THE EFFECTS OF SIMULTANEOUS BUT UNEQUAL RESPONSE-INDEPENDENT PAY TO PAIRS OF HUMAN SUBJECTS ON MASSETER EMG AND BODILY MOVEMENTS

by

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Electromyographic activity and bodily movement of the masseter muscle were recorded in three pairs of human subjects, where one member of each pair was systematically presented with greater pay and each could reduce the value of money received by the other. The number of biting responses was as high or higher for the subject receiving less money immediately after coin delivery. However, the number of masseter contractions for the subject receiving more money remained higher at other times during the unequal pay conditions. No responses of pay reduction were emitted by any subject toward another. As reported previously, biting tended to be highest early in the inter-coin delivery interval, while bodily movements were higher later in the interval. These data are discussed in conjunction with previous human and animal studies indicating that human masseter contractions are a sensitive measure of environmental noxiousness.

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INTRODUCTION

The systematic study and measurement of human aggression has been generally limited to observing attacks against inanimate objects or experimenters' confederates (Buss, 1961; Geen, Rakosky, and O'Neal, 1968; Geen and Stonner, 1971; Harrell, 1973; Kelley and Hake, 1970; and Ulrich and Favell, 1970). These studies have employed "overt-aggressive" responses, such as, punching on a cushion, disruption of play activity, or presumably shocking another subject (confederate). Within the experimental context, these responses were defined as, and assumed to be, aggressive. However, the occurrence of these responses in social experimental situations and outside the laboratory have not been established.

Recent research has demonstrated that increases in the electromyographic activity of the temporalis and masseter muscles of humans provides a valid and sensitive measure of environmental noxiousness and individual aggressivity (Hutchinson and Emley, 1973; Hutchinson and Pierce, 1971; Pierce, 1971; Proni, 1973, and Sauer, 1971). This EMG activity measures the intensity, duration and frequency of biting responses in humans (Alhgren and Owall, 1970; Hutchinson and Pierce, 1971). Temporalis EMG activity indicates eccentric biting, while masseter EMG

activity indicates both eccentric and concentric biting (Hutchinson and Pierce, 1971). Additional evidence supporting the relationship between environmental stimuli and human biting responses has been demonstrated in dental research.

In an attempt to determine the etiology of bruxism, (the non-functional grinding of teeth) several researchers have assessed the effects of stress situations upon temporalis and masseter activity (Perry, Lamie, Main, and Teuscher, 1960; Ramfjord and Ash, 1966; and Yemm, 1969a, 1969b, 1969c, 1972). The studies by Yemm have shown increased EMG activity during initial sessions of a reaction-time task (stressful experimental condition), with subsequent decreases as the task difficulty lessened.

In general, human temporalis and masseter EMG activity parallels animal biting responses, in that each shows similar changes to the same major classes of antecedent stimulation: the onset of intense or noxious stimuli and the offset of pleasant or positive reinforcing type stimuli (Hutchinson, 1972). Difficult tasks, the presentation of loud noises, the increase of fixed-ratio requirements and extinction, the cessation of cigarette smoking, and the decrease of response-independent pay have all produced increased biting responses in humans. Other environmental variables effecting the temporalis and more particularly, the masseter muscle activity (which

indicates both eccentric and concentric biting) still need to be specified.

Previous research has recorded attack responses emitted from a number of animal species against other organisms and inanimate objects (Hutchinson, 1972). Such attack responses have been elicited from pigeons against target birds, both alive and stuffed; and from squirrel monkeys towards other animals and inanimate objects (Azrin, Hutchinson, and Hake, 1966; and Azrin, Hutchinson, and Sallery, 1964). Proni (1973) observed two human subjects exhibit overt-social acts indicative of "aggression" and "hostility", in conjunction with high rates of masseter contractions. These subjects emitted verbal and physical behaviors, such as, swearing at and kicking a coin dispenser when exposed to a condition of decreasing pay. Further corroboration of simultaneously occurring "overt-aggressive" responses and increased masseter EMG activity in humans needs to be established. Presumably, there should exist a direct correlation between these two response classes.

As indicated above the removal of positive reinforcing type stimuli increased the biting responses in humans. Few studies have investigated the effects of these conditions upon human aggressive behavior in a social context to date. Lindsley (1966) demonstrated that the systematic non-reinforcement of one member of a task pair disrupted

"cooperative" behaviors and generated and maintained "competitive" responses. Although differential rates of pay are common in this society, there has not been sufficient empirical evidence presented to determine the effects this condition has on future social behaviors. It has not been established if observing another person receive more pay, is the same or similar to the effect of pay reduction. This information could well further the knowledge of antecedent-stimulus causes of human aggression.

This study was created to assess the effects of unequal response-independent pay in pairs of human subjects who have continual visual and verbal contact. Specifically, a condition of higher pay for one individual should cause increased masseter EMG activity and "overt-aggressive" responses in the lower paid person.

METHOD

Subjects

Six males, 20-23 years old were used as subjects. Five were students at a nearby university. One was discharged from military service and received unemployment compensation.

Each subject completed a medical history questionnaire and passed a physical examination given by the State Hospital. Four of the subjects completed and passed a post-experiment physical exam. At the beginning of the experiment none of the subjects were taking medication. However, during the last thirteen sessions S-3 was taking prescribed medication for an ear infection. Post-experiment interviews indicated that all subjects believed this to be a test measuring physiological changes occurring with experimental stimuli.

Apparatus

An Industrial Accustics Company (IAC) Audiometric testing room Model 402CTN, electrically grounded and air-vented, was utilized as the subject testing chamber. The inside dimensions of the chamber were 132" long x 84" wide x 78" high. There were two doors, each with a window, located at opposite ends of the chamber. A 23½" high x

29½" long window was located in the middle of one side of the chamber's length. A 24" high x 30" long x 12" deep wooden box was mounted on the outside of the chamber surrounding the window. Two Panasonic Panaview Model WV400P T.V. cameras were housed inside this box to provide continual closed-circuit T.V. contact with the subjects (see Figure 1). White noise of a 57db sound level in the audible range, generated from a Grason-Stadler Model 901B Noise Generator, was delivered into the testing chamber and the chamber room. Temperature readings were monitored from two Airguide indoor-outdoor thermometers, one for each half of the chamber. Inside lighting was provided by four 60 watt light bulbs enclosed along the window wall.

A wooden table 42" wide x 84" long x 1 3/4" thick was mounted on top of a 84" long x 31" high x 3/4" thick plywood sheet in the center of the chamber. The table top was 32 3/4" from the floor. Two 81" long x 24½" high x 3/8" thick plexiglass sheets were centered and hinged onto the table top and locked in place into a 84" long x 45" high x 3/4" thick plywood sheet. A 22" high x 77" long opening was cut out of the plywood which permitted visual contact between the subjects.

A red, palm, push-button Microswitch 2PH4 was centered on the plexiglass sheet 42" from either end, and 12" from the table top. Beneath the microswitch, mounted on

the table top, 32" from either end and 7½" from the table's edge, was a 10½" wide x 19" long aluminum panel which served as a cover plate for a junction box secured underneath. Three K-D Company armored clearance lights, model #541-1305 with an amber, white, or red lens, were centered at 5¼" on the panel. The white light mounted 2½" from the edge of the panel, signaled the presentation of two nickels ($.10). The amber light mounted 9½" from the panel's edge, signaled the coin delivery value of two dimes ($.20). The red light, mounted 2½" from the other edge, signaled the coin delivery value of two quarters ($.50).

A 14" long x 10½" wide x 27 3/4" high coin dispenser, purchased from Hamilton Scale Company, was mounted on top of the table opposite the window wall. The coin dispenser was 2½" from the end and ½" from the edge of the table. Mounted and centered on the 10½" side facing the window was a coin cup 5½" up, and an intercom 20½" up. A 10" x 14" junction box was secured to the table's bottom underneath the coin dispenser. Quarters, dimes, or nickels, were dispensed into the coin cup. Electrical connections were made through shielded cables that entered from the window wall and housed in 1" channel secured to the underside of the table.

