The Pennsylvania State University
The Graduate School
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School of Music

AN EXPLORATION OF A MEANS TO INCREASE
PERFORMERS' AWARENESS OF THE INTONATION
TENDENCIES OF THEIR INDIVIDUAL WIND INSTRUMENTS

A Master's Thesis In Music Education By

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Submitted In Partial Fulfillment Of The Requirements For The Degree Of
Master of Education in Music Education
May, 1993
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ABSTRACT

The problem of achieving accurate intonation in the school band has challenged the thinking of many of the finest band directors, musicians and students. There have been countless articles and books written on this subject, all of which have been helpful in guiding the director toward the most effective methods. By placing the emphasis of these writings on increasing the knowledge of the instructors however, the students’ awareness of the general intonation tendencies of their instruments has been neglected. “A little knowledge is a dangerous thing, and pitch is an area in which many have only a little knowledge” (Colwell, 1992, p. 102).

Cooperative learning, a current trend in education, places more of the responsibility for learning directly on the student (Smith, 1987). If students are responsible for learning, then the educational outcome may go beyond what is considered possible (Hosterman, 1992). This concept can be carried into music education as well. “To encourage and develop independent judgment, the conductor should transfer the responsibility (of determining intonation problems) to the band members themselves” (Hovey, 1976, p. 25). And, unless the students are aware that a problem exists with their intonation, it can not be fixed. This study was directed toward determining and extending wind instrumentalists’ knowledge of the general intonation tendencies of their instrument.

The problem of this study was to explore a means to increase performers’ awareness of the intonation tendencies of their individual instruments. The purpose of this study was to determine the extent to which student instrumentalists are aware of the general intonation deficiencies of their instruments and to examine and compare current published materials that provide such information. Specific questions studied included:

1. Does the use of an intonation guide improve the students’ cognitive awareness of the intonation problems of their individual wind instrument?

2. Does the use of an intonation guide improve wind instrumentalists’ intonation accuracy during performance?
The design of the study used a pretest-post-test format. The test consisted of two parts: a questionnaire/background survey to determine the extent of intonation knowledge the student holds and a tuning session with the Amadeus II computer software to determine the students actual intonation accuracy on each individual note. The experimental group received a researcher prepared intonation guide that listed the general intonation tendencies of their own instrument and an individualized intonation chart as a result of the Amadeus II performance session. The group used the charts during their regular band rehearsals by making reference to the notes listed during the warm-up period. The control group received no guides. Both groups then repeated the pretest process.

The researcher found that the use of the intonation guide can significantly improve the cognitive awareness as well as the intonation accuracy during performance of the student wind instrumentalist. The researcher also developed a comprehensive intonation guide that the student can used as a part of the normal rehearsal process to improve intonation. As a result of this study, the researcher suggests the use of these intonation charts as a regular part of the instrumental music curriculum.
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ACKNOWLEDGEMENTS

This thesis would not have been possible without the help of the many people. I would especially like to thank:

DR. KEITH P. THOMPSON for his constant encouragement, his understanding, his ubiquitous knowledge and his devotion to his profession and students - He has served as a model of excellence to me throughout my time at Penn State;

DR. O. RICHARD BUNDY for his relentless efforts to help prepare me for a career in higher education - He has not only prepared me for the marching band field, the concert hall, the methods classroom and the research, but also showed me how to be entirely dedicated to a career, a family, and his students all at the same time;

DR. NED C. DEIHL for his encouragement, his advice, his persistence and for being the catalyst of this study;

MR. STEVEN P. RAISLEY for his friendship, his encouragement, his support and his help during the experimental procedures;

MS. AMY M. O’MAHONY for her love, her encouragement, her support and her understanding throughout the duration of this study and our time at Penn State;

MY PARENTS, MR. WALTER P. AND MRS. MILDRED B. ORZOLEK, for their love, their encouragement, their understanding, their devotion, their belief and their unconditional support throughout my career;

AND ALL OF THE MEMBERS OF THE 1993 PENN STATE UNIVERSITY CONCERT BAND AND CAMPUS BANDS.
AN EXPLORATION OF A MEANS TO INCREASE
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CHAPTER ONE

DESCRIPTION OF THE PROBLEM

Introduction

The problem of achieving accurate intonation in the school band has challenged the thinking of many of the finest band directors, musicians and students. There have been countless articles and books written on this subject, all of which have been helpful in guiding the director toward the most effective methods. By placing the emphasis of these writings on increasing the knowledge of the instructors however, the students’ awareness of the general intonation tendencies of their instruments has been neglected. “A little knowledge is a dangerous thing, and pitch is an area in which many have only a little knowledge” (Colwell, 1992, p. 102).

Cooperative learning, a current educational trend, places more of the responsibility for learning directly on the student (Smith, 1987). If students are responsible for learning, then the educational outcome may go beyond what is considered possible (Fosterman, 1992). This concept can be carried into music education as well. “To encourage and develop independent judgment, the conductor should transfer the responsibility (of determining intonation problems) to the band
members themselves” (Hovey, 1976, p. 25). And, unless the students are aware that a problem exists with their intonation, it can not be fixed. This study will be directed toward determining and extending wind instrumentalists’ knowledge of the general intonation tendencies of their instrument.

Background

“The weakest link in the entire chain of music education is the lack of knowledge and understanding of the simple facts of musical acoustics; no phase of musical performance has been so sadly neglected as the study and practice of musical intonation and harmony” (Kohut, 1973, p. 58).

Over the years there has been a tendency for musicians to neglect the study of intonation and its properties. Many musicians have felt that this area is too theoretical or scientific and has very little to do with their performance. They willingly leave those studies to mathematicians, acousticians and philosophers. Others believe that music is an art, not a scientific or mathematical field. They argue that any attempt to study music from a scientific standpoint takes away from the potential for aesthetic experience. Yet, when asked about the problems related to their instruments, most professional musicians will agree that intonation is one of the most persistent and important problems (Stauffer, 1954, p.5). Musicians continuously search for the “perfect instrument” that has no intonation deficiencies and an even, well-tuned scale. While this is commendable, it is well known that no instrument can be built perfectly in tune (Jurrens, 1991, p. 2).

Although knowledge of acoustics and intonation will not make a musician, it can be helpful in understanding and solving many of the intonation problems related to the instruments and ensembles (Jurrens, 1991, p. 2). Instrumental teachers need high level knowledge of intonation tendencies and acoustical problems in order to improve the performance of their ensembles. In
fact, analysis of adjudication sheets has shown that one comment consistently prevails - poor intonation (Potte, 1966). Most directors have have relied on assumptions and empirical knowledge when dealing with these problems (Potte, 1966). It is obvious that music educators need to focus their attention in this area in order to improve ensemble performance. Potentially, a means to improve intonation could involve placing the information about intonation into the hands of the students.

There have been numerous books and articles that address intonation and acoustical problems. Most of these discuss correct performance as a matter of playing “in-tune” or “out-of tune” - also known as “good intonation” or “bad intonation”. The causes most often indicated for “bad intonation” include: poor instrument quality, poor instrument accessories, poor playing procedures (embouchure, posture, breath support), insufficient warm up (temperature), tuning to a frequency other than A = 440, and/or a poor sense of pitch on the part of the player (or even the director). Many publications supply a number of suggestions to help the director remedy intonation problems that arise during rehearsal. These suggestions include instrument inspections, playing procedure evaluations, careful tuning procedures with or without electronic tuning devices, and the use of tuning chorales, exercises and drills.

Directors have had success with these remedies. Another source of intonation deficiency information is the “Instrument Tuning Guide”. The information on the guides is intended to provide information to the players but they can usually be found in an instrumental methods book or a “band director’s handbook”. Generally, these guides consist of a list of the general intonation deficiencies of individual instruments. Some guides list only the very poor notes and make suggestions on how the user can fix them. Some guides give what is called the “best tuning note(s)” so the director is certain to use these notes prior to performance. The designers of these guides, usually experts in instrumental education, do not provide the director with instructions on how to use the guides to their maximum efficiency nor have they suggested that the guides be given to the students.

If the director were to place the intonation guides in the hands of the students, the
responsibility of the intonation would fall upon those who are directly responsible for the intonation of the ensemble. This idea, the placing of the intonation guides in the hands of the students, coincides with the current learning trends of requiring students to take on the responsibility of learning. The purpose of this study will be to determine if placing intonation guides in the hands of the students is an effective means of improving students’ awareness of the general intonation problems of their instruments and improve their intonation during performance.

Statement of the Problem

The problem of this study is to explore means to increase performers’ awareness of the intonation tendencies of their individual instruments.

Purpose of the Study

The purpose of this study is: a) to examine and compare current published materials and charts that provide information about intonation tendencies and b) to measure the extent to which an “intonation guide” prepared for students will increase their awareness of the intonation tendencies of their instruments. The null hypothesis of the study is that no significant difference exists between those students who use an intonation guide to learn the general intonation tendencies of their instruments and those who do not. Specific questions to be studied include:

1. Does the use of an “intonation guide” increase students' cognitive awareness of the intonation problems of their instrument?
2. Does the use of an “intonation guide” increase a wind instrumentalists’ intonation score during an individual performance session?

Need for the Study

Nilo Hovey devotes an entire chapter to intonation in Efficient Rehearsal Procedures for School Bands (1976, p. 25). He writes: “Perhaps nothing detracts more from a satisfying performance than out-of-tune playing, and yet no problem in instrumental music is more complex than that of achieving the highest standards in intonation.”

Poor intonation has a number of effects on an ensemble, the conductor, its members, and its listeners. “When a group is not in general pitch agreement, it produces a muddy sound, ranging from annoying to blood-chilling” (Colwell, 1992, p. 104). Many directors believe that “good bands and bad bands are not differentiated by the presence or absence of tuning problems, but rather by the degree of their severity” (Hovey, 1976, p. 30). Good intonation is a many faceted problem that is never completely solved in any ensemble.

Poor intonation may force a conductor to take actions, such as adjusting parts or cutting players, that may be opposite to the desire of the composer. It is the opinion of many directors that the primary purpose of the conductor is to interpret the intentions of the composer as carefully as possible including good intonation since “playing out of tune has a great effect on the composition” (Jurrens, 1991, p. 5).

Poor intonation has an effect on the performer and listener as well. Some directors are of the opinion that playing in tune “will be more gratifying to the performer than to the listener” (Jurrens, 1991. p. 5). Others believe that neither the ensemble member nor the listener can fully appreciate the music unless it is performed with the best possible intonation. In all, it is generally agreed that good intonation leads to a good-sounding group and, in turn, good sounding music. “Is
it possible to say what is or is not in tune? The answer to that question must be “yes” because most people, trained musicians or not, cringe when something is out of tune. It is the negative aspect of being out of tune which is more generally obvious; the more positive one of being in tune is less likely to attract attention, except from fellow musicians” (Meffen, 1982, p. 54).

There is a significant amount of interest in intonation correction and improvement in performing ensembles, especially among directors of wind instrument ensembles. Naturally, directors should have a great deal of interest in studying solutions to intonation problems. There have been numerous articles exploring several suggestions on this topic. These include:

1. teach the ensemble to listen
2. use a tuner
3. listen for beating
4. use the ear
5. tune chords and scales
6. check for a bad reed or sticky slides
7. warm-up carefully
8. sing
9. look at embouchures
10. play long tones

In spite of all of these ideas and suggestions, directors still struggle with intonation every time they step to the podium. One might think that all of the innovations in instrument making technology combined with suggestions for improvement would have been completely eradicated the intonation problem and directors could focus on providing other aspects of the aesthetic experiences for their students.

But, since the problems are still prevalent, it would seem appropriate to continue to study different approaches to improving intonation problems. And since it is the performers who ultimately determine the degree of intonation correctness in an ensemble, it seems logical that educators should make certain that their student performers have as much of the available
knowledge as possible concerning the general intonation tendencies of their instruments at their disposal.

Hovey (1976) has developed a list of five steps in the pursuit of good intonation. The third step is especially appropriate for this study. Hovey writes: "Acquaint each player with the deficiencies of his instrument. This refers both to the natural scale tendencies of each type of instrument and the exceptions found on many specific instruments within a type... A competent conductor will learn about these common deficiencies and share this knowledge with his students" (pp. 26-27).

