervals. Voltage was delivered immediately after the next two readings and immediately before the subsequent two readings in order to determine whether the muscle action potential off of the frontalis muscle area was a realistic index of anxiety level.

The first subject (Subject A) was requested to spontaneously speak into a microphone for three 30 minute sessions. During this time, the subject was receiving pseudo-feedback and was instructed to not attend to the auditory stimuli, i.e., the pseudo-feedback. Pseudo-feedback involved the playing of a prerecorded tape of the sounds emitted by the apparatus that were not correlated with the subjects' actual EMG uV level.

This tape recorder was hidden from the view of the subject. The number of part-word repetitions emitted per 60 second interval was assessed in vivo by the experimenter, and later a second year graduate student in Speech Pathology randomly selected six 60 second interval segments per 30 minute session to assess in terms of providing an inter-rater reliability check on the collected data. The rater was blind as to the intent of the study and was instructed to disregard the sound and focus solely on the determination of the frequency of part-word repetitions. Cumulative EMG uV readings per 60 second interval were also recorded in vivo by the experimenter.

A part-word repetition is defined here as follows:

> The acoustically perceived reproduction of a single phone or combination of phones represented only once in a written word and not comprising a complete syllable of the written word nor the whole word itself. [Note: this definition excludes whole syllable repetition and whole word repetition with the exception of "/a/" and "I". (Oelschaeger, 1973)]

Subject A was instructed to recline and close her eyes and attempt to raise the pitch of the sound she was hearing. The cumulative readings of the EMG output was provided to the subject at the end of each minute to provide further feedback. This particular condition was undertaken for fifteen minutes, and for the latter fifteen minutes the subject repeated the same process but kept her eyes opened, thereby permitting her visual access to the EMG meter. Although it was hoped that at the next session spontaneous speaking might be faded in while she was raising the EMG uV level, the subject reported intense headaches as a result of the procedure. Therefore, this phase of the experimental sequence was prematurely terminated. At the next session the same procedure was repeated except that the subject was now instructed to attempt to lower the pitch of the EMG 401 producing sound. At the following session the subject was first instructed to sit upright while maintaining the lowering of the EMG uV levels for the first 15 minutes. For the latter 15 minutes of this session, the subject was instructed to engage in spontaneous speech while attempting to lower her EMG uV level. Finally, the subject was debriefed and thanked.

After obtaining baserate on the second subject (Subject B) for three sessions, during which time pseudo auditory feedback was again provided, the procedure as outlined was undertaken for the next two sessions in order that successful EMG uV level raising while engaging in spontaneous speech might be faded in. For the following three sessions, the subject engaged in spontaneous speech while maintaining the heightened EMG uV level. During this time the subject received auditory and visual feedback but did not receive information relating to his cumulative EMG output scores. Base-rate was again taken for two sessions, during which time pseudo auditory feedback was provided and the subject was instructed to not attend to the sound.

The identical fading in procedure was instigated for the next two sessions, but now the task was to lower the EMG uV level. The subject was instructed to engage in spontaneous speech for the next three sessions while attempting to lower his EMG uV level. Finally, the subject was instructed to attempt to lower his EMG uV level without the aid of feedback information for the last two sessions.

The subject was questioned as to his thoughts on the intent of the study, and any cognitive strategies that he evolved in terms of facilitating completion of the required tasks. The subject was then debriefed and cordially thanked.

Results

Subject A's frontalis EMG uV levels from baseline to the introduction of the two shock conditions (i.e., before and after ten second cumulative EMG uV level readings) are shown in Figure 1. The corresponding data for Subject B is shown in Figure 2.

The mean frequencies of part-word repetitions per ten 60 second intervals for Subject A are shown in Figure 3. The concomitant mean frontalis EMG uV levels and the EMG uV levels from the training sessions (i.e. fading in spontaneous speech) are shown in Figure 4. The later half of the EMG uV level raising procedure (when spontaneous speech was to have been faded in) was terminated due to the fact that Subject A reported intense headaches as a result of this procedure.

The frequencies of part-word repetitions across sessions for Subject B are shown in Figure 5. The corresponding mean frontalis EMG uV levels are shown in Figure 6.

A time-series analysis, specifically an auto covariance and power spectral analysis (Jenkins and Watts, 1968) was performed on both the frequency of part-word repetitions (Series 1) and the frontalis EMG uV levels (Series 2) for Subject B. The data was analyzed in blocks of ten 60 second intervals.

The autocovariance of Series 1 (frequency of part-word repetitions) for a lag of ten minutes is -0.218661. The autocovariance of series 2 (frontalis EMG uV levels) for a lag of ten minutes is -545.714844. The crosscovariance of the two series for a lag of ten minutes is 28.565170 (positive tau) and 1.702668 (negative tau).

A descriptive analysis of the frequencies of part-word repetitions and corresponding mean frontalis EMG uV levels (figure 5 and figure 6 respectively) reveals that both EMG uV level decrease and increase from baseline EMG uV levels corresponded with a decrease in the frequency of part-word repetitions. Examination of the crosscovariances of Series 1 and Series 2 in Table 5 reveals a quantified molecular trend that is consistent with the more molar descriptive trend previously noted.