The subjects were seated on metal, office desk chairs with cushioned seats and back rests. The chairs were

located at the center of the table facing the microswitch and stimulus lights, within reach of the coin cup. A Grass electrode board was mounted to the back of the chair with the cable entering from the window wall. Each chamber half was a mirror image of the other. The data were recorded on an eight channel Offner Electronics, Inc. Dynograph Type 504 using standard Offner Type 146 Amplifiers and specially designed differential pre-amplifiers of high sensitivity. Integrated pre-amplifiers were also used. A Grass Model EB524 electrode panel was mounted on the polygraph feeding the output of the electrode board in the chamber to the polygraph. Six channels of the polygraph were used to record each subject's masseter EMG, integrated EMG, and the EMG of the prefered forearm. A seventh channel recorded coin delivery presentation. The two event pens recorded the onset and duration of the stimulus light which indicated the high-value coin delivery. The eighth channel of the polygraph was not in use. An Esterline-Angus 20 pen event recorder was used to record the onset and duration of the three stimulus lights, the coin delivery value received, and the subjects' responses on the red push-button. A DEC Building Block logic system controlled the functions of the red push-button microswitch, the stimulus lights, and reinforcement delivery. This program rack also controlled the Esterline-Angus and polygraph event pens. Sedaco counters tabulated

the total number of push-button responses, and the number of high- and low- value coin deliveries.

Procedure

The six subjects were grouped into three pairs. None of the subjects had previously met their partners. Only one pair (S-1 and S-2) met and discussed the experiment outside the laboratory. Each pair was tested daily at the same time, Monday through Friday. Each testing consisted of a thirty-minute session and thirty to forty minutes of subject preparation. The subjects were greeted at the door by the experimenter and escorted to a waiting room until their partner arrived. Each subject was requested to sign a "Consent to Experimental Procedure" form and to answer a "Drug and Sleep Questionnaire". This latter form was a brief checklist of food and drug intake, and present physical state.

The subjects were escorted to a preparation room and seated on stools. The following instructions were then read:

> "This is an experiment to record various physiological measures under several conditions. Electrodes will be placed on parts of your body. These electrodes will be used (showed and explained where).
>
> After the electrodes have been put in place, you will be escorted to a testing chamber in the other room. During the experimental session you will receive money dispensed from a coin machine. You may keep all the coins you receive. However, this money will be counted at the end of the

session, and you must sign a receipt for it. In addition, you will receive a $2.00 bonus for each experimental session. This bonus will be paid at the completion of the entire experiment. You will be allowed one excused absence. Any more will result in your termination from the experiment, and you will not receive the bonus. Each experimental session will be conducted at the same time Monday through Friday.

Do you have any questions?"

If there were any questions the instructions were repeated. After several days the subjects indicated that they understood the procedure, and the instructions were no longer read. In addition, watches and jewelry were removed with the explanation that they would interfere with the recording equipment. The experimenter anc an assistant prepared the subjects for the study. All areas where electrodes were to be positioned were cleansed with alcohol. During preparation a Grass E5S silver cup electrode was filled with electrode paste and applied to the tip of the nose and secured using two short pieces of surgical tape. Grass E34S ear clip assemblies containing E4S flat silver discs filled with electrode cream were then attached to each ear lobe. Two Grass E2B platinum alloy subdermal electrodes were then inserted into the dermal layers overlaying the masseter muscle. Electrode placement was even with the bottom of the ear and about 1½" in front of it. These electrode leads were secured to the cheek with two pieces of surgical tape. An elastic bandage was then placed around the head to provide strain relief for the

electrodes. All the electrode leads were wrapped around the elastic bandage and brought down under the bandage at the back of the head. Two more subdermal electrodes were inserted; one in the vertex (the center of the top of the head), and one about 3/4" above the occipital lobe. These were also wrapped around the elastic bandage and brought out with the other electrode leads. This method of preparation was similar to that employed by Hutchinson and Pierce (1971), Pierce (1971), and Proni (1973), and "...has proven quite immune to movement artifacts and particularly suitable for active subjects (Pierce, 1971, p.12)."

Two Beckman surface electrodes were then filled with electrode paste and adhered with Beckman collars to the inside of the subject's prefered forearm. For all subjects this was the right arm. Electrode placement varied slightly for each subject, but was approximately two inches from the wrist for one electrode and three inches from the elbow for the other. The electrode leads were also secured to the forearm with a piece of surgical tape.

The subjects were then escorted to the testing chamber by the assistant and the experimenter. Each subject was assigned to one side of the chamber for the duration of the study. Once seated, the electrodes were plugged into the electrode board on the back of the chair. The nose, the two ears, the vertex, and the occipital electrodes were connected as the reference electrodes.

The two masseter electrodes and the two forearm electrodes, each, were connected in parallel to separate inputs. The subjects sat, facing each other across the table with the plexiglass partition. The following instructions were then read:

> "In front of you are three lights (pointing to them). Each light represents a value of money which you will receive. The money will be dispensed into this cup (pointing to the coin cup dispenser).
> This button controls the lights and money of your partner (pointing to the red palm-microswitch). By pressing it when the lights are on you can control the value of money which your partner receives. Can you reach the button?
> If there should be some emergency, or if you have to leave the chamber for any reason, push this button on the intercom (pointing) and you will be able to talk to me. Reach forward and try to touch the button.
> The session will vary in length, but a noise will be on during the entire session and will go off when the session ends. There will also be a period of a few minutes before and after the session during which I will be calibrating the equipment.
> Do you have any questions?"

If there were any questions, the instructions were repeated. No other explanations were given. Again, after several days the reading of these instructions was discontinued. For Subjects Five and Six the instructions concerning the red push-button were deleted.

The chamber doors were then closed. The experimenter recorded the inside and outside temperatures. Chamber temperatures ranged from 68° to 78°. The closed circuit T.V.'s, intercoms, and tape recorder were all turned on.

The polygraph was turned on and a calibration series run. This consisted of a series of calibration pulses from the electrode board ranging from 5 μv to 500 μv. Adjustments were made at this time if the calibration procedure showed any change from a standard. The input from the subjects was then fed to the polygraph. Within several minutes the session was initiated, indicated by white noise delivered into the chamber. Every two minutes and fifty seconds one of the three stimulus lights would come on for ten seconds, and terminate with a coin delivery. Each subject could readily observe the stimulus lights of his partner. Verbal interaction was freely allowed, although the white noise tended to elevate the subjects' normal conversation level. After the tenth coin delivery the session ended. This was indicated by the termination of the white noise. Another calibration series was run and the temperatures were again recorded. It was explained to the subjects that the assistant would not be available after the session to assist in disconnecting the electrodes. Therefore, one subject at a time was led from the chamber to the preparation room. The electrodes were disconnected and the money which the subject received was counted. The subject then signed a "Release from Experimental Procedure" form and a receipt for the money. The subject was escorted from the laboratory. The experimenter then returned to the chamber for the partner. This procedure proved sufficient in

minimizing subject contact after each session.

Changes in the amount of money which each subject received were varied depending upon the individual's response rates and behavior stability. No changes were introduced on Mondays. The sequence of experimental conditions and coin values received for all subjects is listed in Table 1. The red push-button microswitch was operative under all conditions for Subjects One and Two, and Three and Four. For Subjects Five and Six the push-button was operative only for the subject receiving the lesser coin value during unequal pay conditions. When operative, the red push-button functioned as follows: if either subject responded on his button during the ten second signaled coin delivery interval, his partner's high-coin value stimulus light terminated. The low-coin value stimulus light would then turn on for the remainder of the ten seconds followed by low-value coin delivery.

Data Analysis

To convert the analogue masseter EMG data to a digital format, a 50 μv peak-to-peak criterion was used, i.e., any masseter EMG deflection noted on the non-integrated masseter EMG channel that exceeded the deflection caused by the 50 μv calibration pulse at the beginning of each record was counted as a criterion response. The 50 μv level was chosen because it was above normal

system artifacts but was below most bursts of masseter EMG activity. Movement artifacts were eliminated by utilizing a minimum frequency of 10 CPS. This frequency was chosen because most movement artifacts generated a substantially lower frequency and the masseter EMG integrated channel tended to ignore low frequency criteria. Some judgement was exercised for those instances where movement and masseter EMG activity were concurrent. In recording the number of masseter EMG bursts in a close series of bursts it was required that the amplitude of the masseter EMG signal drop below 50 μv for the activity to be recorded as a new burst. The data analysis was identical to that employed by Proni (1973). The forearm EMG activity assisted in discriminating movement from masseter contractions on the masseter EMG channel. However, since push-button responses were minimal for all subjects, this EMG activity was not completely analyzed.

All masseter EMG criterion responses were classified as either "movements", "social interactions", or masseter contractions. "Movements" included gross physical movements, yawns, swallows, coughs, or other subject noises, such as, whistling. "Social interactions" included those subject behaviors which involved talking, smiling, or laughing. Each of these activities were readily identified by the visual monitoring of the subjects. All events which occurred in the chamber were recorded directly on the

polygraph record. Any criterion masseter EMG activity not identified in the above categories was recorded as a masseter contraction.

