THE ACTIVITY OF CERTAIN FACIAL MUSCLES IN THE B-FLAT SOPRANO CLARINET EMBOUCHURE: AN EXPLORATORY STUDY UTILIZING ELECTROMYOGRAPHY

DISSERTATION

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By

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The problem with which this investigation is concerned is that of facial muscle activity in forming and maintaining the soprano clarinet embouchure.

The purposes of the study are to collect and analyze data in the following areas:

1. Activity of the following muscles during performance on the clarinet: (1) upper orbicularis oris, (2) lower orbicularis oris, (3) upper half of the buccinator, and (4) lower half of the buccinator. Muscular activity is read as electronic potential and is presented on recordings through the use of electromyography.
2. Possible effects which the electromyographic apparatus might impose upon performance. Tape recordings were made of the subjects' performing prescribed tasks both before and during electromyographic analysis. The possible effects of the electromyographic analysis upon performance were then tested by comparing these two recordings.

Judgment on tone quality for the pre-analysis and the in-analysis comparison was provided by a panel of three persons selected on the basis of their experience and ability as instrumental performers, teachers and/or conductors. Pre-analysis and in-analysis tape recordings of each subject performing the tasks on the task sheet were replayed, unidentified and in mixed order, for the panel to rate on a three-point scale of good, fair, or poor.

Upon his entering the laboratory, the subject was seated in the special reclining chair used for this type of analysis. He then performed a few of the prescribed tasks while watching a decibel meter that was used as a control for soft sound and full sound. For full sound, the subject would attempt to hold a level of ninety decibels. Any deviation of ten or more decibels above or below ninety was noted by the investigator.

After the subject had familiarized himself with the sound level, he was asked to perform the tasks on the sheet while the pre-analysis recording was made. Upon completion of this procedure, the electrodes were attached to the subject. The subject then performed the prescribed tasks again, providing both the EMG data and the in-analysis recording.

The following conclusions are among those resulting from this exploratory investigation:

1. The upper, as well as the lower lip is used consistently in forming and maintaining the clarinet embouchure.

2. The use of the upper and lower lip is affected in some way by (1) the angle at which the instrument is held and (2) the amount of mouthpiece taken into the mouth.

3. The lower buccinator is used more consistently than the upper buccinator. It is not, however, used with as much consistency as the upper and lower lip.

4. The upper and lower buccinator may function as units separate from each other.

5. With the EMG equipment utilized in the present study and instruction by properly trained persons, a clarinetist can be trained in a relatively short period of time to incorporate the use of the buccinator (both parts) into the formation and maintenance of embouchure.

6. The internal fine-wire electrode technique of electromyography offers an effective means of investigating the activity of the upper and lower parts of the lip and buccinator in forming and maintaining the clarinet embouchure.

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CHAPTER I

INTRODUCTION

Background and Significance of the Study

> The embouchure is a most important factor in all wind instrument playing. It is with the embouchure that the performer produces beautiful tones combined with sweetness and brightness. There are many schools of thought on this subject, most of them fiercely contradictory (3, p. 25).

This statement, made by Rudolph Dunbar in 1947, briefly describes the problem to which this study addresses itself. Dunbar, a clarinetist, would have been equally accurate had he used the word clarinet instead of including all the wind instruments.

Since the time of Dunbar's statement, there have been changes in the clarinet itself, in tonal concept of the instrument, in schools of performance and pedagogy, and in music composed for the instrument. The clarinet is now manufactured according to principles of acoustics, and, while yet imperfect, it is being developed into a more precise instrument acoustically and mechanically. Tonal concept has been given a new dimension, with the rising prominence of American clarinetists during the past decade. The desire to produce a distinctive clarinet tone for the American symphony orchestra has led to the introduction of new mouthpieces, ligatures, and reed

material, which, for the most part, are designed according to more precise acoustical principles. There are also several electronic devices now available for visual study of sound. In most cases the new challenges are being met successfully, through the utilization of scientific method and equipment, as is made evident by the work of Mooney (5) and Anfinson (1).

The problem of embouchure for clarinetists has also been investigated during this time. Conclusive statements have been difficult to make, however, since findings have been empirical and largely conjectural. The few instances in which the embouchure was studied through valid scientific methods can be attributed to members of the medical profession (7, 8, 10).

Maurice Porter, a dentist, has done extensive study of the facial muscles in relation to performance on wind instruments and is one of a small number of individuals who might be considered an authority on embouchure. He made the following statement:

> To approach the subject [embouchure] from a scientific point of view it is, therefore, the pursuit of a formulated knowledge of the facts which is essential before the embouchure and its problems can be solved. The embouchure is too important a subject to the wind musician--particularly the ambitious professional--to be ignored, as even though it may not be fully studied by some, certain aspects

> of it will at least keep the intelligent musician alert to many of the troubles that might sooner or later overtake him (6, p. 5).

A study presently in progress by Isley and Basmajian (4) gives strong indication that precise scientific study may be successfully conducted into the wind instrument embouchure through the use of electromyography. The study has included certain electromyographic observations of facial muscular activity in establishing the feasibility of using electromyographic technique for achieving accurate measurements of the activity of specific muscles during performance on the instruments.

Statement of the Problem

The problem is a study of facial muscle activity in forming and maintaining the soprano clarinet embouchure.

Statement of the Purposes

The purposes of the study are to:

1. Prepare a performance profile on each subject, containing data for examination in the areas of:
   - A. Experience as a clarinetist
   - B. Physical characteristics
   - C. Instrument and accessories
   - D. Performance habits
2. Conduct a laboratory investigation for collection of data in the following areas:

A. Activity of the following muscles during performance on the clarinet: (1) upper orbicularis oris, (2) lower orbicularis oris, (3) upper half of the buccinator, and (4) lower half of the buccinator. Muscular activity is read as electronic potential and is presented on recordings through the use of electromyography.

B. Possible effects which the electromyographic apparatus might impose upon performance. Tape recordings were made of the subjects' performing prescribed tasks both before and during electromyographic analysis. The possible effects of the electromyographic analysis upon performance were then tested by comparing these two recordings.

3. Conduct an analysis of data collected in steps one and two. The basic questions which form the nucleus of this analysis are stated as follows:

A. What is the general pattern of activity for each muscle of each subject in performance of the prescribed tasks?

B. Do any specific performance tasks result in muscular activity which deviates from the general pattern?

C. What is the relationship of activity of each muscle to those of the others in performance of the prescribed tasks?

D. What is the relationship of the activity of each muscle to the data from the subject information sheet?

4. Draw conclusions which may serve as the basis for experimental studies in this area and eventual modifications in clarinet pedagogy.

Definition of Terms

1. Embouchure is the mode of applying the lips and mouth to the mouthpiece of a wind instrument.

2. Electromyography is a technique for studying muscular activity through the use of various types of electrodes and associated electronic apparatus which can detect, measure, and record minute electrical discharges (emg potentials) produced through muscular contractions (11).

3. Electromyograph is the electronic apparatus involved in electromyography. The basic equipment used in the present study was an Argonaut LA042 differential preamplifier, an Argonaut power supply, a Tektronix 564B storage oscilloscope, and a Hewlett--Packard model 3955 fourteen-channel recorder.

4. Electromyogram is the printout of data from an electromyographic investigation.

5. EMG and emg are abbreviations used in electromyographic research. EMG is used for electromyograph, electromyography, and electromyogram, and emg is used for the adjective electromyographic.

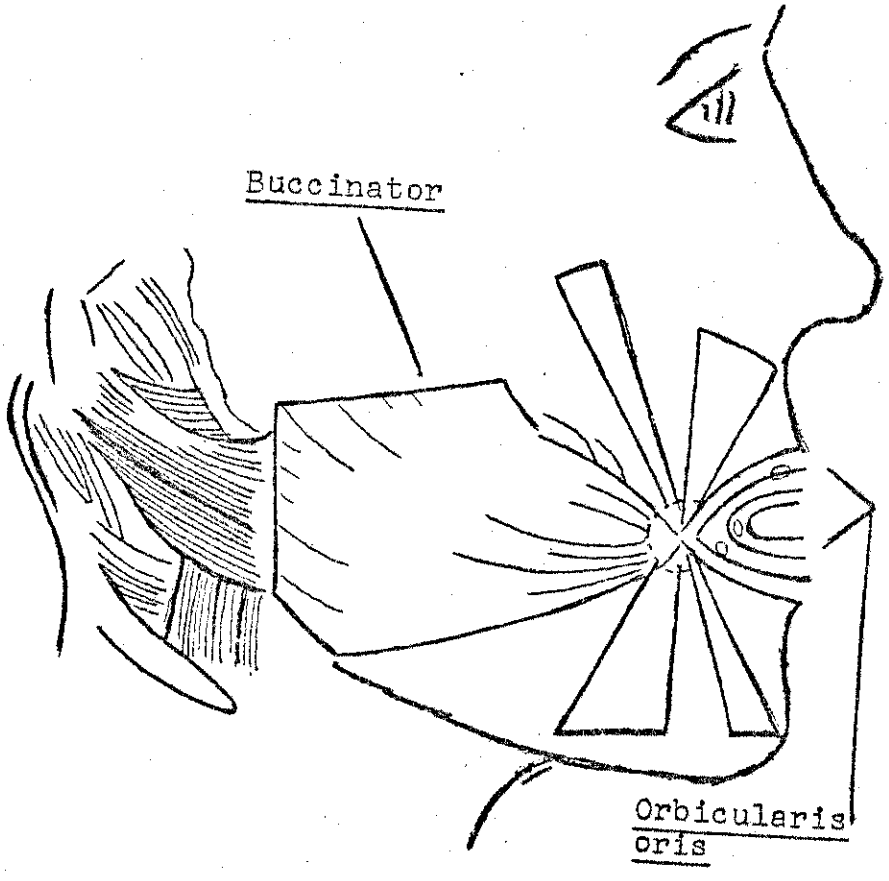
6. Internal, or indwelling, fine wire electrodes are two insulated wires .0011 inch in diameter, which are inserted directly into a muscle and serve as positive and negative conductors to the EMG apparatus.

7. Facial Muscles are very small, dimly outlined bundles of fibers which insert primarily into the deeper layers of the skin of the face and give control to facial expression. The present study is concerned with two of these muscles, both of which are associated with movement of the lips.

