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Two methods of clarinet pedagogy are predominant. Woodwind methods and beginning band texts reflect the dichotomy and therefore conflict concerning clarinet embouchure formation. One embouchure requires the player to pull back the corners of the mouth, as if smiling. The second method requires the player to bring the corners in towards the mouthpiece, as if saying “oo.” This study measured the effects of clarinet embouchure on timbre and on band director tone quality preferences.

Surface electromyography measured electrical activity differences in the risorius and zygomaticus major muscles, those involved both in smiling and in embouchure formation, to quantify embouchure differences and effects on timbre. “Smile” embouchure muscle electrical activity was significantly greater than that of the “Q” embouchure, thereby quantifying physical differences. Timbre produced by the Smile embouchure showed stronger upper harmonics and significantly stronger signal strength in the formant regions at 1500-1700 Hz and 3700-4300 Hz than the Q embouchure.

Subjects (N=46) were randomly selected members of the National Band Association, who completed a 20-item paired-comparison tone quality survey. Two graduate clarinet majors played each survey item. One played with the corners of the mouth pulled back and the second played with the corners forward. Subjects did not prefer tone quality based upon embouchure differences as measured by a chi-square goodness of fit: $c2$ (1, N-46)=.783, $p<.376$. However, a *post-hoc* t-test of the ratio of the number of Q embouchure preferences to Smile embouchure preferences by subject

showed a significant preference for the tone quality of the Q embouchure over that of the Smile embouchure: M=2.024, SD=2.920, $t(45)$=2.378, p<.05, d=.351, w=.63. Subject responses did not differ significantly by race, gender, education, job description, majors instrument, or woodwind text that was used. There were no significant interactions between factors. Test instrument reliability was α=.55.

This study was the first of its kind and sought to quantify factors previously thought subjective. Results indicated a relationship between the Smile embouchure and the prevalence of higher overtones and, therefore a “brighter” tone. Band directors, however preferred the “darker” tone of the Q embouchure.

THE EFFECTS OF CLARINET EMBOUCHURE ON BAND DIRECTOR TONE QUALITY PREFERENCES

by

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APPROVAL PAGE

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CHAPTER I

PROBLEM AND PURPOSE

Teaching beginning band students how to achieve characteristic tone quality is an important skill for middle and high school band directors. A correctly formed embouchure, with sufficient breath support, is one of the first tasks that beginning wind instrumentalists attempt to master. Currently, woodwind methods texts and beginning clarinet books reflect an inconsistency in how to form the clarinet embouchure, leaving band directors and college woodwind methods instructors either unaware of or faced with discrepancies in how to teach clarinet embouchure.

While there are a number of variations, two key components of clarinet embouchure differ. The first is whether the corners of the mouth pull away from the mouthpiece as if smiling or come forward towards the mouthpiece. The second component concerns how the tongue position directs the air stream through the oral cavity: is the middle of the tongue high, as is produced when saying "hee" and producing a fast air stream, or should it be low, as is produced when saying "haa" or "ho" producing a slower air stream? The result of this lack of agreement is a lack of consistent tone quality in clarinet sections and corresponding difficulties with clarinet section and band intonation and blend. Questions exist about whether tone quality differences, attributable to the abovementioned embouchure differences, are discernable to the non-clarinetist and whether differences in tone quality are necessarily undesirable, or even more importantly, whether there is agreement on characteristic clarinet tone quality.

Tone quality is an important aspect of instrumental performance. Technically proficient players lacking pleasant tone quality are likely to be unsuccessful. The same precept applies to the performing ensemble; instrumental ensembles may play the most technically challenging literature only to fall short because bad tone quality contributed to a marred performance. Schleuter (1997) called tone quality, "The most important instrumental skill to be developed . . . Other instrumental skills and musical attempts are not productive if a solid basis for tone production and quality is not established first" (pp. 122-123). According to Kohut (1985), "The first performance objective is to produce a reasonably centered tone, one that is characteristic of the maximum resonance potential of the instrument being played" (p. 145). Bencriscutto (1993) wrote, "Tone is number one, more so than rhythm" (p. 359). Casey (1993) described his views about teaching tone quality, "The connection I want them to make is that the parameters of blend, intonation, etc. are almost wholly dependent upon tone quality. I cannot address intonation, blend, and to some extent balance, without dealing with tone quality, because I see dealing with tone as the umbrella criterion" (p. 365).

Statement of the Purpose

The purpose of this study was to determine the effects of embouchure on band director clarinet tone quality preferences. The study addressed three research questions. The first question involved quantifying prescribed embouchure differences: "Are two clarinet players' embouchures significantly different in relation to the electrical activity in the risorius and zygomaticus major muscles as measured by surface electromyography?" The second research question addressed the effect of mechanical embouchure differences on sustained tone timbre: "Is there a significant difference in the signal strength, measured in dB, of the first nine harmonics and within the two formants in sustained clarinet tone signal envelopes?" The last question related embouchure and tone quality differences to band director preferences: "Is there a significant preference for one clarinet tone quality based upon the effects of two different clarinet embouchures?"

The first research question was, "Are two clarinet players' embouchures significantly different in relation to the electrical activity in the risorius and zygomaticus major muscles as measured with surface electromyography?" Risorius and zygomaticus muscles activate when the corners of the mouth are pulled back and upward, as when smiling. Determining significant physical embouchure differences was both an important step towards quantifying factors that had previously been highly subjective, as well as a means of identifying each player with the one of the respective embouchure types.

The second research question was related to the effects of embouchure on the acoustic aspect of tone quality: "Is there a significant difference in the signal strength, measured in dB, of the first nine harmonics and within the two formants in signal envelopes of sustained clarinet tones?" The study involved analyzing the signal strength of first nine harmonics and those harmonics that fall within the two formants in each of five recorded sustained tones. Identifying harmonic strength differences, related to physical embouchure differences, was again an opportunity to quantify what had previously been subjective. Teachers often use subjective terms such as “dark,” “bright,” “focused,” or “spread” to qualify tone quality. Clarinet players, who tend to play with the corners of the mouth pulled back, as if smiling, have a brighter sound, while those who play with the corners of the mouth in towards the mouthpiece have a darker sound. A prevalence of strong upper harmonics, particularly those in the formant regions at 1500-1700Hz and 3700-4300Hz, would qualify as brighter tone. Research question two was an effort to remove subjectivity and quantify tone quality differences, as well as to determine the effects of embouchure on timbre.

The last research question of this study addressed whether mechanical embouchure differences impact band director tone quality preferences: “Is there a significant preference for one clarinet tone quality based upon the effects of two different clarinet embouchures?” A preference for one tone quality should inform and guide teachers to improved and more consistent clarinet section tone quality. Conversely, if there is no significant preference, one might either assume that there is a lack of agreement about characteristic clarinet tone quality, or that additional research is needed to further isolate and quantify additional physical embouchure differences and their effects on band director tone quality preferences.

The first of a two-part tone quality survey captured subject background and demographic information. The remaining part of the survey measured tone quality preference, based upon paired comparison evaluation. Possible outcomes of the survey were that band directors would not prefer one tone quality based upon clarinet embouchure. The other possibility was that band directors would prefer one corresponding tone quality to the other. The alpha level for determining statistical significance for this research question was $a = .05$ on all tests.

Background of the Problem

It is common for instrumentalists to disagree about pedagogical concepts and clarinetists are not immune to disagreement about the best tone quality. Most clarinetists will agree that characteristic tone quality is dark (which implies stronger lower overtones in the sound spectra), but differences occur over the amount of "ring," or prevalence of higher overtones in the sound. Ridenour (2000) uses the term "ring" when describing the good qualities in the clarinet tone. Before the era of modern world travel, clarinetists were geographically segregated; clarinetists in France and Germany played with widely different tone qualities on dissimilar instruments. Pino (1980) said,

> The word heard most often, perhaps, in connection with the prevailing tone quality of German clarinetists, is 'dark.' Darkness, in this sense, is taken to mean a sort of deep fullness of sound, and a sound that lacks a penetrating, almost harsh, 'edge.' We can say, then that the prevailing German clarinet tone quality is dark and full, as opposed to being 'bright' or 'edgy.' At the same time, however, the German sound is compact and 'contained'; that us, it is not what could be called a 'spread' sound. (p. 225)

Clarinet maker, Fox (n. d.), suggested that German clarinetists were known for their "dark" tone quality, while the French sound contained additional higher overtones; tone quality differences were due, partly, to differences in the French instrument's poly-cylindrical bore and the German cylindrical bored instruments. The French clarinet upper joint is wider at the top end and narrows at the end where it meets the lower joint. The lower joint, then, is narrow at the top and flares over the length of the tube. Adjustments to the upper joint were originally made to improve intonation. The German clarinet, by contrast, is a relatively straight cylinder lacking the additional bore flares (n.d., The German Clarinet Bore, ¶ 2). Pino (1980) describes the French clarinet sound as "bright, clear, and fluid; in addition, it possesses a certain 'edge' that carries it out beautifully across the orchestra and solo passages (p. 228). Over time, American clarinetists adopted the French clarinet—all the while striving to achieve the darker German sound. At the same time, clarinetists adopted two different methods of clarinet embouchure.

Technology contributed to changes in tone quality. With the advent of modern air travel, prominent European clarinetists immigrated to the United States, bringing with them European pedagogy and tone. As they started to teach in America, their concepts of tone and embouchure pedagogy influenced their new students. Also, American clarinetists were soon able to hear audio recordings of the finest players in the world. Pino (1980) said,

> The advent of recorded sound . . . significantly influenced American clarinetists. After all, recordings enable musicians to hear the playing styles of Europeans and Americans. It could be that we are now evolving a uniquely American style . . . a primarily bright, fluid, and clear American sound has been deepened and darkened to some extent by truly first-rate American clarinetists. Brightness, in the French sense, has been replaced or at least tempered by an element of that wonderful 'woody' darkness heard in German playing. What makes the particular American version of this German woodiness so marvelous to hear, however, is that it is coupled with that equally delicious French 'edge'; the resulting sound is rich, full, and expressive with just enough of that tonal edge to carry the sound across a symphony orchestra with ease. (p. 229)

Operational Definitions

To understand the technical aspects of those components that affect a listener's tone quality perceptions, it is necessary to examine physical processes that contribute to tone quality. Tone quality is the human perception of timbre, those physical properties outside of pitch and loudness, that allow listeners to discriminate differences between a trumpet and a clarinet, or in this case, between two different clarinets. Embouchure differences contribute to variance in timbre, and therefore in tone quality perceptions.

Timbre

Hall (2002) defines timbre as "the psychological impression of what characterizes a tone besides its pitch and loudness." Grey and Moorer (1977) define timbre as the overall distribution of sound energy across the steady state harmonic spectrum. The steady state portion of the harmonic spectrum is that portion of the sound exclusive of the initial low amplitude, high—and often inharmonic—frequencies that occur in the initial transient, or onset. The onset of any complex tone occurs in the initial 10-50 microseconds. Formants contribute to tone quality differences and are defined as, "a region of frequency (or pitch) in which the spectrum envelope is likely to have a peak" (Campbell & Greated, 1987, p. 154).

Embouchure

The embouchure is the way that a player forms the mouth when playing a wind instrument. It involves both the external components, such as the facial muscles as well as internal components, such as the oral cavity and the tongue position during playing. Stein (1979) defined the embouchure in this way,

> Embouchure concerns the manner of holding the lips and associated flesh around the mouthpiece to effect a seal. More importantly, the embouchure (aided by the breath) controls the many varied tone colorings, pitch changes, degrees of tonal strength, and nuances . . . (p. 27)

Smile Embouchure

The “Smile” embouchure (see Figure 1) requires the player to pull the corners of the mouth away from the mouthpiece, helping to flatten the chin. Lurie (1959, ¶6) said, “I maintain that if the corners of the mouth are brought back properly, the embouchure takes on a flat, pulled-back aspect. In this way, the muscles of the face and chin will naturally follow in this flat conformation. When pulling back the corners of the mouth, the lip pad produced by the shape of the lower lip and which supports the reed, is stretched and is firm and thin.” A thinner lip pad results in a brighter sound.

Figure 1. ***The Smile Embouchure***

Therefore, teachers of the Smile embouchure instruct students to blow through the instrument as if yawning with the mouth closed, which means that the tongue is very low in the mouth, creating a large, open oral cavity (Stein, 1958). The low-tongue oral cavity results in air moving through the oral cavity at a slower rate. Tones played with less sound pressure lose the strength of their higher partials (Roederer, 1995, p. 138), though players of the smile embouchure still have a brighter sound. One goal of this study was to determine whether pulling the corners of the mouth back, as if smiling, affects the physical properties of clarinet timbre.

Q Embouchure

The second clarinet embouchure requires that the student bring the corners of the mouth forward towards the mouthpiece, as if saying “Q” or “ooo,” while blowing through the instrument with a high tongue position, as if saying “hee” and will be referred to as the “Q” embouchure (see Figure 2). The Q embouchure, in contrast to the Smile embouchure, creates a thicker lip pad on which the reed will rest and vibrate. The thicker lip pad dampens the higher overtones, and the smaller oral cavity created by a higher tongue position, results in a faster air stream. Like the compromise between a thin lip pad and low tongue position of the Smile embouchure, the Q embouchure allows just enough upper harmonic strength to produce ring in the tone, and is yet a “darker” tone.

The Face and Facial Muscles

Clarinet players activate several facial muscles when forming the embouchure. Zygomaticus major and minor muscles pull the lateral corners of the mouth upward and, therefore, are the “smiling muscles” (Marieb, 2004, p. 335).

Figure 2. *The Q Embouchure*

The risorius muscle tenses the lips, draws the corners laterally, and works with zygomaticus muscles. “Risor” is the Latin term for laughter (Marieb, 2004). The orbicularis oris closes the lips as well as purses and protrudes the lips. The depressor anguli oris acts as an antagonist to the zygomaticus muscles and draws the corners of the mouth downward when frowning or grimacing. Masticatory muscles, such as the masseter, temporalis, medial pterygold, lateral pterygold, and buccinator, facilitate chewing (Marieb & Mallat, 2001).

TMJ

The temporomandibular joint (TMJ) is the jaw joint. TMJ is also an acronym for temporomandibular joint disorders. Marieb and Mallat (2001) said, “Because of its shallow socket, the TMJ is the most easily dislocated joint in the body. Even a deep yawn can dislocate it” (p. 227).

Electromyography

Blanke and Stergiou (2000) defined electromyography and its uses:

> Electromyography (EMG) provides data on muscle activity. Electromyography records electrical changes that occur in a muscle during or immediately before contraction. This electrical activity can be captured, amplified, filtered, and recorded as an indication of muscle activity during a performance. (p. 108)

Basmajian and De Luca (1985) defined electromyography as “the study of muscle function through the inquiry of the electrical signal the muscles emanate” (p. 1). Electromyography measured external physical embouchure differences between two clarinet players who produced the tone quality samples for this study.

There are two different types of electrodes used in EMG studies: surface electrodes, which measure electrical changes within the body of the muscle and are attached to the skin surface, and fine wire indwelling or needle electrodes, which measure specific muscle fiber electrical changes and are inserted directly through the skin into the muscle (Heuser & McNitt-Gray, 1993, p. 98). The researcher employed surface electrodes in this study because they measure a larger muscle area and because needle electrodes would be invasive, not to mention uncomfortable, for the volunteer players. Surface electromyography (sEMG) measured risorius and zygomaticus major muscle electrical activity and the degree that the corners of the mouth draw away from the mouthpiece.

Noise

Noise is any unwanted electrical signal, such as those from fluorescent lights and radios. Noise can also occur when electrodes move or shift during a recording session (Loeb & Gans, 1986).

Filtering

Filtering EMG signals reduces noise and accentuates targeted data (Loeb & Gans, 1986).

Timbre Descriptors

"Bright" tone quality contains a prevalence of high overtones, while "Dark" tone exhibits weaker high overtones and/or a prevalence of lower overtones (Roederer, 1995).

Limitations of the Study

Clarinetists continually strive for a dark tone quality with just enough high overtones to produce ring. Players compromise on lip pad thickness, the amount of facial muscle tension, oral cavity size, and on tongue position. Risorius and zygomaticus major muscle activity is only one facet of clarinet embouchure. Many components work together to form a clarinet embouchure, only one of which is muscle tension in the corners of the mouth. Tongue position, or "voicing," plays an important role in tone quality. This study ignored tongue position because of the difficulty in quantifying tongue position in the oral cavity. Another unmeasured embouchure component is tension and downward pressure from the upper lip. Again, this study only examined the effects of risorius and zygomaticus major muscle tension on clarinet timbre and band director tone quality preferences.

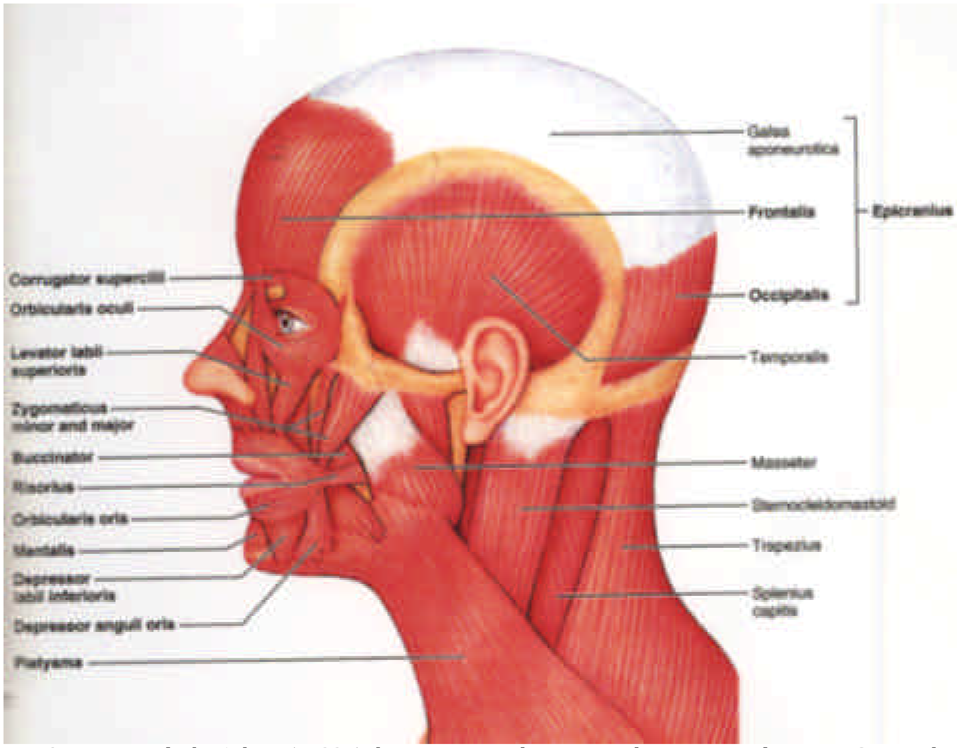
CHAPTER II

REVIEW OF LITERATURE

This study was the first of its kind, thus there are no comparable studies. Literature concerning the form and function of the risorius and zygomaticus muscles is included and is important for understanding how those muscles participate in clarinet embouchure. Information concerning facial electromyography studies, particularly with wind instrumentalists, is also included. The researcher sought to provide a foundation of existing literature related to physical attributes of timbre and subjective evaluations of tone quality, literature concerning the effects of embouchure on tone quality, embouchure discrepancies in pedagogical texts, and preference measurement methodology.

Facial Muscles

To objectively differentiate between the two clarinet player embouchures, it is necessary to measure muscle tension in the facial muscles. Identifying the facial muscles responsible for moving the corners of the mouth back, and away from the mouthpiece, is the first step in measuring differences. Marieb (2004) identified two muscle sets that are responsible for smiling: the zygomaticus, a muscle pair that extends diagonally from the cheekbone to the corner of the mouth; and, the risorius, a muscle that is inferior and lateral to the zygomaticus. According to Marieb, the zygomaticus "raises the lateral corners of the mouth upward," while the risorius "draws the corner of the lip laterally; tenses the lips; and, acts as a synergist of the zygomaticus" (see Figure 3).



From *Human Anatomy and Physiology* (p. 337), by E. N. Marieb, New York: Pearson Education. Copyright 2004 by Pearson Education, Inc. Reprinted with permission.

Figure 3. ***The Facial Muscles***

Surface Electromyography Studies of the Face

There have been a number of studies that used electromyography to measure facial muscle electrical activity. Some studies employed electromyography with dental problems, such as TMJ, while others were concerned with understanding muscle definition. Lapaatki et al. (2006) used electromyography to define topographical characteristics of the lower facial muscle motor units (nerve–muscle connections). They used a new, highly flexible multi-electrode grid, designed specifically for the contours of the face. Root and Stephens (2003) used EMG to study the electrical activity correlations between pairs of muscles in the face, as they contribute to facial expression. Lund, Widmer, and Feine (1995) used EMG output as a means to diagnose potential temporomandibular disorders, such as TMJ. They did not find EMG a valid clinical diagnostic tool. Kelman and Gatehouse (1975) reviewed literature concerning using EMG in phonetics and found a general inconsistency in electrode placement across the research. They used small silver cup EMG electrodes, filled with electrode jelly and attached with adhesive disks, to measure electrical activity of the orbicularis oris during the production of phonetics. They attached the ground electrode to the subject's forehead. They also found that there was minimal difference between the electrical activity on the left and right sides of the orbicularis oris, signifying bilateral symmetry.

White and Basmajian (1974) did a landmark study of trumpet player facial muscle electrical activity using needle electrodes, or fine-wire electromyography. They found significant differences in electrical activity between advanced and beginning players. They also found differences in EMG activity across registers and differences across the four muscles that they measured, based upon playing level. Researchers found that beginning players have greater electrical activity in the upper lip than advanced players. While the White and Basmajian study concerned trumpet players, whose embouchures tend to change across registers, this study was one of the first to use EMG to measure wind player embouchure differences and is cited in the two clarinet studies discussed subsequently.

Heuser and McNitt-Gray (1993) used electromyography to study muscle activity of trumpet players with asymmetrical mouthpiece placement in an effort to provide insight into the effects on mouthpiece placement on trumpet playing. Researchers applied surface electrodes to the zygomaticus major and the depressor anguli oris, and used a ground or reference electrode placed on the left collarbone. While they did not find that mouthpiece placement affects embouchure function, they did find several factors that may have contributed to lack of reliable results: “slight variations in skin preparation, electrode placement, and the interaction of the electrolyte and the electrode may alter the magnitude of the output of the transducer” (p. 101). Heuser and McNitt-Gray (1998) did a case study of the application of EMG to trumpet instruction. In their study, they found that burst pattern clarity improves and random muscle activity decreases as a trumpet player develops in training. Findings indicate that as trumpet player embouchures develop, players tend to isolate facial muscular activity and thereby eliminate interference from adjacent facial muscles and, therefore, EMG signals reflect less interference noise. As in their previous study, they measured muscular activity in the zygomaticus major and the depressor anguli oris but this time used EMG data to help a trumpet student suffering from pain and tension in the upper lip, as well as a callus on the upper lip, and performance issues. The student subsequently used EMG printouts to supplement regular instruction to effect performance improvements.

There have been two clarinet dissertations concerning the use of EMG on facial muscles. Campbell (1999) used EMG to study the masticatory muscles of clarinet players, in an effort to compare the electrical activity of clarinet playing with that of chewing. Subjects participated in four groups of tasks: (a) resting, biting, and resisting tasks; (b) speaking tasks; (c) playing tasks; and (d) chewing tasks. She took EMG readings throughout the tasks and compared differences in muscle activity. She found that clarinet playing EMG readings were similar to EMG readings for eating and suggested that clarinet playing may contribute to jaw problems or exacerbate existing jaw problems. Belcher (2004) used EMG to measure clarinet player orbicularis oris muscle fatigue and determined that clarinet players, like athletes, require a recovery period after continued periods of playing and performing.

