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Effects of Concentric and Eccentric Biting and Biceps Muscle Contraction on Absolute Auditory Threshold

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EFFECTS OF CONCENTRIC AND ECCENTRIC BITING AND BICEPS MUSCLE CONTRACTION ON ABSOLUTE AUDITORY THRESHOLD

by

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INTRODUCTION

Previous research has demonstrated that aggressive behavior, including the act of biting, can be elicited in many species of animals by several experimental procedures. Electric foot and tail shock in rats (Ulrich and Azrin, 1962; Azrin, Rubin and Hutchinson, 1968) and either shock or a physical blow to the tail of a squirrel monkey (Azrin, Hutchinson, and Hake, 1963; Azrin, Hake and Hutchinson, 1965) will elicit a biting response. It has been shown that other paradigms, such as intermittent reinforcement by high fixed-ratio schedules of primary reinforcement and extinction, will cause squirrel monkeys to bite on a rubber hose (Hutchinson, Azrin, and Hunt, 1968).

Recent research has shown that a correlate to the aggression-biting phenomena found in animals is present in humans. The dental literature has reported that bruxism, or the nonfunctional grinding of teeth, has been viewed as a release from psychic tension and/or emotional stress (Ramfjord and Ash, 1966). Electromyographic studies of bruxism in humans have demonstrated an increase in the electrical activity of the temporalis and masseter muscles during conditions of threat or effortful task (Perry, Lammie, Main, and Teuscher, 1960; Yemm, 1969). EMG activity of the temporalis and masseter muscles has been demonstrated to increase as a function of bite force (Hutchinson and Pierce, 1971; Ahlgreen and Owall, 1970).

By utilizing EMG recordings of the temporalis and masseter muscles, several of the paradigms that elicit the aggression-biting response in animals have been replicated in humans. Increased temporalis and masseter EMG activity were produced during high fixed-ratio schedules and extinction from monetary reinforcement (Hutchinson and Pierce, 1971b). The removal of a positive reinforcing agent (cigarettes from habitual smokers) also produced increased masseter EMG activity (Hutchinson, Emley, and Sauer, 1971).

According to operant reinforcement principles, the probability that a response will occur in the future is increased if that response is reinforced. The occurrence and reoccurrence of biting, suggest the possibility that the act may have certain properties that are reinforcing to the organism. Indeed, it has been shown that when an animal is subjected to aversive stimulation, the opportunity to attack becomes a reinforcing event (Azrin, Hutchinson, and McGloughlin, 1965); and that the opportunity to attack is reinforcing subsequent to extinction (Azrin, 1964). Additionally, attack response can be operantly reinforced by overt reduction of aversive stimulation (Azrin, Hutchinson and Hake, 1967). There is, thus, reason to expect that the act of biting may function to produce some reinforcing change for the organism. It is possible that such a reinforcer could occur via a sensory intermediate or response system that is either diverted or attenuated.

There have been some indications that intersensory facilitation and inhibition exists with resulting increase or decrease of sensory thresholds. Absolute auditory thresholds are lowered when a photic pulse is delivered a half-second prior to acoustic stimulation (Child and Wendt, 1938). An increase in the absolute auditory threshold has been demonstrated to accompany induced heart-rate increases (Saxon and Dahle, 1971; Edwards and Alsip, 1969). Audio-analgesia, where pain is suppressed by loud auditory stimulation, has also been demonstrated (Gardner and Licklider, 1959).

The present experiment was devised to discover if biting might either mask or negate sensory systems. To this end, auditory thresholds were tested during both eccentric and concentric biting, and in the presence and absence of simultaneous biceps contraction.

METHOD

Subjects

The subjects were 3 females and 2 males, 19 to 24 years old. All were recruited through word-of-mouth. Three of the subjects, S-2, S-3 and S-4, were employees of the State Home, S-5 was unemployed, and S-1 was a student. Subject histories are summarized in Table 1. Subjects were informed that the object of the experiment was to test their audiometric thresholds while they performed various motor tasks. It was also explained that the experiment would last approximately three to four weeks. Subjects were told they would be paid $5.00 for each session, and that if they completed the entire experiment and missed no session, they would receive a $50.00 bonus.

The subjects filled out a medical history questionnaire which showed all subjects to be without disqualifying characteristics. Interviews conducted prior to and following the experiment showed absence of drug or medication usage during any of the experimental days.

Apparatus

The testing complex consisted of two adjacent rooms; the subject chamber room and the control room. The chamber room contained an Industrial Acoustics Company chamber, Model No. 402

CTL, which was sound-attenuating and designed for audiometric testing. The chamber was electrostatically shielded, air conditioned, and carpeted. Illumination was by three 60-watt lights. Chamber temperature was measured by a standard wall mounted thermometer, and ranged from 70° to 78° F. Continuous visual observation of the subject was via a one-way mirror between the control room and the window of the experimental chamber (Figure 4).

The chamber contained a wooden armchair and a console. The console was 24" wide, 22" deep and 47" high; and the upper sloping portion contained two panels. On the upper panel was an intercom and emergency alert system. The lower panel contained a bite-force feedback meter, instruction cue lights, and instructions. The instruction lights were operated by the experimenter from the control room. The lead wires for the earphones and the tone-response signaller (Edwards) were fed through a grommet in the lower panel. The two bite transducers mated with their respective connectors on the right-hand side of the console. A tray on the right-hand side of the console held a container of isopropyl alcohol solution for sterilizing the bite transducers between sessions (Figure 1). The 5.64 kg weight which the subject lifted to produce biceps contraction was 2" high and 5" in diameter, and was stored on the console.

The intercom provided communication between subject and experimenter, and monitored the subject's verbal behavior. The intercom button was marked "Push to talk" and lighted an adjacent yellow light when pressed. If pressed, the emergency alarm button, marked "Push to call, use only if necessary", illuminated lights next to the button on the console panel, in the adjacent control room occupied by the experimenter, and in the hall over the door leading to the chamber room; and also activated an audible alert. This alarm system was triggered by either a 110-VAC or 28-VDC power failure. A green pilot light, marked "Session On", was located at the top center of the upper panel, and served as the subject's cue that the experimental session was starting.

The instruction lights mounted in the lower panel of the console were miniature 28-VDC lamps with various colored covers. The lamps were in two rows of six, 1/2" separating each lamp and 5 1/2" between the rows. To the left of the instruction lights was an Electro-tec Microampere meter that read 0-200 microamperes. The face of the meter was partially covered, such that the subject could view the range from 80 to 120 microamperes only, and the scale from 90-110 microamperes was marked in red (Figure 2).

Two pressure transducers were used to measure bite-force; one for concentric, the other for eccentric biting (Figure 3). These were designed and calibrated according to Hutchinson and Pierce (1971a).

The transducers were connected to a Grass Model 5D Polygraph with 5P1 preamplifiers, which was used to calibrate and balance the bridge circuit in the transducers, record the incidence and the force of biting, and also to record subject responses on the tone-response signaller. Selection of either the concentric or eccentric transducers and one of five resistance values corresponding to five transducer bite-forces, and inclusion of a meter for observing these forces was provided by a balance/meter circuit. When the appropriate force was applied by biting on one of the two transducers, a meter in the experimenter's control room and the bite-feedback meter in the subject's console would both read 100. Thus, whichever force the subject was biting to obtain, the meter would read 100 microamperes when the requirement was met. Biting forces which the subject was to produce had the following values [expressed in Newtons (kgm/sec^2)]:

	P1	P2	P3	P4	P5
Concentric	0.59	9.81	19.62	32.37	38.25
Eccentric	0.59		51.99	97.11	126.54

For administration of the binaural audiometric tests to determine the minimum audible pressure threshold for pure tones at frequencies of 125, 2000, and 8000 Hertz (Hz); a Beltone Model 5-C clinical audiometer (calibrated to the 1964 ISO scale) was used. The subject earphones were Koss Stereophones of 8-Ohm impedance. A diagram of the apparatus used in this experiment is shown in Figure 5.

