An Analysis of Methods for Teaching Middle School Band Students to Articulate

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Dedication

This dissertation is dedicated to my wife Kimberly, who tirelessly supported me throughout my coursework and dissertation project. I could not have accomplished this goal without your help. Thank you!

Abstract

An Analysis of Methods for Teaching Middle School Band Students to Articulate

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The purpose of this study was to determine what teaching strategies were most effective in achieving clear and accurate articulation among middle school band students. The specific research question was: Are particular teaching methods more effective than others in helping young wind players to articulate clearly with accurate execution across various tempos? Seventh-grade wind players ($N = 353$) served as the participants in this experimental pretest/posttest study, which was carried out during the Fall Semester 2010 near Minneapolis, Minnesota.

The independent variable in this study included five teaching conditions that were implemented over the course of a 10-week treatment period. These included: (a) control group, (b) articulation guide group, (c) practice group, (d) audio model group, and (e) visual model group. During pretest and posttest performances, participants played an articulation exercise at four tempos (60, 80, 100, and 120 bpm); the researcher assessed performances at each tempo independently, using an 8-point Likert-scale. In order to compensate for differences in mean pretest scores between the five teaching conditions, a one-way, between-groups ANCOVA was conducted to compare the degree to which young wind players articulated clearly with accurate execution across various tempos. The dependent variable consisted of the sum of scores (four performance tempos) from

the posttest performance of an articulation exercise. The scores from a pre-intervention performance (pretest) of the same articulation exercise constituted the covariate. After adjusting for the covariate, there was a significant main effect for group regarding the degree to which young wind players articulated clearly with accurate execution across various tempos, $p < .001$. Pairwise comparisons revealed statistically significant differences between the following groups: the practice group outscored the control group, $p = .025$; the audio model group outscored both the control group, $p < .001$, and the articulation guide group, $p < .001$; and the visual model group outscored both the control group, $p < .001$, and the articulation guide group, $p = .007$.

Based on the progressive design utilized in the current study, the treatment conditions that resulted in the maximum degree of difference included a combination of: (a) information about the process of articulation via an articulation guide sheet, (b) regular articulation practice during band rehearsals, and (c) aural models through the inclusion of recordings by professional musicians playing the articulation exercise. The current researcher recommends the combination of these elements within band rehearsals.

Sample materials from the current study can be accessed via the University of Minnesota Digital Conservancy as well as ProQuest Dissertations and Theses Online Digital Repository, including (a) copies of the articulation exercise, articulation guide sheet, and signal graph image sheet; (b) audio tracks of the pretest/posttest accompaniment track, the accompaniment tracks utilized during the treatment period, and the researcher reading the articulation guide sheet and explaining the concept of wind-pattern exercises; and (c) the articulation video used during the treatment period.

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Chapter 1 – Statement of the Problem

Introduction

The act of articulating (or tonguing) is a fundamental component of tone production on a wind instrument, one that parallels the production of consonants and vowels during speech. With the exception of slurred passages, the tongue is utilized to add clarity and definition to the beginning of musical tones. Additionally, the position of the tongue within the oral cavity has a direct impact on the quality of the resulting sounds. Given the fundamental role of the tongue during tone production, the ability to articulate clearly and accurately is of critical importance for successful performance on a wind instrument.

Nevertheless, clear and accurate articulation on a wind instrument can be a deceptively elusive goal. Since the act of tonguing cannot be seen, any determination of success (or lack thereof) regarding the quality of articulation must be based on external physical observations or an assessment of the resulting musical tones, interpreted through the aural lens of the student and teacher. Kohut (1996) stated:

> The wind teacher cannot observe the size and shape of the wind player's oral cavity or the movements of his tongue. Frequently he has to diagnose performance problems primarily on the basis of what he thinks a player may or may not be doing *inside* the oral cavity. (p. 134)

Dietz (1998) likewise stated:

> Since the entire articulation process is hidden from view inside the mouth, it is not always obvious when a problem in tongue placement occurs. A trained ear can sometimes hear a faulty tongue placement and adjust it, but often a problem may go without detection until it becomes a habit, when of course it is much more difficult to remedy. (p. 15)

To complicate matters, research has shown differences between the perceptions of musicians regarding the use of their tongue and what actually takes place within their mouth during performance (Hungerford, 2004; Patnode, 1999). In this regard, Watkins (2003b) stated, "It is easy to *associate a sensation with a formation* and believe it to be true, even if the formation that the performer assumes he or she is making is far from its true shape" (p. 58).

Despite the inherent challenges, correct use of the tongue is paramount for successful performance on a wind instrument. As such, one might surmise that teaching young musicians to articulate correctly would be a priority within beginning band instruction. Curiously, many full-band method books offer little or no instruction regarding the development of effective articulation techniques. Further, information about articulation within these books is often found only in the introductory pages.

Articulation instruction, therefore, has apparently been left to the discretion of individual band directors. Unfortunately, the experiences of the current researcher suggest that the subject of articulation is too rarely addressed in a proactive way within beginning band instruction; rather, articulation is often neglected until a performance problem is observed. Kolwinska (2007) confirmed this explicitly when stating, "So much time in the early lessons is devoted to putting the horn together correctly, forming an embouchure, and learning the positions that the way notes are begun is overlooked" (p. 48). Further, Collins (1986) stated, "It takes an enormous amount of study and concentration to overcome this fault [misuse of the tongue during articulation], which never would have developed if the process had been properly presented and explained to the student" (p. 1218).

The current researcher's eight years of experience teaching instrumental music in the public schools confirmed that articulation (tonguing) is a common problem among young wind musicians. Rather than using the tip of the tongue as the primary way to initiate a musical tone (such as <u>T</u>AH or <u>D</u>AH), young musicians too often articulate in ways that lack clarity, such as <u>TH</u>AH or <u>Y</u>AH. Others use velar-stops (using the back of the tongue and soft palate), including <u>K</u>AH or <u>G</u>AH. Finally, some young musicians do not use their tongue at all during articulation and thus resort to the use of air-starts (as in <u>H</u>AH) or glottal-stops (a disruption of the airstream in the throat, as in <u>A</u>H-<u>A</u>H). Once in place, these ineffective habits can be difficult to correct and can lead to frustration for both student and teacher.

Unless young musicians are taught about correct articulation techniques and challenged to listen critically to the sounds that they produce, they are not likely to be aware of shortcomings in this area; this is clearly illustrated by the frequency with which tonguing problems are found in performers of all ages (Fitzgerald, 1987; Frederiksen, 1996). In this regard, Drake (1986) stated, "One only needs to audition a large group of student clarinetists at a festival or clinic to realize how often the ability to use the tongue artistically falls well below the other achievements in tone production and technical facility" (p. 796). Likewise, Stoutamire (1987) cited teaching experiences that are in line with those of the current researcher when he stated, "I estimate that more than half of the private brass students I have taught have had serious articulation problems stemming from the improper use of the tongue" (p. 611).

In an effort to learn more about the subject of articulation, the current researcher conducted a pilot study at the University of Minnesota (Budde, 2008). Upon the completion of this pilot, a poster summarizing the project method and outcomes was displayed in the halls of the School of Music at the University of Minnesota. Since that time, after seeing the poster, both undergraduate and graduate musicians have engaged in discussions with the researcher in which they acknowledged their own uncorrected problems with articulation and sought information or advice about how to correct these issues. These conversations with advanced musicians further established a need for pursuing the subject of articulation as a line of research.

In summary, correct articulation is a primary component of successful performance on a wind instrument. Teaching students to articulate correctly is a challenging task, since the act of tonguing cannot be observed directly. In addition, research has shown differences between the perceptions of musicians regarding the use of their tongue and what actually takes place within their mouth during performance. As a result, when assessing the process of tonguing, teachers and students must rely on external physical observations or an assessment of the resulting musical tones. Despite the importance of correct tonguing techniques, articulation is often neglected altogether or given minimal attention in full-band method books; it is the experience of the current researcher that this omission is often mirrored in beginning band instruction. Articulation must be taught carefully upon the onset of music instruction and reviewed regularly to ensure that correct techniques are developed and maintained by young musicians.

The Need for an Inclusive Approach

A common method of teaching articulation on wind instruments is the use of vocal models; these have traditionally included: TAH/DAH, TOH/DOH, TOO/DOO, TUH/DUH, and TEE/DEE, although many variations exist (Bailey, Miles, Seibert, Stanley, & Stein, 2008; Brasch, 1987; Byrnes, 2007; Deye, 1987; Farkas, 1962; Fitzgerald, 1987; Frederiksen, 1996; Graham, 1987; Kohut, 1996; Magnell, 1987; Mendéz & Gibney, 1961; Nemoto, 1998; Shoults, 1961; Stanley, 1987; Whybrew, 1987). This approach, however, assumes a commonality between various languages. The past experiences of the current researcher suggest that the impact of native language must be considered when teaching articulation in order to achieve an inclusive approach. Language differences impact the way in which individual consonants and vowels are pronounced and perceived, if indeed they are utilized at all in a given language (Avery & Ehrlich, 1992; Yang, 2005). These differences manifest themselves in various ways as performers articulate on wind instruments and thus must be taken into account when devising a method for teaching articulation to young musicians. This subject will be further investigated within the review of literature.

The Need for Research

There is a paucity of empirical investigations focusing on articulation, particularly regarding the most effective ways to teach young wind players how to articulate correctly. As such, most information on the subject of articulation is based on the ideas and strategies of successful performers and teachers. These ideas, despite lacking consensus, are passed on from teacher to student and are often accepted as canon within the music community. In this regard, Hungerford (2004) wrote, “it was interesting to find that many of the professional performers had not ‘discovered’ the results of any technological study…. Teachers most often continue to base their assessment of tongue position on non-technological approaches. Many simply believe what they’ve been taught” (p. 157).

While the opinions of successful musicians are undoubtedly a valuable resource and worthy of consideration, there is a need for systematic research regarding articulation in order to ascertain the most effective teaching strategies for working with young wind musicians, particularly given the prevalence of opposing opinions found within the review of literature in this regard. This call for research, however, appears to be a perennially identified need. In the introduction to his dissertation study, Meidt (1967) stated:

> Expert, yet frequently contradictory, opinions concerning tongue and throat adjustments which [*sic*] relate to various changes in articulation, dynamics, or pitch, have been expressed in numerous writings; however, scientific

> investigation designed to substantiate or disprove the theories so promulgated has been minimal. (p. 1)

Over 30 years later, Patnode (1999) supported this same premise when he stated, “For pedagogical reasons, saxophonists frequently attempt to describe tongue position when producing altissimo registers. These descriptions may or may not be accurate” (p. 2). Further, although a line of research that investigates the physiological changes that take place during articulation does now exist, few studies have sought to ascertain the most effective ways in which to teach correct articulation techniques to young wind players.

Given the prominence of articulation problems among musicians of all ages (Drake, 1986; Fitzgerald, 1987; Frederiksen, 1996), such research is of great importance. A proactive teaching approach that includes proven strategies for teaching articulation to young wind players would result in more accomplished musicians of all ages. It is the hope of the current researcher that the present study will serve as a step forward in this regard, one that will lead to more informed teaching within the field of music education.

Terms Defined

Before proceeding, it is necessary to clarify several terms. Given the prominence of the function of the tongue during articulation on a wind instrument, it seems appropriate to begin with a description of the tongue itself. The tongue is a complex set of muscles that can be divided into extrinsic and intrinsic muscles (Lindberg-Kransmo, 2002). The extrinsic muscles are primarily responsible for large-scale movements, such as moving the tongue into a general position. The intrinsic muscles primarily provide the small-scale movements that fine-tune and control the gestures of speech. Together, the extrinsic and intrinsic muscles interact "in a complex fashion to produce the rapid, delicate articulations for speech and nonspeech activities" (pp. 18-19). When relaxed, the tongue touches the lower teeth, a position referred to as neutral (or home) position (Miller, 1996).

In the field of music, the word *articulation* can refer both to (a) the manner of initiating a musical tone (such as through the use of the tongue on a wind instrument or the use of a bow on a string instrument) and (b) the manner in which a note is expressed (such as tongued, slurred, accented, legato, etc.). Within this paper, articulation will be used in the manner of the first description, making it synonymous with the term *tonguing*.

A musical tone is made up of three parts: attack, sustain, and release (defined below). As an investigation on articulation, this study will focus primarily on the attack of a musical tone, but the sustain portion of a tone will be given considerable attention as well, since the position of the tongue during the sustain portion of a tone is closely linked to the action of articulation.

Additional terms will be included throughout this paper; these will be defined at present and can be referred to as needed. It should be noted that some terms have multiple meanings; only the meanings that are relevant to the current study have been included here. In order to provide context, related terms will be presented within relevant categories, including dentition, miscellaneous, phonetics, physiology (including Figure 1, which comprises a graphic representation of the oral cavity and surrounding regions), technology, and tonguing. Within each category, defined terms will be presented in alphabetical order.

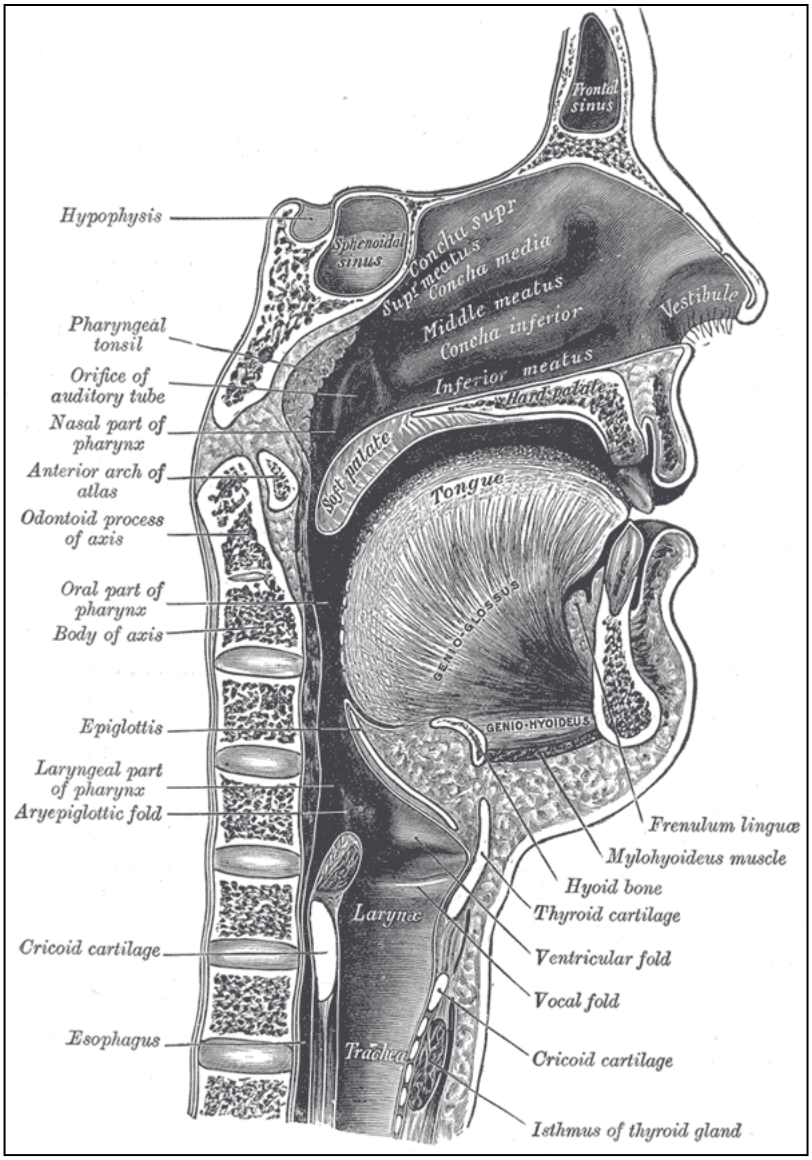

Figure 1. Anatomy of the oral cavity and surrounding regions. Adapted from *Anatomy of the Human Body*, by H. Gray, 1918, Philadelphia, PA: Lea & Febiger. Copyright 2000 by Bartleby.com, Inc. Reprinted with permission.

Dentition

- Class I occlusion: a condition in which the jaw and teeth are in proper alignment
- Class II malocclusion: a condition in which the top teeth significantly overlap the bottom teeth either horizontally or vertically
  - overbite: a type of Class II malocclusion in which the top teeth extend vertically well beyond (and thus cover) the bottom teeth
  - overjet: a type of Class II malocclusion in which the top teeth protrude horizontally well beyond the bottom teeth
- Class III malocclusion: a condition in which the bottom teeth protrude horizontally beyond the top teeth (underbite)
- occlusion: the relationship of the opposing surfaces of the teeth when the two jaws are brought together

Miscellaneous

- aperture: the opening through which air passes when playing a wind instrument; the center of the lips on a brass instrument, the space between the reed and the mouthpiece on a single-reed instrument, or the space between the two reeds on a double-reed instrument
- embouchure: the facial muscles (and shaping thereof) utilized during performance on a wind instrument

Phonetics[1]

- aspiration: the burst of air that follows the release of a stopped consonant
- cognates: consonant pairs that differ in regard to whether or not phonation (voicing) takes place (e.g., /t/ as in *tie* is unvoiced, whereas /d/ as in *die* is voiced)
- glottal-stop: a manner of articulation that is produced by obstructing airflow in the vocal tract, such as AH-AH
- phonation: the process by which the vocal folds produce sounds through quasi-periodic vibration
- phonetics: of or relating to speech sounds; having a direct correspondence between symbols and sounds
- schwa: the unstressed central vowel /ə/ as in *above*
- velar-stop: a form of articulation that utilizes the back of the tongue and the soft palate, such as /k/ as in KAH or /g/ as in GAH
- vowel quadrilateral: a four-sided graphic illustration used to show the position of the tongue within the oral cavity during the pronunciation of vowels

Physiology

- epiglottis: the flap of cartilage at the root of the tongue, which is depressed during swallowing to cover the opening of the trachea (windpipe)
- frenulum: the membrane that attaches the tongue to the floor of the mouth

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[1] The phonetic symbols used throughout this paper are based on the International Phonetic Alphabet (International Phonetic Association, 1999). A description of this system is included within the discussion of phonetics in Chapter 2.

- hyoid: the u-shaped bone that provides attachment for the muscles of the floor of the mouth and the tongue above; aids in tongue movement and swallowing
- larynx: the hollow muscular organ that forms an air passage to the lungs; contains the vocal cords in humans and other mammals (voice box)
- pharynx: the membrane-lined cavity behind the nose and mouth, connecting them to the esophagus
- thyroid: the large cartilage of the larynx, a projection of which forms the Adam's apple
- trachea: the tube that connects the larynx and bronchi (windpipe)
- velum: the soft, fleshy part of the back of the roof of the mouth (soft palate)

Technology

- cinefluorography: the process of making motion picture recordings by means of X-rays and the aid of a fluorescent screen
- electroglottograph: a device that monitors movement of the vocal folds by detecting impedance change as the vocal folds make varying degrees of contact
- endoscope: a small video device with an attached light that is used to look inside a body cavity or organ
- fluorography (fluorescence): a method of photography based on X-ray images
- fluoroscope: a device consisting of a fluorescent screen and an X-ray source that enables an X-ray image to be observed directly
- laryngoscope: an illuminating medical instrument used for visualization of the pharynx and larynx

- probe microphone: a compact microphone for sound pressure measurements in small enclosures
- signal graph images: the computer-generated images of sound that include representations of time and relative loudness
- spectrographic images: the computer-generated images of sound that include amplitude and frequency over time, thus showing how much energy is in the various partials of a complex tone over time
- ultrasonographic images: images generated by high-frequency sound waves; used to generate images of internal structures
- videofluorography: in comparison to cinefluorography, this more advanced technology allows for higher-resolution images while also reducing the degree of radiation exposure
- water manometer: a device that measures air pressure through the use of tubes that connect two systems; in the event of unequal pressure, the water in the middle of the manometer is drawn toward the side with lower pressure

Tonguing

- air-start: the process of using only air (/h/ as in HAH) to start a tone; done without the use of the tongue
- anchor (dorsal) tonguing: a method of tonguing in which the tip of the tongue is anchored behind the bottom teeth, while the middle of the tongue is arched upward to touch the roof of the mouth or reed

- articulation: the act of using the tongue to initiate a musical tone or to separate notes from one another when playing a wind instrument; for the purposes of this document, articulation will be considered synonymous with *tonguing*
- breath-release: the release of a musical tone on a wind instrument through the cessation of the airstream, such as TAH
- double-tonguing: a type of multiple-tonguing; often utilizes the syllables TAH-KAH or DAH-GAH
- multiple-tonguing: the process of alternating between alveolar tonguing (tip of the tongue, such as /t/ as in TAH or /d/ as in DAH) and velar-stops (back of the tongue and soft palate, such as /k/ as in KAH or /g/ as in GAH); an advanced technique utilized to facilitate the production of notes in rapid succession
- release: the manner in which a tone resigns to silence; on a wind instrument, the release can be accomplished with a breath-release (TAH), a tongue-release (TAHT), or through the concurrent release of one tone and the attack of the next tone (TAHTAHTAH)
- single-tonguing: a type of tonguing that utilizes the same syllable (such as TAH) for all tones; this is in contrast to double- or triple-tonguing
- sustain: the duration of a tone (between the attack and release) during which the sound perpetuates; on a wind instrument, the sustain is often associated with a vowel sound, such as /ɑ/ as in *pod*, /o/ as in *bode*, /u/ as in *booed*, /ʌ/ as in *bud*, and /i/ as in *bead*

- tongue-stop/tongue-release: the release of a musical tone on a wind instrument accomplished with the use of the tongue, such as TAHT
- tonguing: the act of using the tongue to initiate a musical tone or to separate notes from one another when playing on a wind instrument; for the purposes of this document, tonguing will be considered synonymous with *articulation*
- triple-tonguing: a type of multiple-tonguing; often utilizes the syllables TAH-TAH-KAH or DAH-DAH-GAH
- Valsalva maneuver: after an inhalation, a condition in which the tongue locks into place and blocks off the flow of air, resulting in a pressurized air-column when attempting to exhale; often results in a stuttered or inconsistent approach to articulation, both when speaking and during tonguing on a wind instrument
- wind-pattern exercises: a practice strategy for wind players that utilizes the action of articulation away from the instrument; done without creating a musical tone

Purpose of the Study

The purpose of this study was to determine what teaching strategies were most effective in achieving clear and accurate articulation among middle school band students. The specific research question was: Are particular teaching methods more effective than others in helping young wind players to articulate clearly with accurate execution across various tempos? A null hypothesis was assumed, meaning that the researcher predicted no significant differences between the levels of the independent variable (five teaching conditions, including a control group and four treatment groups) concerning the degree to which young wind players articulated clearly with accurate execution across various tempos.

Basic Assumptions

The current study was built upon several basic assumptions. First, there was an assumption that correct articulation can be effectively taught to young wind musicians through quality music instruction. This assumption comprises several components:

- Band directors value the development of articulation as an important component in helping young musicians to achieve success in musical performance.
- Young musicians are receptive to and motivated by the development of effective articulation techniques as an important component for achieving success in musical performance.
- There is a distinguishable sound that is produced when utilizing correct articulation techniques; as such:
    - young musicians are able to recognize the sound of quality articulation as a component of a successful musical performance, and
    - teachers/professional musicians are able to identify the sound of quality articulation in a reliable manner when listening to student performances.
- Young musicians are developmentally able to improve articulation within a 10-week treatment period.

Additionally, it is assumed that the design and implementation of the teaching strategies used in this study were effective as a means of helping young wind players to improve their articulation skills. This assumption also comprises several components:

- Rehearsing articulation exercises as a full band is a viable manner in which students can improve articulation skills.
- The articulation exercise utilized in the study was appropriately designed for seventh-grade musicians, including the beliefs that:
    - the four tempos utilized in this exercise provided a sufficient and appropriate spread in order to provide a tempo range that included both accessible and challenging speeds, and
    - seventh-grade band students are developmentally able to perform an articulation exercise at changing (increasing) tempos, such as those utilized in the pretest/posttest as well as during rehearsals within the treatment period.
- Correct articulation can be aurally identified in a reliable manner when listening to recorded performances, as incorporated for the pretest and posttest assessments.

Finally, a progressive design (described fully in Chapter 3) was used when constructing the various levels of the independent variable. When considering the teaching strategies utilized within the current study, each subsequent group added one teaching strategy to those already included within previous levels. Thus, based on this progressive approach, an inherent assumption in this study was that any changes found between levels of the independent variable could be attributed to the additional treatment experience of any given group in comparison to the previous group conditions.

Delimitations

Several delimitations must be considered within the current study. First, this study made use of an articulation exercise as the vehicle for assessing the articulation skills of participants. This process was intended to isolate articulation as a skill set within a static exercise. No attempt was made to evaluate articulation within more authentic settings, such as those found within band rehearsals or when performing solo literature.

Second, the current researcher evaluated performances of an articulation exercise based on clarity of articulation with accuracy of execution across various tempos. Clarity of articulation was defined as *having clear definition at the onset of each note*. No attempt was made to identify incorrect articulation techniques (e.g., glottal-stops, velar-stops, or air-starts) during assessment. Similarly, issues of tone quality and airflow were not addressed. Rather, evaluations regarding clarity of articulation were based solely on the degree of definition at the onset of each tone, as defined above.

Finally, as described previously, this study incorporated a progressive design for the addition of treatment conditions. As such, each additional teaching component was investigated *in combination* with the strategies introduced in previous levels rather than as an isolated teaching strategy.

Concluding Remarks

To summarize this introductory chapter, the combination of (a) the importance of correct articulation techniques for performance on a wind instrument, (b) widespread problems with articulation among wind players of all ages, (c) the negative impact of incorrect articulation techniques on wind instrument performance, (d) the general lack of consideration regarding the impact of native language on articulation, and (e) the lack of empirical research on the subject of articulation (particularly with regard to the teaching thereof) has established a need for the current study. It is the hope of the current researcher that this study will lead to more informed teaching practices regarding how to teach articulation to young wind musicians.

The remainder of this document will provide detailed information regarding the current study, which focuses on ascertaining effective teaching strategies for helping young wind players to articulate correctly. Chapter 2 will include a thorough review of the literature related to articulation on wind instruments, including an overview of the study of phonetics and a consideration of the impact of native language. Chapter 3 will provide detailed information regarding the method of research that was used in carrying out the current study, including: (a) an overview of the pilot study that provided a foundation for the current study, (b) a summary of the participants involved in the current investigation, (c) detailed information regarding the independent and dependent variables as well as the collection of data, and (d) a brief description of the statistical analyses utilized. Chapter 4 will summarize the results of the data analyses, including the statistical significance revealed. Finally, Chapter 5 will present (a) a discussion of the research study as a whole; (b) the conclusions reached as a result of the study, including the practical significance revealed; and (c) recommendations for future research.

Chapter 2 – Literature Review

There is a paucity of empirical investigations focusing on articulation, particularly regarding the most effective ways to teach young wind players how to articulate correctly. Within a scholarly search engine such as ERIC or PsycINFO, the words *articulation* or *tonguing*, in combination with any number of musical terms (music, performance, flute, band, teach, etc.), often resulted in information about the symbols used for notating particular musical styles and effects (or the interpretations thereof), rather than information regarding the process of tonguing. Within research studies that did focus on tonguing technique, most investigated what happened within the oral cavities of performing musicians; only a few empirical studies specifically investigated articulation based on the quality of the resulting musical sounds.

As such, most information pertaining to how articulation takes place is based on the ideas and strategies of successful performers and teachers. These recommendations, which are based on personal experiences, prove problematic, since performers are often inaccurate in their perceptions regarding the position and movement of the tongue during articulation (Hungerford, 2004; Patnode, 1999). As such, it should be no surprise that there are varied and conflicting ideas found in the literature.