Electromyography is becoming a useful tool for measuring muscle electrical activity and will likely continue to be used in music pedagogy and injury prevention. Previously there were no objective measures of muscle activity related to embouchure differences. Surface electromyography allows for objective differentiation between clarinet embouchures. Results from this research may lead to additional research, a new woodwind methods text, or revisions to current materials.

Tone Quality

Tone quality, or timbre, is the tonal attribute that distinguishes tones of identical pitch, loudness, and duration (Radocy & Boyle, 1997, p. 101). Unlike pitch and loudness, which are single dimensional sound attributes, timbre is multi-dimensional: taking into consideration pitch and amplitude of the various partials that make up a complex tone such as that produced by the clarinet (Lipscomb & Hodges, 1996). Plomp (2002) states that testing for listeners' abilities to differentiate between timbres is more difficult than testing for loudness or pitch, as both can be represented one-dimensionally. Timbre, again, is multidimensional, and timbre perception depends on the amplitude strength of the various harmonics within a particular signal shape.

Timbre discrimination depends upon the partials in a signal envelope as well as the attack and decay of the tone (Lipscomb & Hodges, 1996). The ear is a frequency analyzer that, in turn, is able to fuse the individual harmonics of a complex tone into a single sound. Though the listener does not usually hear the individual harmonics in a complex tone, those same harmonics and their individual amplitudes, are what help to define timbre. The first six to eight harmonics of a complex tone activate the central pitch processor, a "neural unit" which allows us to differentiate between different timbres and also contributes to identification of a complex tone with its fundamental. Roederer (1995) stated the following: "It is assumed that we have built into our central processing system basic *templates* with which to compare the complex structures of spatial excitation pattern from the basilar membrane. Whenever a match is achieved, a unique pitch sensation is elicited" (p. 61).

Benade (1992) states that complex tones, such as those of the clarinet, have a "recipe" of partials that differ from note to note throughout the range of the instrument and which differentiate that instrument from others. Plomp (2002) also stated that the overall slope (shape) of the sound spectrum of a complex tone is what determines how timbre is perceived. Westphal (1990) states, "The quality of a tone is determined by the sound wave produced. The best waveform will produce a good quality, another shape(d) wave will produce a poor quality" (p. 287). Backus (1977) suggests that the structure of individual tones changes with increased amplitude and through the range of the instrument:

> For a particular instrument, the structure of a given single tone will depend on a number of factors. It changes with loudness, for example; soft tones will generally have rather few harmonics while loud tones will have many more harmonics covering a greater frequency range. The spectrum of a tone will also depend on how the player produces it. Furthermore, the instrument itself is not consistent throughout its range; the spectra of tones in the high ranges will be quite different from those in the low, and even adjacent tones in the scale of the instrument will frequently show considerable differences in harmonic structure. (p. 117)

Tones in the chalumeau register of the clarinet, written E_3 to $F\#_4$, show "an almost complete absence of the second harmonic . . ." (Fletcher & Rossing, 1998, p. 490). When playing the clarinet in the upper clarion range, written A_5 to C_6, the "second harmonic is quite strong, perhaps because it has been reinforced by reed and vocal-tract resonances . . . In this upper register, the clarinet has largely lost its characteristic hollow tone" (Fletcher & Rossing, 1998, p. 491). Very soft blowing pressure makes a sinusoidal signal and a drop in higher overtones. As the amplitude increases, due to greater air pressure associated with higher tongue position, the upper harmonics appear in greater strength and a degree of "brightness" occurs in the sound (Roederer, 1995). Please see Appendix A for graphs of sustained tone signal envelopes.

Tone Quality Studies

Individual tone quality studies relate to those that involve intonation perception. In one study of the effects of tone quality changes on intonation and tone quality ratings, subjects rated a bright clarinet tone quality worse than a dark tone quality (Geringer & Worthy, 1999). Madsen and Geringer (1981) studied the accuracy of tone quality and intonation ratings by music majors and non-music majors and found that when subjects were evaluating tone quality, they were actually responding to intonation differences.

Worthy (2000) studied the relationship between tone quality and intonation and found that subjects judged bright tone qualities sharper in pitch and dark tone qualities flatter in pitch. Pitt and Crowder (1992) studied how subjects retained timbral mental imagery, like the templates prescribed by Roederer, and found that subjects used spectral properties of timbre instead of the dynamic properties (onset/attack and decay) in developing a mental image of timbre.

Tone Quality, Embouchure, and Pedagogy

Clarinetists continually strive to obtain the perfect sound—a blend of just the right combinations of partials—that is pleasing to the widest audience. Embouchure is a major factor influencing tone quality. Most teachers agree on the importance of a flat chin but disagree about the remainder of the embouchure. The amount of lower lip taken into the mouth is important, as is the degree of tension of and the thickness of the lip pad. This lip pad becomes the crucial resting place of the reed, attached to the mouthpiece, and it dampens the vibrations of the reed and presses against the reed to bend it slightly towards the lay of the mouthpiece—that portion of the mouthpiece that slants away from the reed (de Villiers, 1998). This dampening affects the amount of higher partials in the timbre, which is an important factor in obtaining the dark tone quality (Pay, 1995). Backus (1977) stated that tones with many high frequency harmonics tend to sound brighter.

Formants, fixed frequency regions emphasizing specific harmonics, may affect tone quality. Presence of and differences in formants, regardless of the fundamental, may contribute to tone quality differences (Backus, 1977). Roederer (1995) describes the formant as such:

> A broad resonance region that enhances the upper harmonics lying in a fixed frequency range is called a *formant*. A musical instrument (its resonator) may have several formants. It is believed that formants, that is, the enhancements of harmonics in certain fixed, characteristic, frequency intervals are used by the auditory system as a most important 'signature' of a complex tone in the process of *identification* of a musical instrument. One of the reasons in favor of this hypothesis is the fact that formants are the only invariable characteristic common to most, if not all, tones of a given instrument, whereas the spectrum of individual tones may vary considerably from one note to the other. (pp. 128-129)

De Villiers (1998) discussed the importance of an additional formant created in the vocal tract of the clarinetist, and the importance of vowel sounds: "When a formant is strong enough and in the frequency region of the vibration of the reed is attained, the reed is influenced. Consequently, the waveform of the clarinet is altered and both tone production and tone quality are affected" (de Villiers, 1998, p. 50). Backus (1977) also suggested that two formants exist in clarinet timbre, between the frequencies of 1500-1700 Hz and between 3700-4300 Hz.

Clarinet teachers do not always agree concerning embouchure pedagogy. Colwell and Goolsby (1992) said, "Clarinet embouchures vary a great deal among students and are described very differently by teachers and professional players" (p. 252). Clarinet embouchure is taught two different ways: one where the corners of the mouth are brought back as if smiling and another where the corners of the mouth are brought forward as if saying "Q." Those players who pull back the corners of the mouth often play with a low tongue position (as if saying "haa"), while clarinetists who push the mouth corners forward often play with a higher tongue position (as if saying "hee").

Instructors who utilize the Q method instruct their students to bring the corners of the mouth in and forward as if whistling or saying "Q" or "OO" (Burke, 1991;

Gunlogson, 2006; Hatch, 2001, Ridenour, 2000). This very movement of the lips forward helps to eliminate a potential air leak from the corners of the mouth, reduces fatigue, and contributes to making a slightly thicker lip pad. De Villiers (1998) said that bringing the corners of the mouth forward contributes to a reduction in some of the upper partials in the sound. Klug, (1996) in *The Clarinet*, made the analogy of the lips and mask working in opposite directions:

> By cultivating the gripping pressure of the lips towards the mouthpiece, counterbalanced by the surrounding muscles pulling away from the mouthpiece, one begins to achieve the finesse and control necessary for artist-level clarinet playing. Without the pulling away control of the mask, the embouchure becomes a kind of fist, gripping the reed and mouthpiece excessively and producing a tight, small tone with limited endurance and considerable sharpness in pitch. (p. 16)

Suggestions to pull back the corners of the mouth, as if smiling, result in the Smile embouchure. Stein (1958), in *The Art of Clarinet Playing*, describes the corners pulled up into a quarter-shaped moon. Kirkbride, who wrote the clarinet section in *Teaching Woodwinds: A Method and Resource Handbook for Music Educators*¸ advocates the smile embouchure: “I prefer the one that can be described in terms of ‘smiling.’ The corners of the mouth are pulled back, stretching the red part of the lower lip, which is then pulled over the lower teeth” (Kirkbride, 1998, p. 99). Timm (1971), who authored the method book, *The Woodwinds: Performance and Instructional Techniques* advocated drawing the lips back into a “slight smile” and at the same time, point the chin so that the lower teeth press forward against the reed. Lurie (1959) suggests that clarinetists draw back the corners of the mouth into a smile, with the lip pad firm, but without pinching or biting that contribute to air escaping from the sides of the mouth. Pay (1995), a well known clarinet recording artist, states in *The Cambridge Companion to the Clarinet*, that if the lower lip is "flexed," it leaves a smaller "footprint" on the reed and the resultant sound is richer in the upper partials and the prevalence of higher partials contributes to the perception of a brighter tone quality (Singh & Hirsch, 1992).

Teachers of the Q embouchure disagree with those who advocate a thin lip pad. Portnoy, who taught clarinet at Julliard and Curtis, said, "Generally speaking, a tightly contracted lip pad (muscle) produces a more intense and strident tone; and, conversely, a relaxation of the lip muscle produces a mellowness" (Portnoy, 1956, p. 1). Westphal, in *Guide to Teaching Woodwinds*, does acknowledge both schools of thought. He endorses the thicker lip pad, but acknowledges the thinner one as well:

> shape the lips as if saying the letter 'O.' The corners of the mouth are slightly compressed, and there are wrinkles in the lips, especially the lower lip. This produces a firm, thick cushion to support the vibration of the reed. The thinner cushion preferred by many fine teachers is formed by pulling the corners of the lip back to stretch the lower lip to the required degree. (Westphal, 1990, p. 70)

Table 1 shows the major college woodwind methods texts and how each one addresses clarinet embouchure.

Beginning band methods, used by band directors in the instrumental music classroom, also reflect differences in how clarinet embouchure is taught. Some beginner methods suggest that the student pull back the corners of the mouth, as if smiling (Ployhar, 1977; Swearingen & Buehlman, 1989; Rhodes, Bierschenk, & Lautzenheiser, 1991; Lautzenheiser et al., 1999; Probasco, Grable & Meeks, 1994). Other methods and beginner texts suggest that the student bring the corners of the mouth in towards the mouthpiece, as if saying “Q” or “Ooo” (Froseth, 1997; Grunow, Gordon, & Azzara, 2000; Pearson, 1993; Feldstein & Clark, 2001). Wind instrument teachers have always accepted minor embouchure pedagogy differences; however, major differences in clarinet embouchure pedagogy often result in confusion for teachers and inconsistent clarinet section tone quality. Table 2 shows a comparison of band method texts and their presentation of clarinet embouchure formation.

Table 1

Woodwind Methods Texts

Text	Author	Mouth Corners	Mouth Inside
The Complete Woodwind Instructor	Sheldon & Sheldon (1996)	“Corners of the lips should be drawn to the mouthpiece…” p. 25	“. . . forming the word “OH” or “VO” when blowing air through the clarinet”
Guide to Teaching Woodwinds	Westphal (1990)	“The corners of the mouth are slightly compressed, and there are wrinkles in the lips, especially the lower lip.” p. 70	No mention of tongue position when blowing
Teaching Woodwinds	Kirkbride (1998) Ed. Dietz	“Although there are different approaches to forming the single-lip clarinet embouchure, I prefer the one that can be described in terms of ‘smiling.’” p. 99	No mention of tongue position when blowing

Table 2

Beginning Band Texts and Clarinet Embouchure

Title	Author	Method	Classification
Accent on Achievement	O'Reilly & Williams (1997)	"Tighten the corners of your mouth while saying 'oo.'	Neither
Band Today	Ployhar (1977)	"Your chin and lower lip should be pulled tight and flat."	Smile*
Band Plus	Swearingen & Buehlman (1989)	"The corners of the lips should be drawn back and held firm."	Smile
Best in Class	Pearson (1982)	"Close your mouth muscles equally around the mouthpiece in a 'drawstring fashion.' Firm up the corners of the mouth, keeping your chin pointed."	Neither
Do It!	Froseth (1997)	"Seal the lips around the mouthpiece with a firm inward pucker."	Q*
Essential Elements	Rhodes, Bierschenk, & Lautzenheiser (1991)	"Form a slightly puckered smile to firm the corners of your mouth."	Smile
Essential Elements 2000	Lautzenheiser, Higgins, Menghini, Lavender, Rhodes & Bierschenk (1999)	"Close your mouth around the mouthpiece. Keep the corners of the mouth firm and the chin pointing downward."	Q
Jump Right In	Grunow, Gordon & Azzara (2000)	"Seal the lips around the mouthpiece creating equal pressure from all directions."	Q
Now Go Home and Practice	Probasco, Grable & Meeks (1994)	"the corners of your mouth should be drawn back and held firm"	Smile
Standard of Excellence	Pearson (1993)	"Close your mouth in a drawstring fashion with equal pressure on all sides of the reed"	Q

Note. *NA = Not Prescribed; Q = Q embouchure; Smile = Smile embouchure

Further examination of Table 2 shows that some older texts changed from prescribing bringing the corners of the mouth back, as if smiling, to suggesting that students close their mouths around the clarinet mouthpiece with equal pressure, as if saying “Q” or as in a “drawstring” fashion. *Best In Class* (1982) is one of the earliest methods that suggests bringing the corners of the mouth “in,” but at the same time suggests “firming *up* [emphasis added]” bringing to mind smiling and creating a great deal of confusion. *Accent on Achievement* (1997) and *Essential Elements 2000* (1999) are no less confusing by asking the student to “tighten the corners of your mouth” (smile) while saying “oo’” or “Close your mouth around the mouthpiece…” One need only consider the beginning clarinetist, practicing alone for the first time and trying hard to remember what his teacher told him, to recognize that confusion is likely. Tightening the corners of the mouth is intended to help the student keep the chin muscles flat, which is also the intention of smiling (Lurie, 1959). Flat chin muscles are a point of agreement for the large majority of teachers. There are, however, repercussions that accompany trying to maintain the smile while playing the clarinet, such as air leaks and muscle fatigue. When the corners of the mouth move forward toward the mouthpiece, air leaks and fatigue are less of a problem; however, air pockets in the cheeks, flat intonation due to insufficient muscle support around the mouthpiece, and bunched chin muscles below the mouthpiece become issues. Outside of the above-mentioned physical limitations, there may be significant tone quality differences produced.

Band directors rely mostly on skills attained in instrumental music education and techniques/methods classes to be able to teach students the best embouchure that will produce characteristic tone quality. College music education faculty members are responsible for preparing pre-service teachers to teach characteristic tone quality, how to produce the best tone, and how to detect errors in tone quality. This requires that the teacher be able to recognize what is good tone; and, how to prescribe fixes for tone quality problems. Each new teacher must acquire an aural template of characteristic tone quality by which he compares those of his charges. Questions still remain concerning characteristic tone quality and whether band directors prefer tone quality based upon the effects of clarinet embouchure.

Subjective evaluation of tone quality draws upon learned behaviors. Roederer (1995) stated, "Why some vibration patterns appear to be more beautiful than others is really not known." (p. 153). Clarinet students are taught to value particular attributes of a "good" clarinet tone quality. Also, the ability to discriminate "good" tone from "bad" is an important skill and that ability has perceived value among band directors. Clarinetists value being able to play and teach the best tone quality, whatever the definition of "best." Beautiful tone quality is related to the clarinetist's ability to control things like the spectrum and transients in each tone: achieving the right "mix" of partial strength by the combination of lip pad dampening and air speed intensity through the reed, and fine control on attacks and releases.

Preference Studies

Often, in music education research, there is confusion between the words "preference" and "attitude." Price (1986) defines attitude as the direct result of prior learning related to the attitude object. Preference, although influenced by prior experience, does not require prior knowledge of the stimulus. Preference is an act of choosing, esteeming, or giving advantage of one thing over another. LeBlanc (1984) defines musical preference as an operational construct which represents a subject's demonstrated level of liking specific music stimuli.

Cutietta (1992) recommends paired comparison studies for measuring preferences, as they represent a choice between two stimuli and therefore reliability and validity should be high as long as subjects are assured anonymity. LeBlanc (1984) reinforces the importance of subject anonymity: "It is possible, and perhaps probable, that under the protection of truly anonymous responding subjects will tell nothing but the truth about their music preferences." LeBlanc (1991) discussed the increased reliability and validity that accompanies paired comparison measures: "Since preference is measured as a simple choice between two stimuli, reliability and validity of these measures could be expected to be high where respondents are convinced of their anonymity" (p. 306). LeBlanc further suggests carefully controlling the stimulus presentation and pacing subject responding so that the researcher can link self-reports to specific music events. LeBlanc (1984) said, "When written self-report consists of choosing an objective response option, its validity and reliability characteristics may easily be determined. There is a considerable body of research attesting to the validity of the traditional attitude scales, and if a music version is carefully constructed it is likely to perform acceptably" (p. 4). He also suggests that researchers provide as many stimuli to as many subjects as possible: "In the area of validity, the desirable objective of sampling many responses is linked to the logic of the number of stimuli which can be presented" (LeBlanc, 1984, p. 12).

Existing literature reflects inconsistent clarinet embouchure pedagogy: band method books and woodwind methods texts do not agree on clarinet embouchure. There is, therefore, a need for empirical research to determine the effects of embouchure on timbre and on band director clarinet tone quality preferences. Measuring physical embouchure differences and their effects on timbre, and employing paired comparison items in a tone quality preference survey should provide a credible first attempt at quantifying what has previously been subjective.

CHAPTER III

PROCEDURES

The purpose of this study was to determine the effects of embouchure on band director clarinet tone quality preferences. The researcher began by measuring external embouchure differences and the effects on clarinet timbre; then, she measured band director tone quality preferences to determine the effects of clarinet embouchure. She then evaluated results, determined study limitations, and provided insight to inform practice in the instrumental classroom.

Research Design

The research design was a descriptive study of the effects of clarinet embouchure on tone quality preferences, utilizing a researcher-designed two-part listening survey and data collection instrument.

Subjects and Selection Process

The National Band Association (NBA) provided access to its 2005-2006-membership database for the purposes of this study. The researcher assigned members a number, beginning with 1000 and ending with 5800. She, then, generated random numbers from Microsoft Excel to facilitate the selection of two hundred fifty NBA members who would receive *The Clarinet Tone Quality Survey*. Because of the NBA application format, the researcher did not perform stratified random sampling. Members could choose eight different interest categories such as “elementary,” “junior high/middle school," "college," "military," "community," "retired," "senior high school," and "performing musician" when asked on the application, "What are your primary areas of involvement in band?" Upon inspection of the NBA roster, the researcher determined that stratification was not feasible.

Thirty-six NBA members completed and returned the survey by the December 31, 2006 deadline. To encourage survey completion and return, the researcher mailed reminder postcards in January 2007, prompting an additional two subjects to return the survey. The researcher also established two listening stations at the February 2007 All-Northwest MENC Conference in Portland, OR in efforts to increase the number of subjects. She posted a sign above the listening stations asking for NBA member participation and eight additional subjects participated. Results of a one-way Analysis of Variance testing the ratio of Q to Smile choices showed that All-Northwest subject tone quality choices were not significantly different than their paper survey peers, M=.9820, SD=.667, $F(1,45)$=1.253, p<.269; therefore, forty-six subjects completed the survey.

Subjects were forty-six predominantly white, male, senior brass-player members of the National Band Association. Only two subjects did not describe themselves as Caucasian: one was Hispanic and one was Asian. Seventy-four percent of subjects were male (N=34). Sixty-five percent had graduate degrees (N=30) (see Table 3).

The mean age was 44.6 and the median was 47.5 reflecting a sight negative skew to the sample (-.128). To simplify measuring the effects of age on tone quality preferences, the researcher grouped subjects by age: under 30 (N=11), 31-50 (N=15), and 51 and over (N=20). Subject mean teaching experience was 18.4 years and the median was 17.5, reflecting a slight positive skew (.106). Subjects were also grouped by teaching experience: less than 5 years (*N*=12), 6-20 years (*N*=13), and 21 or more years (*N*= 21). More than half of the subjects described themselves as brass players (*N*=26), while 10 were clarinet players, four played other woodwinds, five were percussionists, and there was one cello player (see Table 4).

Table 3

Subjects by Education

	Frequency	Percent	Cumulative Percent
Bachelors	16	34.8	34.8
Masters	21	45.7	80.4
Doctorate	9	19.6	100.00
Total	46	100.00	

Table 4

Subjects by Instrument

	Frequency	Percent	Cumulative Percent
Clarinet	10	21.7	21.7
Other Woodwind	4	8.7	30.4
Brass	26	56.5	87.0
Percussion	5	10.9	97.8
Strings	1	2.2	100.0
Total	46	100.00	

Fifteen subjects were elementary/middle school directors, ten taught middle and high school, eleven taught high school, six were college band directors, and four subjects listed "other" as occupation (see Table 5).

Table 5

Subjects by Job Description

	Frequency	Percent	Cumulative Percent
Elementary/Middle	15	32.6	32.6
Middle & High	10	21.7	54.3
High School	11	23.9	78.3
College	6	13.0	91.3
Other	4	8.7	100.00
Total	46	100.00	

When asked about woodwind methods texts, two subjects listed the Dietz text, which prescribes the Smile embouchure, and twenty-three listed the Westphal text, which prescribes the Q embouchure. Twenty-one subjects did not list a woodwind methods text. Of the ten subjects listing "clarinet" as the major instrument, three mentioned smiling when describing how they were taught; four mentioned bringing the corners of the mouth towards the mouthpiece; and three mentioned both tightness in the corners and bringing the corners in.

Procedures

Two graduate clarinet majors, originally taught the Smile or the Q embouchure respectively, recorded tone quality samples of sustained tones, scales, and musical excerpts. The players used the same instrument, mouthpiece, ligature, and reed brand and strength. The researcher recorded all samples on the same day, under identical atmospheric conditions to control for effect of humidity changes on reed response and tone quality. To control for player unfamiliarity with the study instrument, two days were set aside prior to the recording session to allow players one hour on each day to play the study clarinet. Players received copies of the musical excerpts, sustained tones, scales, and instructions for the recording session two weeks before recording. Players also received instructions concerning consistent tempos and amplitude, information concerning the use of electromyography, and an informed consent letter to be signed at the recording session.

Recording occurred in the Psychoacoustics Laboratory in the School of Music at The University of North Carolina at Greensboro. All musical samples were unaccompanied. Clarinet players monitored their loudness with a sound pressure meter positioned near the music stand. Researchers also monitored loudness in the recording booth and asked players to re-play any excerpt that was outside the prescribed 83-85 dBA. The first ten musical survey items were selected to represent the various registers of the clarinet as timbre changes from note to note: "In actual instrumental performance, the spectrum changes not only from note to note, but also during steady-state portions of the same pitch as well as from performer to performer and instrument to instrument."

(Lipscomb & Hodges, 1996, p. 118). All scales were performed utilizing the practical range of the instrument and were slurred to eliminate articulation influence on signal onset. Table 6 shows the order of sustained tones and scales as they appear on the survey recording.