The entire autocovariance of Series 1 in ten minute lags is shown in Table 1, and the same information for Series 2 is shown in Table 2. The power spectral estimates of Series 1 is shown in Table 3 and the same information for Series 2 is shown in Table 4. The cross-spectrums of both series are shown in Table 6. The transfer-functions and coherence functions of both time series are shown in Table 7.

Inter-rater reliability checks on the frequency of part-word repetitions for each of the S's derived from Pearson Product-Moment correlations based on six randomly selected 60 second intervals per thirty minute session yielded the following correlation coefficients for Subject A and Subject B respectively: $r_A = .9213$, $r_B = .9017$.

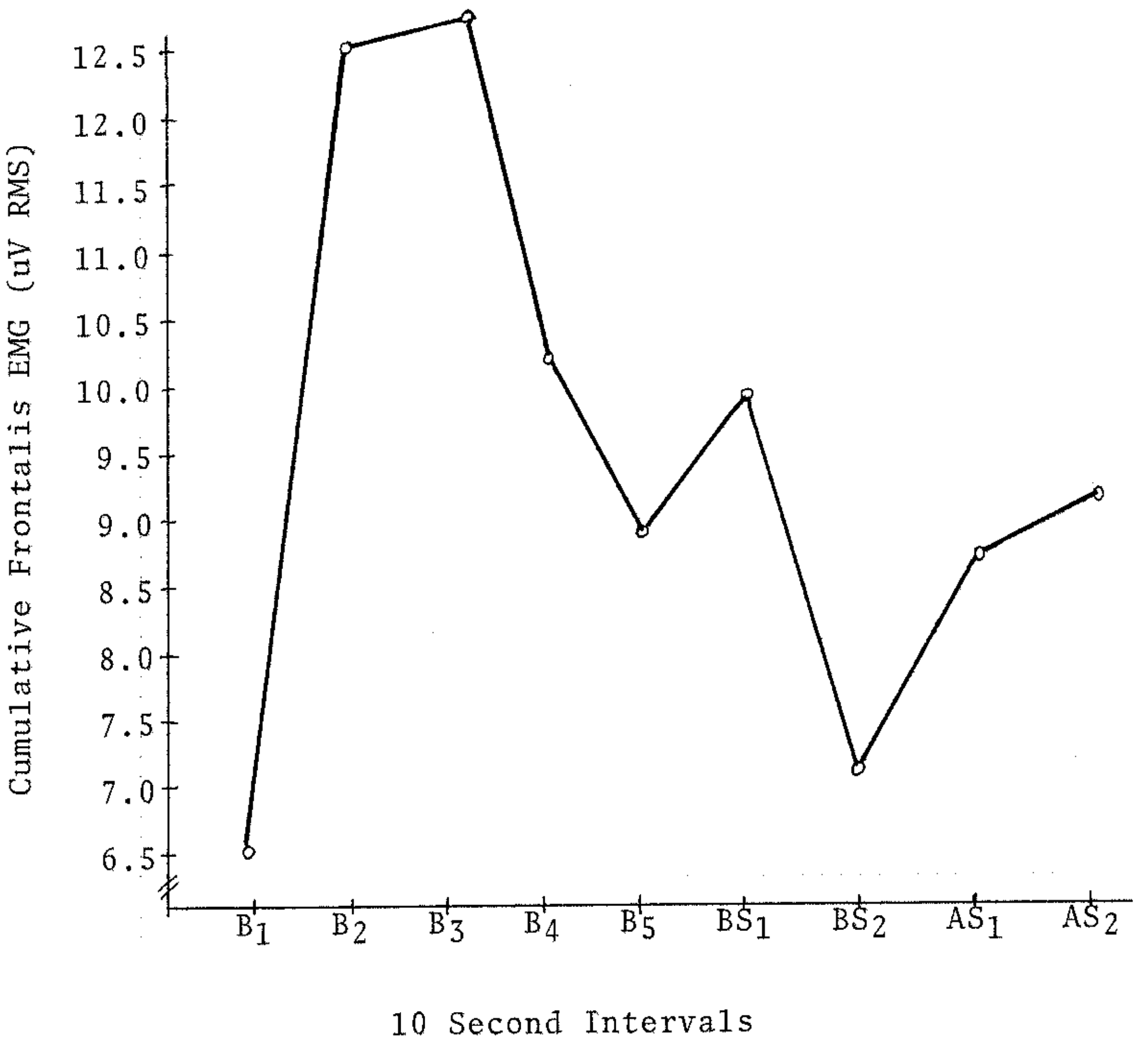

Figure 1. Subject A EMG uV level (frontalis) during shock receiving intervals (B_1 - B_5 - baseline intervals, BS_1 and BS_2 - level immediately preceding shock, AS_1 and AS_2 - level immediately following shock).