RESULTS

There was a definite increase in the number of masseter contractions for the three subjects when first receiving greater pay. Figures 2, 3, and 4 illustrate this effect. One of the subjects who remained at the same pay also showed increased masseter contractions. The absolute number of masseter contractions varied for each subject. Those first receiving more money reached maximum levels of 61, 68, and 226 masseter contractions per session for S-2, S-4, and S-6 respectively. Those maintained at the same pay had maximum levels of 53, 29, and 72 masseter contractions for S-1, S-3 and S-5 respectively, during the unequal pay conditions. The two subjects (S-3 and S-5) who were recipients of greater pay under the final reversal condition showed no elevation in masseter contractions during those sessions, however.

An inverse relationship between masseter contractions and bodily movements was observed for two high-pay subjects (S-2 and S-6). Increased masseter contractions corresponded with decreased movements. This relationship was not observed with the third high-pay subject (S-4). S-4 was frequently observed engaging in behaviors which may be labeled as exercises. These included "shaking" and "flapping" his arms; kicking his feet into the air;

rhythmic breathing; and isometrics. No other subject displayed these behaviors.

One session for each pair was chosen for a closer examination of the distribution of masseter contractions and movements within the inter-coin interval. These sessions, arbitrarily selected, were representative of the observed response differences during a session in the first group of sessions with unequal pay conditions. Sessions used were: Number 10 for Subjects One and Two; Number 9 for Subjects Three and Four; and, Number 12 for Subjects Five and Six. The distributions of responses is graphed in Figures 5, 6, and 7.

High-pay subjects (S-2, S-4, and S-6) displayed a steady rate of masseter contractions throughout the entire inter-stimulus interval. Conversely, low-pay subjects (S-1, S-3, and S-5) showed increased masseter contractions immediately after coin delivery and/or approaching the next delivery, but relatively little biting during the intermediate portions of the interval. Thus, the differences in total masseter contractions between high- and low- pay subjects seen in session averages did not exist on closer examination of the period immediately prior to coin delivery. The amount of masseter contractions prior to coin delivery for two low-pay subjects (S-1 and S-5) was as much as, or greater than, the amount of masseter contractions concurrent for the high-pay subjects.

All high-pay subjects (S-2, S-4, and S-6) showed some movement ten to twenty seconds before coin delivery. Movements and masseter contractions tended to be out of phase during the inter-stimulus interval for S-2 and S-6. Four subjects (S-1, S-4, S-5, and S-6) showed movement following coin delivery.

As a further check on the immediate effects of the unequal pay condition, the first such session was examined. The number of masseter contractions and movements occurring during each three minute interval preceding coin delivery is plotted in Figures 8, 9, and 10. No clear effects are yet observable in Subjects One and Two. Conversely, the effect of unequal coin delivery is already evident for Subjects Five and Six. Of even greater interest is the temporary, but definite increase and greater display of biting in the lower-pay Subject Three, not discernible by Session Number 9. Thus, the low-pay condition did produce locally (immediately after the event) a temporary, but relatively greater biting in the low-pay subjects. Subject Six showed an increase in masseter contractions, and a subsequent decrease in movements.

The push-button responses failed to occur predictably. All subjects initially utilized the button to apparently determine its function. Once known, push-button responses were emitted only during the first experimental change, or else at random times. S-5 used the push-button three times

during the unequal pay condition which presented S-6 with one low-coin value each time.

Verbal behavior and physical responses, which may be indicative of "aggressivity" or "hostility", were recorded. Some of the incidents are listed in Figure 11. Low-pay subjects commented to the experimenter about receiving more pay. Two of the low-pay subjects (S-1 and S-3) talked about quitting and ending the experiment. S-1 was observed twisting the push-button during the stimulus-intervals. Three subjects (S-3, S-4, and S-6) hit and/or kicked the coin dispenser several times. For S-4, this response occurred when the coin dispenser jammed during three different sessions. For S-3 and S-6 this response was not related to any antecedent-stimulus, such as, a jammed dispenser. S-3 hid a book in his shoe and read during several sessions, even though it was explicitly explained that they were not to read during the session.

In post-experiment interviews, Subjects Two and Six expressed "altruistic" statements. S-2 indicated that he quit the experiment first, to enable his lower paid partner, S-1, to receive the bonus. He stated that this would even out the amount of money each received. S-6 stated that he was glad to receive more money, but that he felt "bad" that his partner did not get more also.

Table 1

Experimental conditions and coin values received for each subject. The low-coin value occurred only if a push-button response occurred.

Session	Experimental Condition	Coin Value Received			
		Hi	Lo	Hi	Lo
		S-1		S-2	
1	S-1 20¢/10¢; S-2 20¢/10¢	3	7	3	7
2	same	9	1	8	2
3	same	8	2	8	2
4	same	10	0	10	0
5	S-1 20¢/10¢; S-2 50¢/20¢	9	1	9	1
6-13	same	10	0	10	0
		S-3		S-4	
1	S-3 20¢/10¢; S-4 20¢/10¢	4	6	6	4
2	same	9	1	9	1
3	same	10	0	10	0
4	same	10	0	10	0
5	S-3 20¢/10¢; S-4 50¢/20¢	10	0	9	1
6-11	same	10	0	10	0
12-22	S-3 20¢/10¢; S-4 20¢/10¢	10	0	10	0
23-27	S-3 20¢/10¢; S-4 50¢/10¢	10	0	10	0
28-31	S-3 20¢/10¢; S-4 20¢/10¢	10	0	10	0
32-35	S-3 20¢/10¢; S-4 50¢/20¢	10	0	10	0
36-44	S-3 20¢/10¢; S-4 20¢/10¢	10	0	10	0
45-51	S-3 50¢/20¢; S-4 20¢/10¢	10	0	10	0
		S-5		S-6	
1-8	S-5 10¢/none; S-6 10¢/none	10	0	10	0
9	S-5 10¢/none; S-6 50¢/10¢	10	0	7	3
10-11	same	10	0	10	0
12	same	10	0	9	1
13-19	same	10	0	10	0
20	same	10	0	9	1
21-23	same	10	0	10	0
24	same	10	0	9	1
25-29	same	10	0	10	0
30	S-5 50¢/10¢; S-6 10¢/none	9	1	10	0
31-33	same	10	0	10	0

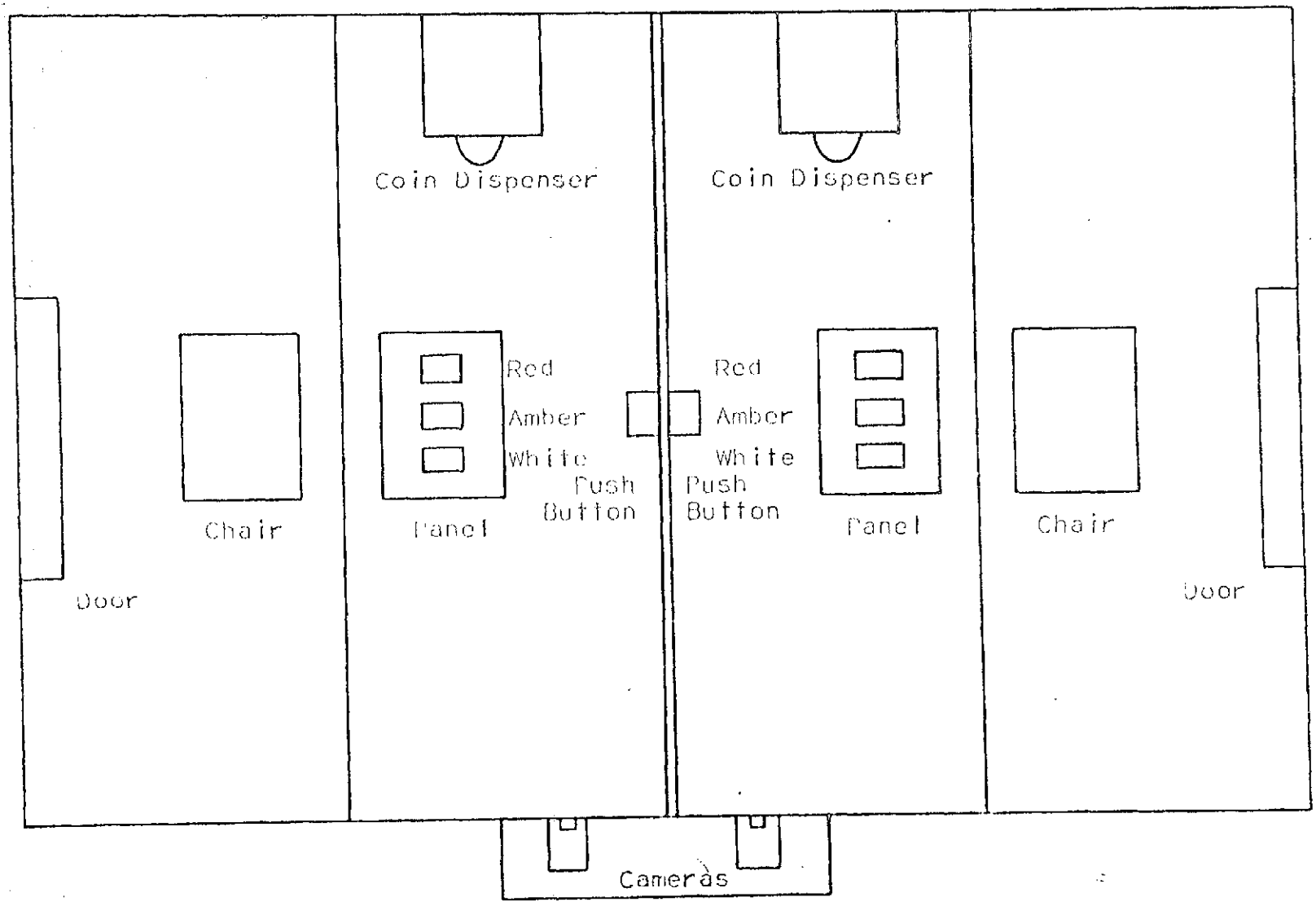

Figure 1

Schematic drawing of testing chamber.