Table 6

Sustained Tones and Scales, Written Notes, Duration, Presentation Order

Tone/Scale	Duration	Order
E_3	4 seconds	S, Q *
C_4	4 seconds	S, Q
G_3	4 seconds	Q, S
C_5	4 seconds	Q, S
C_6	4 seconds	Q, S
F major scale	3 octaves extended range/24 seconds	S, Q
E chromatic scale	3 octaves/40 seconds	S, Q
D major scale	2 octaves extended range /22 seconds	S, Q
C major scale	2 octaves extended range/22 seconds	Q, S
Bb major scales	2 octaves extended range and 22 seconds	S, Q

Note. * Embouchure Type: S is the Smile Embouchure and Q is the Q Embouchure

Because band directors spend more time evaluating clarinet tone quality in context of musical works, melodic lines from concert band first clarinet parts and from clarinet solo literature were used for the second half of the survey. Specific works were selected for their lack of required staccato articulation and for their variety in range. Concert band literature was selected from the North Carolina Bandmasters Association Official Festival List for 2005-2006 and represents works from Grade 2 through Grade 6. Concert band repertoire, the first items in Table 7, was selected because most works are well known to band directors and because of the legato style. To control for differences in interpretation, the researcher marked out dynamic and stylistic markings in the music. Clarinet solo repertoire includes excerpts from an early romantic era concerto to a mid-twentieth century sonata. Solo literature, the last five items in Table 7, was selected because most of it is standard repertoire for the instrument and because the excerpts used require little articulation. Excerpts, their metronome markings, and order are in Table 7.

Recording Process

Clarinet players played the researcher's instrument, a Buffet R13 Festival Bb clarinet, which allowed for coordination of player access and was a "new" instrument for both players. The mouthpiece was a Gregory Smith "Cicero Kaspar," the ligature was a BG "Super Revelation," and the reeds were 3.5 strength Mozart. For hygiene reasons, two different reeds were used. Both players used the same strength and the same brand to reduce a possible confounding variable.

The researcher established a triangulation between the clarinet bell, the left foot of the music stand, and the right side of the sound pressure meter using the following measurements: left foot of music stand to joint of lower joint and clarinet bell (string attached) = 28.5"; left side of microphone stand to lower joint and clarinet bell (string attached) = 27.5"; and, right side of sound pressure level meter stand to lower joint and clarinet bell (string attached) = 22.5.” This triangulation served to keep a consistent distance from the microphone, to allow the player to read the music on the music stand, as well as to keep the player and instrument stationary. Three pieces of “kite” string were attached between the lower joint and bell of the clarinet and connected to the microphone stand, the music stand, and the sound pressure level meter stand (see Figures 4 and 5).

Table 7

Clarinet Repertoire Excerpts

Excerpt	Composer	Tempo	Order
Elsa’s Procession to the Cathedral Cl. solo, pick-up to m.21 to m. 25	Wagner/Cailliet	♩ = 50	Q, S*
Korean Folk Medley Cl. 1, m.28 to m.35	Ployhar	♩. = 80	S, Q
The Wexford Carol Cl. 1, pick-up to m.32 to m.39	McGinty	♩ = 56	S, Q
A Festive Overture Cl. 1, m.245 to eighth note on beat one of m.251	Reed	♩ = 92	Q, S
Toccata for Band Cl. 1, m.73 to m.80	Erickson	♩ = 132	Q, S
Four Short Pieces for Clarinet and Piano Mvt. 3, m.3 to m.11	Ferguson	♩ = 60	Q, S
Sonata for Clarinet and Piano Mvt. 1, m.1 to m.7	Hindemith	♩ = 108	S, Q
Introduction, Theme, and Variations Pick-up to m.21 to m.28	von Weber	♩ = 120	S, Q
Sonata in Eb for Clarinet and Piano Mvt. 1, m.1 to m.8	Brahms	♩ = 100	Q, S
Concerto No. 1 Mvt. 1, m.49 to m.56	von Weber	♩ = 120	S, Q

Note. * Embouchure Type: Q is the Q embouchure and S is the Smile embouchure

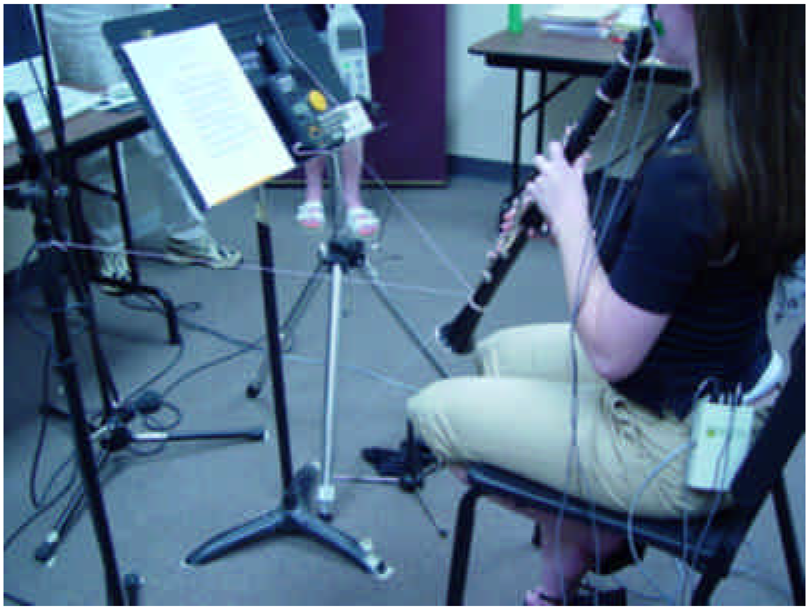


Figure 4. ***Player Set-Up Showing Triangulation from Clarinet Bell and Monitoring Instruments, Such as Metronome, Tuner, Sound Pressure Meter, and Microphone***

Figure 5. ***Triangulation—Another View***

All musical samples were unaccompanied. The musical samples were recorded using a Neumann KM140 condenser microphone. Players visually monitored their loudness levels using an Extech 407762 sound pressure level meter. They were advised to keep the loudness reading between 83 and 85 dBA. The sound pressure level meter, on its stand, can be seen to the right of the music stand in Figures 2, 3, and 4. Intonation was monitored with an Intelli Metro Tuner-IMT204 chromatic tuner, a small white instrument placed on the music stand (see Figure 6). A DB Boss - Dr. Beat metronome, with an attached earphone (in Figure 6, left of the tuner and with white earphones draped over the back of the music stand prior to official recording) was used to determine note length in long tones and maintain consistent tempos in scales and excerpts.

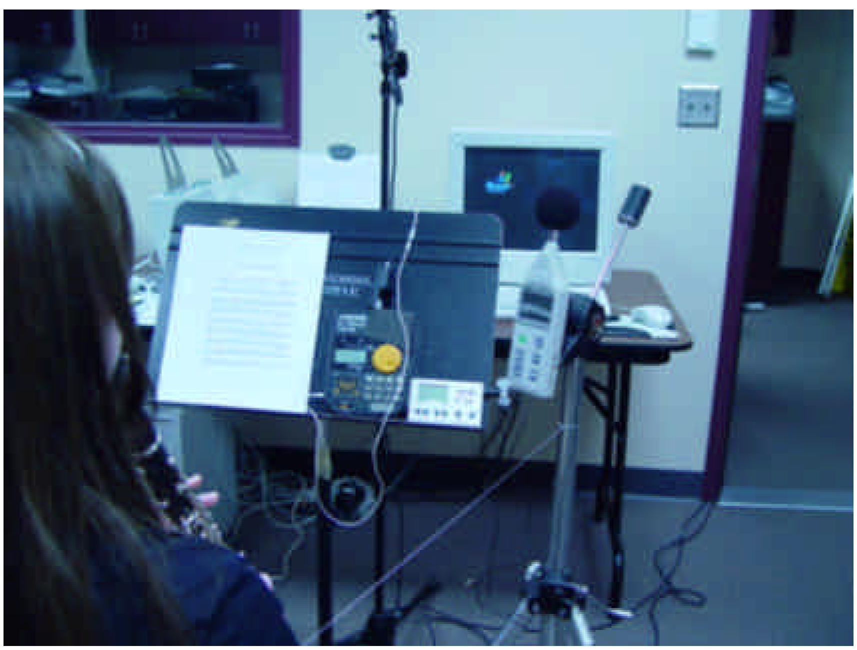


Figure 6. ***View of Instrumentation from behind Clarinetist, Showing (Left to Right) the Metronome and Tuner on the Music Stand and the Sound Pressure Meter to the Right***

Dr. Sandra Mace recorded the musical samples on digital audiotape, using a Fostex D15 digital master recorder. Next, she transferred samples to a Windows-based Gateway PC with a Pentium 3 chip and 850 MHz processor (see Figure 7).

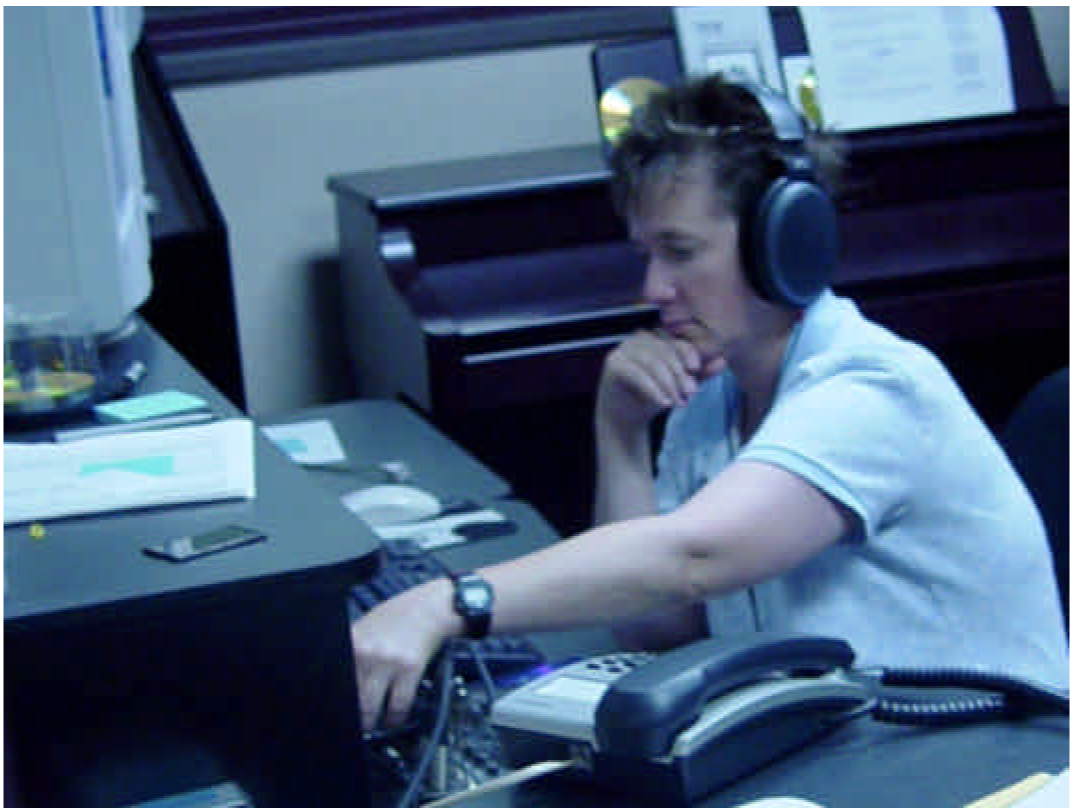


Figure 7. ***Dr. Sandra Mace Recording Clarinetists***

Dr. Natalie Kreutzer, Associate Professor of Music Education at the University of Idaho, recorded the survey instructions and the individual item numbers. Kreutzer recorded the instructions because she spent most of her life in the Midwest and did not have a discernable accent. Her diction and speech tempo made survey instructions understandable to University of Idaho music faculty, who listened to the recording. The researcher edited and compiled samples, recorded instructions, and item numbers using Sony Sound Forge 8.0. To maintain sample validity, the researcher did not process sound files and did not employ noise reduction technology.

Measuring Embouchure Differences

To differentiate embouchures, it was necessary to measure electrical activity of the "smiling" muscles: the risorius and zygomaticus major muscles. Surface electromyography was used, rather than fine wire electromyography, because fine wire EMG requires insertion of a needle in a player's face to measure electrical activity. Surface electromyography, on the other hand, is non-invasive. A DelSys Bagnoli 2 electromyography machine (DelSys Inc., Boston, MA) was used with two DelSys DE-2.1 electrodes along with a reference electrode to measure electrical activity in the prescribed facial muscles. Electrodes were placed parallel to the direction of the muscle fibers, and on the "belly" or largest part of the muscle. For the purposes of this study, the electrodes were placed only on the left side of the face, assuming bilateral symmetry of both players' embouchures. The researcher assigned the channel-one electrode to the risorius muscle and the channel-two electrode to the zygomaticus major muscle (see Figure 8). Bipolar electrodes require that a reference electrode be placed on an area of skin with little or no electrical activity and, for that reason, the reference electrode was attached midline on the collarbone. The reference electrode was secured with additional surgical tape to assure a consistent connection to the skin on the clavicle.

The muscles in the face are very close together, particularly the zygomaticus major and minor muscles. Therefore, there was a question about isolating the zygomaticus major muscle, especially considering the size of the electrodes used in the study. The risorius muscle was easier to palpate, as well as isolate and identify, particularly where it moved away from the orbicularis oris around the mouth.

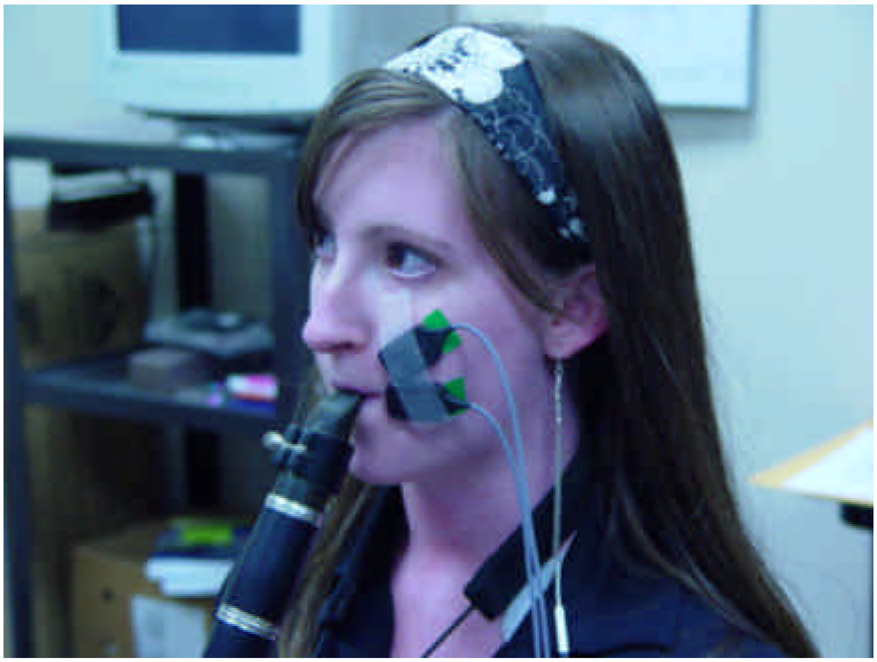


Figure 8. ***Left-Side Facial Electrode Placements***

To achieve maximal electrical connectivity, the attachment sites were swabbed with isopropyl alcohol. Double-sided adhesive patches were attached first to the surface of the electrode and then to the face of the player. Electrodes were further secured with surgical tape to avoid displacement. Precise locations for electrode placements were determined by facial palpation during the muscle constriction when the players smiled. To validate correct placement of the facial electrodes, Evelyn Davis, M. D. verified the muscle identity and location of the appropriate electrode placements (see Figure 9). Because of the slight chance of a skin reaction to the adhesive, a small area on top of each player's hand was cleaned with isopropyl alcohol and an adhesive patch was placed to test for a skin reaction prior to the recording session.

Figure 9. ***Dr. Evelyn Davis Attaches the Surface Electrodes to the Zygomaticus Major and the Reference Electrode is Visible on the Player's Left Median Clavicle***

The researcher connected the DelSys Bagnoli 2 to a Dell Inspiron 2650 laptop computer and captured the EMG data. A National Instruments PCMCIA card and NIDaqMX data acquisition driver software interfaced the electrodes and computer. EMGworks v. 3.1 software was used to analyze the EMG signals and to graphically display the data. The signal amplifier sampling-rate was set at a 10,000 Hz, which is the highest available sampling rate. The location and size of the muscle, in relation to the distance from the skin surface, determines signal strength. As the zygomaticus major and the risorius muscles are relatively small, a higher sampling rate is required (Giakas, 2004).

Raw EMG data were bandpass filtered, using a fourth order Butterworth filter, available on DelSys EMG Works 3.1 (DelSys, Inc., Boston, MA) and was the same used in similar EMG studies (Campbell, 1999). Band pass filtering allows defined frequencies to be captured, while eliminating those outside the desired range. The high-pass filter cut-off was set at 20 Hz and the low-pass rate was 450 Hz. High pass filters eliminate lower frequencies and the low pass filter eliminates high frequencies, which allows the researcher to eliminate "noise" or non-muscular related input.

Because of differences between player facial structures and possible variances in electrode placement, the researcher normalized electrical data. She used mean electrical amplitudes, measured in micro volts (µv), occurring with contractions of the zygomaticus major and risorious muscles, to quantify the differences in the Q and Smile embouchures. She, then, used a one-way ANOVA to determine any significant differences between players' facial muscle electrical activity.

The researcher used Sony Sound Forge 8.0 to record all sound samples. She also used Sound Forge to evaluate the frequencies present in the steady states of sustained tones, particularly those in the formants prevalent in the clarinet sound spectrum at around 1500-1700 Hz and at 3700-4300 Hz. Sound Forge allowed an amplitude measurement, in dB, of any recorded harmonic.

Preparation of Survey

Sample CDs were recorded on blank CD-R discs. The cover letter, the survey instrument (see Appendix B), a sample CD, and a stamped, pre-addressed return envelope were mailed to subjects. The researcher advised subjects to listen to the musical samples on the "best available" playback equipment. Two hundred and fifty band director surveys were mailed on November 30, 2006. The Postal Service returned twenty-two surveys as the addresses were no longer valid and forwarding had expired.

To follow the effects of learning on tone quality perception, subjects were asked to complete an initial survey to collect information about the subject's teaching level, major instrument, education level, teaching experience, current teaching position, and woodwind methods text. Any subject who was a clarinet major was asked how embouchure was taught.

The Survey

Subjects listened to five sustained tones, five scales, and ten excerpts from clarinet solo and concert band literature; each excerpt played once with the Smile embouchure and once with the Q embouchure. The order of the musical samples in both listening tasks was randomly assigned. There were four seconds between paired comparisons and eight seconds between items. These values are based upon those used by Worthy (2000) in a similarly constructed listening study. After hearing each pair of samples, subjects marked their tone quality preferences by circling either "A" or "B" next to the appropriate item number. If there was no preference, they circled "C" (see Appendix B for the survey form).

Variables

The survey captured independent variables such as subject gender, ethnicity, education, teaching experience, and major instrument. Subject "major instrument" was categorized as "woodwind," "brass," "percussion," or "other." The researcher grouped teaching experience as "0-5 years," "6-20 years," "21 or more years." Education was "undergraduate" or "graduate." Demographic data such as gender, ethnicity, and education were also independent variables. Dependent variables were clarinet player facial muscle signal strength, signal envelope harmonic strength, and subject responses recorded on a tone quality survey. Subject listening devices and the listening environment were a possible confounding variables, though subjects were encouraged to listen to the survey "on your best available stereo equipment, to allow for the best sound reproduction" (see Appendix B). In addition, differences in EMG readings between clarinet players–based upon facial differences and EMG recording conditions, may have had a confounding effect on determining embouchure differences. Clarinet player embouchure differences were another possible confounding variable. Yet, another related confounding variable was the reliability and validity of the stimulus and the survey. A sound level meter and metronome were used to try to control for loudness and tempo consistency for each sample. A cover letter to the clarinetists, found in Appendix C, instructed them about the importance of eliminating expression during the recording session. The subject cover letter (see Appendix B) also instructed subjects to evaluate only tone quality and disregard differences in interpretation.

Statistical Analysis of the Data

The researcher used a One-way Analysis of Variance (ANOVA) to measure the effects of clarinet embouchure on electrical activity in the risorius and zygomaticus muscles. She also used an ANOVA to measure the effects of embouchure on the mean amplitudes of harmonics in sustained-tones. Subject tone quality preferences were determined with chi-square goodness-of-fit and a post-hoc *t*-test of the ratio of Q to Smile choices. Descriptive statistics, chi-square, and biographical data were presented in tables. The researcher used an ANOVA to determine effects of subject demographic data on tone quality preferences. Survey reliability was determined using Chronbach's Alpha. The researcher used SPSS v. 15 to perform all statistical analyses. Statistical significance was set at an alpha level of $p = .05$.

Survey Reliability and Validity

Any survey instrument must be evaluated for both reliability and validity. Survey reliability is a measure of consistency; that is, if the survey were administered again, how similar might the second survey results be to those of the first? Validity, on the other hand, is the measure of the truthfulness of the survey; in the case of this survey, did the survey measure band director tone quality preferences based upon electrical activity in the risorius muscles? Perhaps there were additional unmeasured embouchure attributes, such as tongue position inside the mouth, which affected those tone quality preferences. A survey can measure consistently, that is reliably; however, the survey can simultaneously be invalid, not measuring the intended dependent variable. Conversely, any valid survey is also reliable.

There are a number of ways of measuring survey reliability: test-retest, multiple forms, inter-rater reliability, and split-half reliability. Test-retest reliability measures were not practical because this was a one-time test of band director tone quality preferences. Using multiple forms would have required mixing up the survey items and administering the survey to the same subjects twice, which also was not practical. Because the survey included two distinct halves, ten survey items measuring tone quality preferences on sustained tones and scales, and ten items measuring tone quality on existing repertoire, meant that the split-halves method could not be used to determine survey reliability. Comparing two halves of the survey, each measuring tone quality preferences under different circumstances, meant that split half reliability would not be measuring the same traits.

Separate reliability quotients were obtained for the sustained tones/scales and for the clarinet repertoire. Reliability for tones and scales was .136 while the reliability quotient for the repertoire was .484. Overall survey reliability was determined with Cronbach's alpha because it compares each survey item reliability against the reliability of the remaining survey items: α=.55.

CHAPTER IV

RESULTS

Because of the inconsistency in clarinet embouchure pedagogy, there is a need to determine embouchure effects on band director clarinet tone quality preferences and that was the purpose of this study. The study addressed three research questions. The first question involved quantifying prescribed embouchure differences: “Are two clarinet players’ embouchures significantly different in relation to the electrical activity in the risorius and zygomaticus major muscles as measured by surface electromyography?” The second research question addressed the effect of mechanical embouchure differences on sustained tone timbre: “Is there a significant difference in the signal strength, measured in dB, of the first nine harmonics and within the two formants in sustained clarinet tone signal envelopes?” The last question related embouchure and tone quality differences to band director preferences: “Was there a significant preference for one clarinet tone quality based upon the effects of two different clarinet embouchures?”

Two hundred fifty band director subjects received the survey instrument. Surveys returned due to “undeliverable” status went to the next subjects on the random number list to assure that 250 subjects received the survey. Thirty subjects returned the survey by the prescribed December 31, 2006 deadline. The researcher followed up with a reminder postcard to all subjects not completing the survey. The researcher set up two listening stations at the All-Northwest MENC Conference and added additional NBA subjects. As a result, an additional sixteen subjects completed the survey. Forty-six subjects participated in the survey, which reflects 18 percent participation.

First Research Question

The first research question was, “Are two clarinet players’ embouchures significantly different in relation to the electrical activity in the risorius and zygomaticus major muscles as measured with surface electromyography?” Risorius and zygomaticus major muscles activate when smiling, therefore those two muscles were isolated and electrical activity measured to determine differences in muscle contraction between the Smile and Q embouchures. Electrical activity measured in risorius muscles was different between the two clarinet players. The player with the Smile embouchure did show significantly higher electrical activity (*M*=1.48, *SD*=.37) than the player applying the Q embouchure (*M*=1.09, *SD*=.54), $F(1,1)=5.119$, $p<.029$, $f=.119$ (see Table 8). Collecting only twenty (*N*=20) EMG measures contributed to a small effect size.