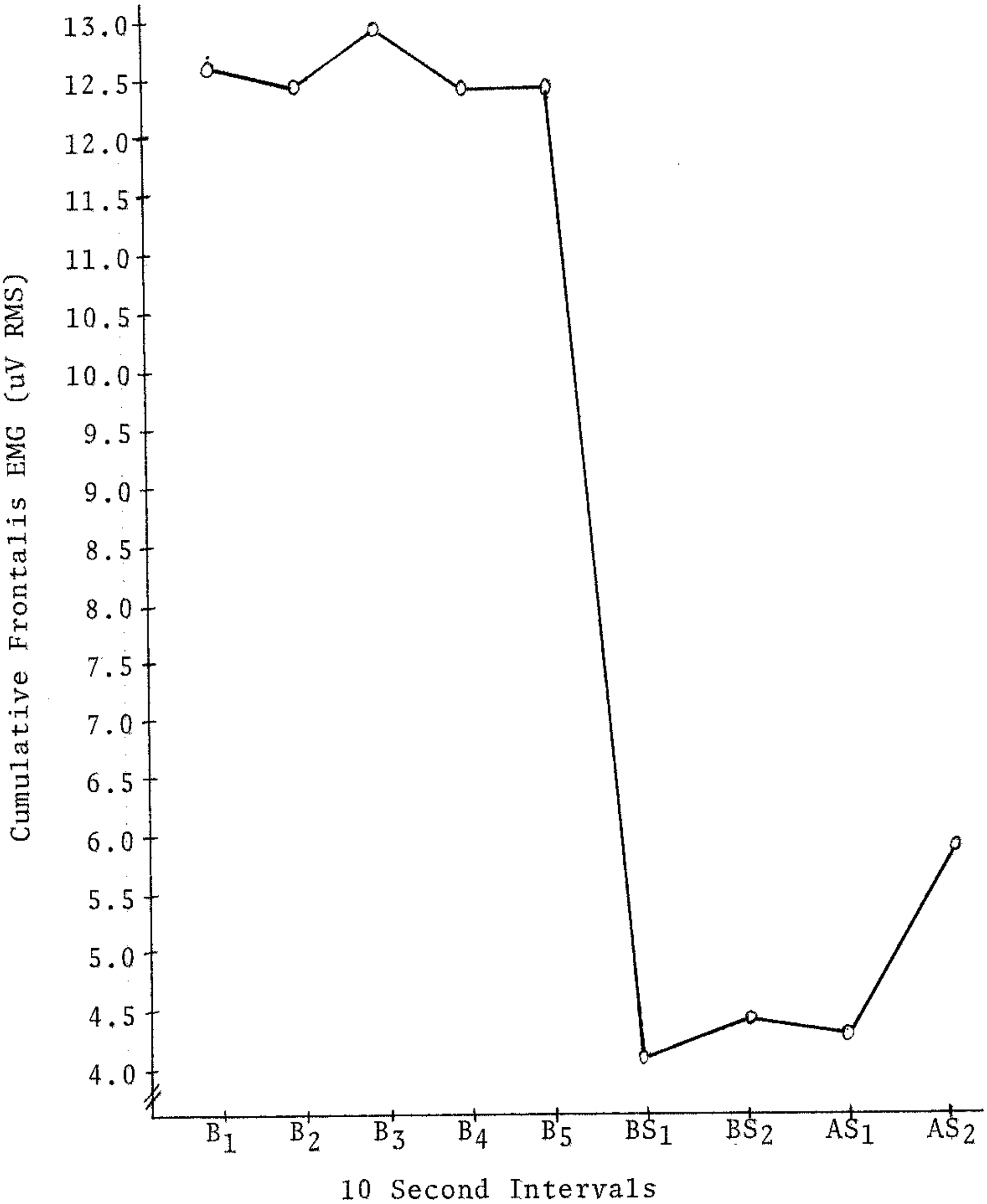

Figure 2. Subject B EMG uV level (frontalis) during shock receiving intervals (B_1 - B_5 - baseline intervals, BS_1 and BS_2 - level immediately preceding shock, AS_1 and AS_2 - level immediately following shock).