In an effort to maintain perspective when considering the divergent ideas found within music pedagogy sources, this literature review will begin by exploring articulation syllables from the vantage point of two subject areas outside of the field of music: (a) an overview of phonetics will be provided, particularly regarding the consonants and vowels commonly recommended as models for articulation on a wind instrument and (b) the impact of native language will be considered, specifically pertaining to differences between languages with respect to the pronunciation of these same consonants and vowels. Next, a summary of music pedagogy sources, including books, journals, and full-band method books, will be provided in order to ascertain how articulation is being taught in the music community. Finally, extant research studies will be explored in an effort to provide music educators with scientific evidence regarding the most effective ways to teach young wind players to articulate correctly. Through the incorporation of a broad approach, this literature review will provide a holistic perspective regarding the process of articulation as it applies to performance on a wind instrument.

Articulation Syllables as a Guide

The most prevalent theme found within music pedagogy sources regarding articulation on a wind instrument was the use of specific syllables as a guide for the placement and movement of the tongue. Articulation syllables are made up of both a consonant for the attack of a tone and a vowel that shapes the mouth during the sustain portion of a tone. Cichowicz (1999) promoted the idea of using language as a model for articulation on a wind instrument, when he stated, “There is no reason to complicate the issue and increase a performer’s self-consciousness by training a skill that is naturally in place. Articulation is simple as long as it is approached through language” (p. 1030). Likewise, Arnold Jacobs stated, “Since you cannot feel what the tongue is doing, use the tongue as speech, not as muscle…. The tongue will automatically assume shape and position according to vowel sounds” (as cited in Nelson, 2006, p. 55).

Unfortunately, music pedagogues do not agree on many aspects of articulation, including the specific syllables to be used as models for the tongue during performance on a wind instrument. Therefore, in an effort to maintain an objective perspective when considering the conflicting opinions of music pedagogues, this literature review will begin with a summary of information from two non-music sources: an overview of phonetics and the impact of native language. Given the prevalence of articulation syllables as a strategy for developing tonguing skills on a wind instrument, this literature review will begin with an overview of phonetics.

Phonetics.

The syllables used as models for articulation on a wind instrument consist of both consonants and vowels; each will be summarized below. The phonetic symbols used throughout this paper are based on the International Phonetic Alphabet (IPA) (International Phonetic Association, 1999). These phonetic symbols will be notated within two forward-slash markings, such as /t/. In order to clarify the meaning of these symbols, sample words with underlined letters in italics will be included as needed (e.g., /ɑ/ as in *pod*). On the other hand, when specific articulation syllables are recommended as models for performance on a wind instrument, these will be indicated using capital letters (e.g., TAH) in order to differentiate them from the generic pronunciation models utilized within the IPA. Finally, vocal models presented within quotations from other authors will be presented in their original format unless further clarification is required.

Consonants.

The International Phonetic Association (1999) identifies several ways to classify consonants in the American English language. The first makes a distinction based on the *place* in which the consonant is articulated and includes the following classifications:

- alveolar: utilizes the tip of the tongue and the tooth ridge, including /d/, /l/, /n/, /s/, /t/, /z/, and /ɹ/ as in *rye*
- bilabial: makes use of both lips, including /b/, /m/, and /p/
- dental: uses the tip of the tongue and the teeth, including /θ/ as in *thigh* and /ð/ as in *thy*
- glottal: incorporates air passing from the windpipe through the vocal cords, including /h/ as in *high*
- labio-dental: utilizes the lower lip and the upper teeth, including /f/ and /v/
- palatal: makes use of the blade of the tongue and the hard palate, including /j/ as in *you*
- post-alveolar: utilizes the blade of the tongue behind the alveolar ridge, with the front of the tongue bunched up (domed) at the palate, including /ʃ/ as in *shy*, /ʒ/ as in *azure*, /tʃ/ as in *chin*, and /dʒ/ as in *gin*
- velar: utilizes the back of the tongue and the soft palate, including /g/, /k/, /w/, and /ŋ/ as in *hang*

In addition, consonants can be classified based on the *manner* in which the articulation occurs (International Phonetic Association, 1999). These include:

- affricative: uses a plosive (stop) followed quickly by a fricative, including /tʃ/ as in *chin* and /dʒ/ as in *gin*
- approximant: utilizes air escaping down the mid-line of the vocal tract in a relatively unobstructed manner, such as /w/, /ɹ/ as in *rye*, and /j/ as in *you*
- fricative: utilizes a partial obstruction of the airstream (resulting in turbulent airflow and a hissing sound), including /f/, /h/, /s/, /v/, /z/, /θ/ as in *thigh,* /ð/ as in *thy,* /ʃ/ as in *shy,* and /ʒ/ as in *azure*
- lateral approximant: similar to the approximant, except that air escapes down the sides (rather than the mid-line) of the vocal tract, including /l/
- nasal: includes air escaping through the nasal cavity, including /m/, /n/, and /ŋ/ as in *hang*
- plosive (stop): makes use of a full obstruction of the airstream followed by a sudden release of that blockage, including /b/, /d/, /g/, /k/, /p/, and /t/

The last means of classification is whether or not the consonant includes phonation (vibration of the vocal folds) (International Phonetic Association, 1999). These include:

- unvoiced: produced without vibration of the vocal folds, including /f/, /h/, /k/, /p/, /s/, /t/, /θ/ as in *thigh,* /ʃ/ as in *shy*, and /tʃ/ as in *chin*
- voiced: produced with concurrent vibration of the vocal folds, including /b/, /d/, /g/, /l/, /m/, /n/, /v/, /w/, /z/, /j/ as in *you*, /ɹ/ as in *rye,* /ʒ/ as in *azure*, /ð/ as in *thy*, /dʒ/ as in *gin,* and /ŋ/ as in *hang*

The term *cognates* refers to consonant pairs that differ in regard to whether or not voicing takes place (Lindberg-Kransmo, 2002). The cognate pairs /t/ and /d/ as well as /s/ and /z/ both represent unvoiced and voiced consonants, respectively. The difference in voicing between members of these cognate pairs can be felt when placing one's fingers on the larynx while alternating between the paired sounds (Celce-Murcia, Brinton, & Goodwin, 1996).

Within the music pedagogy sources explored, the consonants /t/ as in *tie* and /d/ as in *die* were cited most frequently as the models to imitate during a musical attack on a wind instrument. Returning to the summary above, these two consonants are classified as plosive alveolar, meaning that they make use of a full obstruction of the airstream that is created when the tip of the tongue touches the tooth ridge (Avery & Ehrlich, 1992; Celce-Murcia et al., 1996; Gregg, 2002; International Phonetic Association, 1999). Phonation sets these two consonants apart, as /t/ is unvoiced, whereas /d/ is voiced (Avery & Ehrlich, 1992; Celce-Murcia et al., 1996; Conner, 1999; Frederiksen, 1996; Gregg, 2002; International Phonetic Association, 1999; Nelson, 2006).

Other consonant models were less prevalent in the literature. These models are listed below. Each example includes the phonetic symbol, a sample word, and the phonetic classifications into which the consonant is placed, based on the International Phonetic Association (1999). In addition, the specific syllables that were recommended in the review of music pedagogy sources are included within brackets (using capital letters), along with the corresponding source(s):

- /f/ as in *fie*: labio-dental unvoiced fricative [FOO (Kleinhammer, 1963)]

- /g/ as in *g̲uy*: velar voiced plosive [G̲H̲EE/G̲OE/G̲UH/G̲AH (Byrnes, 2007; Phillips & Winkle, 1992)]
- /h/ as in *h̲igh*: glottal unvoiced fricative [H̲EE/H̲OE/H̲A (Phillips & Winkle, 1992)]
- /k/ as in *k̲ite*: velar unvoiced plosive [K̲EE/K̲OE/K̲UH/K̲AH (Bailey et al., 2008; Byrnes, 2007; Phillips & Winkle, 1992; Rocco, 1999)]
- /l/ as in *l̲ie*: alveolar voiced lateral approximant [L̲AH/L̲U/L̲OO (Faulkner, 1999; Fote, 1987; Gay, 1986; Griffiths, 1999; Hickman, 2006; Hunt, 1963; Kleinhammer, 1963; Kohut, 1996; McCathren, 1986; Ott, 1998; Stein, 1958; Teal, 1986; Timm, 1964; Willett, 1986; Young, 1997)]
- /n/ as in *n̲igh*: alveolar voiced nasal [N̲OH (Bailey et al., 2008; Byrnes, 2007; Kohut, 1996; Wright, 1986)]
- /j/ as in *y̲ou*: palatal voiced approximant [Y̲AH (Saucier, 1981)]
- /ɹ/ as in *r̲ye*: alveolar voiced approximant [R̲OH (Griffiths, 1999; Rocco, 1999)]
- /θ/ as in *t̲h̲igh*: dental unvoiced fricative; and /ð/ as in *t̲h̲y*: dental voiced fricative[2] [T̲H̲EE/T̲H̲A/T̲H̲U/T̲H̲OH/T̲H̲AW (Bailey et al., 2008; Byrnes, 2007; Faulkner, 1999; Fitzgerald, 1987; Griffiths, 1999; Kleinhammer, 1963; Phillips & Winkle, 1992; Robertson, 1983; Stein, 1958; Zorn, 1977)]

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[2] The exact pronunciation of "TH" was often unspecified within pedagogical sources, leaving doubt regarding the intent of the author. For example, T̲H̲OH might be interpreted as including either /θ/ as in *t̲h̲igh* or /ð/ as in *t̲h̲y*. As such, the current researcher has included both classifications (/θ/ as in *t̲h̲igh* and /ð/ as in *t̲h̲y)* within one bulleted grouping.

When considering the list above, several consonants were recommended for specialized tasks that fall outside the parameters of the current study: (a) both /g/ and /k/ were commonly recommended for multiple-tonguing, (b) /l/ was recommended for legato tonguing on the trombone, and (c) /h/ was recommended as a practice strategy to focus the embouchure or to start notes without a noticeable attack. Given the infrequent nature of the remaining consonants, their use will not be elaborated upon further.

It is noteworthy that alternative phonetics sources were not always in agreement regarding the specific classifications of consonants. For example, whereas the International Phonetic Association (1999) labeled /w/ as in *why* as velar, Celce-Murcia et al. (1996) and Avery and Ehrlich (1992) each identified /w/ as bilabial. Likewise, the International Phonetic Association labeled /ɹ/ as in *rye* as alveolar, whereas Celce-Murcia et al. labeled /ɹ/ as palatal (with a parenthetical note that it can also be considered alveolar); further, Avery and Erhlich identified /ɹ/ as retroflexed, an additional classification in which the underside of the tongue tip touches the tooth ridge. Finally, the International Phonetic Association as well as Avery and Erhlich each labeled /j/ as in *you* as voiced, whereas Celce-Murcia et al. identified /j/ as unvoiced. However, since these consonants were not commonly recommended by music pedagogues as models for articulation on a wind instrument, these differences will not be explored further.

Vowels.

Whereas the consonants utilized during articulation on a wind instrument relate to the attack of a musical tone, the subsequent vowel sound can be thought of as impacting the position of the tongue during the sustain portion of a tone (Deye, 1987). Vowel sounds feature a less extreme narrowing of the vocal cavity than do consonants, making them less easily distinguished by the placement of articulation within the oral cavity (International Phonetic Association, 1999). Vowels are often presented within a four-sided figure known as a vowel quadrilateral in order to show the position of the tongue within the oral cavity during the pronunciation thereof. The vowel quadrilateral for American English, as presented by the International Phonetic Association (2005), has been included (Figure 2) in order to provide clarification for the descriptions regarding the position of the tongue during the pronunciation of specific vowels.[3]

[3] The International Phonetic Association (2005) provided an updated version of the International Phonetic Alphabet that is only found online. This version does not include the level of detailed narrative found in the most recent text version (International Phonetic Association, 1999). Nonetheless, the vowel quadrilateral found online provided the greatest level of detail and was therefore included within the current report.

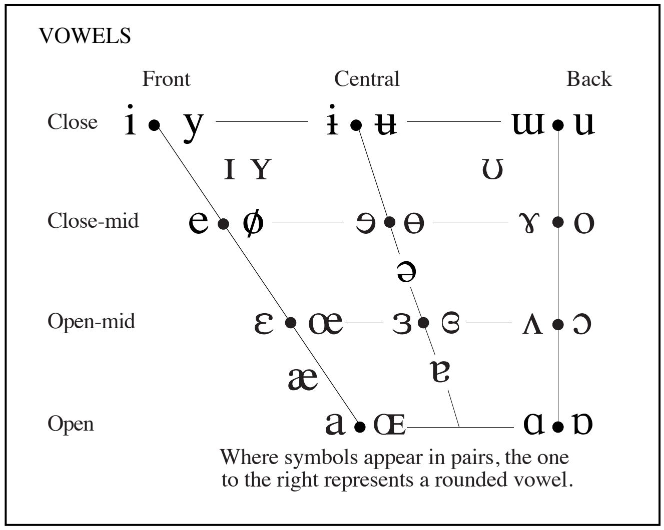

Figure 2. Vowel quadrilateral for American English. Adapted from *The International Phonetic Alphabet (Revised to 2005),* by the International Phonetic Association, 2005. Copyright 2005 by International Phonetic Association. Retrieved from http://www.langsci.ucl.ac.uk/ipa. Reprinted with permission from the International Phonetic Association.

As can be seen in this quadrilateral, vowels can be classified by the vertical position of the high point of the tongue within the oral cavity, including (a) open (lowest tongue), (b) open-mid, (c) close-mid, and (d) close (highest tongue). Second, vowels can be identified by the horizontal position of the high point of the tongue within the oral cavity, including (a) front, (b) central, and (c) back. Third, vowels can be distinguished by the degree of lip roundness or spread during pronunciation, including (a) round, (b) neutral, and (c) spread. According to the International Phonetic Association (1999), the degree of roundness for back vowels progresses when moving up the quadrilateral from /ɑ/ as in *pod* (unrounded) to /u/ as in *booed* (highest degree of roundness). The vowels to the left of the vertical divider lines within the quadrilateral incorporate less rounding in comparison to those appearing to the right of the same lines (e.g., /ʌ/ as in *bud* is less rounded than /ɔ/ as in *bought*). Within front vowels, the degree of spread progresses when moving up the quadrilateral from /a/ as in *cat* (neutral)[4] to /i/ as in *bead* (highest degree of spread). In addition to these classifications assigned by the International Phonetic Association, vowels can be distinguished by the degree of muscular tension in the tongue and mouth, including (a) tense and (b) lax (Avery & Ehrlich, 1992); this classification is not, however, represented in the vowel quadrilateral above.

Within music pedagogy sources reviewed for the current study, a wide variety of vowel sounds were recommended for wind instrument playing; each will be summarized below. These descriptions will include (a) the vertical position of the high-point of the tongue (open/open-mid/close-mid/close) and (b) the horizontal position of the high-point of the tongue (front/central/back), as classified by the International Phonetic Association (1999), as well as (c) the degree of muscular tension in the tongue and mouth (tense/lax) as indicated by Avery and Ehrlich (1992).[5] In addition, the specific syllables that were

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[4] The International Phonetic Association (1999) indicated that /a/ as in *cat* is "rather like the quality of the vowel in *cat* in contemporary Standard Southern British English" (p. 11).

[5] The degree of roundness or spread of the lips will not be included within this summary, since this classification (a) is presented only in general terms by the International Phonetic Association (1999) and (b) does not have a direct impact on the position or use of the tongue during articulation on a wind instrument.

recommended by music pedagogues are included within brackets (using capital letters),[6] along with the corresponding source(s):

- /i/ as in *bead*: close/front/tense vowel [TEE (Bailey et al., 2008; Erlenbach, 1987; Fitzgerald, 1987; Gordon, 1987; Kirkbride, 1998; Kohut, 1996; LeJeune, 1964; Montgomery, 1986; Ott, 1998; Peck, 1986; Phillips & Winkle, 1992; Rehfeldt, 1998; Royer, 1986; Saucier, 1981; Sawhill & McGarrity, 1962; Stein, 1958; Timm, 1964; Willett, 1986; Wright, 1986)]
- /ɪ/ as in *bid*: close-mid/front/lax vowel [TI/TIH (Drake, 1986; Nemoto, 1998; Pace, 1986; Rehfeldt, 1998; Robertson, 1983)]
- /ɛ/ as in *bed*: close-mid/front/lax vowel [TEH (Oldberg, 1986; Willett, 1986)]
- /ɑ/ as in *pod*: open/back/neither-tense-nor-lax vowel [TA/TAH (Bailey et al., 2008; Erlenbach, 1987; Fitzgerald, 1987, 1999; Frederiksen, 1996; Gordon, 1968; Graham, 1987; Hemke, 1986b; Kohut, 1996; Little, 1984; McCathren, 1986; Nelson, 2006; Nemoto, 1998; Oelrich, 1986; Ott, 1998; Phillips & Winkle, 1992; Polisi, 1986; Rehfeldt, 1998; Robertson, 1983; Russianoff, 1982; Saucier, 1981; Stein, 1958; Teal, 1963; Timm, 1964; Waln, 1986c, 1986d; Westphal, 1990; Whitener, 2007)]
- /ɔ/ as in *bought*: open-mid/back/lax vowel [TAW/TAWH (Fitzgerald, 1987; Gay, 1986; Kohut, 1996; Law, 1999; Magnell, 1987; Robertson, 1983; Rocco, 1999; Timm, 1964; Vining, n.d.; Zorn, 1977)]

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[6] In order to eliminate redundancy, vowels will only be paired with the consonant /t/, although various consonant pairings existed within the literature.

- /o/ as in *b<u>o</u>de*: close-mid/back/tense vowel [T<u>OE</u>/T<u>OH</u> (Bailey et al., 2008; Byrnes, 2007; Gray, 1999; Little, 1984; Nelson, 2006; Peck, 1986; Phillips & Winkle, 1992; Stein, 1958; Timm, 1964; Vining, n.d.; Whitener, 2007; Willett, 1986)]
- /u/ as in *b<u>oo</u>ed*: close/back/tense vowel [T<u>U</u>/T<u>OO</u>/T<u>OU</u> (Bailey et al., 2008; Cheyette, 1986; Erlenbach, 1987; Farkas, 1956, 1962; Fitch, 1952; Fitzgerald, 1987, 1999; Frederiksen, 1996; Graham, 1987; Keram, 1986; Kinney, 1987; Kleinhammer, 1963; Kohut, 1996; Law, 1999; LeJeune, 1964; Little, 1984; Mendéz & Gibney, 1961; Montgomery, 1986; Nemoto, 1998; Oldberg, 1986; Ott, 1998; Peck, 1986; Reynolds, 1997; Royer, 1986; Saucier, 1981; Sawhill & McGarrity, 1962; Stein, 1958; Teal, 1963; Timm, 1964; Westbrook, 1986; Westphal, 1990; Whitener, 2007; Willett, 1986; Wright, 1986; Zorn, 1977)]
- /ʌ/ as in *b<u>u</u>d*: open-mid/back/lax vowel [T<u>UH</u> (Fitzgerald, 1987; Hilton, 1986; Kinney, 1987; Kirkbride, 1998; Montgomery, 1986; Phillips & Winkle, 1992; Robertson, 1983; Saucier, 1981)]

The International Phonetic Association (1999) uses two-character symbols within phonetic notation to indicate vowel sounds classified as diphthongs, including /aɪ/ as in *b<u>uy</u>*, /aʊ/ as in *b<u>ough</u>*, and /ɔɪ/ as in *b<u>oy</u>*. Diphthongs incorporate a vowel sound followed by a nonadjacent glide within the same syllable, resulting in a notable movement of the tongue during vocal production (Celce-Murcia et al., 1996). Only two reviewed music pedagogy sources recommended the use of a diphthong for articulation on a wind instrument. Low (1986a) recommended the use of the diphthong /aɪ/ as in *b<u>uy</u>*. Hunt's

(1963) recommendation to imitate "the first syllable of the word beauty (beau-)" (p. 26) implies the use of /ju/, an additional diphthong identified by Clark and Yallop (1995). Since tone on a wind instrument is affected by the use of specific vowels (Clinch, Troup, & Harris, 1980; Hall, 1954; Mooney, 1968; Pappone, 1973) and since clear articulation is dependent upon minimal motion in the pharyngeal cavity (Compagno, 1990; Watkins, 2003a), the current researcher questions the use of diphthongs as a model for articulation on a wind instrument. As such, the use of diphthongs will not be discussed further.

It is noteworthy that phonetics texts are not always in agreement regarding the classifications or the precise tongue position for the articulation of specific vowels. For example, Celce-Murcia et al. (1996) include an additional vowel classification, labeled as a *vowel+glide sequence*, which includes /iy/ as in *tee*, /ow/ as in *toe*, and /uw/ as in *too* (identified as /i/, /o/, and /u/, respectively, by the International Phonetic Association [1999]). According to Celce-Murcia et al., vowel+glide sequences incorporate motion from an original vowel sound to an adjacent glide within one syllable; as such, vowel+glide sequences are similar to diphthongs, but with a smaller range of motion. Avery and Erhlich (1992) identified a similar classification, labeled *off-glides*, which includes /iy/ as in *be*, /ey/ as in *rain*, /uw/ as in *blue*, and /ow/ as in *boat* (identified as /i/, /e/, /u/, and /o/, respectively, by the International Phonetic Association).

Beyond the inclusion of the additional classifications cited above, other differences existed between various phonetics sources regarding specific vowels. For example, whereas the International Phonetic Association (1999) identified /ɔ/ as in *bought* as an open (lowest tongue) vowel, Avery and Ehrlich (1992) labeled /ɔ/ as a mid vowel. Further, whereas Avery and Ehrlich identified /ɔ/ as a lax vowel, Celce-Murcia et al. (1996) labeled /ɔ/ as a tense vowel. In this regard, Celce-Murcia et al. noted that North American linguistic textbooks show considerable variation in the treatment of the vowel /ɔ/ and cited dialectic variations as a possible reason for such discrepancies. Next, whereas the International Phonetic Association identified /ɑ/ as in *pod* as a back vowel, Avery and Ehrlich identified it as both a back and a central-back vowel, while Celce-Murcia et al. identified it as a central vowel. Finally, Avery and Ehrlich classified /æ/ as in *bad* and /ɑ/ as in *pod* as neither tense nor lax, whereas Celce-Murcia et al. classified them as lax and tense, respectively.

Summary of phonetics.

Despite the minor differences between sources as summarized above, the overview of phonetics provides specific information about the position of the tongue when pronouncing the consonants and vowels used as models for articulation on a wind instrument. The consonants /t/ and /d/, which were cited most frequently by music pedagogues as the models to imitate during articulation, are classified as plosive alveolar, meaning that they make use of a full obstruction of the airstream that is created when the tip of the tongue touches the tooth ridge. Phonation sets these two consonants apart, as /t/ is unvoiced, whereas /d/ is voiced. Music pedagogues recommend a variety of vowels as models during wind instrument performance. Phoneticians classify vowels based on (a) the vertical position of the high-point of the tongue (open/open-mid/close-mid/close), (b) the horizontal position of the high-point of the tongue (front/central/back), (c) the degree of roundness or spread in the lips (round/neutral/spread), and (d) the degree of muscular tension in the tongue and mouth (tense/lax) when a particular vowel is produced. These classifications by phonetics experts will serve as a means of comparison when considering the divergent ideas of music pedagogues regarding the consonants and vowels used as models for articulation on a wind instrument, as summarized later within this review of music pedagogy sources.

Native language.

The preceding overview of phonetics was included in order to provide a more complete perspective regarding the consonants and vowels typically used to teach articulation on a wind instrument. However, language differences impact the way individual consonants and vowels are pronounced, if indeed they are utilized at all in a given language (Avery & Ehrlich, 1992; Yang, 2005). The following personal anecdote provides an example from the current researcher's own experience as an applied lesson instructor:

> *Recently, I began teaching private lessons to a young tuba player who had just moved to the United States from China. Like many beginning students, "John" struggled to articulate clearly during performance. Instead of using his tongue, he used his throat as an airflow valve, cutting off and subsequently releasing the airstream as a means of articulation. As someone keenly interested in articulation strategies, I felt confident that I could quickly help John to improve this area of weakness in his playing. I began the process of helping John to use the tip of his tongue, rather than his throat, as the source of articulation. Together, we recorded, listened to, and viewed computer-generated signal graph*

images of our performances of an articulation exercise. John agreed that there were distinct differences, both in the recorded sounds and the onscreen images, when comparing our two performances. Next, we discussed the use of the syllables TAH and DAH as vocal models to imitate during tuba playing and worked on a wind-pattern exercise as a means to this end. While John could do the wind-pattern exercise at a very slow tempo, he struggled with any increase in speed. After several attempts, John regressed in his performance level on the wind-pattern exercise. I asked John to say "TAH-TAH-TAH" and then "DAH-DAH-DAH" to help him to utilize his tongue more effectively; once again, he struggled to say the syllables beyond a moderately slow tempo. As I listened to John, I became aware of a high degree of tension in his approach to speaking these syllables, a fact that, in retrospect, seemed to also affect his level of performance during the wind-pattern exercise and when playing the tuba. Now curious, I asked John to say some Chinese words that began with /t/ and /d/. His pronunciation and approach when saying these words were markedly different from what I was used to hearing from my native-English-speaking students. It was clear that I needed to rethink my strategy in order to effectively help John to achieve success when articulating on the tuba.

In order to attend to the needs of all young wind players, the impact of native language must be considered carefully when developing strategies for teaching articulation. Language differences are perhaps more obvious in vocal music, as singers strive for authentic pronunciations during performances (Chang, 2000). As such, variations between languages are necessarily a focal point within vocal pedagogy. Yet, little attention has been given to this issue when considering how language differences can impact the process of instrumental instruction, particularly regarding articulation on a wind instrument. Given the inclusion of both a consonant (attack) and vowel (sustain) within the vocal models used for articulation on a wind instrument, each will be considered through the lens of native language in this review.

Consonants and native language.

The most frequently utilized consonants for articulation on a wind instrument are /t/ as in *tie* and /d/ as in *die*. As previously described in the overview of phonetics, these two consonants are classified as plosive alveolar, meaning that they make use of a full obstruction of the airstream that is created when the tip of the tongue touches the tooth ridge (Avery & Ehrlich, 1992; Celce-Murcia et al., 1996; Gregg, 2002). Phonation sets these two consonants apart in the English language, as /t/ is unvoiced, whereas /d/ is voiced (Avery & Ehrlich, 1992; Celce-Murcia et al., 1996; Conner, 1999; Frederiksen, 1996; Gregg, 2002; Nelson, 2006).

A review of literature on native languages, however, suggests that variations in pronunciation must be considered. For example, Lindberg-Kransmo (2002) contended that /t/ and /d/ are dental consonants in the French language, meaning that the tip of the tongue contacts the back of the teeth rather than the tooth ridge. Lambacher (1999) pointed out that in English, /t/ is aspirated (meaning that a burst of air occurs after the release of the stop); however, when produced by Japanese speakers, /t/ is not aspirated and is, therefore, often mistaken for /d/. This same phenomenon occurs in many languages, including French, Greek, Italian, Polish, and Spanish (Avery & Ehrlich, 1992), as well as Thai (Wei & Zhou, 2002). Chang (2000) suggested that Chinese speakers must take care to avoid (a) tightening the lips and (b) exaggerating the stoppage of air before the release of plosive consonants, including /t/ and /d/. Finally, within the Korean language, /t/ and /d/ feature an articulation tendency that is not found in other languages: /t/ is pronounced "weakly, with minimal muscular activity," whereas /d/ is "pronounced with great muscular tension" (Lee, 2004, p. 34). Concerning the pronunciation of /t/ and /d/ in various languages, Avery and Ehrlich (1992) reported the following:

- Greek: Nasal sounds are often inserted during the pronunciation of voiced consonants such as /d/: for example, *fodder* might be pronounced *fonder*;
- Hindi and Punjabi: The pronunciation of /t/ and /d/ includes the use of a slightly curled tongue in which the underside of the tongue tip touches the tooth ridge (a phenomenon labeled *retroflexed*). In addition, aspiration of unvoiced plosives (such as /t/) are pronounced with much stronger aspiration than is done in English; thus, Hindi and Punjabi speakers often do not notice aspiration in the English pronunciation of /t/ and, therefore, mistake it for (and pronounce it as) /d/;
- Japanese: When /t/ occurs before a close (high tongue) front vowel (including /ɪ/ as in *bid* and /i/ as in *bead*), the /t/ may be replaced by /tʃ/ as in *chin*; thus, *tee* may be pronounced *chee* (as in *cheese*);
- Korean: There are no voiced plosives (such as /d/) in the Korean language; and

- Spanish: Spanish speakers often substitute /ð/ (as in *thy*) for /d/ when it occurs between vowels; for example, Spanish speakers may say *heather* rather than *header.*

Another variation of /t/ that must be considered is that of flapping (/D/) in North American English pronunciation (Avery & Ehrlich, 1992). During flapping, the tongue touches the tooth ridge and is quickly pulled back, resulting in a shortened version of the voiced /d/. The word *putting* contains an example of flapping, in which /t/ is pronounced in the same manner as that which occurs in the word *pudding*. Flapping exists in American English, but not British English.

