

# The Effects Of Changes In Response - Independent Pay Upon Human Masseter Emg

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HUMAN MASSETER EMG

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Western Michigan University, 1973

Electromyographic activity of the masseter muscle was recorded in five human subjects who were presented with systematically varied rates of non-contingent pay. Rates of pay were varied between sessions in either a descending or an ascending series. The number of masseter contractions was found to be greater during the descending series than during the ascending series, especially when a descending series of pay changes followed an ascending series. Verbal physical displays of anger and aggression were noted during descending series. These data in conjunction with earlier work on humans and animals indicated a possible relation between masseter contractions and aggression.

THE EFFECTS OF CHANGES  
IN RESPONSE-INDEPENDENT PAY  
UPON HUMAN MASSETER EMG

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## INTRODUCTION

It appears that where wages are substantially reduced, the incidence of aggressive behavior rises. The frequency of lynchings in the United States has been strongly and negatively related to an economic index (Hovland, 1940). Systematic, nation-wide wage reduction was associated with popular support for policies of belligerence in an international conflict situation (Tracy, 1938). There is also a negative correlation between the number of work stoppages and disposable personal income (Department of Labor, (1960).

The most ambitious hypothesis based on facts of this kind suggests that violent revolutions may result when periods of increasing prosperity are followed by short periods of sharp reversal (Davies, 1962). If such a large-scale social phenomenon as revolution arises at least in part from the aggressive behavior of individuals, then this particular schedule of pay changes--ascending and then descending--must elicit aggressive behavior in laboratory settings as well.

This experiment was designed to discover if in fact there existed a definite relation between aggression and wage reversals.

Until recently, human aggression has been studied largely by observing attacks on inanimate objects, or by administering various verbal tests. The measures used, such as punching a cushion (Kelly, 1970), are very literal, and subjects could easily be inhibited by social conditioning from displaying aggression in such a setting.

With animals, on the other hand, it has been found that aggression can be elicited in many species by the presentation of noxious stimuli, or by the removal of pleasurable ones (Hutchinson, 1972). In these studies biting was utilized as an effective measure of aggression.

For humans, it has been stated that non-functional grinding of teeth (bruxism) can be viewed as a release from emotional stress (Ramfjord and Ash, 1966). Stressful conditions have been shown to increase the electrical activity of the temporalis and masseter muscles as measured by electromyographic techniques (Perry, Lamie, Main, and Teuscher, 1960; Yemm, 1969). The EMG activity of these muscles has been shown to increase as a function of bite force (Hutchinson and Pierce, 1971; Ahlgreen and Owall, 1970).

Several distinct parallels in conditions eliciting biting in humans and lower animals have been noted. Squirrel monkeys have been observed to attack inanimate objects when subjected to tail shock (Azrin, Hutchinson, and Sallery, 1964); and humans show an increase in masseter EMG activity when subjected to loud noises (Hutchinson and Emley, 1972). Squirrel monkeys on high fixed ratio schedules of reinforcement bit a rubber hose at increased rates (Hutchinson, Azrin and Hunt, 1968); while humans demonstrated a clear increase in temporalis and masseter EMG activity with an increase in ratio size (Pierce, 1971). Cessation of either response contingent or noncontingent reinforcement has been shown to increase attack behavior in pigeons (Azrin, Hutchinson, and Hake, 1966), and

increase masseter EMG activity in humans (Hutchinson, Emley, and Proni, 1972; Hutchinson, Emley, and Sauer, 1971).

Thus the acceptability of employing masseter EMG measurements in an investigation of wage reversals and aggression is suggested by the relationships described above.

## METHOD

### Subjects

Five males, 20-31 years old, were used as subjects. All were students at a nearby college or university. One subject was also employed at a warehouse and worked evenings. All subjects were in good health and passed a physical examination given at the State Hospital. All subjects stated at the beginning of the experiment that they did not use drugs or medication of any kind. No subject was a psychology student and only one subject had taken part in an experiment of any type. From the subject's description this seemed to be a test measuring physiological changes during physical activity.

### Apparatus

The test chamber was an Industrial Acoustics Company IAC Audiometric testing room Model 402CTN. The chamber was electrically grounded and acted as an effective shield against electromagnetic radiation. White noise from a Grason-Stadler Model 901B Noise Generator was delivered into the chamber and the room in which the chamber was located. The generator was set for white noise and produced a 57db sound level in the audible range.

The test console measured approximately 24" x 22" x 40" and was placed against the wall opposite the door of the chamber. On the console were two lights located 30 inches from the floor and seven

inches from each other. The right light was green and was turned on when the session began and turned off when it ended. The left light was amber and was turned on when the subject received money. It remained on for a fifth of a second. On top of the console was mounted a Bogen engineering RIE-1 intercom which was connected to a master unit in the control room. The intercom was operating at all times.

Bolted to the left side of the console was a coin dispenser measuring 26.5" x 10.5" x 14" with a 3.5 inch cup located 5 inches from the bottom of the dispenser and 22 inches from the floor. This dispenser was capable of delivering pennies, nickles, dimes, or quarters in any combination desired and was built with components purchased from Hamilton Scale Company. It was constructed of 16 gauge steel and was of generally sturdy construction.

The subject was seated on a wooden chair with an electrode board mounted on its back. This chair was located near the center of the chamber and facing the console. It was located so that the subject could easily reach the coin cup with his left hand. Electrical connections were made through shielded cables that entered the chamber from behind the console.

The data were recorded on an Offner Electronics, Inc. Dynograph Type 504 using standard Offner Type 146 amplifiers and a specially designed differential pre-amplifier of high sensitivity. Integrating pre-amplifiers were also used. A Grass Model EB524 electrode panel was mounted on the polygraph and used to feed the

output of the electrode board in the chamber to the polygraph. Four polygraph channels were used to record the following: direct EKG, integrated EKG; direct EMG; integrated EMG. The event pen on the polygraph was used to indicate the presentation of money, the other four polygraph channels were not used. A DEC Building Block logic system was used to control the delivery of money and session length. This program rack also controlled the console lights and event pen.