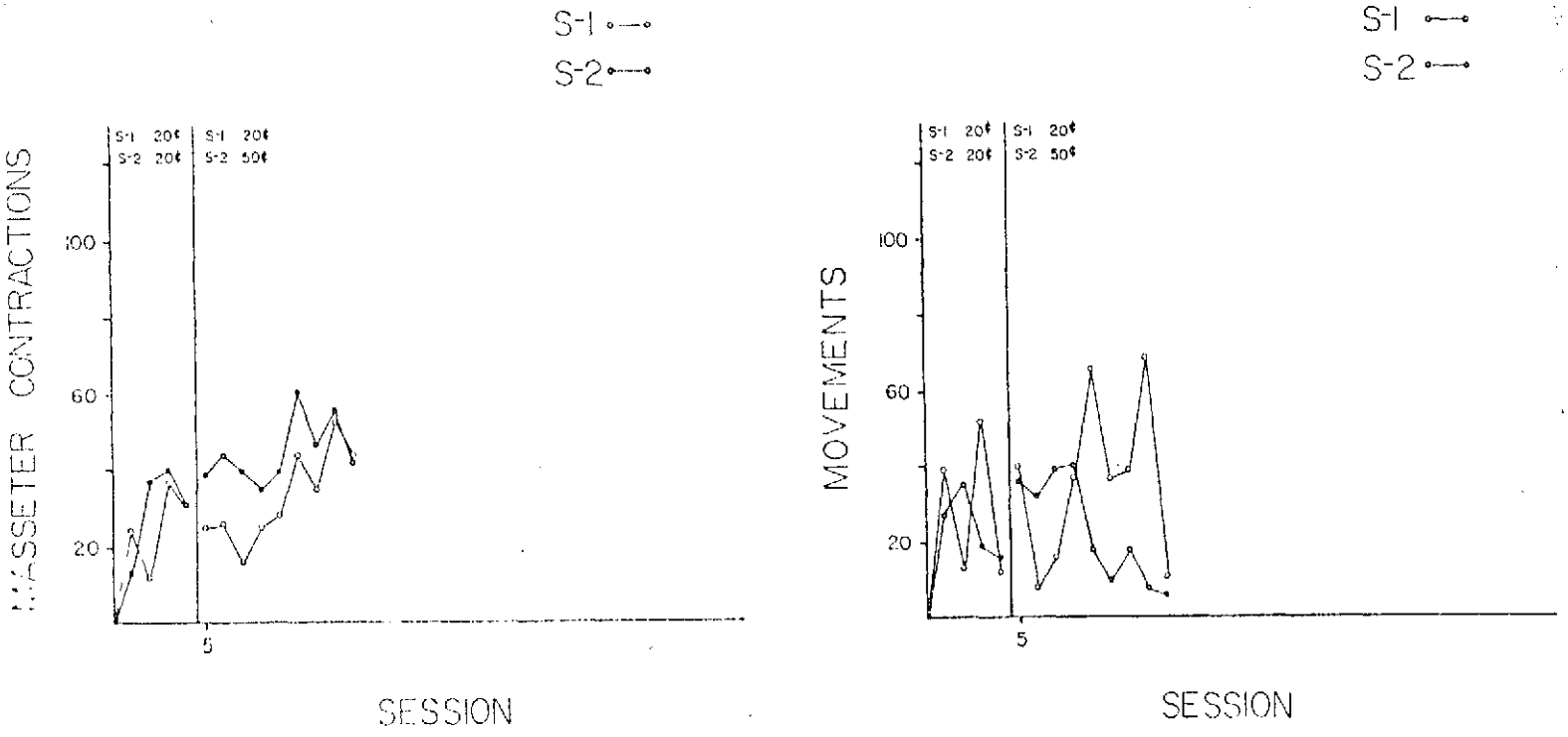

Figure 2

Total number of masseter contractions and movements per session for Subjects One and Two as a function of equal and unequal pay. The data includes responses occurring for one minute beyond the last coin delivery.

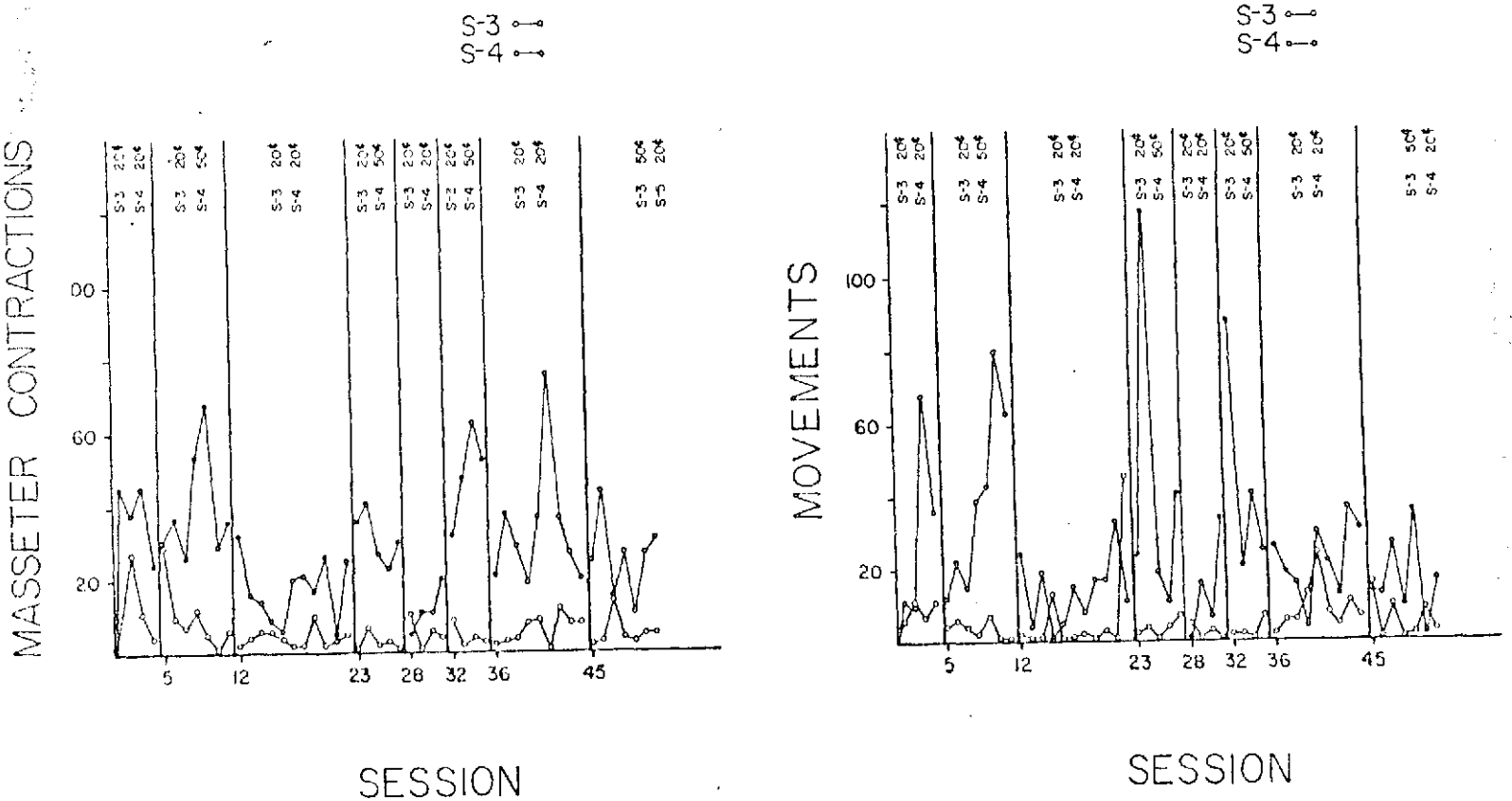

Figure 3

Total number of masseter contractions and movements per session for Subjects Three and Four as a function of equal and unequal pay. The data includes responses occurring for one minute beyond the last coin delivery. Note: The coin dispenser jammed for S-3 during sessions 46 and 47, and for S-4 during sessions 40, 44, and 46.