Based on this review of native language, the consonants used as vocal models for articulation on a wind instrument must be considered carefully. Non-native-English speakers may not distinguish between /t/ and /d/, the consonants most commonly used when teaching articulation. In addition, native language can affect the placement of the tongue, alter the use of aspiration, and may result in the substitution of consonants sounds other than /t/ or /d/. Music educators must keep these differences in mind when working with young wind musicians.

Vowels and native language.

As was described in the overview of phonetics, music pedagogues recommend a variety of vowel sounds as models for the sustain portion of a musical tone on a wind instrument. Yet, these specific vowel sounds may not exist in non-English languages (Lee, 2004). Whereas some languages have only five distinct vowel sounds (Avery & Ehrlich, 1992; Yang, 2005), Gregg (2002) stated that there "are actually eleven [vowel sounds in the English language], or twelve if the schwa is counted" (p. 432). Yang (2005) contended that the English language actually has 17 unique vowel sounds, compared to only 10 in the Korean language. Regardless of the exact number, it is noteworthy that the English language contains vowel sounds that are not found in other languages.

Next, as described within the review of phonetics, vowels can be distinguished by the degree of muscular tension in the tongue and mouth as either (a) tense or (b) lax (Avery & Ehrlich, 1992). Yet, these differences may not exist within non-English languages. Avery and Ehrlich (1992) suggested that many languages (including Chinese, Farsi/Persian, French, Greek, Hindi/Punjabi, Italian, Japanese, Korean, Polish, Portuguese, and Spanish) do not include a distinction between tense and lax vowels; vowel sounds in these languages fall somewhere in-between the fully tense and lax versions found in English. Yang (2005) stated that Korean singers often replace lax vowels with tense vowels, since lax vowels do not exist in the Korean language; further, Korean singers do not lower their tongue and jaw as much as native-English speakers when pronouncing open vowels such as /ɔ/ as in *bought*, /ɑ/ as in *pod*, and /æ/ as in *bad*.

In addition, Avery and Ehrlich (1992) noted further considerations regarding tense and lax vowels. The vowels /ɛ/ as in *bed,* /æ/ as in *bad,* /ɑ/ as in *pod,* and /ʌ/ as in *bud* are often difficult to pronounce or distinguish for non-native-English speakers, including: Arabic (particularly /ɛ/, /æ/, and /ʌ/), Chinese (particularly /ɛ/ and /æ/), Farsi/Persian, French (particularly /ɑ/ and /ʌ/), German (particularly in substituting /ɛ/ for /æ/ and /ɑ/ for /ʌ/), Greek (particularly /æ/, /ɑ/, and /ʌ/), Hindi/Punjabi (particularly /ɛ/

and /æ/), Italian (particularly /æ/, /ɑ/, and /ʌ/), Japanese (particularly /æ/ and /ʌ/), Korean (particularly /ɑ/ and /ʌ/), Polish (particularly /ɛ/, /æ/, and /ʌ/), Portuguese (particularly /ɛ/ and /æ/), Spanish (particularly /ɛ/ and /æ/), and Vietnamese (particularly /ɛ/ and /æ/). In addition, Arabic speakers often have problems distinguishing between /o/ as in *bode* and /ɔ/ as in *bought.* German speakers often produce tense English vowels (including /i/ as in *bead,* /eɪ/ as in *say*, /u/ as in *booed*, and /o/ as in *bode*) without the inclusion of the off-glides included in English (as described previously within the review of phonetics).

Returning to the subject of articulation, several ideas struck the current researcher regarding vowels and native language. First, one cannot assume that specific vowel sounds are common to the native languages of all students. Additionally, the tendency to replace lax vowel sounds with more tense alternatives is noteworthy, given the importance of a relaxed tongue during articulation. One might predict that a student who is utilizing an overly tense tongue while imitating particular vowel sounds will have more difficulty articulating quickly and may be more prone to fatigue; this appeared to the case for "John," as described previously. Music educators must be attentive to these differences between languages in order to meet the needs of all young wind musicians.

Summary of native language.

Native language has an impact on the manner in which particular consonants and vowels are pronounced and perceived, if they are even included within a given language. Further, each student may hear and replicate vocal models differently, based on the filter of their own native language. As such, band directors cannot assume that all students will utilize (or perceive) the consonants and vowels commonly used as models for articulation in the same manner. Regarding consonants, non-native-English speakers may not distinguish between /t/ and /d/, the two consonants most commonly used when teaching articulation. In addition, native language can affect the placement of the tongue, alter the use of aspiration, and may result in the substitution of consonants other than /t/ or /d/. Regarding vowels, the English language includes more distinct vowel sounds than most other languages. In addition, many languages do not distinguish between tense and lax vowels; tense vowels are often substituted for lax vowels when the latter are not found within a given language. As such, the impact of native language must be carefully considered when teaching young musicians how to articulate on a wind instrument.

Regarding the current study, the investigation of native language guided the current researcher when devising an articulation guide sheet (Appendix A) that was distributed to participants within the current study. First, an illustration of the tongue (representing the position of the tongue before the onset of a tone as well as during the sustain portion of a tone) was included to provide information about tongue placement in a manner that was not dependent on language. Second, regarding consonants, the description "a gentle /t/" was included in order to counter any tendency to use an aggressive or tense tongue. Third, the vowel /ɑ/ as in *pod* (classified as open/back/neither-tense-nor-lax) was recommended to counter the tendency of non-native-English speakers to utilize an elevated and tense tongue. Finally, the closing statement on the articulation guide sheet included, "Most importantly, let your ears guide you to a tonguing style that is clear and accurate." This statement, while broad in nature, was included in an effort to reinforce the importance of finding one's own manner of tongue placement, regardless of native language, when working toward clear and accurate articulation.

Vocal models for articulation on a wind instrument.

Having completed a general overview of phonetics and native language, the use of articulation syllables will now be explored based upon information found in music pedagogy sources. The consonants and vowels recommended by music pedagogues will be summarized and compared to the information presented within the previous overviews of phonetics and native language.

Consonants as models.

Across the music pedagogy sources reviewed, the consonants /t/ as in *tie* and /d/ as in *die* were the most common vocal models for articulation on a wind instrument. As previously summarized within the review of phonetics, these two consonants, classified as plosive alveolar, are members of a cognate pair that are distinguished by the presence or absence of phonation. Despite the similarities between /t/ and /d/, as described by phoneticians, there was substantial diversity of thought regarding the manner in which these two consonants should be utilized when articulating on a wind instrument. Some authors stated that both /t/ and /d/ can and should be initiated from the same location within the mouth when articulating on brass instruments (Farkas, 1956, 1962; Tetzlaff, 1987); others asserted that /d/ is initiated further up on the palate (Kohut, 1996; Mueller, 1968; Nemoto, 1998). The use of /d/ was recommended for rapid passages, based on the opinion that it does not fully cut off the airstream (Farkas, 1956, 1962) and also promotes a more relaxed tongue (Kinney, 1987) and throat (Conner, 1999). Many authors proposed that /t/ was to be used for normal playing (or for accented notes), while /d/ was to be used for a more gentle or legato style (Adelstein, 1986; Bailey et al., 2008; Cheyette, 1986; Conner, 1999; Deye, 1987; Fallis, 2003; Farkas, 1956, 1962; Faulkner, 1999; Fitzgerald, 1987, 1999; Frederiksen, 1996; Graham, 1987; Gray, 1999; Kleinhammer, 1963; Kohut, 1996; Montgomery, 1986; Nemoto, 1998; Reiss, 2006; Reynolds, 1997; Robertson, 1983; Rocco, 1999; Saucier, 1981; Shoults, 1961; Spencer, 1958; Stein, 1958; Teal, 1963; Timm, 1964; Vining, n.d.; Westphal, 1990; Whitener, 2007; Whybrew, 1987; Winter, 1964). This assertion is in stark contrast to the pronunciation of these consonants within the Korean language, in which /t/ is pronounced weakly, whereas /d/ is pronounced with a great deal of muscular tension (Lee, 2004). Next, Farkas (1962) and Whybrew (1987) suggested that /t/ utilizes a more pressurized airstream and a faster downward motion of the tongue in comparison to /d/. Finally, some authors suggested that the relative hardness of an attack was influenced by both consonants and vowels. For example, Westphal (1990) recommended TEE for a harder attack and DU for a softer attack. Montgomery (1986) suggested TEE/TOO/TUH/DUH as representing a range of articulations from sharp to legato.

In summary, the ideas presented by music pedagogues regarding the use of the consonants /t/ and /d/ differ from those presented by phoneticians. Whereas /t/ and /d/ are classified as members of a cognate pair by phoneticians, they are often treated as distinct entities by music pedagogues, including considerations of tongue position, tongue movement, degree of accent, and degree of tension. Further, the music pedagogy sources reviewed by the current researcher did not include a consideration of native language when recommending consonants as models for articulation on a wind instrument.[7]

Based upon information found in the review of phonetics literature, the current researcher maintains that the consonants /t/ and /d/ are pronounced using the same basic motion of the tongue within the English language. Although differences in phonation and aspiration exist when comparing these two consonants within the English language, these differences are negated when performing on a wind instrument, since (a) phonation is not included during performance and (b) an active airstream is required regardless of the consonant used. Further, it is the experience of the current researcher that many young wind players inadvertently phonate during articulation, a habit that can be disruptive to performance. This tendency may be the result of using /d/ as a vocal model, which includes phonation in the English language. As such, the current researcher recommended /t/ as in *tie* as an appropriate model for articulation on a wind instrument within the articulation guide sheet supplied to participants in the current study.

Vowels as models.

Within music pedagogy sources, there were many reasons cited for choosing a specific vowel as a vocal model during performance on a wind instrument. Many authors indicated that the tongue should be lower in the mouth for notes in the lower register, in a

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[7] As will be seen in the review of pedagogical themes, a regional difference was found regarding a tendency to tongue between the lips on brass instruments in various European countries. This difference, however, did not appear to be based on any inherent differences between languages, but rather appeared to reflect a difference in performance traditions within these regions.

more neutral position for notes in the middle register, and higher in the mouth for notes in the upper register (Callet, 1987; Davidson, 1999; Erlenbach, 1987; Faulkner, 1999; Fitzgerald, 1987, 1999; Gordon, 1968; Jenkins, 1999; Magnell, 1987; Mueller, 1968; Phillips & Winkle, 1992; Saucier, 1981; Shoults, 1961; Stanley, 1987; Whitener, 2007). While there was widespread agreement on this general premise, the specific vowel sounds to be utilized in this regard varied between sources. For example, Gay (1986) recommended the progression TOE/TAH/TWO/TEE when moving from low to high, Willett (1986) suggested TOH/TOO/TEH/TEE, and Bolvin (2007) recommended TAW/TEW/TEE/TSS. Despite inconsistencies regarding the specific vowels to utilize, the premise that the tongue should move from low to high when moving from the low register to the high register of a wind instrument was a common thread within music pedagogy sources.

Several additional considerations arose within the literature regarding the appropriate vowel to use for articulation on a wind instrument. Some authors stated that low-pitched instruments should utilize broad and open vowels, such as /ɑ/ as in *pod* or /o/ as in *bode* (Fitzgerald, 1987, 1999; Vining, n.d.), while high-pitched instruments should incorporate vowels with a higher tongue position, such as /i/ as in *bead* (Kohut, 1996). This recommendation, however, is in conflict with the consideration of range *within* a given instrument, as previously described.

Individual vowel sounds have additional physiological effects that must be considered. The use of particular vowels can impact the formation of the embouchure. For example, some flautists prefer the use of /i/ as in *bead* (Kohut, 1996) or /u/ as in *booed* (Hinch, 1997), since the shape of the lips for these vowels matches the formation of the flute embouchure. Likewise, the vowel /u/ as in *booed* promotes a rounded aperture that lends itself well to the needs of brass playing (Farkas, 1956; Griffiths, 1999; Whitener, 2007). Vowel sounds can also impact the throat. For example, Gay (1999) suggested that /o/ as in *bode* promotes a relaxed and open throat, a trait that is desirable for wind playing in general. Erlenbach (1987) indicated that /u/ as in *booed* and /i/ as in *bead* tend to produce tension and constriction in the throat, which both restricts the airflow necessary for clear articulation and affects overall tone quality. Scheid (1986) recommended a whispered (rather than spoken) TU (/u/ as in *booed*) as an appropriate model, based on the belief that the spoken version promotes tension in the throat.

There is widespread agreement that the tongue should function with a minimal degree of tension during articulation (Bailey et al., 2008; Brasch, 1987; Ewell, 2003; Faulkner, 1999; Fitzgerald, 1987, 1999; Frederiksen, 1996; Gallops, 1999; Gay, 1986; Gordon, 1987; Hanson, 1968; Kleinhammer, 1963; Little, 1984; Low, 1986b; Mendéz & Gibney, 1961; Ott, 1998; Pace, 1986; Peck, 1986; Shoults, 1961; Spencer, 1958; Teal, 1963; Timm, 1964; Westphal, 1990). Interestingly, despite this commonly held premise, many of the vowels associated with commonly recommended articulation syllables are categorized as tense vowels by phoneticians, including /i/ as in *bead*, /o/ as in *bode*, and /u/ as in *booed*.

In summary, there is no consensus among music pedagogy sources regarding the vowels to be used as models during performance on a wind instrument. Although many theories were proposed, these were often in conflict. Further, phoneticians classify many of the vowel sounds recommended within these sources as tense vowels, a proposition that is in conflict with the recommendation that the tongue should remain relaxed during articulation. Within these music pedagogy sources, the current researcher found no consideration for the impact of native language regarding the use of vowels as models during performance on a wind instrument.

The current researcher has found, based on eight years of teaching in the public schools, that many young musicians utilize an elevated and tense tongue when performing on a wind instrument. Further, as previously summarized, the literature regarding the impact of native language indicates that there is a tendency for non-native-English speakers to incorporate tense tongue positions. Avery and Ehrlich (1992) classified /ɑ/ as in *pod* as a low vowel that is neither tense nor lax. As such, the current researcher recommended the use of /ɑ/ as in *pod* within the articulation guide sheet supplied to participants within this study.

Summary of articulation syllables as a guide.

This overview of the use of articulation syllables as a guide for tonguing was intended to provide authoritative information about the consonants and vowels utilized during articulation on a wind instrument. This section began with an overview of information from non-music sources, including a summary of phonetics and native language, to which common ideas from music pedagogues regarding the articulation syllables used during wind instrument performance were compared. This broad consideration of articulation syllables helped the current researcher to develop the articulation guide sheet that was distributed to participants during the treatment period in the current study. Additionally, it is the hope of the current researcher that this broad overview of articulation syllables will (a) inform music educators and performers regarding the use of the tongue and (b) provide a means of comparison when considering the diverse (and often conflicting) ideas presented within the review of music pedagogy sources related to articulation on a wind instrument.

Additional Recommendations within Music Pedagogy Sources

Within the review of music pedagogy sources, many themes regarding the process of articulation on a wind instrument moved beyond the use of articulation syllables as summarized above. Some themes applied to all wind instruments; others were intended solely for brass or woodwind instruments; still others were instrument-specific. In addition, several authors presented unique strategies for developing articulation skills that fell outside the realm of the common practice ideas known previously to the current researcher. Finally, several authors addressed components of articulation that were beyond the scope of the current study. Each of these categories will now be summarized.

General literature-based recommendations for articulation.

Within the music pedagogy sources reviewed, two general articulation themes applied to all wind instruments. These included general strategies for improving articulation as well as specific techniques that were applicable to all wind instruments. These two general categories will be summarized individually.

Practice strategies for improving articulation.

Several authors recommended specific strategies for improving articulation on a wind instrument. Not surprisingly, practice was cited as a critical component in this regard (Farkas, 1962; Fitzgerald, 1999; Kolwinska, 2007; Mendéz & Gibney, 1961; Shoults, 1961; Young, 1997). As a muscle, the tongue should be developed and trained until the act of articulation is performed instinctively (Gordon, 1987; Hickman, 1999; Mendéz & Gibney, 1961; Reynolds, 1997). The use of a metronome allows for graduated increases in the speed of articulation and helps to develop evenness and control (Burnette, 1986; Griffiths, 1999; Reynolds, 1997; Ward, 2002; Wright, 1986). The middle register is a suitable place to begin working on articulation, since this range of a wind instrument responds more easily than the low register and causes less fatigue than the upper register (Reynolds, 1997).

Increased practice time, however, does not necessarily lead to improved articulation. Low (1986b) asserted that practice "*does not* make perfect" (p. 699) when done incorrectly, such as when practicing with a tense tongue. Likewise, Dietz (1995) stated, "no amount of practice will improve tonguing if the basic technique is incorrect" (p. 93). Jones (1986) cited muscle fatigue and a muscle-bound tongue as negative consequences of the traditional practice routine, which typically includes numerous repetitions at gradual increases of speed; instead, he recommended short sequences of rapid tonguing (such as five 16^{th}-notes followed a rest) as a superior strategy. Westbrook (1986) suggested that learning to tongue quickly is a gradual process that cannot be rushed; when the tongue tires, the performer should move to another activity to avoid the formation of incorrect habits. Finally, O'Donnell (1987) recommended a sequence for improving articulation that included (a) information and modeling regarding correct articulation techniques, (b) supervised practice time with teacher feedback, and, eventually, (c) practice time with diminishing feedback as the student becomes increasingly autonomous.

Wind-pattern exercises are an additional strategy for improving articulation on a wind instrument (Byrnes, 2007; Cichowicz, 1999; Whitener, 2007; Zingara, 2006). Cichowicz (1999) described wind-pattern exercises as "blowing the musical pattern with the wind and articulation only. This should be done without the instrument or mouthpiece and without buzzing the lips" (p. 1030). The current researcher refers to wind-pattern exercises as *whisper tonguing* in an effort to clarify the processes involved. Arnold Jacobs suggested that musicians first sing a passage, then use "unvoiced diction blown against the back of your hand, keeping a large volume of air flowing as evenly as possible" (as cited in Nelson, 2006, p. 55). A variation of this strategy is to sing a musical pattern, using articulation syllables such as TAH or DAH (Rocco, 1999; Russianoff, 1982). In all cases, these approaches consist of a practice strategy that incorporates the mechanics of tonguing, but are done without producing a tone on the instrument itself.

Pound (1986) recommended a grouping technique as a strategy to increase tonguing speed. The performer begins by rapidly counting groups of three or four notes out loud, while accenting the first note of each set (ONE-two-three-ONE-two-three). Next, the musician plays the pattern, accenting the first note and allowing the tongue to lightly bounce for the remaining notes, while still thinking of counting using the same grouping technique. The goal of this strategy is to get the musician to focus on (and execute) a group of notes as one unit. Willett (1986) suggested a similar strategy, but referred to this technique as a tongue-bounce sensation.

Finally, careful listening is an important component for improving articulation (Byrnes, 2007; Frederiksen, 1996; Rose, 1986). Since the tongue does not provide a great deal of sensory information to the brain, the musician should focus on the resulting sounds rather than the feel of the articulation within the mouth (Frederiksen, 1996). Moving beyond listening, modeling and imitation can be effective teaching tools (Rose, 1986). In this regard, Arnold Jacobs stated, "Imitation was, is, and always will be the best method of teaching" (as cited in Frederiksen, 1996, p. 146). Modeling helps students to develop listening and evaluation skills as they strive to match the sounds produced by more experienced musicians (Haston, 2007; Jenkins, 1999).

General articulation techniques.

In addition to the general practice strategies summarized above, many authors recommended articulation techniques that applied to all wind instruments. First, the tongue should act as a release valve for the airstream, as it is pulled down and back (Bailey et al., 2008; Deye, 1987; Drake, 1986; Eifert, 1986; Farkas, 1956, 1962; Fitch, 1986; Fitzgerald, 1987; Groth, 1986; Hanson, 1968; Heim, 1986; Hickman, 2006; Holvik, 1986; Jenkins, 1999; Law, 1999; LeJeune, 1964; Lindskoog, 1999; Little, 1984; McCarrell, 1986; Mueller, 1968; O'Donnell, 1987; Ott, 1998; Phillips & Winkle, 1992; Reimer, 1986; Riley, 2008; Russianoff, 1982; Sawhill & McGarrity, 1962; Schmid, 1987;

Shoults, 1961; Sprenkle, 1961; Stein, 1958; Teal, 1963; Timm, 1964; Waln, 1986d; Westphal, 1990; Whybrew, 1987; Winter, 1964; Young, 1997; Zingara, 2006). For brass instruments and the flute, this action releases the air and sets the lips or the air column into vibration. For reed instruments, this equates to removing the tongue from the reed(s), thus allowing for vibration of the reed(s).

Several authors voiced concern over the use of the word *attack*, the term used to describe the onset of sound (as in *attack-sustain-release*). The nature of this descriptor implies that the tongue should strike during articulation, rather than act as a release valve (Drake, 1986; Ewell, 2003; Farkas, 1956, 1962; Fitzgerald, 1987; Frederiksen, 1996; Groth, 1986; Hanson, 1968; Hickman, 2006; Hoss, 1987; Hovey, 1986; Kohut, 1996; Mueller, 1968; Pace, 1986; Reynolds, 1997; Spencer, 1958; Sprenkle, 1961; Teal, 1963; Waln, 1986a; Westphal, 1990; Young, 1997). This misconception can lead to hard attacks and uncontrolled tones. Instead, a light touch and delicate release are of prime importance for articulation on a wind instrument (Enloe, 2009; Figert, 1986; Gay, 1986; Heim, 1986; Krebs, 2009; Low, 1986b; Nelson, 2006; Pace, 1986; Reimer, 1986; Waln, 1986c, 1986d).

Regarding the motion of the tongue, some authors suggested that the tip of the tongue should move primarily up-and-down rather than front-and-back (Bailey et al., 2008; Conner, 1999; Drake, 1986; Farkas, 1956, 1962; Gray, 1999; Hoss, 1987; Kleinhammer, 1963; Little, 1984; Mendéz & Gibney, 1961; Nelson, 2006; Sprenkle, 1961; Stein, 1958). Others recommended a forward-and-up/down-and-back motion (Fitch, 1986; Heim, 1986). The method of tonguing has an impact on the direction of the tongue motion as well. For example, O'Connell (1986) suggested that normal (tip-to-tip) tonguing on the clarinet utilizes a forward-backward motion, whereas anchor (dorsal) tonguing utilizes an up-and-down motion. Anchor tonguing involves placing the tip of the tongue behind the bottom teeth while arching the middle of the tongue upward against the upper palate or reed during articulation (Westphal, 1990).

For performance on non-reed instruments, most authors recommended that the tongue should not move between the teeth or lips when articulating (Bailey et al., 2008; Conner, 1999; Davidson, 1999; Erlenbach, 1987; Farkas, 1956, 1962; Gray, 1999; Hanson, 1968; Hickman, 2006; Hoss, 1987; Kleinhammer, 1963; Law, 1999; Little, 1984; Mueller, 1968; Neilson, 1999; Ott, 1998; Phillips & Winkle, 1992; Schmid, 1987; Shoults, 1961; Whitener, 2007; Winter, 1964; Zorn, 1977). Other authors suggested that the tongue could be inserted between the lips (a) when playing in the low register on low-brass instruments (Bailey et al., 2008; Brasch, 1987; Deye, 1987; Fitzgerald, 1999; Hunt, 1963; Kleinhammer, 1963; Mendéz & Gibney, 1961; Phillips & Winkle, 1992; Stoutamire, 1987; Winter, 1964) and the flute (Hinch, 1997; Kohut, 1996; Timm, 1964) or (b) to create heavy sforzando accents (Farkas, 1956, 1962; Kohut, 1996; Manous, 1987; Montgomery, 1986; Timm, 1964). Still others recommended touching the tongue against (but not between) the lips to articulate (Griffiths, 1999; Tulou, 1995). Finally, regional differences were found. A tongue-between-the-teeth approach is common in Germany and England (Winter, 1964) as well as in France (Rose, 1986).

The tip of the tongue should move as little as possible to facilitate rapid tonguing (Enloe, 2009; Erlenbach, 1987; Farkas, 1956, 1962; Fitzgerald, 1987; Gay, 1986;

Hanson, 1968; Hedrick, 1986; Hovey, 1986; Kohut, 1996; Law, 1999; McCarrell, 1986; Montgomery, 1986; Spencer, 1958; Stein, 1958; Stoutamire, 1987; Teal, 1963; Timm, 1964; Waln, 1986b). The tongue should move quickly, regardless of the speed of the notes being played; this minimizes the disruption in the airstream during articulation and also makes legato articulation possible (Cheyette, 1986; Gay, 1986; Hanson, 1968; Little, 1984; Nelson, 2006; Ott, 1998; Pace, 1986; Reynolds, 1997; Waln, 1986a). In addition, there should be no superfluous motion in the mouth, jaw, or face when articulating on a wind instrument (Bailey et al., 2008; Burnette, 1985; Drake, 1986; Hanson, 1968; Heim, 1986; Hinch, 1997; Hoss, 1987; Hovey, 1986; Kleinhammer, 1963; Law, 1999; Little, 1984; Mendéz & Gibney, 1961; Mueller, 1968; Nelson, 2006; Ott, 1998; Pace, 1986; Phillips & Winkle, 1992; Rocco, 1999; Spencer, 1958; Stoutamire, 1987; Teal, 1986; Tetzlaff, 1987; Timm, 1964; Vining, n.d.; Waln, 1986a; Westphal, 1990; Whitener, 2007; Willett, 1986).

The tongue should remain relaxed during articulation, which allows it to move quickly and lightly (Bailey et al., 2008; Brasch, 1987; Enloe, 2009; Ewell, 2003; Faulkner, 1999; Fitzgerald, 1987, 1999; Frederiksen, 1996; Gallops, 1999; Gay, 1986; Gordon, 1987; Hanson, 1968; Kleinhammer, 1963; Little, 1984; Low, 1986b; Mendéz & Gibney, 1961; Ott, 1998; Pace, 1986; Peck, 1986; Shoults, 1961; Spencer, 1958; Teal, 1963; Timm, 1964; Westphal, 1990). Jones (1986) and Farkas (1956) added that a fully-relaxed tongue allows the airstream to push the tongue down (out of the way) during the release, reducing the need for muscular movement. While vocalists use many techniques to promote a relaxed tongue, including a yawn-sigh technique, singing exercises that integrate alternating vowel sounds, musculoskeletal tension massage, tongue protrusion techniques, chewing motions, rolled-/r/ exercises (as in the Spanish word *perro*), and general relaxation techniques (Lindberg-Kransmo, 2002), the present literature review did not reveal similar suggestions for instrumentalists.

Finally, the tongue impacts the degree of pressure in the air column during articulation on a wind instrument (Drake, 1986; Holvik, 1986). In this regard, several authors cited the need for the tongue to create a seal with the back of the teeth, the roof of the mouth, or the reed, an act that creates the pressurized air column necessary for tone production (Deye, 1987; Griffiths, 1999; Holvik, 1986; Kay, 2007; Ott, 1998; Pace, 1986; Reiss, 2006; Shoults, 1961; Westphal, 1990; Whybrew, 1987; Zingara, 2006). Other authors stated that backpressure should be avoided, citing harsh attacks, delayed attacks, and excessive muscular effort as negative side effects (Frederiksen, 1996; Hoss, 1987; Lindskoog, 1999; Nelson, 2006); instead, these authors stressed the importance of coordination between the movement of the tongue and the flow of air to avoid excessive backpressure.

Additional considerations.