8. Orbicularis Oris, (Oral Sphincter) is a complex muscle that surrounds the mouth opening and forms the primary musculature of the lips. It has no direct attachment to the skeleton. Its fibers can be divided into an upper and a lower group, which cross each other at acute angles laterally to the corner of the mouth (9). In addition, the majority of upper and lower fibers are confined to one side only, interlacing at the midline with the fibers of the other side. Thus, the muscle is only functionally but not anatomically a unit.

9. Buccinator is a wide, rather thin muscle plate, lying on a deeper plane than that of the other muscles around the mouth. The muscle bundles, arising from a horseshoe-shaped line, run in a generally forward direction, but are not arranged parallel to each other. The bundles arising from the

upper jaw have a tendency to descend in their forward course; whereas those arising from the lower jaw ascend slightly toward the corner of the mouth. Close to the corner of the mouth, the fibers end in a rather intricate manner. Most of them insert into the mucous membrane of the cheek, while others interlace with those of the neighboring muscles and terminate in the skin of the upper and lower lips.



10. Pre-analysis Tape Recording is a sound recording of each subject performing the tasks listed on the task sheet. The subject is seated in the laboratory chair, and conditions are the same as for the actual electromyographic analysis, except that the EMG apparatus has not been attached.

11. In-analysis Tape Recording is a sound recording of each subject performing the tasks listed on the task sheet while he is attached to the EMG apparatus and undergoing electromyographic analysis.

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CHAPTER II

REVIEW OF RELATED LITERATURE

Facial Anatomy and Electromyography

A survey of several standard anatomy texts (3, 16, 25, 34, 35, 47) reveals agreement among all the authors concerning the general location (origins and insertions) of facial muscles. All of the texts give a similar account of the general function of each muscle, but show considerable disagreement concerning specific description and identification of each muscle. No account is given of the facial muscles related to opening or closing the lips or to thinning or thickening the lips. Basmajian has pointed out to Isley (20) that little more is known today about the normal function and kinesiology of the muscles of facial expression than has been known by the medical profession for the last one hundred years--knowledge gained through the dissection of cadavers and through observation.

Porter (31, 32) and Strayer (38) take exception to the first statement above. They have labored to relate facial muscle activity to wind instrument embouchures. Their efforts, however, must be assumed to be within the confines of the statement by Basmajian.

Electromyography appears to offer a promising method of studying the facial muscles involved in the wind instrument embouchure, since these muscles seem to be little understood by pedagogists and performers, as well as by anatomists and kinesiologists (46).

The basic technique of electromyography was developed almost forty years ago, and, for its first two decades, was applied to man more for diagnostic and clinical reasons than for functional kinesiology. Since the end of World War II, with a marked improvement of electronic apparatus, it has been applied more and more to the study of the functional aspects of muscles by anatomists, kinesiologists, and orthopedic surgeons (2, p. 6, 56).

Electromyography may be used to study the action of muscles as prime movers, synergists, stabilizers, accessory movers, antagonists, co-contractors, and contra-lateral function. The total amount of voltage varies with the number of muscle fibers contracting simultaneously, the more fibers contracting, the greater the voltage (46). A detailed study of electromyography is offered by Basmajian (2, p. 26) and Isley (20).

Several EMG studies of the muscles of mastication have been conducted, including studies of the temporomandibular (jaw) physiology and the muscles which protrude, retract, elevate, and depress the mandible (2, p. 325, 29, 30).

However, in 1967, Basmajian states:

> Systematic electromyography of the muscles of [facial] expression has been neglected, although clinical electromyographers are constantly concerned with facial palsies. To my knowledge no organized study of normal function has been done in this field, perhaps because the muscles are so superficial and their isolated actions seem to be apparent . . . . These muscles are . . . virgin territories for electromyographic exploration (2, p. 333, 354).

Licht (23) and Moldaver (27) express similar views.

A few recent EMG studies which involve the muscles with which the present study is concerned are available. One of these, by Baril and Moyers (1), investigates the temporalis muscles and the mentalis, orbicularis oris (upper lip only) as well as the buccinator muscles in thumb and finger-sucking children. They find marked activity in the upper orbicularis oris and in the mentalis muscles during swallowing and sucking.

Lindquist (24) has studied the buccinator muscle as an aid to denture retention and stabilization, finding that (1) the buccinator muscle contracts most actively and exerts pressure on the buccal flange only on the working side of unilateral chewers and that (2) it is effective bilaterally as an aid in denture retention and stabilization only if the subject is a bilateral chewer.

Blanton, et al. (6) have made an EMG analysis of the buccinator muscle, utilizing indwelling, fine-wire electrodes. Electromyograms were made from subjects with normal dentition

during various oral activities. The buccinator muscle was found to be markedly and consistently active during swallowing, blowing, sucking, masticating, and various lip and mandibular movements.

De Sousa (12) has studied the buccinator muscle in male students using a two-channel electromyograph with concentric needle electrodes inserted into the upper and lower parts of the muscle. The muscular activity was tested during distension of the cheeks with air, blowing, whistling, compression of the lips and lateral retraction of the angle of the mouth, as in smiling, swallowing liquids, suction, mastication with empty and full mouth. In this last performance, the activity of the upper buccinator and masseter was observed simultaneously. It was observed that the lower buccinator was constantly active while retracting laterally the angle of the mouth and during the lips' compression. It was not active during distension of the cheeks with air, blowing and whistling.

Tallgren (40) has used monopolar surface electrodes in investigating the neuromuscular response to loss of posterior teeth and to subsequent complete denture treatment. Muscles studied were the upper and lower orbicularis oris, the buccinator, the mentalis and the masseter. He has found that all

these muscles make adjustments, characterized by imbalance in activity, when the teeth had been removed and improved in balance with insertion of the dentures. Of the facial muscles the upper orbicularis oris was one of the most affected by the removal of the teeth.

These findings indicate that the upper and lower orbicularis oris do not act synergistically (in parallel and reciprocative motion) and that the upper lip plays a more passive role than the lower in the function of the mouth.

Studies in progress by Isley and Basmajian (20) and White and Basmajian (46) have utilized subjects playing the trumpet and trombone to investigate by electromyographic techniques by the normal kinesiology of the facial muscles. By the permission of the authors, the following statements may be made at this time concerning these studies:

1. The internal electrode technique of electromyographic analysis is an effective means of observing facial muscle activity in forming and maintaining the trumpet and trombone embouchure.

2. The surface electrode technique of electromyographic analysis is not effective for observation of the small muscles of the face, as the muscles are too close together.

3. The following facial muscles have been observed as a single channel unit on the four channel equipment being

utilized for this study: (1) upper orbicularis oris, (2) lower orbicularis oris, (3) buccinator, upper half, (4) buccinator, lower half, (5) levator anguli oris, (6) levator labii superioris alaeque nasii, (7) depressor anguli oris, (8) risorius--platysma, (9) mentalis.

4. The electromyograph utilized for this study provides data for treatment on a four to ten point scale.

5. A synchronized tape recording of all tones sounded in any work on the present electromyograph equipment may be utilized.

It may be noted here that preliminary investigation by the present investigator, working with Basmajian and his staff with two subjects playing the B flat soprano clarinet, offers evidence that the internal fine-wire technique of electromyographic analysis should be as effective for observation of muscular activity on this instrument as it is for the trumpet and trombone. The basic difference in the instruments is that the clarinet mouthpiece is inserted into the mouth, but this did not interfere with the wire electrodes, four of which were inserted inside the mouth and allowed to come out the corner of the mouth.

The Clarinet Embouchure

In any discussion of the embouchure, tone quality, or other facets of reed instrument performance, the problem of

terminology is encountered. The clarinet embouchure is a very complex mechanism, and clarinetists are not anatomists or kinesiologists; therefore, terminology in the literature is rather vague and ambiguous.

Smith (36) makes an effort to clarify terminology for discussion. He describes the embouchure as consisting of seven component parts: (1) chin position, (2) lower lip, (3) upper lip, (4) bite, (5) jaw pressure (6) diaphragm (breath), and (7) tone color.

The only ambiguity noted here is that of the terms "bite" and "jaw pressure," as both refer to the combined contractions of jaw, lip, and possibly levators and depressors of the lip muscles in controlling the mouthpiece and reed while they are in the mouth. The term "bite" is used more accurately by Kruth (22), Bellison (7, p. 8), and others in simply describing the amount of mouthpiece taken into the mouth when forming the embouchure.

The present study, which is limited to the activity of two facial muscles in the embouchure, will utilize the following categories in discussing the literature: (1) primary position and activity of the upper lip, (2) primary position and activity of the lower lip, (3) use of facial muscles other than the lips, (4) the bite (amount of mouthpiece taken into the mouth in forming the embouchure), and (5) muscular adjustments made during performance.

Primary Position and Activity of the Upper Lip

Cerminara (9, p. 5) states that the upper lip and teeth should be firmly placed over the top of the mouthpiece. Collis (10, p. 58) goes further and states that holding the teeth away from the lips is far better for better control of embouchure. Waln (43, p. 54) states that an important aspect of the embouchure is that the upper teeth rest on the mouthpiece with no part of the upper lip between teeth and mouthpiece.

Haugen (17, p. 17) notes that the upper lip gives support for the sides of the mouthpiece, hence should rest lightly on the top of the mouthpiece. Portnoy (33, p. 51) agrees with Haugen and states somewhat more precisely that the upper teeth rest on the mouthpiece, lightly, about three-fourths of an inch down. Bellison (7, p. 8) concurs with the preceding statement also, adding that he feels the player must allow the upper lip to find its own place.

Kruth (22) states the upper lip must be over only the upper teeth, which are resting firmly on the top of the mouthpiece. Marconi (26, p. 87) states that the placement of upper lips and teeth should be what is natural when the lower lip has been placed and the amount of bite set properly. Holz (18, p. 90) has the teeth placed firmly on the mouthpiece, then the lips drawn around the mouthpiece like a purse string,

and Stein (37, p. 12) uses a similar analogy. Stein (37, p. 14) also tells of hearing some professional clarinetists declare that embouchure success rests largely on the manner in which the upper lip assumes its share of activity. The present writer has heard this same statement from various sources and has had some success with students in having them concentrate on utilizing the upper lip more. Timm (41, p. 53) and Bonade (8, p. 6) say that the upper teeth come down on the mouthpiece and can be thought of as a fulcrum.