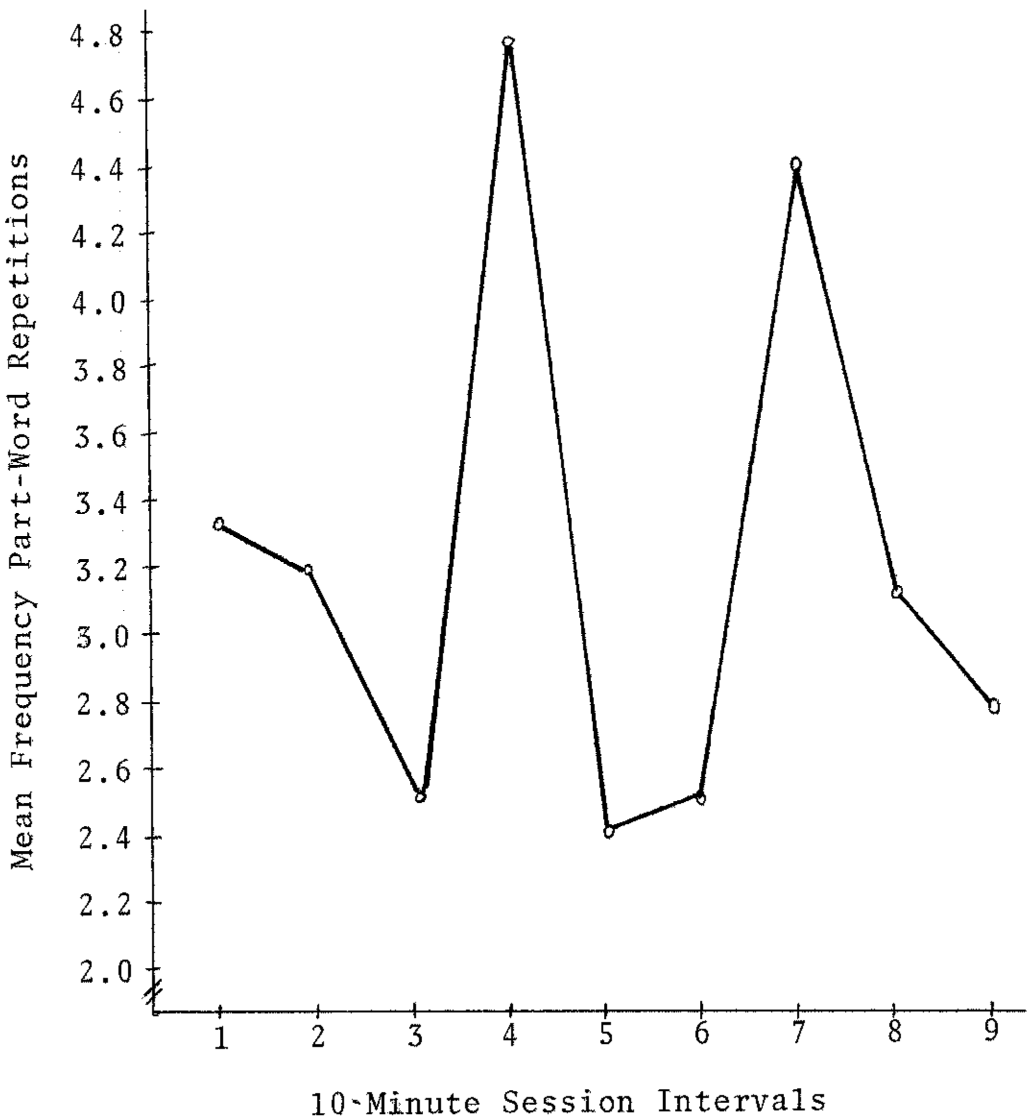

Figure 3. Subject A mean frequency part-word repetitions per 10 minute session intervals during baserate condition.