Finally, several authors addressed components of articulation that were beyond the scope of the current study, but will be mentioned briefly at present. First, since each person is physically unique, there are necessarily individualized variations in the most effective strategies utilized during articulation. Individual physical differences regarding the size and shape of the tongue, teeth, and oral cavity must be considered (Brasch, 1987; Fitzgerald, 1987, 1999; Hickman, 2006; Kleinhammer, 1963; O'Connell, 1986; Phillips &

Winkle, 1992; Stein, 1958; Timm, 1964; Westphal, 1990; Whittaker, 1998). For example, anchor tonguing might be preferable or even necessary for musicians with a long tongue (O'Connell, 1986; Whittaker, 1998), a severe underbite (Hickman, 2006), or a short frenulum (Hickman, 2006).

Additionally, the act of articulating is codependent with other important components of wind performance. The embouchure must be correctly shaped in order for an articulated note to speak clearly; many performance problems are incorrectly identified as articulation issues, when in fact they are embouchure-related (Farkas, 1956, 1962). Problems with articulation can also result from inadequate breath support or a lack of coordination between the tongue and airstream (Burnette, 1985; Dietz, 1998; Fallis, 2003; Fitzgerald, 1999; Gray, 1999; Grocock, 1987; Kohut, 1996; Kolwinska, 2007; Little, 1984; Westphal, 1990; Whybrew, 1987). Thus, the tongue, airstream, and embouchure must work together in order to achieve quality articulation on a wind instrument (Davidson, 1999; Deye, 1987; Hickman, 2006; Hilton, 1986; Jones, 1986; Kleinhammer, 1963; Mueller, 1968; O'Connell, 1986; Phillips & Winkle, 1992; Spencer, 1958; Sprenkle, 1961). Finally, coordination is required between the motion of the fingers and the tongue during the performance of melodic lines with changing pitches (Burnette, 1985; Young, 1997). Although important, these considerations fall beyond the scope of the current study and will not be elaborated upon further.

Instrument-specific, literature-based recommendations for articulation.

Moving beyond the general recommendations for articulation as summarized above, many music pedagogy sources contained recommendations that were specific to brass or woodwind instruments. Considerations for brass playing will be presented first, since there is general consistency of approach among the various brass instruments; in contrast, woodwind instruments, which include non-reed (flute), single-reed (clarinet and saxophone), and double-reed (oboe and bassoon) instruments, present a need for instrument-specific strategies.

Brass instruments.

For brass instruments, the tip of the tongue should touch the base of the top teeth near the gum line (Bailey et al., 2008; Brasch, 1987; Davidson, 1999; Erlenbach, 1987; Fallis, 2003; Farkas, 1962; Fitzgerald, 1999; Gray, 1999; Hoss, 1987; Hunt, 1963; Kleinhammer, 1963; Kohut, 1996; Law, 1999; Manous, 1987; Schmid, 1987; Stoutamire, 1987; Tetzlaff, 1987; Vining, n.d.; Whitener, 2007; Winter, 1964; Zingara, 2006), against the back of the top teeth (Hickman, 2006), or against the top lip (Callet, 1987; Hickman, 2006; Smiley, 2001). The tongue should create a seal when articulating on brass instruments; as such, the exact amount of tongue contact changes as the jaw is lowered or raised to accommodate the various pitch ranges within a specific instrument (Griffiths, 1999). Finally, anchor tonguing is possible on brass instruments and may be preferable, based on the size and shape of the tongue and oral cavity or when playing in the upper register (Hickman, 2006).

Woodwind instruments.

As non-reed woodwind instruments, the flute and piccolo[8] are articulated in a manner similar to brass instruments, namely with the tip of the tongue touching near the base of the top front teeth (McCarrell, 1986; Rehfeldt, 1998; Saucier, 1981; Westphal, 1990) or on the upper palate just behind the upper teeth (Ott, 1998). TU/DU and TA/DA are the most common articulation syllables for the flute (Westphal, 1990). However, some flautists prefer the use of TEE since the shape of the lips during the pronunciation of this syllable matches the formation of the flute embouchure (Kohut, 1996).

The addition of a reed necessitates changes to the articulation process. Teal (1986) suggested that the primary role of the tongue on a reed instrument is to stop the vibration of the reed(s), rather than to interrupt the flow of air. Holvik (1986) summarized the articulation process on a reed instrument as follows: “Take a breath; place the tongue on the reed; blow; then release the tongue” (p. 657).

During articulation on single-reed instruments (clarinets and saxophones), the tip of the tongue (Drake, 1986; Holvik, 1986; McCarrell, 1986; McCathren, 1986; Rehfeldt, 1998; Saucier, 1981; Stein, 1958; Teal, 1963; Waln, 1986c; Wright, 1986) or the top of the tongue just behind the tongue tip (Enloe, 2009; Heim, 1986; Hemke, 1986a; Kirkbride, 1998; Kohut, 1996; Rehfeldt, 1998; Russianoff, 1982; Saucier, 1981; Stein, 1958; Teal, 1963; Timm, 1964; Waln, 1986d; Westphal, 1990; Whittaker, 1998) should touch either the tip of the reed (Burnette, 1985; Gay, 1986; McCathren, 1986; Saucier,

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[8] Throughout the remainder of this document, references to the flute should be interpreted to include all members of the flute family.

1981; Teal, 1986; Timm, 1964; Waln, 1986d; Wright, 1986) or just below the tip of the reed (Drake, 1986; Enloe, 2009; Holvik, 1986; Kirkbride, 1998; McCarrell, 1986; Pace, 1986; Whittaker, 1998). TU/DU are the most common articulation syllables used for single-reed instruments (Westphal, 1990). Care must be taken to avoid excessive tongue motion on the clarinet, due to the vertically-oriented angle of the mouthpiece and reed; a point of contact that is one-quarter inch (or more) below the tip of the reed can help to alleviate this issue (Kohut, 1996; Westphal, 1990). Differences of opinion exist concerning the amount of pressure the tongue should exert on the reed. Kirkbride (1998) recommended that the tongue should touch only hard enough to stop the reed from vibrating and suggested that care should be taken to avoid blocking the airstream by closing off the opening between the reed and the mouthpiece. In contrast, Whittaker (1998) recommended that the single-reed player "push the reed against the tip of the mouthpiece and hold the reed shut" (p. 347). The placement of the tongue (point of contact) on the reed impacts the degree of accent for the resulting tone. Timm (1964) recommended touching the corner of the reed for legato tonguing on the clarinet and tonguing aggressively in the center of the reed for strong accents. Finally, anchor tonguing can be utilized on single-reed instruments, particularly for performers with long tongues (Kohut, 1996; Stein, 1958; Timm, 1964; Westphal, 1990). Although anchor tonguing is possible on most wind instruments, it is most commonly utilized on single-reed instruments (Westphal, 1990).

For double-reed instruments (oboe and bassoon), the tip of the tongue (Fitch, 1986; Hedrick, 1986; Hilton, 1986; Rehfeldt, 1998; Saucier, 1981; Sawhill & McGarrity, 1962; Spencer, 1958) or the top of the tongue just behind the tongue tip (Dietz, 1998; Eifert, 1986; Fitch, 1952; Polisi, 1986; Rehfeldt, 1998; Reimer, 1986; Saucier, 1981; Timm, 1964; Weiger, 1998) should touch either the tip of the reeds (Eifert, 1986; Fitch, 1952; Hedrick, 1986; Oelrich, 1986; Polisi, 1986; Reimer, 1986; Saucier, 1981; Timm, 1964), just under the tip of the reeds on the bottom blade (Dietz, 1998; Sawhill & McGarrity, 1962; Weiger, 1998), or on the corner of the reeds (McCarrell, 1986; Weiger, 1998). In order to avoid a harsh attack, the reeds can be twisted slightly so that the top of the tongue touches the corner of the blades, an action that does not completely close off the tip of the double-reeds (Kohut, 1996; Sprenkle, 1961; Timm, 1964). Anchor tonguing can be accomplished on double-reed instruments, but is not common (Westphal, 1990).

Unique approaches for developing articulation skills.

Several authors presented unique strategies for developing articulation skills that fell outside the realm of common practice ideas known previously to the current researcher. Given (a) the prevalence of articulation problems among young wind players and (b) the current researcher's desire to improve upon the ways in which articulation is taught to young musicians, these alternative ideas are worthy of consideration. Each will be summarized briefly.

Mueller (1968) suggested that students practice on a recorder to improve brass articulation. This approach allows the teacher and student to compare the performance of rapidly articulated notes on both instruments. Mueller suggested that if there is a noticeable increase in speed when articulating on the recorder, then “some self-analysis of brass playing habits is in order” (p. 19).

Low (1986a) described a pedagogical approach to tonguing for beginning clarinet players. This method includes closing the mouth (teeth together), with the lips relaxed and slightly open, and then repeating the syllable TIE (/aɪ/ as in *buy*) with the teeth still closed. Low suggested that this approach promotes the use of a relaxed tongue, with minimal movement that is focused at the tongue tip, “thus forestalling the convulsive movements of the throat and jaw before they happen” (p. 698).

McCathren (1986) suggested a three-part exercise to improve articulation on the clarinet. In a measure of common time, the tip of the tongue is placed on the tip of the reed on beat one, the breath is initiated on beat two, and the tongue is pulled away from the reed to play a half-note on beats three and four. Conscientious repetitions of this process can instill and reinforce correct tonguing habits for the young clarinetist.

Griffiths (1999) suggested a reverse-placement experiment to find the optimal position for the tip of the tongue during articulation on a low-brass instrument. This technique involves blowing air through the instrument without tonguing, then cutting off the airstream with the tip of the tongue. A placement of the tongue that effectively creates a seal will also yield a clearly articulated tone.

Finally, Hickman (1999, 2006) suggested the use of flutter-tonguing (a rolled-/r/, as in the Spanish word *perro*) as a method for finding the body’s natural approach for articulating with the tip of the tongue. He suggested alternating between flutter-tonguing and rapid single-tonguing in an effort to replicate the inherent tendencies within the body when articulating on the trumpet.

Summary of additional recommendations within music pedagogy sources.

In summary, music books and journals contain a wealth of information regarding articulation on a wind instrument. Most ideas presented in these sources were based on the opinions of the authors themselves or those of respected wind musicians and teachers. Some recommendations were general in nature, including practice strategies and general articulation techniques. Many of these ideas were widely accepted, including the use of articulation syllables as a model; the use of the tongue as a release valve for the airstream; the need for a relaxed tongue; the avoidance of motion in the tongue, jaw, and face during articulation; and the use of wind-pattern exercises as a practice technique. This information was used by the current researcher as the basis for developing an articulation guide sheet (Appendix A) that was incorporated into the treatment period for the current study.

Other recommendations were more specific in nature. Unfortunately, many of these suggestions, such as the precise location for tongue-to-reed contact and the degree of pressure exerted by the tongue during articulation, revealed a lack of agreement between sources. Furthermore, many of the vowels recommended as models for articulation by music pedagogues are classified by phoneticians as tense vowels, including /i/ as in *bead*, /o/ as in *bode*, and /u/ as in *booed*; this is in conflict with the premise that the tongue should be relaxed during articulation.

Finally, most recommendations found within music pedagogy sources did not appear to consider either the impact of native language or the study of phonetics. The prevalence of conflicting opinions within these music pedagogy sources further establishes the need for empirical research in order to ascertain the most effective ways to teach young wind players how to articulate clearly and accurately.

Full-Band Method Books

Full-band (group) method books were the final source of pedagogical materials investigated within this literature review. The current study utilized intact seventh-grade bands within the public school system. Within this type of learning environment, full-band method books are typically incorporated as a source of unison practice exercises during rehearsals. Although method books for individualized instruction are prevalent, these are not designed for full-group activities, such as those incorporated within the current study. As such, only full-band method books were examined within this review.

Based on eight years of public school teaching, the current researcher found that information about the fundamentals of playing, including articulation, is most often included within the first book of a given series (viz., Book One). More advanced books (viz., Book Two or Book Three) often bypass an introductory section altogether and move immediately to additional (more advanced) playing exercises. During the investigation of full-band method books, the current researcher nonetheless examined a number of these advanced books; in most cases, the researcher’s assumption was confirmed, as these books moved immediately into more advanced playing exercises. Although some advanced method books contained a duplication of the introductory materials from the first book in the series, this researcher found no additional materials regarding articulation within the advanced-level books inspected. As such, only the first book within each series will be summarized in the current literature review.

Examination of individual full-band method books.

The current researcher analyzed twenty-one full-band method books regarding the ways in which the associated authors addressed the subject of articulation. Each book was examined for specific information about the act of tonguing. Statements about articulation styles (such as the performance of accents, slurs, etc.) were not included in this review, since, as stated previously, this represents a different meaning of the term *articulation* than that which constitutes the focus of the present study. Each method book will be discussed individually. A summary will be provided at the conclusion of this section.

Several full-band method books contained no information regarding the subject of articulation on a wind instrument. These included two related series of method books: (a) *Tunes for Flute Technic: Student Instrumental Course* (Steensland & Weber, 1969)[9] and *Studies and Melodious Etudes for Flute* (Ployhar & Weber, 1969) as well as (b) *The*

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[9] The title of several method books included the specific instrument for which the book was written, such as *Tunes for Flute Technic: Student Instrumental Course* (Steensland & Weber, 1969), *Studies and Melodious Etudes for Flute* (Ployhar & Weber, 1969), and *Rubank Elementary Method: Flute or Piccolo* (Peterson, 1934). Although the flute books are specifically cited here, all wind-instrument books within these series were investigated.

Yamaha Advantage (Feldstein & Clark, 2001)[10] and *The Yamaha Advantage: Primer* (Feldstein & Clark, 2002).

All other full-band method books reviewed by the current researcher contained at least some information about articulation. *Band Method* (Sueta, 1974) included no explanation of tonguing, but included a chart that assigned specific syllables to note values of different durations. These included: "Too oo oo oo" for whole-notes, "Too oo oo" for dotted-half-notes, "Too oo" for half-notes and dotted-quarter-notes, "Too" for quarter-notes, "Ta e (soft a, long e)" for dotted-eighth-notes, "Ta (soft a)" for eighth-notes, "T (spoken letter T)" for sixteenth-notes, and "Da Da Da (soft a)" for triplets (p. 1).[11] These syllables were also included above the musical staff for many exercises throughout the book.

Breeze-Easy Method (Kinyon, 1984) contained the statement, "Start each note with the tip of your tongue" (p. 4). No other reference to tonguing was found, although the statement, "Your teacher will show you how to play correctly" (p. 4) was included.

In the flute book, *Rubank Elementary Method: Flute or Piccolo* (Peterson, 1990) included: "Attack each Note with the syllable 'Tu' not 'Thu'" (p. 1). However, no references to articulation were found in the remaining woodwind books or in any of the brass books within this series.

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[10] The word TOO was included in several of the woodwind books within this series; however, this seemed to be in reference to an intended shape of the mouth rather than a reference to tonguing. For example, the flute book contained the instructions "Form your lips as if saying 'too'" (p. 2).

[11] Each of these vocal models (such as "*Too oo oo oo*")) included a slur marking over the top of the letters, connecting the vowels together.

Band Technique: Step-by-Step (Elledge & Haddad, 1992) contained no information about the process of tonguing. However, each unit within the book (every two pages) contained an exercise labeled *Tonguing Study*. These scale-based exercises featured a consistent rhythm pattern, with an ascending scale made up of four 16th-notes and one quarter-note on each scale degree, followed by a descending scale made up of four 16th-notes on each scale degree. However, no information was supplied regarding the manner in which to play these exercises.

Accent on Achievement (O'Reilly & Williams, 1997) included instrument-specific information about articulation in the introductory pages, including:

- flute: "…start blowing a focused stream of air by whispering 'doo'…. Next, produce several notes on one breath by whispering 'doo-doo-doo', being sure that your tongue is behind your teeth" (p. 4);
- single-reed instruments: "Lift your tongue slightly so that it contacts the reed. Now start to exhale and then release the reed as if saying 'Too,'" (p. 4); and "Next, produce several notes on one breath by touching the reed with your tongue as if saying 'Too-too-too-too--' while exhaling" (p. 4);
- double-reed instruments: "Lift your tongue so that it touches the tip of the reed. Now start to exhale and then release the reed with your tongue as if saying 'Too'" (p. 4); and "Next, produce several notes on one breath by touching the reed with your tongue as if saying 'Too-too-too-too--' while exhaling" (p. 4); and
- brass: "Take a deep breath through the corners on your mouth, then buzz through the mouthpiece starting with the syllable 'Tah'" (p. 4).

Do It! Play in Band: A World of Musical Enjoyment at Your Fingertips (Froseth, 1997) included the following statement for the flute in the introductory pages: “Blow your lips apart with the syllable ‘du’ (as in ‘duty’)” (p. 2). No instructions regarding articulation were given for the remaining woodwind instruments or for any brass instruments, with the exception that the musician was instructed to “keep the embouchure stable when changing notes or tonguing” (p. 2).

Premiere Performance: An Innovative and Comprehensive Band Method (Sueta, 1999) included specific instructions for each instrument, including:

- flute and single-reed instruments: “Release your breath by whispering a firm ‘Too’” (p. 3);
- double-reed instruments: “Place your tongue lightly on the tip of the reed and release your breath by whispering a firm ‘Too’” (p. 3); and
- brass: “Bring your lips firmly together and release your breath by whispering a firm ‘Too’ which will create a buzzed tone” (p. 3).

Additionally, the instructions, “Always use your tongue (Too) to start each note” (p. 7) and “Tongue each quarter note clearly” (p. 8) were included on several examples within the opening pages of each book.

Musical Magic (Jarrard, 2002a) contained no information about articulation in many books, with the exception of the word TOO appearing above notes on selected exercises within the first 11 pages.[12] Some instruments, however, were given specific instructions, including:

- clarinet/bass clarinet: "On Pg. #1 you will begin to tongue the reed to begin your tones" (introductory materials – no page number provided);
- bassoon: "Tongue the reed by saying 'tah' for each tone" (introductory materials – no page number provided); and
- brass: "Tongue by saying 'too' or 'doo' for each note" (introductory materials – no page number provided).

Musical Magic: Rehearsal Preps and Pieces (Jarrard, 2002b) contained no information about how to use the tongue to articulate. However, one page was dedicated to exploring various articulation styles and included instructions such as, "Legato tongue (soft tongue strokes…)" (p. 4). *Musical Magic: Band Rehearsal Book 1* (Jarrard, 2005) contained an exercise titled, "Tongue Carefully" (p. 2), although the exercise itself was not unique regarding the use of the tongue. No other references to articulation were found.

Essential Elements 2000 (Lautzenheiser et al., 2004)[13] contained at least three references to articulation within the opening pages of each book. These included the statements: "Slowly whisper [TOO or TAH][14] as you gradually exhale air into your palm" (p. 2); "Your tongue is like a faucet or valve that releases the airstream" (p. 2); and

[12] Individual syllables were suggested for each instrument, including: TOO for flute, oboe, clarinet, bass clarinet, alto and tenor saxophone, trumpet, French horn, trombone, baritone/euphonium, and tuba; and TAH for bassoon.
[13] All participating bands within the current study utilized the *Essential Elements 2000* series within the seventh-grade band program.
[14] Each instrumental book recommended a specific syllable, including TOO for all woodwind instruments and TAH for all brass instruments.

"Whisper [TOO or TAH] and gradually exhale your full airstream" (p. 2), which was written near two whole notes that included an articulation syllable (either TOO or TAH) under the noteheads. In addition, specific instructions were given for some instruments, including:

- oboe: "Adjust the position of the reed so the tip barely touches your tongue" (p. 2); and
- brass: "Start your buzz with the syllable 'tah'" (p. 2).

In addition, this method book contained a CD-ROM that included a video presentation about articulation. Instrument-specific videos were included in each individual method book and contained both verbal instructions as well as recommended articulation syllables for each instrument; these coincided with the written information found within the method book itself. *Essential Elements* (Rhodes, Bierschenk, & Lautzenheiser, 1991), the predecessor to *Essential Elements 2000*, contained nearly identical information, with the exception that all instruments were assigned the syllable TAH (rather than TOO for woodwinds and TAH for brass) within the earlier book; in addition, this earlier version did not include a CD-ROM.

Standard of Excellence: Comprehensive Band Method (Pearson, 2004a) and *Standard of Excellence: Enhanced Comprehensive Band Method* (Pearson, 2004b) contained information about articulation only in the flute book, which instructed, "Take a full breath of air and blow over the hole using the syllable 'doo' to play a long steady tone" (p. 3). For all other instruments, the instructions included only, "Take a full breath of air and play a long, steady tone" (p. 3).

Essential Musicianship for Band: Fundamental Ensemble Concepts (Green, Benzer, & Bertman, 2005) included instructions under particular playing exercises, including: “The tongue should move up and down naturally; the same part of the tongue should go to the same spot with the same strength each time” (p. 3); “The tongue and fingers should move at exactly the same time” (p. 6); and “Pay close attention to when notes are tongued or slurred” (p. 11). These instructions were repeated verbatim on various exercises throughout the book.

Measures of Success: A Comprehensive Musicianship Band Method (Sheldon, Balmages, Loest, & Sheldon, 2010) contained the statement, “Articulation is how the tongue and the air begin a note. Your director will show you how to articulate a note” (p. 4). No other references to tonguing were found in this method.

Sound Innovations for Concert Band: A Revolutionary Method for Beginning Musicians (Sheldon, Boonshaft, Black, & Phillips, 2010) contained both instrument-specific and general instructions on the introductory pages. Instrument-specific instructions included:

- flute: “Start the sound by saying ‘poo’ or ‘too’ as you blow a focused stream of fast air across the center and outside edge of the embouchure hole” (p. 3); additionally, the authors recommended that the tongue should stay “behind your teeth” (p. 3);
- oboe: “Touch your tongue gently against the tip of the reed and exhale quietly as you say ‘too’” (p. 3);

- clarinet: "Touch your tongue gently against the reed and exhale quietly as you say 'tee'" (p. 3);
- bass clarinet/tenor-baritone saxophone: "Touch your tongue gently against the reed and exhale quietly as you say 'too'" (p. 3);
- alto saxophone: "Exhale quietly into the mouthpiece as you say 'hah.' Once you have achieved a sound, touch your tongue gently against the reed and exhale quietly as you say 'tah' or 'too'" (p. 3); and
- brass: "Buzz and exhale through the mouthpiece while you say 'tah'" (p. 3).

In addition, a general statement was included: "Play several sounds on one breath by saying, [TOO, TOO, TOO][15] as you exhale. This is called 'tonguing' since you are using your tongue to start the new sound" (p. 3). This method book also contained a CD-ROM that included a video presentation about articulation. Instrument-specific videos were included within each individual method book and contained both verbal instructions as well as recommended articulation syllables for each instrument. However, the information within these videos was not in agreement with the written information found within the method book itself. For example, the trumpet video found on the CD-ROM recommended the articulation syllables TU or DU, but the method book itself contained instructions to use the syllable TAH.

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[15] Each instrument was assigned a specific syllable, including: DOO for flute; TOO for oboe; TEE or TOO for clarinet, bass clarinet, tenor saxophone, and baritone saxophone; TAH or TOO for alto saxophone; and TAH for all brass instruments.

Summary of full-band method books.

To summarize, there is surprisingly little attention paid to articulation within full-band methods books. Figure 3 was included in an effort to summarize the materials found regarding articulation within the 21 full-band method books reviewed. As can be seen in this summary chart, four method books contained no information about articulation (neither articulation syllables nor instructions about how to articulate). Of the remaining 17 books, six contained no suggestions for articulation syllables, four recommended syllables only for some instruments, one recommended syllables for some instruments *and* included generic instructions (TOO under note heads), three recommended the same syllable for all instruments, and three had instrument-specific suggestions for each instrument. Likewise, of the 17 remaining books, two had no instructions regarding how to articulate, four provided specific instructions for only some instruments, five had generic instructions for all instruments, three provided generic instructions for all instruments as well as instrument-specific suggestions for some instruments, one contained (only) instrument-specific suggestions for each instrument, and two provided both instrument-specific instructions as well as generic suggestions for all instruments. Regarding the location of information about articulation within these books, 10 of the remaining 17 books included information about articulation in only one section (usually an introductory page), two had information within the main body of the book (but not in the introductory section), and five included information both in the introductory section and within the main body of the book. Finally, two method books contained CD-ROMS with video presentations that supplemented the method book itself; these represented the most thorough presentation of information regarding articulation.

The information presented in full-band method books reflects the findings within other music pedagogy sources; similar themes and strategies were found, but these were not consistent between (and sometimes within) method books. All too often, such information was relegated to the introductory pages. Accurate and consistent information regarding articulation must be presented to young wind players from the onset of instruction and reviewed regularly. Most full-band method books do not include this combination.

	No Info found	ARTICULATION SYLLABLES				ARTICULATION INSTRUCTIONS				LOCATION OF INFORMATION		Other
		None	Generic	Only Some Instruments	Specific for All	None	Generic	Only Some Instruments	Specific for All	Specific Location	Throughout	
Studies and Melodious Etudes for [Flute] (Ployhar and Weber, 1969)	✓	✓				✓						
Tunes for [Flute] Technic: Student Instrumental Course (Steensland & Weber, 1969)	✓	✓				✓						
Band Method (Sueta, 1974)			✓			✓				✓	✓	Syllables based on length of notes
Breeze-Easy Method (Kinyon, 1984)		✓					✓			✓		
Rubank Elementary Method: Flute or Piccolo (Peterson, 1990)				Flute				Flute		✓		
Essential Elements (Rhodes, Bierschenk, & Lautzenheiser, 1991)			✓				✓	Oboe, Brass		✓	✓	
Band Technique: Step-by-Step (Elledge & Haddad, 1992)		✓				✓					✓	Tonguing exercises throughout
Accent on Achievement (O'Reilly & Williams, 1997)					✓				✓	✓		
Do It! Play in Band: A World of Musical Enjoyment at Your Fingertips (Froseth, 1997)				Flute			✓	Flute		✓		
Premiere Performance: An Innovative and Comprehensive Band Method (Sueta, 1999)			✓				✓		✓	✓	✓	
The Yamaha Advantage (Feldstein & Clark, 2001)	✓	✓				✓						
The Yamaha Advantage: Primer (Feldstein & Clark, 2002)	✓	✓				✓						

Figure 3. Summary of full-band method books reviewed.

	No Info found	ARTICULATION SYLLABLES				ARTICULATION INSTRUCTIONS				LOCATION OF INFORMATION		Other
		None	Generic	Only Some Instruments	Specific for All	None	Generic	Only Some Instruments	Specific for All	Specific Location	Throughout	
Musical Magic (Jarrard, 2002a)			✓	Bassoon, Brass				Clarinet, B.Clarinet, Bassoon, Brass		✓	✓	
Musical Magic: Rehearsal Preps and Pieces (Jarrard, 2002b)		✓					✓			✓		Page for articulation styles
Essential Elements 2000 (Lautzenheiser et al., 2004)					✓		✓	Oboe, Brass		✓		CD-ROM
Standard of Excellence: Comprehensive Band Method (Pearson, 2004a)				Flute				Flute		✓		
Standard of Excellence: Enhanced Comprehensive Band Method (Pearson, 2004b)				Flute				Flute		✓		
Essential Musicianship for Band: Fundamental Ensemble Concepts (Green, Benzer, & Bertman, 2005)		✓					✓				✓	
Musical Magic: Band Rehearsal Book 1 (Jarrard, 2005)		✓					✓			✓		One exercise
Measures of Success: A Comprehensive Musicianship Band Method (D. A. Sheldon, Balmages, Loest, & Sheldon, 2010)		✓					✓			✓		
Sound Innovations for Concert Band: A Revolutionary Method for Beginning Musicians (R. Sheldon, Boonshaft, Black, & Phillips, 2010)					✓		✓		✓	✓		CD-ROM
Totals	4	10	4	5	3	6	10	8	3	15	6	0

Research Studies

In addition to the pedagogical materials previously summarized, the current researcher found a number of studies that relate to the subject of articulation on a wind instrument. First, a set of non-empirical research studies provides (a) an historical perspective regarding articulation and (b) an investigation of musical stuttering. Next, empirical research studies comprising two categories will be presented: (a) studies that utilized technology to provide evidence of specific physiological responses that occurred during performance on a wind instrument and (b) studies that investigated specific techniques or teaching methods pertaining to articulation on a wind instrument. Individual research studies within each of these three categories of investigation will be discussed separately, with summary materials provided at the conclusion of each section.