In summary of this category: Four sources making comments on the upper lip activity in forming the clarinet embouchure maintain that its primary function is that of covering the teeth and helping seal the corners of the mouth. Neither of these activities require more than minimal effort. Four others make reference to the upper teeth only, without specifying any particular function for the lip, and this stand can be interpreted as supporting the contention that the upper lip has only a minimal function in the embouchure. Tallgren (4) supports this general contention, although his subjects were not forming the clarinet embouchure.

The opinion of two of the sources is that the upper lip has a more definitive function, requiring more than minimal activity. Baril and Moyers support this opinion, as does Stein (37, p. 13) in his statement that the success of the embouchure itself rests largely in the manner in which the upper lip assumes its share of the activity.

Primary Position and Activity of the Lower Lip

Hovey (19, p. 6) states that a small amount of lip should be used as a cushion. A large amount of lip destroys the optimum amount of vibrating power. Only enough lip to control the tone should be used. Haugen (17, p. 17) says nothing concerning the amount of lower lip. He does say that strength of embouchure and tone must come from the lip itself.

Portnoy (33, p. 51) says that the lower lip controls tone and dynamics from pp through FF. He thinks most players take in too much lower lip and should use only a narrow cushion, allowing more reed to vibrate. Overly tight lips produce very strident tones. Bates (5, p. 8) simply states that the lower lip should be rolled over the teeth (nothing is mentioned concerning the amount of embouchure). Stein (37) gives a somewhat more exacting description of use of the lower lip for proper amount of embouchure. He states:

> In using a double embouchure more lower lip should be used, thus enabling considerable bulk and cushion. However, single lip playing requires a very exact amount of lower lip and this can be known only by the individual player (37, p. 12).

Stein wants the lower lip drawn up to form a cushion and to allow a "moon shaped" dip in it which accommodates the reed.

Marconi (26, p. 87) states that it is extremely important to put very little of the lower lip over the teeth. Holz (18, p. 90) agrees with this and suggests that the student roll the red portion of the lip slightly over the teeth. Bonade (8, p. 5) speaks of the lower lip's being stretched tightly over the teeth but then of the mouth's closing "naturally" around the mouthpiece. Timm (41, p. 53) has the student point the chin to bring the lower lip tension across the teeth. The reed is placed "firmly" against the lip without pressing hard.

In summary: The clarinetists writing on this subject refer almost exclusively to the position of the lower lip. There is only peripheral reference to the function of it, although there are inferences in the material regarding the upper lip which relate to the importance of the lower lip.

Two sources refer to the lower lip as giving strength and control to the embouchure, while two others speak of "drawing up" the lower lip around the mouthpiece. Tallgren (4) gives evidence that, in general functions of the mouth, the lower lip is the more active of the two.

Use of Facial Muscles Other than the Lips

Stein (37, p. 12) refers to a "two-way stretch" in the chin area, whereby the jaw and the muscles in the lower half of the chin are pulling downward and the lower lip is pulling upward so as to keep bulky and to cushion the reed properly. Timm (41, p. 53) offers a description very similar to this. Stubbins (39, p. 194), Kruth (22), and Dunbar (13, p. 25) speak of the corners of the mouth as being pulled back in a smile position, but in such a manner as to prevent any air from escaping from the sides of the mouth. Maintaining a flat and pointed chin is recommended by these and most other clarinetists.

Kruth (22) advocates instructing the student to blow a thin, intense stream of air at the palm of his hand in order to achieve the basic muscular function of the "facial mask."

It is Dunbar's (13, p. 26) contention that the plane of the face, i. e., the way the masseter, buccinator and the upper and lower zygomaticus muscles contour around the skull, determines the potentiality of the person as a clarinetist. All these muscles should be drawn tight, he states, and when the mouthpiece is placed in the mouth, for those with the correct plane of muscle over skull, this action takes place automatically.

In summary: In this category literature from clarinetists is scarce, and terminology is particularly ambiguous. The names of particular muscles are rarely used, and efforts to describe muscular function are even less precise here than the descriptions in the lip categories.

General reference is made to contracting the muscles supporting the lips to strengthen the embouchure and to the fact that this results in the flesh around the jaws and chin appearing stretched. This reference implies the use of the buccinator muscle generally, but does not account for any particular activity being related directly to it.

The findings of Lindquist (24), DeSousa (12), and Blanton, et al. (6) are more specific in linking the buccinator to particular tasks, although their subjects were not playing wind instruments. Results from these studies, for the most part, support statements from anatomy texts on the function of the buccinator. Blanton, et al. (6, p. 393) go somewhat further than these general statements in their report that the buccinator was found markedly and consistently active during swallowing, blowing, sucking, masticating, and various other lip and jaw movements. This would support speculation that this same type of activity would be observed in the playing of a clarinet.

DeSousa's (12, p. 116) observation that the lower buccinator is constantly active while retracting laterally the

angle of the mouth and during the lips compression and not active during distension of the cheeks with air, blowing and whistling also goes beyond the anatomists' general description, and would suggest that the buccinator might not necessarily be active constantly in playing the clarinet.

The Bite

Forest (14, p. 7), Cerminara (9, p. 5) and Thurston (42, p. 2) all feel that the exact bite depends upon the player's mouth formation and lay (tip opening) of mouthpiece, which can only be discovered by the individual through experimentation. Kruth (22) and Stubbins (39, p. 194) have said that the tip of the lower lip should extend one-half inch down on the mouthpiece; however, here again the optimum amount of bite depends upon the player.

Bellison (7, p. 8) states that five-sixteenths of an inch of bite is the optimum amount, and the bite itself changes as the player goes up in pitch. Portnoy (33, p. 51) maintains that the bite is important to the control of volume. Marconi (26, p. 87) specifies that enough mouthpiece should be taken in to allow one-quarter inch of reed free inside the mouth, but Holz (18, p. 90) contends this should be one-half inch. Bonade (8, p. 6) and Stubbins (39, p. 194) have the upper teeth placed about one-half inch down on the mouthpiece.

These sources mention three different ways to speak of the amount of bite: (1) the lower lip extending down on the mouthpiece, (2) the amount of free reed inside the mouth, and (3) the placement of the upper teeth on the mouthpiece. There is no mention of exactly how the measurement is made, whether it is from the teeth or from the exterior part of the lip to the tip of the mouthpiece.

In summary: The literature in this category covers a rather wide scope of opinion, and it is difficult to interpret because of the lack of uniformity in making measurements of the amount of bite.

Two sources maintain that the amount of bite is variable to a slight degree and that this variation is important in changing volume from soft to full sounds.

Five other sources contend that there should be an attempt to establish a definite measurement of mouthpiece in the mouth, but they do not refer to the necessity of any deliberate adjustments in this bite during performance. The measurements mentioned by these sources are not uniform, but could be interpreted as approximating one-half inch of mouthpiece in the mouth.

Three sources feel that the amount of bite depends upon the player's mouth formation and the lay of his mouthpiece and that this must be determined by each player through experimentation. They do not mention adjustments in the bite or importance of the bite.

Muscular Adjustments Made During Performance

Bellison (7, p. 8), in speaking of the bite, says it changes as the player goes upward, and he cautions that one must "lip" (adjust the lower lip) with deliberation and repose and as one plays an ascending passage turn the clarinet from left to right, which helps to produce a sonorous tone. Portnoy (33, p. 51) states that an FF tone requires that pressure be exerted on the tip and a pp tone requires less lip and pressure closer to the tip. This action, however, is hardly perceptible. Gigliotti (15, pp. 4, 5) states that it is necessary to tighten the embouchure when slurring up and to release the jaw pressure when slurring down.

Delecluse (11, p. 8), Kruth (22), Cerminara (9, p. 5), and Collis (10, p. 58) are in general agreement that support around the mouthpiece should be applied equally and should be elastic from all sides and that there should be no pinching (combined jaw pressure and contraction of the lips) for high notes.

Marconi (26, p. 87) maintains that there must definitely be change in the embouchure while playing. This is because loud playing requires more free-vibrating reed inside the mouth than does soft playing; therefore, there must be a slight shifting of the mouthpiece to allow for this activity. This shifting, he states, is accomplished by pushing the jaw

forward, putting the teeth further down the reed where it is stronger, and then applying more pressure (source of pressure not stated) to compensate for the stronger part of the reed and maintain the playing pitch.

Timm (41, p. 53) and Thurston (42, p. 2) agree that pressure changes are necessary in going from one range to another, but they are made with the lips and breath drive. They do not speak of the instrument's moving in the mouth. Bonade (8, p. 5) cautions against having pressure which would bind the reed from above and below brought to bear on the same spot. He has the pressure from below on the lower part of the reed and pressure from above to the upper part of the mouthpiece, as though the clarinet were a lever between the jaws.

From other sources (44, 45, 13, 21, 28) one may find statements which will differ very little in content from those discussed. There is, however, the continuing disparity in terminology.

In summary: Nine of the sources mention adjustment while performing in one way or another, including (1) use of the lower lip only, (2) slight push or pull of the mouthpiece, (3) tightening of the whole embouchure, (4) shifting the jaw, and (5) using the lips combined with breath drive. The fact that others do not mention breath drive or breath support does not mean that they would not advocate this. They are probably commenting on the embouchure separately from other

facets of performances on the instrument, as is the case with the present study.

Six sources advocate little or no adjustment in the basic embouchure formation during performance. They do, however, speak of "elasticity" in the embouchure, and this poses the question of how much difference there is in "slight adjustment" and "elasticity."

For a statement to summarize this portion of the literature and relate it directly to the present study the following quotation from Westphal serves well:

> Among fine clarinet teachers there is considerable difference of opinion on exactly how the best embouchure should be formed, but at the same time there are many points on which there is unanimous agreement. Much of the difference of opinion can be traced to the semantics with which the formation is explained, since it is difficult to write and talk about something which is physical and musical. Those familiar with embouchure formation on other instruments will recognize immediately that the same dichotomy exists not only in the other woodwind instruments but on instruments in the brass family as well (44, pp. 28, 29).

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CHAPTER III

METHODS AND PROCEDURES

Twelve subjects were utilized in the present study. They were selected by the investigator on the basis of (1) their experience as clarinetists and (2) their willingness and availability to participate in the study.

The subject information sheet (Appendix A) was designed to include any information which might have even a peripheral effect upon the present study and also information which might be of documentary value in future investigations.

The information on appearance of embouchure, shape of face, lip thickness, length of upper lip, position of jaw and teeth, condition of teeth, breathing, and angle of instrument is based upon empirical observation by the present investigator, with assistance from other clarinetists present during the laboratory activity.