#### Procedure

All subjects were tested daily, except weekends, and each subject was tested the same time each day. The usual procedure was that the subject was greeted at the door by the experimenter and escorted to the waiting room area where he was asked to sign a "Consent to Experimental Procedure" form and to answer a short checklist on his intake of food and drugs as well as his present physical state.

The subject was then escorted to a preparation room where he was seated on a stool. All areas where electrodes were to be placed 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. A length of elastic bandage was next wrapped around the head to provide strain relief for the electrodes. All electrode leads were

wrapped once around the elastic bandage for strain relief and brought down under the bandage at the back of the head.

Two subdermal (Grass E2B) platinum alloy electrodes were then inserted into the dermal layers overlaying the masseter muscle. Electrode placement was even with the bottom of the ear and about 1 1/4 inches in front of it. These electrodes and leads were secured to the cheek with two pieces of surgical tape, then wrapped around the elastic bandage and brought out with the other electrode leads.

Two EKG flat electrodes were covered with electrode paste and one was strapped to the right arm and the other to the left leg. The electrode placement varied slightly between subjects but was generally a few inches above the ankle for the leg and on the inside of the wrist for the arm. The rubber straps holding the electrodes in place were adjusted to give a tight fit but the subject was always asked if they were too tight. If this were the case they were loosened.

After preparation, the subject was escorted to the chamber and instructed to sit in the chair. For the first few sessions he was told that if there were some emergency or if he had to leave the chamber for any reason he was to push the call button on the intercom. He was asked to reach out and make sure he could reach the button without getting out of the chair or pulling on the electrode leads. He was then told that the session would begin when the green light went on and would end when it went off. He was told that the session

would be about half an hour long but that it would take "a little time" to calibrate the equipment before and after each session. He was reminded that he could keep whatever money the machine gave him and that the amount given was totally out of the experimenter's immediate control. These last two instructions were repeated before each session.

The experimenter then closed the chamber door and recorded the inside and outside temperatures. Chamber temperatures ranged from 78°F to 84°F. The experimenter could observe the subject by way of a closed-circuit TV which was placed behind a one-way mirror. The polygraph was turned on and a calibration series run. This consisted of a series of calibration pulses from the electrode board ranging from 5MV to 500MV. Adjustments were made at this time if the calibration procedure showed any change from a standard. The input from the subject was then fed to the polygraph and any further adjustments made (it was sometimes necessary to reduce the amplification on the integrated channels). Money was then delivered every 1.5 minutes for half an hour. The presentation of money was marked on the record, as was the start and end of the session.

The amount of money each subject received was varied systematically. For some subjects, a period of increasing money payments was followed by a period of decreasing payments while for others a period of decreasing money payments was followed by a period of increasing payments. The exact amounts of money paid in each session are recorded on Table 1. Each subject was kept at his

initial level of pay for five days to let him accustom himself to the experimental situation. After this period, the payments were changed every two to four days, the exact number depending on the stability of the subjects behavior and an avoidance of introducing a new amount of pay on a Monday. The following combination and number of coins were used to pay the subject the different dollar amounts: \$1.00: 20 nickles; \$2.00: 20 dimes; \$3.00: 20 nickles and 20 dimes; \$4.00: 40 dimes; \$5.00: 20 quarters. The subject always received 1/20th of the total payment every 1.5 minutes during the session.

After the session terminated another calibration series was run. The chamber and room temperatures were recorded and the chamber door was opened. The leads were disconnected and the subject was led out of the chamber and back to the preparation room. The electrodes were disconnected and the subject signed a "Release from Experimental Procedure" form. The money the subject had earned during the session was then counted by the experimenter and the subject was asked to sign a receipt. The subject was then escorted from the laboratory.

#### Data Analysis

To convert the analogue EMG data to a digital format a 50 MV peak-to-peak criterion was used. I.e. any EMG deflection noted on the non-integrated EMG channel that exceeded the deflection caused by the 50 MV calibration pulse at the beginning of each record was counted as one masseter contraction. The 50 MV level was chosen

because it was considerably above normal system noise but was below most bursts of EMG activity. In order to eliminate movement artifacts a minimum frequency of 10 CPS was used as a criterion. This frequency was chosen because most movement artifacts generated a substantially lower frequency and the EMG integrated channel tended to ignore low frequency signals and thus provided an easy means of checking frequency criteria. The only difficult cases were those in which movement occurred at the same time as EMG activity. In these cases some judgment had to be exercised. In recording the number of EMG bursts in a close series of bursts it was required that the amplitude of the EMG signal drop below 50 MV for the activity to be recorded as a new burst. There were very few long duration bursts.

An EMG burst meeting the criterion was classified as either a masseter contraction, physical movement, swallow, or yawn. Subject 2 also displayed some scab picking behavior which produced EMG bursts and these were recorded separately. Yawns and to a lesser degree swallows were easily identified by visual monitoring of the subjects. Movements were limited to those of the head and shoulders in that observation of the rest of the body was impossible through the one-way mirror. The procedure was to record, on the polygraph record, any event that occurred in the chamber. Any EMG burst not identified as a yawn, swallow, or physical movement was recorded as a masseter contraction.

## RESULTS

A strong and inverse relation was found between masseter contractions and the absolute value of subject pay. Figure 1 illustrates this effect. This relation was true for all subjects and when the number of masseter contractions was averaged for all subjects this relation proved to be almost linear. The absolute number of masseter contractions varied widely between subjects as shown in Figure 6. Some subjects responded at a low level, never having more than 27 masseter contractions per session (S2), while maximum levels of 63, 69, and 90 were reached by S4, S3, and S1 respectively. The zero dollar condition was administered only to one subject (S1).

The relationship between physical movements and subject pay was positive and moderately strong. Figure 1 shows a consistent increase in the average number of physical movements with increases in pay. On an individual basis there was a significant amount of variability, some subjects showed clear and consistent increases in movements with increases in pay while others showed a weaker relation between pay and physical movement. It should be noted that the graph in Figure 1 combines ascending and descending series to derive a single value for each dollar amount.

Chi Square tests performed on the data in Figure 1 indicated that the differences between the number of masseter contractions for each dollar amount is significant ( $p < .05$ ) and that the difference

between the number of physical movements and masseter contractions is also significant ( $p < .05$ ). However the differences between the number of physical movements for each dollar amount is not significant ( $p < .50$ ). To evaluate these effects further ascending and descending series were plotted separately.