The researcher is of the opinion that this area of intonation is consistently neglected by directors primarily due to the lack of access to pertinent information. Consequently this situation has had a negative effect on the instrumental student. A study directed at determining what students actually know about the general intonation tendencies of their instruments could certainly provide educators with information that might assist in solving the problem of intonation. It is for the purpose of aiding the students and director that this study is devoted. The author has no knowledge of a similar study attempting to determine and improve the cognitive intonation knowledge of students.
Definition of Terms

Amadeus II - An electronic device that is a precision tuner and note generator that also connects to a computer for pitch and rhythmic drill purposes. The pitch drills provide graphic graded reports, display results, and suggest areas of intonation that need improvement. It was created and designed by the Pyware Corporation.

Beats: A slight, steady pulsation in intensity that results from the interference between two sound waves of slightly different frequency. The frequency of the beats will be equal to the difference between the frequencies of the sound waves. Since the beats will disappear if the two frequencies are made identical, the phenomenon is useful in the tuning of musical instruments (Randel, 1986).

Cent: The unit used for measuring frequency intervals - equal to the hundredth part of an equally tempered semitone (Meffen, 1982).

Dissonance: A frequency interval in which beats are produced by the two notes and by their harmonics (Meffen, 1982).

Flat: Incorrectly tuned below the correct pitch (Randel, 1986).

Frequency: Rate of recurrence of vibrations; measured in Hertz (Meffen, 1982).

Guide: A chart or listing of notes that are generally of poor intonation on a specific wind instrument. (Same as "Intonation Guide")
Intonation: The degree to which pitch is accurately produced in performance, especially among the players of an ensemble (Randel, 1986).

Individualized Intonation Chart: A listing of those notes that are generally of poor intonation based upon the readings of the Amadeus II.

Intonation Guide: A chart or listing of notes that are generally of poor intonation on a specific wind instrument. (Same as "Guide")

Pitch: The perceived quality of a sound that is chiefly a function of its fundamental frequency - the number of oscillations per second (called hertz, abbr. Hz) of the sounding object or of the particles of air excited by it (Randel, 1986).

Tuning: The act of adjusting the fundamental sounding frequency or frequencies of an instrument, usually in order to bring it or them into agreement with some predetermined pitch (Randel, 1986).

Tuning Slide: On brass instruments, a length of tubing, usually U-shaped, that can be made to slide in such a way as to alter the instrument's effective length, thus making it possible to adjust its pitch slightly (Randel, 1986).

Sharp: Incorrectly tuned above the correct pitch (Randel, 1986).
CHAPTER TWO

REVIEW OF RELATED LITERATURE

Overview

There has been no research directly related to the students' awareness of the intonation characteristics of their individual instruments, but there has been some study of the intonation problems faced by musicians and ensemble directors. There have also been several books and methods written that contain the opinions and experiences of many musicians and directors. Although these studies and books have little direct impact on this research, they do give an indication of the methods of intonation correction in use today. There have also been several researchers who have designed wind instrument tuning guides for use by directors and educators. Following a brief description of the intonation information contained in some of the standard instrumental music texts, this chapter will review some of the related research about intonation.

Historical Background

The subject of intonation has intrigued scientists, philosophers, musicians and pedagogs throughout history. Of all the tuning systems that have evolved throughout the ages, the Pythagorean, diatonic, mean-tone and equal-tempered systems have received the most attention.

In 550 B.C., Pythagoras devised a tuning system developed from the perfect fifth. This system included the perfect fifth, perfect fourth and major second and was the primary system
used throughout the Middle Ages. The Pythagorean major third is quite sharp thus creating intonation problems when tertian harmony came into practice.

The sharp third led to the development of the mean-tone system first discussed by the Spanish theorist Salinas. The system was derived from the major third and was in vogue from 1500 to 1750. All of Bach’s organs were tuned to this system, it could not be used in keys with more than three flats or sharps as the perfect fifth is flat.

Diatonic or just tuning is derived from the harmonic series. This system would seem to be the best of both the Pythagorean and mean-tone worlds since it has the pure third and perfect fifth. But this creates two sizes of whole step and intonation problems in harmonic music.

In 1650, equal temperament was developed in Europe. It is a complete compromise in that the octave is divided into twelve equal parts, with the unison and the octave being the only pure intervals. Today this system is used as the tuning basis for pianos, fixed intonation instruments and tuning devices. The pitch chosen as the basis of all tuning is $A = 440$ Hz.

Equal temperament has been the established system utilized in the tuning of organs for at least one hundred years. Donald Stauffer, one of the first to research intonation deficiencies of wind instruments, suggested that if any band, orchestra, or chamber group played as well in tune as a finely tempered organ or piano, the problems of intonation for that group will have reached the vanishing point (Stauffer, 1954).

**Related Literature**

As one of the first thinkers about intonation tendencies of wind instruments, it was Stauffer who concluded that the equal tempered scale is the most appropriate tuning standard for the various wind instruments used in an ensemble. Prior to Stauffer, Wesley Pearce (and several others) studied intonation and made general conclusions regarding tendencies of instruments.
However, it was Stauffer who compiled these ideas, summarized them, and attempted to apply them to the ensemble.

Stauffer's study, *intonation Deficiencies of Wind Instruments in Ensemble* (1954), had three main purposes related to the acoustical and mechanical features of the various wind instruments. The three main questions were:

1. Does the phenomenon of differing the harmonic spectra of several instruments of widely separated tonal coloring effect the actual frequency measurement of the tones as considered against the apparent pitch registering upon the ear of the player and listener (Stauffer, 1954, p. 1)?

2. What are the intonation inaccuracies to be expected in wind ensemble that result from the faulty internal pitch relationships of single tones and registers existing in the several wind instruments (Stauffer, 1954, p. 1)?

3. What techniques can be used to efficiently utilize the Stroboconn for improvement of ensemble intonation through developing pitch consciousness of young players (Stauffer, 1954, p. 1)?

Following lengthy discussions of temperament and the principles of acoustics, Stauffer discusses several of the human, psychological and physiological problems, as well as the environmental factors that influence the intonation tendencies of instrumentalists. Stauffer lists the most important human factor as the individual player's tone production. "It is naturally desired to bring the tone quality to as high a state as possible, because the quality of the sound varies directly with the ease of production of the tone producer, and the tone resonator must coincide exactly with the frequency of the vibrations of the desired tone itself, if optimum resonance and correct pitch are to be achieved together" (Stauffer, 1954, p. 119). The factors which inevitably determine tone production are listed as lip formation, air stream, and volume of the aural cavity. After further study, Stauffer concluded that all of these factors directly influence intonation.

Stauffer also discusses some of the psychological and physiological factors that influence intonation. He is quick to point out that the "most fundamental element of the intonation problem,
the ability of the individual to distinguish differences in pitch, is dependent upon the physiological endowment of the player’s hearing organ”. Stauffer goes on to say that “musical training and achievement is undoubtedly limited by a certain inherent capacity in this respect.”

Stauffer also makes some comparison between beginning string and wind players regarding their musical and listening training. He attributes intonation problems of wind players to the lack of hearing ability developed during early years of playing. String players must use their ears to find each pitch from the very first note they play. Wind instrumentalists depress keys or valves to find the correct pitches, however they are only relatively correct. He also suggests that the direction of the sound wave of a wind instrument is generally away from the player. Stauffer quickly points out that both reasonings are ridiculous as he believes that it is the “lack of consistent critical use of the ear in producing tones on the instrument” (Stauffer, 1954, p. 159).

Stauffer also discusses the effect of timbre on the ear’s perception of intonation. He suggests that when comparing two tones having a fundamental of exactly the same frequency but with different overtones, the ear often judges the tones to be of different pitch. In general, he found that a tone rich in harmonics will give the impression of a higher pitch than a relatively pure tone. In order to understand this effect in relation to the ensemble, Stauffer designed the Band Profile Graph with the purpose of seeing how groups of instruments line up with each other as far as average pitch level when in an ensemble. The graph proved to be extremely useful as it allows directors to see how the pitch levels of different instruments tend to vary from the standard.

Another interesting aspect of this particular experiment was Stauffer’s use of the Stroboconn. The Stroboconn is an early electronic device that measures the relative intonation of tones in a visual manner to within one hundredth of a semitone of the frequency standard used. Stauffer was interested in how this new device could be used to help the intonation problems in the public schools. He concluded that the use of the Stroboconn in an intelligent and consistent manner would “do a great deal over a period of time to improve the intonation consciousness of the band and thus would bring about much more quickly a satisfactory ensemble pitch impression with which the individuals could judge better the intonation of their instruments. It must be kept in mind.
that no effort is being made to supplant the use of the ear in ensemble, only to aid in its
development” (Stauffer, 1954, p. 174).

Stauffer also discusses the effect of environmental situations on intonation. His major
concern was that of temperature. Stauffer found that the human breath seldom falls below 95
degrees Fahrenheit in conditions of 70 degrees or higher and the temperature inside the air column
of an instrument varies from 70 degrees to 95 degrees depending upon the instrument. Thus,
smaller instruments would achieve optimum playing temperature sooner and remain there for a
longer period of time. This also means that smaller instruments would tend to rise in pitch more
quickly during the warm up period. Stauffer concluded that it is especially important for smaller
instruments to be warmed up prior to tuning.

Probably the most significant part of Stauffer’s work were his findings on the intonation
tendencies of the individual instruments. Stauffer made use of the Stroboconn to carefully plot the
tendencies of pitches on all instruments. He also prepared a Master Profile Chart that included a
side-by-side comparison of all instruments’ tendencies. These charts became the foundation for
intonation study to the present date and they will be reviewed later in this study. His insightful
research coupled with his opinion became the standard source for information regarding intonation
in the band.

In 1960, Ralph Pottle published Tuning the School Band and Orchestra with the purpose
of “bringing up to date the findings of research, summarizing and interpreting them in light of the
present day demands so that band and orchestra directors and others may utilize improved tuning
procedures” (Pottle, 1960, p. vii). His work and conclusions (based on previous knowledge and
summarized here) have become very valuable.

Pottle advocates the need for a deeper understanding of the principles underlying desirable
and effective tuning practices. These principles included: (1) that instruments have been designed
to perform with optimum intonation at A-440 and at a room temperature of 72 degrees F; (2) that
instruments tuned above or below this level only may be sacrificing the optimum tuning provided
in the construction of the instrument; and (3) that musicians have a strong inclination to tune and
play sharp to the accepted standard of $A = 440\, \text{Hz}$. It is upon the third factor that Pottle places the most emphasis stating that his research has proved that “improper warm-up and sharp tuning constitute the most unfortunate intonation errors committed presently by musical organizations” (Pottle, 1960, p. 1).

After some insight regarding scalar systems and temperament, Pottle discusses several of the general mechanical problems with the wind instruments. He calls this section “Resolving Tuning Problems” and intends to make directors “aware of the problems encountered by manufacturers in building instruments and the methods used to resolve those problems” (Pottle, 1960, p. 6). Although this section is very helpful, the most useful section of the book is a series of “Tuning Guides” that appear in the appendix. These guides were prepared by Mark H. Hindsley, at that time Director of Bands at the University of Illinois, and will be further reviewed later in this study.

As a result of the work of Stauffer and Pottle, many researchers and educators have attempted to include a section about the intonation tendencies of instruments in their writings about instrumental pedagogy. Daniel Kohut and Robert Garofalo are two educators/authors who devoted considerable space to the discussions of intonation in the ensemble. They are very thorough in the area of intonation and have been selected to be a part of this review as they offer rather comprehensive “tuning guides” for all of the instruments.

Daniel Kohut's Instrumental Pedagogy: Teaching Techniques for School Band and Orchestra Directors (1973) offers an outstanding section on intonation. He writes: “When a complex subject is studied in detail and analyzed thoroughly, there is a tendency to become so intensely engrossed in minuscule details that perspective of the whole tends to be lost. The study of tone quality and intonation is no exception. Theoretical knowledge including Pythagorean tuning, pure intervals, harmonic content of a complex tone and related subjects are helpful toward a better understanding of the whole subject but have little practical value to musicians and teachers of music when viewed only as ends in themselves” (p. 66).

After an overview of the general principles of acoustics and basic tuning systems, Kohut
describes several of the acoustic problems in the design and manufacture of instruments much in the style of Stauffer and Pottle. In this section Kohut prepares several charts which offer the director a visual representation of many of the problems that will be reviewed later in this study.

Kohut details other objective factors that affect tone quality and intonation. He lists these factors as: standard pitch, temperature, dynamics, reeds, and mouthpieces. Kohut also describes several subjective factors that influence tone quality and intonation. These include: embouchure, breath support, volume of the oral cavity, and vibrato. The detailed explanations for each of these factors offer suggestions for improving and correcting each area. He also offers suggestions on how to make the most appropriate pedagogical use of the Strobona tuner in pedagogy.