Procedure

All sessions were run on weekdays except session 6, which was on a Saturday. Table 2 lists the sessions and gives the procedure used for each subject during each session. The blank areas on days 2, 11, 12, and 13 reflect equipment failures, and blanks on days 14 and 15 for S-2 were due to scheduling difficulties. The duration of each session was approximately 50 minutes.

Prior to the first session, all subjects completed a medical history questionnaire (Appendix A). At each session, the subjects signed a "consent to experimental procedure" form (Appendix B) beforehand, and a "release from experimental procedure" form (Appendix C) afterwards.

Upon arrival at the laboratory, the subject was escorted directly to the experimental chamber and seated in the chair facing the console, directly in front of the bite-pressure feedback meter. The subject was then instructed concerning the proper positioning of the two bite transducers in the mouth, and the correct position and adjustment of the earphones. The operation of the intercom and alarm system was explained, as was the functions of the session-on light, which indicated both the beginning and end of the session. The subject was informed that the experimenter would be in the adjacent room and would have visual access to the chamber. The subject was also asked to refrain from having gum, candy, or other objects in the mouth during the session.

In Part I of the study, the experimenter asked the subject to concentrate to hear the faintest tone audible to them and to follow the instruction on the panel next to the illuminated cue light. The instructions read:

1. Insert I transducer
2. Insert T transducer

3. Bite on transducer such that meter reads in the red area

4. Listen for tone...Push button when tone is heard

5. Relax

6. Remove transducer from mouth

These instructions were further clarified. The subject was shown which of the transducers was the I (concentric) and which was the T (eccentric). Also, it was explained that it would take varying amounts of bite force on the transducer to move the needle of the feedback meter into the red area; that the light indicating that tones were about to be presented would not come on until the needle was in the red area; and that if, while tones were being presented, the needle moved out of the red area, no tones would be presented until the needle returned to the red area. The subject was then shown the push-button signaller and its operation, and told that it could be held in whichever hand was most comfortable. Finally, the subject was reminded that when the "Relax" light came on, the subject was to do precisely that, including removing the transducer from the mouth. The instruction to "Remove the transducer from mouth" was designed to be used if the subject didn't remove the transducer from his mouth, while relaxing. This instruction was found to be unnecessary.

The subject was then advised that sitting quietly and keeping body movements to a minimum would help them to hear the tones. They were then asked if they had any questions concerning the procedure. If there were any, the experimenter again explained these details.

Finally, the subjects were told that there would be a ten-minute period before the session started which enabled them to become accustomed to the quiet of the chamber. At the end of ten minutes, the "Session On" light would come on, and they should then put the earphones on, grasp the push-button signaller, and follow the cue-light instructions as they came on. At this point, the chamber temperature was recorded and the experimenter exited and closed the door.

Following the ten-minute adaption period, the "Session On" light was illuminated and a preliminary test trial was run to determine the subject's approximate auditory threshold. Following this, several practice trials were run until measures appeared consistent. At this point, test trials began and, for Part I, followed the sequence of bite pressures as shown in Table 3, Part I. During eccentric bite test sessions, frequencies of 125, 2000 or 8000 Hz were employed, and during concentric bite test sessions, 2000 Hz was used.

The testing procedure was as follows: the cue light corresponding to the appropriate transducer, either concentric or eccentric was turned on. Only one transducer and one frequency were used during any one session. Then the cue light to bite on the transducer until the meter was in the red area was turned on. Whenever a cue light was turned on, the previously illuminated light automatically went off. When the subject had held the needle continuously in the red area for five seconds, the cue light signalling the forthcoming presentation of tones was turned on. A series of tones was then presented according to a modified method of limits, starting about 10 decibels (db) above threshold in a descending order of 2 db decrements, until the subject failed to respond. To be certain that the absence of response was not a false negative, another tone 2 db lower was presented. If at this value there was a response the descending pattern was continued. If no response occurred, however, an ascending series of tones 2 db apart were presented, starting at the first no-response level, until the subject responded. The value of the last descending tone and the first ascending tone were later averaged to arrive at the threshold. This method was derived from Hirsh (1952). Tone duration was approximately 2 seconds, the inter-tone interval varied from 4 to 8 seconds, and the interval between trials varied from 20 to 30 seconds.

On the third session, each subject was informed that if he or she should respond when a tone had not been presented, the cue lights would be turned off and the trial would start over. This was done to provide feedback to the subjects whenever they made a false response. They were also informed that a varying number of tones would be presented, ranging from three to ten tones per trial.

Following the last trial, the subject's "Session On" light was turned off, and the subject was escorted from the chamber to the secretary's office. There the subject was paid and signed a receipt before leaving the laboratory.

The procedure for Part II was identical to Part I except that, when testing at 2000 and 8000 Hz during concentric biting, a fifth bite force was required. The sequential presentation of these force requirements is shown in Table 3.

Part III of the experiment introduced a second task, in which subjects were required to lift a 5.64 kg weight cradled in one hand with their elbow on the armrest of the chair and forearm extended at 45° from vertical. This necessitated an additional two instructions, which read: "With weight" and "Without weight". During half of the Part III sessions, when not using the weight, the sequence of events was identical to Parts I and II. The procedure was as follows when the subject had to lift the weight: the cue for which transducer was to be used came on, and then the cue to lift the weight was illuminated; when the subject had the weight in the proper position, the cue light to bite on the transducer so as to keep the needle in the red area of the meter was illuminated; after this point in the procedure, the tones were presented as described for Part I. The order in which the bite forces were presented for Part III is also shown in Table 3.

Data Analysis

The absolute auditory threshold was computed by averaging the lowest descending and first ascending tones to which the subject responded. During each session for Part I and Part II, threshold values were determined four times at each bite force. (P1 was tested six times, but only the first four thresholds were used for computational purposes.) A mean value was calculated from the four threshold values at each bite-force during each session. During

Part III, two threshold values were computed at each bite force and weight or no-weight test. (P1 and P1w were tested three times, but only the first two values were used for computational purposes.) Again a mean value was calculated from the two values at each bite force and weight or no-weight test.

The bite forces were always presented in an ascending sequence, and the sequence was then repeated a second time. Further calculations were therefore made to determine the magnitude of sequence or order effect. The differences during a session for each bite-force from the first sequence to the second sequence were all totalled, and a mean of the total computed. This value represented the threshold change over the duration of the session.

During determination of threshold values at 2000 Hz, subjects S-1, S-3, S-4 and S-5 exhibited audiometric thresholds below the 0 db indication of the audiometer. This necessitated electrical measurements which allowed inferential extension of the audiometer's indicated lower limit to -10 db.

RESULTS

All subjects displayed a decreasing sensitivity to pure tones as a function of increasing bite-force, both eccentric and concentric.

Figure 6 shows that as eccentric bite-force increases, absolute auditory threshold also increases. This is so for all five subjects at all frequencies tested; 125, 2000, and 8000 Hz. Bite-force, as measured in newtons (kgm/sec^2), is displayed along the abscissa and is the same for all graphs. The mean db value of the absolute auditory threshold is shown on the ordinate of each graph, and varies with frequency for each subject and among subjects. The dashed line represents the auditory threshold change over the duration of the session, which was typically an increasing function.

The bite-force, corresponding to 0.59 newtons and used to approximate a non-bite situation, is a minimal force and provides a control for procedural and attention variables. Of the 45 mean auditory threshold values at bite-forces exceeding the minimal value of 0.59 newtons, 43 are in excess of the threshold value at 0.59 newtons, shown in Figure 6. Thus, while biting eccentrically at any of the three frequencies, the value of the absolute auditory threshold is raised as the force of the bite increases.