The task sheet (Appendix B) was designed, in collaboration with other clarinetists, to include at least a minute sampling of all the basic problems a clarinetist encounters in performing on the instrument.

Prior to his entering the laboratory for electromyographic analysis, each subject was given a briefing by the investigator

on the tasks which were to be performed and an explanation of the EMG apparatus. The subject was then given the information sheet and asked to complete sections A and C.

The laboratory investigation was for the collection of data in the following areas:

1. Activity of the following muscles during performance on the clarinet: (1) upper orbicularis oris, (2) lower orbicularis oris, (3) upper half of the buccinator, and (4) lower half of the buccinator. Muscular activity is read as electronic potential and is presented on recordings through the use of electromyography.

2. Possible effects which the electromyographic apparatus might impose upon performance. Tape recordings were made of the subjects' performing prescribed tasks both before and during electromyographic analysis. The possible effects of the electromyographic analysis upon performance were then tested by comparing these two recordings.

Equipment for these recordings was an Ampex Model PR10 sound tape recorder with a Sony C37 FE and T solid state condenser microphone which was placed next to the microphone of the sound level meter.

Judgment on tone quality was provided by a panel of three persons selected on the basis of their experience and ability as instrumental performers, teachers, and/or conductors.

Pre-analysis and in-analysis tape recordings of each subject performing the tasks on the task sheet were replayed, unidentified and in mixed order, for the panel to rate on a three point scale of good, fair, or poor. These ratings were then entered on the subject information sheet for later treatment.

Immediately prior to entering the laboratory, each subject was allowed a ten minute period to prepare himself and his instrument for performance.

Upon his entering the laboratory, the subject was seated in the special reclining chair used for this type of analysis. He then performed a few of the prescribed tasks while watching a decibel meter that was used as a control for soft sound and full sound. The microphone for the meter was placed fourteen inches above the floor and thirty inches from the subject chair. For full sound the subject would attempt to hold a level of ninety decibels. Any deviation of ten or more decibels above or below ninety was noted by the investigator.

After the subject had familiarized himself with the sound level, he was asked to perform the tasks on the sheet while the pre-analysis recording was made. Upon completion of this procedure, the electrodes were attached to the subject by Basmajian and an assistant. The subject then

performed the prescribed tasks again, providing both the EMG data and the in-analysis recording.

An additional research procedure, involving the recruitment of the buccinator muscle, was suggested by Basmajian and inacted after the laboratory investigation was in progress. This procedure is described as follows:

After viewing on the oscilloscope the activity in the two parts of the buccinator muscles of the first two subjects, Basmajian suggested that additional tasks be given the subjects after they had completed the formal task sheet. The intent here was to have the subjects attempt recruitment of the buccinator with audio-visual assistance from the oscilloscope.

Lights were turned off in the laboratory so that the screen might be seen more clearly, and the volume level of the audio was raised until the electronic output from each muscle could be heard as well as seen.

The subjects, without instruments at the time, were asked to make various facial movements which should recruit the buccinator. They did these first with the mouth open, and later with the mouth closed. Then they were asked to perform certain tasks on the instrument, one time with no attempt to recruit the buccinator and another time with conscious effort to recruit the buccinator.

These procedures involved nine of the twelve subjects. The results are included with the other research findings.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The purposes of this chapter are to present (1) the data from the subject information sheets and the EMG recordings and (2) an analysis of the data, leading to conclusions and recommendations for further research in this area.

Presentation of the Data

Data from the Subject Information Sheet

The compilation of this data has produced some subject profiles which form an extremely wide strata for some items and an extremely narrow strata for others. When EMG data was compared to information sheet data it was found that some of these items with extremities were of negligible value to the present study. These were, therefore, deleted from the tabulation. They may be found tabulated, for documentary purposes, in Appendix C.

Four items, those pertaining to lip thickness, length of upper lip, position of the jaw and teeth, and condition of teeth, were grouped together for the comparison of data and are referred to as facial characteristics. This larger grouping is less definite than the separate items would be,

but was found to be of some value as an indicator of similarities in subjects.

Table I is a tabulation of that subject information sheet data which was found to have at least peripheral value to the present study.

The subjects are listed by number vertically at the left. The item of information is identified horizontally at the top.

Four subjects are principal performers on woodwind instruments other than the clarinet. Six of the eight subjects who are principal performers on clarinet were observed to have a good embouchure. None of the non-clarinet principals' embouchure was rated better than fair.

No subject had any extreme facial features, such as extra thick lips or extreme overbite or underbite. None had teeth more than moderately uneven.

The angle at which the clarinet was held ranged from thirty-five to sixty-five degrees, with the two largest angles being those of non-clarinet principals who are primarily saxophonists. This angle approximates that of the mouthpiece when playing the saxophone.

Five of the six most experienced subjects took at least one second average preparation time. Five of the six least experienced took less than this.

TABLE I

TABULATION OF DATA FROM THE SUBJECT INFORMATION SHEET

Subjects	Principal Instrument	Experience on Clarinet	Private Study	Amount of Private Study	Age	Appearance of Embouchure	Lip Thickness	Length of Upper Lip
1	Saxo-phone	10 Years	No		38	Fair	Thin	Medium
2	Clari-net	5 Years	No		15	Fair	Full	Medium
3	Clari-net	9 Years	No		16	Fair	Medium	Medium
4	Clari-net	6 1/2 Years	No		18	Good	Medium	Long
5	Clari-net	24 Years	Yes	6 Years	36	Good Firm	Medium	Long
6	Bas-soon	5 Years	Yes	6 Months	22	Poor	Medium	Long
7	Clari-net	5 Years	Yes	2 Years	21	Good	Medium	Medium
8	Clari-net	9 Years	Yes	2 Years	18	Good	Full	Long
9	Saxo-phone	3 Months	No		20	Poor	Medium	Medium
10	Saxo-phone	11 Years	Yes	1 1/2 Years	21	Fair	Medium	Medium
11	Clari-net	9 Years	Yes	4 Years	21	Good	Medium	Medium
12	Clari-net	27 Years	Yes	6 Years	39	Good	Full	Medium

Position Jaw and Teeth	Condition of Teeth	Average Preparation Time (Seconds)	Amount of Mouthpiece in Mouth (Bite) in Inches	Angle of Instrument	Tone Quality No. 1 (Pre-analysis)	Tone Quality No. 2 (In-analysis)	Subject Comment on Performance During Analysis
Overbite	Even	.4	13/16	45°	Fair	Fair	Slightly Inhibited
Slight Overbite	Even	.6	11/16	55°	Poor	Fair	Normal
Even	Even	.5	7/16	45°	Good	Fair	Slightly Inhibited
Even	Moderately Uneven	**	7/16	35°	Good	Good	Normal
Slight Overbite	Moderately Uneven	1.3	11/16	35°	Good	Good	Slightly Inhibited
Slight Overbite	Moderately Uneven	.8	13/16	65°	Fair	Fair	Normal
Even	Even	.7	11/16	50°	Good	Good	Normal
Overbite	Moderately Uneven	1.5	12/16	55°	Fair	Fair	Normal
Slight Overbite	Even	.8	12/16	55°	Poor	Poor	Normal
Slight Overbite	Moderately Uneven	1	13/16	60°	Fair	Fair	Normal
Slight Overbite	Moderately Uneven	1	12/16	50°	Good	Good	Normal
Slight Overbite	Moderately Uneven	1	11/16	40°	Good	Good	Normal

*Average preparation time: The time lapsed (as indicated on recording) between recruitment of the muscles and the production of the sound.

**Continuous activity.

The amount of mouthpiece in the mouth (bite) was measured from the exterior of the upper lip to the tip of the mouthpiece. The literature makes no mention of how others have made this measurement, and this must be taken into consideration when interpreting this data. The measurements for these subjects ranged from seven-sixteenths to thirteen-sixteenths of an inch.

The pre-analysis and in-analysis ratings of tone quality in the table represent consensus of the three judges. In all but three cases the opinions are unanimous.

One subject received a higher rating for the pre-analysis recording and one received a higher rating for the in-analysis recording. In all other cases the ratings were identical. The recordings for subjects number eight, eleven and twelve were not available for analysis because of technical difficulties. These three subjects did not feel that the EMG electrodes affected their playing.

It is apparent from this data that the EMG equipment had very little effect upon the performance of the subjects in this study.

Three subjects felt that the EMG apparatus inhibited their playing slightly, while the other nine did not feel affected by it.

Data from the EMG Recordings

The EMG recordings provide for analysis of the data based upon a four point numerical scale, described as follows:

1. No electronic output (zero output) from the muscle, indicating that the muscle is not recruited at all for a particular task. The recording shows a straight line. An example may be seen in Appendix D.

2. Minimum electronic output, indicating slight recruitment of the muscle for a particular task. It is difficult at times to distinguish minimum output from nervous tension in the subject or slight interference with the fine wire electrodes. The recording shows slight disturbances in a straight line. An example may be seen in Appendix D.

3. Moderate electronic output, indicating definite recruitment of the muscle, but obviously not the maximum amount which could be indicated. The recording shows an obvious wave line with the waves less than full length. An example may be seen in Appendix D.

4. Marked electronic output, indicating the maximum recruitment of the muscle for a particular task. The recording shows an obvious wave line with the waves at maximum length. An example may be seen in Appendix D.

This scale is recommended by Basmajian (personal communication) as the most effective for interpretation of this data. It is employed throughout the present study.

An examination of the recordings reveals the following data pertaining to activity in the upper lip for the twelve subjects, listed here by number:

1. The subject recruited marked output throughout the eighteen tasks.

2. The subject recruited marked output throughout the tasks.

3. The subject recruited marked output throughout the tasks.

4. The subject recruited marked output in all tasks except number ten, where moderate output appears.

5. The subject recruited moderate output throughout the tasks.

6. The subject recruited moderate output throughout the tasks.

7. The subject recruited marked output in all tasks except numbers eleven, twelve, fourteen and eighteen, which show moderate output.

8. The subject recruited marked output throughout the tasks.

9. The subject recruited marked output in tasks numbers one, two, three, five, six, ten, fifteen, seventeen and eighteen. There is moderate output in tasks numbers four, seven, eight, nine, eleven, twelve, thirteen, fourteen and sixteen.