Kohut suggests there are two principles to be remembered as the most important in regards to intonation:

1. Work toward production of a good tone, using the strobe as an aid.
2. Obtain lots of ensemble experience, especially in a small ensemble.

Robert Garofalo also has an outstanding section on intonation in his *Rehearsal Handbook For Band Students and Orchestra Students* (1983). This book is designed to be a comprehensive handbook for secondary band and orchestra students. It is a series of “rehearsal enrichment study units covering the fundamentals of music, intervals and chords, transposition, acoustics, tuning and intonation, music terms and symbols, sight-reading, conducting and music history” (Garofalo, 1983, p. 2). Each unit contains learning goals, important facts and resource materials. Garofalo believes the format is effective and makes efficient use of time.

There are three sections pertaining to intonation in the Garofalo book; “Understanding Notation”, “Techniques for Adjusting Problem Notes”, and “Tuning Your Instrument”, preceded by a brief section on the “Acoustics of Music”. All of the sections are done in a manner that will be easily understood by the students, especially the section on acoustics. Garofalo proposes that a fundamental understanding of acoustics of music will help the student “better understand the process of intonation and tuning” (Garofalo, 1983, p. 16). The brief “Acoustics of Music” section describes the properties of sound, the harmonic series, and the acoustical properties of all the wind
instruments.

The section entitled “Understanding Intonation” defines “bad” intonation and presents several of the factors that can cause poor intonation. These include: condition and quality of the instrument and accessories, basic playing procedures, insufficient warm up, playing off the standard tuning frequency and psychological and musical phenomena. “Some of the psychological phenomena related to intonation are: 1. People tend to hear loud low tones as being flat and loud high tones as being sharp; 2. People are more tolerant of sharpness than of flatness; and 3. People tend to hear two widely different tone timbres with the same frequency as being out of tune” (Garofalo, 1983, p. 17). This section also refers to the phenomena of acoustical beats and some suggestions on how to eliminate them.

Garofalo (1983) introduces the next unit, “Techniques for Adjusting Problem Notes”, by writing: “The ability to play in tune is a performance skill that must be developed by every student instrumentalist. The skill requires careful listening and the ability to adjust pitches quickly while playing. The ability to adjust presupposes a knowledge of the techniques involved and a general understanding of the deficiencies and tendencies of musical instruments. This unit is designed to provide you with that knowledge and understanding so that you can begin to improve your intonation” (p. 19).

“Techniques for Adjusting Problem Notes” also provides the student with a summary of the reasons why instruments have intonation flaws. Garofalo lists two general reasons for the out of tuneness of woodwinds. They include the fact that they only use one or two register keys to overblow when they should have a separate register key for each chromatic note and because they use one set of tone holes for different registers when different size tone holes are needed for each octave. Garofalo also writes that the general reason for the out of tuneness of brass instruments is due to the flaws caused by the harmonic series and inability of the valve system to adequately compensate for those flaws. The second part of this unit, “Techniques for Adjusting Pitch”, provides the reader with some well designed charts of the general intonation tendencies for each note of each instrument. These will be further reviewed later in this study.
The third unit, "Tuning Your Instrument", presents the student with a suggested tuning procedure and specific tuning notes. It also suggests how to make the necessary adjustments of the instrument for correct intonation. This section also provides an "Intonation Chart" where the student is asked to plot the tendencies of each note on the instrument. The student is to use the Stroboconn (or a similar device) to determine the tendencies of each note and make reference to the chart whenever they perform. The tuning procedures will be further reviewed in the latter part of this study.

Related Research

In addition to the books previously listed, a number of research projects have focused on the problems of intonation in instrumental ensembles. Most of these studies were done on the foundations laid by Stauffer (1954) and Pottie (1960). Unfortunately many of these studies are only related by the fact that their attention is to some aspect of intonation. However, most of them point to a need for directors to focus their attention on the students themselves when solving the intonation problems of their ensembles. The subjects of these projects are very broad. They are presented here in chronological order.

According to Miles (1972), in the late 1950's Leeder and Haynie, followed by other music educators, began to advocate teaching a tuning procedure long used by piano tuners, physicists, and some musicians. The procedure became known as beat elimination and was considered to be a dependable aural method of achieving correct intonation. However, Miles found that the process was not familiar to most music educators and was seldom used.

Miles determined that the ability to play in tune starts with the ability to recognize slight deviations in pitch readily. Since teachers have used electronic devices which indicate deviation visually rather than aurally, Miles believed that the students were not trained adequately in pitch
perception. Thus Miles (1972) set out to determine whether or not beginning instrumentalists could be taught to play in tune by using the beat elimination process.

Miles used 118 subjects who compared notes that they played to a note produced by an electronic device and later with other students. The students were asked to first recognize beats and then attempt to eliminate them at the unison. The student then attempted to eliminate beats when playing fifths and major thirds with the investigator and then with other students. In the final session the students were asked to eliminate beats in a triad played with other students.

Miles found that every student was able to recognize beats and most were able to eliminate beats at the unison. Miles concluded that beginning wind students can use the beat elimination process as a means of achieving correct intonation. This information would be extremely helpful to the director of beginners since most of their ensemble literature is based on unison playing. However, as the performance level increases, the amount of "unison-type" literature decreases and "beating" becomes less reliable. Even at the advanced level, however, pitch matching at the unison is required for players on an identical parts.

The use of beat elimination steadily became popular as a result of the Miles study. However, a recent study (Keislar, 1991) produced results that oppose the conclusions of Miles. In this study Douglas Keislar conducted a similar experiment in which students were asked to recognize beats and attempt to eliminate them. This experiment used an electronic device and only the perfect fifth and major third. Keislar also altered the amplitudes and adjusted partials of some of the notes.

Keislar found that beating does not contribute significantly to the perception of out of tuneness because "it made no statistical difference whether or not the beat amplitude was minimal or maximal." He also found that frequency shifting of the partials has about as much effect on the perceived intonation as mistuning the interval.

Keislar concluded that the perception of intonation in music is dependent on the actual interval tuning rather than the beat rate. This is in direct contrast to previous studies. It implies to directors that they should carefully train their students to play intervals correctly in tune.
The perception of intonation in regards to intervals and scales has been another area of interest. Geringer (1978) investigated the relationship between the performance of intonation and the perception of intonation regarding ascending scalar patterns. Following differential verbal feedback regarding their performances, subjects either performed a second time or listened to their individual performances and retuned them using a variable-speed recorder. Geringer found that the subjects indicated a tendency toward sharp intonation throughout the study, relative to the standard of equal temperament. He also found that changes or adjustments in pitch level within the duration of individual tones were easier perceived if the note was of greater length. Results also indicated that intonational perception of unaccompanied scales appears to be less accurate than the performance of unaccompanied scales, however performance and perception of accompanied scales was not significantly different.

The previous study had measured intonation deviation across each tone, using an averaged cent deviation per tone as the data for analysis. Geringer and Sogin (1988) examined the extent of intonation deviation within the duration of selected tones since actual music performance demands that musicians discriminate and make rapid and appropriate adjustments within the duration of individual notes.

Geringer and Sogin concluded that musicians performing sustained ascending tones tend to become increasingly sharp with duration. This information would be useful to the director in helping to establish good intonation in the ensemble. The results are also in agreement with previous studies.

There has also been interest in the effect of timbre on intonation performance and perception. Ely (1988) studied the effects of timbre on intonational performance and perception by college performers on selected woodwind instruments. Subjects were saxophonists, flutists and clarinetists. The experiment involved two phases: a listening task and a performance task. During the performance phase the students were asked to listen and play in tune with a prerecorded performance of a melody. During the listening phase the subjects listened to a series of varied timbral duets and were asked to indicate out of tune notes on a response sheet.
Results indicated a low correlation between subjects’ abilities to perform in tune and their abilities to detect intonation problems. Results also indicated that timbre had a significant effect on subjects’ abilities to detect intonation problems during listening tasks, but that there was no significant difference between instrument groups in their abilities to detect intonation problems in performance. Results of the performance data indicated there was no significant difference between subjects’ abilities to play in tune with differing timbres. Finally, in contradiction to previous studies, it was found that subjects played more flat than sharp across all instrument timbres.

Few musicians would dispute the importance of tone quality and its relationship to correct intonation. Madsen and Geringer (1982) investigated the discrimination between tone quality and intonation in unaccompanied flute and oboe duets. Music and non-music majors were asked to check good and bad quality/intonation classifications after a series of listening tasks. The examples were performed with good or bad tone quality or intonation adjustments of up to 50 cents sharp.

Results indicated that music majors made more correct discriminations than non-majors. Subjects perceived more intonation errors than tone quality errors. However, their perceptions of the intonation errors were incorrect as they perceived too many examples as flat. The researchers also concluded that when subjects were indicating a preference for tone quality, they were actually responding to intonation variables as opposed to tone quality variables throughout the comparisons.

The results of this study indicate that good intonation is a direct result of good tone quality. Therefore, in order to achieve a quality band sound, the director should focus his/her attention on developing the intonation perception skills of his/her students.

Smith (1984) investigated the effects of vocalization on the intonation of college wind players under performance conditions. Subjects underwent two conditions, play and sing/play. In the play condition the subjects performed a set of selected exercises on their instruments. In the sing/play, subjects were asked to sing the exercises prior to playing them.

Results indicated there were no significant differences between the two conditions and therefore Smith concluded that vocalization did not affect the intonation of wind players prior to
performance. This suggests that singing is not necessarily the answer to correcting intonation problems.

Finally, Freeman (1991) attempted to construct and validate a scale of band intonation. Freeman found there was a serious amount of interest in the attainment of good intonation in the band, but no tools to evaluate it. In order to accomplish this, Freeman asked the following questions:

1. What aspects of band intonation can be assessed?
2. What type of rating scale can be developed for judging band intonation?
3. What problems can be identified in using the rating scale approach to band intonation evaluation?
4. To what extent is the scale a valid instrument for the assessment of band intonation?
5. To what extent is the scale a reliable instrument

After a brief period of use, Freeman found that the scale could be used for evaluation of band progress and improvement of instruction, along with other materials in the training of future educators. Freeman also suggested the use of the scale with rating sheets currently used at adjudication festivals and contests. Again, this information would be extremely useful to the director as a reference for developing and improving the intonation skills of the ensemble through the individuals.

Summary

There has been considerable interest in wind instrument intonation on the part of educators and directors. This interest is justifiable since correct intonation will lead to better performances. Many of these studies focus their attention on helping the directors by providing them with information that could lead to improving the intonation of the ensemble. Ultimately, however, the best means to improve the intonation of the ensemble is by improving the intonation of the individual players. Therefore it would seem logical to focus a study of intonation problems on the
students themselves. It would seem appropriate to begin this “new” area of research by determining precisely what students know about intonation and the intonation deficiencies of their instruments. That will be the focus of this study.
CHAPTER THREE

PROCEDURES

Overview

The problem of this study was to explore a means ways to increase the performers' awareness of the intonation tendencies of their individual instruments. The primary purpose of this study was to determine the extent to which student instrumentalists are aware of the general intonation deficiencies of their instruments. A review of related literature revealed that little research has directly studied the student instrumentalist's knowledge of intonation deficiencies. Presented in this chapter are the design of the study, description of the instruments, selection process of the subjects, and the procedures.

Design

The design of this study consisted of a control group pretest-posttest format. The independent variable was the use an intonation guide and the individualized intonation chart that listed the general intonation tendencies of the instruments. The dependent variable was the student's perceptions of the general intonation tendencies of their instruments as measured by two scores, the playing score and the written score. The null hypothesis of the study was that no significant difference exists between the scores of those students who used a tuning guide to learn
the general intonation tendencies of their instruments and those who do not.

Measurement Instruments

The pretest and identical post-test consisted of two sub-tests. The first measurement instrument was a questionnaire that included a background information survey. The questionnaire included questions relevant to intonation and intonation tendencies. Specific questions included:

1. What are the general intonation deficiencies of your instrument?
2. What are the “poor” notes on your instrument?
3. What is the best note(s) for tuning your instrument?
4. What is the effect of instrument temperature on intonation?
5. What intonation problems are caused by overblowing?
6. What effect does a crescendo have on intonation?
7. What is the effect of a poor reed on intonation?
8. What is the best instrument from which to tune?
9. What are the intonation tendencies of the extreme registers of your instrument?

The first two questions were answered by requiring students to draw the “poor” notes on a musical staff and indicate the tendency of that note by including an “up” arrow for sharp and a “down” arrow for flat. The background survey required responses relating to the students major, age, instrument, years of experience on that instrument, years of total band experience, amount of private study, and if the student has ever received any “intonation guides” during their experiences. The questionnaire can be found in Appendix A.