Figure 2 shows a clear and consistent increase in the number of masseter contractions as the amount of money paid in the descending series is reduced. A decrease in masseter contractions is also noted in the ascending series with an increase of money paid. However, the total number of masseter contractions for any given dollar value is greater in the descending series than in the ascending series ( $p < .001$ ). This indicates that the number of masseter contractions is not related solely to the amount of money paid. Figure 2 also shows the effect of two differing series following one another. When a descending series follows an ascending series, masseter contractions increase significantly ( $p < .001$ ). The magnitude of this increase is more than twice that of a descending sequence that precedes an ascending sequence. An opposite, though weaker, effect was noted for ascending sequences. When an ascending sequence occurred after a descending one there is a smaller number of masseter contractions than when the ascending sequence occurs first ( $p < .001$ ). The above observations indicate a clear interaction between amount paid, series of payment, and order of series.

A similar analysis of physical movements also yields an

interaction. In the case of physical movement there is an increase in movements as payments increase and a decrease in movements as subject pay decreases. There also appears to be a slightly higher overall number of physical movements for the ascending series than for the descending series ( $p < .001$ ). The results, however, generally are not as clear as in the case of masseter contractions. This is especially true when noting the effect of order of series on movement. Figure 3, which reports the results on physical movements shows much greater variability than Figure 2, which reports the number of masseter contractions. Also, physical movements appear to increase slightly when the descending series occurs first and decrease when it occurs second. In the case of the ascending series there is a general increase in movement with an increase in subject pay and this increase seems to be greater when the ascending series occurs second ( $p < .001$ ). This effect is weaker than for masseter contractions. In addition to studying the number of masseter contractions and movements for varying dollar amounts paid, the distribution of masseter contractions and movements within the session was also studied.

Two groups of sessions were chosen for examination of the distribution of EMG activity. These sessions were those in which the effect of both type of series and amount of pay should have been maximal. The first is a session during which subjects received \$5.00 after having received increasing amounts of money during previous session. The second session is one in which the

subjects have received \$1.00 after having received decreasing amounts of money during previous sessions. The sessions used for the \$5.00 group were: Number 13 for Subject 2 and 3; Number 15 for Subject 1; Number 22 for Subject 4; and Number 23 for Subject 5. The sessions used for the \$1.00 condition were: Number 14 for Subjects 4 and 5; Number 21 for Subjects 3 and 2; and Number 24 for Subject 1. Figure 4 graphs the distribution of the average number of masseter contractions and movements for these two groups of sessions and Figure 7 graphs the distribution for each individual subject.

The most noticeable effect seen in these graphs is that in the \$5.00 group movements occur with a much higher frequency than masseter contractions ( $p < .001$ ) and that in the \$1.00 group masseter contractions occur much more frequently than movements ( $p < .001$ ). This supports the observation that movements and money are directly related while masseter contractions and money are inversely related. The pattern of masseter contractions is marked by a major peak in masseter contractions 20-30 seconds after the presentation of money and a lesser peak 10-20 seconds before the presentation of money with a notable reduction in contractions immediately before and during the presentation of money. This pattern does not hold for the \$5.00 group of sessions where the maximum number of masseter contractions occur immediately after the presentation of money and decline to zero during the 10 seconds before the presentations of money.

The patterns for movements differ between the \$1.00 condition

and the \$5.00 condition in a significant manner. Both show peaks immediately after the presentation of the money; but while a peak in physical movements occurs 10-20 seconds before the presentation of the money for the \$5.00 condition, this is not true for the \$1.00 condition.

In addition to these quantitative EMG data, several of the subjects made occasional verbal comments inside or outside the chamber. At times the subjects also displayed unusual behavior inside the chamber. These verbal and other behaviors are recorded in Figure 5 for two subjects. The other subjects displayed little or no behavior of note. It was not always possible to record subject behavior out of the chambers, but subjectively the experimenter can say that Subject 1 displayed a host of "aggressive" and "hostile" behaviors when his amount of pay began to be reduced. These ranged from frowning and slamming his books down to complaining and even threatening the experimenter. This was true even though the subject did not direct his main hostility toward the experimenter and accepted the experimenter's statement that the amount of money paid was beyond the experimenter's control. Subject 4 also complained to the experimenter while his pay was being cut. However, after Session 17, when he received an increase in payments, he no longer complained. It should be noted that when the subject is said to have kicked the machine this was observed by the experimenter as a loud thump through the intercom. Later observation showed that paint had been scratched on the bottom of

the console.

Heart rate data seemed to bear no clear relation to any of the factors studied, i.e., money, schedule, or order of schedule. However, a relation between movements and brief changes in heart rate was found. Physical movements seemed to correlate with heart rate increases, as did yawning. There was also a lower correlation between masseter contractions and heart rate. Figure 8 shows the typical yawn pattern. All subjects displayed this yawn pattern of gradually increasing EMG followed by one or more sharp peaks. Identification of yawns by this pattern alone was 80-90% accurate.

Figure 1

Average number of masseter contractions and physical movements per session as a function of subject pay.