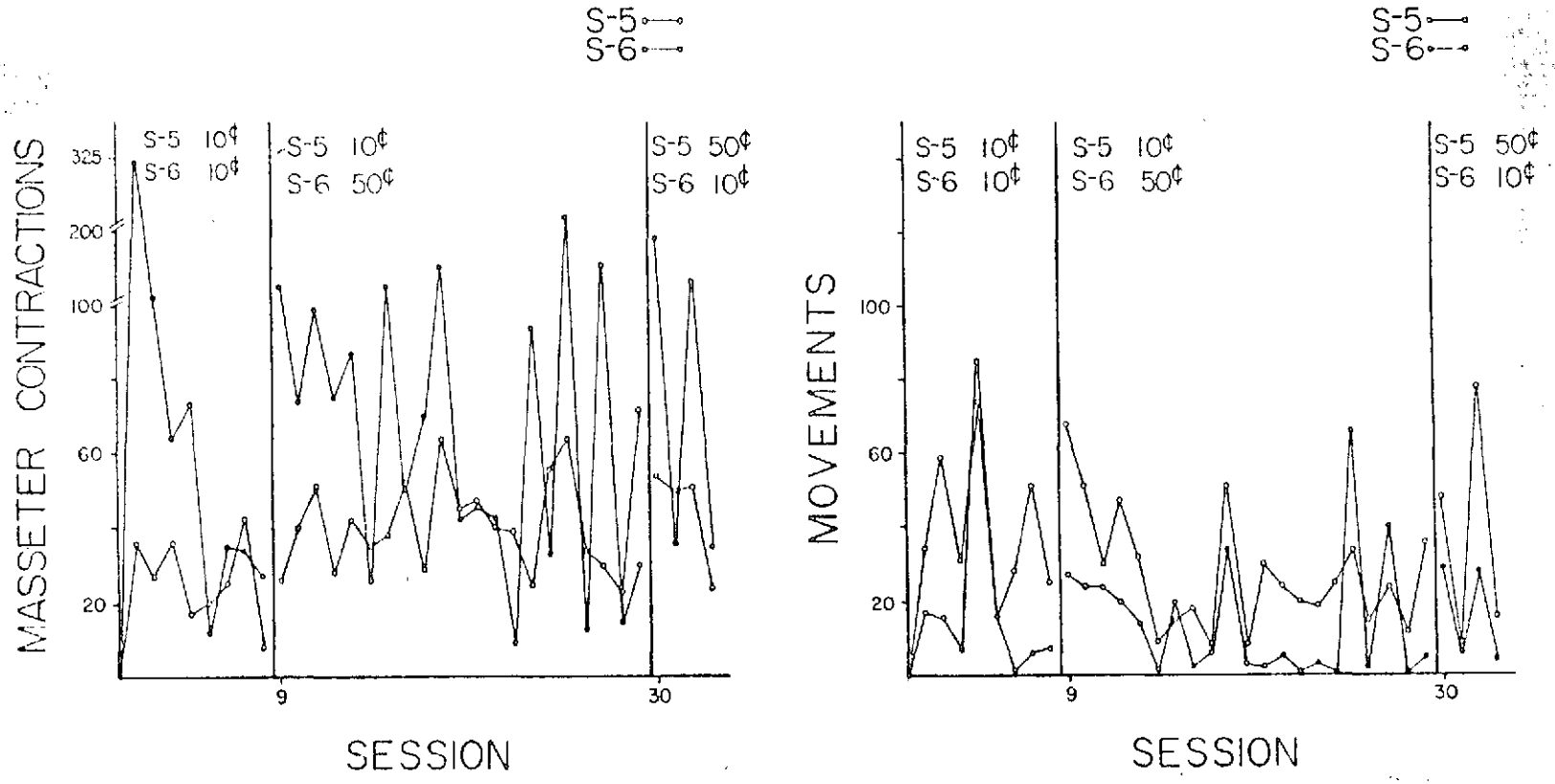

Figure 4

Total number of masseter contractions and movements per session for Subjects Five and Six as a function of equal and unequal pay. The data includes responses occurring for one minute beyond the last coin delivery. The total responses for Session 22 are based upon an average number of responses per minute, due to a program failure during the last ten minutes of the session. Note: The coin dispenser jammed for S-6 during sessions 19 and 29.

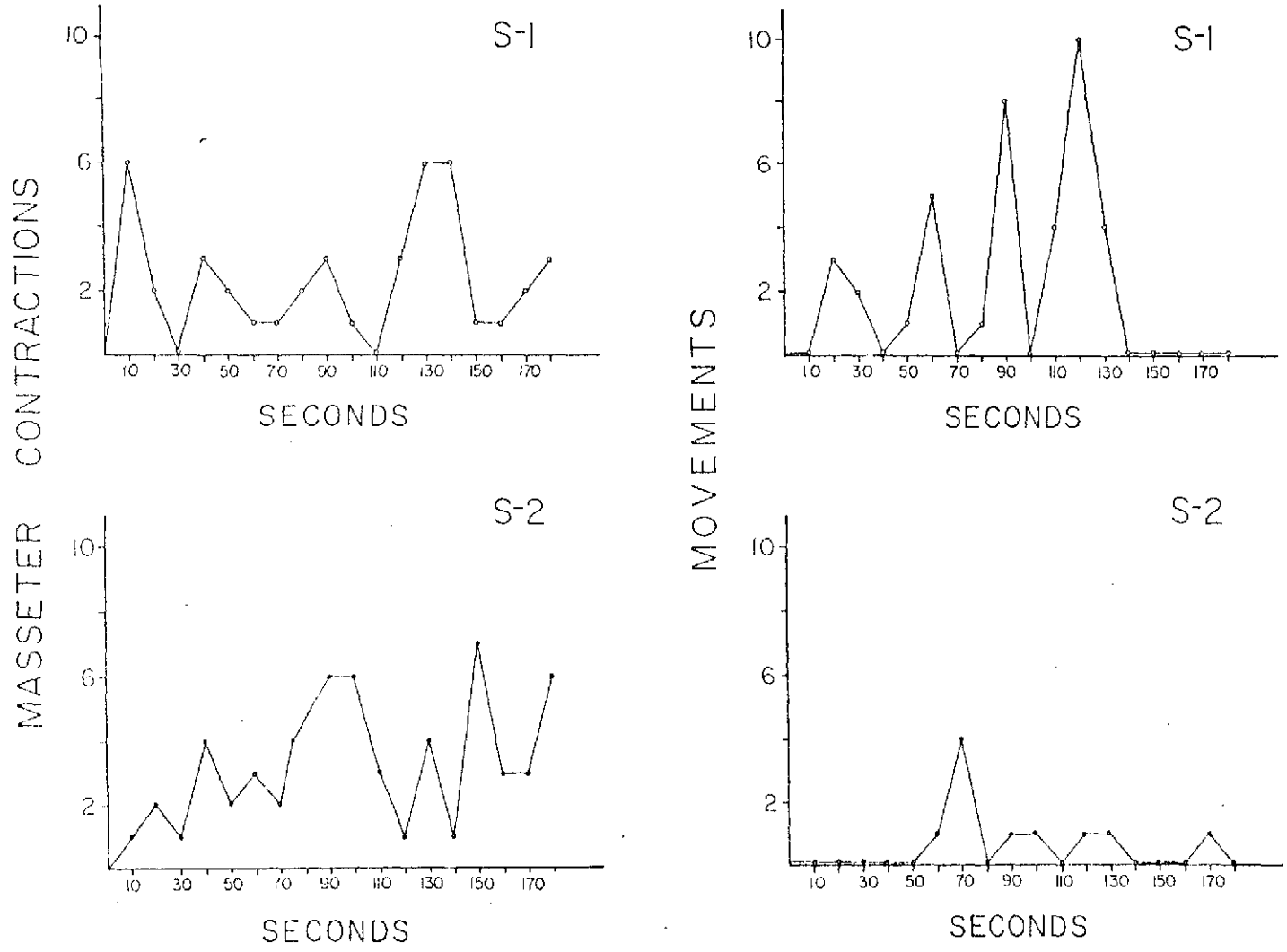

Figure 5

Distribution of masseter contractions and movements during the inter-stimulus interval of session 10 for Subjects One and Two.