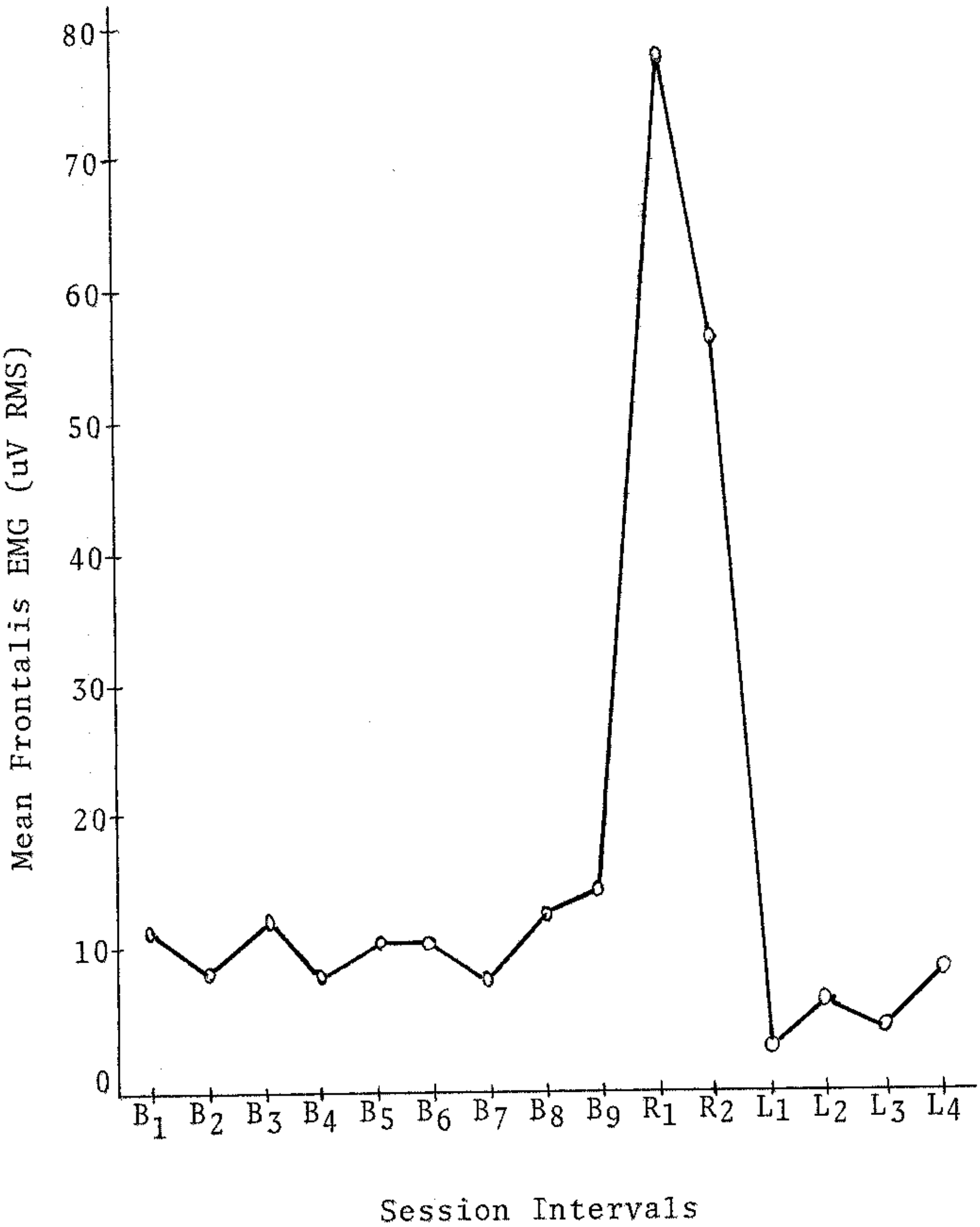

Figure 4. Subject A mean frontalis EMG levels across session intervals (B_1 - B_9 - baseline, R_1 and R_2 - EMG raising training session intervals, L_1 - L_4 - EMG lowering training session intervals).

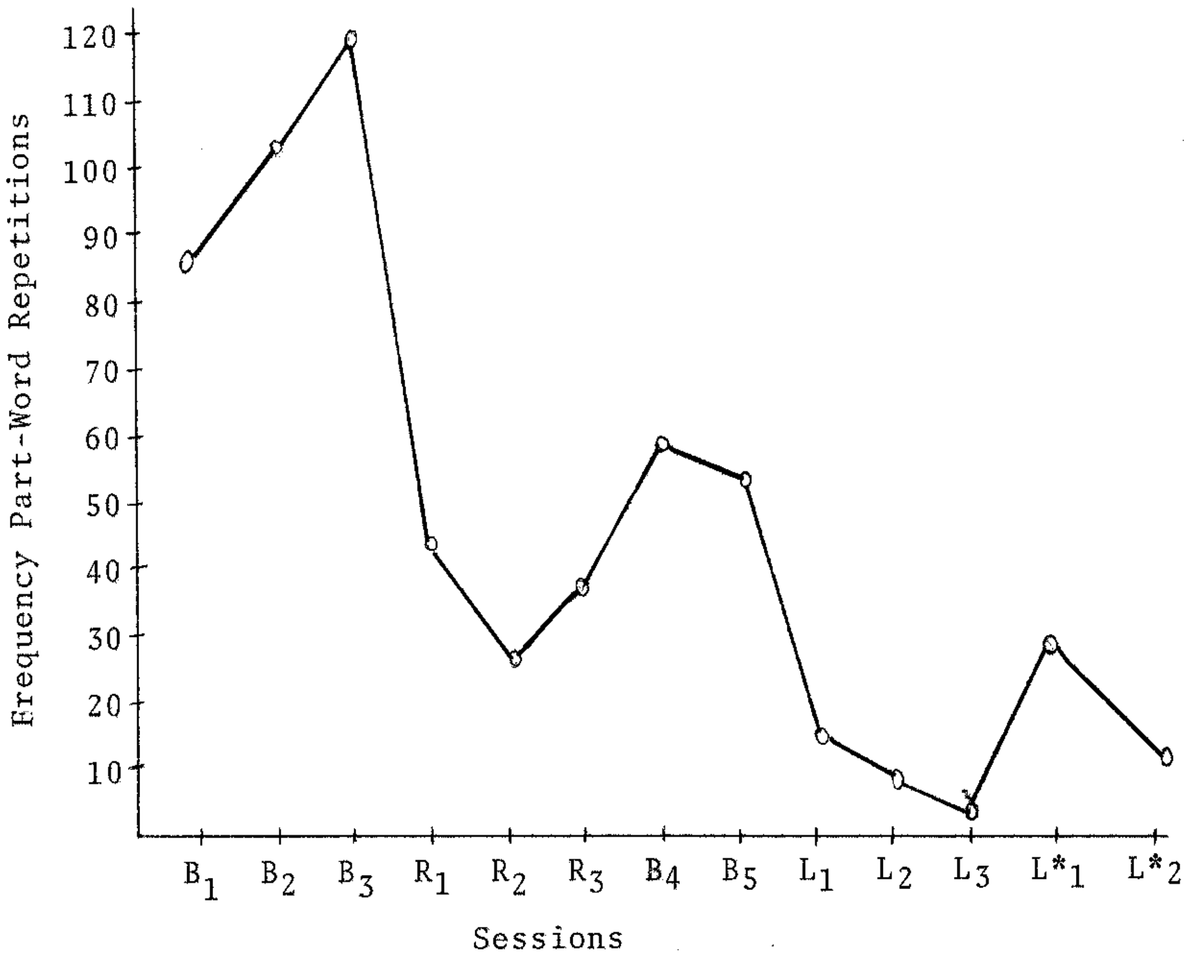

Figure 5. Subject B frequency part-word repetitions across sessions (B_1 - B_5 - baseline, R_1 - R_3 - EMG uV level raising, L_1 - L_3 - EMG uV level lowering, L^*_1 and L^*_2 - EMG uV level lowering without feedback).