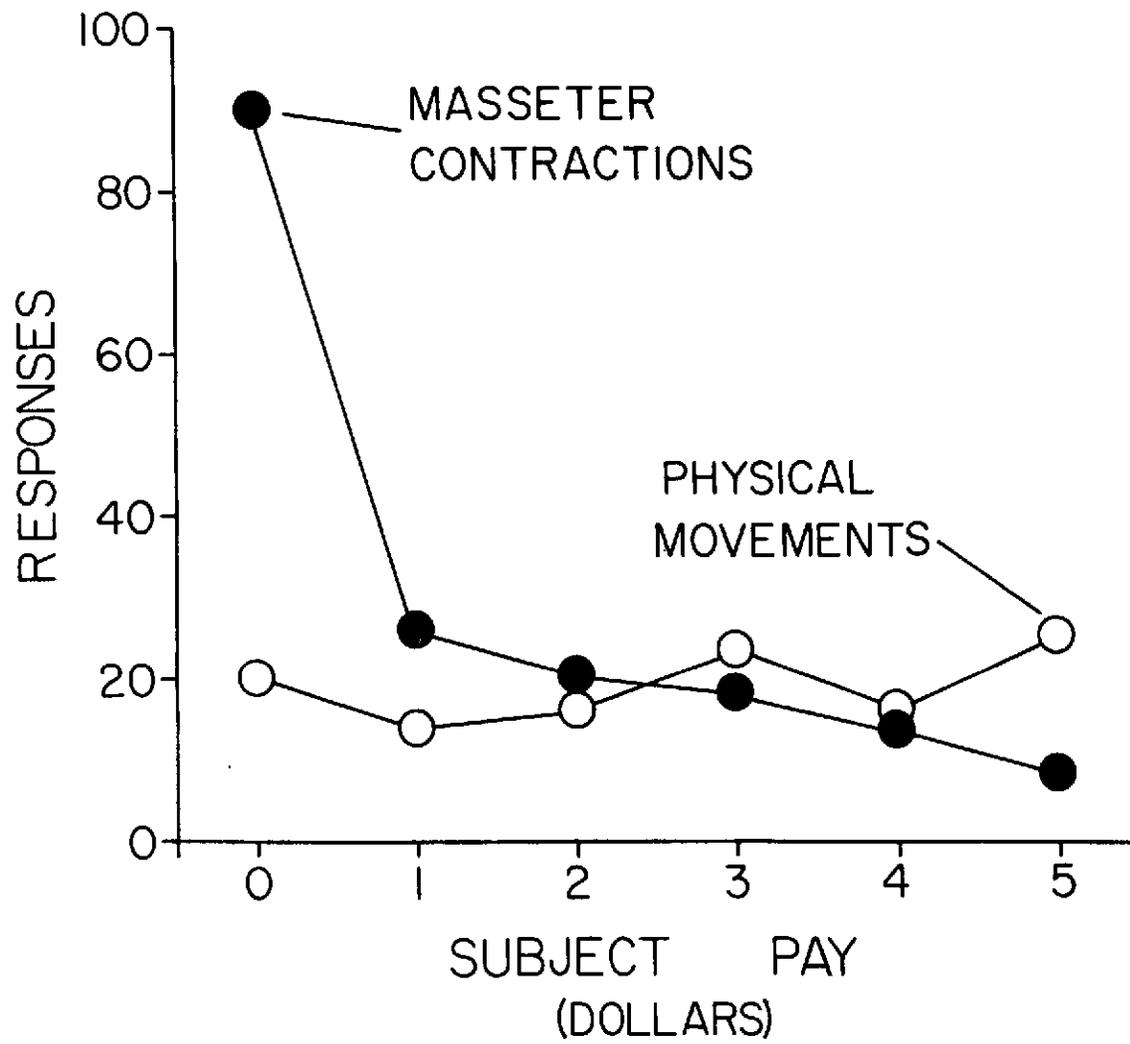


Figure 2

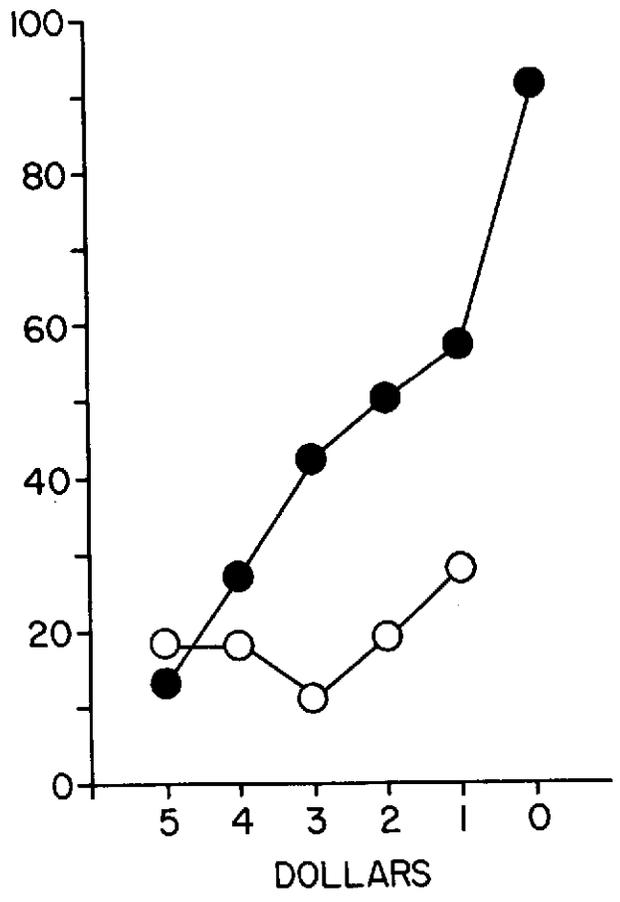
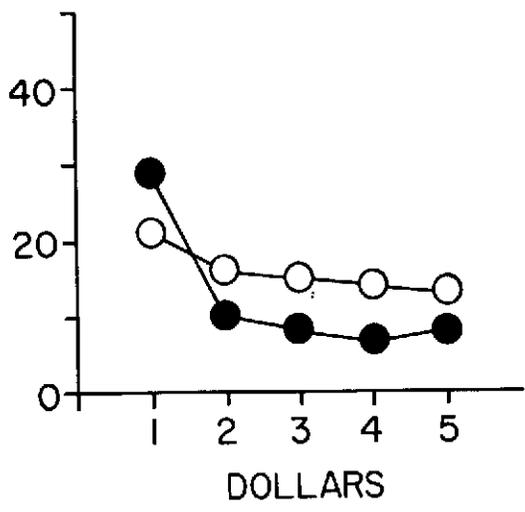
Influence of changes in subject pay on masseter contractions. The points on the graphs are the average number of masseter contractions per session. Each subject was given one ascending and one descending series of payments; "first" and "second" refer to which series was administered first.