The same functional relationship was found for all subjects when biting in a concentric relation, as shown in Figure 7. An additional bite-force value was tested at frequencies of 125 and

8000 Hz (Part II in Table 2). Data at 2000 Hz were collected using the same procedure as for Part I. The abscissa and ordinate are scaled in the same manner as described for Figure 6. Again, the bite-force of 0.59 newtons is a minimal bite value and the dashed line depicts a threshold generally increasing over the duration of the session. Of the 55 mean threshold values at bite-forces exceeding the minimal force (0.59 newtons), 52 are above the respective thresholds at minimal bite-force. Here again, there is a general relation between increasing threshold values and increasing bite-force.

To determine if increased tonus of another muscle group than that involved in biting might cause this same functional relationship, auditory thresholds were determined while biting was accompanied by simultaneous contraction of the biceps muscle. No consistent effects on threshold values were obtained. Figure 8 illustrates performance during trials, half of which necessitated the lifting of a 5.64 kg. weight, and half of which did not. Trials were otherwise identical. Absolute auditory thresholds at 8000 Hz for all subjects while only biting (closed circles) and while simultaneously biting and lifting the weight (open circles) are illustrated. All biting was concentric. When tested while biting at the minimal force, three subjects showed no threshold change while lifting the weight versus no weight lift. Two subjects showed a decrease in threshold when lifting the weight. Of the 20 threshold values for bite-forces in excess of the minimum, addition of the weight-lift requirement produced a decrease in threshold in 17 cases. Here again, all subjects showed an increase of threshold as a function of bite-force, both with and without the lifting task. The mean absolute threshold changes due to time into session are represented in Figure 8 by dashed and dashed/dotted lines for non-weight and weight sessions respectively.

Table 1

Subject History

Subject	S-1	S-2	S-3	S-4	S-5
Age	19	21	23	21	24
Sex	F	F	F	M	M
Marital Status	M	S	S	M	M
Occupation	Student	Special Ed. Teacher	Language Therapist	Student	Electrical Repairman

Table 2

Session Days

SUBJECTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
S-1		P	P	P	P		T	P	T	P	T	T	P	T	T				Pw	Pw	Pw	Tw
S-2		P	P	P	P		T	P	T	T						T	T	T	Pw	Pw	Pw	Tw
S-3	P	P	P	P	P		T	T	T	P			T	T	T				Pw	Pw	Pw	Tw
S-4	P		P	P	P		T	P	T	P	T	T		T	T				Pw	Pw	Pw	Tw
S-5			P	P	P	P	T	P	T	P	T	T		T	T				Pw	Pw	Pw	Tw

KEY:
T = Normal test session
Tw = Test session while lifting 5.68 kg. weight
P = Practice session
Pw = Practice session while lifting 5.68 kg. weight

Table 3

Sequential Order of Bite-Forces

Part I	P1	P1	P3	P3	P4	P4	P5	P5	P1	P1	P3	P3	P4	P4	P5	P5	P1	P1				
Part II	P1	P1	P2	P2	P3	P3	P4	P4	P5	P5	P1	P1	P2	P2	P3	P3	P4	P4	P5	P5	P1	P1
Part III	P1	P1	P3	P3	P4	P4	P5	P5	P1	P1	P3	P3	P4	P4	P5	P5	P1	P1				
		w		w		w		w		w	w		w		w		w					

KEY: P = Bite-force
w = while lifting weight

FIGURE 1

Experimental chamber viewed through doorway into chamber.

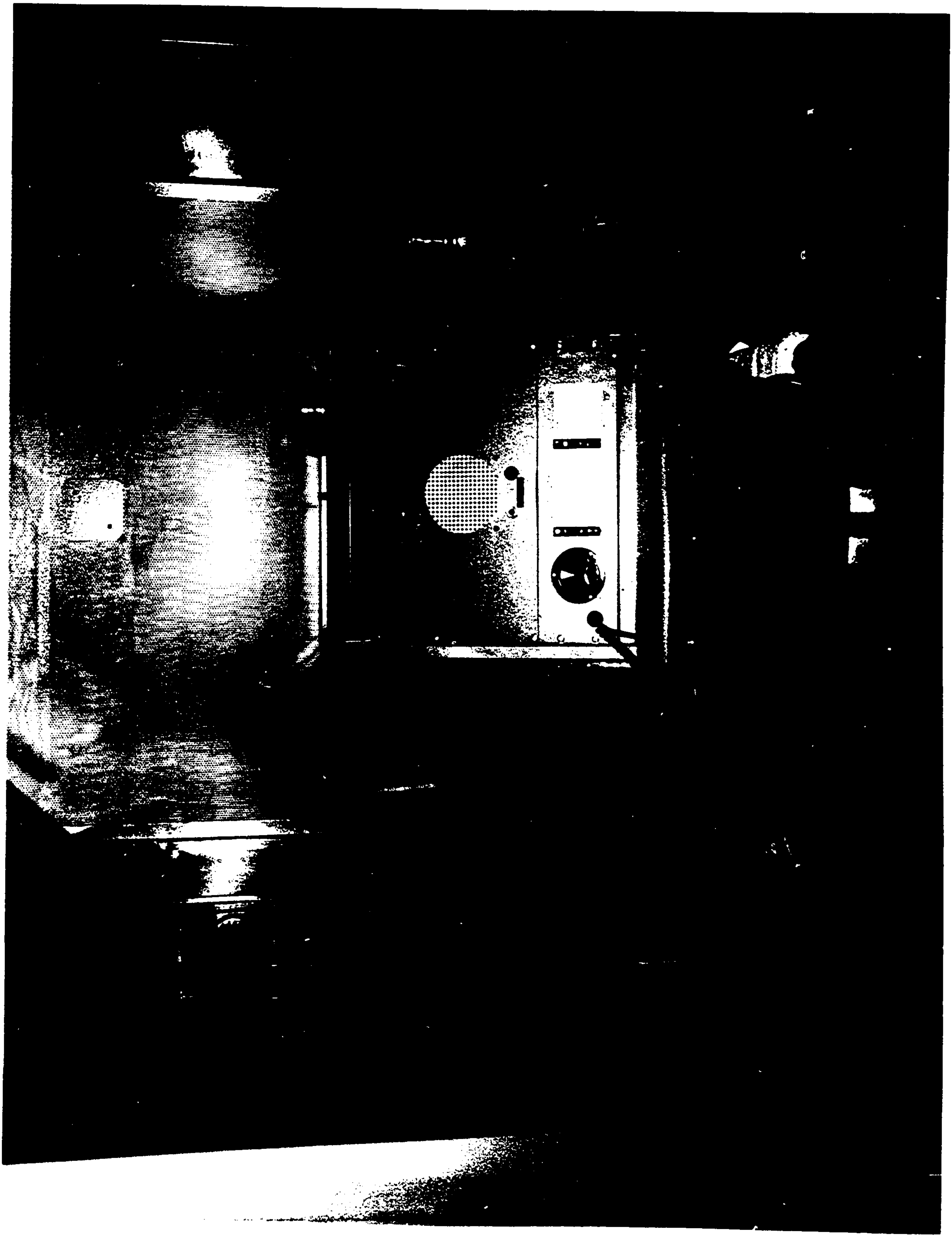


FIGURE 2

Close-up of console in experimental chamber.