10. The subject recruited marked output in tasks numbers one, three, four, five, eight, nine, thirteen, fourteen, fifteen, sixteen, seventeen and eighteen. Moderate output appears in tasks two, six, seven, ten and twelve. Task eleven shows marked changing to moderate output.

11. The subject recruited marked output throughout the tasks.

12. The subject recruited marked output throughout the tasks.

In summary: Seven out of twelve subjects recruited minimum output throughout the tasks. Two others show a predominance of marked output. Two subjects show moderate output throughout, and one shows an equal division of marked and moderate output. Nine subjects show a single output indication throughout the tasks.

Subjects numbers seven, nine and ten are the only subjects who exhibited noticeable variance in output as they performed the tasks. These variations, from marked to moderate output, produced some evidence of patterns. There were six tasks requiring full sound in which all three subjects showed marked output. In one task requiring full sound staccato all subjects had moderate output, and this same task performed with soft sound showed the same moderate output for the three subjects.

There was negligible evidence in the recordings to indicate that any subjects modified the recruitment of the upper

lip to meet the changing performance requirements within certain tasks, such as those where notes slurred through the practical range of the instrument.

An examination of the tabulated subject information sheet data for any patterns in the subject profiles which might show a relationship to the upper lip EMG data produced the following results:

The nine subjects who showed a total or a predominance of marked output have other similarities in (1) principal instrument, with the clarinet the principal for seven of them and the saxophone the principal for two, and (2) angle of the instrument, with eight holding the clarinet at an angle of forty degrees or more.

The two subjects showing a total moderate output had negligible patterns in the subject profiles.

The three subjects showing noticeable variance in output had other similarities in (1) chronological age, (2) facial characteristics, (3) amount of mouthpiece in the mouth, with eleven to thirteen sixteenths, (4) angle of the instrument, with fifty to sixty degrees.

A factor which should be taken into consideration at this point is that of the effect of muscle training (muscle tonus) upon EMG analysis. Reference to this is provided by Basmajian (1, p. 96) and supported by DeVries (2).

These sources have demonstrated that EMG potential tends to become longer and the amplitude less for a particular muscle as it is trained. In effect, interpretation of the data becomes more difficult and could be considered less reliable.

This evidence is not to be considered conclusive as far as the present study is concerned, since none of it comes from research utilizing facial muscles or wind instrument performance. It can, however, be of value in offering insight into the present analysis.

An example for consideration of this evidence is the case of the three most experienced subjects: two of them showed marked output in the upper lip throughout the tasks and the other (who would be adjudged the better clarinetist of the three and was observed to have a well formed and firm embouchure) showed only moderate output in the upper as well as the lower lip.

An examination of the recordings reveals the following data pertaining to activity in the lower lip for the twelve subjects, listed by number:

1. The subject recruited marked output throughout the tasks.

2. The subject recruited marked output throughout the tasks.

3. The subject recruited minimum output throughout the tasks.

4. The subject recruited marked output throughout the tasks.

5. The subject recruited moderate output throughout the tasks.

6. The subject recruited marked output in all tasks except numbers five and ten, where moderate output is shown.

7. The subject recruited marked output throughout the tasks.

8. The subject recruited marked output throughout the tasks.

9. The subject recruited moderate output in tasks one through ten, fifteen and sixteen, minimum output in tasks eleven through fourteen, moderate to marked in seventeen, and minimum to moderate in eighteen.

10. The subject recruited marked output throughout the tasks.

11. The subject recruited minimum output in tasks one through twelve, seventeen and eighteen, and moderate output in thirteen through sixteen.

12. The subject recruited marked output throughout the tasks.

In summary: Seven subjects recruited marked output throughout the tasks and one had a predominance of marked

output. One subject had moderate output throughout and one had a predominance of moderate output. One subject had minimum output throughout and one had a predominance of minimum output.

Subjects number nine and eleven had noticeable variance in output through the tasks. They showed minimum and moderate output in a reverse pattern, i. e., one had minimum where the other had moderate.

There was negligible evidence in the data to indicate that any subjects modified the recruitment of the lower lip to meet changing performance requirements within certain tasks.

The examination of the tabulated subject information sheet data for any patterns in the subject profiles which might show a relationship to the lower lip EMG data has produced the following results:

The eight subjects who had a total or predominance of marked output had other similarities in (1) facial characteristics and (2) amount of mouthpiece in the mouth, with six of them measuring eleven sixteenths inch or more.

The two subjects who had a total or predominance of moderate output had negligible patterns in the subject profiles.

The two subjects who had a total or predominance of minimum output had other similarities in (1) experience on

the clarinet, with nine years for each, (2) principal instrument, with the clarinet the principal for both (3) facial characteristics, (4) angle of the instrument, with angles of fifty and fifty-five degrees, and (5) pre-analysis tone quality, with both rated good.

The tasks (numbers eleven, twelve, fifteen through eighteen) involving short notes separated by a rest provided for observation of the manner in which the subjects recruited and relaxed the muscles to start and stop the tone. Nine of the twelve subjects showed obvious parallel use of the upper and lower lip in meeting these task requirements.

The examination of recordings reveals the following data pertaining to activity in the upper buccinator for the twelve subjects, listed by number:

1. The subject recruited marked output in all tasks except numbers five and ten, where there was moderate output.

2. The subject recruited marked output in tasks numbers one, six, seven, ten through fourteen, and sixteen. There was moderate output in numbers two through five, eight, nine, and fifteen, with marked to moderate in seventeen and moderate to marked in eighteen.

3. The subject recruited zero output throughout the tasks.

4. The subject recruited minimum output in all tasks except number one, where there is moderate output.

5. The subject recruited moderate output throughout the tasks.

6. The subject recruited minimum output in tasks numbers one, two, fourteen, and sixteen through eighteen. There is moderate output in tasks three through thirteen and fifteen.

7. The subject recruited zero output throughout the tasks.

8. The subject recruited minimum output in tasks one through ten, and moderate output in tasks eleven through eighteen.

9. The subject recruited minimum output in tasks one, nine, eleven through thirteen, and fifteen. There was no output in the other tasks.

10. The subject recruited marked output in all tasks except number one, where there is minimum output.

11. The subject recruited no output in any tasks except numbers thirteen, with moderate output, seventeen, with moderate, and eighteen, with marked output. In each of these tasks the muscle was recruited after the subject began playing the instrument.

12. The subject recruited zero output in all tasks except twelve through fourteen, where there was minimum output. In each of these three tasks the muscle recruitment varied from zero to minimum output during performance of the task.

In summary: Two subjects had a predominance of marked output. One subject had moderate output throughout and one had predominant moderate output. One subject had predominant minimum output. Two subjects had zero output throughout the tasks, and three had predominant zero output.

Subjects two and eight had noticeable variance in output throughout the tasks. These variances did not form any patterns or similarities.

There was only slight and sporadic evidence in the data to indicate that any subjects modified the recruitment of the upper buccinator to meet the changing performance requirements within certain tasks.

The examination of the tabulated subject information sheet data for any patterns in the subject profiles which might show a relationship to the upper buccinator EMG data has produced the following results:

The two subjects showing predominant marked output had other similarities in (1) principal instrument, with the saxophone the principal instrument of both, (2) appearance of embouchure, with both rated as fair, (3) amount of mouthpiece in the mouth, with both measured at thirteen-sixteenths inch, (4) pre-analysis and in-analysis tone quality, with both rated as fair.

The five subjects who had a total or predominance of zero output had other similarities in (1) principal instrument,

with the clarinet the principal for four of them, (2) amount of mouthpiece in the mouth, with four of them showing eleven sixteenths or more, (3) pre-analysis tone quality, with four of them rated good.

Three of the four most experienced clarinetists had predominant marked or moderate output.

The three subjects using the largest amount of mouthpiece in the mouth also had high output for the upper, as well as the lower, part of the buccinator. These subjects are primarily saxophone players. Their embouchures were rated in appearance as fair and poor but would very likely rate good as saxophone embouchures.

The two subjects who used the least amount of mouthpiece in the mouth also had low output for both parts of the buccinator. Their principal instrument is the clarinet.

Evidence of the upper buccinator being recruited in parallel with the upper lip was negligible.

The examination of recordings reveals the following data pertaining to activity in the lower buccinator for the twelve subjects, listed by number:

1. The subject recruited marked changing to moderate output in tasks thirteen and fourteen, moderate output in tasks one through four, seven through twelve, and sixteen through eighteen. There was minimum output in task five, and zero output in task six.

2. The subject recruited minimum output in tasks one through five, and nine through sixteen. There is moderate output in tasks six through eight, and minimum changing to moderate in tasks seventeen and eighteen.

3. The subject recruited minimum output throughout the tasks.

4. The subject recruited minimum output in tasks one through three and eleven, with zero output in all other tasks.

5. The subject recruited zero output throughout the tasks.

6. The subject recruited marked output in tasks three through eighteen, and moderate output in tasks one and two.

7. The subject recruited marked output in all tasks except two through four, where there was moderate output.

8. The subject recruited marked output in tasks one through five and thirteen. There was moderate output in tasks eleven, twelve, and fourteen through eighteen, with minimum in tasks six through ten.

9. The subject recruited zero output in all tasks except one and fifteen, where there was minimum output.

10. The subject recruited zero output throughout the tasks.

11. The subject recruited marked output in tasks seven through eighteen, with moderate in tasks one through three,

and five and six. There was marked changing to moderate in task number four.

12. The subject recruited marked output in all tasks except number fifteen, where there was moderate output.

In summary: Four subjects had a predominance of marked output. One subject had minimum output throughout the tasks, and one had predominant minimum output. Two subjects had zero output throughout, with predominant zero output showing for two others.

Subjects one and eight had noticeable variance in output through the tasks. They had identical moderate output in tasks seven and eight, and both had a mixture of marked and moderate output in tasks eleven through eighteen.

There was only slight and sporadic evidence in the data to indicate that any subjects modified the recruitment of the lower buccinator to meet the changing performance requirements within certain tasks.

The examination of the tabulated subject information sheet data for any patterns in the subject profiles which might show a relationship to the lower buccinator EMG data has produced the following results:

The four subjects who had predominant marked output had other similarities in (1) private study on clarinet, as each has had some amount of private study, (2) principal instrument,

with the clarinet the principal instrument for three of them, (3) appearance of embouchure, with three of them rated good, (4) amount of mouthpiece in the mouth, with all four subjects measuring eleven sixteenths or more, and (5) pre-analysis and in-analysis tone quality, where three were rated good.