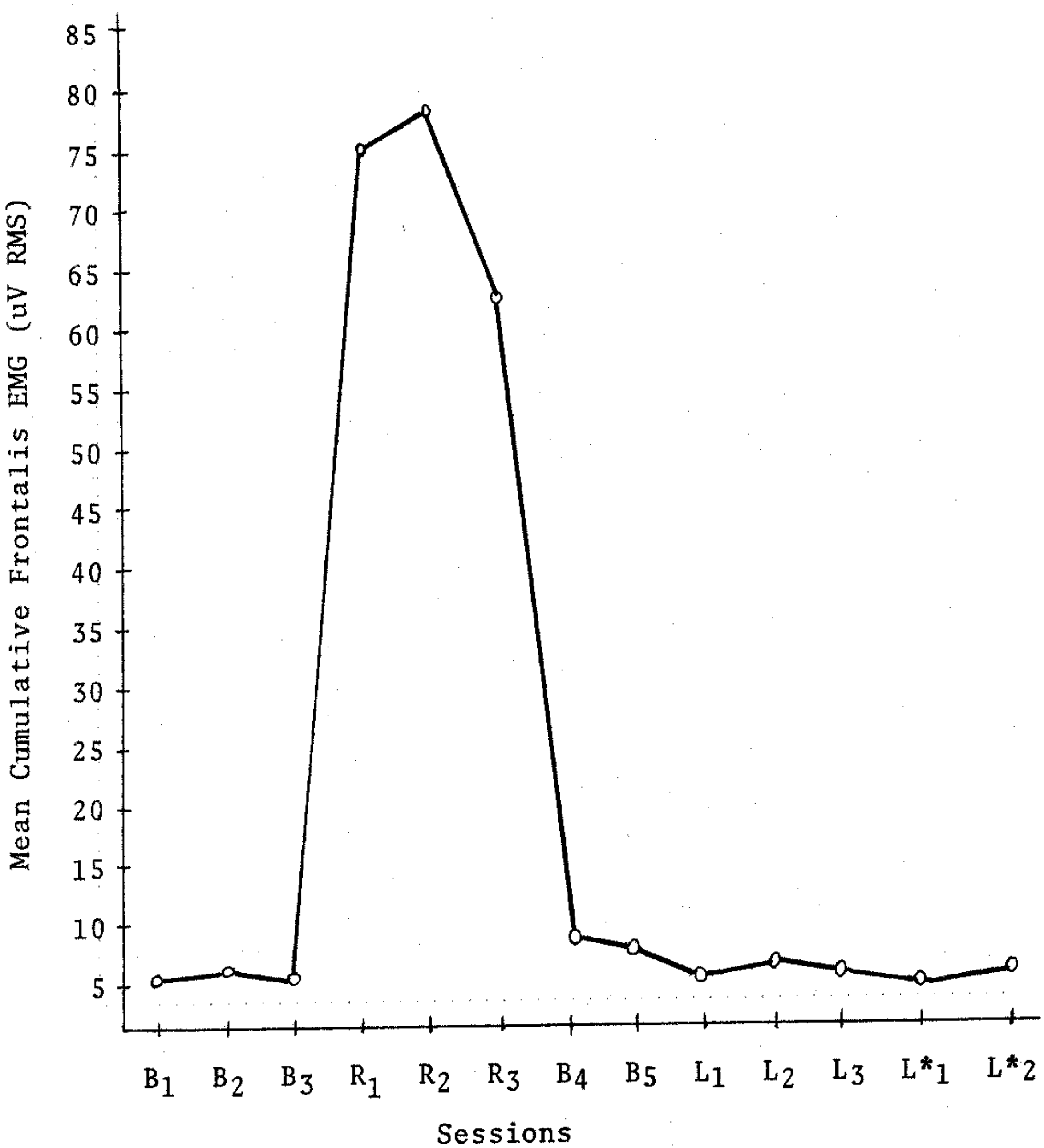

Figure 6. Subject B mean cumulative frontalis EMG (uV RMS) per 60 second intervals across sessions (B_1 - B_5 - baseline, R_1 - R_3 - EMG uV level raising, L_1 - L_3 - EMG uV level lowering, L^*_1 and L^*_2 - EMG uV level lowering without feedback).