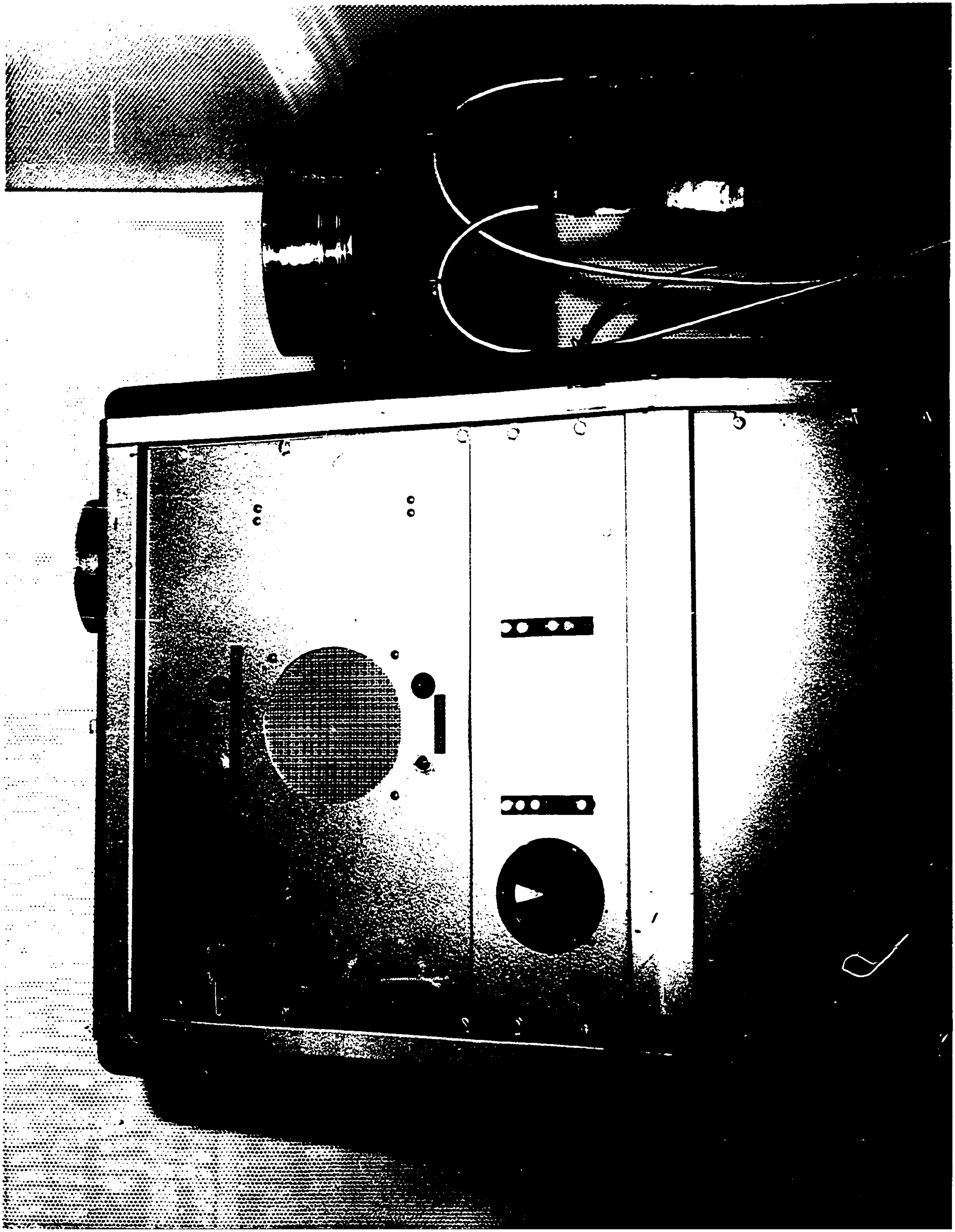


FIGURE 3

Concentric and eccentric bite transducers.

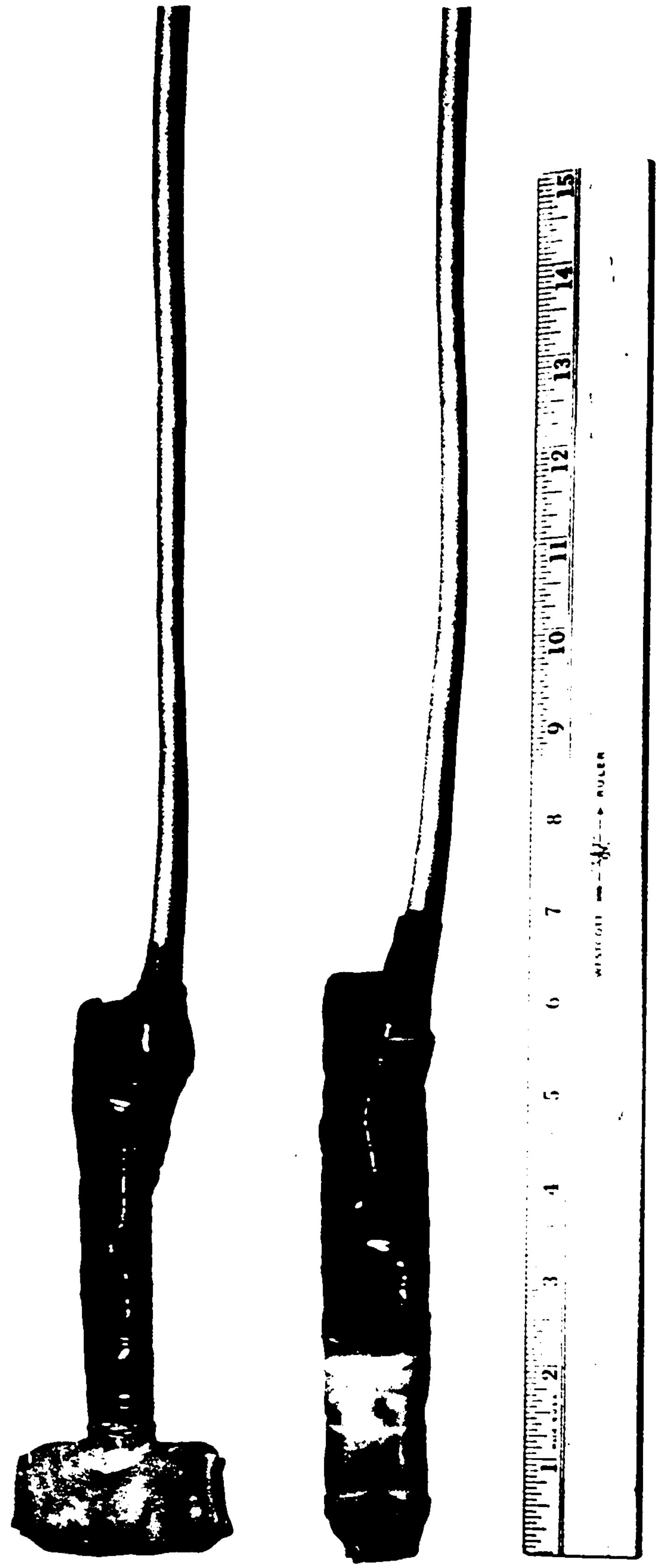


FIGURE 4

Control room, with view of mock subject in the experimental chamber biting on transducer, holding push button signal, and wearing the earphones.