ASCENDING SERIES

DESCENDING SERIES

MASSETER CONTRACTIONS

○ FIRST  
● SECOND



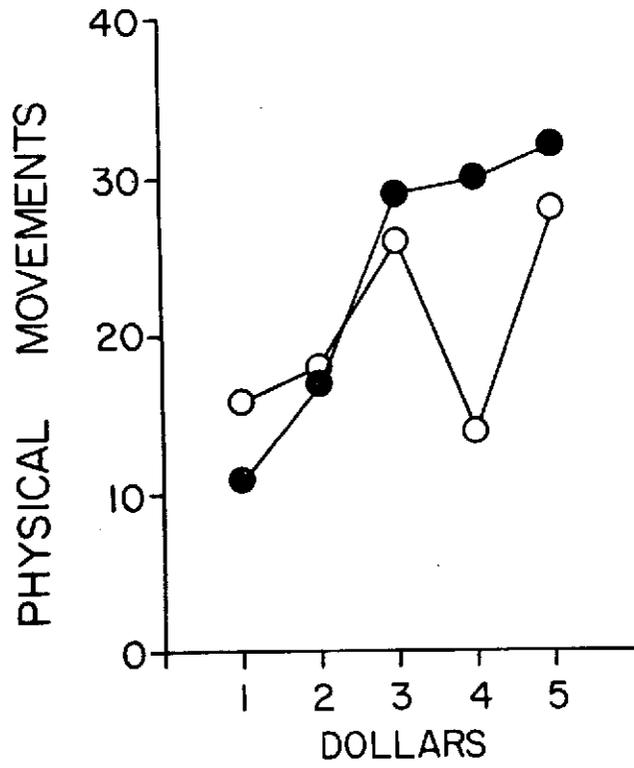
SUBJECT

PAY

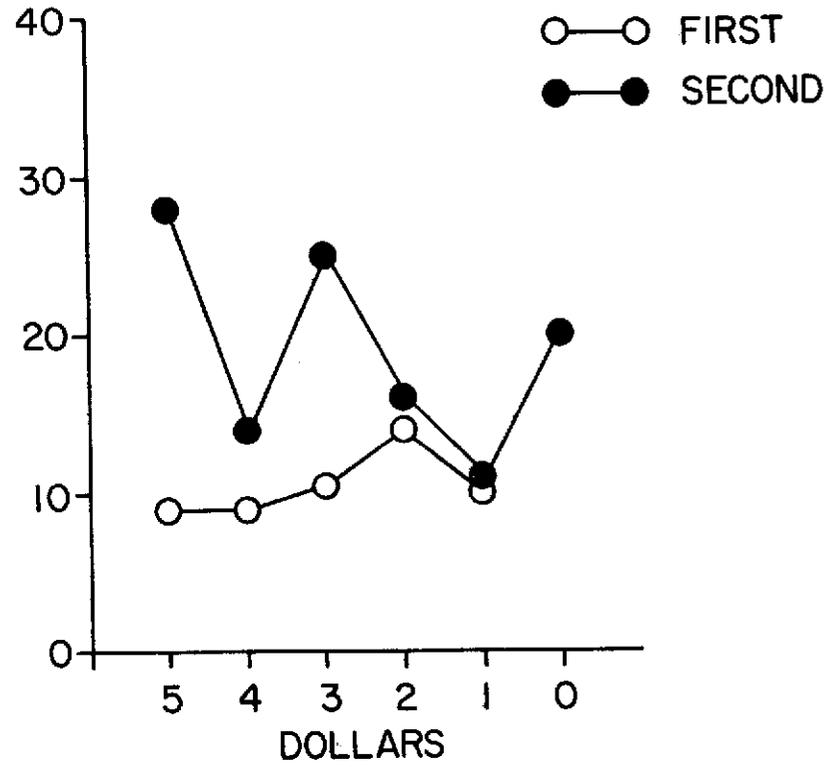
Figure 3

Influence of changes in subject pay on physical movements. The points on the graphs are the average number of physical movements per session. Each subject was given one ascending and one descending series of payments; "first" and "second" refer to which series was administered first.

ASCENDING SERIES



DESCENDING SERIES



SUBJECT PAY

Figure 4

Distribution of masseter contractions and physical movements during the inter-stimulus interval for two selected values of subject pay. The graphs are the average of the number of responses of selected sessions for all five subjects.