Non-empirical research studies.

The first category of research included non-empirical studies related to the general topic of articulation on a wind instrument. McCann (1989) investigated brass articulation from an historical perspective. He found that the consideration of tongue arch with regard to brass playing stemmed from Germany. The inclusion of vocal models to initiate the action of the tongue appeared within German method books from 1885-1907. These models received a great deal of attention in the United States beginning in 1935, when the "use of various syllables, usually an 'OO' through 'EE' sequence, to simulate the desired raising of the middle arch of the tongue for different registers becomes prominent in the pedagogy literature" (p. 119). This strategy aligns with the recommendations found within the music pedagogy sources summarized previously. Regarding the placement of the tongue during articulation, McCann stated, “Prior to 1920 a majority of authors favor placement of the tongue between the lips when making initial and repeated articulations. After this date almost all authors favor placement of the tongue behind the top teeth for articulation” (p. 103). This study was unique in providing an historical perspective on the topic of articulation, including a documented change in the United States during the 20th century regarding the recommended tongue position for articulation on a brass instrument.

Cochran (2004) conducted a study to investigate musical stuttering, which he considered analogous to stuttering in speech. Musical stuttering occurs when the tongue locks into place after an inhalation, causing a build-up of pressure in the mouth, throat, and lungs. When the tongue is released, the resulting note “is ‘stuttered’ rather than articulated clearly. The desired syllable ‘toh’ is replaced by a series of one or more short repetitions, such as ‘t-t-toh’” (p. 3). In more extreme cases, the performer is unable to release the tongue and is forced to stop and try again; Cochran compared this severe locking of the tongue during musical performance to the Valsalva maneuver, which is a parallel condition that can take place during speech.

Cochran (2004) cited the tendency to dwell on the mechanics of performance within brass pedagogy as a source of this problem. In this regard, he stated, “Specifics about the location of the tongue… should be avoided whenever possible” (p. 53). Further, Cochran suggested that the expectations of perfection that are placed on college students can create too much pressure for immediate success, which can lead to musical stuttering. Cochran recommended audio recordings, tactile approaches (such as blowing an articulated airstream on the back of the hand), and visual models of relaxed playing as strategies to prevent or eliminate musical stuttering during performance. Cochran's suggestion of *tactile approaches* appears to the current researcher to parallel the use of wind-pattern exercises, as described previously. In addition, his recommendation to incorporate modeling in place of specific physiological instructions was noteworthy, since most music pedagogy sources utilize the latter.

Although the review of literature revealed only two non-empirical research studies, each added a unique perspective to the overall view of articulation. McCann (1989) found that teaching strategies regarding articulation changed in the early 20th century in the United States. Cochran (2004) recommended the use of audio recordings, tactile approaches, and modeling in order to avoid the development of musical stuttering on a wind instrument.

Empirical studies that investigate physiology.

In the early 20th century, any determination of success (or lack thereof) regarding articulation was necessarily based on external physical observations or an assessment of the resulting musical tones, interpreted through the aural lens of the student and teacher. Advances in technology during the mid-20th century, however, allowed for "precise knowledge of the role performed by the tongue" (Amstutz, 1970, p. 2). As such, studies emerged that utilized technology to investigate the internal physiological changes that take place during musical performance.

A number of these empirical studies investigated physiological changes during vocal performance (Appelman, 1954; Burton, 1975; Hohn, 1959; Hunt, 1970; Jones, 1971; Lindberg-Kransmo, 2002; Russell, 1931; Whitworth, 1961). Other studies investigated wind playing, but did not focus on the movement or use of the tongue (Bailey, 1989; Brown, 1973; Carter, 1999; Peters, 1984).[16] Since the current study is focused primarily on the use of the tongue during articulation on a wind instrument, studies that focused on vocal performance or other (non-tongue) physiological aspects of performance on a wind instrument will not be elaborated upon, unless their role in this line of research was otherwise noteworthy. Only those studies that focused on the role of the tongue during wind instrument performance will be summarized in depth within the current review of literature. At the conclusion of this section, a summary will be provided of the most pertinent information as it relates to the current study of articulation.

Hall (1954) is considered a pioneering investigation into the use of technology for research in wind instrument performance. Hall used both photography and X-ray photography to investigate the position of the tongue and jaw, as well as the size and shape of both the oral and pharyngeal cavities during trumpet performance in the low, middle, and high registers (concert A-flat^3, A-flat^4, and A-flat^5, respectively).[17] Nine adult male professional-quality trumpet players were selected as participants, including

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[16] Some of these studies included discussions regarding the tongue, but were focused on other physiological changes; for example, Peters (1984) investigated changes in the larynx when tonguing. Since the focus of this study was on the larynx rather than the tongue, this study and others like it were not summarized within the current review of literature.

[17] Specific pitches will be identified based on Laitz (2003). Within this system, middle C is labeled C^4.

two members of the Oklahoma City Symphony, a former member of the Birmingham Symphony Orchestra, three high school band directors, and three undergraduate students. Participants were selected based on their ability to easily change registers, as determined by self-assessment and the observations of the researcher.

During performances, Hall (1954) took lateral X-ray pictures of the oral cavity of each performer when playing the trumpet at each of the three specified pitch levels. This allowed Hall to ascertain the position of the jaw and tongue as well as the size and shape of the oral and pharyngeal cavities. Frontal photographs and audio recordings were utilized during performances at all three pitch-levels during trumpet performance. Finally, Hall used spectrographic images to compare how physiological changes impacted tone quality within each register. This complete procedure was carried out on each participant's personal trumpet as well as a control trumpet (used by all participants to compare tone quality).

In addition, Hall (1954) investigated the position of the tongue and jaw when singing particular vowel sounds (including /ɑ/ as in *pod*, /i/ as in *bead*, and /u/ as in *booed*) through the use of lateral X-ray pictures. Three participants sang each of the three vowel sounds in the upper register (B-flat^3 and C^4), three sang in the middle register (F^3 and G^3), and three sang in the low register (B-flat^2 and C^3), thus covering what Hall considered to be a comfortable range within the adult male voice. This investigation of sung vowels allowed Hall to compare the position of the tongue and jaw when singing with those assumed when playing the trumpet. However, it was unclear to the current researcher why Hall did not have each participant sing within all three pitch-levels, which would have allowed for a comparison of the tongue and jaw between singing and playing the trumpet within each participant.

Although no statistical analysis was conducted in this study, Hall (1954) made the following observations regarding the use of the tongue:

- Participants tended to assume unique (individualistic) positions of the tongue and jaw during trumpet performance. The most common oral shape utilized during trumpet performance approximated the position of the tongue and jaw when saying the vowel /ɑ/ as in *pod.*
- Trumpet performers tended to use the same basic oral shape in all registers. The variations in the shape of the oral cavity were not large between registers within subjects; additionally, these changes were less pronounced during trumpet performance than during singing.
- When moving from the middle to the low register, the most common tendencies included: (a) lowering the tongue, (b) moving the high point of the tongue to the rear, or (c) moving the high point of the tongue slightly forward and upward.
- The act of moving to the upper register showed the most individualistic tendencies between participants; the most common tendency was to move the high point of the tongue forward and downward.
- The use of various vowels (/ɑ/ as in *pod* and /u/ as in *booed*) resulted in formant changes in the resulting pitches, both in terms of cycles per second (cps) and the strength of the formant in comparison to the fundamental; this occurred within both low and high tones.

Based on observed differences in tone quality, Hall recommended that the movement of the tongue between registers should be minimized.

Hall (1954) also briefly discussed an additional high-tone experiment done with only three participants. This supplemental investigation was not a formal part of the study, but seemed to represent the desire by three participants to further explore physiological differences between ranges. When playing an "extreme high E" (p. 250),[18] all three participants shifted to the vowel /i/ as in *bead*.

Despite its importance as a pioneering investigation into the into the use of technology for research in wind instrument performance, the lack of statistical analysis and the small number of participants in this study preclude generalizations regarding the findings. Additionally, although Hall (1954) included a listing of the most common tendencies observed, these tendencies were superseded by Hall's statement that trumpet players assumed unique (individualistic) positions of the tongue during trumpet performance. Nonetheless, this study initiated a chain of further investigations that utilized technology to explore the physiology of wind instrument performance.

Whitworth (1961) appears to be the first to use cinefluorography (motion picture X-rays) as a tool for investigating physiological changes during musical performance. Although this study focused on vocal performance, the inclusion of cinefluorography as a

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[18] Hall did not specify precisely which octave he was referring to within the body of the study and did not include a representation on the musical staff. He did, however, label this note "e^{111}" (p. 291) within Appendix D. Assuming that this method of classification was the same as that utilized by Anfinson (1965), this would correspond to the note E^6 as specified by Laitz (2003).

tool for scientific exploration regarding the physiology of musical performance was an important step forward in this line of research.

Anfinson (1965) used cinefluorography to investigate supralaryngeal adjustments in clarinet playing, including staccato versus legato tonguing at a set tempo, staccato tonguing at various tempos,[19] and tonguing and slurring in different registers. Using projected film images, Anfinson made tracings at the point of contact with the reed (beginning of a tone) and the point of maximum tongue withdrawal from the mouthpiece (middle of a tone); these tracings, an example of which can be seen in Figure 4, included: (a) the pterogomaxillary fissure, (b) the anterior upper incisor, (c) the anterior lower incisor, (d) the anterior nasal spine, (e) the clarinet mouthpiece, (f) the tongue, (g) the hard and soft palate, and (h) the posterior wall of the pharynx. The pterogomaxillary fissure, anterior nasal spine, anterior upper incisor, and hard palate served as fixed reference points from tracing to tracing. Reference lines were drawn, including: (a) an upper horizontal reference line from the pterogomaxillary fissure through the anterior nasal spine; (b) a vertical reference line, at a right angle to the upper reference line, through the tip of the anterior upper incisor; and (c) a lower horizontal reference line at a right angle to the vertical reference line, through the tip of the anterior upper incisor to the posterior wall of the pharynx. Measurements were made from: (a) the high point of the tongue to the upper horizontal reference line, in order to show the height of the tongue in the oral cavity; (b) from the high point of the tongue to the vertical reference

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[19] It was unclear to the current researcher why Anfinson (1965) chose to include only staccato tonguing within this portion of the performance exercise.

line, in order to show the anterior-posterior placement of the tongue high-point; (c) from the posterior wall of the pharynx on the lower horizontal reference line to the posterior portion of the tongue, in order to show the throat opening; (d) from the posterior portion of the tongue on the lower horizontal reference line to the vertical reference line, in order to show the posterior placement of the posterior tongue; (e) from the tip of the anterior upper incisor to the tip of the lower anterior incisor, in order to show the opening between the incisors; (f) from the upper portion of the tongue touching the mouthpiece to the lower portion during contact, in order to show the extent of tongue contact; (g) from the closest anterior portion of the tongue to the upper incisor during withdrawal, in order to show the amount of horizontal withdrawal from the upper incisor; and (h) from the high point of the anterior portion of the tongue during withdrawal to the upper horizontal reference line, in order to show the height of the anterior portion of the tongue during withdrawal.[20]

[20] The level of detail provided within this description of Anfinson (1965) will not be duplicated in subsequent studies, but was included at present to provide an example of the measurements utilized within this line of research.

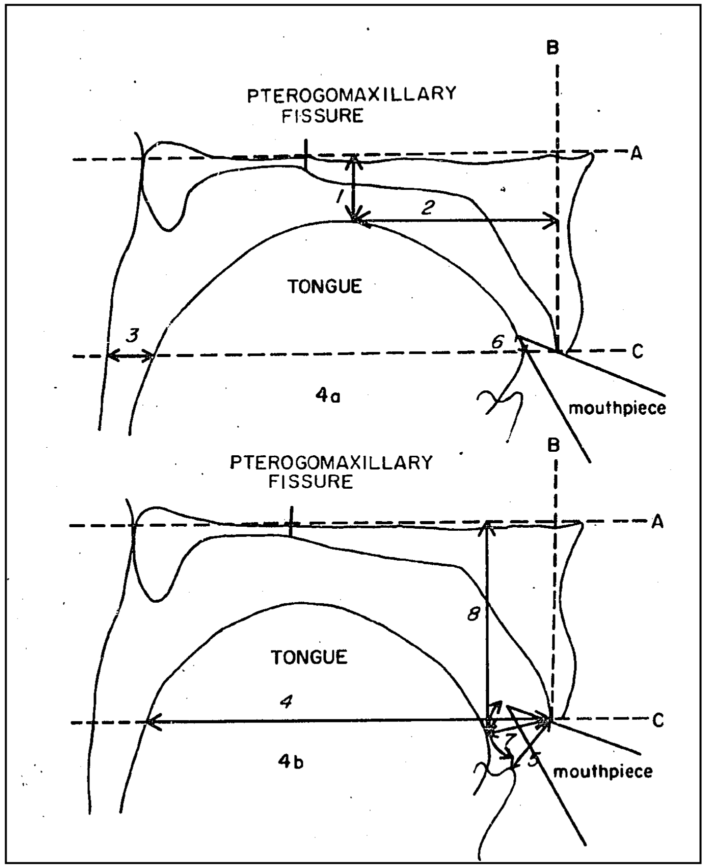

Figure 4. Sample of tracing procedures from Anfinson (1965). Two sample tracings are included, showing: (4a) tongue contacting mouthpiece, (4b) tongue withdrawn, (A) upper horizontal reference line, (B) vertical reference line, (C) lower horizontal reference line. Measurements included: (1) tongue high point (vertical dimension), (2) tongue high point (horizontal dimension), (3) throat opening, (4) posterior tongue (horizontal dimension), (5) incisor opening, (6) contact size, (7) anterior tongue (horizontal withdrawal), (8) anterior tongue (vertical withdrawal). Adapted from *A Cinefluorographic Investigation of Supralaryngeal Adjustments in Selected Clarinet Playing Techniques*, by R. E. Anfinson, 1965, State University of Iowa: University Microfilms, Inc. Copyright by Roland Emmett Anfinson. Image published with permission of ProQuest LLC. Further reproduction is prohibited without permission. Image produced by ProQuest LLC as part of ProQuest® Historical Newspapers. Inquiries may be made to: ProQuest LLC, 789 E. Eisenhower Pkwy, P.O. Box 1346, Ann Arbor, MI 48106-1346 USA. Telephone (734) 761-7400; Email: info@proquest.com; Webpage: http://proquest.com.

Among the nine collegiate clarinetists who participated, four used anchor tonguing, while the remaining five used tip-to-tip tonguing; all subjects contacted the reed with the tongue at or near the tip of the reed on its underside. Regarding the movement of the tongue, Anfinson (1965) stated, "the complex musculature of the tongue does not allow the tip to operate with complete independence while contacting and withdrawing from the reed" (p. 53); rather, the tongue as a whole showed movement when the tip of the tongue was utilized. Upon withdrawing from the reed, the tip of the tongue moved down and back.

Data were analyzed, based on the measurements described previously, using an analysis of variance (ANOVA). There were significant differences, $p < .05$, found between various playing conditions, including:

- when comparing staccato and legato tonguing, the basic action of the tongue was the same. However, during the performance of staccato notes, the high point of the tongue was higher in the oral cavity and the tongue tip withdrew less (horizontal dimension) from the mouthpiece than on legato notes. In addition, when comparing the contact and withdrawal position of the tongue among both articulation conditions, the high point and the posterior portion of the tongue moved further back (horizontal dimension) during withdrawal from the mouthpiece
- when comparing performances of staccato passages at various tempos, the tip of the tongue withdrew less (horizontal dimension) from the mouthpiece at faster tempos (accelerated sixteenth-notes versus eighth-notes). Likewise, trends in the

means for the dimensions of both the high point and posterior portion of the tongue (horizontal dimensions) reflected a more forward position during the performance of accelerated sixteenth-notes versus eighth-notes (although these differences did not achieve statistical significance). In addition, when comparing the contact and withdrawal position of the tongue among all speeds, the high point of the tongue was further back (horizontal dimension) during withdrawal

- when comparing changes in register during both tongued and slurred passages, trends emerged regarding the high point of the tongue (horizontal and vertical dimensions) as well the posterior position of the tongue (horizontal dimension). Adjustments within the low register were slight or non-existent. However, as the music ascended, the high point of the tongue moved progressively forward and further downward and the posterior position of the tongue moved forward. These trends began upon the onset of the sixth or seventh notes in the performance exercise (concert B-flat^4 and D^5, respectively) and achieved a level of significance by the seventh or eighth notes (concert D^5 and F^5, respectively) in comparison to the lowest notes played (concert D^3 and F^3).

Anfinson's (1965) study appears to be the first to include both cinefluorography and statistical analysis regarding an investigation of the physiological changes within the oral cavity during performance on a wind instrument. However, the inclusion of only one instrument (clarinet) and the small sample size ($N = 9$) limit the ability to generalize the results beyond the clarinet players within the study. Although the study effectively ascertained physiological changes that occurred during clarinet performance, no attempt was made to connect these changes to the quality of the performances themselves. It is noteworthy that Anfinson found statistically significant differences regarding the tendency of the high point of the tongue to move progressively forward and downward during an ascent in pitch, as this goes against common beliefs found within the review of pedagogical literature.

Two studies investigated the supralaryngeal adjustments that take place during French horn and trumpet performance (Meidt, 1967; Merriman, 1967).[21] Meidt used cinefluorography to compare (a) tonguing in various registers, (b) supralaryngeal position immediately prior to the sounding of a tone versus the position during the tone, and (c) single-, double-, and triple-tonguing on various repeated pitches among five French horn and five trumpet players (college students and faculty).[22] Performance tasks included slurred and tongued arpeggio patterns at loud (forte) and soft (piano) dynamic markings, slurred scale patterns in various ranges, double- and triple-tonguing exercises, and sung vowels (including TEE, TOO, and DAH). The sung vowel task was included in order to make comparisons of the position of the tongue in various playing ranges with those observed during the production of particular sung vowels. Regarding the use of the

[21] These two separate documents appear to summarize the same study. Frohrip (1972) and De Young (1975) noted this similarity in their studies. In this regard, Frohrip indicated that any discussion of the "objectives, procedures, equipment, and conclusions for the Meidt study should be considered as applying to Merriman's project as well" (p. 28). Since Merriman's document is classified as a *summary report*, only Meidt's study will be referenced from this point forward, although both documents are implied.
[22] Meidt does not provide a breakdown other than to note that all participants had played professionally and had earned varying degrees of recognition as soloists.

tongue, measurements included the anterior position of the tongue (horizontal and vertical dimension) and tongue high point (horizontal and vertical dimension).

Meidt (1967) analyzed data using ANOVA.[23] He found that trumpet and French horn players assumed individualistic oral shapes during musical performance. The most common tongue position was intermediate between /ɑ/ as in *pod* and /u/ as in *booed*. For six participants, the tongue tended to move forward and upward for higher notes (and thus backward and downward for lower notes), while the remaining four participants exhibited minimal supralaryngeal variation throughout the entire playing range. In this regard, Meidt indicated that the variation found between subjects "negated the possibility that a particular vowel formation would generally correspond to a specific range" (p. 61). In addition, Meidt found that the pharyngeal dimensions of French horn players tended to be smaller (tongue raised) for higher notes, whereas the opposite tended to be true among trumpet players. No relationship was found between the position of the tongue before the attack and the register of the tone produced after the attack. The same supralaryngeal positions were used for corresponding pitches played at forte and piano dynamic levels. The tongue tended to remain slightly higher and more forward during tongued notes than during corresponding slurred notes.

Meidt (1967) concluded that specific vowel formations did not relate to particular pitch ranges; this is noteworthy for its digression from a common claim within pedagogical sources that specific tongue positions (and vowel formations) correspond to

[23] Although Meidt included 245 tables and 187 figures in his report, he did not include precise information within the body of this study regarding the statistical significance of specific outcomes and how these related directly to his stated results.

various performance ranges. Despite Meidt's inclusion of tendencies regarding physiological changes during trumpet and French horn playing, these must be viewed within the greater context that individualistic tendencies were found between performers. Finally, the range of experience levels among participants (college students and faculty) raises questions regarding the outcomes reported within this study.

Haynie (1967) utilized the combination of videofluorography and video recordings to investigate physiological changes during trumpet playing.[24] Haynie stated that "over seventy [college] students" (p. 2) were examined over the course of five years.[25] Although no attempt was made to critically evaluate the data (Amstutz, 1970), Haynie's report summarized many observations, including the position of the lower jaw, teeth aperture, instrument- or head-pivot, and the degree of mouthpiece pressure during trumpet performance. Regarding the tongue, Haynie observed the following tendencies: (a) the tongue arched during the performance of high notes, but the exact location of the arch varied based on the size of the tongue and oral cavity; (b) the tongue moved between the teeth (and sometimes touched the lips) during articulation for notes in the lower register, but touched behind the upper teeth for notes in the upper register; and (c) the positions of the teeth, jaw, and tongue when speaking the words TU and KU were different than the corresponding positions assumed when performing on the trumpet; however, "in forming the embouchure and not making a vocal sound, the position of the tongue for attack is almost identical with the position of [the] tongue while playing" (p.

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[24] The summary information provided here was based on the information found in Haynie's conference brochure; a separate research document was not found.
[25] Haynie did not specify the exact number of students within his report.

15). Although Haynie's description of unvoiced attacks (forming the embouchure, but not making a vocal sound) lacked detail, the current researcher interpreted this process to be similar to wind-pattern exercises, as described previously. If this interpretation is correct, Haynie's observation would indicate that wind-pattern exercises (unvoiced attacks) more closely resemble the act of tonguing on a wind instrument than does the use of spoken (voiced) syllables.

The lack of statistical analysis within Haynie (1967) precludes the ability to generalize the findings beyond the sample for the study and reduces the current researcher's confidence regarding the claims made in this study. Nonetheless, Haynie's presentation of this research at the conference of the College Band Director's National Association paved the way for future research utilizing videofluorography (De Young, 1975; Frohrip, 1972).

Hiigel (1967) used cinefluorography to compare: (a) the action of the tongue (contact and withdrawal positions) when performing specific pitches (high and low registers) and styles (staccato and legato) with (b) the action of the tongue when speaking selected syllables and (c) the action of the tongue when performing while using syllabic imagery (thinking about a specific syllable while playing). Six professional musicians served as the participants, including two trumpet, two French horn, and two trombone players. The syllables used as a basis for comparison included TAW/TAH/TOO/TEE (for staccato notes, listed from low to high, respectively) and DAW/DAH/DOO/DEE (for legato notes); these were selected based on the results of a survey of college band directors and brass instructors (91 responses, representing a 63% response rate).

Data were analyzed using *t*-tests and ANOVA. Hiigel (1967) reported the following significant differences regarding tongue placement during performance on brass instruments:

- style (staccato versus legato): during staccato playing, the contact tip placement of the tongue was lower, $p < .05$; the withdrawal tip placement was further forward, $p < .01$; and the withdrawal posterior arch was further forward, $p < .01$, than during legato playing. The contact placement of the posterior arch of the tongue showed no significant effects
- performance versus enunciation of matched syllables: the tip of the tongue was further forward and the posterior arch was higher for the enunciation of syllables than during performance (both for contact and withdrawal positions), $p < .01$
- register: as pitch ascended, the withdrawal tip moved upward and further forward, $p < .01$; the contact posterior arch was higher and further back, $p < .01$; and the withdrawal posterior arch was higher and further forward, $p < .01$. The contact placement of the tip of the tongue showed no significant differences between the high and low registers
- between subjects: significant differences were found between the placement of the tongue for respective subjects in all measurement dimensions, $p < .01$; no trends or patterns of differences were established

Finally, the directional tendencies of the tongue for both performance and syllabic recitation were similar; however, no relationship was observed between the tongue placement when reciting selected syllables and the tongue placement when performing related pitches and styles.

Hiigel (1967) concluded that there was no evidence to support the idea that syllabic imagery (thinking a specific syllable) during performance will tend to simulate the tongue position resulting from the enunciation of that syllable. The fact that significant differences were found between participants in all measurement dimensions supports prior research findings, which found oral shape to be individualistic among brass players. Hiigel did not investigate interaction effects between the subjects and each variable. This omission raises questions regarding the significant differences claimed for each individual variable, since (possible) interaction effects influence the ability to make conclusions about individual main effects. In addition, Hiigel used a *p*-value of .05 to claim significant differences regarding the contact tip placement of the tongue between staccato and legato performances; this *p*-value represents a liberal qualifier, one that increases the likelihood of alpha error (α) when including multiple analyses. Finally, the small sample size ($N = 6$) once again raises questions regarding the ability to generalize beyond the brass players in this study.

Hanson (1968) used motion picture X-rays to investigate the larynx, diaphragm, tongue, and lips during trumpet performance.[26] Hanson observed that the vocal cords adduct (close) immediately prior to the production of sound on the trumpet and abduct

[26] The summary provided within this review was based on information found in Hanson's (1968) book; a separate research document was not found. Specific details regarding the subjects and analysis were not included; it appeared to the current researcher that the conclusions were drawn from observations of the X-ray photographs.

(open) at the “immediate moment that sound is produced by the instrument” (p. 55). She concluded that the larynx was the sole determining factor in stopping and starting tone production, as “the lips and tongue showed no contact between the back of the lips and the tongue at the time the sound was interrupted” (p. 56). This conclusion, however, was refuted by Bailey (1989), who (a) discredited the ability of the equipment used in Hanson’s study to support such a claim and (b) suggested that Hanson’s claim was “not upheld by any supportive logic” (p. 27).

Mooney (1968) investigated the effect of the oral cavity on tone production during clarinet performance. In this regard, he constructed a mechanical blowing chamber with an artificial embouchure to replicate the mechanisms of clarinet playing; this allowed him to compare the tone production of the mechanical blowing chamber with that of human performers. Eight college students (undergraduate and graduate) performed four pitches on a clarinet: written G^3, C^4, C^5, and F^5.[27] All participants used the same clarinet, reed, and mouthpiece; pitches were performed at a fixed volume, pitch, and air pressure (based on the use of a sound level meter, stroboscope, microphone, and water manometer [a manometer measures air pressure through the use of tubes that connect two systems; in the event of unequal pressure, the water in the middle of the manometer is drawn toward the side with lower pressure]). X-ray photographs were used to determine the point at which each participant damped the reed and to study the

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[27] Mooney (1968) referred to these pitches as G_4, C_4, C_5, and F_5 and noted that written C_4 referred to “concert A#$_3$ just below middle C on the piano” (p. 27). Since no graphic notation was included, the current researcher is left to assume that the first note listed (G_4) is the lowest pitch within this set of four notes and thus represents G^3 within the notation system (Laitz, 2003) utilized throughout the current study.

position of the tongue during the performance of each of the four tones; this allowed Mooney to replicate these conditions with the mechanical blowing chamber. Each of the four tones were performed using a tongue position corresponding to /i/ as in *bead*, /ɑ/ as in *pod*, and /u/ as in *booed* for both the mechanical and human performers.

A stroboscope, wave analyzer, frequency recorder, and tape recorder were utilized to capture and analyze all performances. Comparisons were made between the position of the tongue during performance and when speaking the vowel sounds. Mooney (1968) found that participants with "adequate tone qualities" (p. 64), as determined by wave spectrum analysis, exhibited a similar pattern for tongue position: during the production of low tones, the tongue was arched in the back of the mouth with the tip of the tongue curved down and back from the lower teeth; as pitch ascended, the tongue arch was lowered and the tip of the tongue moved forward. Participants who did not follow this pattern had "less than average" (p. 75) tone quality, based on wave spectrum analysis. The current researcher questions Mooney's decision to base conclusions regarding tone quality on acoustical analyses rather than the determination of expert judges. However, Mooney did include a discussion regarding the manner in which one participant's weak tone (based on Mooney's own evaluation) was confirmed by acoustical analysis: this participant's tone was "weaker in all the rich tone-producing partials, while in the upper partials it becomes stronger" (p. 47). In addition, Mooney cited additional (extant) research to support the use of acoustical analysis for assessing tone quality.