The second measurement instrument was a chromatic scale. The intonation accuracy of this scale was measured by the “Amadeus II” computer software produced by the Pyware Corporation. Amadeus II is an electronic device that is a precision tuner and note generator that
connects to a computer for pitch and rhythmic drill purposes. The pitch drill provides graphic graded reports, displays results, and suggests areas of intonation that need improvement. The program permits students to perform a scale or any musical excerpt into the computer. Following a student's performance, the computer presents an intonation score based on the student's performance as well as a line graph that appears on the computer screen that can be printed and given to the student. Additional information about the Amadeus II system as well as a sample printout can be found in Appendix D.

The Amadeus program was chosen because it is an excellent measurement tool of intonation, and because the testing process makes use of reference pitches being played by the computer as the student performs.

A pilot study was completed to test the usability of the instruments prior to the actual study. The validation of the written instrument was a result of expert review and consensus agreement.

Equipment

Equipment required to complete the study included: Amadeus II software package, Pyware corporation; Macintosh Computer and printer; and the measurement instruments described above.

Subjects

Subjects were chosen from two of four concert bands at the Pennsylvania State University in the Spring of 1993. The Concert Band (the “third band”) yielded 38 subjects and the Campus band (the “fourth band”) yielded 36 subjects. These bands were used since they both meet for the same amount of rehearsal time and require an audition for placement.

This yielded a total of 74 subjects of evenly distributed instrumentation. These subjects
were also chosen due to the lack of influence of on-going private instruction. Due to the limitations of the Amadeus II discovered in the pilot study, the tubas, bassoons, piccolos and bass clarinets were not used in the study.

The experimental group was the Campus Band. Although this is the "fourth band," it was felt that a greater degree of impact could be made with this group of students primarily because the researcher worked with this group on a regular basis.

During a selected rehearsal early in the semester subjects completed the pretest. The experimental group had their treatment during six regularly scheduled rehearsals. Following the experimental procedures, all subjects completed the post-test.

**Procedures**

The entire test was administered by the researcher. The written portion of the pre-test was given to all the members of each band at the beginning of their regularly scheduled rehearsal. Subjects first completed the background information and then completed the questionnaire regarding the intonation tendencies of their instrument. Students were also required to sign an "Informed Consent" form prior to testing. The Informed Consent Form as well as the Approval Letter from The Pennsylvania State University Office of Regulatory Compliance can be found in Appendix B. Completion of the questionnaire and the Informed Consent form required approximately 5 minutes to complete.

Once the subjects completed the written portion of the pretest, they were individually taken from rehearsal to a separate room where the researcher explained the performance part of the test. The student was asked to perform a chromatic scale, one octave, both ascending and descending. The Amadeus II, due to its' current limitations, would only permit the concert Bb or concert F chromatic scale to be performed. One of those two scales was selected for each instrument based on the following criteria:
1. the scale should be in a comfortable and frequently played register of the instrument.
2. the scale should allow for the playing of some of the perceived “poor” notes of the instrument.
3. all performers on the same instrument must play the same scale.

After being instructed which scale they were to perform, subjects listened to the scale played by the Amadeus II through headphones. The Amadeus II then played the scale again, and this time the subjects played the scale with the computer. As the scale was performed it was recorded by the computer and following the completion of the performance, a detailed line graph was printed out from each subject’s performance.

After completing the pretest, the experimental group was presented with the researcher prepared intonation guide as well as the resultant individualized intonation chart (the line graph printed by Amadeus II) from their tuning session. The intonation guide is the result of compiled information about the general intonation tendencies of the various wind instruments used in the study. These guides were compiled from five different sources considered to be extremely reliable sources of such information. These guides can be found in Appendix C. The individualized intonation charts were the printouts from the performing session with the Amadeus. The charts were edited by the researcher to help point out some of the very poor notes to the subjects. The researcher decided to present both, the compiled intonation guide and the individualized intonation chart, to the experimental group due to the number of researchers in the review of literature that stress that intonation was a very individual phenomena.

The researcher explained the format of the guides and charts and made suggestions for their use during rehearsal and individual practice to the entire experimental group at the next rehearsal. The researcher required that the experimental group use the guides and charts during the ten minute warm-up period for six rehearsals by checking to see if they appeared on the students stands. The researcher used the following activities to promote interaction with the charts:

1. subjects marked their guides and charts with individual tendencies based on the graph from the Amadeus II.
2. the group performed specific scales while being instructed to pay careful attention to those notes the researcher had indicated as very poor.

3. the guides and charts were used to respond to questions from the researcher about tendencies throughout the warm-up time.

The control group, the Concert band, did not have any guides or charts but used the same warm-up procedures during the experimental period. Warm-up activities included major scales and descending chromatic interval drills. No special emphasis was placed on intonation tendency instruction during the rehearsals of the control group.

At the end of the six rehearsal treatment period, all subjects were given the post-test which was identical to the pretest. In all, the entire procedure was completed in five weeks.

Data Analysis

Subjects responses on the questionnaire for item numbers 3 through 12, general intonation questions, were compared to the intonation guide prepared by the researcher. The comparison to the intonation guide provided information regarding the extent to which the subject understood the general intonation tendencies of their particular instrument. One point was awarded for each correct response. The comparison of the questionnaire results for item numbers 1 and 2 were compared to the results of the individualized intonation chart from the performance measure (Amadeus II). This comparison provided an indication of how close the subjects perceptions of the intonation tendencies of their instrument were to their actual performance tendencies. Scores were determined by assigning one point for each correct response on the questionnaire as compared to the results of the Amadeus II performance measure. The total number of correct responses for all items was averaged to yield the written score for the test.

The determination of the score for the playing portion of the test was completely tabulated
by the Amadeus II program. The student's score on each note was determined by the percentage of time the student was playing within a 20 cent window preset by the researcher as a result of a previous study (Stauffer, 1954). Each note lasted approximately two seconds. The scores from each note were then averaged by the computer to yield an overall playing score.

The score from the written portion and the playing portion were averaged to obtain a total intonation score. The post-test was analyzed and scored by the same process. Correlations and comparisons were made through use of statistical processes including Pearson's correlation and a t-test.
CHAPTER FOUR

FINDINGS

Overview

This chapter will present the findings of this study. The chapter will review and compare five different intonation guides selected for inclusion in the study. These intonation guides were reviewed for the purpose of developing an intonation guide for use in this study. The second portion of the chapter will present the results of the experimental procedures described in the previous chapter.

Findings from Selected Intonation Guides

There have been several intonation guides designed for use with wind instruments. Many of these have been directed toward the educator rather than at the student. A closer review of several of these guides might help determine the best approach to designing an intonation guide specifically prepared for the student instrumentalist.

The five intonation guides and charts chosen for review here include: (1) Charts from Donald Stauffer's Intonation Deficiencies of Wind Instruments in Ensemble, 1954; (2) Mark

The five guides were chosen for review for various reasons. In the case of the Stauffer and Hindsley guides, they were chosen primarily because of their place in the history of intonation study. Both are considered to be leaders in intonation research. The Kohut guides are typical of those found in most pedagogical books for future band directors and are particularly detailed. The Garofalo guides are the only ones known to be designed specifically for students. The Jurrens' guide was the most recently produced and was the catalyst for this study. All of the guides were very well detailed and interestingly span the years from 1954 through 1991.

There are several interesting comparisons that can be made regarding these guides. These include: recommended notes for tuning, listing of bad notes and natural tendencies, terminology used, the general format and design of the guides, a listing of the causes for bad notes, and a listing of remedies for bad notes. All of the guides are geared to help increase the director's awareness of the intonation tendencies of wind instruments. In order to prepare a guide that lists all of the recommended notes for tuning and the bad notes and natural tendencies on one guide, it was useful to review all of the previous guides. This information was used to form the consensus, more student friendly guides used in this study.

With the tuning guides from his book *Intonation Deficiencies of Wind Instruments in Ensemble*, 1954, Donald Stauffer hoped that a "contribution to the pedagogy of ensemble wind intonation will result from a comparison of the information gleaned in this study on the individual instruments by graphing and charting that will tend toward a better understanding of how the various factors might work against one another in an ensemble situation" (Staaffer, 1954). Stauffer described his guides as merely a starting point since so many other factors play into intonation. Stauffer used the members of the United States Navy Band of Washington, D.C. and
the Stroboconn to determine the tendencies.

Although Stauffer does not recommend any specific tuning notes for the band, he does suggest that the concert Bb should be the fundamental basis for the band. This suggestion is made because it is "considered the most fundamental scale to the majority of the wind instruments" (Stauffer, 1954, p. 54). He also suggests Bb since "most band music is written in Bb or a closely related key" (Stauffer, 1954, p. 54).

Stauffer's guides, twelve in all (one for each note of the chromatic scale), list each of the instruments in score order and give a description of note tendencies for each instrument. The instruments are listed next to a grand staff that uses brackets and arrows to explain to which octave the tendency refers. In the case where an instrument may be able to play the particular note in another octave, all tendencies are listed. Tendencies are described as very flat, flat, slightly flat, O.K., slightly sharp, sharp, or very sharp. Stauffer does not list any specific causes or remedies for intonation problems as a part of his guides nor does he suggest how the guides be implemented.

Ralph Pottle asked Mark Hindsley, Director of Bands at the University of Illinois, to prepare the intonation guides for his book, Tuning the School Band and Orchestra. Hindsley was chosen since he, and several of the faculty members at Illinois, had been conducting intonation mini-experiments with the students at the school of music. In his introduction to the guides, Hindsley writes: "Removing the scientific and mechanical hazards of the instruments will make good intonation easier and more natural" (Pottle, 1960, p. ix).

Each of Hindsley's guides presents a basic note for tuning and a suggested means of approaching that note. Every instrument has a different note and the reason for the selection of this note is offered on each guide. The approach to each tuning note is usually in the pattern of SOL-LA-TI-DO. Hindsley also explains the intonation tendency of each instrument as the temperature of the instrument rises. All instruments are told to adjust outward as the instrument gets warmer and higher in pitch.

After a brief description of the correct method for use of the Stroboconn, Hindsley lists some of the intonation flaws on each of the individual instruments. Rather than listing every note
of the scale, Hindsley lists only those notes that he considers to be of particular concern. Hindsley also discusses some of the tendencies of specific registers on certain instruments. He suggests that students should not hesitate to make necessary temporary adjustments or use alternate fingerings to fix these flaws.

Hindsley created a separate guide for every instrument except the combined baritone, euphonium and BBb tuba chart. He also includes tuning guides for percussion instruments as well as the strings. All of the guides consist primarily of text and some notation. The terminology would be easily understood by most high school aged students. The charts assume that the student already produces and understands the qualities of a good tone. Hindsley does not list any causes for the production of poor intonation, however these are substantially covered by Pottle in other sections of the book. There are also no suggestions for the implementation of these guides.

In his book, Instrumental Music Pedagogy, 1973, Daniel Kohut also presents guides related to the intonation tendencies of the wind instruments. These guides were prepared for the use of the future educator, not for the student performer. Kohut has three guides; one for the intonation deficiencies in the brasses, one for the intonation deficiencies in the woodwinds, and one for the register intonation deficiencies of the woodwinds. The guides and the terminology would be easily understood by students.

The guides first list several methods of adjusting pitch. In the case of the brasses, these methods include:

1. Alternate fingerings
2. Thumb trigger
3. Third valve slide
4. Varying lip tension
5. Use of fourth valve
6. Tuning slide trigger
7. Use of right hand in the bell
In the case of the woodwinds, the methods of alteration include:

1. Varying lip tension
2. Alternate fingerings
3. Amount of reed in mouth
4. Finger shading
5. Jaw movement
6. Rolling embouchure hole

Following these lists, Kohut presents the instruments in score order next to notation that contains the bad notes. Next to the notation, Kohut has a list of numbers that refer to the methods of alteration. Above and below the bad notes, Kohut has placed an arrow that indicates the tendency of that particular note. An up arrow indicates sharpness, while a down arrow indicates flatness. After the guide, he lists valve combination tendencies as well as some general information about the listed methods of alteration.

The guide referring to the register intonation tendencies is done slightly differently. Each instrument has its own set of notation that includes every playable note. Below the notation is a thick, straight line that refers to the standard pitch level for the playable notes. Kohut then has a line that looks similar to a line drawn by a seismograph. The jagged line goes above the line if the tendency is sharp and below the line if the tendency is flat. Kohut does not suggest any specific tuning notes or list any specific causes for the intonation problems other than the information presented prior to the guides regarding the manufacture of the instruments. He does not offer any suggestions for implementation of the guides either.