TABLE I

AUTOCOVARIANCE OF SERIES I

IN TEN MINUTE LAGS

Lag (Minute)	Autocovariance of Series I
0.0	1.832132
1.0000	1.203707
2.0000	1.007424
3.0000	0.994177
4.0000	0.746146
5.0000	0.587383
6.0000	0.248185
7.0000	-0.039727
8.0000	-0.205060
9.0000	-0.362922
10.0000	-0.218661

TABLE II

AUTOCOVARIANCE OF SERIES 2

IN TEN MINUTE LAGS

Lag (Minute)	Autocovariance of Series 2
0.0	859.078613
1.0000	750.360352
2.0000	637.534668
3.0000	512.830078
4.0000	352.119873
5.0000	181.891876
6.0000	-9.183331
7.0000	-188.225204
8.0000	-367.038574
9.0000	-543.307861
10.0000	-545.714844

TABLE III

POWER SPECTRAL ESTIMATES

FOR SERIES I

Frequency (Cycles/Minute)	Power Spectral Estimates of Series 1
0.0	2.9609680
0.050	2.2008591
0.100	0.6671398
0.150	0.1498370
0.200	0.2582712
0.250	0.2430065
0.300	0.2249757
0.350	0.2299988
0.400	0.2101070
0.450	0.1200652
0.500	0.0942208

TABLE IV

POWER SPECTRAL ESTIMATES

FOR SERIES 2

Frequency (Cycles/Minute)	Power Spectral Estimates of Series 2
0.0	1467.4089355
0.050	1318.8674316
0.100	454.7827148
0.150	48.1883240
0.200	46.2740784
0.250	33.1589355
0.300	30.3575897
0.350	22.2847900
0.400	25.2383118
0.450	14.2498817
0.500	14.8588781

TABLE V

CROSSCOVARIANCES OF SERIES 1

AND SERIES 2

Lag (Minute)	Crosscovariance of Series 1 and 2 (Positive Tau)	Crosscovariance of Series 1 and 2 (Negative Tau)
0.0	- 8.555737	-8.555737
1.0000	- 5.177483	-7.987140
2.0000	0.016206	-6.566252
3.0000	6.427608	-4.060557
4.0000	8.910602	1.119927
5.0000	10.585850	0.613198
6.0000	22.023392	5.412525
7.0000	27.585617	5.320155
8.0000	30.543945	7.082524
9.0000	30.571732	6.033636
10.0000	28.565170	1.702668

TABLE VI

CROSS-SPECTRUMS OF SERIES 1 AND SERIES 2

Frequency (Cycles/Minute)	Amplitude of Cross-Spectrum of Series 1 and 2
0.0	13.8699570
0.050	17.3195343
0.100	12.2682762
0.150	2.6176710
0.200	2.4591866
0.250	1.3226290
0.300	1.5903683
0.350	0.3266898
0.400	1.5985975
0.450	0.6029812
0.500	1.1330795

TABLE VII

TRANSFER-FUNCTIONS AND COHERENCE FUNCTIONS OF SERIES 1 AND 2

Frequency (Cycles/Minute)	Coherence Square of Series 1 and 2	Amplitude of Transfer Function From 1 to 2	Amplitude of Transfer Function From 2 to 1
0.0	0.0442757	4.6842642	0.0094520
0.05000	0.1033424	7.8694420	0.0131321
0.1000	0.4960738	18.3893585	0.0269761
0.1500	0.9490066	17.4701080	0.0543217
0.2000	0.5060216	9.5217209	0.0531439
0.2500	0.2170988	5.4427710	0.0398876
0.3000	0.3703331	7.0690660	0.0523878
0.3500	0.0208227	1.4203968	0.0146598
0.4000	0.4819227	7.6084929	0.0633401
0.4500	0.2125099	5.0221128	0.0423148
0.5000	0.9170393	12.0257874	0.0762560

Discussion

The first hypothesis, namely that EMG uV level reduction would result in a decrease in the frequency of part-word repetitions appears to have been tentatively supported. However, this support needs to be modified in light of the fact that not only was the second hypothesis (i.e. EMG uV level increase would result in a greater frequency of part-word repetitions) not supported, but rather, the results appear to have been in the opposite direction.

Although the results of the intervention of the treatment on Subject B are apparent enough descriptively, a time-series design analysis was performed 1) to offer statistical support for the efficacy of the intervention in each of the two series, and 2) to quantitatively study the concomitant variation in the two series analyzed for Subject B (i.e., EMG uV levels and frequency of part-word repetitions). By examining this co-variation, it is possible to generate hypotheses of causal connection (Glass, Wilson, and Gottman, 1975, p. 6). Although causal connection can never be proven as such, examination of the crosscovariance in Table V suggests at least a noteworthy relationship that is consistent with the descriptive trends that have been noted.

The specific time-series analysis that was employed here, the spectral analysis, can be considered as a nonparametric method to be generally used when the experimenter cannot specify a parametric form for the spectral density or covariance sequence. As such, the spectral analysis is more flexible than parametric inference in terms of assumptions; but not nearly as precise (Anderson, 1971, p. 549). This should serve to caution any reader who hastily attempts to draw equivocal conclusions from the presented data analysis.

With regard to the results of the prelude procedure in which anxiety was to be induced and compared to corresponding EMG uV levels, it appears that either the situation was not stress-producing or that both subjects employed here were not "autonomic responders," or that the procedure simply does not adequately discriminate between "autonomic responders" and "non-autonomic responders" (Cameron, 1944). In any event, a longer baseline period in the prelude procedure appears to be warranted. If the latter was indeed the case, it is possible that it was not the designed intervening variable that was effecting the dependent measure but rather a "patient expectancy" effect of some sort (Frank, et.al., 1959). The more pronounced differential effect of the EMG uV level lowering condition might have been due to a mutuality of experimenter and subject expectation. When Subject B was debriefed, he indicated that he believed that both interventions were designed to accrue him some therapeutic gain.