Mooney (1968) also compared the position of the tongue during clarinet performance with the position of the tongue when speaking. Based on an analysis of the resulting tones (both wave spectrum analysis and pitch intonation), Mooney recommended /u/ as in *b<u>oo</u>ed* for the low register and either /ɑ/ as in *p<u>o</u>d* or /ʌ/ as in *b<u>u</u>d* for the transition to the upper register. Mooney recommended against the use of /i/ as in *b<u>ea</u>d*, with the exception that this vowel can help to shape the facial muscles into an appropriately stretched position, as utilized during clarinet playing. Mooney concluded that the position of the tongue within the oral cavity has an effect on tone quality and pitch intonation during clarinet performance.

Mooney's (1968) conclusion that the position of the tongue within the oral cavity has an impact on both tone quality and pitch intonation aligns with the ideas summarized within the review of pedagogical music sources. However, it is noteworthy that the specific syllables recommended by Mooney (/u/ as in *b<u>oo</u>ed* for the low register and either /ɑ/ as in *p<u>o</u>d* or /ʌ/ as in *b<u>u</u>d* for the transition to the upper register) are in conflict with the suggestions of music pedagogues, as summarized previously. Finally, the current researcher questions Mooney's inclusion of a mechanical blowing chamber within this study. Given the number of possible variables during performance, any attempt to replicate clarinet playing would seem to be flawed, despite the care with which Mooney devised and altered this machine.

Amstutz (1970) used videofluorography to investigate the functions of the oral cavity and tongue during performance on the trumpet, including teeth aperture, instrument pivot, and tongue arch. Through this study, Amstutz sought to continue the work of Haynie (1967). College students and faculty served as participants, including 15 undergraduate students, seven graduate students, and three faculty members. Participants performed three selected exercises, first tongued and then slurred. These exercises included an ascending/descending arpeggio exercise, a second arpeggio exercise that included leaps between non-adjacent notes in the harmonic series, and an exercise consisting of octave leaps. Each exercise spanned from written C^4 to C^6. Measurements were assessed at all three dimensions (teeth arch, instrument pivot, and tongue arch) for each note performed.

Data were analyzed using Hotelling's T^2 statistic. Significant differences were found in tongue arch when moving between notes in the low (C^4) and high (C^6) registers during the performance of the three playing exercises, $p < .01$. Amstutz (1970) determined that the degree of tongue arch increases as pitch ascends (creating a smaller aperture between the tongue and palate) and decreases as pitch descends. When higher pitches were produced, 17 participants arched the dorsum of the tongue and the remaining eight arched the pharyngeal portion of the tongue.[28] Changes in the degree of tongue arch were less pronounced during tongued performances when compared to slurred performances of the same exercises. In addition, there was a notable increase in the amount of tongue motion when the intervals being performed included a skip of at least one tone in the harmonic series (and thus represented larger leaps) in comparison to the performance of adjacent notes within the harmonic series; however, the current researcher noted that Amstutz did not address the differences in spacing between notes of the harmonic series in the lower register (larger gaps between adjacent notes) versus the

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[28] Amstutz (1970) did not provide information regarding the level of experience/performance skill (e.g., undergraduate, faculty) within the presentation of these findings.

upper register (smaller gaps between adjacent notes). In the lower register, the tongue was either flattened against the floor of the mouth or slightly balled behind the pharyngeal portion of the tongue. Amstutz concluded that tongue arch contributed to the quality of the tones produced on the trumpet.

During the presentation of results, Amstutz (1970) stated that statistically significant differences were found for tongue arch between various ranges. However, Amstutz was less precise regarding his remaining claims, leaving the current researcher unsure whether these were merely observations or represented statistically significant differences. For example, despite the use of the word *significant* to describe the differences in the degree of tongue arch when comparing tongued and slurred passages, specific statistical results and *p*-values were not provided.

Frohrip (1972) used videofluorography and X-ray images to investigate the oral cavity during selected tasks while playing the trombone, including the degree of overbite or underbite in the jaw opening, the degree of opening between the upper and lower teeth, and the degree of pharyngeal opening. Participants were comprised of both college students and professional performers/teachers, including six trombonists (four undergraduate students and two professional performers/teachers) and three (non-trombone) brass musicians (one graduate trumpet player, one undergraduate French horn player, and one professional trumpet player), who nonetheless played trombone for the purposes of the study. Two sets of playing tasks were included: one set, designed for non-trombonists, contained basic exercises; a second, more difficult, set was designed for the trombonists. However, only two of the three non-trombone participants played the basic exercise set; the professional trumpet player played the more advanced exercise set, an act that Frohrip considered appropriate based on the resulting performance. The current researcher questions Frohrip's decision to include both trombone players (including undergraduate students and professional teachers/performers) as well as non-trombone-playing brass musicians in this study, given the broad range of performance abilities and experiences within this sample. Additionally, no apparent attempt was made to compare these two categories of participants within the data analysis. This issue was further magnified by the inclusion of two separate playing exercises, which created unequal testing parameters between participants. As such, the current researcher questions the conclusions drawn in the study.

Data were analyzed using a two-way ANOVA, with repeated measures on each of the four tones performed (B-flat^2, F^3, B-flat^3, and F^4) and in each of the three specific anatomical locations (the degree of overbite or underbite in the jaw opening, the degree of opening between the upper and lower teeth, and the degree of pharyngeal opening). Significant differences were found between subjects in all measures, $p < .01$, but only for pharyngeal opening within subjects, $p < .05$. The use of the Scheffé test for post hoc analysis revealed that the significant difference occurred between the highest (F^4 within the basic exercises or G^4 within the more difficult exercises) and lowest (B-flat^3) tones measured. An examination of the data indicated that six participants narrowed the pharyngeal opening by raising the high point of the tongue during the production of higher tones; yet, "at least two performers actually increased the size of the opening" (p. 103), including one trombone and one non-trombone performer. Frohrip (1972) found little or no difference in tongue placement when comparing staccato and legato playing. Instead, performers simply changed the amount of time that the airstream was interrupted (legato playing utilized a quicker release of the airstream after the interruption).

Frohrip (1972) found significant differences in the pharyngeal opening within subjects at various registers as well as significant differences between participants regarding changes in the pharyngeal opening (high point of the tongue) at various registers. Based on the latter, Frohrip rejected the strategy of syllabic imagery as an aid for moving to various registers on the trombone, a finding that is counter to the recommendations commonly found within pedagogical music sources.

Pappone (1973) used cinefluorography and audio recordings to investigate differences in tongue position and tone on the clarinet between an audio-lingual tonguing technique and a controlled-tonguing technique. Audio-lingual tonguing was defined as "saying a specific syllable to allow the tongue to release the air stream into the clarinet to produce a tone" (p. 2), whereas controlled-tonguing was defined as "removing the tongue from the reed to release the air stream into the clarinet to produce a tone by 'willing' it" (p. 2). A survey was sent to 90 of the "nation's leading woodwind instructors and institutions" (p. 27) to ascertain the prevalence of these two systems of tonguing on the clarinet as well as to determine the recommended syllables for the low-, middle-, and high-registers for any respondents who utilized the audio-lingual system. Responses were returned from 82 instructors, representing a 91% return rate. Based on the responses from this survey, the syllable TOE was assigned to the lowest two pitches (specified below), TOO was assigned to the middle three pitches, and TEE was assigned to the highest two pitches.

Each participant (six college students) played seven pitches on the clarinet (written F^3, B-flat^3, F^4, B-flat^4, F^5, B-flat^5, and F^6) using both methods of tonguing; the order of performances for each note (beginning with audio-lingual tonguing or controlled-tonguing) was randomly assigned by a coin toss. After a training session during which participants were instructed on both tonguing techniques, performances were recorded using tape recording and cinefluorography for the purposes of assessment. Copies of this recording were sent to five external judges (clarinetists), who evaluated performances in order to determine which tone within each paired set was more acceptable (or if there was no difference). In addition, spectrographic analysis was conducted on each tone to determine the intensity of each harmonic within all tones produced. In this regard, linear measurements (in millimeters) from each individual harmonic within a given tone were summed in order to determine the "total intensity present in each tone" (p. 47); the tonguing technique that yielded the greatest total linear length was considered to be superior in tone quality. Finally, the cinefluorographic films were analyzed to compare the tongue position (vertical measurement of the posterior arch of the tongue) at the moment of attack for each F performed (F^3, F^4, F^5, and F^6) between playing conditions. Although descriptive statistics were provided, there was no evidence of more advanced statistical analysis in this study.

Pappone (1973) determined that there was an observable change in tongue position from register to register at the moment of attack for both tonguing techniques:

the tongue was in a low-forward position for notes in the upper register and a high-back position for notes in the lower register, although this was not consistent for all participants. Tongue position was not consistent between subjects on the same pitch while using the same tonguing technique, providing further evidence of the individualistic tendencies for tongue position between performers when playing on a wind instrument.

Pappone (1973) concluded that the audio-lingual model was "generally somewhat superior" (p. 63) to the controlled-tonguing technique. However, the current researcher questions the practical significance of the reported differences in tone between tonguing techniques. Although the analysis of spectrographic images indicated a superior tone quality for the audio-linguistic technique within 28 of the 42 comparisons made, the external judges did not support this conclusion. In this regard, Pappone indicated that within the 210 total comparisons between sets, the external judges (a) preferred the audio-lingual technique for 73 sets, (b) preferred the controlled-tonguing technique for 57 sets, and (c) indicated *no difference* for the remaining 80 sets. Therefore, the current researcher questions Pappone's conclusion regarding the supremacy of the audio-lingual technique, based on the fact that the expert judges favored the audio-linguistic technique in less than 35% of the tone sets performed.

Wheeler (1973, 1986)[29] conducted research in 1967, 1971, and 1972 that utilized X-ray (fluoroscope) motion-pictures to determine the position of the tongue within the mouth for various registers during music performance. The studies in 1967 and 1971 included clarinet playing and singing, while the study in 1972 included saxophone, oboe, and bassoon playing in addition to clarinet playing and singing. Wheeler himself served as the sole performer on all instruments in this study. During clarinet performance, Wheeler found that the upper rear portion of the tongue was in a high and rearward position within the oral cavity for low notes (chalumeau register) and gradually moved downward and forward during an ascending scale into the upper register (clarion and altissimo registers). During the performance of leaps from written D-flat^{4} to A-flat^{5} to F^{6}, the changes in tongue position occurred quickly when moving from note to note. Similar tongue patterns were found during performance on the saxophone, oboe, and bassoon, although minor changes were noted, including: (a) the tongue position for low notes on the saxophone was lower than for the corresponding range on the clarinet, resulting in more moderate vertical movements of the tongue between registers; (b) the back of the tongue was used almost exclusively to stabilize tones throughout the various registers of the bassoon; and (c) the tip of the tongue was prominently more forward during oboe performance as intervals ascended in comparison to the other woodwind instruments.

Wheeler (1973) also investigated the use of syllables commonly used to teach woodwind playing, including TAW, TOE, TIE, TOO, TEH, and TEE, in an effort to

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[29] Two separate summary reports were found regarding Wheeler's research: Wheeler (1973) and Wheeler (1986). The current researcher was not able to procure the original (full) report of Wheeler's study on which these two summaries were based.

compare the position of the tongue during singing to the position of the tongue during performance on woodwind instruments. He concluded that:

> These syllables have no value whatsoever as a method for helping students to shape or position the *main body* of the tongue for various notes. They do, however, have value for helping students to learn how to use the *front* part of the tongue during articulation at the reed. (Wheeler, 1986, p. 1386)

As stated above, Wheeler (1973) himself served as the sole participant in his investigations carried out in 1967, 1971, and 1972. While his research represents unique case studies in which physiological changes were investigated within one performer when playing on various woodwind instruments, the current researcher questions Wheeler's ability to generalize these findings to *students* (as inferred in the quote above) in any capacity. In addition, the researcher was left with questions about Wheeler's conclusions regarding the use of syllables. For example, Wheeler stated, "x-ray [*sic*] images of vowel or syllable vocalizations (taw, tow, tie, too, teh, and tee) showed these syllables to have tongue positions not entirely adequate for shaping the air stream correctly for the clarinetist" (p. 5), yet did not give further details regarding the manner in which he determined what actually constitutes an *adequate* position. Further, it appeared to the current researcher that Wheeler was justifying observations of his own playing habits based on personal opinions rather than empirical evidence, such as when he stated, "There is a satisfactory explanation for that unexpected tongue elevation…. Embouchure adjustment was not necessary or desirable; to have done so would have changed the tone quality of D from that of adjacent tones" (p. 5) and again, "it is doubtful if significant differences would be noticed in other players' technic [*sic*] for intonation control" (p. 6). This perceived level of bias calls into question the results of Wheeler's study.

De Young (1975) used videofluorography to investigate the pharyngeal opening during trombone playing on selected exercises in an effort to further the research of Frohrip (1972). Participants ($N = 12$) in this study included the researcher and 11 additional undergraduate trombone players, all concurrent or previous students of the researcher. Participants performed exercises designed to investigate the pharyngeal opening during changes in register (B-flat^2, B-flat^3, and B-flat^4), dynamics (ranging from forte to piano), and articulation style (slurred and tongued). De Young did not conduct statistical analysis in his study, but instead indicated the number of participants who fell into various categories. Regarding changes in register, De Young noted that (a) 10 of the 12 participants increased the size of the pharyngeal opening when moving from lower to higher notes, a finding that was contrary to that of Frohrip; (b) seven of the 12 participants arched the tongue when moving to the upper register, an act that did not reduce the size of the pharyngeal opening in any of those seven participants; and (c) nine of the 10 participants who increased the pharyngeal opening when moving to the upper register either arched their tongue or brought their teeth closer together (or both). When considering changes in the position of the tongue and pharynx between legato and staccato performances on repeated pitches, De Young reported that (a) no change was observed in seven of the 12 participants, (b) two participants used considerably more tongue action for staccato notes, and (c) the pharynx of three participants was more open for legato notes.

In addition to the observations summarized above, De Young (1975) made note of the level of success in performance when considering observed physiological changes. He reported that the two subjects who decreased their pharyngeal opening when ascending in pitch struggled to play in the upper register. However, he also noted that participants who increased the pharyngeal opening were not always able to play in the upper range with ease. These conclusions regarding performance success, however, appeared to be based on anecdotal observations rather than empirical evidence.

In comparison to the research conducted by Frohrip (1972), De Young's (1975) study eliminated the use of multiple sets of playing exercises and reduced the gap in performance levels and experiences between participants. Yet, the inclusion of De Young himself as a participant (a) resulted in the inclusion of a single graduate student along with the additional undergraduate students; (b) introduced an additional confound, given the teacher-student relationship between De Young and the remaining participants; and (c) ensured that *at least* one participant (De Young) was fully aware of the purpose of the study during testing procedures. In addition, the lack of statistical analysis in De Young's study relegates the results to observations void of statistical significance.

Carr (1978) used cinefluorography and a synchronized stereo tape recording to investigate the throat and tongue during performances on the flute, oboe, clarinet, bassoon, and saxophone. Fourteen specific playing tasks were targeted within a single performance exercise, including: dynamic changes; ascending and descending scales; various syllables (including TOO, TAH, TEE, DA, and KA) in the low, middle, and high registers; harmonic series; ascending and descending slurs; tonguing in the low, middle, and high registers (including legato, staccato, and double-tonguing); changes in intonation (sharp and flat in the high and low registers); and vibrato versus straight tone. Carr randomly selected 150 professional woodwind players from the directory of the American Federation of Musicians near Los Angeles, California. Using this list, Carr invited musicians to participate in the study until five accepted within each of the five instrument groups listed above, resulting in 25 total participants.

Data were analyzed using (a) a one-way ANOVA to investigate the 60 performance tasks (14 categories for five instrument groups) across all instruments, (b) a two-way ANOVA to investigate the 14 performance categories for each of the five instrument groups, and (c) the Tukey multiple comparison test in order to further investigate individual differences among means. It was unclear to the current researcher why Carr (1978) included both a one-way and two-way ANOVA, given that (a) the one-way ANOVA would be incorporated within the two-way ANOVA and (b) running multiple analyses increases the potential for alpha error (α).

When comparing participants within like-instrument groups, Carr (1978) found that the high point of the tongue (degree of tongue arch) was significantly different between the five participants within each of the following instrument groups: flute, clarinet, and bassoon, $p < .05$. However, the high point of the tongue was not significantly different between instruments; generally, as pitch ascended, the tongue dropped. However, it is important to note that, with the exception of the findings presented above, Carr included only general statements within the main body of his report regarding the results of his study. The current researcher attempted to verify these general statements using the 119 tables included in the appendices. From this review, it would appear that each of the findings presented by Carr (summarized below) represented a level of statistical significance, $p < .05$. However, this process proved problematic. For example, Carr stated, “The extreme dimension [high register] was only executed by the clarinet group. There was a significant difference in the tongue positions between clarinet players for both the soft and loud dynamic levels” (p. 41). However, the corresponding tables indicated that there was a significant difference between groups, $p = .046$, but not within groups. Given the complications in attempting to parse these data and having explicitly expressed the challenges faced in confirming the stated outcomes, the following list presents the conclusions regarding the high point of the tongue as presented by Carr:

- the tongue position dropped during an increase in dynamic level for all instrument groups, with the exception of the middle register for the clarinet and bassoon groups;
- the tongue was lowest in the oral cavity among bassoon players and highest among flute players;
- the tongue was lowered as pitch ascended and raised as pitch descended among all instrument groups, regardless of the syllable being utilized;
- the tongue was slightly higher in the mouth during tongued (vs. slurred) passages;
- the position of the tongue during woodwind performance was similar to the position of the tongue when singing and speaking the syllables utilized in the study;

- the use of TOO produced the largest supralaryngeal cavity and therefore "could be selected to facilitate the large tongue and throat dimensions needed to play the higher register tones" (p. 76), whereas TAH and DA "placed the tongue higher in the mouth and closed the throat which is basically the position used for the low register tones" (p. 76);

- during staccato playing, the tongue displayed less motion, the tip of the tongue remained closer to the point of attack, and the tongue remained on the reed at the point of attack longer in comparison to legato playing;
- the tongue tip remained closer to the point of attack during faster articulations, but the supralaryngeal opening was not affected by the speed of tonguing; and
- the tongue and throat aperture were smaller (the supralaryngeal cavity closed) when intentionally moving a pitch from sharp to flat.

Carr's (1978) presentation regarding the use of syllables was unclear to the current researcher. Despite the conclusions above, Carr also stated, "There was not a significant difference in the variance of the tongue and throat positions between the syllables 'Too,' 'Tah,' and 'Tee' to establish a definite syllable usage pattern" (p. 76). He later concluded, "the choice of syllable is not of vital importance when producing a tone" (p. 84). These statements appear to be in conflict with the conclusions presented above. The combination of (a) the lack of clarity when presenting data regarding statistically significant differences and (b) the seemingly contradictory information presented make it difficult to ascertain the significance of the findings within this study.

Clinch, Troup, and Harris (1980) used X-ray fluorography to examine changes in the vocal tract during performance on the clarinet, soprano saxophone, and recorder.[30] These researchers investigated vowel sounds in order to compare the shape of the vocal tract during performance on the clarinet and soprano saxophone to the shape of the vocal tract when speaking. Clinch et al. included an illustration of the positions of the vocal tract during spoken vowels from Ladefoged (1962), including /i/ as in *bead*, /ɪ/ as in *bid*, /ɛ/ as in *bed*, /æ/ as in *bad*, /ɑ/ as in *pod*, /ɔ/ as in *bought*, /ʊ/ as in good, and /u/ as in *booed*. The researchers stated that it was "convenient to present this material rather than data from the individual players because it has already been analyzed, and is readily available in the literature" (p. 282). The current researcher questions this convenient use of material, since the shapes assumed in the vocal tract during the production of vowels would likely vary between individual speakers and musicians. Nonetheless, Clinch et al. reported that the tongue assumed a position similar to that used for /i/ as in *bead*, /ɪ/ as in *bid*, and /ɛ/ as in *bed* as pitches rose into the higher register of the clarinet and soprano saxophone.

In addition, sound spectra from vibrations both inside the mouth and near the bell of the clarinet were recorded during performances in order to determine how changes within the vocal tract impacted the resulting tones. Although no data analysis was

[30] The current researcher was not able to procure the original research document; therefore, the current overview is based on Clinch et al.'s (1980) summary article and other resources that report details about the study. Information regarding participants was not included within the summary; however, Watkins (2002) indicated that the performers were professional musicians and Hungerford (2004) indicated that Clinch himself played the clarinet and saxophone, while another musician played the recorder.

conducted, Clinch et al. (1980) made observations based on the X-ray images and sound spectra analyses. These observations included the following: (a) as pitch ascended within the low register of the clarinet, the tongue and larynx also rose, decreasing the volume of the vocal tract; (b) when pitch ascended within the higher register of the clarinet and soprano saxophone, the tongue (which was more forward in the mouth than it was for performances in the lower register) and larynx were lowered; and (c) tongue movements during clarinet and soprano saxophone performance paralleled those used in forming speech vowels.

Finally, Clinch et al. (1980) determined that tone quality on the clarinet and soprano saxophone is dependent on the shape of the vocal tract. During performances that were identified as having good tone quality, performers altered the length and shape of the vocal tract in a manner that changed the first formant of the resulting tone inside the mouth; in this regard, the fundamental frequency within the mouth was found to be amplified, while subsequent harmonics were minimized in comparison to the sounds recorded near the bell of the instrument. In contrast, performances that were identified as having poor tone quality were found to have nearly identical sound spectra inside the mouth and near the bell of the instrument.

The current researcher was left with many questions regarding the method used by Clinch et al. (1980), due to the nature of the summary article upon which this review is based. It is noteworthy, however, that the direction of tongue motion changed during the performance of ascending pitches, based on the register of the notes being performed.

The tongue rose during an ascent in pitch within the lower register of the clarinet, but lowered during an ascent within the upper register of the clarinet and soprano saxophone.

Compagno (1990) utilized a fiber-optic laryngoscope and sound-synchronized video tape recording to investigate laryngeal movements within the arytenoid cartilages, glottis, aryepiglottic folds, larynx, and tongue during clarinet and flute performance. Undergraduate and graduate collegiate musicians, including eight clarinetists and five flutists, served as the participants. Musical performance tasks included scales, arpeggios, expanding intervals, dynamics (forte/piano and crescendo/decrescendo), articulation style (staccato and legato), and vibrato (flute only).[31] Compagno himself served as the sole judge of the laryngeal movements, which were evaluated at two separate times using a 5-point Likert-type scale. Structural movements and positions were categorized as observed and presented in table form for ease of comparisons; for example, the tongue position was categorized as front-high, front-low, back-high, or back-low.

The inclusion of a video recorder allowed Compagno (1990) to consider the quality of a performance in conjunction with physiological measurements. As such, Compagno made the following observations and recommendations regarding articulation:

- during articulation, a relationship was found between a forward/backward motion of the tongue and the abduction/adduction of the glottis. Participants who abducted and adducted the glottis during articulation were unable to produce a clearly defined staccato or legato articulation; participants who kept the glottis

[31] Although Compagno included no rationale for investigating vibrato only among flute players, the current researcher assumed this decision to be based on the common practice use of vibrato, which is traditionally utilized by flutists but not clarinetists.

and tongue stable and positioned the tongue forward in the pharyngeal cavity were able to produce clearly defined articulation. Compagno concluded that "the least amount of tongue motion in the pharyngeal cavity produced the most consistent and defined articulation" (p. 129);

- during clarinet playing, the position of the tongue was found to be high in the pharyngeal cavity for low register tones and gradually progressed downward and forward as pitch ascended, an action that increased the size of the pharyngeal cavity. Tongue movement varied between flute players;
- during clarinet playing, the position of the tongue affected the voicing of the resulting tones; for example, participants who kept the tongue in a low and forward position produced tones "without any undue tension or constriction" (p. 85). On the flute, tone production was similar for forward and backward positions of the tongue.

The current researcher questioned why Compagno (1990) did not include external judges during the assessment process. Despite the check for intrajudge reliability (after an interval of one month), the omission of external evaluators raises questions regarding the reliability of the findings, since the assessment process was based solely on the evaluations of the researcher himself. Additionally, the inclusion of both undergraduate and graduate students raises questions regarding the outcomes of the study, due to the range of performance experiences among participants. Although the lack of statistical analysis relegates the findings of this study to observations without statistical significance, the consideration of quality of sound within performances made this study particularly pertinent to the current investigation.

Patnode (1999) made use of a fiber-optic scope to determine the accuracy with which saxophonists could describe their tongue positions when playing in the altissimo register. Graduate-level and post-graduate saxophonists (*N* = 9) performed two groups of exercises in the altissimo register. Both groups of exercises included an upward slur between two notes; the interval between the two notes in the first grouping was an octave (beginning with written E^5 to E^6 and ending with F^6 to F^7), while the interval in the second grouping was a half-step (beginning with written E^6 to F^6 and ending with E^7 to F^7). Following the execution of each slur, participants were asked to identify any perceived change of tongue position by providing a yes/no response to the following questions: (a) Has your tongue changed position? (b) Has your tongue moved forward? (c) Has your tongue moved backward? (d) Has your tongue arched upward toward the roof of the mouth? and (e) Has your tongue moved downward into a flat position? Each performer's oral cavity was video recorded during performances via a fiber-optic scope inserted through the left corner of the lips. Three woodwind pedagogues evaluated the video recordings, using the same set of questions posed to the performers (although the judges were also given an option to indicate that they were unable to determine whether or not the tongue had changed positions). These two sets of scores (performer-perceptions and judge observations) were compared to determine the accuracy with which saxophonists could describe the motion of their tongue in the altissimo register.

Patnode (1999) reached the following conclusions: (a) performers could more accurately assess tongue motion when performing octave examples than during chromatic passages; (b) most participants could more accurately sense an upward motion of the tongue (compared to other directions of motion) while playing octave intervals; (c) a forward motion of the tongue was most often accompanied by an upward motion when playing octaves, although performers were often less aware of the forward motion than the upward motion; (d) in the extreme altissimo register (beginning with written D-sharp^6 to D-sharp^7), participants were less able to sense motion in the tongue; (e) there was no perceived change in tongue position when playing chromatic examples; (f) subjects were less able to determine changes in their tongue position as they played higher throughout the chromatic exercises; (g) the tongue tended to move downward when playing in the extreme high-register chromatic examples, although many participants sensed an upward tongue motion; (h) very little forward motion of the tongue occurred when playing chromatic examples; and (i) each of the nine participants utilized many different tongue positions to execute octave and chromatic examples.

Patnode (1999) concluded that saxophonists use individualistic tongue movements to achieve desired pitches in the altissimo register. However, the actual direction and position of the tongue were inaccurately self-assessed by many participants. When playing in the altissimo register, performers were most aware of an upward motion of the tongue and least aware of a forward motion of the tongue.

Although the results of Patnode's (1999) study should not be generalized beyond the altissimo register of the saxophone, the current researcher was particularly interested in the participants' incorrect self-assessments regarding tongue position and movement. This finding is particularly pertinent, given (a) the hidden nature of the tongue during performance on a wind instrument and (b) the prevalence of pedagogical sources in which discussions regarding the use of the tongue are based on self-assessments rather than empirical research. However, the current researcher was troubled by Patnode's statement that the position of the camera within the mouth made it difficult to ascertain a forward motion of the tongue, since this could impact many of the findings in this study.

Watkins (2002, 2003a, 2003b) conducted multiple research projects and reinvestigated images from prior research studies (including Carr [1978], Clinch et al. [1980], Patnode [1999], Peters [1984], and Wheeler [1973]) in an effort to accumulate and compare knowledge from past research publications with additional methods and technologies. This comprehensive approach facilitated "progress toward the truth" (Watkins, 2002, p. 67) regarding what takes place within the vocal tract during saxophone performance. Five individual projects were summarized within Watkins's three summary reports; only the first, third, and fourth projects will be reviewed at present, since the second (Moorhead, Minnesota, January 1999) and fifth (Rexburg, Idaho, April 2002) were not directly pertinent to the current study.