The Rehearsal Handbook for Students, written by Robert Garofalo, contains guides that are specifically designed for use by students. The guides are contained in a series of units for use within the rehearsal setting. The guides are well designed and easy for students to read and understand. There are three sets of guides; one for the techniques for adjusting pitch on brass instruments, one for the techniques for adjusting pitch on woodwinds, and one for the suggested tuning procedures for all of the instruments. Following these guides, Garofalo presents a sample
guide to be completed by students when using an electronic tuning device. This mainly consists of the full chromatic range of the instrument in notation and the student is asked to place their instruments tendencies on the guide.

The Garofalo guides for both the brasses and woodwinds begin with a large highlighted area that lists several methods of correcting problems. These are almost identical to those used by Kohut. Then each instrument is listed next to the notation of notes with inherent intonation flaws. The notes are bracketed and an arrow is placed above and below the group indicating its tendency for flatness or sharpness. Following the notation, a list of suggested remedies is presented as well as some general comments about tone quality, air support, and reeds. Garofalo offers no suggestions for the use of these charts.

The Garofalo's Instrument Tuning Guides outline specific procedures for tuning each individual instrument. The guides are preceded by a list of general procedures for tuning. This list includes:

1. Warm up before tuning
2. Do not use vibrato when tuning
3. Tune to a mezzo-forte dynamic level
4. Tune to a reliable frequency (Stroboconn, etc.)
5. Tune to the basic tuning note(s) listed in the charts
6. Do not humor the tuning note, play it straight. Adjust the main tuning mechanism.

Each instrument has notation that indicates the suggested tuning note(s) as well as a suggested approach to each note, similar to those used by Hindsley. The guide also lists the main tuning mechanism, the procedure, and some general comments about the procedure. The guides for the brasses make reference to an additional chart called "Tuning the Valves". This guide describes procedures for tuning the tuning slides for each of the valves. There are also guides for the strings and the timpani. Here again, Garofalo does not suggest how to use the guides effectively.
The most recent publication regarding intonation of wind instruments is James Jurrens’ *Tuning the Band and Raising Pitch Consciousness*, 1991. The entire book is a series of charts about intonation. There are five chapters entitled: Warm-up and Tuning, Recommended Notes for Length Adjustment, Tuning Sheets, Possible Adjustments for Selected Pitch Tendencies, and Graphing the Instrumentalist’s Intonation. The book is written so that the terminology would be read and understood by the student.

The Tuning Notes for Length Adjustment is a guide that lists each of the instruments with the suggested note(s) for tuning. Jurrens also suggests that proper tuning of a note should be done by approaching the note in a scalar pattern similar to that of Hindsley.

The tuning and intonation guide sheets are intended to be put in the hands of the student. They direct the student in the following manner:

1. The student is instructed how to tune the instrument.
2. The sheet indicates which notes are likely out of tune and their tendencies.
3. Causes and remedies for the intonation problems cited.

The tendencies of the bad notes are listed chromatically with arrows above the notes indicating their tendencies. Arrows pointing up indicate sharpness and down arrows indicate flatness. The discussion about the causes and remedies include things like, reeds, embouchure, mouthpiece, dynamics, alternate fingerings, range, and articulation and endurance considerations. All of these are specific to the individual instruments.

Possible Adjustments for Selected Pitch Tendencies is a series of guides that list problem notes and suggestions for fixing them. The notes are listed on the staff and their tendency is presented directly to the right. In the case where several adjustments might be presented, the student is reminded to use the first adjustment as the first means to fix the problem. This section is followed by the Graphing of the Instrumentalist’s Intonation. This provides the students and the directors with the general concepts necessary for the student to chart the intonation problems of their own instruments. Jurrens does not suggest how to implement the guides for maximum effectiveness.
Results of Comparison of Intonation Guides

The data from these published materials were compared and condensed in the process of constructing the intonation guides for use in this study. These intonation guides were used as a part of the experimental procedure described in the previous chapter. The resultant intonation guides can be found in Appendix C.

Conclusion

The task of developing intonation guides based on expert opinion was much more difficult than originally perceived. It was extremely difficult to find consensus among the five experts about particular notes. Several music educators who previewed the guides were not in total agreement with the information on the guides, yet they felt the use of guides would be beneficial and urged pursuit of the idea. Although the researcher also disagreed with some of the information on the guides, the information was compiled from the consensus of five experts and it is a starting point from which students can begin their understanding of the intonation problems of their instruments. It should also be noted that not one of the experts indicated or suggested how to implement their charts.

Findings from Experimental Procedures

The purpose of this section of this chapter is to present and interpret the data collected from the experimental procedures. The general format of this section will be to discuss the purpose of
the data collection, present the data and offer an interpretation of the data.

Overview

The problem of this study was to explore a means to increase the performers' awareness of the intonation tendencies of their individual instruments. The purpose of this study was: a) to examine and compare current published materials and charts that provide such information about intonation tendencies and b) to measure the extent to which an intonation guide prepared for students will increase their awareness of the intonation tendencies of their instruments. The null hypothesis of the study was that no significant difference exists between those students who use an intonation guide to learn the general intonation tendencies of their instruments and those who do not. Specific questions studied included:

1. Can the use of an intonation guide improve the cognitive awareness of the intonation tendencies of wind instrument students?

2. Can the use of an intonation guide improve the level of intonation accuracy of a wind instrument student during performance?

A detailed review of related literature and related research was completed. It was found that there had not been a great deal of research done in the area of instrument intonation and none in the area of student awareness of the intonation problems inherent in their own instruments.

The design of the study was a control group pretest-post-test format. The testing procedure, identical for both the pretest and post-test, included two parts. The first part was a researcher-designed questionnaire that measured the student's cognitive awareness of the intonation tendencies of their instruments. The second part was a measure of the subject's actual intonation level during individual performance. Both yielded scores that could be used to measure the effectiveness of the experimental procedure. A pilot study was done to determine the reliability of
the measuring tools and their scores. Instrument validity was determined as a result of expert review and consensus opinion.

The experimental procedure took place over six rehearsals during the warm-up period of the experimental group. The experimental group made use of researcher prepared intonation guides and individualized intonation charts during this time. The intonation guide was a guide that listed the general tendencies of an instrument as determined by the careful comparison of five previously done intonation guides (See Appendix C). The other chart, the individualized tuning chart was the graph printout from the subjects performance session with the Amadeus II. The researcher highlighted some of the very poor notes on the student's chart prior to use by the student. The researcher guaranteed interaction with the charts by requiring that students use them on their music stand during the warm-up period and other various means.

Pilot Study

The procedures described in Chapter Three were carried out using a sample of high school students to determine their efficiency in collecting data for this study. It was determined that both parts of the testing procedures would be useful for this study. One item, #8, was re-worded to accommodate a more desirable response. The data collected from the pilot study was determined to be conducive for the study as well.

Pretest

The pretest was conducted over a period of two successive rehearsals for the Concert and Campus Bands at Penn State University. In both cases, the entire group was first given the written portion of the test, a questionnaire, as well as being required to sign the Informed Consent Form.
The sample size was 74 total subjects; 38 from the Concert Band (control group) and 36 from the Campus Band (experimental group).

The results of the written portion of the pretest presented the amount of awareness or knowledge the subjects held regarding the general intonation tendencies of their particular instruments. Subjects responses on the questionnaire for item numbers 3 through 12 were compared first to the tuning guide prepared by the researcher. The comparison to the “tuning guide” provided information regarding the extent to which the subjects understand the intonation tendencies of their particular instrument. Subjects were awarded one point for each correct response. The comparison of the questionnaire results for item numbers 1 and 2 to the performance measure, the Amadeus II, provided an indication of how close the subjects perceptions of the intonation tendencies of their instrument are to their actual performance tendencies. Scores were determined by assigning one point for each correct response on the questionnaire as compared to the computer resultant individualized intonation chart. The total number of correct responses were divided by the total number of responses to yield a percentage score for the written portion of the test. All portions of this test were evaluated by the researcher. The results from the written portion of the test are listed in Table 4.1 - Results of Pretest.

Table 4.1 - Results of the Pretest

<table>
<thead>
<tr>
<th>GROUP</th>
<th>WRITTEN</th>
<th>PLAYING</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>st. dev.</td>
<td>mean</td>
</tr>
<tr>
<td>Concert Band (Control Group)</td>
<td>60.05</td>
<td>14.76</td>
<td>79.61</td>
</tr>
<tr>
<td>Campus Band (Experimental Group)</td>
<td>60.53</td>
<td>16.97</td>
<td>76.56</td>
</tr>
<tr>
<td>t-score</td>
<td>.1287</td>
<td>1.6968</td>
<td>.6768</td>
</tr>
<tr>
<td>probability</td>
<td>.4467</td>
<td>.0451</td>
<td>.2539</td>
</tr>
</tbody>
</table>

A t-test was completed using the “Statistics with Finesse” (Bolding, 1984) computer
program to determine if there was any degree of significant difference between the two groups in the written portion of the pretest. The results of the t-test yielded a t-score of 1.287 with a probability of .4467. This indicates that there was no significant difference in the knowledge of the general intonation tendencies of their instruments between the two groups at the beginning of the treatment period. However, since both groups had mean scores of approximately 60%, it was concluded that the subjects had a moderate amount of knowledge about the general intonation tendencies of their instruments.

The second portion of the pretest was the performance of a chromatic scale, the intonation of which was measured by the Amadeus II. The purpose of this test was to determine the intonation level at which each subject performed. The determination of the score for the playing portion of the test was completely tabulated by the Amadeus II program itself. The student’s score on each note was determined by the percentage of time the student was playing within a preset 20 cent window. Each note lasted approximately two seconds. The scores from each note were then added, and the computer determined the mean to yield an overall “playing” score. The results from the playing portion of the test are also presented in Table 4.1 - Results of the Pretest.

A t-test was completed to determine if there was any degree of significant difference between the two groups in the playing portion of the pretest. The results of the t-test yielded a t-score of 1.6968 with a probability of .0451. This indicates that there was a significant difference in the intonation performance levels between the two groups prior to testing with the members of the Concert Band performing with superior intonation. This was expected since membership for both groups is by audition and the higher rated players are assigned to the Concert Band.

The total intonation score was tabulated by adding the written and playing scores and dividing by two. The results of that computation are listed in Table 4.1 - Results of the Pretest. A t-test was completed to determine if there was any degree of significant difference between the two groups in the total intonation score of the pretest. The results of the t-test yielded a t-score of .6768 with a probability of .2549. This indicates that there was not a significant difference in the total intonation scores between the two groups.
As a result of the data from the written portion of the pretest, the researcher concluded that the subjects had some knowledge of the intonation tendencies of their instruments, however the amount of this knowledge was at best minimal. The researcher also concluded that the Concert Band performed with superior intonation to that of the Campus Band based upon the performance measurement. This was attributed to the fact that the Concert Band contained players already determined to be better performers.

Post-Test

Following the experimental treatment described in Chapter Three and a time period of six rehearsals, both groups underwent the post-test. The post-test procedures were identical to that of the pretest.

The results of the written portion of the post-test were determined by the same means as the pretest. As in the pretest, all portions of the written test were evaluated by the researcher. The results from the written portion of the post-test are listed in Table 4.2 - Results of the Post-test.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>WRITTEN</th>
<th></th>
<th>PLAYING</th>
<th></th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>st. dev.</td>
<td>mean</td>
<td>st. dev.</td>
<td>mean</td>
</tr>
<tr>
<td>Concert Band</td>
<td>61.58</td>
<td>13.03</td>
<td>79.47</td>
<td>7.51</td>
<td>70.79</td>
</tr>
<tr>
<td>(Control Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Campus Band</td>
<td>81.67</td>
<td>9.01</td>
<td>81.11</td>
<td>7.85</td>
<td>81.33</td>
</tr>
<tr>
<td>(Experimental Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t-score</td>
<td>-7.6736</td>
<td></td>
<td>-.9173</td>
<td></td>
<td>-6.6320</td>
</tr>
<tr>
<td>probability</td>
<td>.6707</td>
<td></td>
<td>.1879</td>
<td></td>
<td>.0001</td>
</tr>
</tbody>
</table>

A t-test was completed to determine if there was any degree of significant difference between the two groups in the written portion of the post-test. The results of the t-test yielded a t-
score of -7.6736 with a probability of .6707. This indicates that there was no significant difference in the knowledge of the general intonation tendencies of their instruments between the two groups following the experimental treatment.