SUBJECT PAY

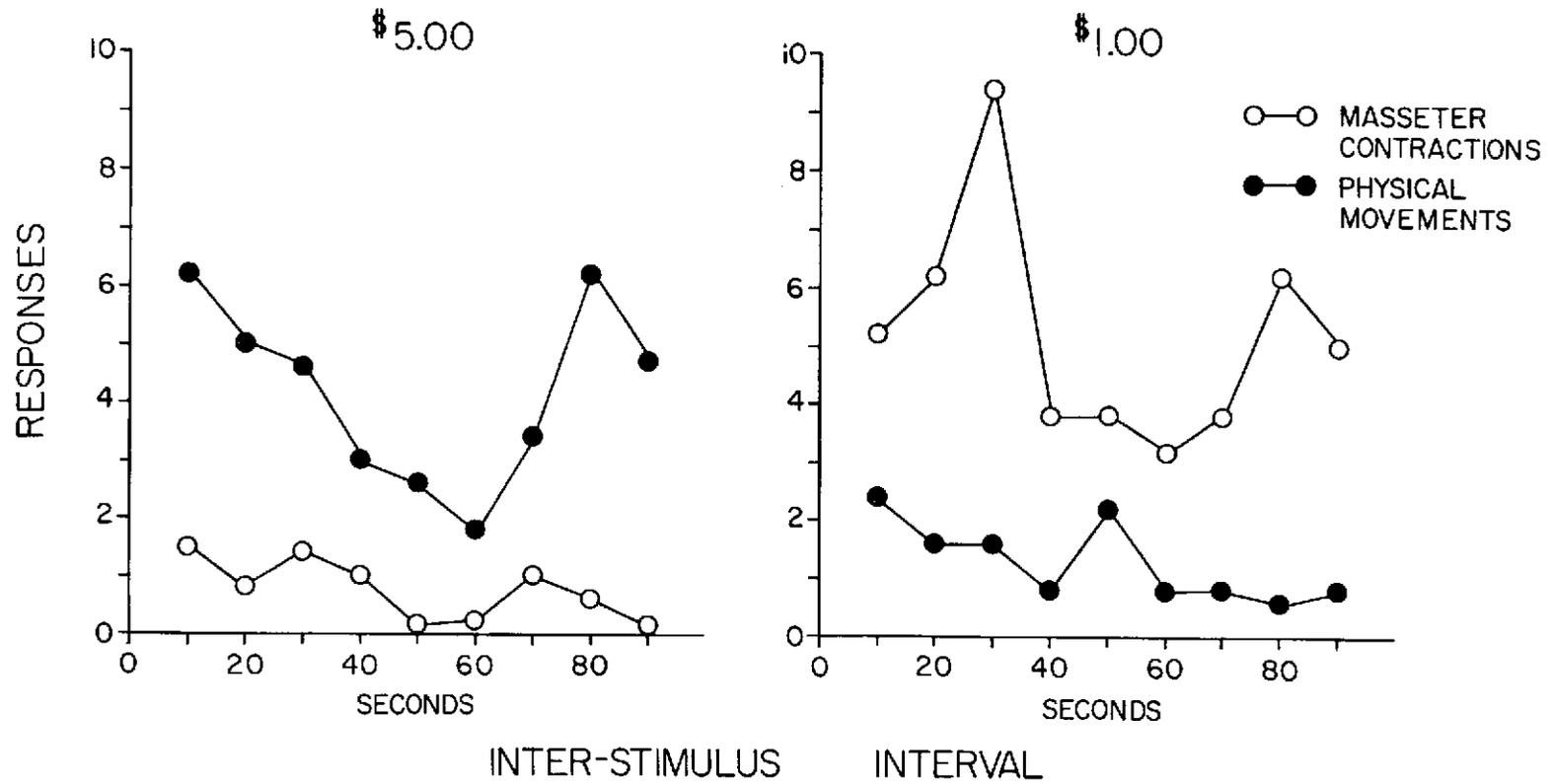


Figure 5

Verbal statements emitted by two subjects at varying pay levels.

Asterisk denotes behaviors that occurred outside the chamber.

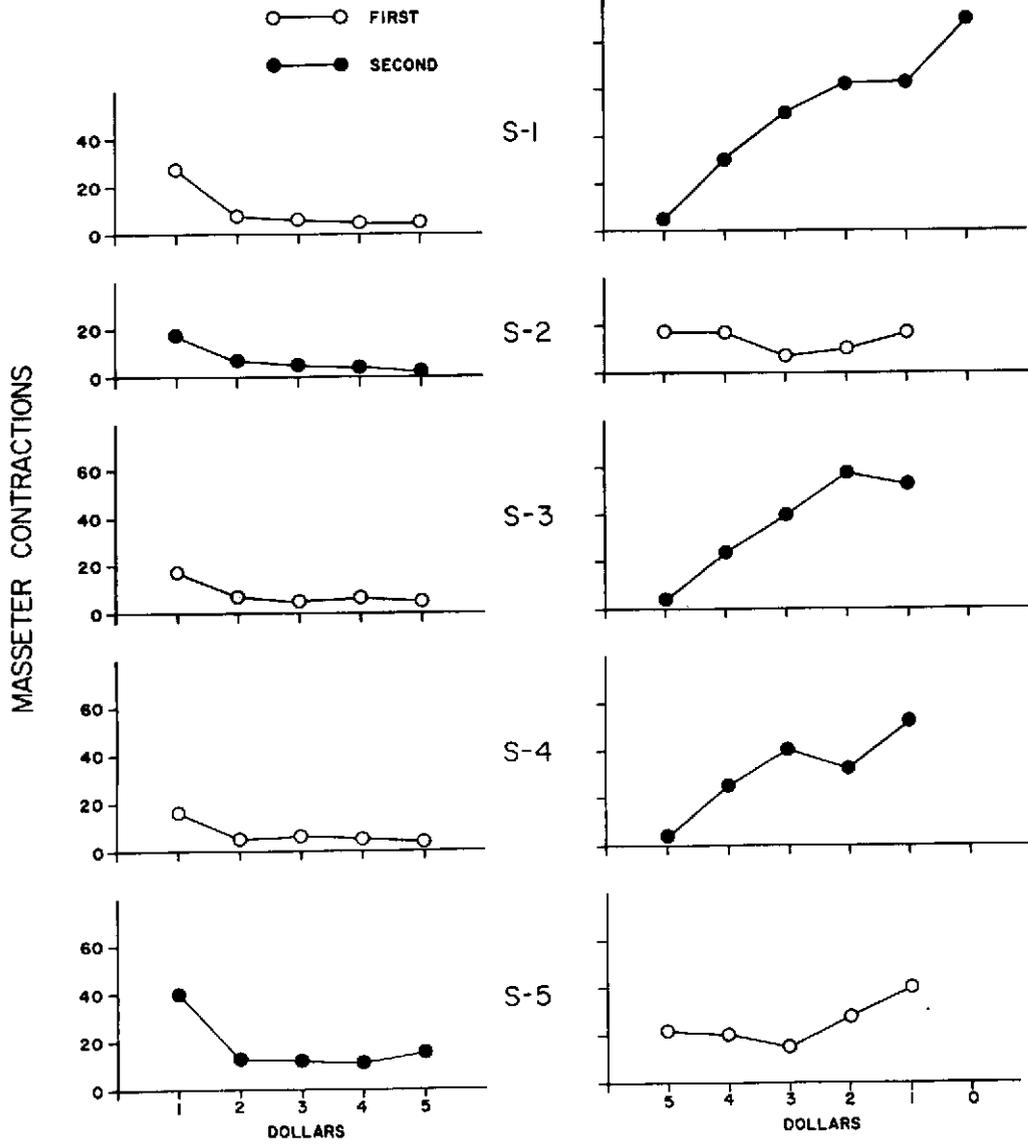


Figure 6

Influence of changes in subject pay on masseter contractions for each individual subject. The points on the average number of masseter contractions per session. Each subject was given one ascending and one descending series of payments; "first" and "second" refer to which series was administered first.

ASCENDING SERIES

DESCENDING SERIES



SUBJECT PAY

Figure 7

Distribution of masseter contractions and physical movements for each individual subject during the inter-stimulus interval for two selected values of subject pay.