The researcher's first project (Watkins, 2002) took place in Salt Lake City, Utah in February 1998 and incorporated the use of a fluoroscope and endoscope (a small video device with a light attached that is used to look inside a body cavity or organ) to investigate the vocal tract during saxophone performance. Participants ($N = 11$) included three professors of saxophone and eight additional college students and professional performers in the region. Performance tasks included octave slurs, scales, arpeggios, altissimo tones, overtones, mouthpiece pitch (the resonant tendency of the mouthpiece alone, without being attached to the neck or body of the saxophone), vibrato, articulation, vowel pronunciation with and without the mouthpiece, movements of the larynx and vocal folds, and additional tone studies and excerpts. Fluoroscopic images were captured in profile during the performance of the selected tasks; additionally, endoscopic images (which were accrued after the completion of the fluoroscopic images) captured front contours, allowing for multiple vantage points during the recording processes. Using translucent paper pressed against a monitor screen, Watkins traced still images from the videos to ascertain the dimensions of the oral cavity during performances of written C^4, C^5, C^6, and C^7.

Watkins's (2002) third project took place in Fargo, North Dakota in June 1999 and included the use of a fluoroscope, probe microphone (a compact microphone used for sound pressure measurements in small enclosures), and water manometer. Participants included two saxophone professors (including the researcher himself) along with "a few top students and the Hard-Bop Saxophone Quartet" (p. 68). In addition, two professional clarinetists were included to assess similarities in the vocal tract between clarinet and saxophone performance, and one professional vocalist was included to document vowel formations, relationships between sung and spoken vowels, and relationships between sung pitches and pitches played on the saxophone.

The researcher's fourth project (Watkins, 2002) took place in Provo, Utah in March 2000 and investigated articulation, embouchure, and mouthpiece pitch through the use of an endoscope and pressure gauge. Participants included three saxophone professors, one professional saxophone player, and five collegiate saxophone players. Participants' tongue lengths were measured, enabling a comparison between tongue length and point-of-contact on the reed, as viewed through the endoscope.

Watkins (2002) did not include statistical analysis in his studies, but did arrive at specific conclusions based on the observations made during his study as well as from the review of images from previous studies, as described above. Regarding the posterior tongue position, Watkins found that the tongue was in a high posterior position for C^4 and progressed downward as pitch ascended from octave to octave. The anterior of the tongue progressed slightly forward and minimally upward with an ascent in pitch until the altissimo register (C^7), when the anterior of the tongue continued forward, but moved downward. Comparing tongue position during performance on the alto and tenor saxophones, Watkins found more anterior space and slightly less posterior space within the vocal tract during performance on the tenor saxophone in comparison to the alto saxophone. Finally, comparing the vocal tract during saxophone and clarinet performance, Watkins found the vocal tract to function in a similar manner between the two instruments, with one exception: the larynx was raised during an ascent from the chalumeau to the clarion register on the clarinet, but showed no change in position during a corresponding ascent in range on the saxophone.

The use of both a fluoroscope (profile view) and endoscope (frontal view) allowed Watkins (2002) to make observations that were not possible in previous studies. In this regard, he found that the contour of the tongue changed from the low register to the high register and was markedly different between participants. During an ascent in pitch, as the tongue moved forward, a valley (channel) formed down the length of the tongue; the degree of channeling varied between participants. A deep channel in the tongue was often observed in participants who utilized a higher overall tongue position (as seen in the profile images), whereas a less-pronounced channel was often found in participants who incorporated a lower overall tongue position. However, since images from the fluoroscope and endoscope were not recorded concurrently, the current researcher is unsure how Watkins was able to conclusively ascertain this relationship.

Watkins (2002) also considered how differences in physical stature impacted the shape or volume of the vocal tract; in this regard, he compared participants who were 5’8”, 6’3”, and 6’4”. Watkins used a small metal rod, placed along the side of the mouthpiece, in order to “obtain accurate measurements by ratio from the video images” (p. 73). It was unclear to the current researcher how these ratios were calculated as well as how the addition of this rod might have impacted the formation of the oral cavity, as these issues were not specifically addressed within the summary report. Measurements (in millimeters) were taken between the (a) tongue and tip of the mouthpiece, (b) tongue and hard palate, (c) tongue and soft palate, and (d) tongue and pharynx wall. Profile views from the fluoroscope suggested that the tallest participant used a smaller overall vocal-tract chamber. However, additional measurements and perspectives, including average vocal-tract length and width as well as frontal-views of the tongue (showing contours and valleys), revealed that the three performers utilized similar vocal-tract chambers (volumes and contours), but accomplished this by raising or lowering their tongues to varying degrees, based on the size and shape of their vocal tract.

Within the second of his three summary reports, Watkins (2003a) compared the position of the tongue during spoken and sung vowels to the position of the tongue during performance on the saxophone at various pitch ranges. Based on similarities in tongue position, as observed for both spoken vowels and during saxophone performance, Watkins recommended vocal guides for beginning instruction, including /u/ as in *booed* for notes in the low register, /ʊ/ as in good for notes around C^5, /e/ as in *bayed* for notes around F-sharp^5, and /ə/ as in *above* for notes in the upper register. No relationship was found between the shape of the vocal tract when singing in various registers compared to the shape of the vocal tract when playing in comparable registers on the soprano, alto, tenor, or baritone saxophone. However, the current researcher questions the use of a single vocalist as the model for comparison, since it would seem likely that vocalists, like instrumentalists, would utilize variations in oral shape during performance.

Regarding articulation, Watkins (2003a) used a fluoroscope and endoscope to investigate movements in the anterior of the tongue (direction and distance), movements in the body of the tongue (center and posterior), tongue-to-reed contact points, the relationship between tongue-length and contact-point on the reed, and possible differences between jazz and classical performance. Participants performed tones across the various ranges of the saxophone at both soft and loud dynamics, including the following articulation styles: legato, tongue-stopped staccato, air-stopped staccato, and accents. Watkins's observations included:

- at louder dynamic levels and for accents, the amount of tongue contact on the reed surface increased both laterally (toward the reed corners) and horizontally (toward the bottom lip) in comparison to softer and unaccented tones;
- the tip of the tongue remained closer to the reed during fast articulations and during staccato playing in comparison to legato playing;
- the main body of the tongue showed minimal movement during legato and tongue-stopped staccato tones; participants who exhibited the most movement at the base of the posterior portion of the tongue had difficulties with note stability;
- although Watkins observed a tendency for participants with shorter tongues to use tip-to-tip tonguing and those with longer tongues to use anchor tonguing, this tendency was not consistent across participants; and
- jazz and classical performers tended to use the same tonguing techniques, although jazz performers utilized more variations during performance.

In comparison to prior studies, Watkins's (2002, 2003a, 2003b) observations were based on a much larger sample size, since he included analysis of his own (multiple) studies along with a reinvestigation of the images from previous studies. As such, despite the lack of statistical analysis, the observations by Watkins would seem to be more reliable than those from studies that included small sample sizes.

Zimmer (2002) used fiber-optic video equipment to investigate the throat and tongue during articulation on the saxophone in order to compare jazz and orchestral styles of playing. Areas of examination included the shape of the tongue, the point at which the tongue touched the reed, the throat position utilized during various articulation schemes, and the angle at which the tongue approached the reed. Collegiate saxophonists who were proficient in both jazz and orchestral styles (*N* = 7) served as the participants; each performed a transcription of *Now's the Time* by Charlie Parker (jazz) and excerpts from *Sonata* by Berhnard Heiden (orchestral). External adjudicators (three accomplished saxophonists and teachers) evaluated the video recordings to look for any physiological differences between performances in the jazz and orchestral styles. Zimmer found only slight variations between the jazz and orchestral tasks regarding the region of the tongue used to touch the reed, the region of the reed touched by the tongue, and the distance the tongue moved during articulation. However, these variations were not consistent between performance tasks. Other aspects of tongue position were consistent, regardless of performance style (jazz or orchestral tasks): (a) movements in the back of the tongue were more pronounced during slurred examples than in legato, staccato, and alternative articulation examples and (b) the back of the tongue moved lower for notes in the upper register and higher for notes in the lower register.

Zimmer (2002) did not include statistical analysis in his study. Additionally, the small number of participants was noteworthy, particularly given the manner in which the results were interpreted. In this regard, the current researcher questions Zimmer's conclusion that jazz performances included more variance regarding the location of the reed touched by the tongue, since this conclusion was based on the fact that *one* participant touched the tip of the reed during jazz performance (a happening that did not occur within the classical performances). Finally, Zimmer included only participants that were proficient in both jazz and classical performance. The current researcher questions if the same conclusions would be reached when investigating differences in the tongue and throat of jazz performers and classical performers who were not proficient in both performance styles.

Hungerford (2004) used a fiber-optic laryngoscope to (a) determine movement within clarinet performers' oral cavities during performance and (b) investigate similarities and differences for performers who had attained varying degrees of proficiency. Participants ($N = 23$) included eight amateur musicians (one high school student, six collegiate undergraduate non-music majors, and one doctoral oboe player who was just beginning to study the clarinet), eight collegiate music majors (including seven undergraduate clarinet players and one doctoral saxophone player who regularly played the clarinet), and seven professional musicians (including one retired professional and six practicing professionals) (D. A. Hungerford, personal communication, May 5, 2011). Performance tasks consisted of 12 exercises, including tongued and slurred passages, glissandos, and bugle calls. A fiber-optic laryngoscope and light were inserted through the corner of the lips in order to examine the oral cavity during performances. Images from the laryngoscope were recorded using a digital videocassette recorder; these images were transferred to DVD for the purpose of assessment by six professional clarinetists, who, after viewing the images, responded to open-ended questions about observed changes within the oral cavity. In addition, Hungerford analyzed the images and compared them to the images procured from five previous studies, including Mooney (1968), Wheeler (1973), Patnode (1999), Watkins (2002), and Zimmer (2002).

Although no statistical analyses were conducted, Hungerford (2004) listed observations from her study that aligned with the five additional reviewed studies, including the following:

- during an ascent in pitch, the posterior portion of the tongue lowered, while the middle portion of the tongue curled and rose within the oral cavity;
- for notes in the low (chalumeau) register, the tongue was low and forward, creating a more narrow throat opening, although variations existed between participants; during an ascent in pitch within this range, the tongue rose until reaching the middle (clarion) register, at which point the tongue lowered for the throat tones; upon reaching written D^4, the back of the tongue rose again until reaching the upper (altissimo) register;
- for the altissimo register, the tongue dropped dramatically into the throat, resulting in the front of the tongue being further from the reed; the middle and back of the tongue were low (and often flat) for the altissimo register, resulting in an open throat;
- the tongue is an important factor in voicing; in this regard, the tongue changed positions until the proper pitch and tone were achieved; and
- the tongue bounced back to the voiced position after a note was articulated.

The current researcher is uncertain how these observations coexist, since Hungerford stated that the tongue was lowered as pitch ascended, but also indicated that the tongue rose as pitch ascended within both the chalumeau and clarion registers.

In addition, Hungerford (2004) listed several observations, made possible by the inclusion of a fiber-optic laryngoscope, that were also noted in the additional studies reviewed that included fiber-optics (Patnode [1999] and Zimmer [2002]):

- the tongue pulsated during the performance of slurred passages with large leaps;
- the quality and pitch accuracy of a tone were affected by tongue position; particularly with more advanced performers, the body and tip of the tongue flattened longitudinally and laterally;
- movements in the tip of the tongue were subtler than those of the back of the tongue;
- some participants exhibited a mid-sagittal tongue groove during performance; and
- advanced performers exhibited more accurate and precise movement of the tongue than less advanced performers, who tended to be more erratic while also exhibiting less overall tongue movement.

In addition, although not included within the summary section of Hungerford's report, she noted that (a) during staccato passages, more of the tongue touched the reed than on legato passages; (b) as pitch ascended, the tip of the tongue pulled away from the reed; and (c) the posterior of the tongue showed minimal movement during articulation.

Based on the analysis of images from both her study and the additional studies reviewed (as stated previously), Hungerford (2004) concluded that (a) most clarinetists, regardless of their experiences and background, cannot perceive the motion of their tongue during performance and (b) inexperienced performers demonstrate tongue motion that is less accurate in assuming a proper tongue position than more experienced performers. Despite the observations summarized above, Hungerford stated, “It was difficult to see the tip of the mouthpiece and actual tonguing motion for many subjects” (p. 161). This statement elicits questions in the mind of the current researcher regarding the reliability of the conclusions enumerated above.

Gardner (2010) used ultrasonographic imaging to examine multiple-tonguing on the clarinet. Gardner himself was the only participant in this exploratory study. The performance task consisted of six continuous beats of sixteenth-notes on a single pitch at a speed of 40 beats per minute (bpm). This pattern was performed on concert D^3, D^4, A^4, D^5, A^5, D^6, and A^6, thus encompassing the functional range of the clarinet. Performances on the clarinet were compared to eight spoken consonant-vowel-consonant-vowel patterns (e.g., DEE-GEE); these included (a) the consonant pairs /t/-/k/ as well as /d/-/g/ in combination with (b) the vowels /ɑ/ as in *pod*, /i/ as in *bead*, /u/ as in *booed*, and /ɛ/ as in *bed*. These speech sequences utilized the same rhythmic pattern as the performance tasks described above.

Images captured by the ultrasound machine were recorded onto the researcher’s computer. In order to quantify tongue motion during performances, mid-sagittal (center-line) tongue contours were extracted from individual ultrasound images using a semi-automatic detection program (EdgeTrak® by LTV Lab). During this process, contour data were converted from pixels to millimeters, allowing a standardized unit by which measurements could be made. The data were segmented into individual articulation cycles; each sequence was equalized to 22 frames and re-sampled on a three-dimensional grid using CAVITE (Contour Analysis VIsualization TEchnique), a software program designed for tongue analysis. Additionally, 10 articulation cycles were averaged into a composite in order to compensate for limited temporal resolution and subject variability; these articulation cycle composites were used for data analysis.

Gardner (2010) found minimal variance in tongue motion between cycles within the performances of the seven individual pitches performed on the clarinet (0.80 mm) and the eight consonant-vowel sets (0.86 mm), suggesting a consistent tongue motion between repetitions. A three-way ANOVA was performed to explore the relationship between the mean root-mean-square error for each frame and the three controlled factors: pitch (seven tones on the clarinet), spoken vowels (four), and spoken consonants (two sets of consonant pairs), as well as the two-way interactions between these variables (three-way interactions were not explored). When comparing tongue surface measurements between speech and performance, Gardner found significant differences for pitch, consonant, and vowel, $p < .001$. In addition, significant interaction effects were found for consonant-vowel and pitch-vowel, $p < .001$. The Tukey HSD post-hoc test revealed significant differences between all spoken vowels, a finding that Gardner predicted, based on the unique tongue shapes and sounds associated with particular vowels. In addition, the fifth frame of each articulation cycle was examined to investigate the position of the tongue during the sustain portion of a tone during each of the seven pitches performed. Significant differences were found between the four vowels, but little difference was found between the two consonants. The /t/-/k/ consonant pair utilized a slightly higher tongue position for all vowel contexts than did /d/-/g/.

Regarding pitch, Gardner found that tongue shape was relatively stable across the seven pitches used during the multiple-tonguing exercise (mean *SD* = 0.77 mm).

When comparing the shape of the tongue between clarinet performance and speech, Gardner (2010) found that the vowels /ɛ/ as in *bed* and /u/ as in *booed* most closely matched the position of the tongue during clarinet performance, based on numeric error values; these error values were calculated based on differences between measurements when comparing the position of the tongue during speech and clarinet performance. Upon further investigation, Gardner found that the spoken vowel /ɛ/, which had the lowest degree of error, used a tongue shape that was different than that utilized during clarinet performance, based on a visual inspection of the computerized images. On the other hand, the spoken vowel /u/, aside from a notable difference in the tongue root when comparing speech to clarinet performance, exhibited an overall shape that most closely resembled clarinet performance, based on a visual inspection. The vowel /ɑ/ as in *pod* positioned the anterior of the tongue too low in the mouth, whereas the vowel /i/ as in *bead* resulted in the posterior of the tongue being placed too high in the mouth.

Gardner (2010) concluded that ultrasonographic imagery was a safe and viable manner in which to examine tongue motion during clarinet performance. The current researcher, however, questions the findings of the study, based on the performance speed (40 bpm) of the multiple-tonguing exercises utilized during testing. Gardner justified this slow performance tempo based on the need to avoid data loss as a result of the ultrasound scan rate (28 Hz). Yet, the current researcher questions the validity of testing multiple-tonguing at slow tempos, when this technique is utilized for fast tempos during real-world performances. In addition, the current researcher questions the manner in which Gardner determined the moment of posterior articulations (the mid-point between articulation cycles). In this regard, he stated, "Temporal alignment was maintained by using a metronome during the recording session, ensuring a consistent rate of articulation. The posterior articulation, therefore, occurs near the eleventh frame of the cycle" (p. 100). Given that 22 separate frames were included during each articulation cycle, the current researcher would contend that even a slight deviation from the tempo established by the metronome would result in notable timing differences within the 22 frames; this possibility did not appear to be accounted for within the study. Despite these concerns, the current researcher acknowledges that this study provides new possibilities for observations of the tongue during performance on a wind instrument.

Summary of empirical studies that investigate physiology.

The empirical research studies summarized within the current literature review included a variety of tonguing-related considerations. Given the diversity, these findings will now be briefly summarized by topic.

Tongue and register.

The most common subject of investigation within the empirical research studies summarized above focused on the position of the tongue at various pitch levels during performance on a wind instrument. The majority of these studies revealed that as pitch ascended, the tongue moved forward and downward (Anfinson, 1965; Carr, 1978; De Young, 1975; Hall, 1954; Mooney, 1968; Pappone, 1973; Watkins, 2002; Wheeler, 1973;

Zimmer, 2002). This finding was contrary to the commonly held belief that the tongue moves higher within the oral cavity as pitch ascends, as summarized within the review of music pedagogy sources. Within these studies, however, only Anfinson included statistical analyses that revealed significant differences between groups; the remaining studies within this category included only general observations made during the collection of data.[32] Yet, the small sample size in Anfinson's study (*N* = 9) limits the ability to generalize results. Other studies found that the tongue moved upward and forward as pitch ascended (Amstutz, 1970; Frohrip, 1972; Haynie, 1967; Hiigel, 1967). While both Amstutz and Hiigel included statistical analyses in their studies, the small number of participants in Hiigel's study (*N* = 6) once again limits the ability to generalize results. Three additional studies revealed mixed results. Meidt (1954) found that trumpet players increased pharyngeal dimensions as range ascended, whereas French horn players decreased pharyngeal dimensions. Clinch et al. (1980) found that, as pitch ascended within the low register of the clarinet, the tongue rose within the vocal tract; however, during an ascent in pitch within the upper register on the clarinet and soprano saxophone, the tongue lowered within the vocal tract. Hungerford (2004) found that the tongue rose during an ascent in pitch in the low register of the clarinet until reaching the middle register, at which point the tongue lowered for the throat tones; upon reaching written D^4, the back of the tongue rose again until reaching the upper register. Within these three studies, however, only Meidt included statistical analyses. Finally, Gardner

[32] As previously discussed, the current researcher was unable to ascertain whether Carr's (1978) findings were statistically significant.

(2010) found minimal change in tongue position between registers on the clarinet. Yet, despite the inclusion of statistical analyses, his study was exploratory in nature and included the researcher himself as the only participant.

The lack of consensus among these studies regarding the pharyngeal opening at various pitch levels supports the conclusion that wind players exhibit individualistic tongue positions during performance (Carr, 1978; Frohrip, 1972; Hall, 1954; Hiigel, 1967; Meidt, 1967; Patnode, 1999). Further, this lack of agreement mirrors the diversity of ideas found within the review of music pedagogy sources and reinforces the need for additional systematic, empirical research regarding articulation on a wind instrument.

Use of vocal models.

Several studies investigated the use of vocal models in an effort to determine whether specific vowels could be used as an aid to simulate tongue positions during performance on a wind instrument. Many researchers concluded that vocal models were an effective strategy for wind instrument performance (Carr, 1978; Clinch et al., 1980; Gardner, 2010; Mooney, 1968; Pappone, 1973; Watkins, 2003a). Mooney recommended /u/ as in *booed* for the low register of the clarinet and either /ɑ/ as in *pod* or /ʌ/ as in *bud* for the transition to the upper register. Pappone concluded that the use of specific syllables (including TOE for the low register, TOO for the middle register, and TEE for the upper register) resulted in a superior tone quality on the clarinet in comparison to performances that did not incorporate the use of syllabic imagery. Carr found that the position of the tongue was similar when comparing singing or speaking to playing on woodwind instruments. Yet, as previously reported, Carr's conclusions were contradictory; although he recommended the use of particular syllables for various playing ranges, he also stated that the use of specific syllables was not of vital importance. Clinch et al. found that tongue movements during clarinet and soprano saxophone performance paralleled those used when forming speech vowels. Watkins recommended /u/ as in *booed* for low notes on the saxophone, /ʊ/ as in *good* for notes around C^5, /eɪ/ as in *say* for notes around F-sharp^5, and /ə/ as in *above* for notes in the upper register, based on a comparison of tongue positions between spoken vowels and instrumental performance. Finally, Gardner found that the position of the tongue during the pronunciation of /u/ as in *booed* most closely resembled the position of the tongue during clarinet performance.

Other researchers rejected the use of vocal models as an effective strategy for positioning the tongue during performance on a wind instrument (Hall, 1954; Hiigel, 1967; Meidt, 1967). Meidt found that the use of syllabic imagery was not effective as an aid to move to different registers on the trumpet and French horn. Hall found more pronounced changes in tongue position when singing in comparison to playing on the trumpet. Hiigel found that the tip of the tongue was further forward and the posterior arch was higher when enunciating in comparison to playing on brass instruments. The rejection of the use of vocal models within these studies is noteworthy, since this contradicts the common assertion that specific syllables can guide the tongue during wind instrument performance, as summarized in the review of music pedagogy sources.

Finally, two studies revealed mixed results. Haynie (1967) found differences in tongue position when comparing spoken vowels to performance on the trumpet, but noted that the use of unvoiced attacks revealed tongue positions that matched those used during performance. Wheeler (1973) concluded that the use of vocal models did not help to shape the mouth or position the main body of the tongue during woodwind performance, but they were effective as an aid in guiding the tip of the tongue during articulation.

When considering the findings summarized above, a lack of consensus was once again found between studies, with some researchers supporting and others rejecting the premise that vocal models are a useful strategy for performance on a wind instrument. Further, it is important to note that only Hiigel (1967), Meidt (1967), Carr (1978), and Gardner (2010) included statistical analyses within studies that investigated the effectiveness of vocal models during wind instrument performance.

The role of the tongue during specific tasks.

Several studies investigated the use of the tongue with regard to specific performance tasks on a wind instrument. When comparing staccato and legato playing, Anfinson (1965), Carr (1978), Hiigel (1967), and Watkins (2003a) found that the tip of the tongue remained closer to the point of contact during the performance of staccato notes. Additionally, Anfinson found that the high point of the tongue was higher in the mouth during the performance of staccato notes on the clarinet. Carr found that there was less motion of the tongue during staccato playing on woodwind instruments. Hiigel found that (a) the tip of the tongue was lower at the moment of contact and (b) the posterior of the tongue was further back during the withdrawal when playing staccato on brass instruments. Hungerford (2004) found that a greater portion of the tongue touched the clarinet reed during the performance of staccato notes. On the other hand, Frohrip

(1972) found no differences in tongue placement between staccato and legato playing on the trombone. De Young (1975) reported mixed results: seven participants showed no differences between styles on the trombone, while two used more tongue movement for staccato notes. When comparing slurred and tongued passages, both Carr and Meidt (1967) found that the tongue was slightly higher in the mouth during the performance of tongued passages (on woodwind instruments and trumpet/French horn, respectively). Amstutz (1970) found that changes in the degree of tongue arch were less pronounced during the performance of tongued passages on the trumpet. Zimmer (2002) found that movement in the back of the tongue was less pronounced during tongued passages on the saxophone. When comparing the motion of the tongue during performances at various tempos, Anfinson, Carr, and Watkins each found that the tip of the tongue stayed closer to the point of attack at faster tempos on woodwind instruments. Finally, when comparing performances at various dynamic levels, Carr found that the tongue was lower in the mouth at louder dynamic levels on woodwind instruments. Watkins found that the amount of tongue contacting the surface of the reed increased both laterally (toward the reed corners) and horizontally (toward the bottom lip) at louder dynamic levels on the saxophone. In comparison to the studies within previous categories (including the exploration of register as well as the use of vocal models), these studies, which explored the role of the tongue during specific musical tasks, exhibited a greater degree of agreement.

Tongue motion and quality of performance.

Several studies considered the quality of the resulting tones when noting physiological changes during performance. Hall (1954) recommended that tongue movement should be minimized between registers on the trumpet, based on differences in tone quality. De Young (1975) noted that trombonists who decreased their pharyngeal opening during an ascent in pitch struggled to play in the upper register in comparison to those who increased the pharyngeal opening during an ascent in pitch. Clinch et al. (1980) found that tone quality on the clarinet and soprano saxophone is dependent on the shape of the vocal tract. Compagno (1990) and Watkins (2003a) found that the least amount of motion in the pharyngeal cavity produced the most consistent and defined articulation (on the clarinet/flute and saxophone, respectively). Finally, Hungerford (2004) observed that inexperienced clarinetists demonstrated tongue motion that was less accurate in assuming a proper tongue position than the more experienced performers. Unfortunately, none of the studies within this summary included statistical analysis.

Awareness of the tongue.

Finally, two studies investigated the awareness of performers regarding the use of the tongue during performance on a wind instrument (Hungerford, 2004; Patnode, 1999). Patnode concluded that, while saxophonists were often aware of movements of the tongue, particularly within large leaps between notes, many inaccurately assessed the actual direction of motion and the position of the tongue during performance. Performers were most aware of an upward motion and least aware of a forward motion of the tongue.

Hungerford concluded that most clarinetists, regardless of their experiences and background, couldn't perceive the motion of their tongue during performance. Given the hidden nature of the tongue during wind instrument performance and the prevalence of conflicting opinions within the review of music pedagogy sources, these findings are particularly noteworthy.

Overall summary of empirical studies that investigate physiology.

At first consideration, it might seem impressive that 20 separate empirical research studies were found that investigated a topic as specific as the use of the tongue during performance on a wind instrument. However, these studies merit a deeper examination. For example, 12 of the 20 studies did not include statistical analysis (Clinch et al., 1980; Compagno, 1990; De Young, 1975; Hall, 1954; Haynie, 1967; Hungerford, 2004; Mooney, 1968; Pappone, 1973; Patnode, 1999; Watkins, 2002; Wheeler, 1973; Zimmer, 2002). The omission of quantitative analysis relegated the conclusions drawn within these studies to observations without the confidence in outcomes associated with statistically significant differences.

In addition, most studies used a small number of participants. Within the 20 empirical research studies that specifically investigated the use of the tongue during wind instrument performance, only eight studies included 10 or more participants (Amstutz, 1970; Carr, 1978; Compagno, 1990; De Young, 1975; Haynie, 1967; Hungerford, 2004;

Meidt, 1967; Watkins, 2002).[33] Of these eight studies, only Amstutz and Meidt included statistical analyses. The small sample sizes within the remaining studies limit the ability to generalize results beyond the participants involved.

Many studies included notable diversity regarding the age and performance experience of the participants. Some studies included college students along with either college faculty members or professional performers (Amstutz, 1970; Frohrip, 1972; Meidt, 1967; Watkins, 2002). Two studies included both undergraduate and graduate students (Compagno, 1990; Mooney, 1968). Patnode (1999) included graduate-level and post-graduate participants. The spread in age and training within these studies, done without including this as an independent variable in the research design, calls into question the conclusions drawn.[34]

Next, a lack of consensus was found between the empirical research studies summarized above. This lack of agreement (a) mirrors the diversity of opinions that was found within the review of music pedagogy sources and (b) further establishes the need for systematic research on the subject of articulation.