The results of the playing portion were completely tabulated by the Amadeus II program and the computer. The results are listed in Table 4.2 - Results of the Post-test. A t-test was completed to determine if there was any degree of significant difference between the two groups in the playing portion of the post-test. The results of the t-test yielded a t-score of -.9173 with a probability of .1879. This indicates that there was not a significant difference in the intonation performance levels following the experimental treatment.

The total intonation score for the post-test was determined identically to the means of the pretest. The results of this tabulation are listed in Table 4.2 - Results of Post-test. A t-test was completed to determine if there was any degree of significant difference between the two groups in the total intonation score of the pretest. The results of the t-test yielded a t-score of -6.6320 with a probability of .0001. This indicates that there was a significant difference in the total intonation scores between the two groups following the experimental treatment.

A main purpose of this study was to determine if an intonation guide could increase the student’s cognitive awareness of the intonation tendencies of their instruments as well as their intonation performance level. When asked if they felt an intonation guide would help their intonation, 100% of the subjects responded that it would. Two statistical procedures were employed to determine if the charts had improved either the knowledge of intonation tendencies or the intonation in performance of the experimental group.

A t-test was used to determine if there was a significant difference between the pretest and the post-test of both the written and playing portions of the test for the Concert Band. The results are presented in Table 4.3 - t-test Results for Concert Band from Pretest to Post-test.
Table 4.3 - t-test Results for Concert Band (Control Group) from Pretest to Post-test

<table>
<thead>
<tr>
<th>TEST</th>
<th>WRITTEN</th>
<th>PLAYING</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>st. dev.</td>
<td>mean</td>
</tr>
<tr>
<td>Pretest</td>
<td>60.05</td>
<td>14.76</td>
<td>79.61</td>
</tr>
<tr>
<td>Post-test</td>
<td>61.58</td>
<td>13.03</td>
<td>79.47</td>
</tr>
<tr>
<td>t-score</td>
<td>.4779</td>
<td>.0733</td>
<td>.4257</td>
</tr>
<tr>
<td>probability</td>
<td>.3197</td>
<td>.4700</td>
<td>.3376</td>
</tr>
</tbody>
</table>

These results indicate that there was not a significant difference in either the knowledge of intonation tendencies or the intonation level in performance scores from pretest to post-test for the control group. It was expected that the mean scores might improve slightly as the students might have become used to the testing procedures. However, the slight decrease in the playing score was surprising and unexpected. This may indicate that the control group is consistent in their intonation during performance and that the measuring instruments are highly reliable.

A t-test was used to determine if there was a significant difference between the pretest and the post-test of both the written and playing portions of the test for the Campus Band. The results are presented in Table 4.4 - t-test Results for Campus Band from Pretest to Post-test.

The results indicate that there was a significant difference between the pretest and post-test scores for both the knowledge of intonation tendencies and the intonation performance for the experimental group. The researcher anticipated that the knowledge score would show improvement since the post-test questions were identical to those of the pretest and because all of the information required to respond correctly to the post-test was contained on the researcher prepared tuning guides given to the group. Although the mean score for the performance measurement only increased about 5 points, the difference was significant (p<.0062). These data suggest that the experimental procedure did improve the experimental group’s knowledge of
intonation tendencies and their intonation level in performance.

Table 4.4 - t-test Results for Campus Band (Experimental Group) from Pretest to Post-test

<table>
<thead>
<tr>
<th>TEST</th>
<th>WRITTEN</th>
<th>PLAYING</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean st. dev.</td>
<td>mean st. dev.</td>
<td>mean st. dev.</td>
</tr>
<tr>
<td>Pretest</td>
<td>60.53 16.97</td>
<td>76.56 7.28</td>
<td>68.81 7.75</td>
</tr>
<tr>
<td>Post-test</td>
<td>81.67 9.01</td>
<td>81.11 7.85</td>
<td>81.33 5.53</td>
</tr>
<tr>
<td>t-score</td>
<td>6.5991 2.5535</td>
<td>7.8912</td>
<td></td>
</tr>
<tr>
<td>probability</td>
<td>.0001</td>
<td>.0062</td>
<td>.0001</td>
</tr>
</tbody>
</table>

Additionally, the researcher determined the gain for each of the three areas for the subjects of both groups. The gain scores were also subjected to a t-test to determine if there was any significant difference between the gain scores of the two groups. The mean gain scores and the standard deviation of all three areas for both the Concert Band and Campus Band as well as the results of the t-test are listed in Table 4.5 - Results of Gain Score Tabulation.

Table 4.5 - Results of Gain Score Tabulation

<table>
<thead>
<tr>
<th>GROUP</th>
<th>WRITTEN</th>
<th>PLAYING</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean gain</td>
<td>standard deviation</td>
<td>mean gain</td>
</tr>
<tr>
<td>Concert Band (Control Group)</td>
<td>1.55 7.33</td>
<td>-.29 5.39</td>
<td>8.59 4.46</td>
</tr>
<tr>
<td>Campus Band (Experimental Group)</td>
<td>21.14 16.96</td>
<td>4.50 6.24</td>
<td>12.47 8.59</td>
</tr>
<tr>
<td>t-score</td>
<td>-6.5080</td>
<td>-3.5397</td>
<td>-7.3820</td>
</tr>
<tr>
<td>probability</td>
<td>.0001</td>
<td>.0005</td>
<td>.0001</td>
</tr>
</tbody>
</table>
The results of this tabulation indicate that there is a significant difference between the gain scores of the experimental and control groups in the written (p<.0001), playing (p<.0005), and total scores (p<.0001).

Summary

As a result of the data from the t-test between the pretest and post-test gain scores of both groups and the t-test, the researcher concluded that the experimental procedure of providing the experimental group with tuning guides and individualized intonation charts improved the knowledge of intonation tendencies and the intonation in performance of the experimental group. The improvement in the knowledge score was anticipated by the researcher since the tuning guide provided all of the correct answers to help the experimental group respond to the post-test. However, the improvement in the performance measurement was not expected since the amount of time (six rehearsals) the experimental group had with the charts was not considerable. The researcher can only speculate at the amount of improvement that would have occurred had the group spent more time with their guides and charts. The unvarying scores from pretest to post-test of the control group indicated that the testing instruments were reliable.
CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The problem of achieving accurate intonation in the school band has challenged the thinking of many of the finest band directors, musicians and students. There have been countless articles and books written on this subject, all of which have been helpful in guiding the director toward the most effective methods. By placing the emphasis of these writings on increasing the knowledge of the instructors however, the student awareness of the general intonation tendencies of their instruments has been neglected.

Cooperative learning, a current educational trend, places more of the responsibility for learning directly on the student (Smith, 1987). If students are responsible for learning, then the educational outcome may go beyond what is considered possible (Hosterman, 1992). This concept can be carried into music education as well. “To encourage and develop independent judgment, the conductor should transfer the responsibility (of determining intonation problems) to the band members themselves” (Hovey, 1976, p. 25). And, unless the student is aware that a problem exists with their intonation, it can not be fixed. This study was directed toward determining and extending the wind instrumentalist’s knowledge of the general intonation tendencies of their instrument as well as determining the effectiveness of a means to increase that awareness.

The problem of this study was to explore a means to increase the performers’ awareness of
the intonation tendencies of their individual instruments. The purpose of this study was to determine the extent to which student instrumentalists are aware of the general intonation deficiencies of their instruments and to examine and compare current published materials and charts that provide such information. The null hypothesis of the study was that no significant difference exists between those students who use an intonation guide to learn the general intonation tendencies of their instruments and those who do not. Specific research questions studied included:

1. Can the use an “intonation guide” improve the cognitive awareness of the intonation tendencies of wind instrument students?

2. Can the use of an “intonation guide” improve the intonation accuracy of a wind instrument student during performance?

A detailed review of related literature and related research studies was completed. It was found that there was not a great deal of research done in the area of instrument intonation and none in the area of student awareness of the intonation problems inherent in their own instruments.

The design of the study was a control group pretest-post-test format. The testing procedure, identical for both the pretest and post-test, included two parts. The first part was a researcher-designed questionnaire that measured the student’s cognitive awareness of the intonation tendencies of their instruments. The second part was a performance measure, the Amadeus II, that determined the intonation level during individual performance. Both tests yielded scores that could be used to measure the experimental procedure. A pilot study was done to determine the reliability of the measuring tools and their scores. Instrument validation was completed by expert review and consensus opinion of those experts.

A total of 74 subjects from The Pennsylvania State University Concert Band (38 subjects) and Campus Band (36 subjects) were selected for the study during the Spring semester of 1993. Both groups met for the same amount of rehearsal time, twice a week. The Campus Band was chosen as the experimental group. Both groups underwent identical pretests and post-tests.

The experimental procedure took place over six rehearsals during the warm-up period of the experimental group. The experimental group made use of a researcher prepared intonation
guides and an individualized intonation chart during this time. The intonation guide was a guide that listed the general intonation tendencies of individual instruments as determined by the careful comparison of previously completed intonation guides designed by five different experts (See Appendix C). The other chart, the individualized intonation chart was the graph printout from the subjects session with the Amadeus II. The researcher highlighted some of the very poor notes on the student's printout prior to use by the student. The researcher guaranteed interaction with the tuning guides by requiring that students put them on their music stand during the warm-up period, requiring the subjects to write the tendencies for their highlighted notes above the notes, and other activities.

Following completion of the experiment, both groups underwent the post-test. All of the data were recorded and analyzed by the researcher. The data were also subjected to statistical testing to help clarify the results. The measuring tools proved to be effective in providing the data required for the study.

From the data collected from the pretest, the researcher found that the students did have some awareness of the general intonation tendencies of their instruments, although scoring only in the 60% range. The pretest also revealed that there was a significant difference (p< .05) between the two groups intonation performance. This could probably be attributed to the fact that the control group was actually comprised of better performers since the members of the control group were placed in the Concert Band based upon higher audition scores earlier in the semester. There was not a significant difference in any other area of the pretest.

An additional part of the study included the development of intonation guides that would list the general tendencies of each instrument. The final charts were developed as a result of careful comparison and compilation of the charts described and discussed previously. (The charts can be found in Appendix C.)

Following the collection and analysis of the post-test data, the researcher was able to make additional conclusions. The experimental group was found to have a significant difference in their written scores (p<.0001), their playing scores (p< .0062), and their total intonation score (p<
.0001) from the pretest to the post-test. The control group had no significant difference in any area from pretest to post-test. Additionally, a significant difference was found between the gain scores of the two groups in all of the area (written - p< .0001; playing - p< .0005; total intonation score - p< .0001). These data suggests that the experimental process did improve the subject's cognitive knowledge of intonation tendencies and the intonation performance level of the experimental group. There were no significant differences found between the pretest and post-test scores of the control group.

Conclusions

Based upon the findings, the researcher is able to draw several conclusions that provide answers to the research questions.

Students do possess some knowledge about the intonation tendencies of their instruments, however that amount is limited and at times incorrect. When asked if they had ever made use of an intonation guide, most students responded that they had not but they also overwhelmingly felt that an intonation guide would be very helpful. The lack of information about intonation could only be attributed to the lack of information presented to them by their previous teachers and band directors or the improper dissemination of such information. However, due to the lack of research and publication about the intonation of wind instruments, the fault may not be entirely with the teachers.

It was possible to develop intonation charts for use with the students based upon the information of those who had previously developed similar charts. This task, however, was much more difficult then originally perceived. It was extremely difficult to find consensus among the five experts about particular notes that were potential intonation problems. Several music educators who had previewed the charts were also in mild disagreement with some of the information on the
guides, yet they felt the use of guides would be beneficial and urged pursuit of the idea. Although the researcher also disagreed with some of the information on the guides, the information was compiled from the consensus of five experts and it is a starting point from which students can begin their understanding of the intonation problems of their instruments.

The measuring tools provided the data needed for this study. There were very few questions about the questionnaire and most students found it self explanatory. After some trial and error with the Amadeus II system, the researcher found it to be very useful and certainly effective for the purposes of this study. In addition to the tabulation abilities, the researcher was very content with the means by which the testing took place. The fact that the Amadeus II uses a reference pitch throughout the testing time makes the system more realistic since students in a band are required to play with others constantly. The system also allows for a great deal of flexibility for the teacher to adjust the program and testing to his/her liking and needs. The printouts from the system are easy to read and understand. They provide an efficient means to improve the intonation of those who make use of them. The system caught the attention of the subjects and sparked many questions about its potential usage.