The two subjects who had a total or predominance of minimum output had other similarities in (1) private study, as neither has received any, (2) principal instrument, with the clarinet the principal for both, (3) appearance of embouchure, with both rated fair, (4) average preparation time, with approximately one half second averaged for each of them, and (5) in-analysis tone quality, with both rated as fair.

The four subjects who had total or predominant zero output do not have other patterns or similarities indicated in the subject profiles.

Analysis of the Data

The predominance of marked output in the upper lip activity of these subjects, and the consistency in which this muscle was recruited through the various tasks are good evidence that it is significant in the clarinet embouchure. This evidence is supported even by those subjects who did not show predominant marked output, as they recruited the muscle moderately in a consistent manner.

The similarity in principal instrument for these subjects with predominant marked output could also be considered

supportive to this evidence. The clarinet embouchure normally requires more grip, or tightness of the lips, than does the saxophone embouchure. The subjects who play the clarinet principally, then, could be expected to recruit the muscle in this manner normally, whereas the saxophone principals could be recruiting in this manner to afford the extra amount of firmness required by the clarinet embouchure. The fact that all the subjects who recruited less than marked output did not have this principal instrument similarity gives some further emphasis to this evidence.

The similarity in angle of the instrument for these subjects does not appear at this point to be related to the amount of EMG output. This similarity appears again in this category and another time in lower lip data, but each time with a different type of output.

The three subjects who had variable output produced a pattern of consistant marked output for tasks requiring full sound. This type of recruitment could be seen as normal for the reed instrument player, as it affords an accomodation to the increased air pressure in the mouth which is necessary to produce the full sound called for in the task sheet. This was supported only slightly, however, in data from the other muscles, which was unexpected. One of the primary functions of the buccinator muscle is to give control to the fleshy portions of the cheeks during chewing and to keep this flesh

clear from the action of the mandible. It would appear, in view of this, that there would be recruitment of both parts of the buccinator as a reaction to the increased air pressure. Evidence of this is negligible, however, and there is no evidence of any accomodation to this in the lower lip.

The four subject profile similarities for these same subjects may be accounted for in the following manner: (1) This was the only instance in all the data of a similarity in chronological age, and this for only three subjects. It is, therefore, assumed that this type of data could prove useful only with a larger subject population. (2) Facial characteristics similarity occurred at this point and also in two places in lower lip data. Each occurrence, however, was with a different type of output, and facial characteristics has already been established as a vague area in the subject profiles. This leads to the assumption that more specific data from a larger subject population would be necessary before any evidence of a relationship to the EMG data might be established. (3) Similarity in amount of mouthpiece in the mouth occurred also in lower lip data and upper buccinator data, again, with a different type of output each time. There are indications, however, that a relationship does exist between amount of mouthpiece in the mouth and marked output.

These three subjects did show marked output in the full sound tasks, and most of those subjects with this similarity in other muscles had marked output also. (4) Similarity in angle of the instrument, mentioned earlier, occurred at other times, but with a different type of output for the subjects. There may be an indication that this similarity for these subjects could have some significance, however, when these rather extreme angles of the instrument are compared to the marked output shown by the three subjects for the full sound tasks. It is conceivable that the instrument, held at this large angle, could be forcing the upper lip into a position whereby it is difficult to maintain consistent recruitment except when the air pressure within is rather strong, such as that required for full sound. There was some support of this in lower lip data, and this will be discussed in that category.

The predominance of marked output in the lower lip function of these subjects, and the consistency in which this muscle was recruited through the various tasks are good evidence that it is significant in the clarinet embouchure. Some support to this is given by the subjects showing moderate output, as they did this in a consistent manner.

A comparison of this data to that of the upper lip revealed marked output which was almost identical in amount and consistency for the two muscles. This similarity of data

could have more significance than the amount of output itself. There is a definite indication here that the two lips are employed in parallel and reciprocative function in forming and maintaining the embouchure. Further support of this was provided by the demonstration of parallel recruitment and relaxation of the lips in performing the tasks involving separated short notes.

The similarity in amount of mouthpiece in the mouth for the marked output subjects which appeared here has been referred to previously. These subjects give support to an indicated relationship between amount of mouthpiece in the mouth and marked output in the upper lip, lower lip, and upper buccinator.

The two subjects who recruited predominant minimum output had two similarities which have been mentioned previously. One of these, the similarity in angle of the instrument, gives some support to an observation in upper lip data that extreme angles of the instrument could be affecting normal recruitment of the lip in producing soft sounds, but not affecting it to any extent while producing full sound. Both of these minimum output subjects held the instrument at extreme angles, and one of them had moderate output during most of the full sound tasks.

The similarities of these subjects in experience on the clarinet, principal instrument, and pre-analysis tone quality

could be seen as some support for the effect of muscle tonus. These subjects have played clarinet for nine years, and produced a tone which was rated good in the pre-analysis rating. They produced the tone with minimum output. This could indicate either (1) a well-trained muscle in normal recruitment, or (2) lower lip activity which would be considered unusual for a performer with this amount of experience.

Another observation worth consideration for these two subjects is that both of them had predominant marked output for the upper lip. This evidence would tend to oppose the idea of muscle tonus, since the upper lip would be likely to exhibit training in the same manner as the lower lip. It could be support for the above alternative number two, in that strong upper lip support allows these subjects to achieve good results with less reliance upon the lower lip.

The absence of a predominant type of output for the upper buccinator is quite a contrast to the data on the upper and lower lip. The indication here is that the muscle is used sporadically in forming and maintaining the embouchure. There are, however, some patterns apparent in this data which indicate that the buccinator (both parts) could have significance in forming and maintaining the embouchure.

The subject profile similarities for the subjects who recruited marked and moderate output all point to a positive

relationship between amount of mouth opening and use of the buccinator (both parts). These subjects are primarily saxophone players, and the saxophone mouthpiece requires a larger mouth opening (more space between upper and lower teeth) than does the clarinet. The appearance of embouchure rating and the tone quality rating for these subjects is further support that they are playing the clarinet in the same manner as they would play the saxophone, i. e., the mouth more open and more mouthpiece taken in. There is also support here for the indicated relationship between amount of mouthpiece in the mouth and marked output, which was noted in upper and lower lip data.

The subject profile similarities for the subjects showing minimum and zero output give some further support to the above evidence. Most of these subjects are primarily clarinet players, which is an indication that they would not open the mouth as much as the saxophone players. Two of them used the least amount of mouthpiece in the mouth and the others used a moderate amount, indicating, again, that the mouth is not open as much as with the saxophone players.

The lower buccinator was recruited by these subjects slightly more than was the upper part. There was more predominant marked output and not as much zero output. This indicates a slight pattern of parallel use with the lower lip, which might be expected. The absence of predominant

moderate output could be some evidence that the muscle is either recruited heavily or hardly at all, although this observation is not supported in other data.

The subject profile similarities for the four subjects showing predominant marked output indicate that a clarinet player who has a well developed embouchure and is producing a good tone does employ the lower buccinator in forming and maintaining the embouchure. This is given some support by the similarities of the subjects showing predominant minimum output, as their embouchure appearance and tone quality was rated only fair.

It is also worth note that the marked output subjects had all received some private instruction on the instrument and the minimum output subjects had not. There is an inference here that traditional embouchure pedagogy, which is based upon visual observation of the lower part of the face and noted improvement or lack of improvement in performance, is effective to some extent in bringing about consistent employment of the lower buccinator. This inference is supported by the fact that five of these six marked and minimum output subjects under discussion are primarily clarinet players, and would therefore be seeking the same results in their performance.

There was no substantial evidence of parallel use of the two parts of the buccinator. There was, in fact, rather

striking evidence that the two parts of this muscle are quite capable of functioning as separate units.

This data resulted from the procedures suggested by Basmajian while the laboratory research was in progress. It was found that every subject could recruit marked activity in the upper and lower buccinator jointly and separately with the mouth open and closed. More significantly, each subject was then able to play the clarinet with marked activity in the two parts of the buccinator and also with hardly any buccinator activity.

In this situation no subject required over ten minutes time to learn how to recruit the two parts of the buccinator.

An observation by Basmajian during this portion of the investigation was that the buccinator muscle was apparently able to perform more complex tasks, especially tasks involving separate use of the upper and lower parts, than it had previously been known to do.

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CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The purposes of this chapter are to:

1. Present conclusions which are based upon, and limited to, the data which has been presented and analyzed in the present study.

2. Compare these conclusions with current thought and practice pertaining to the clarinet embouchure as indicated in the discussion of related literature.

3. Bring recommendations for further research as they result from these conclusions and comparisons.

Conclusions

The conclusions from the present study are stated as follows:

1. The upper lip is used consistently in forming and maintaining the clarinet embouchure.

2. There is (1) very little adjustment made in the upper lip in meeting the various performance requirements of the clarinet, or (2) adjustment made which is so minute that the EMG apparatus utilized in the present study received very slight and sporadic output from it, or (3) adjustment made which is the result of the action of facial muscles or of

other causes not included in the present experimental procedures.

3. The persons who have studied and practiced primarily the clarinet make more use of the upper lip in the embouchure than do those who have studied and practiced primarily the saxophone.

4. The upper and the lower lip are recruited in some amount of parallel and reciprocative function in forming and maintaining the clarinet embouchure. Anything affecting lower lip function could, therefore, affect upper lip function.

5. The use of the upper lip in the clarinet embouchure is affected in some way by (1) the angle at which the instrument is held and (2) the amount of mouthpiece taken into the mouth.

6. The lower lip is used consistently in forming and maintaining the clarinet embouchure.

7. There is (1) very little adjustment made in the lower lip in meeting the various performance requirements of the clarinet, or (2) adjustment made which is so minute that the EMG apparatus utilized in the present study received very slight and sporadic output from it, or (3) adjustment made which is the result of the action of facial muscles or of other causes not included in the present experimental procedures.

8. The use of the lower lip in the clarinet embouchure is affected in some way by (1) the angle at which the instrument is held and (2) the amount of mouthpiece taken into the mouth.

9. The upper buccinator is given random and sporadic recruitment in forming and maintaining the embouchure.

10. The upper buccinator may function as a unit separate from the lower buccinator.

11. The use of the upper buccinator in the clarinet embouchure is affected in some way by the amount of opening of the mouth in accepting the mouthpiece.