Table 8

Risorius Muscle Electrical Activity Differences

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Correct Model	1.491	1	1.491	5.119	**.029	.119
Intercept	65.770	1	65.77	225.739	.000	.856
Embouchure	1.491	1	1.491	5.119	.029	.119
Error	11.071	38	.291			
Total	78.332	40				

Note. ** Significant at $p<.05$

Electrical activity measured in the zygomaticus major was not significantly different between the players. Although not statistically significant, the player with the Smile embouchure had greater electrical activity in the zygomaticus major muscle (*M*=1.41, *SD*=1.17) than the player with the Q embouchure (*M*=1.07, *SD*=.66), $F(1,1)=1.363$, $p=.25$ (see Table 9).

Table 9

Zygomaticus Major Muscle Electrical Activity Differences

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Correct Model	1.225	1	1.226	1.363	.250
Intercept	61.517	1	61.517	68.396	.000
Embouchure	1.226	1	1.226	1.363	.350
Error	34.178	38	.899		
Total	96.921	40			
Corrected Total	35.404	39			

The answer to the first research question is that yes, the risorius muscle electrical activity was significantly different between players. The player with the Smile embouchure had higher electrical activity in the facial muscles than the player with the Q embouchure. The zygomaticus muscle electrical activity was also different, though not significantly so.

Second Research Question

The second research question addressed objective, measurable acoustic differences between the timbres represented by the two clarinet players: “Is there a statistically significant difference in the signal strength of the first nine harmonics and within the two formants in signal envelopes of sustained clarinet tones, based upon the effects of mechanical embouchure differences?” Using sustained clarinet tones allows for measuring harmonic strength across each; those tones selected for this study are (written/sounding) E_3/D_3, C_4/Bb_3, G_4/F_4, C_5/Bb_4, and C_6/Bb_5. Data were analyzed by a one-way ANOVA (see Table 10). For an additional chart showing each tone, frequency, and strength of the first nine harmonics and formants see Appendix D.

Additional analysis of the signal envelope, comparing the effects of embouchure on formant harmonic strength did show significant mean dB differences. Smile embouchure signal strength in combined first and second clarinet formants (1500-1700Hz and 3700-4300Hz) was M=-67.74, SD=10.10 while Q embouchure signal strength was significantly weaker at M=-84.86, SD=-7.73. Results of a one-way ANOVA showed that Smile embouchure formant signal strength was significantly stronger than that of the Q embouchure, $F(1,8)=9.06$, $p<.02$, $\eta^2=.531$, $f=.751$. Therefore, the answer to the second research question was yes, there were significant effects of embouchure on clarinet timbre.

Third Research Question

The third research question was “Was there a statistically significant preference for one clarinet tone quality based upon the two different clarinet embouchures?”

Table 10

One-way ANOVA of Signal Strength of the First Nine Harmonics and Formants by Embouchure Type

	M(dB)	SD	F	df	Sig.
Harmonic 1					
Smile	-42.820	4.102			
Q	-45.360	3.019	1.244	1	.297
Harmonic 2					
Smile	-72.020	16.868			
Q	-67.500	14.562	.206	1	.662
Harmonic 3					
Smile	-50.260	5.371			
Q	-53.420	10.257	.372	1	.559
Harmonic 4					
Smile	-64.720	10.413			
Q	-65.500	7.403	.019	1	.895
Harmonic 5					
Smile	-59.440	8.049			
Q	-63.720	15.988	.286	1	.607
Harmonic 6					
Smile	-71.140	9.352			
Q	-69.760	14.326	.033	1	.861
Harmonic 7					
Smile	-71.020	14.651			
Q	-76.120	16.946	.263	1	.624
Harmonic 8					
Smile	-76.660	-76.660			
Q	-79.320	-79.320	.816	1	.816
Harmonic 9					
Smile	-69.525	4.624			
Q	-76.300	20.541	.813	1	.544
Formant					
Smile	-67.74	10.10			
Q	-84.86	7.73	9.060	1	.020**

Note. ** Significant at p<.05

Chi-square analysis of survey results showed no significant preference for one tone quality (see Table 11). Chi-square measures how many subjects preferred the Smile embouchure tone quality and how many subjects preferred the Q embouchure tone quality. Chi-square does not consider the magnitude of any subject's preference, that is, how many times the subject preferred one tone quality to the other.

Table 11

Chi-Square Analysis of Tone Quality Preferences

	Observed N	Expected N	Residual
Smile embouchure	20	23	-3.0
Q Embouchure	26	23	3.0
Total	46		

	Preference
Chi-Square	.783
df	1
Asymp. Significance	.376

However, a *post-hoc* comparison of the preference counts did show a significant tone quality preference. A t-test of the ratio of the number of Q preferences to Smile preferences by subject was tested against the null hypothesis of no preference (ratio = 1). The results showed a significant preference for the tone quality of the Q embouchure over that of the Smile embouchure: M=2.0236, SD=2.920, $t(45)=2.378$, $p<.02$, d=.351 and ?=2.38, power = .63. Sixty-three percent of the time one would expect to find a significant difference between this sample and those members of the population who had no tone quality preference. The effect size, .351, is relatively low: Small, *d*=.20, Medium, *d*-.50, and Large, *d*=.80 (Howell, 2002, p. 228) (see Table 12).

Table 12

One Sample t-Test, Test Value=1, of Ratio of Subject "Q" to "Smile" Preferences

	t	df	Sig. (2-tailed)	Mean Difference	95% CI of Difference (Lower)	95% CI pf Difference (Upper)
Ratio Q/S	2.422	45	.019**	1.02007	.1721	1.8680

Note. ** Significant at p<.05

Based upon *t*-test results, several one-way analysis of variance tests were performed to identify any effects such as demographic data, job description, major instrument, woodwind method texts, and teaching experience. None of the factors listed above affected the Ratio of Q to S Preferences, nor were any significant interactions noted (see Tables 13 and 14).

Based upon the results of the *post-hoc t*-test, the answer to research question one is that NBA member band directors do prefer the tone quality of the Q embouchure significantly more than the tone quality of the Smile embouchure. There were no significant effects on tone quality preference related to demographic or educational factors.

Table 13

Factor Analysis (ANOVA) of Ratio of "Q" to "Smile" Preferences by Subject Demographic Data

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	53.611	15	3.574	.325	.988
Intercept	58.723	1	58.723	5.338	.028
Gender	1.660	1	1.660	.151	.700
Ethnicity	7.350	2	3.675	.334	.719
Education	1.485	2	.743	.068	.935
Age (Grp)*	5.028	2	2.514	.229	.797
Gen X Edu	1.098	2	.549	.050	.951
Gen X Age	1.031	2	.515	.047	.954
Gen X Edu X Age	1.310	1	1.310	.119	.732
Error	330.011	30	11.00		
Total	571.991	46			
Corrected Total	383.622				

Note. * Age Grouped: 1 (under 30), 2 (31-50), and 3 (51 and over)

Table 14

Factor Analysis (ANOVA) of Ratio of "Q" to "Smile" Preferences by Subject Instrument, Job, Teaching Experience, and Woodwind Methods Text

Source	Type III sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	146.323	34	4.304	.199	1	.381
Intercept	52.820	1	52.820	2.448	.146	.182
Instrument	.741	3	.247	.011	.998	.003
Job	7.627	4	1.907	.088	.984	.031
Teach Exp*	28.516	2	14.258	.661	.536	.107
Ins X Job	3.200	2	1.600	.074	.929	.013
Ins X Text	.118	1	.118	.005	.942	.000
Job X Text	2.889	3	.963	.045	.987	.012
Job X Exp	23.676	4	5.919	.274	.888	.091
Error	237.300	11				
Total	571.991	46				
Corrected Total	383.622	45				

Note. *Teaching Experience Grouped: 1 (less than 5 years), 2 (6-20 years), and 3 (21 or more years).

CHAPTER V

CONCLUSIONS

This study was the first of its kind and was a first step in identifying the significant effects of the “smiling” muscles on clarinet timbre and tone quality preferences. Results showed players with the Smile embouchure have significantly greater risorius muscle contraction when playing. Results also showed that clarinet embouchure does affect clarinet timbre, particularly in the harmonics that fall in the formants. Clarinet embouchure also affected band director tone quality preferences.

The first research question was, “Are two clarinet players’ embouchures significantly different in relation to the electrical activity in the risorius and zygomaticus major muscles as measured with surface electromyography?” Risorius and zygomaticus muscles activate when the corners of the mouth are pulled back and upward, as when smiling. Determining significant physical embouchure differences was both an important step towards quantifying factors that had previously been highly subjective, as well as a means of identifying each player with the one of the respective embouchure types.
The players’ embouchures were different: the player with the Smile embouchure had significantly higher electrical activity in the risorius muscle than the player with the Q embouchure. The player with the Smile embouchure also had greater activity in the zygomaticus major than the Q player, though not significantly so.

The second research question was related to the effects of embouchure on the acoustic aspect of tone quality: "Is there a significant difference in the signal strength, measured in dB, of the first nine harmonics and within the two formants in signal envelopes of sustained clarinet tones?" The study involved analyzing the signal strength of first nine harmonics and those harmonics that fall within the two formants in each of five recorded sustained tones. Identifying harmonic strength differences, related to physical embouchure differences, was again an opportunity to quantify what had previously been subjective. Teachers often use subjective terms such as "dark," "bright," "focused," or "spread" to qualify tone quality. Clarinet players, who tend to play with the corners of the mouth pulled back, as if smiling, have a brighter sound, while those who play with the corners of the mouth in towards the mouthpiece have a darker sound. A prevalence of strong upper harmonics, particularly those in the formant regions at 1500-1700Hz and 3700-4300Hz, would qualify as "brighter" tone. Research question two was an effort to remove subjectivity and quantify tone quality differences, as well as to determine the effects of embouchure on timbre.

Signal strengths of the first nine harmonics were different by embouchure, however not significantly so. Significant differences existed in the higher harmonics found in the two clarinet formants between 1500 and 1700Hz and at 3500 and 4300Hz. Formant harmonic strengths were significantly greater in the Smile embouchure tone than in the Q embouchure tone. Strength of the harmonics, particularly those that fall within the two formants, provided physical evidence that those stronger harmonics contribute to perceived tone quality brightness.

The last research question of this study addressed whether mechanical embouchure differences affect band director tone quality preferences, “Was there a significant preference for one clarinet tone quality based upon the two different clarinet embouchures?” A preference for one tone quality should inform and guide teachers to improved and more consistent clarinet section tone quality. Conversely, if there is no significant preference, one might assume that there is a lack of agreement about characteristic clarinet tone quality, or that additional research is needed to further isolate and quantify additional physical embouchure differences and their effects on band director tone quality preferences.

The researcher used two measures to determine band director tone quality preferences. Subjects preferred the Q embouchure tone quality more than the Smile tone quality, but not significantly as measured by a chi-square test of goodness of fit. Subjects significantly preferred the Q tone quality when the researcher measured the preference magnitude with a one-sample *t*-test.

Summary of Results

The researcher made preliminary determinations concerning whether or not the clarinet player embouchures were different and how each player’s timbre differed. Surface electromyography showed that electrical activity in the zygomaticus major and the risorius muscles of the Smile embouchure player was greater than that of the player using the Q embouchure. While the activity of the zygomaticus major was not significantly different, the risorius muscle activity was significantly different to the alpha level of .03, though the effect size was small due to the number of measures. Difficulty isolating the zygomaticus major from the surrounding muscles may have contributed to the lack of statistical significance. The physician who placed the electrodes was concerned about differentiating between the zygomaticus major and minor muscles without using the more invasive fine wire electrode placement, which would have meant placing needle electrodes in the faces of the clarinet players. There were also issues related to interference between the zygomaticus major and minor and the large size of the electrodes may have affected data collection.

Timbre analysis by measuring the strength of the first nine harmonics and formants of recorded sustained tones showed that the two players' signal envelopes were different. The first nine harmonics were not significantly different, where the largest difference was in the first harmonic, or fundamental. The player with the Smile embouchure showed higher signal strength than the player with the Q embouchure (see Table 10). In fact, the Smile player had higher mean harmonic strengths in all but the second and sixth harmonics. Analysis of the higher harmonics, those in the clarinet formants at 1500-1700Hz and 2700-4300Hz, showed larger differences in harmonic strength. The player of the Smile embouchure had significantly stronger signal strength in both formant ranges, which may have contributed to brightness in the tone quality. High power and moderate effect size suggest that harmonics in the formants may play an important role in perception of bright and dark qualities.

Band directors preferred the Q embouchure tone quality to the Smile embouchure tone quality in a chi-square test, though not significantly. Band directors significantly preferred the Q tone quality to the Smile tone quality in a *t*-test of the ratio of Q selections to Smile selections. The small sample size (N=46) contributed to a small effect size and low power.

Using statistics to analyze data requires a researcher to objectively evaluate any significant result. For example, a significant F value on the signal strengths in the clarinet formants means that the differences cannot be attributed to error; however, the statistically significant result says nothing about the practical importance. One test of a significant result is the measure of effect size. When evaluating results from a one-way ANOVA, effect size is expressed as eta squared (η^2), a measure of test result magnitude independent of sample size. In the case of the formant signal strength, $\eta^2 = .531$ means that 51% of the variation in formant harmonic strength can be attributed to embouchure differences. When evaluating the significant results of a t-test, Cohen's d allows the interpretation of effect size: Small effect size=.20, Medium effect size=.50, and Large effect size=.80 (Howell, 2002).

Power is another test of a significant result and is the probability of correctly rejecting a false null hypothesis. Power, unlike effect size, is affected by the sample size. Power is also affected by the alpha level, set at α=.05 for this study. If the null hypothesis is false, as measured in this instance by a *post-hoc* t-test of the ratio of Q to smile choices, 63% of the time statistical significance will occur if the study is replicated in its current form. Likewise, 37% of the time t will not be significant. Increasing the number of subjects would increase power. A power of .80 (high) would have required a minimum of 64 subjects.

Chi-square results, while not statistically significant, were likely impacted by the small sample size (N=46). Researchers often use chi-square tests for preference surveys, however chi-square does not reflect the magnitude of preference. The chi-square test counts the number of subjects that prefer the Smile embouchure tone quality and the number of subjects who preferred the Q tone quality and compares the counts against the premise that the number of subjects that prefer the Smile tone is not equal to the number of subjects that prefer the Q tone. Chi-Square tests do not measure magnitude of a subject's preference. For instance, if a subject chose the Smile embouchure tone eleven times and the Q tone nine times, then that subject preferred the Smile embouchure. However, if another subject chose the Smile embouchure nineteen times and the Q embouchure one time, that subject's preference is the same as the first. For this reason, the *post-hoc t*-test was chosen to measure the ratio of the number of times the tone quality of the Q embouchure was chosen versus the number that the Smile was chosen. Results showed that subjects preferred tone quality of the Q embouchure over that of the Smile embouchure: M=2.0236, SD=2.920, $t(45)$=2.378, p<.02, d=.351 and ?=2.38, power = .63. The effect size, .351, is rather small; however, the power is moderate. Because the small sample size and effect size, there is no way to generalize to a larger population.

Implications

Risorius muscles pull back the corners of the mouth to help keep the chin flat in Smile embouchure players. Results showed that the Smile embouchure relies on continued risorius tension, which may contribute to player fatigue. Pulling back the corners also stretches the lower lip, keeping the skin of the lower lip from effectively dampening higher harmonics. Significantly stronger upper harmonics in the formants, produced by the Smile embouchure, may contribute to bright tone quality and likely contributed to band directors choosing the Q embouchure tone quality over Smile embouchure tone. Even with a small sample size, band director tone quality preferences were affected by clarinet embouchure. While embouchures can never be reduced to one factor, such as the activity in one muscle group, this study is a first step in isolating one factor influencing clarinet tone quality. Based on the results of this study, band directors should examine the possibility of teaching young clarinetists to bring the corners of the mouth towards the mouthpiece, thereby reducing fatigue and likely improving clarinet tone quality.

The small effect size and power associated with significant statistical results on the one-sample *t*-test reflects the very small sample size. Scheduling the survey administration at the end of November, hoping to find band directors less busy, did not improve subject participation. An eighteen percent survey return rate is disappointing, but also implicates all who immediately throw away any mail identified as survey material. Reminder postcards also had little effect on potential subjects. Few teachers want to take time away from busy careers to complete paper-and-pencil surveys. Online surveys may produce better subject participation as they require less time and are not as offensive as unwanted paper mail.

Limitations of the Study

Looking at the demographic data of subjects who responded to the survey, one can see that the survey sample likely does not represent demographics of the National

Band Association's 5000 plus membership: 96% of subjects were white, 74% were male, 65% had graduate degrees, 56.5% were brass players. No demographic data are captured on National Band Association membership applications so there are no data to show whether the random sample adequately represents the population. Sample size and lack of a representative subject base restrict the use of any of this data, other than to guide replication and further research.

Also, clarinet majors, when asked how they were taught clarinet embouchure, provided unclear results. The survey item asked an open-ended question related to initial instruction, "If clarinet is your primary instrument, please explain how you were taught clarinet embouchure." Perhaps the item should be re-written: "If clarinet is your primary instrument, which of the following best describes your embouchure? a.) corners of the mouth are pulled away from the mouthpiece, b.) corners of the mouth are pushed forward towards the mouthpiece, c.) neither of the above.

There are many components in a clarinet embouchure, only one of which is muscle tension in the face. Tongue position, or voice, also plays and important role in tone quality, and its effects were not measured in this study. Tone quality preferences could have been affected by tongue position in the player's vocal tract. Another component is tension and downward pressure from the upper lip. This study was limited to the effects of risorius and zygomaticus contraction on timbre and band director tone quality preferences.

Survey reliability and validity were a concern. Sustained tones and scales that comprised the first half of the survey were very unreliable. Second half reliability, which included only repertoire, was more than three times higher, Cronbach's Alpha=.484. Item number fifteen was recorded at an incorrect tempo; the correct tempo was quarter note equals 60 and it was recorded at quarter note equals 132. Even though subjects were reminded to evaluate only tone quality, a tempo mistake of this magnitude is bound to effect validity. Because the majority of inter-item correlation coefficients were low, the item was not removed from the survey.

An important survey validity issue emerged during the recording session. The clarinet player selected to represent the Smile embouchure was undergoing an embouchure change to the Q embouchure between the time of selection to play for the survey and the recording session. Tone quality differences between the two players were likely smaller than they would have been had the Smile player not changed. Nonetheless, there remained a significant difference in electrical activity in the risorius muscles and a measured preference for the tone quality of the Q embouchure. Efforts to replicate the study should focus on finding players that best represent the prescribed embouchure qualities.

Recommendations for Future Research

Finding significant effects of embouchure on timbre and tone quality preferences should help stimulate further research. Because this study is the first of its kind, initial results should inspire additional efforts to replicate the study. A first change would be to conduct the survey online, using one of the commercially available online survey products such as Survey Monkey (www.surveymonkey.com). Survey Monkey is an inexpensive subscription service that includes unlimited survey construction, distribution, measurement, and management.

A replication of this study might involve sampling and surveying outside the National Band Association roster by randomly selecting school systems across the nation. One would need to contact selected systems to obtain potential subject names and email addresses. Once potential subject data is input into a bulk emailing, a link to an online tone quality preference survey would be disseminated immediately.

A separate study of the effects of clarinet embouchure on timbre is also a logical choice for additional research. The results from this study showed that tension in the risorius muscles affects the signal envelopes in five tones. Additional research might involve recording all sustained tones from E_3 to E_5 to determine the effects of embouchure on the timbre throughout the range of the clarinet.

While evaluating sustained tones remains important for timbre analysis, the sustained tone and scale survey items were slightly less reliable. Another suggestion, therefore, would be to eliminate the sustained tones and scales from the survey because of the low reliability. Additional survey items could come from first clarinet parts in standard wind band works, representing Grade 2 through 6 literature, as well as additional clarinet solo repertoire.

Because clarinet embouchure involves more than just risorius and zygomaticus activity, additional research should be carried out that would determine the effects of other embouchure attributes, such as tongue position and the activity in the muscle above the upper lip, the orbicularis oris on timbre and tone quality preferences. A multiple regression study evaluating the effects of additional factors, such as muscle tension in the orbicularis oris and tongue position in the oral cavity, may provide greater insight into how embouchure contributes to timbre and its perceived tone quality.