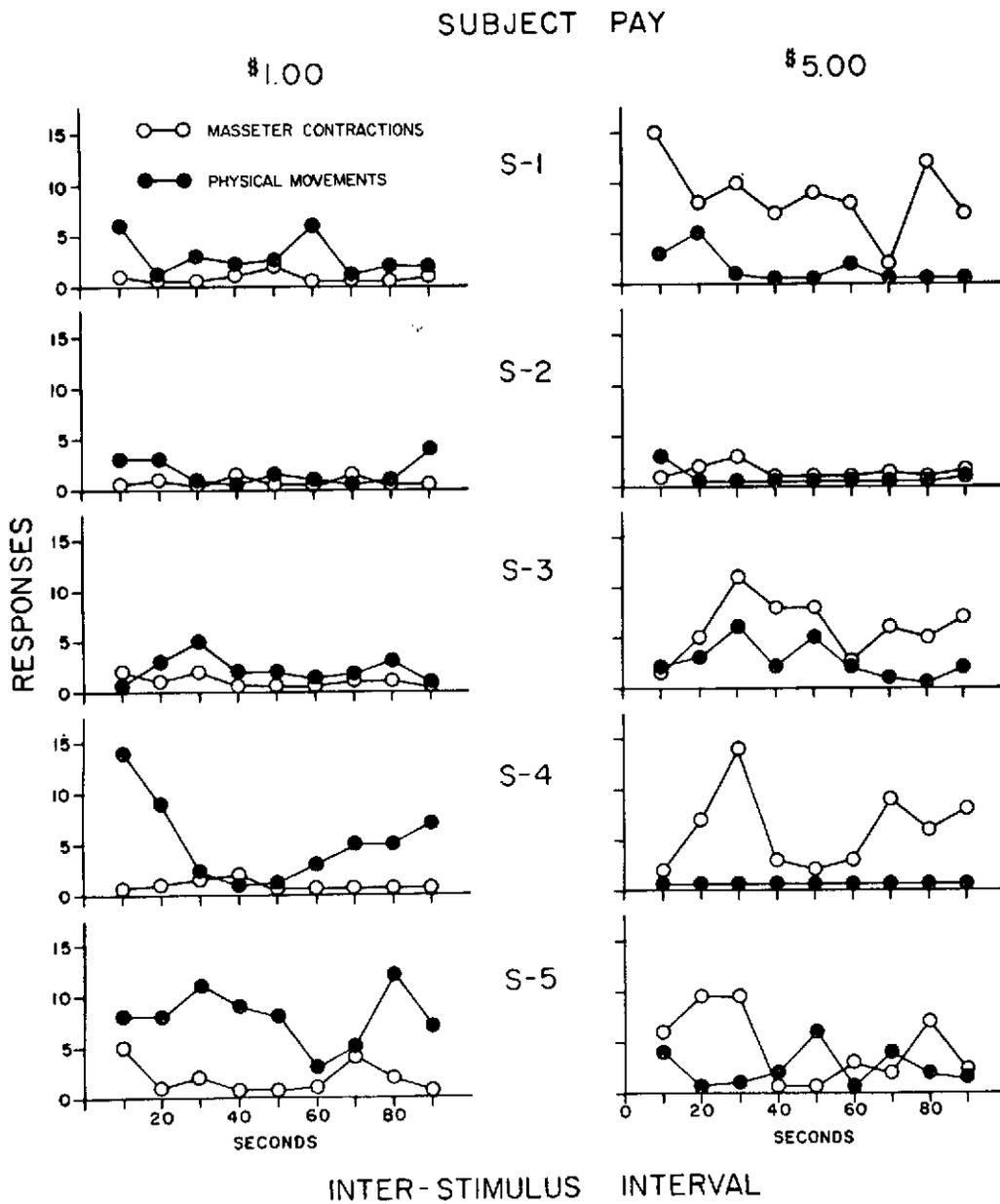
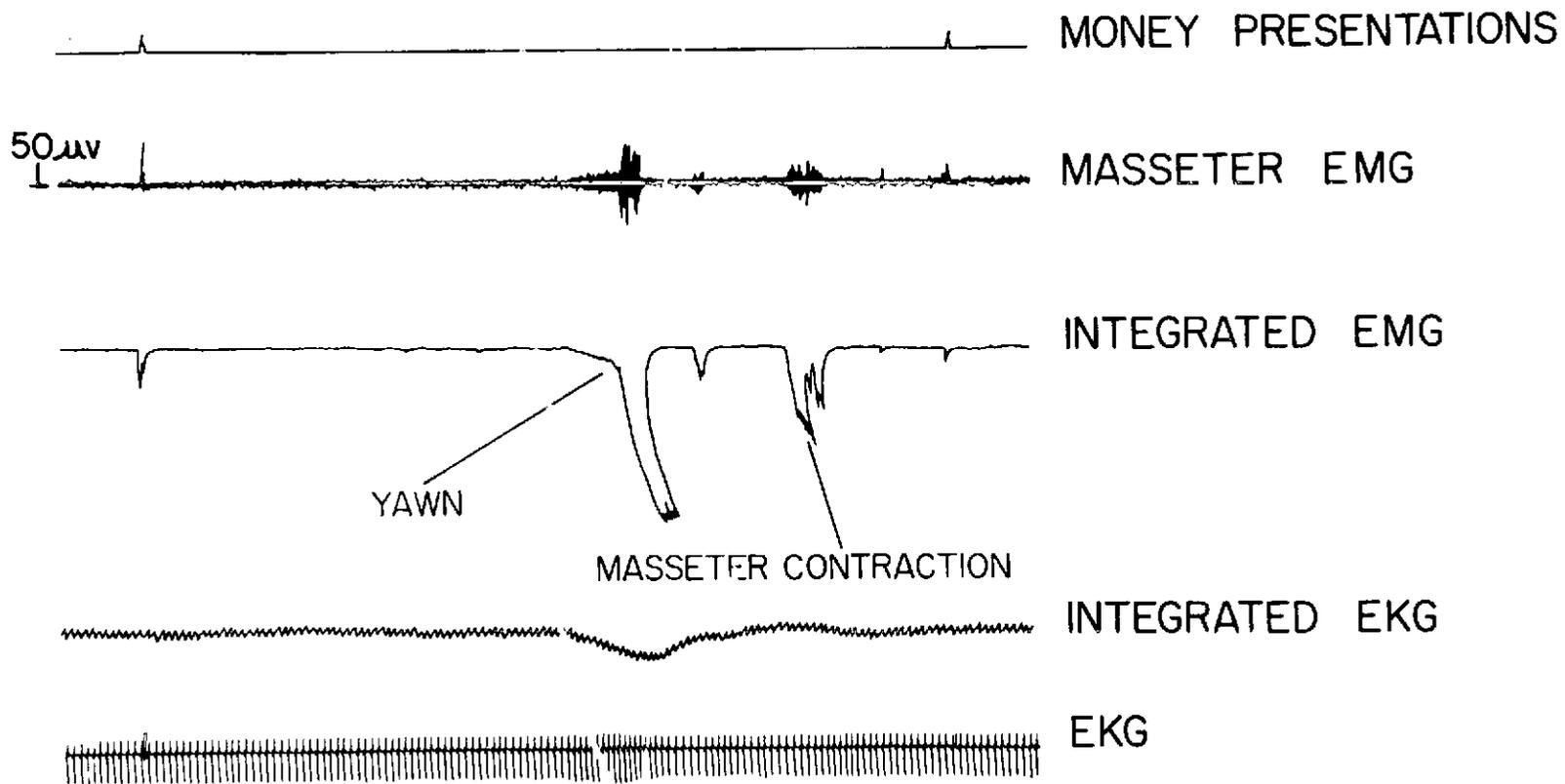