With regard to the latter results of studies by Porter (1939), Berwick (1955) and Hansen (1956) indicate that the amount of speech disfluences that a stutterer emits may be significantly affected by the listener's reaction as perceived by the stutterer. As the experimenter here was not blind to the intent of the study, it is possible that an "experimenter expectancy effect" (Wilkins, 1973) was in operation.

In the stuttering literature, one often encounters a phenomenon referred to as the "distraction effect." Bloodstein (1969, p. 192) makes the following statement about the distraction effect: "Almost any circumstance that momentarily reinforces the stutterers awareness of himself as a stutterer or focuses his attention on cues representative of stuttering is likely to bring on more stuttering. Conversely, any condition under which his attention to such cues is weakened by competing stimuli may bring about a temporary elimination of speech difficulty." In the present study, pseudo auditory feedback was introduced in the base-rate sessions in an attempt to mitigate any confounding influence of the distraction effect. Nonetheless, it is quite possible that the frequency of part-word repetitions decreased in the experimental conditions simply as a function of the subject being instructed to attend to the auditory stimuli.

The successful transition of Subject B from the feedback condition to the non-feedback situation in the last two sessions suggests that when the controlling stimuli are properly faded out, "cure," as opposed to "maintenance" might be affected with this procedure. In addition, this successful transition tends to render the above hypothesis (i.e., the "distraction effect") less tenable in light of the fact that the subjects were not instructed to attend to the external indicies of their EMG uV level during these two sessions. Nonetheless, it would next be necessary to demonstrate successful transition to the natural environment so that the procedure might be rightfully viewed as a therapeutic tool rather than simply as a pedantic laboratory exercise. Finally, it is entirely possible that only a one-way relationship between anxiety and muscle action potential exists, and this would account for the second hypothesis not being confirmed. Further research is needed to test this hypothesis.

Even in light of all of the aforementioned, the results of this study are indeed promising when correctly conceptualized as an exploratory study in a virgin area of research. It should behoove future researchers in the area to devise creative experimental conditions as a means of circumventing any confounding influence of the mentioned extraneous variables. Future research efforts might be aimed at 1) an extension of this design to a group study, with one group being trained to raise their EMG uV level (and thus eliminating any confounding influence of carry-over effects), 2) a group study comparison of the differential effect of EMG feedback on "autonomic responders" and "non-autonomic responders", and 3) the employment of EMG feedback as an adjunctive relaxation procedure to systematic desensitization therapy with stutterers.

APPENDIX A

Topics Used by Subjects in Spontaneous Speech Sessions

Fantasy
Communication
Dreams
Arab/Israeli conflict
Tornadoes
Dishonesty
Record albums
Vietnam War
Medicine
Rain
T.V.
Favorite books
Trains
Indians
Feminism
Letters
Space travel
Science
Red China
Over-population
Plays
History
Russia
Favorite professions
Crime problem
Drugs
Marriage
Colors
Religion
Are intelligent people happier?
Family
Medical Doctors
Philosophy
Machismo
President Ford
Country music
United Nations
Jacqueline Onasis
Elitism
Communism
Dormitories
Movies
Colors/Art
George Wallace
Poetry

North Texas State University

Denton, Texas 76203

Department of Psychology

APPENDIX B

BIOFEEDBACK TRAINING RELEASE FORM

I, ______________________, understand the general procedure regarding the use of biofeedback training, and am satisfied with the explanation given to me concerning the function and safety of the equipment. I voluntarily agreed to participate.

I am currently in reasonably good health, and am not being treated for any medical disorder which would prohibit the use of biofeedback training.

Yes ______ No ______

I, the undersigned, agree to hold North Texas State University and/or their authorized representatives harmless from liability for any injuries or damages resulting from the intentional or unintentional use or misuse and/or negligent use or misuse of any procedures included herein.

I understand that the data collected will be used primarily for my benefit and strict anonymity will be adhered to if the data is utilized for other purposes such as the advancement of knowledge in this area.

____
Date

______________________ ______________________
Participant Witness

N.T. Box 13587 • AC 817-788-2131

North Texas State University
Denton, Texas 76203
Department of Psychology

APPENDIX C

FARADIC SHOCK RELEASE FORM

I, ______________________, understand the general procedure regarding the use of faradic anxiety relief conditioning, and am satisfied with the explanation given to me concerning the function and safety of the equipment. I voluntarily agreed to participate in this research.

I am currently in good health, do not have a heart condition, and am not being treated for any medical disorder which would prohibit the use of faradic shock.

Yes ______ No ______

If NO, please explain ______________________________________

____

____

____

____

____
Date

______________________________ ______________________________
Participant Witness

N.T. Box 13587 • AC 817-788-2131

APPENDIX D

Newspaper Advertisement

Anyone who stutters and is interested in participating in faculty supported research please contact Dr. Mary Oelschlaeger or Joe Pachman.

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