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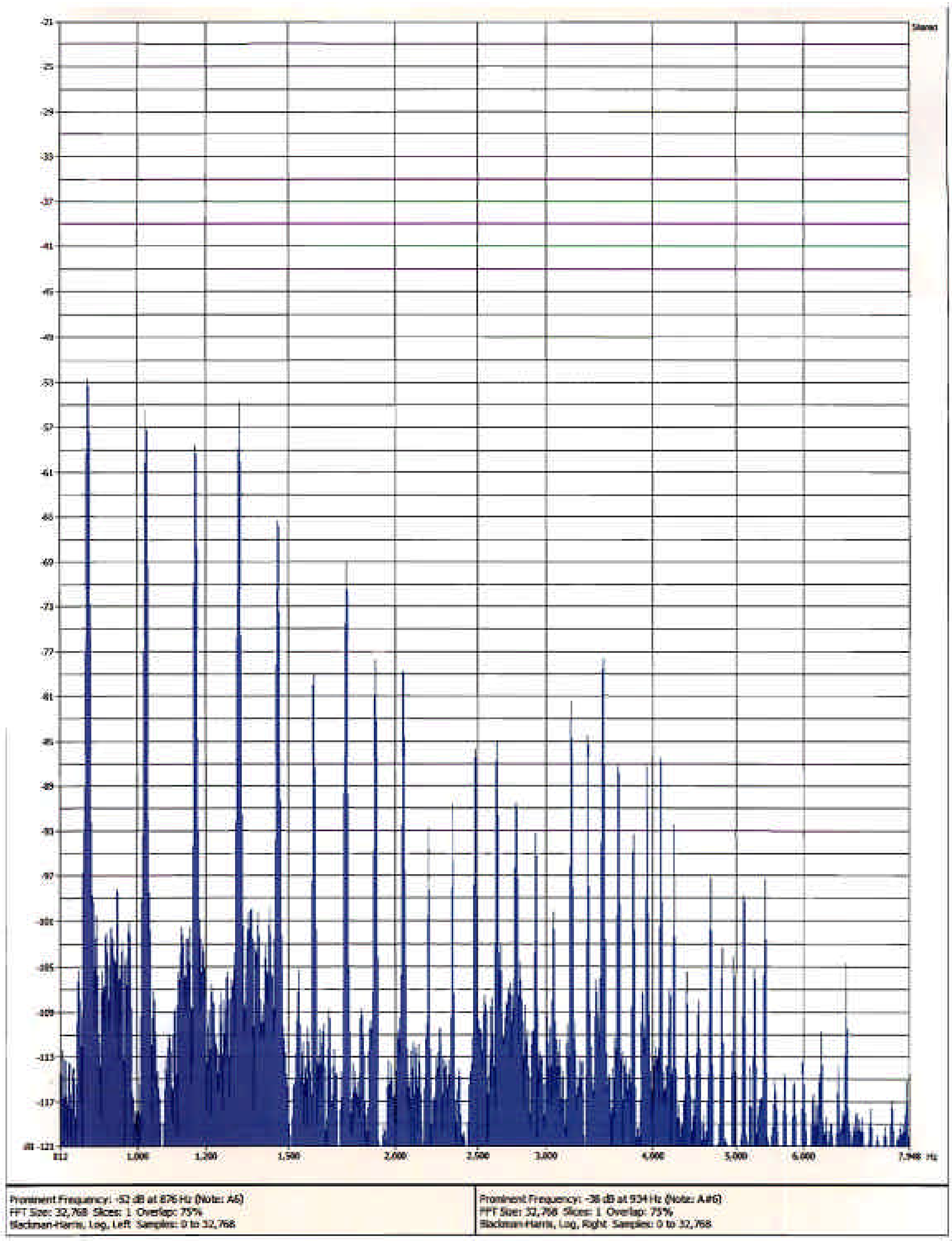
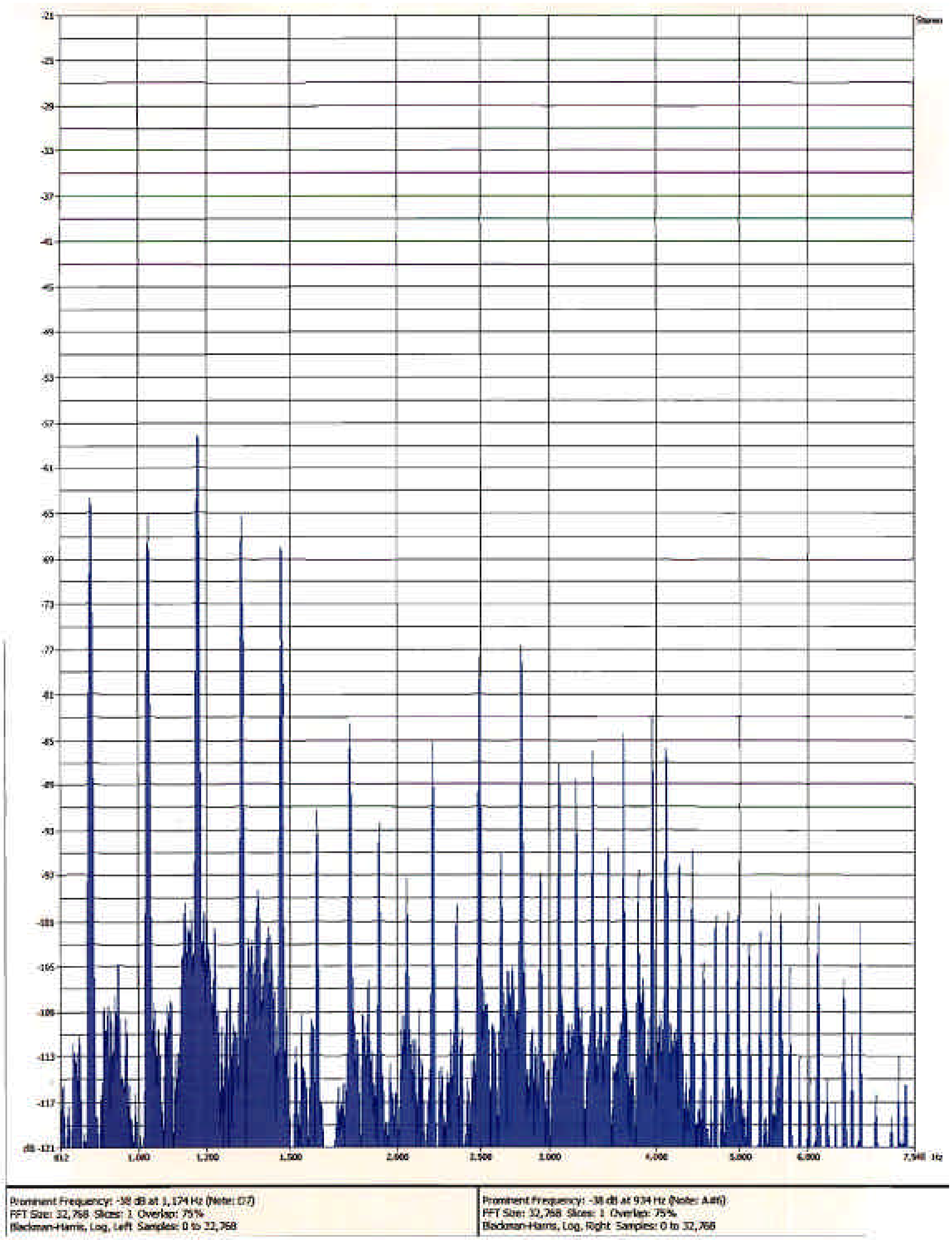
APPENDIX A