Based upon the findings of the study, the researcher has concluded that the use of an intonation guide can improve a student’s cognitive awareness of intonation problems as well as their intonation level during performance. It was anticipated that the guides would make a large difference in the written portion of the test, but the difference in the playing portion was unexpected considering the fact that the experimental group only used the guides for six total rehearsals. The researcher would speculate that if the students had spent an entire semester with the guides, the improvement would have been even greater as well as long lasting.

**Recommendations**

The researcher recommends that music educators require their students to take a more active role in the making of music. By merely increasing the student’s awareness about a particular
area of music making, this study found vast improvements in the final product. By encouraging students to take a closer look at their intonation and discussing their tendencies, the teachers will not only improve the intonation of their students, but also inevitably improve their ensembles as well.

The researcher would recommend that band directors and instructors implement the use of intonation guides into their rehearsals. The information for these guides could be found in any of the sources listed throughout this study or the director could design individualized guides for their students by having the students play into a tuner and then record the results. The use of these guides, if used during the rehearsal and practice of the student, is sure to improve the intonation performance levels of the individuals and the ensemble.

For those directors who have the means to purchase the Amadeus II program, the researcher would highly recommend the system. The entire program is user friendly and certainly caught the attention of the students who used it. Just the fact that the students were interested in the system may have actually influenced their concern about their intonation. The charts printed out by the computer were easy to follow and understand. The system could greatly enhance the musical potential of any ensemble.

The researcher would suggest that a follow-up study of the same students be done in the Fall to see if any of the information contained on the guides was retained by the students. The researcher would also suggest that this study be duplicated with an extended experimental procedure. Additionally, the researcher would recommend that more study of the intonation tendencies of wind instruments be done in the near future. All of these recommendations could only lead to better performances.

Summary

The motivation of this study was to find a means to increase the intonation performance level of an ensemble through improvement of the individuals. It is clear that there are means to
improve and increase the intonation performance level of an ensemble. The use of an intonation guide that increases a student instrumentalist’s cognitive awareness of the intonation problems inherent in their own performance as well as the general tendencies of their instrument will improve and increase their intonation performance level. The director interested in improving ensemble intonation should present these intonation guides to their students and require the use of the guides during rehearsal. By making the students aware of the intonation problems of their instruments, the students can now pay careful attention to those notes and adjust as needed. Eventually, this practice will result in more satisfying performances.
REFERENCES


APPENDIX A

SAMPLE QUESTIONNAIRE
Study of Intonation Tendencies of Wind Instruments

Douglas Orzolek
The Pennsylvania State University

Background Information

Name ____________________________
Age ________________
Major ____________________________

How long have you participated in band? ____________________ years

Instrument ____________________________

How long have you played this instrument? ________________ years

How much private instruction have you had on that instrument? ________________ years

Have you ever used a Tuning Guide (a chart that indicates the tendencies of different notes on your instrument)?

(Circle One) Yes No

Have you ever received any verbal instruction regarding the intonation tendencies of your instrument?

(Circle One) Yes No

Do you feel that a chart listing the intonation tendencies of your instrument would be helpful to your performance?

(Circle One) Yes No

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Intonation Questionnaire

1. On the staff provided below, place a whole note for the notes that you believe are of "poor" intonation on your instrument.

2. Above the notes that you placed on the staff, indicate the intonation tendency of that note by placing a sharp sign (#) for sharpness and a flat sign (♭) for flatness.

3. What is the best note(s) for tuning your instrument? (for example, "fourth line F")

4. As my instrument gets warmer, the pitch of it ______ (Circle One) Raises Lowers

5. If I overblow my instrument, the pitch ______ (Circle One) Raises Lowers

6. If I crescendo while I play, the pitch ______ (Circle One) Raises Lowers

7. (Reeds Only) If my reed is too soft, the pitch____ (Circle One) Raises Lowers

8. The best note in the band to listen to for intonation is the ________________________ (Fill In)

9. The upper register of my instrument is usually_____ (Circle One) Sharp Flat

10. The lower register of my instrument is usually_____ (Circle One) Sharp Flat

11. (Brass Players) If I were to use a mute, the pitch_____ (Circle One) Raises Lowers

12. If my instrument is SHARP, I adjust the tuning by____ (Circle One) Pulling Pushing

After you have completed this questionnaire, wait to be called for the second portion of the test.
APPENDIX B

INFORMED CONSENT FORM AND
APPROVAL OF THE PENNSYLVANIA STATE UNIVERSITY
OFFICE OF REGULATORY COMPLIANCE
Informed Consent Form

AN INVESTIGATION OF THE EXTENT OF STUDENT AWARENESS OF THE GENERAL INTONATION TENDENCIES OF THEIR WIND INSTRUMENTS

Douglas Orzolek, investigator
218 Chambers Building - 865-3982
February 15, 1993

The purpose of this study is to determine how much knowledge you have of the general intonation tendencies of your instrument. You will be asked to complete a questionnaire that requires you to respond to questions about the intonation of your instrument. You will also be asked to perform a brief musical excerpt into a computer that will determine your intonation levels for each individual note. Following this procedure, some participants may receive an “Intonation Guide” which you may use at your discretion. Approximately one week later, you will be asked to complete the same process. (The remainder will receive the “Intonation Guide” following the post-test)

The information form this study will be in no way reflected as a portion of your semester grade and you are free to excuse yourself from the study at any time. However, as musicians, a study of this nature could have a positive impact on your performance. Information about your performance will be provided if you are interested following completion of the study. YOUR NAME WILL NOT BE USED IN ANY MANNER IN THE REPORT OF THIS STUDY.

Please complete the following:

This is to certify that I, ____________________, hereby agree to participate as a volunteer in this study as an authorized part of the education and research program of the Pennsylvania State University under the supervision of Douglas Orzolek.

Please place an “X” on the line next to the following statements to indicate that you have read the statements:

_____ I have been given the opportunity to ask whatever questions I may have and all such questions and inquiries have been answered to my satisfaction.

_____ I understand that I am free to deny any answers to specific items or questions.

_____ I understand that any data or answers to questions will remain confidential with regard to my identity.

_____ I FURTHER UNDERSTAND THAT I AM FREE TO WITHDRAW MY CONSENT AT ANY TIME AND TERMINATE MY PARTICIPATION AT ANY TIME.

DATE_________________ SIGNATURE__________________
Date: January 26, 1993

From: Lorraine M. Mulflinger, Compliance Coordinator

To: Douglas Orzolek

Subject: Proposal for Use of Human Subjects in Research - Exemption

"An Investigation of the Extent of Student Awareness of the General Intonation Tendencies of their Wind Instruments"

I have examined your proposal for use of human subjects in your research. Subjects in your research are at minimal risk. You may proceed with your study.

COMMENT: Contact information (phone number/address) should be included in the Explanation of Study/Informed Consent Form in case subjects may wish to contact you at a later date. If you include this information in the Explanation of Study/Informed Consent Form, please send a revised copy for our records.

Attached are mailing labels you can use to forward to 114 Kern Building the original, signed informed consent forms obtained from the subjects of your study. Contact this office if you need more labels.

Subjects must receive a copy of the informed consent form and the written explanation of your study that was submitted to this office for review.

By accepting this decision you agree to notify this office of (1) any additions or changes in procedures for your study that modify the subjects’ risks in any way and (2) any events that affect the safety or well-being of subjects.

The University appreciates your efforts to conduct research in compliance with the federal regulations that have been established to ensure the protection of human subjects.

LMM/cdv

Attachments

cc: O. R. Bundy
    K. P. Thompson
    E. V. Williams

An Equal Opportunity University
APPENDIX C

RESEARCHER PREPARED INTONATION GUIDES

(THE RESULTS FROM THE COMPARISON OF THE INTONATION GUIDES FROM FIVE EXPERTS IN THE AREA OF WIND INSTRUMENT INTONATION)
INTONATION GUIDE

FLUTE

The best note for tuning your instrument is: \( \text{\textit{b} \alpha} \)

The best way to approach that note is:

The following is a listing of the notes that are "generally" of poor intonation for your instrument:

Note Tendency -

UPPER REGISTER
The intonation of the upper register of your instrument is generally: SHARP

LOWER REGISTER
The intonation of the lower register of your instrument is generally: FLAT

TEMPERATURE
As your instrument gets warmer, the pitch generally: SHARPENDS

OVERBLOWING
If you were to overblow your instrument, the pitch would generally: SHARPEN

CRESCENDO
As you crescendo, the intonation of your instrument generally: SHARPENDS

DIMINUENDO
As you diminuendo, the intonation of your instrument generally: FLATTENS

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INTONATION GUIDE

CLARINET

The best note for tuning your instrument is: \[\text{Note} \]

The best way to approach that note is: \[\text{Note} \]

The following is a listing of the notes that are "generally" of poor intonation for your instrument:

Note Tendency - \[\text{Note} \]

UPPER REGISTER
The intonation of the upper register of your instrument is generally: SHARP

LOWER REGISTER
The intonation of the lower register of your instrument is generally: FLAT

TEMPERATURE
As your instrument gets warmer, the pitch generally: SHARPENS

OVERBLOWING
If you were to overblow your instrument, the pitch would generally: SHARPEN

CRESCEndo
As you crescendo, the intonation of your instrument generally: FLATTENS

DIMINUENDO
As you diminuendo, the intonation of your instrument generally: SHARPENS

REEDS
A HARD reed will generally force the intonation of your instrument to: SHARPEN

EMBOUCHURE
Too much mouthpiece will generally cause the intonation to: FLATTEN
INTONATION GUIDE

OBOE

The best note for tuning your instrument is:

The best way to approach that note is:

The following is a listing of the notes that are "generally" of poor intonation for your instrument:

Note Tendency -

UPPER REGISTER
The intonation of the upper register of your instrument is generally: SHARP

LOWER REGISTER
The intonation of the lower register of your instrument is generally: FLAT

TEMPERATURE
As your instrument gets warmer, the pitch generally: SHARPENS

OVERBLOWING
If you were to overblow your instrument, the pitch would generally: FLATTEN

CRESCErNO
As you crescendo, the intonation of your instrument generally: FLATTENS

DIMINUENDO
As you diminuendo, the intonation of your instrument generally: SHARPENS

REEDS
A HARD reed will generally force the intonation of your instrument to: SHARPEN

EMBOUCHURE
Too much reed will generally cause the intonation to: SHARPEN
INTONATION GUIDE

BASSOON

The best note for tuning your instrument is:

The best way to approach that note is:

The following is a listing of the notes that are "generally" of poor intonation for your instrument:

Note Tendency -

UPPER REGISTER
The intonation of the upper register of your instrument is generally: FLAT

LOWER REGISTER
The intonation of the lower register of your instrument is generally: SHARP

TEMPERATURE
As your instrument gets warmer, the pitch generally: SHARPENS

OVERBLOWING
If you were to overblow your instrument, the pitch would generally: FLATTEN

CRESCEndo
As you crescendo, the intonation of your instrument generally: FLATTENS

DIMINIENDO
As you diminuendo, the intonation of your instrument generally: SHARPENS

REEDS
A HARD reed will generally force the intonation of your instrument to: SHARPEN

EMBOUCHURE
Too little pressure around the reed will cause the intonation to: FLATTEN
INTONATION GUIDE

SAXOPHONE

The best note for tuning your instrument is: \( \text{E}_3 \), and the best way to approach that note is: \( \text{F}_3 \).