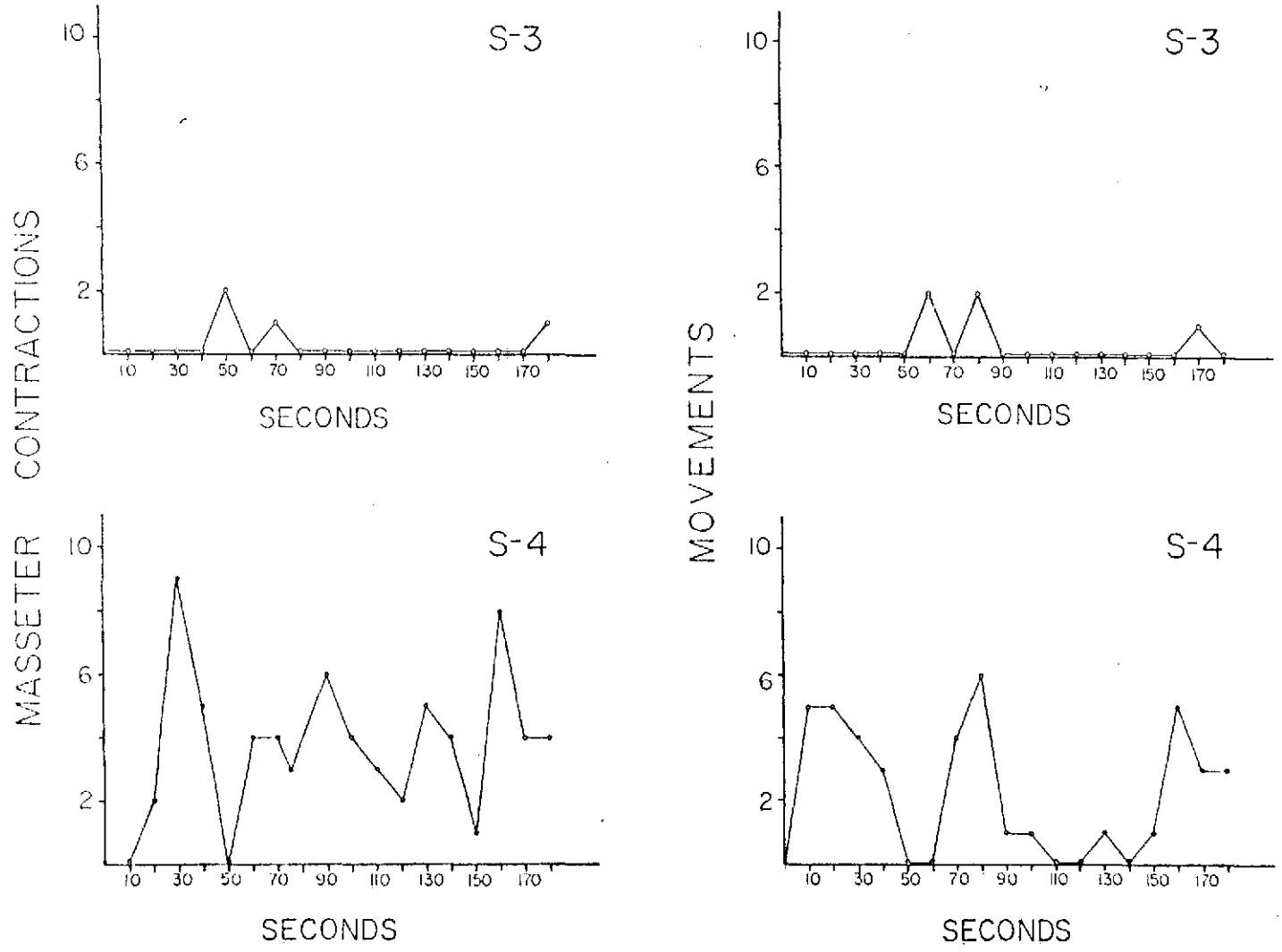

Figure 6

Distribution of masseter contractions and movements during the inter-stimulus interval of session 9 for Subjects Three and Four.

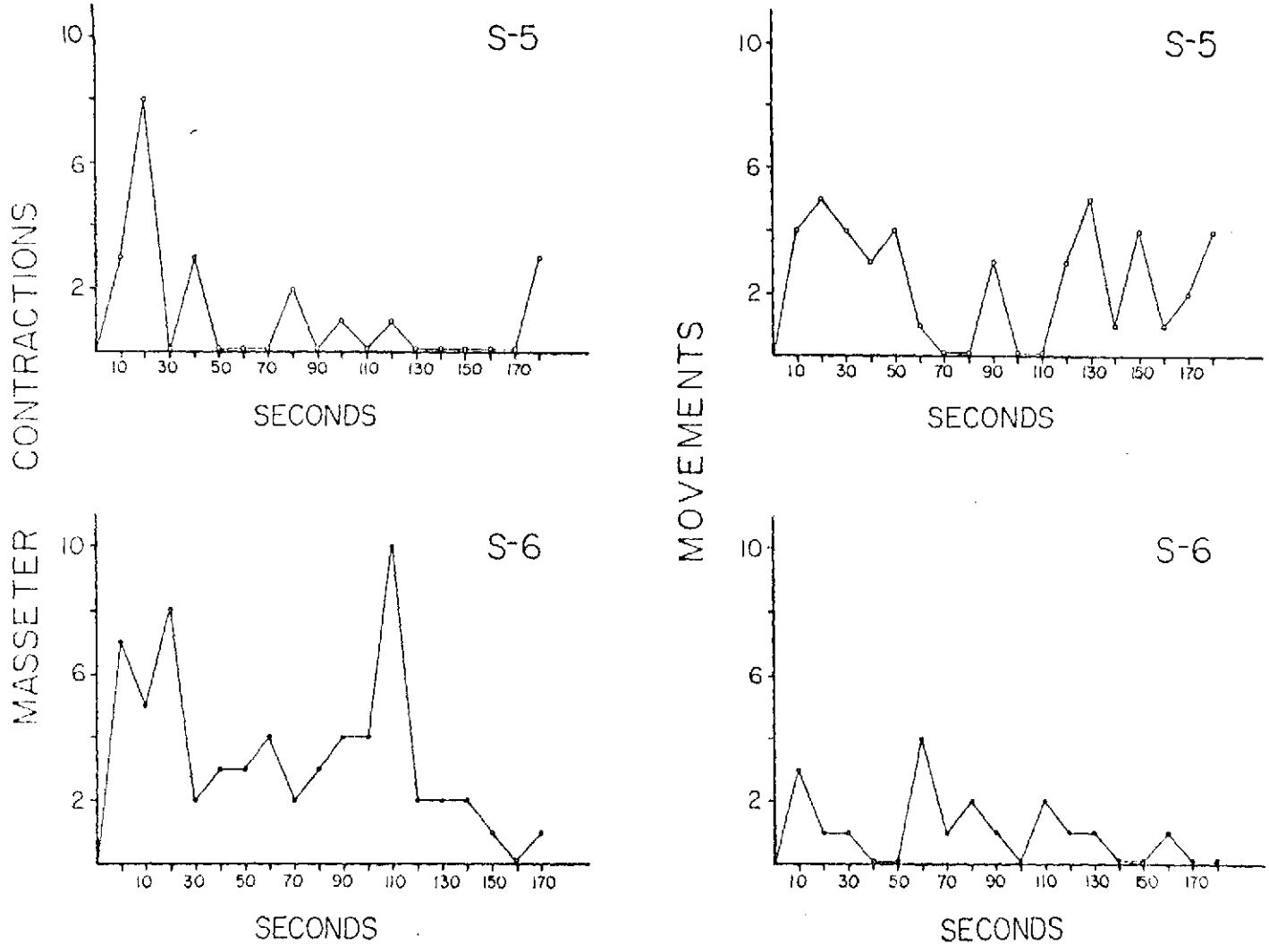

Figure 7

Distribution of masseter contractions and movements during the inter-stimulus interval of session 12 for Subjects Five and Six.