12. The lower buccinator is used more consistently in the clarinet embouchure than is the upper buccinator. It is not, however, used with as much consistency as the upper and lower lip.

13. The lower buccinator may function as a unit separate from the upper buccinator.

14. A clarinet embouchure which is observed to be correct and which is producing good performance results can be assumed to include some amount of recruitment of the lower buccinator.

15. With the EMG equipment utilized in the present study and instruction by properly trained persons, a clarinetist can be trained in a relatively short period of time to incorporate the use of the buccinator (both parts) into the formation and maintenance of embouchure.

16. The internal fine-wire electrode technique of electromyography offers an effective means of investigating the activity of the upper and lower parts of the lip and buccinator in forming and maintaining the clarinet embouchure.

17. The relative effectiveness of the above technique could be determined by the effect of muscle tonus (muscle training) upon the EMG apparatus.

18. The buccinator (both parts) has the capability of performing more sophisticated tasks than those it had previously been known to perform.

Comparison of Research Conclusions and Available Literature Comment

There is obvious dichotomy in the opinion of most of the available literature sources and the conclusions from the present study regarding upper lip activity in the clarinet embouchure. Most of these sources contend that the upper lip plays a minor role and serves primarily to cover the teeth and seal the corners of the mouth. The present conclusions are that the upper lip is used consistently and with as much recruitment as the lower lip.

One source states that the success of the embouchure depends upon the extent to which the upper lip assumes its share of the activity. The present conclusions support this statement strongly, and particularly in the case of the two

subjects who produced good clarinet tone with minimum lower lip output but with marked upper lip output.

The implication from this comparison is that there is a need for further investigation of the activity of the upper lip in forming and maintaining the clarinet embouchure. Details for this research are implied in the present findings and are presented in the recommendations.

The comparison of present research findings with the available sources in the literature regarding lower lip activity reveals general agreement that the lower lip is significant in the clarinet embouchure. The literature provides very little specific reference to lower lip activity, but activity is inferred in the descriptions of position and initial setting. The importance of the lower lip is also referred to in some of the literature on the upper lip.

It is possible that these sources say little of the activity of the lower lip because they assume every clarinetist is aware of this activity and the importance of it. It is a common assumption among clarinetists that the most important muscular activity in forming and maintaining the embouchure is that of the lower lip.

It is more likely, however, that specific activity in the lower lip is not discussed for the same reasons that other facial muscle activity is not discussed. These reasons

are (1) lack of knowledge of these muscles and (2) lack of terminology with which to work in discussion.

The present research gives some support to the literature on lower lip activity. However, the lack of specific comment on lip activity and the ambigious terminology in the literature, when compared to the detail and precise reference provided by electromyography, are sufficient evidence of the need for further investigation in this area. Details for this research are implied in the present findings, and are presented in the recommendations.

There is no comment in the available literature which makes direct reference to specific activity of either part of the buccinator muscle in forming and maintaining the clarinet embouchure. The use of this muscle can be inferred, however, in the statements of some of the clarinetists making comment. The prevailing opinion of these is that the two parts of the buccinator, and other unspecified facial muscles, are active to some extent in drawing the lower part of the face taut to provide support for the lips in accepting the mouthpiece, and to support against the air pressure inside the mouth and help direct it into the instrument.

Some of this comment implies that the two parts of the buccinator are used primarily in parallel and reciprocative activity. The present research findings offer quite a contradiction to this.

Findings from previous EMG studies of facial muscles, which did not involve subjects playing any wind instrument, present mixed opinions on the use of the buccinator. Some can be interpreted as supportive to the contention that the buccinator is active in the clarinet embouchure, and others do not support this contention.

The present conclusions appear to be in contrast to those of Blanton, et al. (1), and to lend some support to those of De Sousa (2).

Literature pertaining to the bite, or amount of mouthpiece in the mouth, was composed primarily of opinions on precisely how much mouthpiece should be in the mouth, and whether or not every clarinetist should attempt to maintain a certain identical measurement for this. These opinions are varied, and there is no consensus evident. Those sources who favor a certain measurement for all clarinetists do not state specific reasons for their opinion. Some of those who do not advocate a certain measurement for all clarinetists make mention of a need for flexibility to adjust the bite during performance for soft and loud sounds.

The technique for measuring the amount of bite was not detailed in the literature. The inference was that there is no particular technique which has general acceptance among clarinetists.

There was no literature regarding specific effects which the bite would have upon the activity of particular facial muscles during performance on the instrument. There is obvious reference throughout the comment on this aspect of the embouchure, however, to the idea that the bite is significant in embouchure. Clarinetists need factual and precise knowledge of facial muscular activity and a body of terminology in order that ideas and hypotheses may be properly expressed and pursued.

In the present study the amount of mouthpiece in the mouth refers to the space measured from the front of the upper teeth to the tip of the mouthpiece. The measurements for the twelve subjects ranged from seven-sixteenths inch to thirteen-sixteenths inch, which is quite a large strata for only twelve subjects. It tends to support those clarinetists who maintain that the amount of bite should be set by the individual, and that there is no valid reason for prescribing any certain amount to which all clarinetists should conform.

There is some indication in the present data that the amount of mouthpiece in the mouth could have some effect upon the function of certain muscles in embouchure formation and maintenance. Precise data of this nature has been previously unavailable to clarinetists. It provides the

possibility that the bite is a significant factor in the embouchure and further supports the need for more research of this type. Details for this research are implied in the present findings and are presented in the recommendations.

The comparison of present research data with the available literature sources regarding muscular adjustment during performance reveals an obvious contrast. The prevailing opinion in the literature is that there is some type of adjustment occurring quite often during performance, and that this, in one form or another, is necessary to meet the demands of good performance. Terminology is again a problem, but comment in this area is more specific than that in other areas.

The research data, on the other hand, indicates that muscular adjustment during performance is very slight, even negligible. The task sheet was designed to present a thorough sampling of the problems of range and articulation faced by clarinetists, and it was expected that there would be more evidence of adjustment.

A further expectation was that the muscle showing the most adjustment would be the lower lip, as this would support the assumption of many clarinetists that this is the most active and important muscle in the embouchure. There was, however, only minute evidence of this, and that came from the least experienced subject. There was, indeed, stronger

evidence that the lower lip does not become active in adjustments during performance. It was concluded from these findings that there is (1) very little adjustment made in the lower lip by these subjects in meeting the various performance requirements of the clarinet, or (2) adjustment which is so minute that the EMG apparatus utilized in the present study received very slight and sporadic output from it, or (3) adjustment being made which is the result of the action of facial muscles or other causes not included in the present experimental procedures.

This contrast in opinion from the literature and research data provides ample evidence of the need for further investigation in this area. Details for this investigation are implied in the present findings and are presented in the recommendations.

Recommendations

As a result of the information gained and the ideas generated from this exploratory study of the activity of certain facial muscles in forming and maintaining the clarinet embouchure utilizing electromyography, the following recommendations for further research are presented:

1. The need for uniform terminology referring to specific muscular activity in forming and maintaining the

embouchure is quite apparent from the efforts of this investigation and others preceding it. A logical first step toward establishing such terminology would be the detailed examination, with EMG and videoflouragraphy, of all the facial muscles which might be active to any extent in forming the embouchure. These would include the upper and lower orbicularis oris, upper and lower buccinator, platysma, risorius, quadratus labii inferioris, quadratus labii superioris, mentalis, and possibly the canius and the masseter.

2. The effect of muscle training (muscle tonus) upon EMG analysis of muscle function in the embouchure could be significant in future research. Laboratory procedures similar to those of the present study, but utilizing a subject population with defined performance maturity levels, are recommended for further investigation of these effects.

3. Further investigation which pertains primarily to the upper and lower orbicularis oris should proceed pursuant to the following objectives:

A. More documentation to the present evidence of consistent activity of these lip muscles in the embouchure. This could be provided by laboratory procedures similar to those of the present study, but involving several more subjects with a wide strata in performance experience.

B. More evidence to the present question concerning adjustment during performance in these muscles. Laboratory procedures similar to those of the present study, but including (1) several more subjects, particularly some who maintain that they do make adjustment, (2) performance tasks including more stringent requirements in range and articulation than those of the present study, and (3) EMG equipment with the maximum available sensitivity to muscular output, could provide this evidence.

C. More evidence to the present question concerning the effect (1) the angle at which the instrument is held, and (2) the amount of mouthpiece taken into the mouth have upon the function of these muscles in the embouchure. Laboratory procedures similar to those of the present study, but involving (1) several more subjects, with a wide strata in performance experience, and (2) performance tasks which would include (1) holding the instrument at extreme angles and (2) inserting extreme amounts of the mouthpiece into the mouth could provide this evidence.

D. More documentation to the present evidence of synergistic (parallel and reciprocative) activity

of these muscles in forming and maintaining the embouchure. Laboratory procedures similar to those of the present study, but involving several more subjects with a wide strata in performance experience could provide this documentation.

4. Further investigation which pertains primarily to the upper and lower parts of the buccinator should proceed pursuant to the following objectives:

A. More documentation to the present evidence that (1) the two parts of this muscle can be trained to be active consistently in the clarinet embouchure, and (2) each part of this muscle will function as a unit separate from the other part. Laboratory procedures similar to those which produces the present findings, but involving several more subjects with a wide strata in performance experience, could be utilized for this purpose.

B. More evidence to the present question concerning the effect the amount of opening of the mouth has upon the upper part of this muscle. Laboratory procedures similar to those of the present study, but involving (1) several more subjects with a wide strata in performance experience, and

(2) performance tasks which would include inserting extreme amounts of the mouthpiece into the mouth, could be utilized for this purpose.

5. The buccinator (both parts) has demonstrated in the present study the capability of performing more sophisticated tasks than it had previously been known to perform. Using EMG knowledge new to the medical profession as well as to wind instrument performers and pedagogists could come from a more thorough investigation of this muscle.

6. When further EMG, and possibly videoflouragraphic, research has produced a larger body of embouchure knowledge, there will be a need to relate this knowledge directly to pedagogy. A series of exercises, designed to recruit and train certain muscles critical to the embouchure to perform their specific tasks more quickly and efficiently, is suggested as a first step in this direction.

The effectiveness of the EMG equipment utilized as an audio-visual aid to muscle training was made obvious in the present study. This equipment, however, is bulky, sophisticated, and quite expensive. It would be presumptious to expect it to be available for the teacher's studio at any time in the near future.