SIGNAL ENVELOPES FROM SUSTAINED TONES

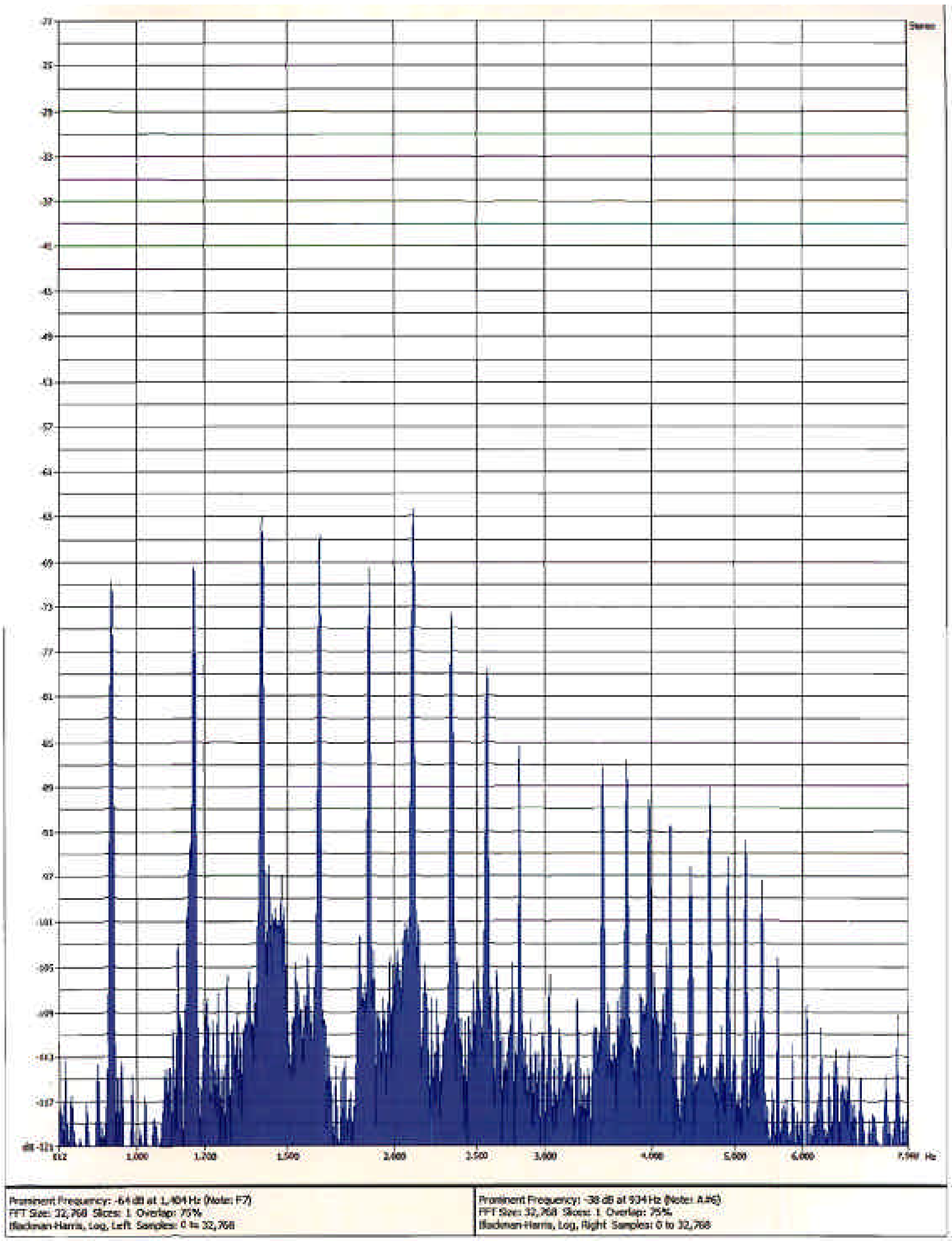
Low E, Q Embouchure



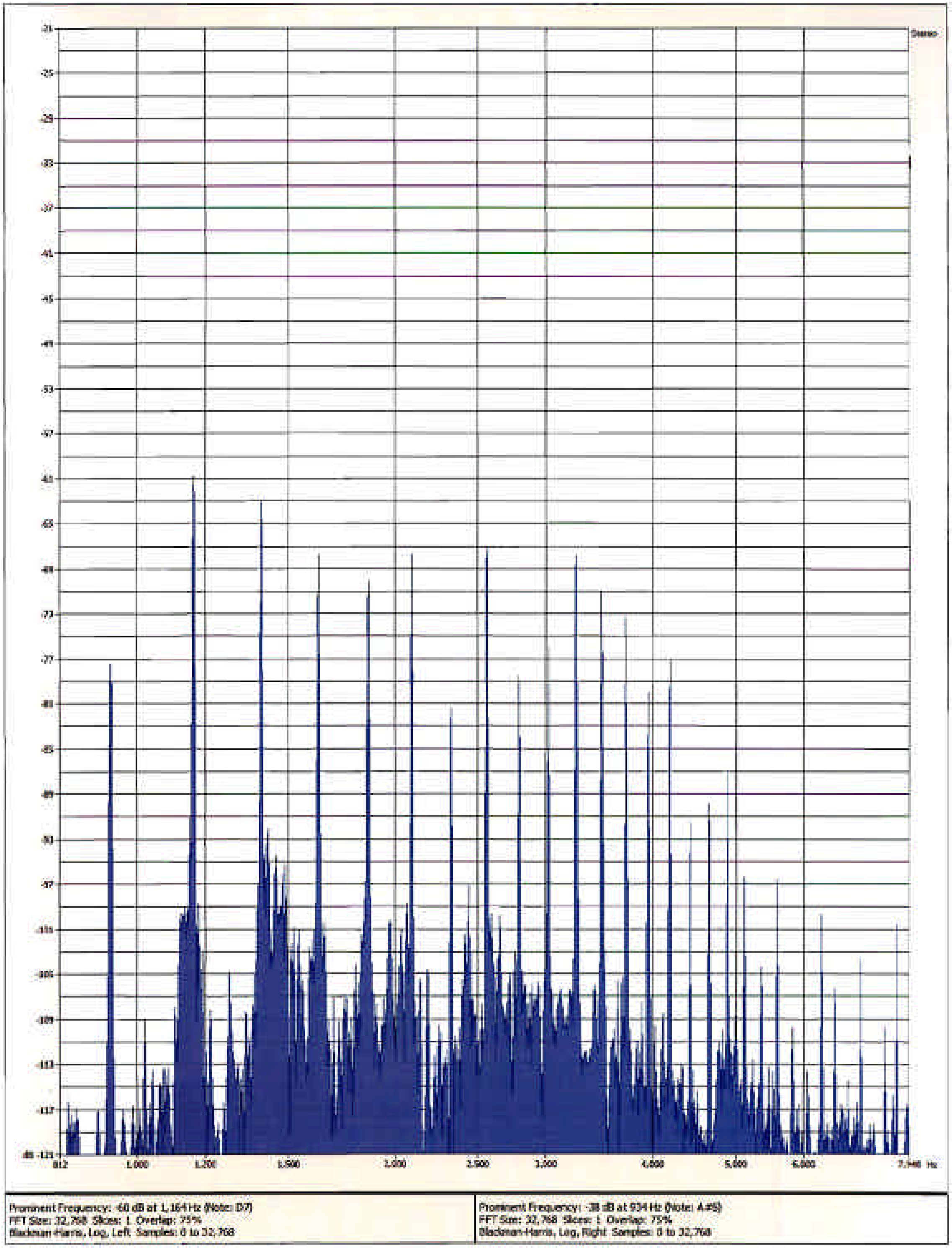
Low E, S Embouchure



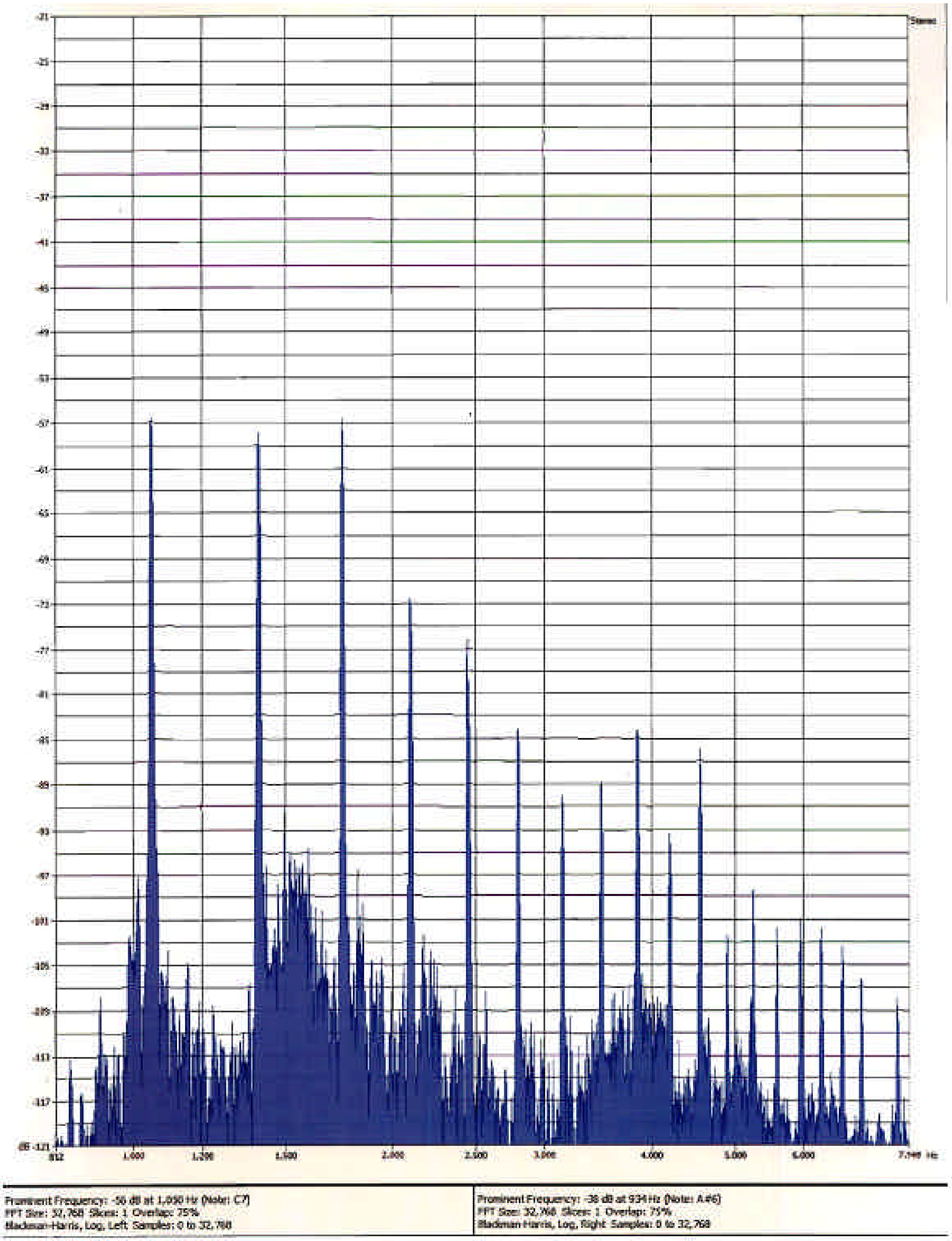
Low C, Q Embouchure



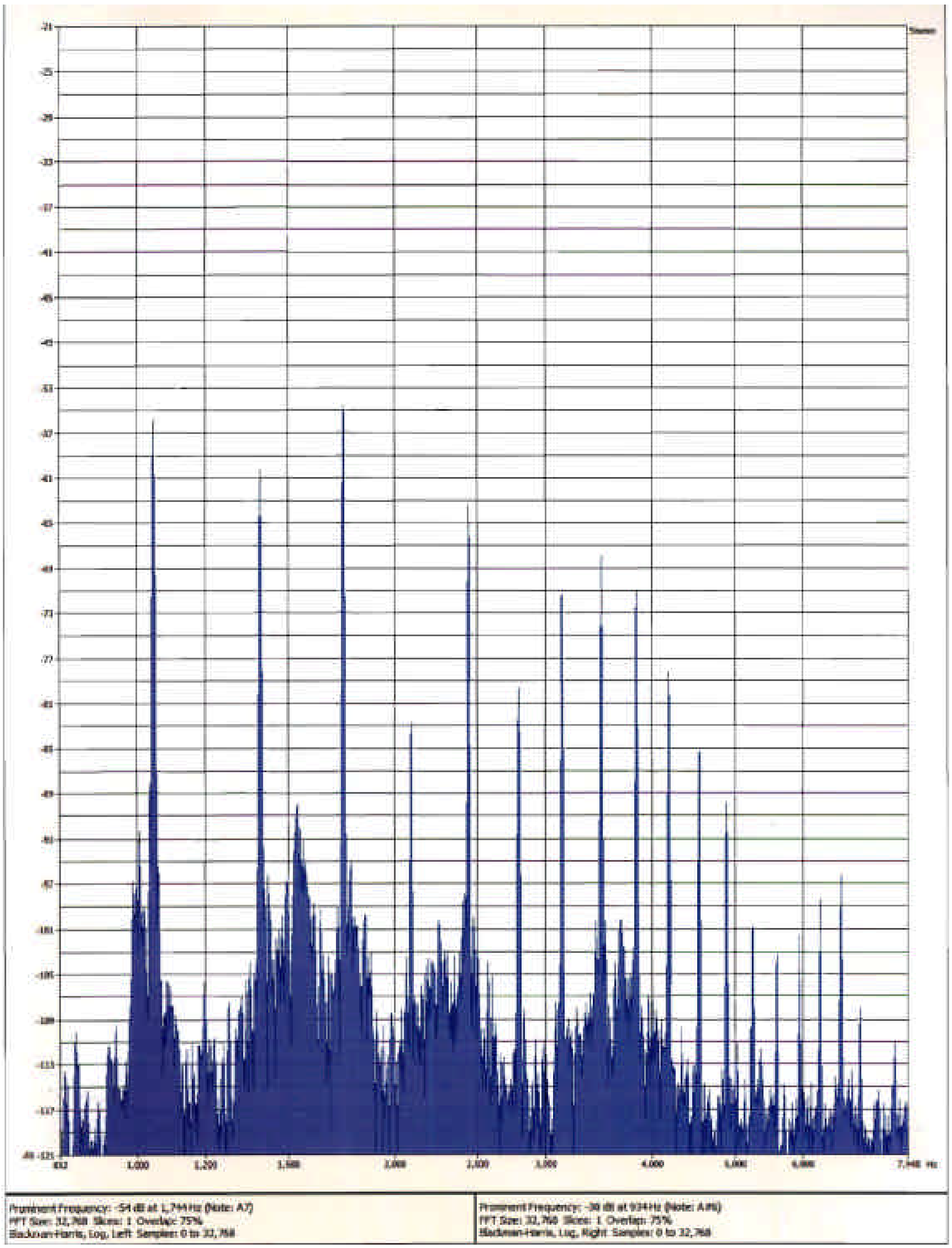
Low C. S Embouchure



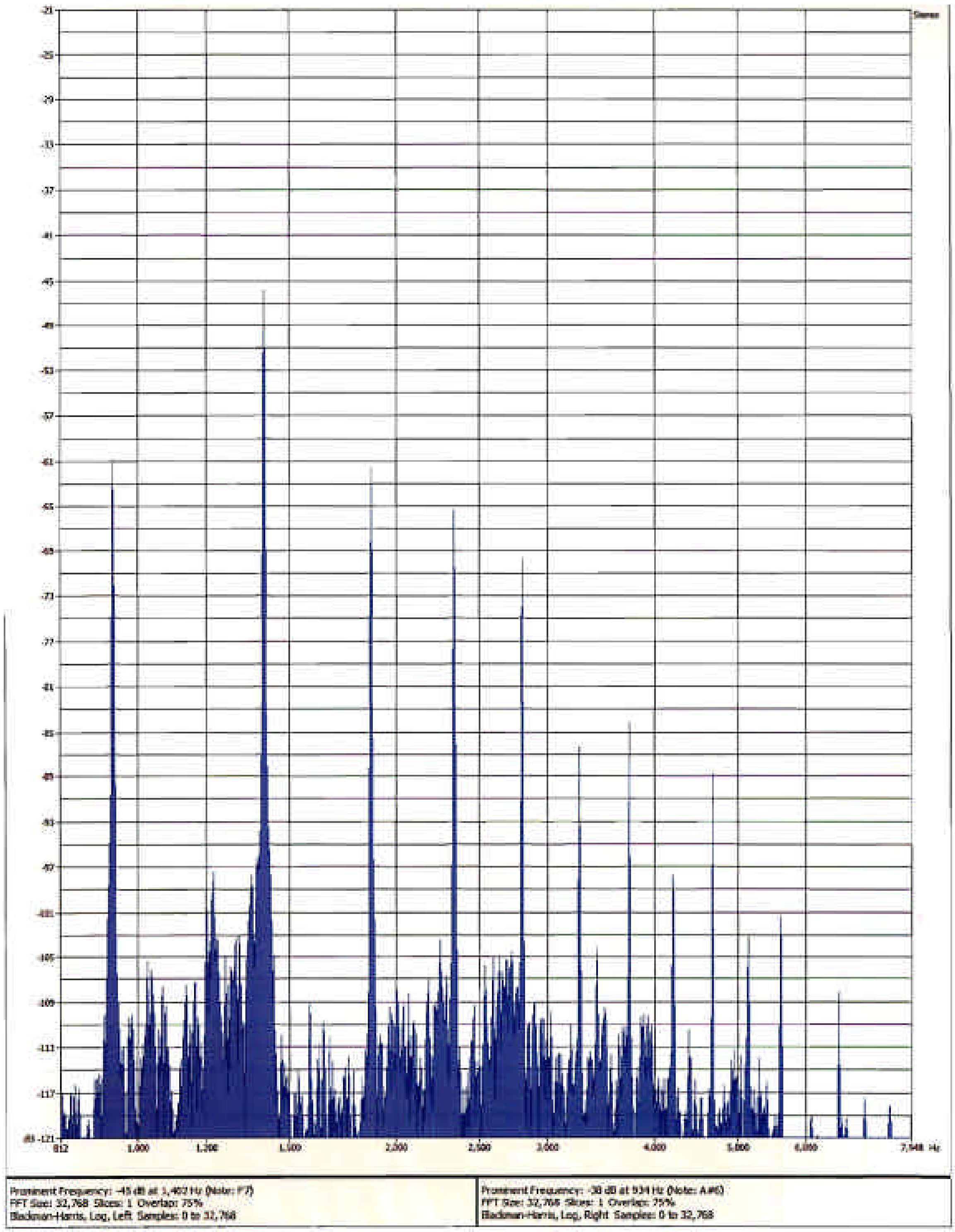
Open G, Q Embouchure



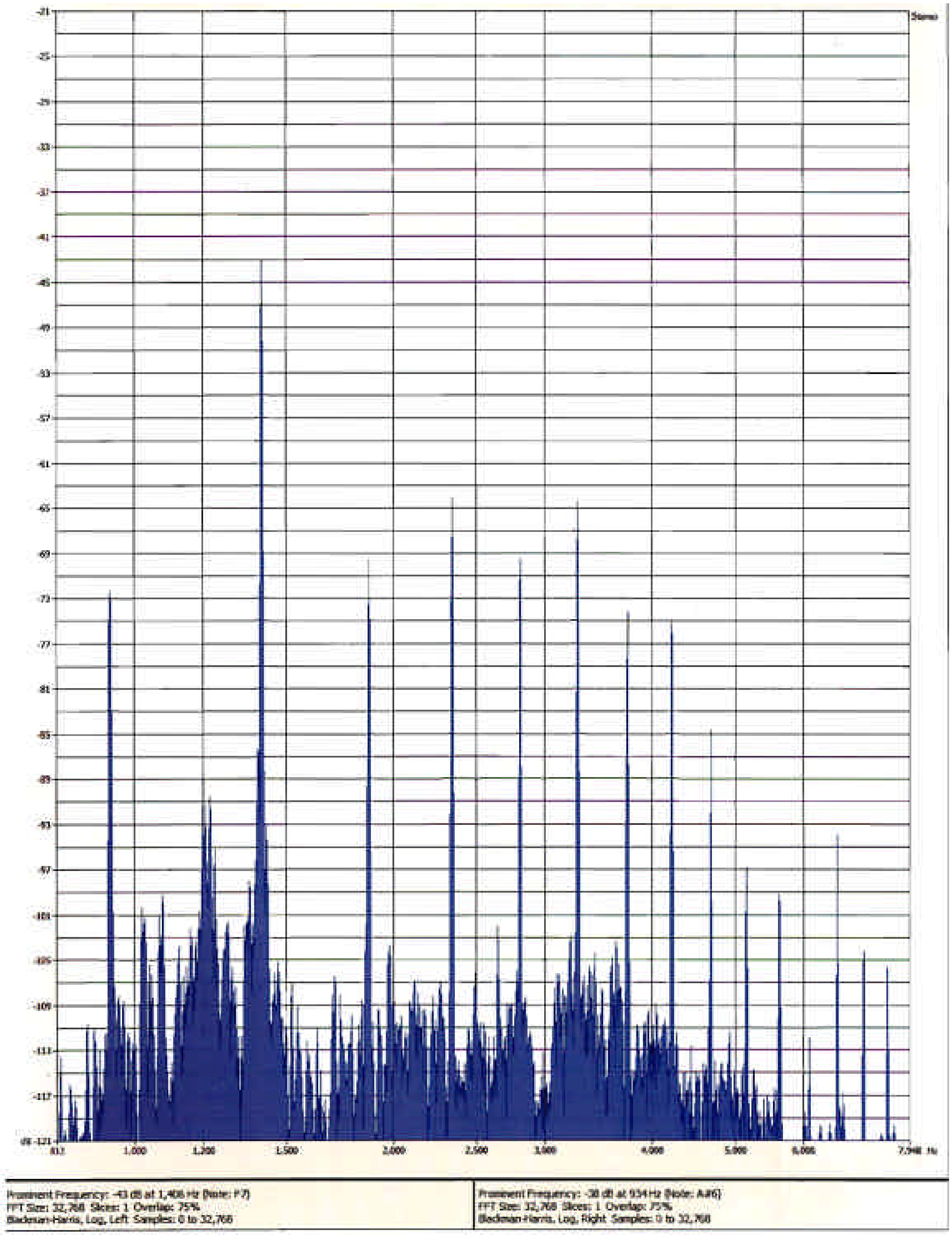
Open G, S Embouchure



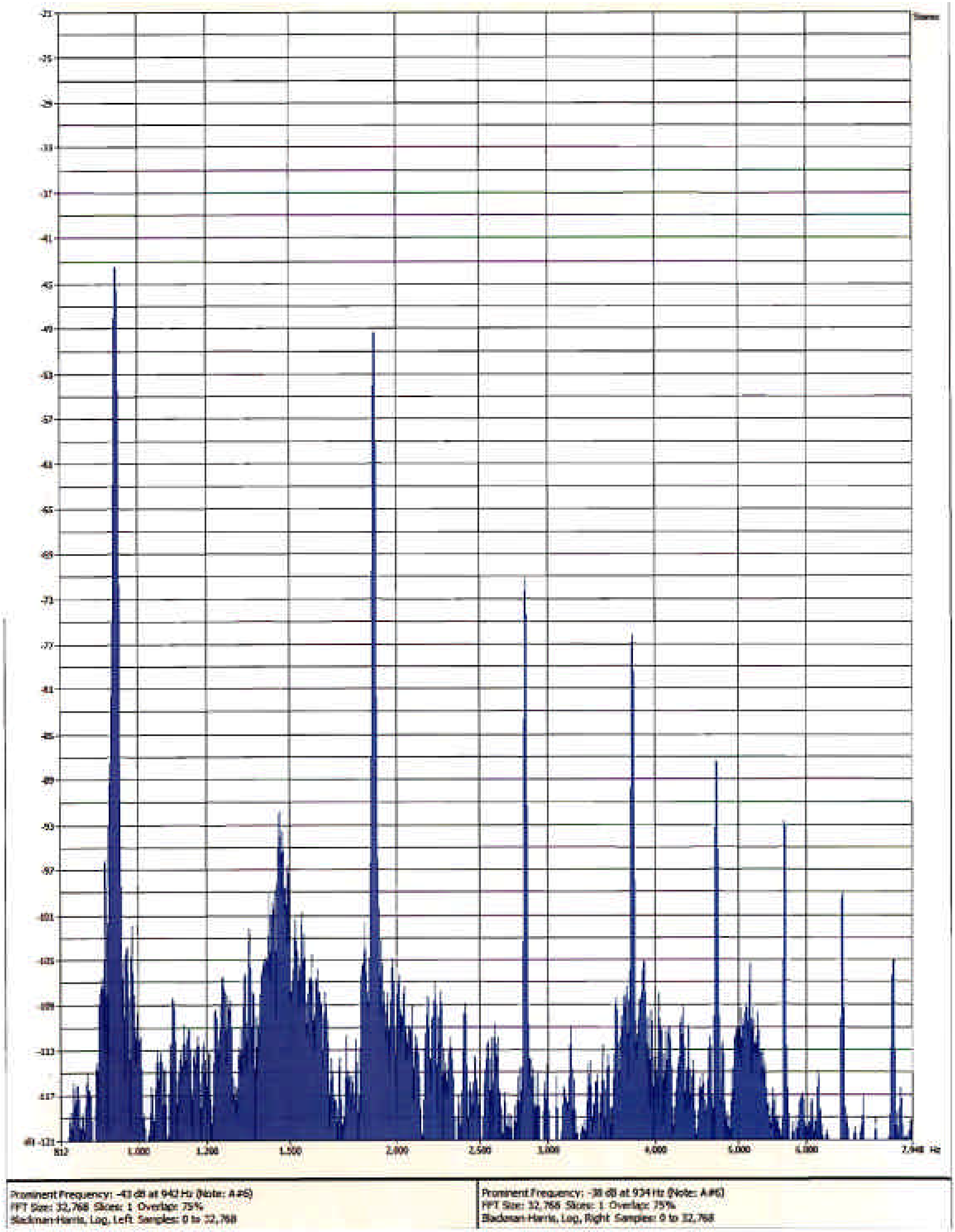
Clarion C, Q Embouchure



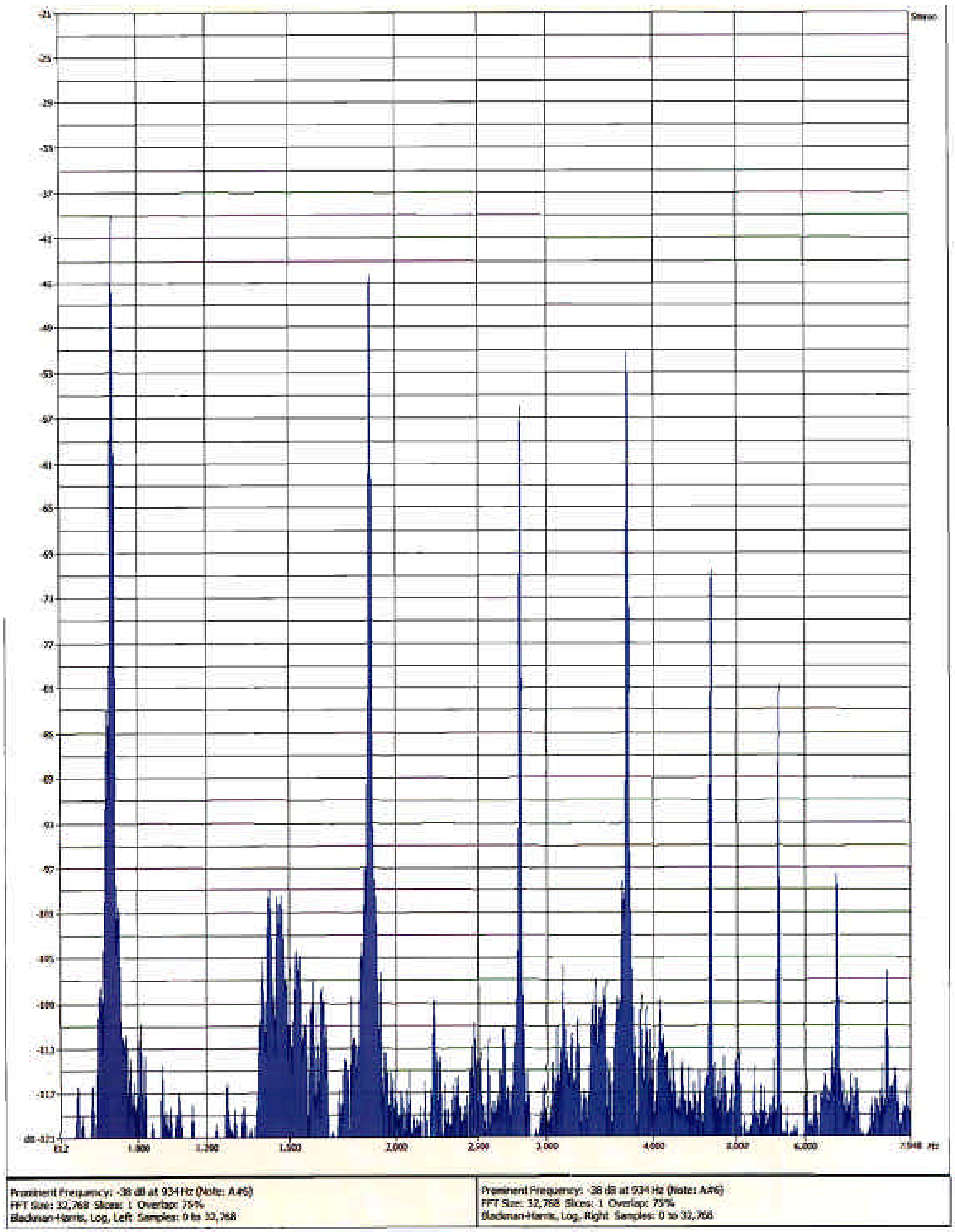
Clarion C, S Embouchure



Altissimo C, Q Embouchure



Altissimo C, S Embouchure



APPENDIX B

CLARINET TONE QUALITY SURVEY

Loraine Davis Enloe
Lionel Hampton School of Music
P.O. Box 444015
The University of Idaho
Moscow, ID 83844-4015

Dear Participant:

I am a doctoral student at The University of North Carolina at Greensboro. As part of my dissertation, I am conducting a survey of the clarinet tone quality preferences of band directors. Your participation in this study is strictly voluntary and you may withdraw at any time without penalty. Results from this study can help you improve teaching beginning clarinetists and will help improve your clarinet section tone quality. The survey should take less than 30 minutes to complete. Your survey answers will be confidential as no personal identifiers are used on the survey. The surveys will be retained in a locked file for five years, after which I will shred the forms and data.

You were selected, at random, from band directors and college clarinet teachers across the U.S., to participate in this study and I welcome your voluntary participation. Enclosed, you should find an instruction sheet, a CD of recorded tone quality examples, a tone survey sheet to record your background information and to collect your tone quality preferences, and a self-addressed stamped envelope in which to return your survey. Completion and return of the survey shall indicate your consent to participate. Please keep this letter for your reference.

To allow for best sound reproduction I suggest listening to the compact disc on your best available stereo equipment. To avoid distractions, please use a relatively quiet area in which to complete the survey. Your listening device should be set to a comfortable listening level. The first part of the survey is designed to capture information about you, including education and teaching experience; the second part is the beginning of the two-part listening portion of the survey and is a collection of sustained tones and scales; and, the last part of the survey is a collection of clarinet solo and concert band repertoire. It is important that you evaluate only the tone quality and ignore any perceived style differences. The total completion time should be 30 minutes or less. The research compliance officer for The University of North Carolina at Greensboro is Eric Allen. Should you have questions about human participants in this research project, please feel free to call him at 336-256-1482.

I appreciate your help with this project. Should you have any questions, or suggestions for further research, of if you would like a copy of the survey results, please feel free to email me a laenloe@uncg.edu or call me at 208-874-3523.

Sincerely,

Loraine D. Enloe,
Assistant Professor of Music Education

CLARINET TONE QUALITY PREFERENCE SURVEY

Instructions

1. Carefully read the cover letter.

2. Take out the survey and complete Part I, which collects individual information, such as gender, age, and ethnicity; and, professional information, such as teaching experience, major instrument, and undergraduate institution.

3. Please open the compact disc and insert the disc in the CD player that provides the best playback quality. Be careful to adjust the loudness to a comfortable level before playing the CD.

4. The survey is designed to capture your clarinet tone quality preferences. Though the recording of the sound samples was highly controlled to reduce confounding variables such expression or articulation, it is still important to remember to focus only on the tone quality of each sample.

5. Part II of the survey is a collection of sustained tones, extended-range scales, and clarinet solo and concert band repertoire. You will hear two recordings of each sample. Listen carefully to each, select and circle A on your survey sheet if you think that the first version reflected the best tone quality, or B if you think that the second version was best. If you do not have a preference, circle C. The listening portion of the survey begins with a practice item.

6. Place the completed survey in the self-addressed, stamped envelope and mail it before December 31, 2006.

7. All participants who return the survey will be entered in a drawing to win one of 20 $20.00 Barnes and Noble gift cards.

8. Results from the survey are available by contacting Lorie Enloe, Assistant Professor of Music Education, Lionel Hampton School of Music, Music Building Room 206, The University of Idaho, Moscow, ID 83844-4015.

9. Thank-you.

CLARINET TONE QUALITY PREFERENCE SURVEY

Part I

This part of the survey provides information about you, your education, and your teaching experience. Please take a moment to provide this important information.

1. Please circle the job description that best describes what you do:

Elementary/Middle School Band Director	High School Band Director
Elementary/Middle and High School Band Director	College Band Director
College Clarinet Teacher	Private Clarinet Teacher

2. Years of teaching experience: _______

3. Highest education level attained (Please circle one):

BA/BS/BM	MA/MFA/MMEd./MS
Ph.D./DMA/Ed.D	

Other: ________________

4. **Undergraduate institution:____**
Major: ________________________

5. **Graduate institution(s): ____**
Major (s): ______________________

6. **Primary musical instrument: ____**

7. **If clarinet is your primary instrument, please explain how you were taught clarinet embouchure:**
____
____

(Continued)

(Part I Continued)

8. **Please circle the woodwind methods text that your college used:**

Dietz, W., *Teaching Woodwinds*

Westphal, F., *Guide to Teaching Woodwinds*

Timm, E., *The Woodwinds: Performance and Instructional Techniques*

Sheldon, R. S. & Sheldon, D., *The Complete Woodwind Instructor*

Other: ____

9. **Gender (please circle):** Female Male

10. **Age:** ___________

11. **Ethnicity (please circle):**

African American

Asian

Hispanic – Other origin

Mexican American

Mixed

White/Caucasian

END OF PART I

Place the enclosed CD in your listening device and turn the page to Part II

Part II

TONE QUALITY PREFERENCE SURVEY

Press “Play” now on your listening device.

Part II of the survey is a collection of sustained tones, extended-range scales, and clarinet solo and concert band repertoire. You will hear two recordings of each sample. Listen carefully to each, select and circle A on your survey sheet if you think that the first version reflected the best tone quality, or B if you think that the second version was best. If you do not have a preference, circle C. The listening portion of the survey begins with a practice item. *Remember: you are only evaluating tone quality.*

Circle the letter of the sample with the best tone quality, or C if no preference:

	First Excerpt	Second Excerpt	No Preference
Practice Item	A	B	C

II. a. Sustained Tones and Extended Range Scales

Item 1	A	B	C
Item 2	A	B	C
Item 3	A	B	C
Item 4	A	B	C
Item 5	A	B	C
Item 6	A	B	C
Item 7	A	B	C
Item 8	A	B	C
Item 9	A	B	C
Item 10	A	B	C

End of Part II. a.
(Continue to Part II. b.)

(Part II. b. Continued)

Part II. b. Concert Band and Clarinet Solo Repertoire

	First Excerpt	Second Excerpt	No Preference
Item 11	A	B	C
Item 12	A	B	C
Item 13	A	B	C
Item 14	A	B	C
Item 15	A	B	C
Item 16	A	B	C
Item 17	A	B	C
Item 18	A	B	C
Item 19	A	B	C
Item 20	A	B	C

END OF SURVEY

APPENDIX C

CLARINET PLAYER LETTER

June 26, 2006

Dear Clarinet Player:

Thank you for your time and effort preparing and performing the tone-quality samples for this research study. You were asked to participate because of the manner in which you were taught clarinet embouchure. The purpose of the study is to determine clarinet tone quality preferences of band directors based upon embouchure differences. Results of this study will help you better teach beginning clarinet students and will help you to develop the best tone quality in your students. Your participation in this study is strictly voluntary and you may withdraw at any time without penalty.

I have enclosed the sustained tones, extended-range scales, and short excerpts from concert band and clarinet solo repertoire. Because I am trying to control for differences between instruments, mouthpieces, ligatures, and reeds, recorded material will be performed on one common R13 Festival Bb clarinet, mouthpiece, ligature, and brand of reeds for the study. To allow time to practice with the instrument and mouthpiece, ligature, and reed, you will need to check-out the instrument for an hour or more July 13 or 14, the week before the recording session. The recording session will likely be July 16-20 and should take no more than 3 hours. Once, again, your participation is strictly voluntary and you will remain anonymous in the study.

It is vitally important that performances reflect prescribed tempos, as defined by the metronome markings provided. It is also important to play each sample at *mezzo forte*, with no inflection, no rubato, and no expression as the goal of these samples is to provide tone quality samples. To effectively measure tone quality preferences, I must eliminate any confounding variables that might interfere with subject responses such as musicality and interpretation. Also, to control for the effect of articulation on tone quality, the selected excerpts have little or no articulation; scales will be performed slurred.

You are participating in a carefully controlled recording session. Below are some of the control measures that will be in place during the session:

1. A metronome, set on "visual only," will be placed on the music stand to assist the maintenance of a steady tempo.

2. In an effort to reduce the effect of movement on the recorded spectral envelope (timbre), the clarinet will remain a specified distance from the music stand and microphone.

3. To control for dynamic level, a sound pressure meter will be placed beside the music stand. You will have an opportunity to practice with the apparatus during the recording session.

4. Electrodes will be placed on the skin of your cheeks to measure electronic activity in the facial muscles. This is a non-invasive and painless procedure. The cables, which connect the electrodes to the electromyography apparatus, will be placed over your shoulder and connected to the unit. Physical risk is minimal; please read and sign both copies, indicating that you have been advised of any risks, and that you consent to voluntary participation in the study. Retain one copy of this letter for your records and return one other copy prior to beginning the recording session.

We will test the skin on top of your hand for possible allergic reaction to the adhesive used to attach the electrodes. This will require cleaning the skin with isopropyl alcohol, and applying an adhesive patch for approximately 15 minutes.

5. You will play the sustained tones and scales in the order listed. You will be asked to stop after each tone and each scale. After the sustained tones and scales are recorded, you will be able to relax – still in position – before we record the band and solo repertoire excerpts, where – again – you will stop after each excerpt.

I will keep the master and any additional recordings for five years in a locked file, after which I will shred the CDs.

Thank-you for your participation in this study. If you have questions, suggestions for further research, or would like a copy of the results, please do not hesitate to contact me at laenloe@uncg.edu or by phone at 336-558-4130. The research compliance officer for UNCG is Eric Allen. If you have any questions about human subject participation in research, please contact him at 336-256-1482.

Sincerely,

Lorie Enloe, Graduate Student
School of Music
The University of North Carolina at Greensboro

(continued)

(continued)

INFORMED CONSENT

You have thoroughly read this letter and are aware of the potential risks involved in this study. By signing below, you are voluntarily providing consent to participate in this research.