Figure 8

A section of a typical polygraph record showing the EMG patterns associated with yawns and masseter contractions. Note that the yawn and, to a lesser degree, the masseter contraction are associated with increases in heart rate.

S-2



MONEY PRESENTATIONS

MASSETER EMG

INTEGRATED EMG

INTEGRATED EKG

EKG

30 SEC.

## DISCUSSION

The results of this experiment demonstrate that reductions in pay will bring about an increase in masseter contractions. It must be noted, however, that past pay schedules have an even greater effect. By far the greatest number of masseter contractions occurred when a period of pay increases is followed by a period of pay decrease. However, there also appears to be a fairly strong relation between the absolute amount of money paid and the number of masseter contractions. If masseter contractions are indeed a good index of aggression, then this would tend to support the hypothesis that lower paid workers are more likely to engage in aggressive behaviors.

In addition to these major effects, there was also a slight increase in masseter contractions over time. This seems to correlate with an increase in the number of times the subjects would question the experimenter as to how much longer the experiment would continue. It was, unfortunately, impossible to record all of the subjects' behavior prior to the session. In that this behavior appears to be related to the in-chamber behavior, future experiments should make some effort at recording these behaviors.

In-chamber behavior was more easily recorded. A major restriction here was the limited area of vision afforded by the television camera. This did not permit observation of the subject's entire body. Recorded physical movements were thus limited to those of the upper body. It should be possible to rectify this

situation through the use of a wide angle camera, or by placing additional EMG electrodes on other parts of the body.

Movements should be studied further in that they appeared to have a direct relation to subject pay. This relation, which is opposite that for masseter contraction, would tend to suggest higher levels of activity with higher rates of pay. It would be very interesting to see if a subject's rate of response on some simple manual task would also increase when pay was increased. In this experiment, the subject was not given any task, in part so as not to make the subject's pay appear contingent to the subject on his in-chamber behavior. The subjects reported after the experiment that they looked upon their half-hour stay in the chamber as a "boring job" and one subject who was working at a warehouse commented that his stay in the chamber "was just like my other job".

For two subjects the in-chamber behavior proved to be an unexpected and useful adjunct to the EMG data. During his decline from \$5.00 to \$1.00, Subject 1 displayed a host of behaviors that must be classified as aggressive. These began with swearing out loud in session 18 and continued with further swearing and actual kicking of the machine. These behaviors continued and increased until session 23 when after seeing the first payment the subject leaned forward and promptly fell asleep. This may have been a form of escape by the subject or an attempt at non-cooperation. During the next session, when the subject noted a further reduction in money paid, he again began to swear. The subject's facial

expressions during this period ranged from a frown to what the experimenter subjectively would classify as rage. All of the above behavior correlates well with the increase in masseter contractions thus supporting their use as a measure of aggression.

A striking similarity exists between the distribution of masseter contractions in the present study and the distribution of bites in experiments on non-contingent shock using monkeys. Specifically, monkeys usually bite a rubber hose at a high rate immediately after receiving a shock. There follows a period of very low response rate which not infrequently gives way to another period of high response prior to the administration of the next shock. There is also a characteristic pause in responding just prior to the shock and during the shock (Hutchinson and Emley, 1970).

Humans receiving \$1.00 after a period of reducing pay exhibit a similar pattern. That is, maximum response (masseter contractions) following the presentation of money, followed by a noticeable drop-off and then another increase in response shortly before the presentation of the next payment. Humans also show a characteristic drop in masseter contractions just prior to and during the presentation of the money.

The importance of this similarity is that it exists between a clearly aversive condition (shock) and a condition which this study is attempting to show is aversive (pay reduction). In this context it is important to note that when pay was increasing this pattern was not noted. What was noted in the condition of high pay after a

period of increasing pay, was a dramatic decrease in masseter contractions.

This decrease parallels the finding that monkeys receiving non-contingent food deliveries show virtually no biting (Hutchinson and Emley, 1972). These monkeys also show a characteristic increase in movements as the moment of food delivery approaches, followed by a sharp drop just before and during the presentation of food. This pattern is similar to that of physical movements of humans receiving \$5.00 after a period of increasing pay. I.e., humans show an increase in the number of movements as the moment of money delivery approaches, with a characteristic drop immediately before and during the presentation of money. The similarity of the patterns of responses for humans and monkeys is important in that it shows that receiving food (a known positive event) produces some of the same type of responses as receiving large amounts of money.

The above similarities are also important in that they support a continuity between animal and human behavior. I. e., certain events, positive and negative, elicit comparable responses from both humans and animals. One of the underlying assumptions of this study was that masseter contractions are indeed a good measure of aggression. The similarities between human and animal patterns of response noted above support this. But also of great importance in supporting this assumption is the fact that the subjects exhibited other behaviors such as swearing and kicking which are generally accepted as aggressive, in conjunction with high rates of masseter contractions.

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