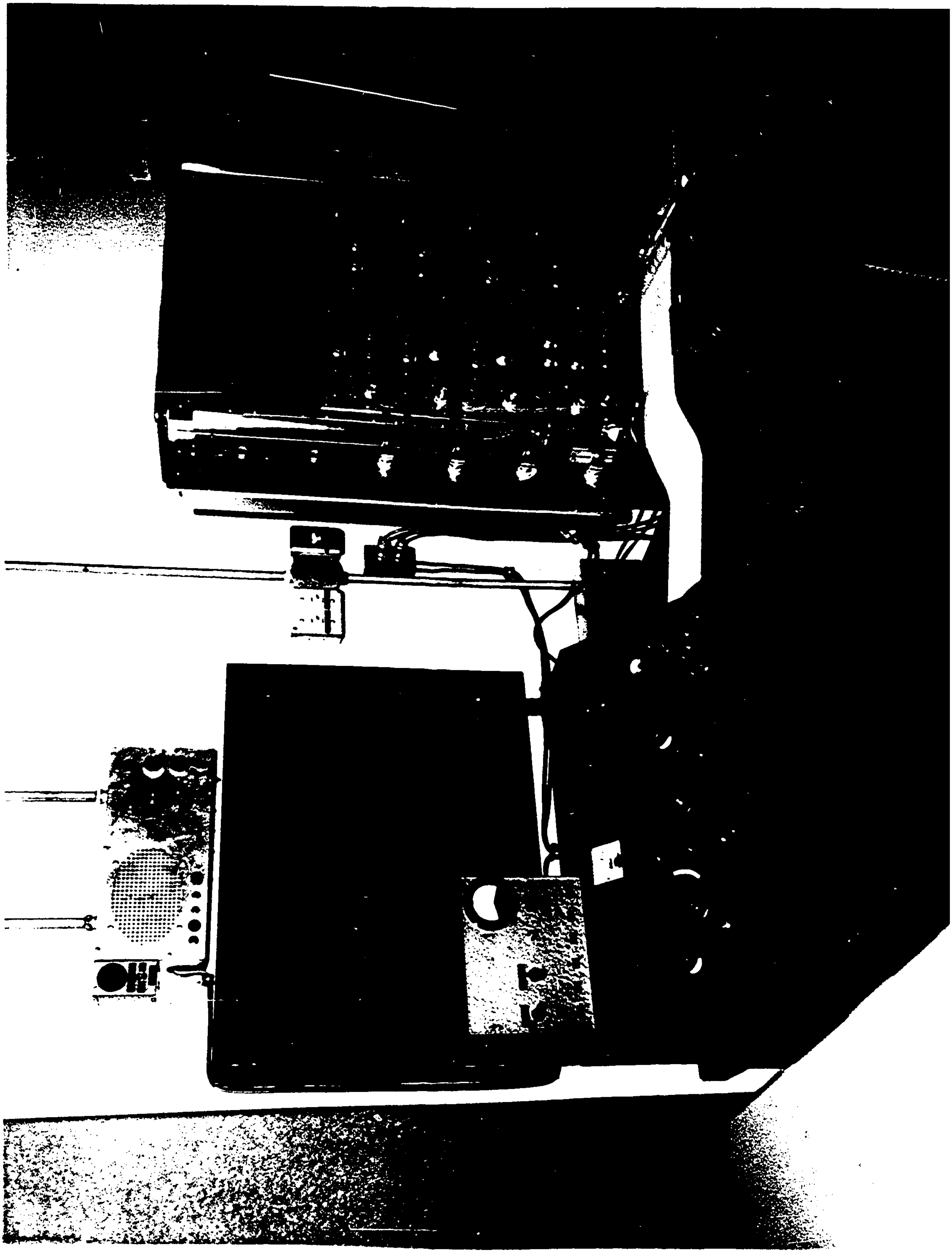


FIGURE 5

Schematic diagram of apparatus.

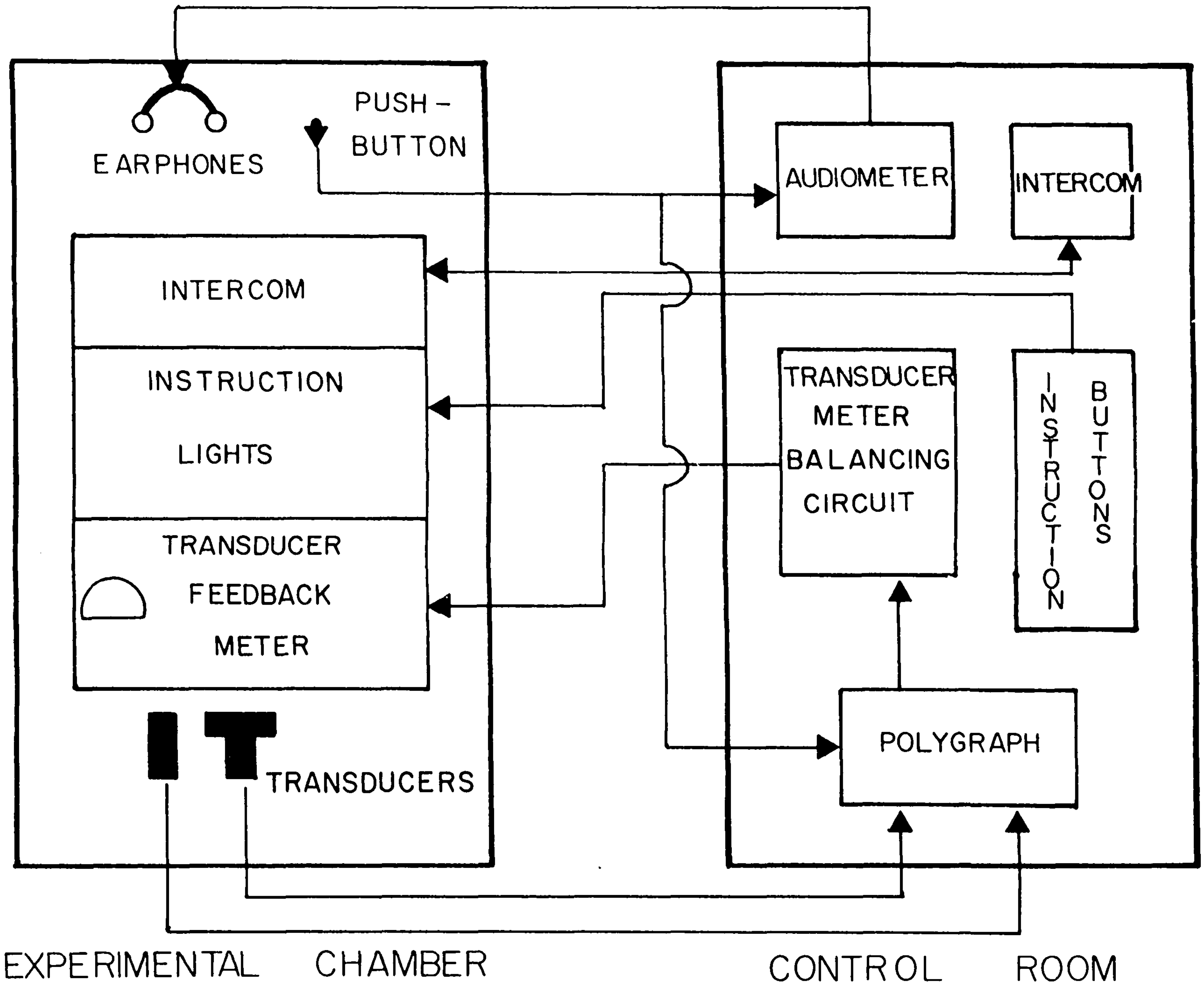
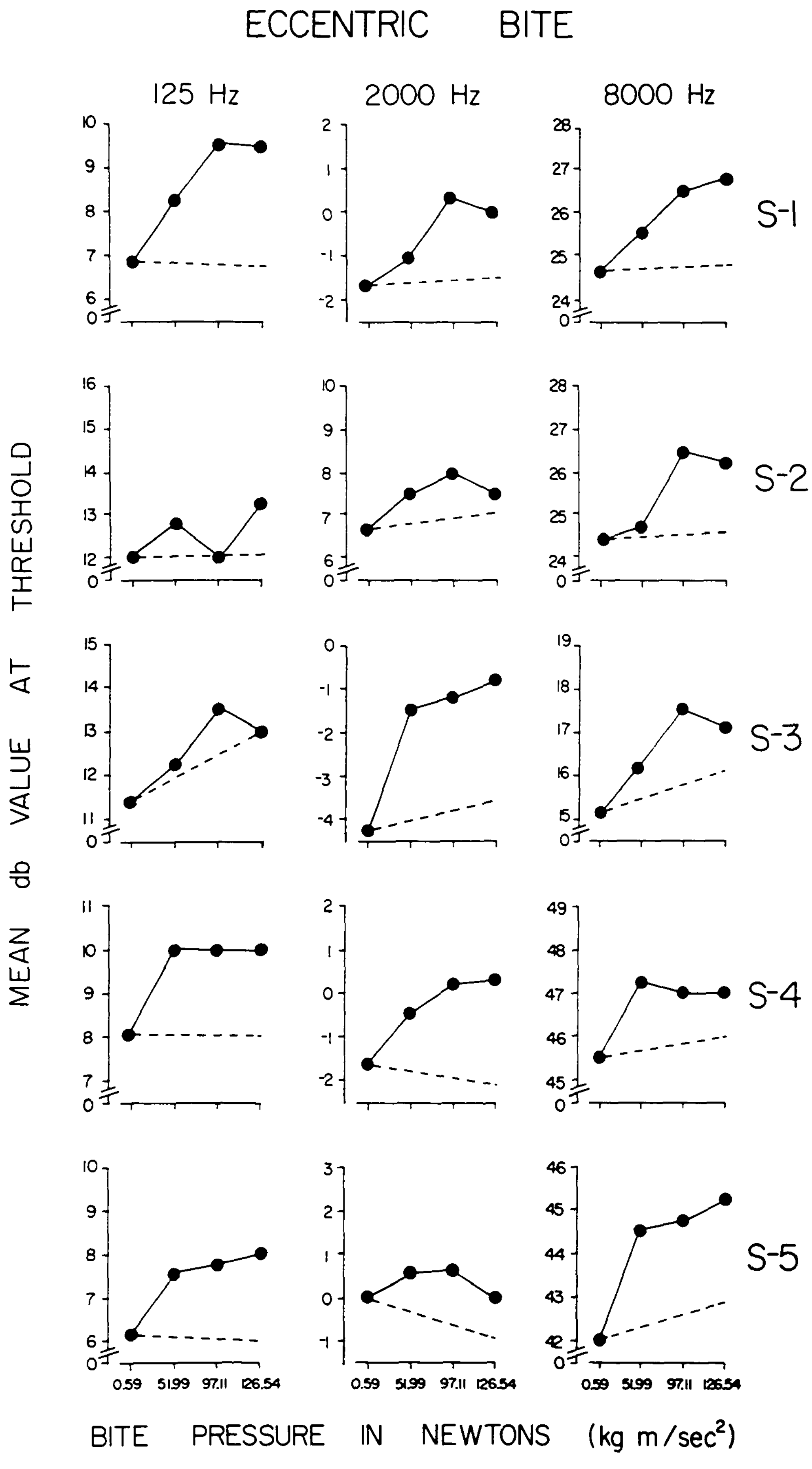