The following is a listing of the notes that are “generally” of poor intonation for your instrument:

Note Tendency -

- **UPPER REGISTER**
  - The intonation of the upper register of your instrument is generally: **SHARP**

- **LOWER REGISTER**
  - The intonation of the lower register of your instrument is generally: **SHARP**

- **TEMPERATURE**
  - As your instrument gets warmer, the pitch generally: **SHARPENS**

- **OVERBLOWING**
  - If you were to overblow your instrument, the pitch would generally: **SHARPEN**

- **CRESCENDO**
  - As you crescendo, the intonation of your instrument generally: **FLATTENS**

- **DIMINUENDO**
  - As you diminuendo, the intonation of your instrument generally: **SHARPENS**

- **REEDS**
  - A HARD reed will generally force the intonation of your instrument to: **SHARPEN**

- **EMBOUCHURE**
  - Too much mouthpiece will generally cause the intonation to: **FLATTEN**
INTONATION GUIDE

HORN

The best note for tuning your instrument is:  

The best way to approach that note is:  

The following is a listing of the notes that are "generally" of poor intonation for your instrument:

Note Tendency -  

**UPPER REGISTER**  
The intonation of the upper register of your instrument is generally: **SHARP**

**LOWER REGISTER**  
The intonation of the lower register of your instrument is generally: **SHARP**

**TEMPERATURE**  
As your instrument gets warmer, the pitch generally: **SHARPENS**

**OVERBLOWING**  
If you were to overblow your instrument, the pitch would generally: **SHARPEN**

**CRESCEVENDO**  
As you crescendo, the intonation of your instrument generally: **SHARPENS**

**DIMINUENDO**  
As you diminuendo, the intonation of your instrument generally: **FLATTENS**

**VALVE PROBLEMS**  
The 1-2-3 and 1-3 combinations are generally VERY: **SHARP**

**MUTES**  
The use of a mute generally causes the intonation to: **SHARPEN**

* The use of alternate fingerings reduces intonation problems.
INTONATION GUIDE

TRUMPET

The best note for tuning your instrument is:

The best way to approach that note is:

The following is a listing of the notes that are “generally” of poor intonation for your instrument:

Note Tendency:

UPPER REGISTER
The intonation of the upper register of your instrument is generally: SHARP

LOWER REGISTER
The intonation of the lower register of your instrument is generally: SHARP

TEMPERATURE
As your instrument gets warmer, the pitch generally: SHARPENS

OVERBLOWING
If you were to overblow your instrument, the pitch would generally: SHARPEN

CRESCEndo
As you crescendo, the intonation of your instrument generally: SHARPENS

DIMINUENDO
As you diminuendo, the intonation of your instrument generally: FLATTENS

VALVE PROBLEMS
The 1-2-3 and 1-3 combinations are generally VERY: SHARP

MUTES
The use of a mute generally causes the intonation to: SHARPEN
INTONATION GUIDE

TROMBONE

The best note for tuning your instrument is:

\[ \text{\textbullet} \]

The best way to approach that note is:

\[ \text{\textbullet} \]

The following is a listing of the notes that are "generally" poor intonation for your instrument:

Note Tendency -

\[ \text{\underline{\text{\textbullet}}} \]

UPPER REGISTER
The intonation of the upper register of your instrument is generally: SHARP

LOWER REGISTER
The intonation of the lower register of your instrument is generally: FLAT

TEMPERATURE
As your instrument gets warmer, the pitch generally: SHARPENS

OVERBLOWING
If you were to overblow your instrument, the pitch would generally: SHARPEN

CRESCENDO
As you crescendo, the intonation of your instrument generally: SHARPENS

DIMINUENDO
As you diminuendo, the intonation of your instrument generally: FLATTENS

MUTES
The use of a mute generally causes the intonation to: SHARPEN
INTONATION GUIDE

BARITONE HORN/EUPHONIUM

The best note for tuning your instrument is:

The best way to approach that note is:

The following is a listing of the notes that are "generally" of poor intonation for your instrument:

Note Tendency -

UPPER REGISTER
The intonation of the upper register of your instrument is generally: SHARP

LOWER REGISTER
The intonation of the lower register of your instrument is generally: SHARP

TEMPERATURE
As your instrument gets warmer, the pitch generally: SHARPENS

OVERBLOWING
If you were to overblow your instrument, the pitch would generally: SHARPEN

CRESCEPDO
As you crescendo, the intonation of your instrument generally: SHARPENS

DIMINUENDO
As you diminuendo, the intonation of your instrument generally: FLATTENS

VALVE PROBLEMS
The 1-2-3 and 1-3 combinations are generally VERY: SHARP

MUTES
The use of a mute generally causes the intonation to: SHARPEN
INTONATION GUIDE

TUBA

The best note for tuning your instrument is: \( \text{\textbf{Fb}} \)

The best way to approach that note is: \( \text{\textbf{F}} \)

The following is a listing of the notes that are "generally" of poor intonation for your instrument:

**Note Tendency**

\[ \begin{align*}
\text{\textbf{#}} & \quad \text{\textbf{#}} & \quad \text{\textbf{b}} & \quad \text{\textbf{b}} & \quad \text{\textbf{b}} \\
\text{\textbf{F}} & \quad \text{\textbf{Fb}} & \quad \text{\textbf{Gb}} & \quad \text{\textbf{Ab}} & \quad \text{\textbf{Bb}}
\end{align*} \]

**UPPER REGISTER**
The intonation of the upper register of your instrument is generally: \( \text{\textbf{SHARP}} \)

**LOWER REGISTER**
The intonation of the lower register of your instrument is generally: \( \text{\textbf{SHARP}} \)

**TEMPERATURE**
As your instrument gets warmer, the pitch generally: \( \text{\textbf{SHARPENS}} \)

**OVERBLOWING**
If you were to overblow your instrument, the pitch would generally: \( \text{\textbf{SHARPEN}} \)

**CRESCEPDO**
As you crescendo, the intonation of your instrument generally: \( \text{\textbf{SHARPENS}} \)

**DIMINUENDO**
As you diminuendo, the intonation of your instrument generally: \( \text{\textbf{FLATTENS}} \)

**VALVE PROBLEMS**
The 1-2-3 and 1-3 combinations are generally VERY: \( \text{\textbf{SHARP}} \)

**MUTES**
The use of a mute generally causes the intonation to: \( \text{\textbf{SHARPEN}} \)
APPENDIX D

INFORMATION PERTAINING TO THE AMADEUS II
Purpose

The Scale Drill program is a "Practice and Assessment" application for the purpose of developing and testing knowledge and performance of any scale type. Pitch performance is continually "tracked" in order that students can evaluate pitch.

Features

- Time based lessons - Each lesson operates for a predetermined time period making it easier to schedule students on the computer.

- Adaptive lessons - When a student achieves the target scored (target score is determined by the instructor) they are congratulated and advanced to the next level.

- Hall of Fame - The top 10 students in each lesson are recorded in a hall of fame that is displayed each time the lesson is ended.
Results of students are recorded in an easy-to-use database for instructors' needs.

With the Alternate Fingering Module attached, a student can click on any note and the note name, fingering, alternate fingering, and a graphic tutor will display for the student to practice the note.

With the Curriculum Module, this program can be assigned to a class for a particular week and will automatically select and start up the program for a student and exit at the end of their lesson time. This way, the student always launches the Curriculum application and the program determines which application and lesson the student is to use next.

- Scales that are practiced are determined by the instructor. The options are: Any key, Major, Minor, Chromatic, Dorian, Lydian, Mixolydian, Phrygian.

- Difficulty is determined by the required accuracy to achieve a good score. The instructor may set the In-Tune Boundary to be from hardest setting of ±3 cents to the easiest setting of ±25 cents.

- 2nd Attempt Option - When a student scores below a target score (chosen by the instructor) the poorest notes will be displayed and the student will be coached by the program through the tuning of each note. The student is shown the note that needs to be tuned and two notes of the scale that are before the note. The student is then instructed to play all three notes, ending with the note to tune. The pitch of the note is displayed on a graph. If the Fingering Module is installed and the note is still out of tune, the fingering for the note will be displayed. After practicing the notes, the student will have a 2nd chance to play the scale and improve their grade.

- The instructor can create an unlimited number of lessons with the included Lesson Designer program.

### Requirements

- Macintosh with 1 Meg. available RAM, 100k Hard disk space
- Amadeus II® hardware
Amadeus II™ is truly a breakthrough in music education. For the first time, the instrumental and vocal teaching tools you need are combined in one: a precision tuner and note generator that also connects to a computer for pitch and rhythmic drill studies - and even creates standard MIDI files.

Beyond the basic tuner. No presetting is needed. The response is automatic, instant and accurate. The illuminated graphic display - big enough to view from across a room - moves up or down when the pitch goes sharp or flat.

Add headphones, and Amadeus II™ accompanies in real time. Feedback is instant on every note played. The graphic display indicates when a note is sharp or flat while the student simultaneously hears comparisons through the headset of the played note with Amadeus’ tuned note.

Connect Amadeus II™ to a computer for virtually limitless possibilities with teaching and testing software, from structured drills to educational games.

Software for Amadeus II™ includes:

- Pitch Development Video Ping-Pong Game
- Pitch Development Drills - with graphic graded reports; screen displays of results and areas of needed improvement; and automatic increases in level of difficulty. Includes a large selection of drills or drills can be created directly on the computer.
- Remote-Control Rhythm Drills - An attachable remote control allows push-button operation of rhythm drill software. Program guides students through the increasingly difficult drills, monitors accuracy of the rhythm, and evaluates results.
- Pitch to MIDI Converter - When a vocal or instrumental passage is input to Amadeus, a standard MIDI file is created that can be used by many programs, from notation software to sequencers.

From elementary basics to high-level applications for professionals, Amadeus II™ elevates music education to a new realm of possibilities.

Pygraphics • P.O. Box 639 • Grapevine, Texas 76051

1-800-222-7536
Pyware
Marketing Dept. / ATTN. Shannon
P.O. Box 639
Grapevine, TX 76099

February 1, 1993

First, please accept my sincere appreciation for your consideration of allowing me the opportunity to discuss the nature of my project with you. I first came across the Amadeus equipment when a friend introduced me to it at his school. Immediately I thought the potential uses were virtually unlimited and I began to formulate a study that might make use of this equipment. Unfortunately, the cost of the equipment does not fall into the budget of a graduate student. Should you allow me to make use of the materials, I'm sure that you will find the project is mutually beneficial.

Enclosed you will find a detailed explanation of the study and its components. The projected amount of time required for the equipment is approximately two months (2/19/93 through 4/19/93). This would allow for me to familiarize myself with the equipment prior to the actual project as well as prepare for presentations of the equipment at two research exhibitions. The first exhibition takes place at Penn State University on March 19-20. This exhibition is an opportunity for some of the research currently done at Penn State to receive national recognition through adjudication and an open forum setting. The other exhibition would take place in conjunction with the Pennsylvania Music Educators Association convention being held in Wilkes-Barre, PA on April 14-17. The presentation would be done in conjunction with the research displays and discussions that take place throughout the convention. Both conventions offer me to not only display the equipment but actually show it at work.

The project is a first of its kind and will certainly be enhanced if the Amadeus equipment can be made available. The results of the study will be submitted for publication to several of the field's journals and magazines. Those publications that will be contacted following the completion of the study include: The Journal of Research in Music Education; The Journal of Band Research; The PMEA Journal of Research; The Music Educators Journal; The Instrumentalist; and The Band Directors' Guide. Due to the nature of this study, my advisors and I are certain that publication of the study will not be difficult.

The study has been approved by the Penn State University of Regulatory Compliance. Please feel free to contact the following persons regarding the legitimacy of this study:

Dr. Keith Thompson (814) 863-4220 office (814) 231-2642 home
Dr. O. Richard Bundy (814) 865-3982 office (814) 238-0651 home

I sincerely appreciate your consideration and I hope to hear from you in the near future.

Douglas Orzolek
March 11, 1993

Mr. Doug Orzolek
University Bands
Penn State University
217 Chambers Building
University Park, PA 16802-3206

Dear Mr. Orzolek:

As promised, please find the Amadeus II® unit and software enclosed. I apologize for the delay and thank you for your interest and willingness to support our product.

Because this is the first model of Amadeus II®, we ask you to be forgiving of any glitches you find. We have found several innovative ways to enhance the features, look, and capabilities of the actual Amadeus II® unit. Goals include more streamline production thus lowering cost per unit and possibly providing a new voice activated product for the disabled.

Mr. Py Kolb is the programmer who will walk you through each step of the software installation process. Please call our office before you use any of the software.

Again, thank you for your support. If I can be of further assistance please do not hesitate to contact me. I look forward to helping you.

Sincerely,

Shannon Stout
Sales Director
Pygraphics
P.O. Box 639
Grapevine, TX 76099

May 3, 1993

Dear Shannon and Py:

First I'd like to thank you for permitting me the use of the Amadeus II for the purposes of completing my study. The system worked to my expectations and I was very happy with the results. It is an amazing piece of equipment and I am grateful for your kindness in letting me borrow the system for a short period of time.

For those directors who have the means to purchase the Amadeus program, I would highly recommend the system. The entire program is user friendly and certainly caught the attention of the students who used it. Just the fact that the students were interested in the system may have actually influenced their concern about their intonation and in turn increased their awareness of their intonation problems. The charts printed out by the computer were easy to follow and understand. The system could greatly enhance the musical potential of any ensemble.

I am certain that the few "bugs" that I came across during my use of Amadeus will be worked out for the upcoming Amadeus III. The staff at Pygraphics should be very proud of this accomplishment. It is truly a breakthrough in music education. I look forward to hearing more great things from the Pygraphics Company in the near future.

Thank you again for your assistance. I will forward a complete copy of the study upon its completion.

Sincerely,

Douglas Orzolek
Graduate Assistant, University Bands