Clarinetist Signature: Date:

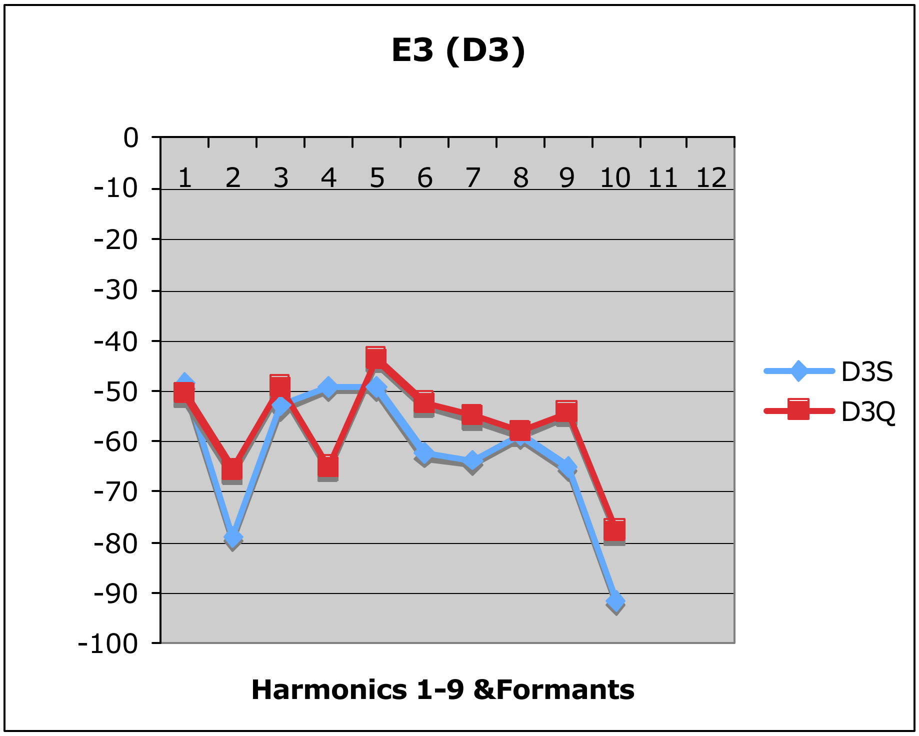
______________________________________ ____________

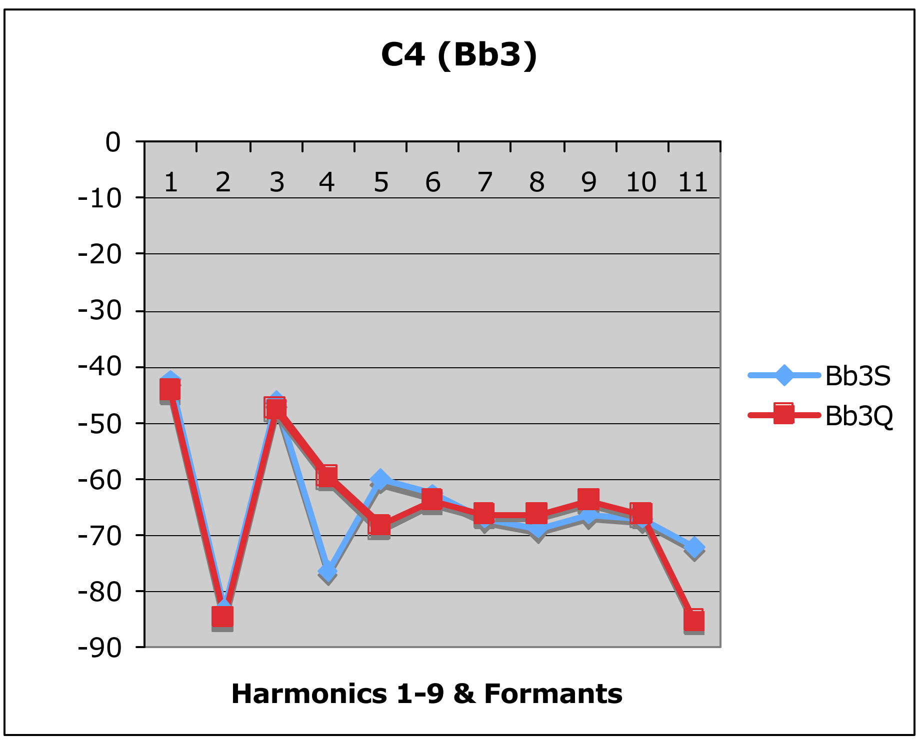
Clarinetist Signature (Please print)

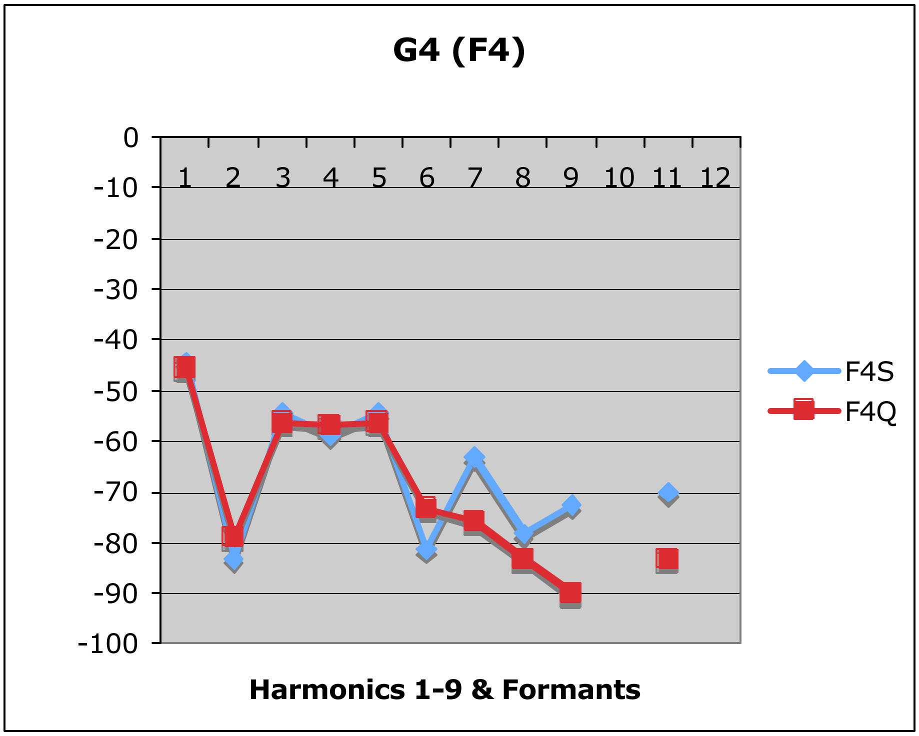
____

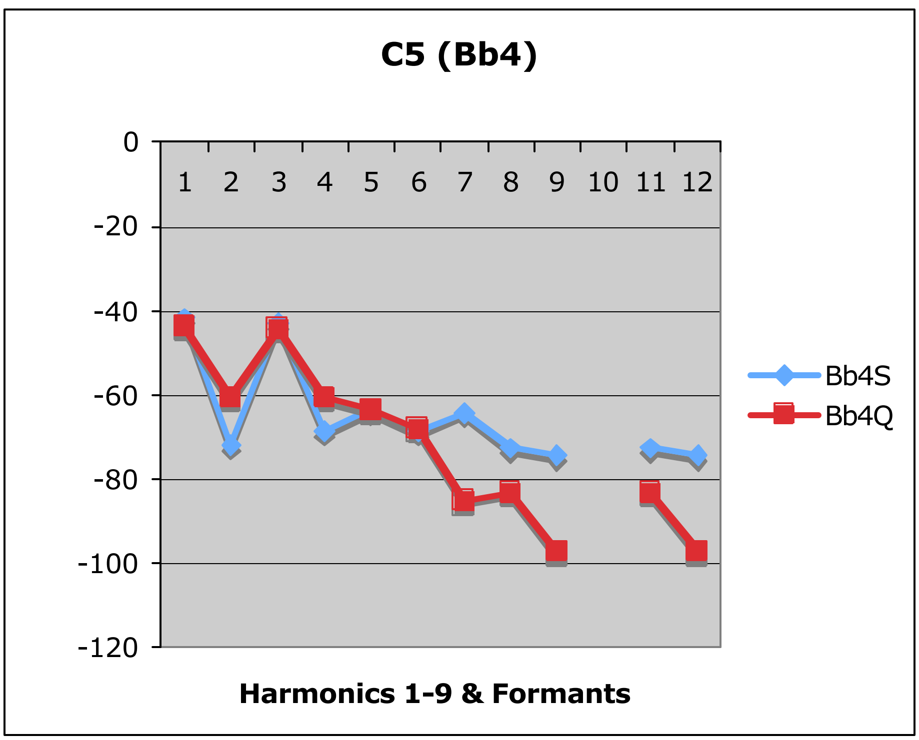
APPENDIX D

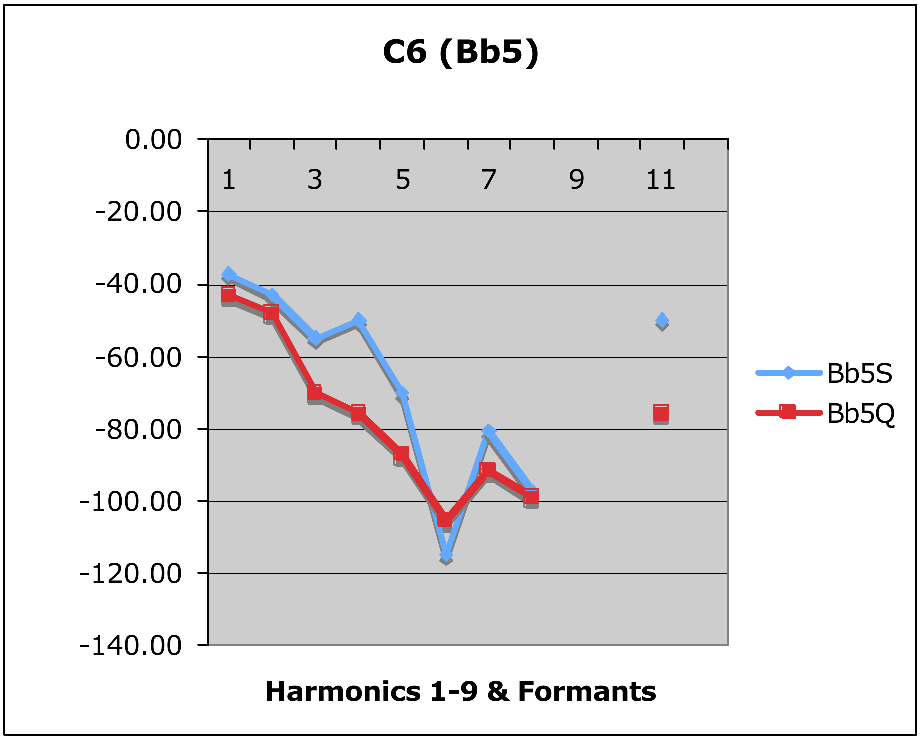
COMPARISON OF SIGNAL ENVELOPES


E3 (D3)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
1 2 3 4 5 6 7 8 9 10 11 12
D3S
D3Q
Harmonics 1-9 &Formants


C4 (Bb3)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
1 2 3 4 5 6 7 8 9 10 11
Bb3S
Bb3Q
Harmonics 1-9 & Formants


G4 (F4)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
1 2 3 4 5 6 7 8 9 10 11 12
F4S
F4Q
Harmonics 1-9 & Formants


C5 (Bb4)
0
-20
-40
-60
-80
-100
-120
1 2 3 4 5 6 7 8 9 10 11 12
Bb4S
Bb4Q
Harmonics 1-9 & Formants



C6 (Bb5)
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
-140.00
1
3
5
7
9
11
Bb5S
Bb5Q
Harmonics 1-9 & Formants

APPENDIX E

SURVEY REPERTOIRE

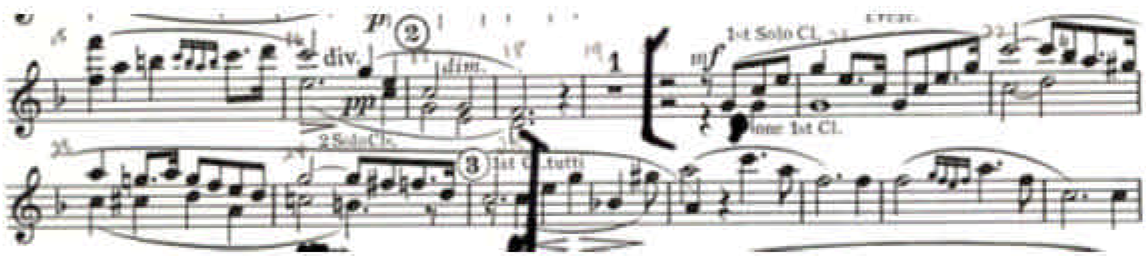
Sustained Tones and Scales

Enloe

2006

Concert Band and Clarinet Solo Repertoire

1. Elsa's Procession to the Cathedral (From "Lohengrin"), R. Wagner/transcribed by Cailliet. (Solo: pick-up to m. 21 to m. 25) mm: ♩ = 50



2. Korean Folk Medley, arr. J. Ployhar. (m. 28 to m. 35) mm: ♩ = 80

3. The Wexford Carol, arr. McGinty. (pick-up to m. 32 to m. 39) mm: ♩ = 56

4. A Festive Overture, Reed. (m. 245 to eighth note on beat one, m. 251) mm: ♩ = 92

5. Toccata for Band, Erickson. (m. 73 to m. 80) mm: ♩ = 132

6. Four Short Pieces for Clarinet and Piano, Movt. III, Ferguson. (m. 3to 11) mm: ♩. = 60

7. Sonata for Clarinet and Piano, Mvt. 1, Hindemith. (m. 1 to 7) mm: ♩ = 108

8. Introduction, Theme and Variations, Theme, von Weber (pick-up to m. 21 to m. 28) mm: ♩ = 120

9. Sonata in Eb, Brahms (m. 1 to 8) mm: ♩ = 100

10. Concerto No. 1, Movt. 1, von Weber (m. 49 to 56) mm: ♩ = 120

APPENDIX F

NARRATOR SCRIPT

Narrator's Script

Thank-you for participating in the clarinet tone quality survey. By now, you should have completed Part I of the survey. Part II is the listening portion of the survey and is composed of two parts: Part II. a. includes sustained tones and extended range scales; Part II. b. includes concert band and clarinet solo repertoire.

You will hear two recordings of each sample. Listen carefully to each, select and circle A on your survey sheet if you think that the first version reflected the best tone quality, or B if you think that the second version was best. If you do not have a preference, circle C. The listening portion of the survey begins with a practice item. *Remember: you are only evaluating tone quality.*

Part II. a. Sustained Tones and Extended Range Scales
Practice item.
A.
B.
1
2
3
4
5
6
7
8
9
10

This concludes Part II. a. of the tone quality preference survey.
Part II. b. Concert Band and Solo Repertoire.

11
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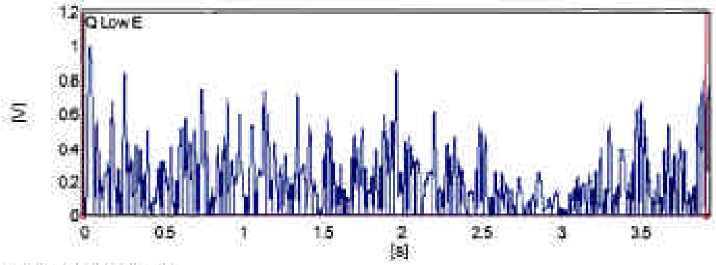
END OF SURVEY You have now completed the tone quality preference survey. Please fold the survey form, place it in the stamped, self-addressed envelope provided and mail it as soon as possible. Thank-you for participating.

APPENDIX G

ELECTROMYOGRAPHY TRACINGS



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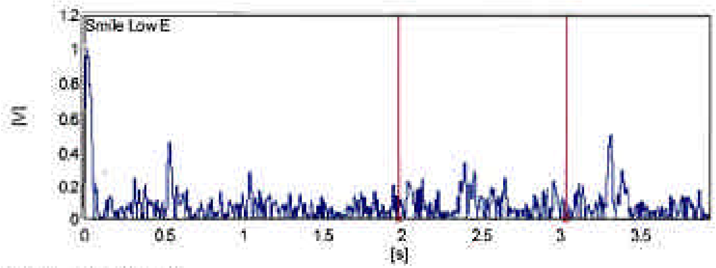

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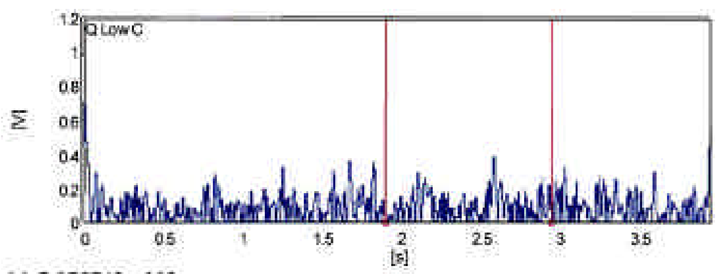

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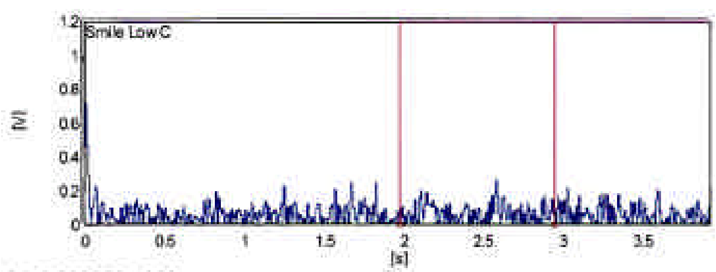

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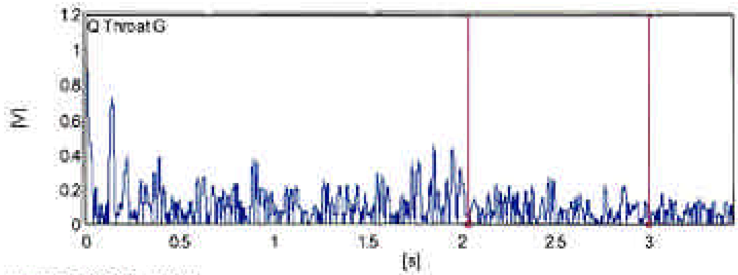

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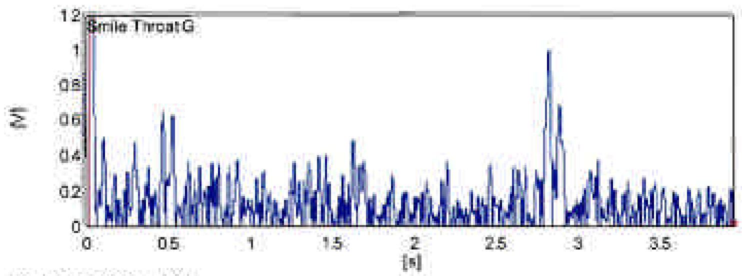

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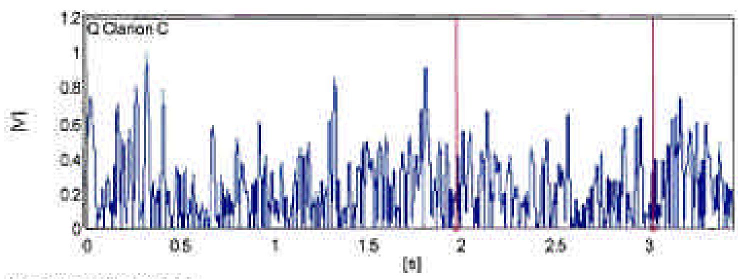

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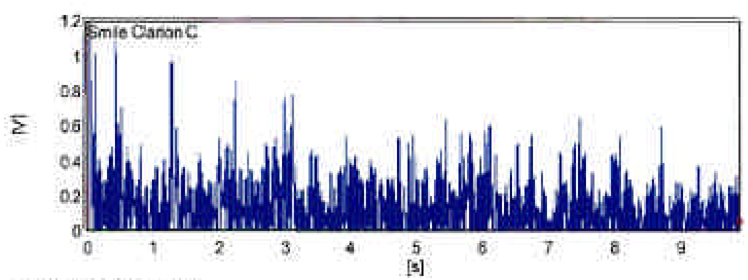

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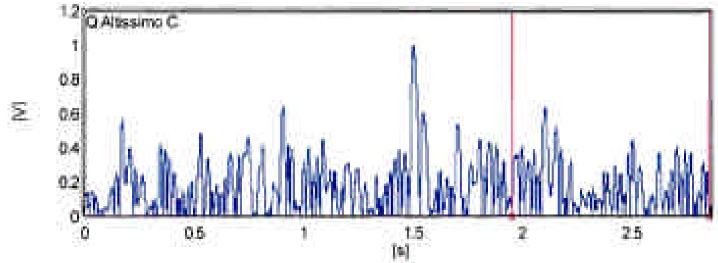

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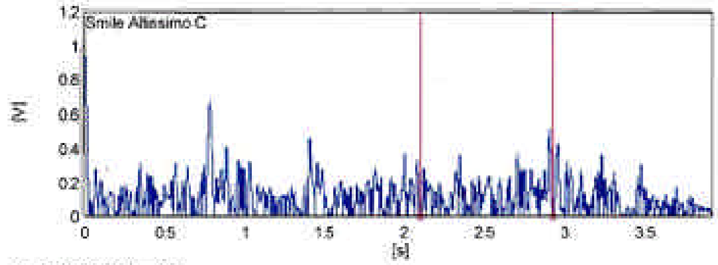

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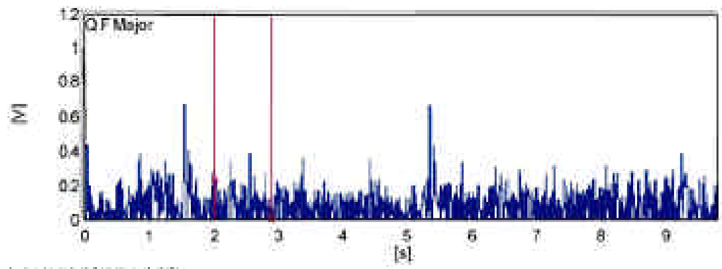

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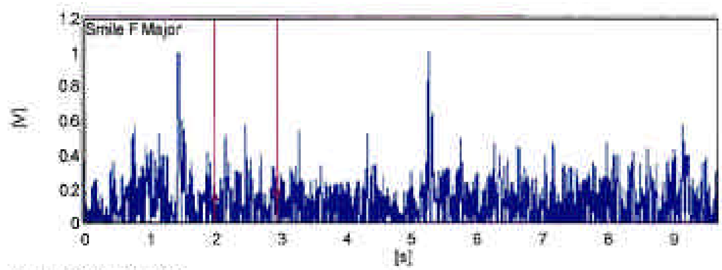

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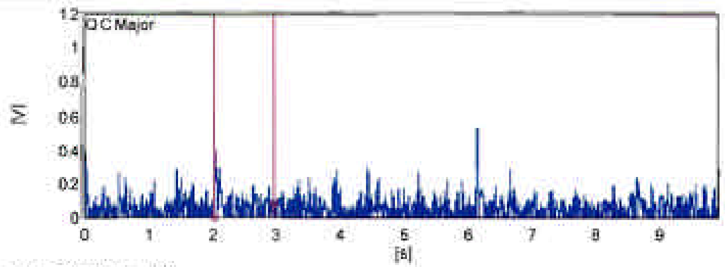

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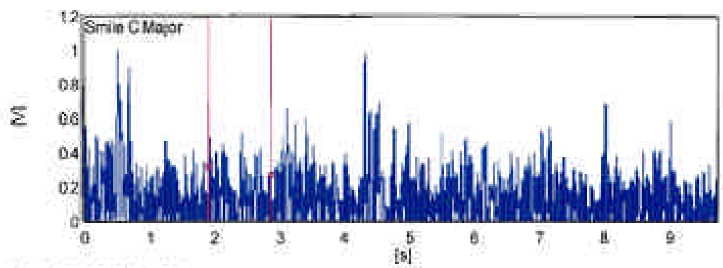

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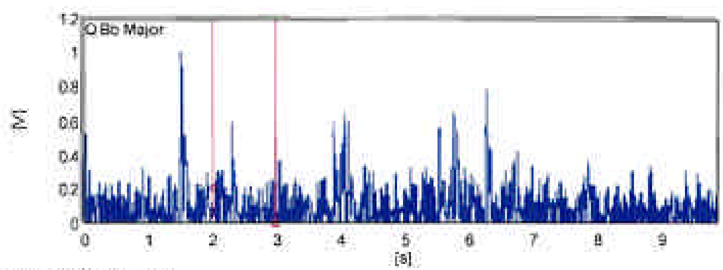

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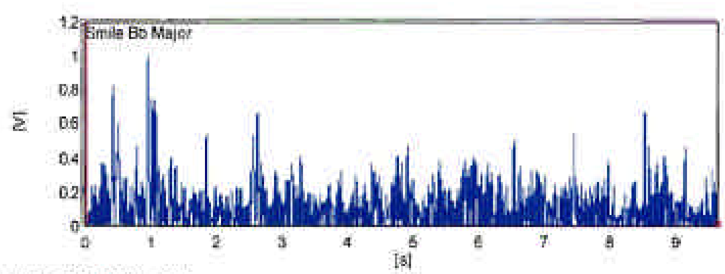

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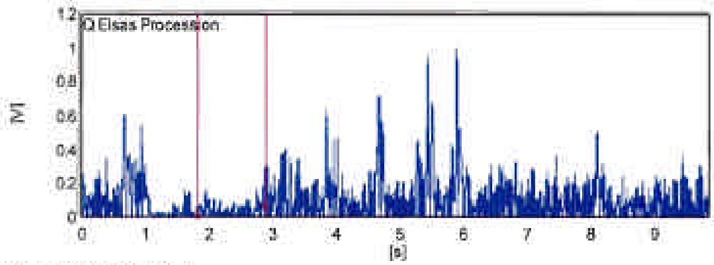

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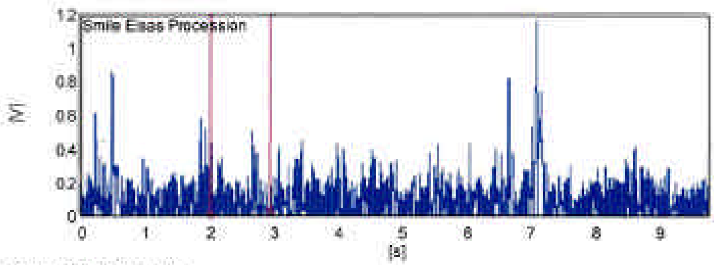

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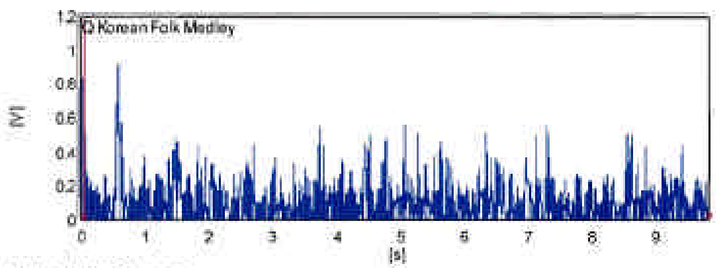