EARPHONES
PUSH-BUTTON
AUDIOMETER
INTERCOM
INTERCOM
INSTRUCTION LIGHTS
TRANSDUCER FEEDBACK METER
TRANSDUCER METER BALANCING CIRCUIT
INSTRUCTION BUTTONS
POLYGRAPH
TRANSDUCERS
EXPERIMENTAL CHAMBER
CONTROL ROOM

FIGURE 6

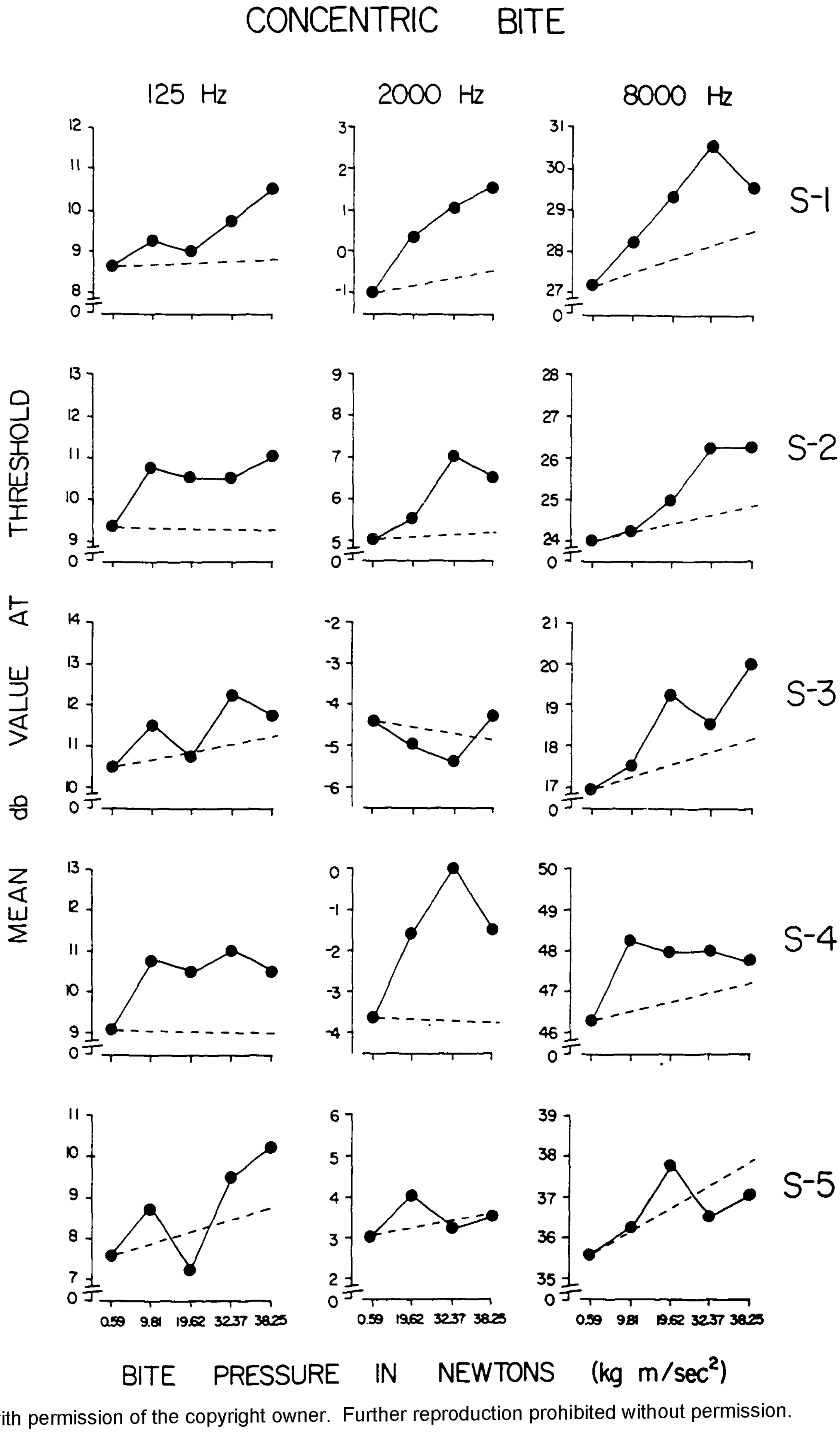
Mean absolute threshold values at frequencies of 125, 2000, and 8000 Hz while biting in an eccentric relation at four increasing bite-forces. The dotted line represents mean absolute threshold change over duration of the session.



ECCENTRIC BITE
125 Hz
2000 Hz
8000 Hz
S-1
S-2
S-3
S-4
S-5
MEAN db VALUE AT THRESHOLD
0.59
51.99
97.11
126.54
BITE PRESSURE IN NEWTONS (kg m/sec²)