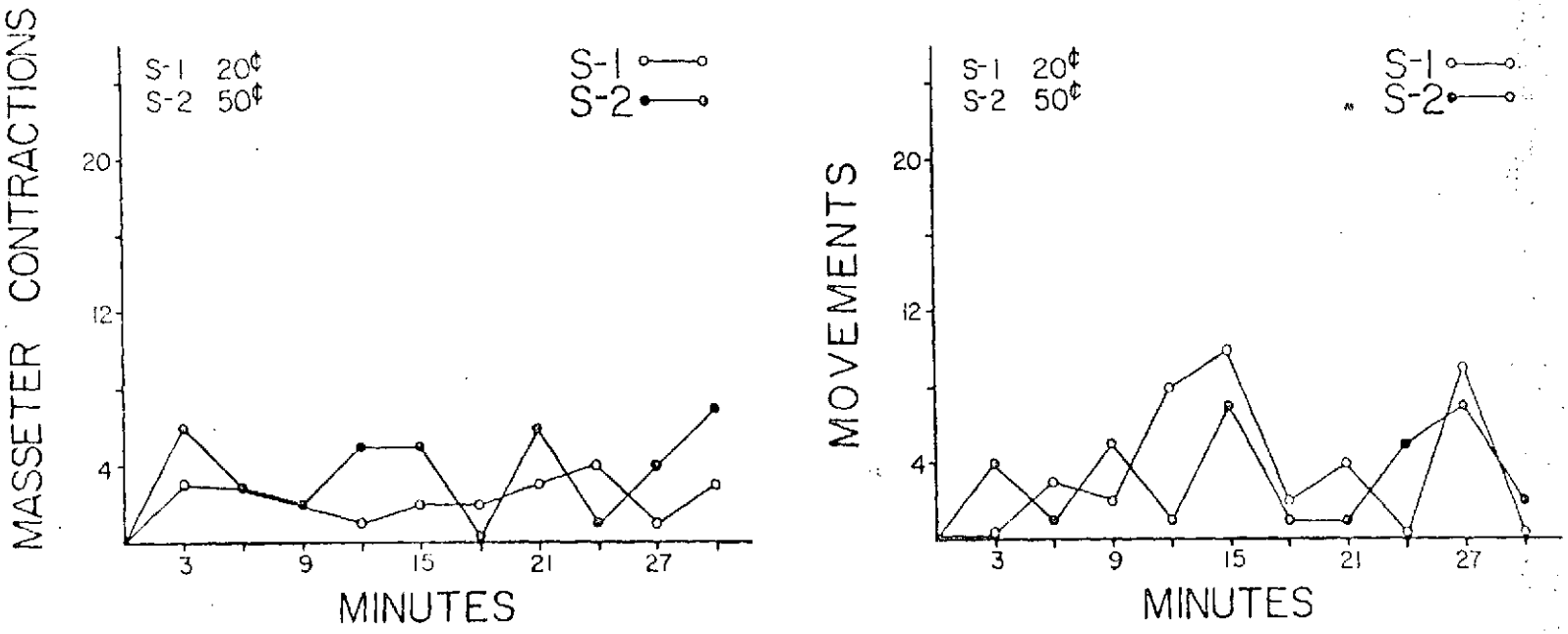

Figure 8

Total number of masseter contractions and movements during each three minute interval of session 5 for Subjects One and Two. Coins were delivered at the end of each three minute interval.

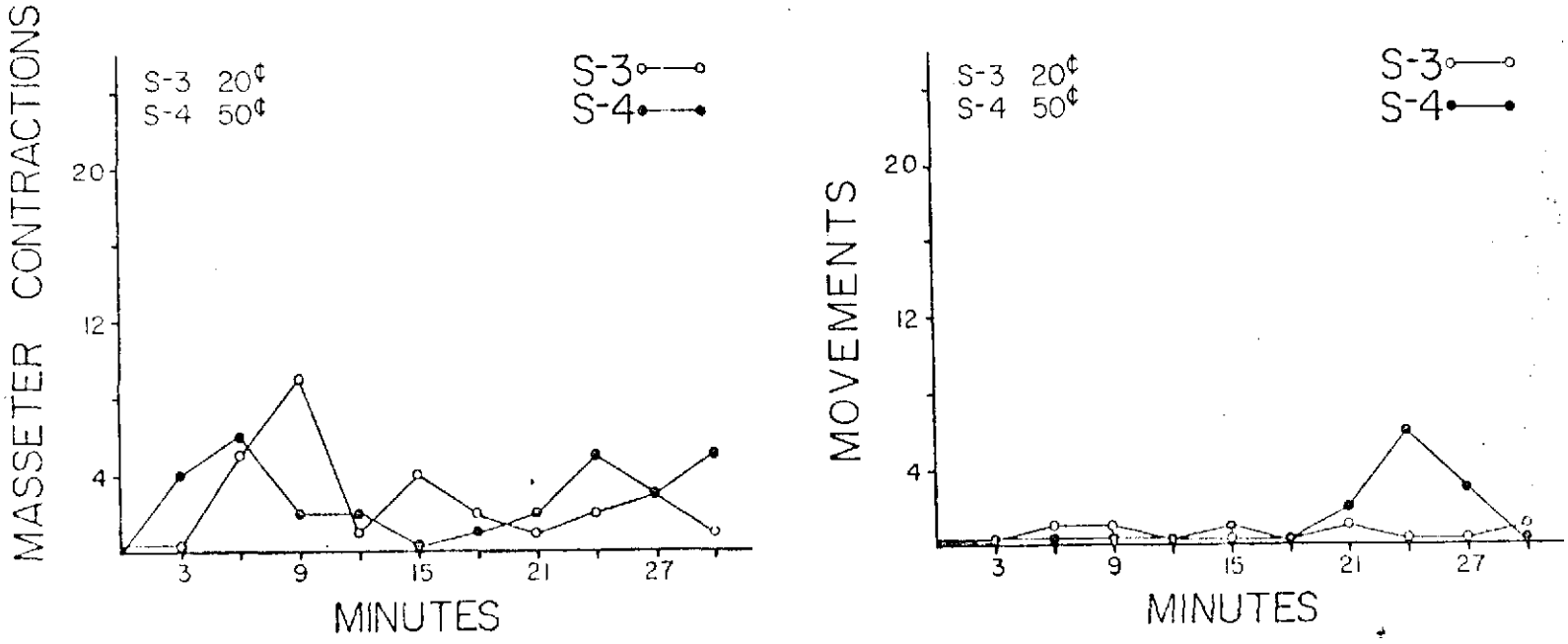

Figure 9

Total number of masseter contractions and movements during each three minute interval of session 5 for Subjects Three and Four. Coins were delivered at the end of each three minute interval.

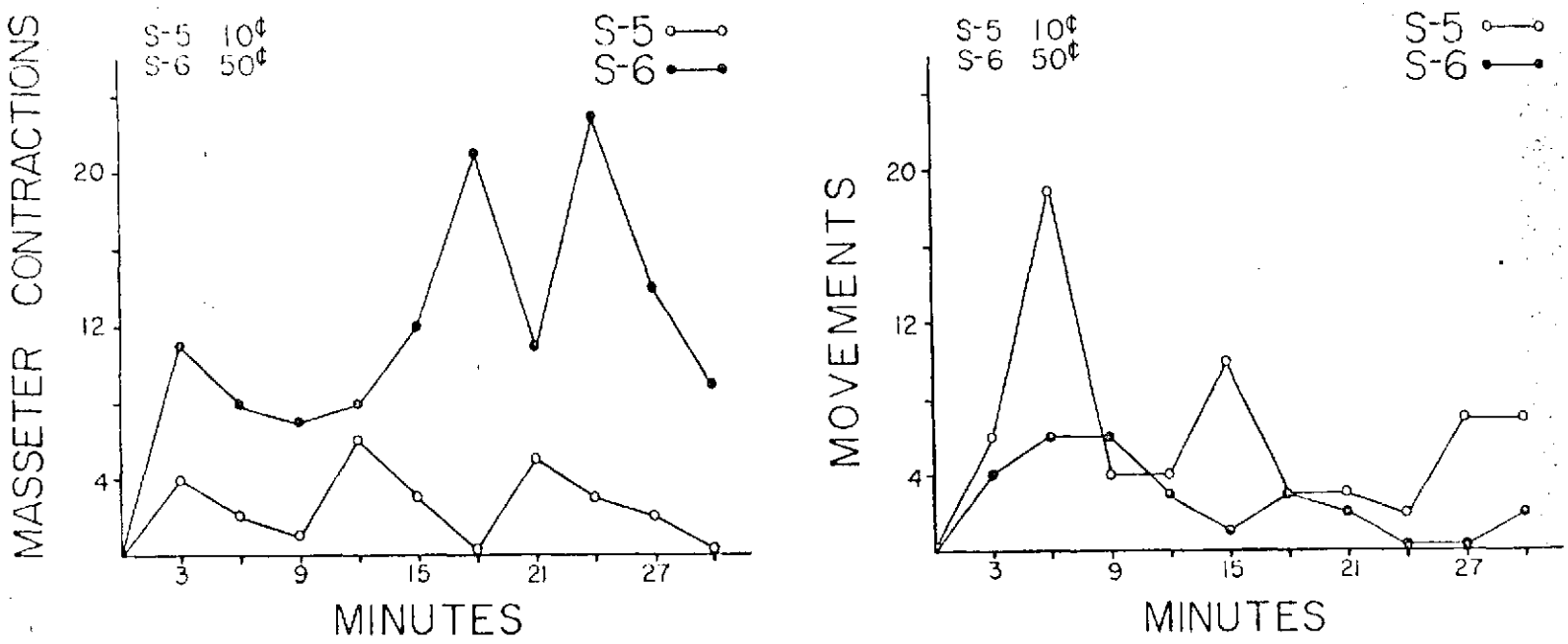

Figure 10

Total number of masseter contractions and movements during each three minute interval of session 9 for Subjects Five and Six. Coins were delivered at the end of each three minute interval.