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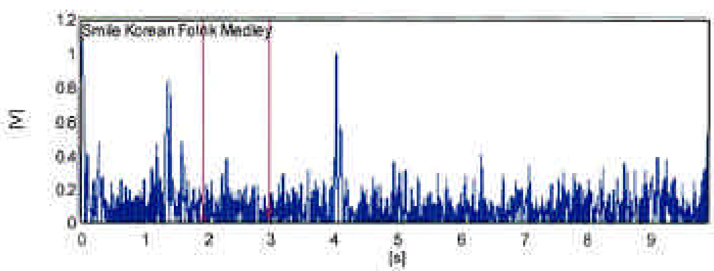

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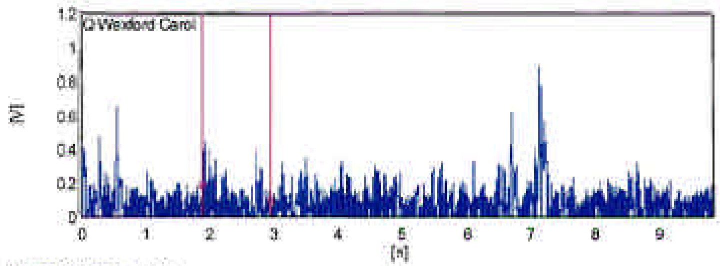

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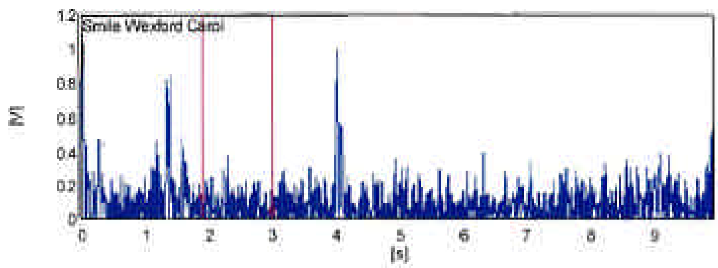

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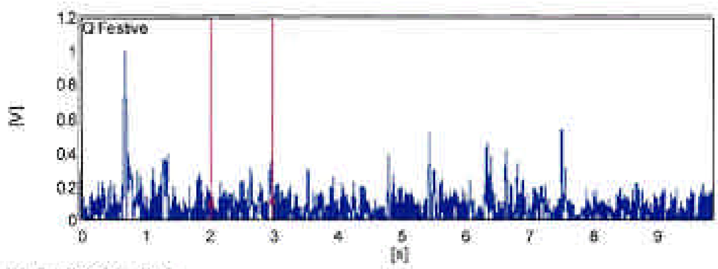

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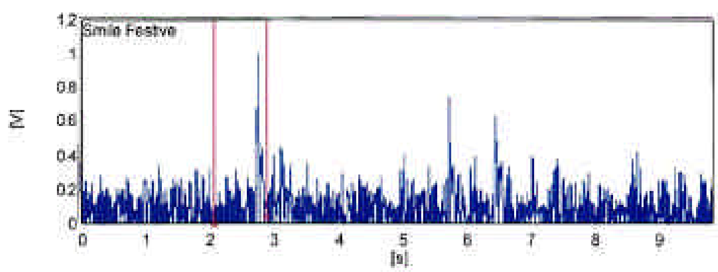

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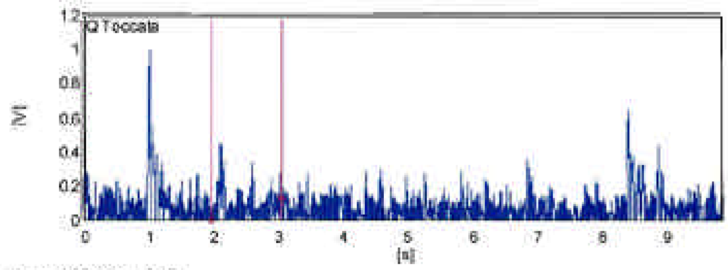

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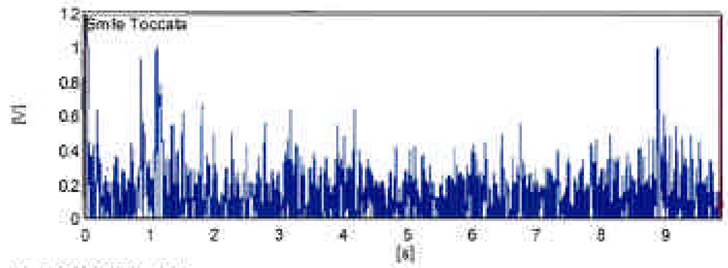

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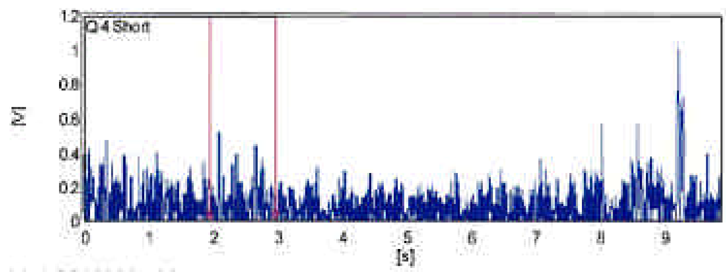

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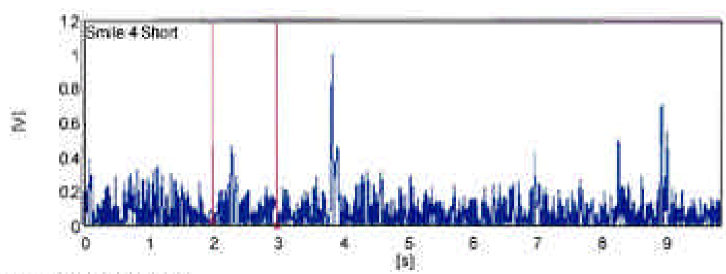

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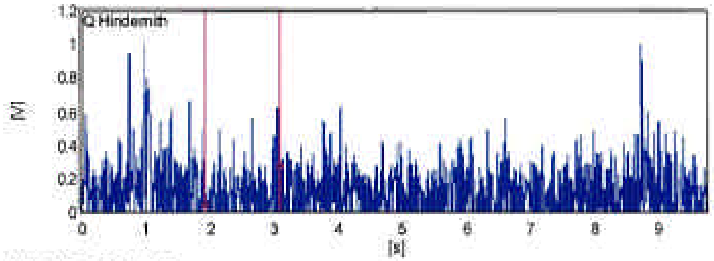

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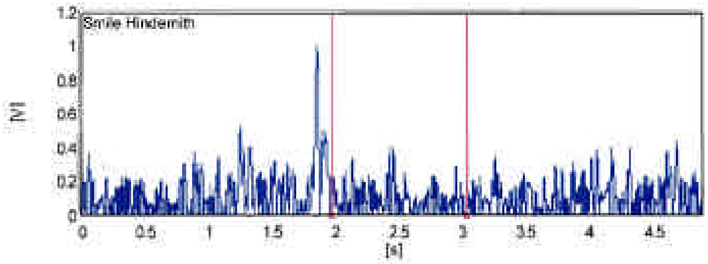

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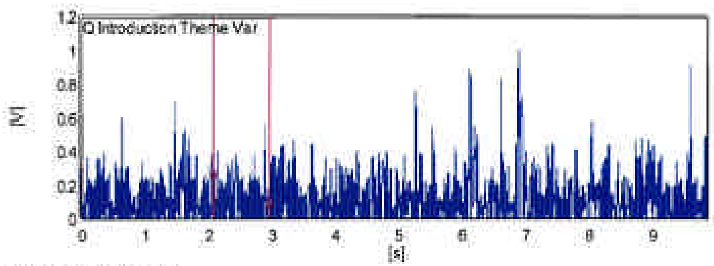

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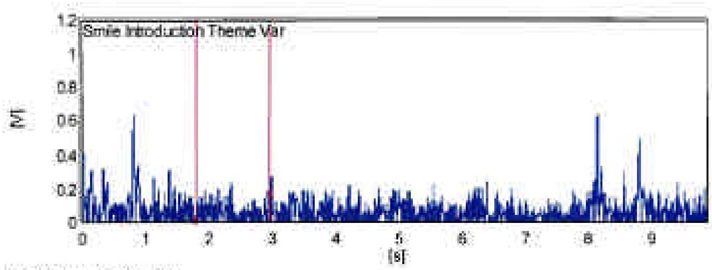

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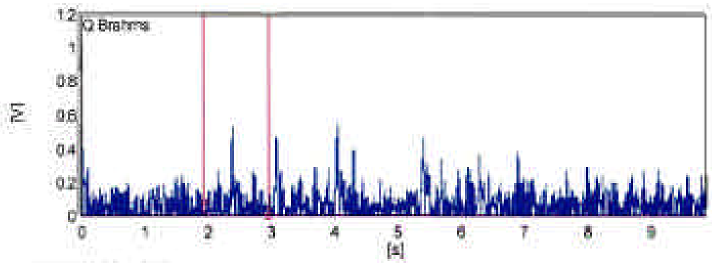

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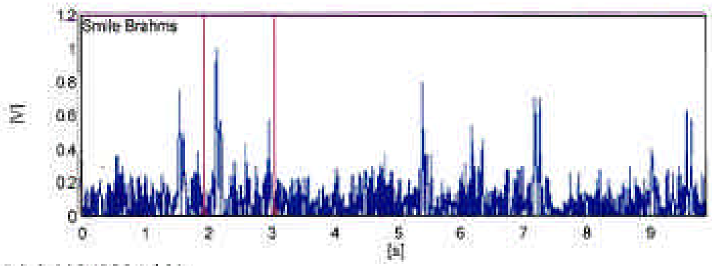

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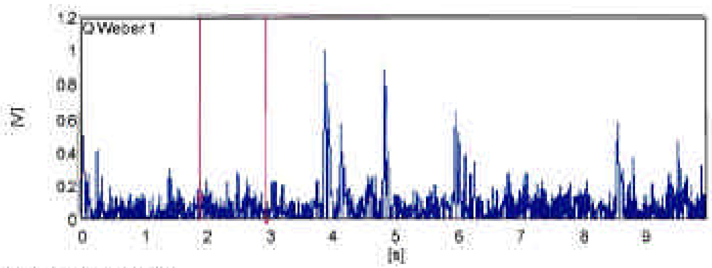

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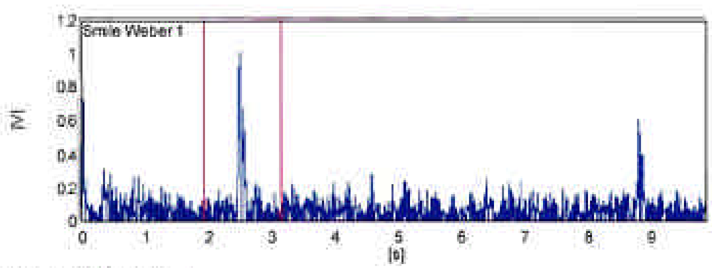

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APPENDIX H

SURVEY COMPLETION REMINDERS

It’s NOT too late!

You should have received The Clarinet Tone Quality Survey, including an envelope and CD, in December. Your participation is important and responses are still needed.

Please take a moment to complete the survey and mail it in the self-addressed envelope provided.

Thanks.

Lorie Enloe: laenloe@uncg.edu

APPENDIX I

IRB APPLICATION

Application For the Use of Human Participants in Research

Part I

Date Submitted to Departmental Reviewer: 6/21/2006
Project Title: THE EFFECTS OF CLARINET EMBOUCHURE ON TONE QUALITY PREFERENCES OF SELECTED MEMBERS OF THE NATIONAL BAND ASSOCIATION

Principal Investigator(s): Loraine Davis Enloe

Email Address(es) of Principal Investigator(s): laenloe@uncg.edu

Phone Number(s) of Principal Investigator(s): 336-558-4130

Address(es) of Principal Investigator(s): 1660 Coleridge Rd., Siler City, NC 27344

Relationship to the University (specify): ____ Faculty _X__ Student ____ Other

If student, name of faculty sponsor: Donald A. Hodges, Ph. D.

Faculty Sponsor's Campus Address: Room 348, Music Building

Faculty Sponsor's email address: dahodges@uncg.edu

School/College: Music Department: Music Education

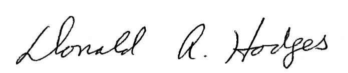
Funding Agency/Sponsor (if applicable): NA

Projected data collection dates*: From 9/1/2006 To 12/31/2006

*The beginning data collection date should be at least one month after review of the IRB application by the departmental reviewer. Data collection cannot begin before IRB approval is received.

6/27/06

Researcher's Signature(s) Date



6-27-06

Faculty Sponsor's Signature Date

IRB Initial Reviewer's Signature Date Reviewed

Application For the Use of Human Participants in Research

Please provide responses to the following Application Prompts.

Application Prompts *The Principal Investigator completes this column.*	**Check by Faculty Sponsor or Principal Investigator**	**Check by IRB Departmental Reviewer**
1. At any time, will members of the research team or their immediate family members have financial interest in, receive personal compensation from, or hold a position in an industry sponsoring this study or otherwise have a potential conflict of interest regarding the conduct of this study? ___ YES __X_ NO ___ N/A (no industry sponsors) If YES, the Potential Conflict of Interest in Research must be attached to this application.	Please Initial	Please Initial
2. As part of this study, will you obtain personally identifiable health information (PHI) from a hospital, health care provider, or other HIPAA-defined Covered Entity? ___ YES _X__ NO If YES, attach the Application to Use PHI in Research to this application.	Please Initial	Please Initial
3. Have you attached evidence of training in the protection of human participants in research for all principal investigators? __X_ YES ___ NO	Please Initial	Please Initial
4. If the principal investigator is a student, have you attached evidence of training in the protection of human participants in research for the faculty sponsor? _X__ YES ___ NO ___ Not Applicable	Please Initial	Please Initial
5. Will persons who are <u>NOT</u> principal investigators have access to research data (e.g., research assistants, transcribers)? ___ YES _X__ NO If YES, principal investigator(s) must agree to keep Certificates of Confidentiality on file by checking the statement below. Certificates of Confidentiality will be kept on file with the Principal Investigator's research records.	Please Initial	Please Initial

IRB Application and Checklist

Please provide responses to the following Application Prompts.
Insert additional space for your responses as needed.

Application Prompts *The Principal Investigator completes this column.*	**Check by Faculty Sponsor or Principal Investigator**	**Check by IRB Departmental Reviewer**
6. State the goals for the project clearly and describe the need for human participants' consent. To determine band director tone quality preferences based upon the effects of two different clarinet embouchures. Two clarinetists, trained in either of the two different embouchures will perform sustained tones, scales, and repertoire representative of clarinet solo literature and concert band literature that will serve as tone quality samples for the survey. During the recording session, facial muscle electrical activity in the right-side zygomaticus major and risorious muscles will be captured by a Bagnoli 2 electromyography apparatus in an effort to quantify physical differences in muscle tension between embouchures. The EMG electrodes used in this study are surface electrodes and are non-invasive. There is a slight risk of skin reaction to the adhesive used to attach the electrodes to the facial skin surface or to the isopropyl alcohol that is used to clean the skin prior to electrode placement. A compact disc of tone quality samples and a survey instrument will be sent to randomly selected band directors to collect subject tone quality preferences.	Please Initial	Please Initial
7. How will data be collected? If data collection tools are not well known, attach copies to this application. Facial muscle electrical activity will be collected by electromyography to differentiate levels of muscle tension between embouchures. Band director tone quality preferences will be collected using a researcher-designed survey instrument.	Please Initial	Please Initial
8. How will data be recorded? Include your plans for written, electronic, audiotaped, videotaped, or other means for recording data. Facial muscle electrical voltage data will be recorded using a PC laptop computer running Windows XP and Delsys EMGWorks v.3.1.	Please Initial	Please Initial

Application Prompts *The Principal Investigator completes this column.*	**Check by Faculty Sponsor or Principal Investigator**	**Check by IRB Departmental Reviewer**
Subject responses will be written, and recorded on the survey instrument.		
9. How many persons will participate in the study? How did you arrive at that number? Surveys will be sent to 250 (5%) randomly selected members of the National Band Association. Surveys will also be sent to 50 college clarinet teachers in the United States.	Please Initial	Please Initial
10. How will participants be selected for the study? Clarinetists recording the tone quality samples CD are UNCG graduate student volunteers. Participants will be randomly selected, using a table of random numbers (Howell, 2004, pp.525-526). Band directors will be selected from the National Band Association roster, available to all NBA members and college clarinet teachers from the College Music Society.	Please Initial	Please Initial
11. Will you exclude any person from participating in the study on the basis of race, gender, or ethnicity? ___ YES _X__ NO If YES, what is your justification for excluding persons on the basis of race, gender, or ethnicity?	Please Initial	Please Initial
12. How much time will participating in the study require for participants? Clarinetists will spend 3 hours each in the recording session Subjects (band directors and college clarinet teachers) will spend no more than 30 minutes completing the survey.	Please Initial	Please Initial
13. Is there a relationship between the researcher, participants, and participating institutions/agencies? ___ YES _X__ NO If YES, describe the relationship.	Please Initial	Please Initial

Application Prompts *The Principal Investigator completes this column.*	Check by Faculty Sponsor or Principal Investigator	Check by IRB Departmental Reviewer
14. Is there any need for deception or less than full disclosure? ___ YES _X__ NO If YES, describe and justify the deception or need for less than full disclosure.	Please Initial	Please Initial
15. Will the research be conducted in class? ___ YES _X__ NO If YES, what will students do if they are not participating?	Please Initial	Please Initial
16. How will participants be recruited? If advertisements will be used please include copies with this application. No recruitment required	Please Initial	Please Initial
17. Will any agencies be involved with recruitment of participants or data collection? ___ YES _X__ NO If YES, attach a copy of a letter of support from each agency. Data collection cannot begin at a site until a letter of support is received by ORC.	Please Initial	Please Initial
18. What are the benefits to individual participants from this research study? Knowing that this research may contribute to improved instrumental music pedagogy.	Please Initial	Please Initial
19. What are the benefits to society from this research study? Improvement in clarinet pedagogy and improvement in band and woodwind methods teaching materials.	Please Initial	Please Initial

Application Prompts *The Principal Investigator completes this column.*	Check by Faculty Sponsor or Principal Investigator	Check by IRB Departmental Reviewer
20. What is the level of risk for participants in this study? Clarinet Players ____NONE __X__ MINIMAL ____ MORE THAN MINIMAL Survey Participants _X___NONE ____ MINIMAL ____ MORE THAN MINIMAL	Please Initial	Please Initial
21. Describe the risks to the participants in this study. Slight chance of skin reaction to electrode adhesive or isopropyl alcohol used in skin prep for the clarinetists. NO risk for the band director and clarinet teacher subjects.	Please Initial	Please Initial
22. What precautions are being taken to minimize risks to participants? Informing clarinetists of risks and testing the skin on top of the hand prior to exposure to isopropyl alcohol and electrode adhesive to the face,	Please Initial	Please Initial
23. How will confidentiality for participants be maintained? No identifying information is being collected	Please Initial	Please Initial
24. How long will data be kept? Five years 25. What provisions have been made to store the data in a secure location? Statistical data be stored on a compact disc and locked in a file cabinet with the paper surveys.	Please Initial Please Initial	Please Initial Please Initial
26. How will data eventually be destroyed? Statistics compact disc and paper surveys will be shredded after five years.	Please Initial	Please Initial
27. Will you use materials to recruit participants? ___ YES __X_ NO	Please Initial	Please Initial

Application Prompts *The Principal Investigator completes this column.*	**Check by Faculty Sponsor or Principal Investigator**	**Check by IRB Departmental Reviewer**
If YES, attach copies of all materials to this application.		

Consent Procedures and Forms

Application Prompts	**Check by Faculty Sponsor**	**Check by IRB Reviewer**
28. How will consent be obtained from participants? Clarinet players providing the tone quality samples will sign two copies of the consent form. The player will be provided a signed copy and the researcher will retain a copy. Band director and clarinet teacher subject completion and return of the survey will reflect their consent to participate. A cover letter accompanying the survey will reflect IRB requirements and informed consent status. ***Any participant under the age of 18 must have written parental consent, and the participant must give assent, which requires a separate consent form. **If you are recruiting participants from a college campus community, some may be under the age of 18.** Are you recruiting participants under the age of 18? ___ YES _X__ NO If yes, what arrangements are you making to obtain both parental consent and child/participant assent?	Please Initial	Please Initial
29. What procedure will you use to provide a copy of consent (and assent documents, if applicable) documents to participants? Clarinet players will be asked to sign two copies of the consent letter; they will be provided a copy and the researcher will retain one. Band director and clarinet teacher subjects will retain the cover letter, which contains all information necessary for informed consent.	Please Initial	Please Initial
30. Is a clear explanation of the purpose of the research included on the Consent Form? __X__ Yes ____ No	Please Initial	Please Initial
31. Is a clear explanation of the procedures to be used included on the Consent Form? __X__ Yes ____ No	Please Initial	Please Initial

Application Prompts	Check by Faculty Sponsor	Check by IRB Reviewer
32. Is a description of the benefits of the study to PARTICIPANTS provided on the Consent Form? __X__ Yes _____ No	Please Initial	Please Initial
33. Is a description of the benefits of the study to SOCIETY provided on the Consent Form? _X___ Yes _____ No	Please Initial	Please Initial
34. Are the risks of participation described on the Consent Form? __X__ Yes _____ No If the study entails more than minimal risk, the Consent Form must include a statement regarding compensation, availability of treatment, and directions for contacting the Research Compliance Officer.	Please Initial	Please Initial
35. On the Consent Form, are participants given the opportunity to ask questions about the study? __X__ Yes _____ No	Please Initial	Please Initial
36. On the Consent Form, are participants given the opportunity to withdraw from the research without penalty? __X__ Yes _____ No	Please Initial	Please Initial
37. Is the amount of time required of participants for participation in the study described on the Consent Form? __X__ Yes _____ No	Please Initial	Please Initial
38. Is a description of how confidentiality will be maintained included on the Consent Form? _X___ Yes _____ No	Please Initial	Please Initial
39. Is a statement describing how long data will be kept included on the Consent Form? _X___ Yes _____ No	Please Initial	Please Initial
40. Is a statement describing provisions for storing data in a secure location included on the Consent Form? _X___ Yes _____ No	Please Initial	Please Initial

Application Prompts	Check by Faculty Sponsor	Check by IRB Reviewer
41. Is a statement of how data will eventually be destroyed included on the Consent Form? _X___ Yes _____ No	Please Initial	Please Initial
42. Are the researcher's name, phone number or email if applicable for questions about the study included on the Consent Form? _X___ Yes _____ No	Please Initial	Please Initial
43. Does the Consent Form include the Research Compliance Officer's name and phone number for questions about the rights of human participants in research? _X___ Yes _____ No	Please Initial	Please Initial
44. Is a space for the signature of a witness to the oral presentation provided on the Consent Form, when the short form with oral presentation is used? _____ Yes _____ No __X__ Not Applicable	Please Initial	Please Initial
45. Is a script for the oral presentation provided with the application, when the short form with oral presentation is used? _____ Yes _____ No __X__ Not Applicable	Please Initial	Please Initial
46. Is a separate form for the assent of minors provided, if necessary? _____ Yes _____ No _X___ Not Applicable	Please Initial	Please Initial
47. If research participants are non-English speakers, have the consent documents been provided in the appropriate language? _____ Yes _____ No __X__ Not Applicable	Please Initial	Please Initial