FIGURE 7

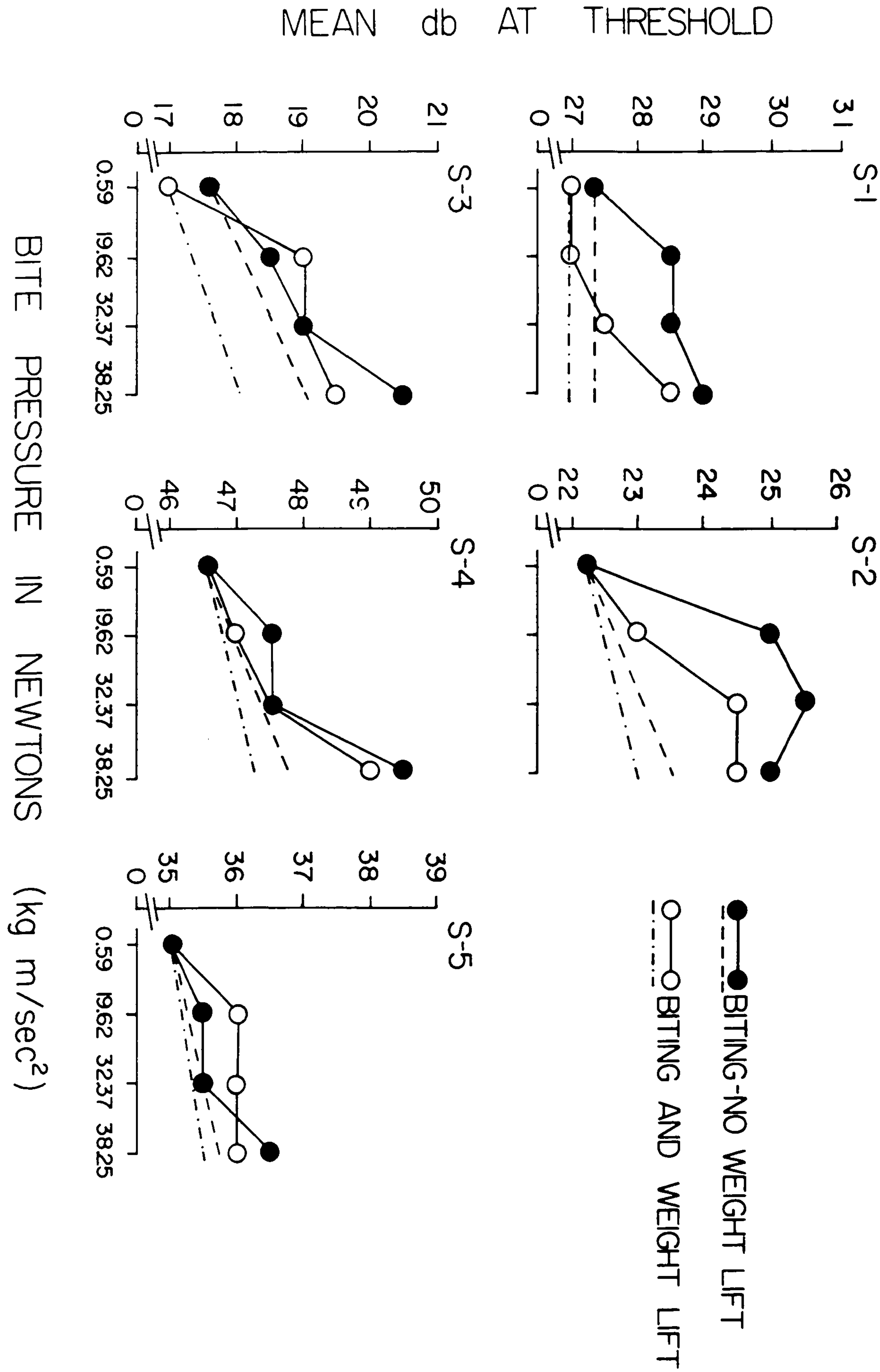
Mean absolute threshold values at frequencies of 125 and 8000 Hz while biting in a concentric relation at five increasing bite-forces, and at a frequency of 2000 Hz while biting concentricly at four increasing bite-forces. The dotted line represents mean absolute threshold change over duration of the session.



CONCENTRIC BITE
125 Hz
2000 Hz
8000 Hz
S-1
S-2
S-3
S-4
S-5
MEAN db VALUE AT THRESHOLD
0.59
9.81
19.62
32.37
38.25
BITE PRESSURE IN NEWTONS (kg m/sec²)

FIGURE 8

Comparison of mean absolute thresholds at a frequency of 8000 Hz while biting in a concentric relation at four increasing bite-forces, with the mean absolute thresholds at the identical frequency, bite-force, and bite relation, but while simultaneously lifting a weight and eliciting contraction of the biceps muscle. The dashed line represents mean absolute threshold change over the duration of the session while biting only. The dashed and dotted line represents the mean absolute threshold change over the duration of the session while biting and lifting the weight.


MEAN db AT THRESHOLD
S-1
S-2
S-3
S-4
S-5
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
50
48
47
46
39
38
37
36
35
0
0.59
19.62
32.37
38.25
BITING-NO WEIGHT LIFT
BITING AND WEIGHT LIFT
BITE PRESSURE IN NEWTONS (kg m/sec²)

DISCUSSION

This experiment demonstrated a functional relationship between increases in absol -e auditory threshold and increasing bite-force. The elevation of auditory threshold occurred at all three frequencies tested: 125, 2000 and 8000 Hz; which comprise a representative sample of the range of auditory frequency response utilized in pure-tone audiometry (O'Neill and Oyer, 1966). The threshold changes were similar under both eccentric and concentric biting relations. The results of the sessions at a minimal bite-force, comparing the normal paradigm with the addition of a weight lift, indicate that contraction of the biceps muscle has a negligible effect on auditory sensitivity.

Several alternative explanations could be made to account for the reduced auditory sensitivity found under conditions of biting. As the subjects' force of bite increased, this might necessitate more attention to the bite-force feedback meter, thus reducing attention to the task of threshold discrimination. The signal from the polygraph, however, was amplified to activate the feedback meter in a manner whereby the lower the bite-force, the more sensitive the system became to input changes. If anything, more attention was therefore necessary at a minimal bite-force.

The results of the experiment have shown that auditory sensitivity changed as a function of time into session. Thus, the possibility exists that this effect was due to auditory adaptation or fatigue (Bekesy, 1947; Licklider, 1951). However, the degree of auditory adaptation has been shown to be dependent upon the loudness of the stimuli, and when the auditory signal is near threshold, the adaptation is negligible (Bekesy, 1967). Furthermore, the subject's ten-minute rest period prior to initiation of the testing procedure was designed to minimize the initial effect of threshold facilitation in the absence of noise (Bryan, Parbrook, and Tempest, 1965). This adaptation period may not have been long enough, however, and what appears to be a gradual decrease in sensitivity during the session may have been a facilitation of sensitivity at the onset that dissipated over the duration of the session.

It also seems unlikely that the threshold change was due to contraction of the middle-ear muscles, even though they have been shown to attenuate sound by as much as 20 db (Galambos and Rupert, 1959). Non-acoustic factors, such as stimulation of the pinnae and meatal entrance of the external ear, elicit contraction of the interaural muscles (Carmel and Starr, 1963). This being the case, the pressure of the earphones would elicit contraction of the interaural muscles throughout the session (Guilick, 1971). Most importantly, the attenuated effect of these muscles does occur at frequencies of 125 to 8000 Hz, but only from 75 to 95 db, well above the range tested in this experiment (Jepsen, 1955).

The basic finding of this experiment was that the act of biting produces a reduction of auditory sensitivity. If further research indicated that other sensory modalities are affected in a similar fashion, a plausible explanation of why biting during or following noxious or stressful events is reinforcing to the organism could be advanced. It would be of further interest to delineate the mechanism by which biting alters sensory input and/or processing system functions.

REFERENCES

Ahlgren, J. & Owall, B. Muscular activity and chewing force: A polygraphic study of human mandibular movements. Archives of Oral Biology, 1970, 15, 271-280.

Azrin, N. H., Aggression. Paper presented at American Psychological Association, Los Angeles, 1964.

Azrin, N. H., Hake, D. F., & Hutchinson, R. R. Elicitation of aggression by a physical blow. Journal of the Experimental Analysis of Behavior, 1965, 8, 55-57.

Azrin, N. H., Hutchinson, R. R., & Hake, D. F. Pain induced fighting in the squirrel monkey. Journal of the Experimental Analysis of Behavior, 1963, 6, 620.

Azrin, N. H., Hutchinson, R. R., & Hak-, D. F. Attack, avoidance, and escape reactions to aversive shock. Journal of the Experimental Analysis of Behavior, 1967, 10, 131-148.

Azrin, N. H., Hutchinson, R. R. & McGlaughlin, R. The opportunity for aggression as an operant reinforcer during aversive stimulation. Journal of the Experimental Analysis of Behavior, 1965, 8, 171-179.