It is presently conceivable that wind instrument performers and pedagogists could arrange to do observational

and experimental activity in an EMG laboratory to familiarize themselves with muscular activity in the embouchure. With this first-hand knowledge they would be in a better position to enact practical methodology such as the aforementioned exercises.

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APPENDIX A

SUBJECT INFORMATION SHEET

1. Full name _____

2. Age _____ Weight _____ Height _____ Sex _____

SECTION A: To be filled in by subject.

3. Your musical position (student, teacher, professional performer, etc.) _____

   Year in school, if student _____

4. Number of months of years you have played the clarinet.

   _____

5. Have you studied privately? _____ How Long? _____

6. Do you play any other wind instruments? _____

   What are they? _____

7. Have you ever been a subject for EMG analysis before?

   _____

SECTION B: To be filled in by investigator.

8. Appearance of embouchure: Poor Moderate Good

   Comment: _____

9. Shape of face: Oval medium skeletal

   Comment: _____

10. Thickness of lips: full medium thin

    Comment: _____

11. Length of upper lip: Long Medium Short

    Comment _____

12. Position of jaw and teeth: Overbite Even Underbite

    Comment: _____

13. Condition of teeth: Very uneven Moderately Uneven Even

    Comment: _____

SECTION C: To be filled in by subject.

14. What is the brand name and model of your clarinet?

    _____

15. What is the brand name and the facing number of your mouthpiece? _____

16. What is the brand name of your ligature? _____

17. a. What is the brand name and number of the reeds you use most frequently? _____

    b. What reed are you using for this investigation?

    _____

    c. How many hours have you played on this reed? _____

    d. What is your opinion of the reed you are using at this time in terms of strength, response and tone quality? _____

18. Do you consider all of the above equipment to be in maximum playing condition at this time? _____

    Comment (if applicable) _____

19. Amount of mouthpiece taken into mouth (in fractions of one inch) _____

20. Does this appear to change any while subject is playing? _____

21. At what angle is the instrument held? _____

22. Comment on breathing while playing. _____

23. Judgement on tone quality: pre-analysis: good fair poor During analysis: good fair poor

24. Comment on posture while playing. _____

25. Comment on use of arms and hands while playing. _____

_____

26. Comment of subject on how he thinks he played during the investigation. _____

_____

_____

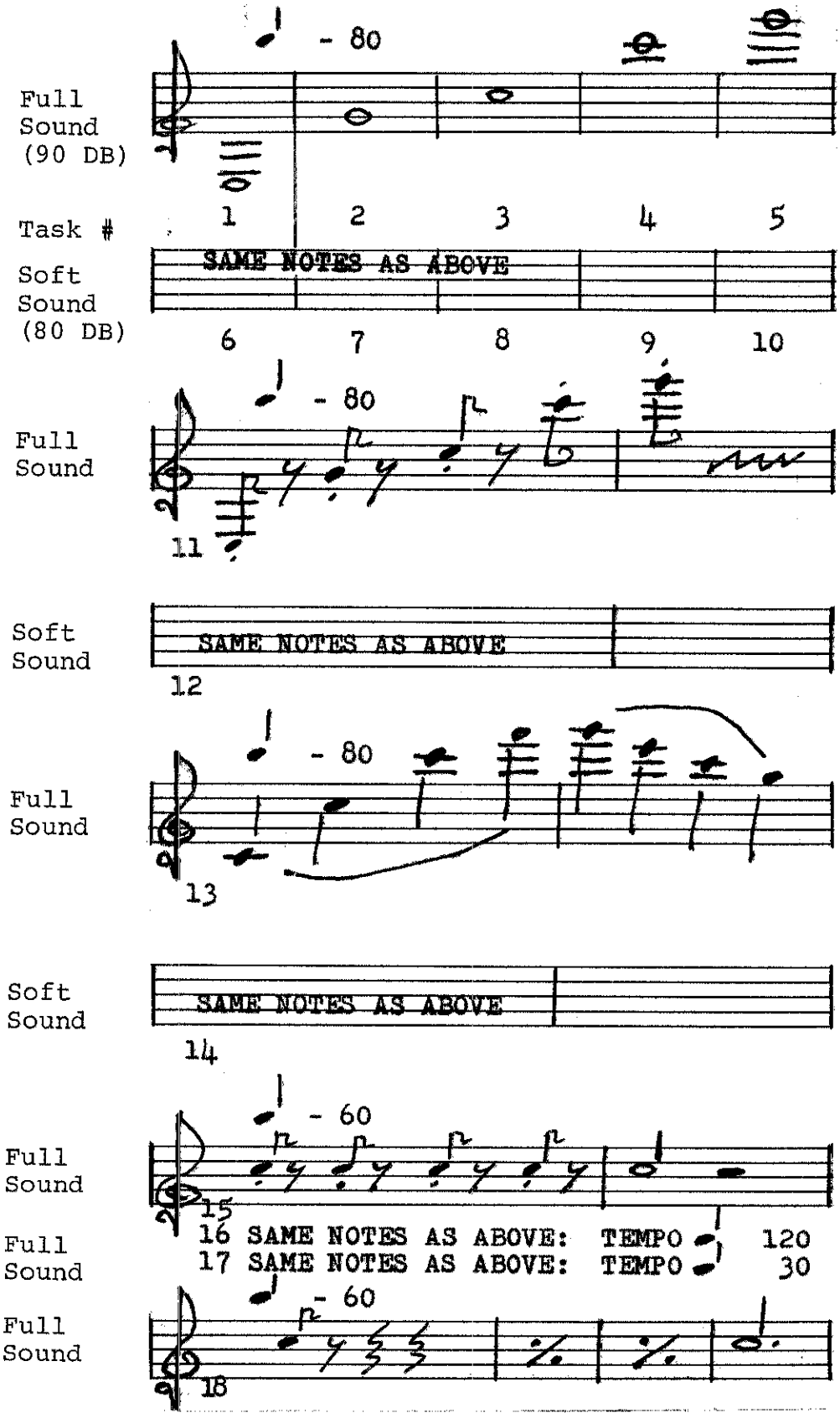
_____

27. Discrepancy in decibel level during analysis. (Five or more decibels either way.) _____

_____

Appendix B

Task Sheet



APPENDIX C

This tabulated subject information sheet data was deleted from the analysis in the present study. It is available here for documentary purposes.

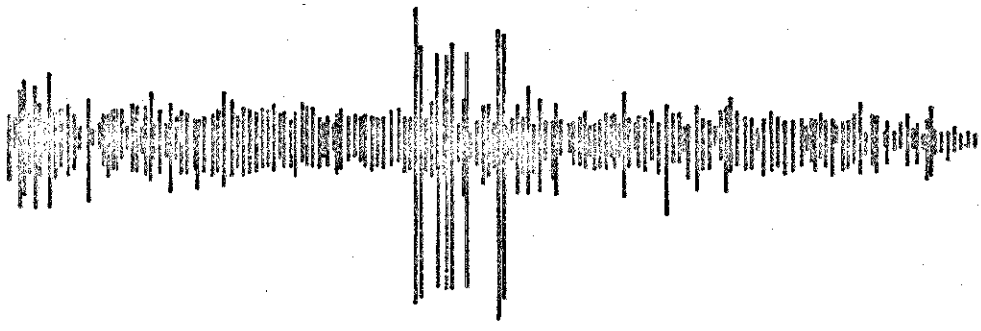
Subjects	Principal Instrument Experience	Shape of Face	Lip Thickness	Make of Mouthpiece	Breathing
1	20 yrs.	Med.	Thin	LeBlanc 4L	Correct
2		Med.	Full	Woodwind 08	Incorrect
3		Med.	Med.	Vandoren	Incorrect
4		Med.	Med.	Kaspar 13	Correct
5		Med.	Med.	Bay 34-11	Correct
6	4 yrs.	Med.	Med.	Bay	Correct
7		Med.	Med.	Kaspar 16	Correct
8		Med.	Full	Newline Custom	Correct
9	10 yrs.	Med.	Med.	Golden-tone 3	Correct
10	5 yrs.	Med.	Med.	Bay	Correct
11		Skel-etal	Med.	Kaspar 16	Correct
12		Oval	Full	Kaspar 14	Correct

APPENDIX D

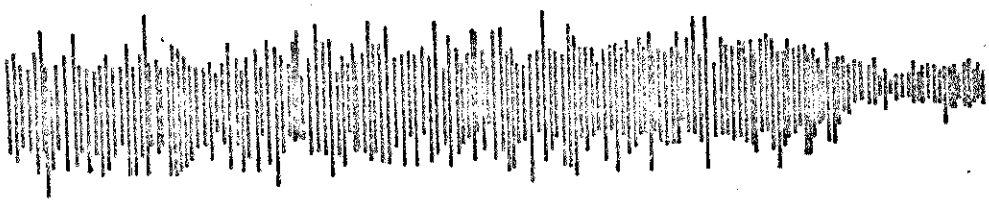
The following tracings from an EMG photo process recording are reproductions of electronic output from a single channel for each of the four scale degrees utilized in the present study. The recorder was tracking at twenty five millimeters per second.

1. Zero output.

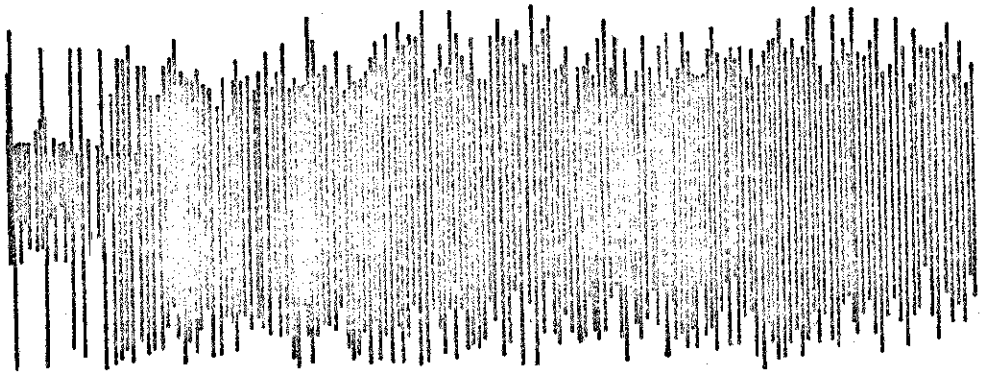
2. Minimum output.



3. Moderate output.



4. Marked output.



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