Figure 11

Verbal statements and physical responses emitted by the subjects at various sessions. Asterisk denotes behaviors which occurred outside the chamber.

Session	Comments and Behaviors
4	S-2: Demand a raise. S-1: Change machine to dimes and quarters.
6	S-1: Another $2.00 day. S-2: You can't do anything with the quarters but spend them.
7	S-1: Its going to be a bum experiment; would they find another person if I quit or are you finished also?
8	S-1: "growled" and "hissed" at his amber stimulus light
10	S-2: kicked the coin dispenser
13	S-1: talked S-2 into quitting the experiment so that S-1 could get the bonus
11	S-4: smoked marijuana during the session
24	S-3: asked experimenter if he would receive $5.00*
28	S-3: commented that he would like to change sides with S-4*
31	S-3: read a book hidden in his shoe
32	S-4: commented that the way to get quarters was to come to the session "high"
38	S-3: kicked coin dispenser
40	S-4: yelled at coin dispenser and hit and kicked it S-3: kicked coin dispenser
44	S-4: hit and kicked the coin dispenser
46	S-4: kicked coin dispenser and tried to pick the lock
9	S-5: hit the table; stated that this would be a good study for aggression
13	S-5: spelled "T.V." with his coins and signaled to the camera
15	S-6: told S-5 that he felt "bad" that S-5 did not get quarters also
25	S-6: hit coin dispenser; pushed on the button with his foot

DISCUSSION

The results of this experiment indicate that initial higher pay for one member of a pair of subjects is aversive for both individuals, but that for these conditions, "overt-aggressive" responses were relatively minor.

Subjects receiving less money showed greater, but less sustained, biting reactions. Contrary to expectations, the number of masseter contractions for the subjects initially receiving greater pay increased, and were maintained over longer periods. For these same subjects, the bodily movements did not increase. This effect was disparate from previous research where a dramatic decrease in masseter contractions and a subsequent increase in movements occurred in a shift to a condition of high pay from one involving lower pay (Proni, 1973). Proni (1973) demonstrated the existence of an inverse relationship between response-independent pay and masseter contractions and a direct relation between movements and pay in individually tested subjects.

The distribution of masseter contractions for low-pay subjects seen here, was similar to a pattern previously observed with other humans receiving experimentally lowered rates of pay (Proni, 1973). Masseter contractions increased subsequent to and prior to coin delivery, with

a noticeable decline during the middle of the interval. The similarity between this pattern and that observed by Proni (1973), and one described by Hutchinson and Emley (1972) with the distribution of biting responses in experiments on non-contingent shock using monkeys, indicates the aversiveness of observing another individual receive more money.

The apparent inhibition of the "overt-aggressive" response of pay-reduction among low-pay subjects may have been due to the experimental design which permitted both individuals the opportunity to reduce their partner's pay. Other research has shown that the possibility of effective counter-aggression will generally inhibit an attack response (Azrin, et. al., 1966). When the threat of counter-attack exists, animals frequently tend to engage in display rather than contact behaviors. These observations have been made in both experimental and natural environments. However, other social and environmental variables may have been operative. When "retaliation" was not possible, as with the third pair, this "overt-aggressive" response still did not increase. The importance of reinforcement was suggested in the subjects' verbal statements to the effect that they felt they had "no reason to reduce their partner's pay". It may be that some human "overt-aggressive" responses will be emitted only if currently or previously reinforced.

The finding that high-pay subjects displayed greater biting throughout the experiment and during the inter-coin interval (particularly approaching coin delivery) suggests that such conditions are in some manner aversive to these individuals.

No definite conclusions can be stated regarding the similarity between the effects of pay reduction and the effects of observing another receive higher pay. The increased biting responses of the low-pay subjects may indicate aggressivity. Although, this conclusion is tenative since "overt-aggressive" responses did not occur.

The results do suggest that a condition of unequal response-independent pay in pairs of subjects who have visual and verbal contact creates an aversive environment for both members; and that masseter EMG activity provided a sensitive measure of this noxious environmental condition.

REFERENCES

Ahlgren, J. and 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., Hutchinson, R. R. and Hake, D. F. Extinction-induced aggression. Journal of the Experimental Analysis of Behavior, 1966, 9, 191-204.

Azrin, N. H., Hutchinson, R. R. and Sallery, R. D. Pain-aggression toward inanimate objects. Journal of the Experimental Analysis of Behavior, 1964, 7, 223-228.

Buss, A. H., The Psychology of Aggression. John Wiley and Sons, Inc., 1961, 47-52.

Geen, R. G., Rakosky, J. J. and O'Neal, E. C. Methodological study of the measurement of aggression. Psychological Reports, 1968, 23, 59-62.

Geen, R. G. and Stonner, D. An extended apparatus for measuring aggression in humans. Behavioral Research Methods and Instrumentation, 1971, 3, 197-198.

Harrell, W. A., The effects of an aggressive model on the magnitude of extinction-induced aggression. Journal of Social Psychology, 1973, 90, 311-315.

Hutchinson, R. R., Environmental causes of aggression. Nebraska Symposium, 1971. Lincoln: University of Nebraska Press, 1972, 153-181.

Hutchinson, R. R. and Emley, G. S. Schedule-independent factors contributing to schedule-induced phenomena, Schedule Effects Drugs, Drinking, and Aggression, Gilbert, R. M. and Keehn, J. D. (Eds.) Toronto: University of Toronto Press, 1972, 174-202.

Hutchinson, R. R. and Emley, G. S. Effects of nicotine on avoidance, conditioned suppression and aggression response measures in animals and man. In W. L. Dunn (Ed.) Smoking Behavior: Motives and Incentives, Washington, D.C., V. H. Winston, 1973, 171-196.

Hutchinson R. R., Emely, G. S. and Sauer, R. A. Effects of cessations of cigarette smoking on jaw clenching. Paper presented at the American Psychological Association, Washington, D.C., September, 1971.

Hutchinson, R. R. and Pierce, G. E. Jaw clenching in humans; its measurement and effects produced by conditions of reinforcement and extinction. Paper presented at the American Psychological Association, Washington, D.C., September, 1971.

Kelley, J. F., and Hake, D. F. An extinction-induced increase in an aggressive response with humans. Journal of the Experimental Analysis of Behavior, 1970, 14, 153-164.

Lindsley, O. R. Experimental analysis of cooperation and competition. In Thom Verhave (Ed.) The Experimental Analysis of Behavior, New York, Appleton-Century-Crofts, Inc., 1966, 470-501.

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

Pierce, G. E. Effects of several fixed-ratio schedules of reinforcement and of extinction upon temporalis and masseter muscle contractions in humans. Unpublished Master's Thesis, Western Michigan University, Kalamazoo, Michigan, April, 1971.

Proni, T. J., The effects of changes in response-independent pay upon human masseter EMG. Unpublished Master's Thesis, Western Michigan University, Kalamazoo, Michigan, December, 1973.

Ramfjord, S. P. and Ash, M. M. Occlusion. Philadelphia, W. B. Saunders Company, 1966.

Sauer, R. A.., Effects of concentric and eccentric biting and biceps muscle contraction on absolute auditory threshold. Unpublished Master's Thesis, Western Michigan University, Kalamazoo, Michigan, August, 1971.

Ulrich, R. E. and Favell, J. E. Human aggression. In Neuringer, C. and Michael, J. C. (Eds.) Behavior Modification in Clinical Psychology, 1970, 105-132.

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

Yemm, R. Masseter muscle activity in stress: Adaption of response to a repeated stimulus in man. Archives of Oral Biology, 1969b, 14, 1437-1439.

Yemm, R. Temporomandibular dysfunction and masseter muscle response to experimental stress. British Dental Journal, 127, 1969c, 508-510.

Yemm, R. Stress-induced muscle activity: A possible etiologic factor in denture soreness. Journal of Prosthetic Dentition, 28, 1972, 133-140.