Azrin, N. H., Rubin, H. B. & Hutchinson, R. R. Biting attack by rats in response to aversive shock. Journal of the Experimental Analysis of Behavior, 1968, 11, 633-639.

Bartley, S. H. Principles of Perception, New York: Harper and Row, 1958.

Bekesy, G. von. A new audiometer. Acta Oto-laryngology, 1947, 35, 411-422.

Bekesy, G. von. Sensory Inhibition, Princeton, New Jersey: University Press, 1967.

Bryan, Parbrook, and Tempest. J. Sound and Vibration, 1965, 2, 147.

Carmel, P. W. and Starr, A. Acoustic and non-acoustic factors modifying middle ear muscle activity in waking cats. Journal of Neurophysiology, 1963, 26, 598-616.

Case, J. Sensory Mechanisms, New York: The Macmillan Company, 1966.

Child, I., & Wendt, G. R. The temporal course of the influence of visual stimulation upon the auditory threshold. Journal of Experimental Psychology, 1938, 23, 109-127.

Edwards, D. C. and Alsip, J. E. Stimulus detection during periods of high and low heart rate. Psychophysiology, 1969, 5, 431-434.

Galambos, R. and Rupert, A. Action of the middle ear muscles in normal cats. Journal of Acoustical Society of America, 1959, 31, 349-355.

Gardner, W. J. and Licklider, J. C. R. Audio-Analgesia. Journal of American Dental Society, 1959, 59, 1144-1149.

Guilick, W. R. Hearing: Physiology and Psychophysics. New York: Oxford University Press, 1971, 111.

Hirsh, I. J. The Measurement of Hearing. New York: McGraw-Hill Book Company, 1952. Chapter 4

Hutchinson, R. R., Azrin, N. H. & Hunt, G. M. Attack produced by intermittent reinforcement of a concurrent operant response. Journal of the Experimental Analysis of Behavior, 1968, 11, 489-495.

Hutchinson, R. R., Emley, G. S., & Sauer, R. A. Effects of cessation of cigarette smoking on jaw clenching. Paper to be presented at American Psychological Association, Washington, D. C., Sept., 1971.

Hutchinson, R. R. & Pierce, G. E. A method for quantitative and unobtrusive measurement of biting and clenching behavior in humans (personal communication), 1971 (a).

Hutchinson, R. R. & Pierce, G. E. Jaw clenching in humans: its measurement and effects produced by conditions of reinforcement and extinction. Paper to be presented at American Psychological Association, Washington, D. C., Sept., 1971.

Jepsen, O. Middle ear muscle reflexes in man. Modern Developments in Audiology, James Jerger (Ed.), New York: Academic Press, 1963, 206.

Licklider, J. C. R. Basic correlates of the auditory stimulus, Chapter 25 in Handbook of Experimental Psychology, S. S. Stevens (Ed.), New York: Wiley, 1951.

O'Neill, J. J. and Oyer, H. J. Applied Audiometry. New York: Dodd Mead and Company, 1966, 61.

Perry, H. T., Lammie, G. A., Main, J. & Teuscher, G. W. Occlusion in a stress situation. The Journal of the American Dental Association, 1960, 60, 626-633.

Ramjord, S. P., & Ash, M. M. Occlusion. Philadelphia: W. B. Saunders Company, 1966.

Saxon, S. A. and Dahle, A. J. Auditory threshold variations during periods of induced high and low heart rates. Psychophysiology, 1971, Vol. 8, No. 1, 23-29.

Ulrich, R. E. and Azrin, N. H. Reflexive fighting in response to aversive stimulation. Journal of the Experimental Analysis of Behavior, 1962, 5, 511-520.

Wybum, G. M., Pickford, R. W. & Hirst, R. J. Human Senses and Perception. London: Oliver and Boyd, 1964.

Yemm, R. Variations in the electrical activity of the human masseter muscle occuring in association with emotional stress. Archives of Oral Biology, 1969, 14, 873-878.

APPENDIX A

Medical History Form

NAME_______________________________AGE___________SEX_________

ADDRESS_______________________________________PHONE____________

DATE OF BIRTH___________________________MARITAL STATUS___________

OCCUPATION______________________________

ARE YOU A UNITED STATES CITIZEN? YES_____ NO_____

Medical History:

1. Do you consider yourself to be in good health at the present time?

   yes_____ no_____

2. Have you ever been refused employment, insurance or rejected from the armed forces because of your health? yes_____ no_____

3. Do you now or have you ever had any of the following illnesses?

	Yes	No
asthma	____	____
bronchitis	____	____
hay fever	____	____
rheumatic fever	____	____
epilepsy	____	____
tuberculosis	____	____
diabetes	____	____
increased blood pressure	____	____
stomach trouble	____	____
heart trouble	____	____
migraine headache	____	____
serious infections	____	____
skin trouble	____	____
arthritis	____	____
tooth ache	____	____
bleeding gums	____	____
bladder or kidney trouble	____	____
nervous or mental disorder	____	____
infectious mononucleosis	____	____

4. Do you have any allergies to drugs, foods, animals, plants, insects, dust, etc.?

   yes_______ no_______ If yes, please explain.

5. Are you presently under the care of a physician, psychiatrist or therapist?

   yes________ no________

6. Are you presently or have you recently received any medication for any reason (including vitamins, pep pills, diet pills, tranquilizers, etc.)?

   yes________ no________

7. Are you on any special diet? yes________ no________

8. Has anyone in your family had any of the following illnesses? (grandparents, parents, brothers, sisters, children)

asthma	YES______	NO______	RELATIONSHIP_______
hay fever	______	______	_______
epilepsy	______	______	_______
nervous or mental disorder	______	______	_______
cancer	______	______	_______
heart disease	______	______	_______
severe headache	______	______	_______
high blood pressure	______	______	_______

9. When was your last physical exam?

10. When did you last have a dental check up?

GENERAL INFORMATION

1. Have you ever taken part in any experimental studies? yes__ no__

   If yes, did these studies involve any of the following:

ingestion of food substances	YES______	NO______
ingestion or injection of drugs	______	______
metabolic tests	______	______
blood or urine tests	______	______
blood pressure recording	______	______
abstinence of any sort	______	______
heart rate recording	______	______
EEG recording	______	______
confinement	______	______
physical exertion tests	______	______
written tests	______	______
performance tests	______	______
sleep	______	______

2. Are you right handed? yes______ no______

3. Do you wear any of the following:

	YES	NO
false teeth or bridge	______	______
hearing aid	______	______
glasses	______	______
braces for teeth	______	______

4. Have you ever been bothered by claustrophobia? yes______ no_____

5. Are you currently enrolled in an educational program of any sort?

   yes_________ no_________

6. Please indicate daily or weekly frequency of the following:

   a. sleep (hrs.)

   b. alcohol consumption

   c. exercise (hrs.)

   d. tobacco consumption (cigars, cigarettes, pipe)

   e. chewing gum

   f. coffee

   g. tea

7. Do you suffer from headaches? yes________ no_________

   If yes, what is the frequency of their occurrence?

8. Are you a nail biter or pencil chewer? yes______ no______

9. Do you participate actively in sports? yes______ no______

Signed ______________________________

Witness ___________________________

Date ______________________________

APPENDIX B

Consent to Experimental Procedure

Consent to Experimental Procedure

I, _____________________________ here by consent to serve as a volunteer experimental subject for the Research Department of Fort Custer State Home. I have been informed of the experimental procedure. I understand that I may withdraw at any time from participation in this research.

Signed ____________________________

Witness __________________________

Date _____________________________

APPENDIX C

Release from Experimental Procedure

Release From Experimental Procedure

I,___________________________have served as a volunteer experimental subject for the Research Department of Fort Custer State Home. I felt_____, did not feel_____, unpleasant side effects. If so they were____

____

____

____

Signed___________________________

Witness________________________

Date___________________________