Finally, no empirical studies were found that investigated physiological changes during performances by young wind players. The current researcher acknowledges that this is likely due to the risks associated within the methods of measurement incorporated

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[33] As previously noted, the review of Clinch et al. (1980) was based on a summary article that did not specify the number of participants; however, Hungerford (2004) indicated that Clinch himself and a recorder player were the only participants.

[34] Hungerford (2004) also included a diversity of ages and experience levels in her study; however, this diversity was intentionally incorporated into the design of the study in order to compare performers with various levels of experience.

into many of these studies. Nonetheless, this fact further supports the premise that there is a need for additional empirical research on the subject of articulation.

In summary, within the 20 empirical studies reviewed by the current researcher, (a) 12 did not include statistical analysis, (b) 12 had fewer than 10 participants, and (c) none included young wind players. Further, a lack of consensus was found between studies regarding the conclusions drawn therein. These findings support the premise that there is a need for additional empirical research on the subject of articulation. Such research must be sound, including appropriate statistical analyses along with a sufficiently appropriate sample size.

Empirical studies that investigate ways to improve articulation.

The final category of research explored in this literature review focused on determining whether particular strategies were more effective than others for executing or teaching articulation on a wind instrument. After a presentation of each individual study, an overall summary will be provided.

Moody (1965) conducted a study to compare various methods of triple-tonguing on brass instruments. Two strategies for triple-tonguing were incorporated, based on the results of a survey sent to all schools affiliated with the National Association of Schools of Music in 1963 (140 responses, representing a 56% return rate). Moody designated the triple-tonguing model TU-TU-KU, TU-TU-KU as the control group, based on the preference of this model within the survey responses. Moody's preferred method of triple-tonguing (TU-KU-TU, KU-TU-KU) was designated as the experimental condition.

Two concurrent experiments were conducted. The first took place at the University of Southern Mississippi and included 10 trumpet, four French horn, eight baritone, and 10 trombone players. In the initial weeks of the treatment period, all students were taught to double-tongue (TU-KU). During the eighth week of instruction, each participant performed a double-tonguing exercise as a means of preliminary assessment; these performances were recorded and later evaluated in order to ascertain each participant's ability to effectively utilize the syllable KU, as required for both triple-tonguing methods. After this assessment, participants were assigned to matched pairs, based on instrument played, grade level, instructor, and performance level (as determined by the double-tonguing assessment). Within each paired set, one participant was randomly assigned to the treatment condition and the other to the control group. Throughout the remaining eight weeks in the treatment period, participants received instruction regarding triple-tonguing, based on group assignment.

At the conclusion of the treatment period, all participants were recorded while performing a triple-tonguing exercise. A graphic recorder was utilized to visually represent the intensity (amplitude) of sound over time. These visual representations of performances were analyzed by the researcher for differences in volume and spacing between the three notes in the triplet sets. In addition, the participating teachers compared the performances by each member of the paired sets to determine which performance was superior. Data were analyzed using (a) the sign test for paired observations, (b) the signed rank test for paired observations, (c) the sum of ranks for two samples (Mann-Whitney), (d) the sum of ranks test for k samples (Kruskal and Wallis),

(e) the chi square test, (f) the test of significance for rank order coefficient, and (g) the test of significance for the confidence interval of the binomial $(.5 + .5)^N$.

A second concurrent study took place at Washington Junior High in Duluth, Minnesota. All participants in this study were given equal instruction in both methods of triple-tonguing throughout the 16-week treatment period. The summary of this portion of the study was not clearly presented, leaving questions regarding the processes. For example, Moody (1965) indicated that participants within this group served as their own control; 14 rows of data were listed in the summary tables provided, with the first column labeled *Pair*. Yet, Moody stated, "The participants [at Washington Junior High] were not paired; the full sixteen weeks were given to the equal practice of both methods" (p. 93). Later, in the presentation of the results, Moody stated, "The total volume difference… for each experimental student was subtracted from the total volume difference for his control mate. The same process was followed for the spacing differences" (p. 112). This discrepancy left the current researcher unsure of the processes being utilized within this section of the study.

Data from the University of Southern Mississippi and Washington Junior High were analyzed separately. Within the participants at the University of Southern Mississippi, Moody (1965) found that the experimental group (TU-KU-TU, KU-TU-KU) scored significantly higher than the control group on evenness of volume, evenness of spacing, and on the combination of evenness of volume and spacing (overall performance), $p < .01$. Additionally, comparisons of each note within the triplet sets were made from measure to measure within the performances, including evenness of volume and evenness of spacing (first vs. second measurement, second vs. third measurement, and third vs. first measurement) for all participants. The experimental group significantly outperformed the control group on five of the six comparisons, including: evenness of volume between the first and second notes, $p < .01$; evenness of volume between the second and third notes, $p < .01$; evenness of volume between the third and first notes, $p < .01$; evenness of spacing between the first and second measurements, $p < .025$; and evenness of spacing between the third and first measurements, $p < .025$. The scores from participating teachers did not differ significantly from the ratings derived from evaluations of the graphic recorder output.

Results of the study conducted at Washington Junior High revealed no significant differences between the control and experimental methods regarding evenness of volume, evenness of spacing, and the combination of evenness of volume and spacing. Scores from the participating teacher in this portion of the study differed significantly from the ratings derived from evaluations of the graphic recorder output, $p < .01$; the ratings by the participating teacher were higher for the experimental group than were the ratings from the graphic recorder output. Additionally, comparisons of each note within the triplet sets were made from measure to measure within the performances, including evenness of volume and evenness of spacing (first vs. second measurement, second vs. third measurement, and third vs. first measurement) for all participants. The experimental group significantly outperformed the control group on two of the six comparisons, including: evenness of spacing between the first and second measurements, $p < .01$; and evenness of spacing between the third and first measurements, $p < .05$. Given the lack of clarity regarding the processes involved within this portion of the study (as stated previously), the current researcher is unsure how Moody (1965) determined that participants were using the appropriate articulation syllables during the recorded performances, if, in fact, the participants were tested using both methods of triple-tonguing as Moody suggested. Finally, when looking at treatment as a main effect between both study groups, the experimental group outperformed the control group in evenness of spacing at a level of significance, $p < .05$.

In the summary section of his report, Moody (1965) appeared to present only the findings from the University of Southern Mississippi study, as he stated:

> The experimental method was found to be significantly better than the control method in a comparison as to evenness of volume, in a comparison as to evenness of spacing, and in a comparison on the combined criteria – evenness of volume and spacing. (pp. 144-145)

The discrepancies found in Moody's report undermine the veracity of findings in his study. Further, the current researcher questions the practical significance of Moody's study. Participating teachers found that the experimental method, which utilized three duple-sets over two beats (<u>TU-KU</u>-<u>TU, KU</u>-<u>TU-KU</u>), presented difficulties for students during performances that changed pitch (authentic settings), as these naturally tended to accentuate the triple-division of the beat. Despite the concerns presented above, Moody's investigation represented the earliest study reviewed by the current researcher that compared multiple strategies for teaching articulation. The study of multiple-tonguing techniques, however, distinguishes Moody's study from the current investigation.

Pino (1975) conducted an experiment to compare traditional multiple-tonguing techniques on the clarinet with an experimental condition labeled *on-the-reed multiple-tonguing*. Since articulation on the clarinet is normally accomplished by touching the tongue to the reed, traditional multiple-tonguing is problematic, due to the alternation between alveolar tonguing (tip of the tongue) and velar-stops (back of the tongue and soft palate). In contrast, on-the-reed multiple-tonguing is "accomplished by passing the tip of the tongue up and down over the tip of the reed, first in one direction and then in the other" (p. 18), thus eliminating the need for velar-stops.

The current researcher had numerous concerns about the validity and reliability of Pino (1975). First, when describing his dissertation as a case study, Pino stated, "The experiment included musicians who attempted an execution of the technique to show simply that it could be done, and to show no more than that" (p. 42). Later, Pino stated:

> It is also significant that the results of all who made an attempt at the introductory states of the Procedure have been included here; in other words, the cases studied represent the entirety of the cases approached by the author for the purpose. (p. 43)

To the current researcher, Pino's report appeared to represent a summary of experiences rather than a formal case study. Next, Pino supplied the participants with written instructions in advance of the testing procedures regarding how to perform on-the-reed multiple-tonguing. A few days later, he met with participants to discuss this technique and subsequently attempt it for the first time. The current researcher is unsure how Pino determined that participants did not experiment with this technique on their own in the interim between receiving the instructions and the testing date. Further, Pino later stated:

> According to those instructions, triple-tonguing is not actually gone into, since it is not supposed to be attempted until double-tonguing has been fairly well established in a player's technique. However, the author asked each participant to try it anyway (at the end of the initial session) just to see what would happen…. Then it may be deduced, by comparing the third marking with the first two, what the fourth one would probably become if that player ever should develop triple-tonguing later on. (pp. 44-45)

Finally, during performances, metronome markings were recorded for the fastest speed at which participants performed the four repeated tones per beat smoothly and evenly over the course of at least four beats; the precise manner in which this was determined was unclear to the present researcher. Further, no external judges were included for reliability testing. Given these sizable concerns on the part of the current researcher regarding validity and reliability, Pino's study will not be further detailed.

Goddard (1987) investigated how two methods of tonguing (anchor tonguing and tip-to-tip tonguing) interacted with orthodontic characteristics regarding tone quality and articulation on the clarinet. Goddard randomly assigned 82 seventh-grade clarinetists to one of the methods of tonguing. Orthodontic characteristics (assessed by an orthodontist for each participant) included:

- dental occlusion: the relationship of the opposing surfaces of the teeth when the two jaws come together, including class I occlusion, class II malocclusion, and class III malocclusion;
- overjet: a measurement of the horizontal proximity of the upper and lower teeth; measured in millimeters and classified as low, medium, and high; and
- overbite: the degree to which the top teeth extend vertically beyond the bottom teeth; based on the percentage of the lower teeth covered by the upper teeth and classified as low, medium, and high.

The current researcher questions Goddard's assignment of categories (low, medium, and high) for both overjet and overbite. Goddard classified the median score (and *only* the median score) as the medium category; all measurements below the median score were classified as the low category and all scores above the median score were classified as the high category. When considering overjet, this system resulted in unequal categories of low (0 to 2 millimeters), medium (3 millimeters), and high (4 to 11 millimeters).

During the 10-month treatment period, Goddard (1987) checked each participant's tonguing technique twice through the use of dye transference. In this regard, the lower lip, incisors, and gums were coated with a dye (disclosing solution). Participants were trained to keep their tongue away from the dye as the clarinet was placed in their mouths. After tonguing multiple notes, the participant's tongue was inspected; the presence of dye on the tongue suggested that anchor tonguing was utilized, whereas a lack of dye on the tongue suggested that tip-to-tip tonguing had occurred.

At the end of the treatment period, participants recorded the performances of five exercises that were designed by the researcher. Using a five-point Likert scale, three judges (professional clarinetists and pedagogues) rated each performer on articulation and tone quality. Interjudge reliability was checked in two ways. First, correlations between judges were assessed and found acceptable, with r-values ranging from .409 to .658, $p < .001$. Additionally, a repeated measures analysis of variance was computed for the scores for each subject. Although significant differences were found between judges, $p < .03$, Goddard (1987) indicated that one judge consistently awarded scores lower than the other two judges. As such, he concluded that interjudge reliability was acceptable. The current researcher, however, questions this conclusion, based on the correlation value of .409 as well as the significant differences between the scores of the external judges.

Data were analyzed using a four-way ANOVA to compare treatment (tonguing method), occlusion classification, overbite, and overjet. No significant differences in tone or articulation were revealed for the main effects of tonguing technique or orthodontic characteristics. Regarding interaction effects, Goddard (1987) drew the following conclusions:

- occlusion: Of the students assigned to anchor tonguing, those with class III occlusion were the most successful; of the students assigned to tip-to-tip tonguing, those with class II occlusion were the most successful. Although these results did not rise to a level of statistical significance, $p < .07$, Goddard provided an interesting consideration in this regard. Given the forward protrusion of the lower jaw in class III occlusion, the forward position of the tongue might make anchor tonguing more practical, since the middle of the tongue arches up to touch the reed in this approach. Conversely, in class II occlusion, the lower jaw is further back in relation to the top jaw, which might make tip-to-tip tonguing easier to accomplish.

- overjet: A significant interaction ($p < .01$) was found between tonguing technique and overjet; students with a high degree of overjet performed less well when using tip-to-tip tonguing.
- overbite: A significant interaction ($p < .04$) was found between tonguing technique and overbite; students with a low degree of overbite performed better when anchor tonguing.

During the treatment period, 16 participants changed tonguing-method (five changed from tip-to-tip tonguing to anchor tonguing and 11 changed from anchor tonguing to tip-to-tip tonguing). For the purposes of analysis, data from these participants were included within the tonguing classification being utilized at the conclusion of the study. This group of participants who changed tonguing-methods scored higher (but not significantly) than the mean for all participants. Goddard (1987) suggested that these 16 participants might have changed tonguing-methods due to a need to match tonguing technique to dental condition, which he proposed could explain the elevated mean scores within this group. Nonetheless, these 16 participants represented nearly 20% of the overall sample; a change of this magnitude within the treatment period calls into question the results of the study.

According to Goddard (1987), "Describing a single, 'correct,' tongue position or tip placement at the early stages of clarinet instruction might inhibit the pupil's naturally finding the position and tip placement that is most efficient for his or her oral physiology" (p. 80). Goddard recommended that an investigation of oral physiology should be used to guide students to appropriate tonguing techniques.

Lee (1996) conducted a study to compare articulation instruction that included vocalization techniques to traditional note-to-note instruction (no use of vocalization) on the performance level of young musicians. Participants included 48 fifth-grade band students. During the treatment period, participants in the control group practiced selected exercises on their instrument (no vocalization techniques were utilized), whereas participants in the experimental group practiced the selected exercises on their instrument and also sang the exercises using TEE for tongued notes and EE for slurred notes.

The *Musical Aptitude Profile* (Edwin Gordon) was administered to students as both a pretest and posttest. Difference scores (pretest to posttest) were calculated for all participants in both group conditions. A *t*-test indicated that no significant differences existed between groups, although the mean difference score for the experimental group was greater than the control group.[35] In addition, the posttest included performances of selected exercises from the *Sounds Spectacular* band method book (Andrew Balent) as well as teacher-generated playing exercises. An external judge[36] evaluated performances

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[35] It is important to note that only overall difference scores were presented, despite the inclusion of this test to investigate both articulation and phrasing.
[36] This judge was referred to only as "a colleague of the researcher" (p. 37); no additional qualifications were provided.

based on the correct execution of articulation (correctly tonguing and slurring during performance) and phrasing, using a scale of 1 (no mistakes) to 5 (four or more mistakes). A *t*-test indicated that there were no significant differences between groups during the performance of exercises from the *Sounds Spectacular* book, but there were significant differences during the performances of two of the five teacher-generated exercises, $p < .05$, with the experimental group outperforming the control group. Composite mean scores between both sets of playing exercises indicated that participants in the experimental group outscored participants in the control group, but this difference did not achieve a level of statistical significance. Still, based on the differences found within the teacher-generated playing exercises, Lee (1996) concluded that the use of vocalization enhanced beginning instrumentalists' conception and performance of articulation over traditional instruction.

It should be noted that the current researcher had concerns with the analysis of data in Lee's (1996) study. For example, Lee reported a *p*-value of 2.021 within Table 7 (p. 41), representing a statistical impossibility. Further, Lee stated, "Table 8… represents data obtained from an analysis of covariance through the use of the Pearson Product-Moment Coefficient Correlation. Pretest/posttest comparisons for each group are illustrated by mean and r values" (p. 40). These errors are a cause of concern regarding the reported outcomes of Lee's study.

Finally, using a five-point Likert scale, Lee (1996) surveyed elementary band directors in West Virginia to determine the extent to which vocalization techniques were being utilized (31 responses, representing a 31% response rate). In addition, regardless of whether participants incorporated vocalization strategies within their own classroom settings, they were asked to rate vocalization strategies based on their perceived effectiveness. Of the participants, 97% considered vocalization techniques to be an extremely effective method of instruction, but less than half of the participants utilized this strategy themselves on a regular basis.

Despite the current researcher's concerns regarding statistical analysis, Lee's (1996) research is relevant to the current study for several reasons. First, he investigated multiple strategies in an effort to determine the most effective ways to teach articulation. Second, Lee included young band students as participants. In both regards, his approach aligned with the current study. However, Lee's investigation of articulation focused on the accurate execution of tongued and slurred passages according to the patterns notated in various musical examples. Thus, the primary focus of Lee's study differed from the current study, which investigated tonguing based on clarity of articulation with accuracy of execution across various tempos.

Sullivan (1998) conducted a study to compare a multi-syllabic approach for single-tonguing with a one-syllable approach. Participants, including 66 woodwind players in grades 10 through 12, explored various articulation markings (including fundamental, legato, staccato, half-staccato, and mixed articulations).[37] During the treatment period, participants practiced articulation techniques through verbalization, mental rehearsal, and performance. The control group used only one syllable (TAH) for

[37] Although the term *fundamental* was not defined, the current researcher interpreted this to mean that no specific articulation marking was indicated.

all articulation markings. The multi-syllabic treatment group incorporated four different vocal syllables, including both breath releases (TAH and DAH) and tongue-releases (TUT and TAHT); a syllable was assigned to each of the various articulation markings to "serve as an aid in producing the tonguing skill and to serve as a mnemonic device" (p. 87). The dependent variable in this study consisted of scores based on both individual and small group performances of selected music, including both rehearsed music and sight-reading. Three judges, described as "musically trained" (p. 92), assessed individual performances based on accuracy (defined as the correct execution of the written articulations). Ensemble performances were evaluated based on group accuracy (as defined above) and precision (defined as moving together or ensemble unity).

Based on a two-way ANOVA, participants in the treatment group outperformed those in the control group at a level of significance on individual articulation accuracy in both the rehearsed music, $p < .001$, and sight-reading contexts, $p < .001$.[38] No significant differences were found between instruments (flute, clarinet, saxophone, double-reeds) regarding articulation accuracy. Further, no interaction effects were found. These findings indicate that a multi-syllabic approach is effective for improving articulation accuracy for all woodwind instruments.

Within group settings, the results were mixed; *median* tests indicated that significant differences were found in favor of the treatment group only for (a) articulation accuracy of rehearsed music by the saxophone and double-reed sections, (b) ensemble

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[38] Sullivan (1998) recorded the *p*-value for rehearsed music as $p < .0001$ and for the sight reading context as $p < .0011$; these have been reported here as $p < .001$ to conform to APA style manual requirements.

precision by the saxophone section, and (c) articulation accuracy for ensemble sight-reading, $p < .05$. However, in this regard, Sullivan (1998) did not account for an increase in alpha error (α) due to multiple analyses. Finally, significant differences were found between articulation styles, including: (a) fundamental, half-staccato, staccato, and legato articulations were performed more accurately than mixed articulations during the performance of a rehearsed measure and (b) fundamental and legato articulations were performed more accurately than half-staccato, staccato, and mixed articulations during the performance of a sight-reading measure, $p < .05$.

Sullivan (1998) concluded that the multi-syllabic approach was an effective strategy for improving articulation accuracy and sight-reading accuracy for individuals and groups. Although the current researcher questions the practical significance regarding the results of group settings for various articulation styles (given the mixed results), the findings for individual performances indicate that a multi-syllabic approach should be considered within the music classroom.

In summary, only a few empirical studies specifically investigated ways to improve articulation on a wind instrument. Two studies focused on multiple-tonguing (Moody, 1965; Pino, 1975), a topic that falls beyond the scope of the current study. Goddard (1987) investigated two methods of tonguing on the clarinet (tip-to-tip and anchor tonguing), while also considering the impact of dental characteristics; he concluded that oral physiology should be used to guide students to appropriate tonguing techniques. Finally, two studies investigated the use of vocal models for articulation on a wind instrument (Lee, 1996; Sullivan, 1998). Lee investigated the use of articulation instruction that included vocalization techniques in comparison to traditional note-to-note instruction (no use of vocalization) on the performance level of young musicians; he concluded that the use of vocalization enhanced beginning instrumentalists' conception and performance of articulation over traditional instruction. Sullivan compared a multi-syllabic approach for single-tonguing with a one-syllable approach; she concluded that the multi-syllabic approach was more effective than the one-syllable approach for improving articulation accuracy and sight-reading accuracy for both individuals and groups. Although both Lee and Sullivan included young wind players within their studies, each focused on the execution of specific articulation (style) markings within the music (such as tongued, slurred, staccato, or legato). This focus on articulation style distinguishes these studies from the current investigation, during which articulation was assessed based on clarity of articulation with accuracy of execution across various tempos. As such, despite the fact that each of the investigations within this subset of empirical studies sought to improve articulation skills, none of them fulfilled the intent of the current researcher to determine what teaching strategies were most effective in achieving clear articulation with accurate execution across various tempos among young wind players.

Literature Review Summary

The current researcher intended to provide a literature review that considered articulation on a wind instrument in a holistic manner. As such, this review began with an exploration of two topics that fall outside of the field of music. First, the exploration of phonetics provided an authoritative perspective regarding the consonants and vowels commonly recommended as guides for articulation on a wind instrument. Second, an investigation of the impact of native language highlighted the need to carefully reconsider the strategies utilized to teach articulation, since native language has an impact on the manner in which particular consonants and vowels are pronounced and perceived, if indeed they are even included within a given language. Given the diversity of the student population in public schools within the United States, band directors must consider the impact of native language.

Next, a summary of music pedagogy sources was provided in an effort to ascertain how articulation has been taught. A wealth of material on articulation exists in music books and journals. However, most ideas presented within these sources are based on the opinions of prominent performers and teachers, rather than on scientific research. As such, conflicting opinions dominated this portion of the literature review. Finally, full-band method books were found to contain minimal instruction regarding how to articulate on a wind instrument. Most commonly, this information was relegated to the introductory section of these books.

Research studies were the last category of investigation within the current literature review. The majority of extant studies were empirical investigations regarding physiological changes that occur during articulation on a wind instrument. Of the 20 studies reviewed within this line of research, (a) 12 did not include statistical analysis, (b) 12 contained small sample sizes (less than 10 participants), and (c) none included young wind players. Further, a lack of consensus was found between these studies regarding the specific role of the tongue during articulation on a wind instrument. Only a few empirical studies investigated ways to improve the act of articulation on a wind instrument. None of these fulfilled the intent of the current researcher to determine what teaching strategies were most effective in achieving clear articulation with accurate execution across various tempos among young wind players.

Having completed an exhaustive review of related literature, the methods and procedures used within the current study will be summarized in Chapter 3. This will include (a) an overview of the pilot study that provided a foundation for the current study; (b) detailed information about the main experiment, including the participants, the independent and dependent variables, and the method of data collection; and (c) a brief overview of the statistical analyses utilized.

Chapter 3 – Method

The classroom experiences of the current researcher suggest that a substantial number of young wind players do not use their tongue correctly when articulating. In addition to general misuse of the tongue (such as THAH [including both /θ/ as in *thigh* and /ð/ as in *thy*] or /j/ as in YAH), many students use air-starts (/h/ as in HAH), glottal-stops (a disruption of the airstream in the throat, such as in AH-AH), or velar-stops (/k/ as in KAH or /g/ as in GAH) as the primary way to initiate a musical tone rather than the tip of the tongue (/t/ as in TAH or /d/ as in DAH). Once acquired, these habits can be difficult to correct and can lead to frustration for both student and teacher. It is the hope of the current researcher that this study will lead to more informed pedagogical practices regarding how to teach young wind players to articulate correctly.

Pilot Study

The current study was guided in part by both the procedures and findings from a pilot study conducted at the University of Minnesota (Budde, 2008). The pilot study provided a foundation for the current study. As such, the pilot study will be summarized in detail, including its method, results, and a summary of considerations that guided this researcher when devising the current study.

Pilot study summary.

The purpose of the pilot study was to determine what teaching strategies were most effective in achieving clear and accurate articulation at rapid tempos among young brass students. Participants (*N* = 69) included sixth- and seventh-grade brass players from a suburban school district near Minneapolis, Minnesota.

Specific research questions included:

- Are particular teaching methods more effective than others in helping young brass students to articulate clearly and accurately at rapid tempos?
- Will the specific instrument played impact the degree to which young brass students articulate clearly and accurately at rapid tempos?
- Will grade level impact the degree to which young brass students articulate clearly and accurately at rapid tempos?
- Will the range of an exercise impact the degree to which young brass students articulate clearly and accurately at rapid tempos?
- Are particular teaching methods more effective than others in helping young brass students to eliminate the use of the throat during tonguing/articulation?

A null hypothesis was assumed for all research questions, meaning that no significant main effect would be revealed for any of the independent variables (test, instrument played, range, grade level, and group) or in their interactions concerning the degree to which young wind players articulated clearly and accurately at rapid tempos. The level of alpha error (α) was set a priori at .05.

The pilot study was an experimental pretest-posttest design. Scores from two playing exercises (mid-range and low-range) and data from an electroglottograph (EGG) served as the dependent measures.[39] Playing exercises (Figures 5 and 6) were designed by the researcher to assess a participant's performance level, based on clarity of articulation and accuracy of execution at rapid tempos. During the pretest, each participant first played the mid-range exercise at 60 beats per minute (bpm); with each successful performance, the researcher increased the speed of the metronome by 8 bpm until a tempo was reached that was unplayable within two attempts. This process was then repeated for the low-range exercise. A four-week interval separated the pretest and posttest. The same protocol for data collection was followed during the posttest.

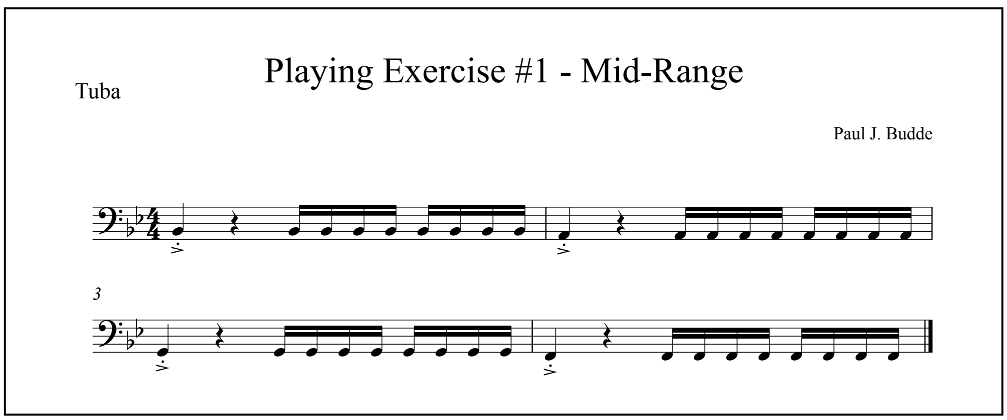

Figure 5. Pilot study mid-range exercise (tuba).

[39] An electroglottograph (EGG) is a device commonly used in speech and voice physiology. The EGG monitors movement of the vocal folds by detecting impedance change as the vocal folds make varying degrees of contact. It was the hope of the current researcher that the EGG would conclusively ascertain whether or not participants were utilizing their throat to articulate; this did not prove to be the case. Many variables (including neck size and shape, snugness of fit, and movement during the performance) affected the readings from the EGG; thus, between-subjects analysis was not practical. As such, the use of the EGG will not be discussed further within this report.

Figure 6. Pilot study low-range exercise (tuba).

All pretest and posttest performances were recorded (audio) for the purposes of assessment; in addition, a video recording served as a backup in the event of technical problems. At the conclusion of the study, the researcher assessed all pretest and posttest performances from the audio recordings. The metronome markings for the fastest successful performances of both the mid-range and low-range exercises were recorded as the dependent measures for both the pretest and posttest.

A random sampling of 10 pretest and 10 posttest performances underwent reliability testing by two external judges. Judge #1 was an active performing musician (trumpet) and high school band director. Judge #2 was an active performing musician (trombone) and middle school band director. The Pearson product-moment correlation coefficient was used to compare the researcher's assessment scores with those of the two external judges. There was a strong positive correlation between the scores of the researcher and both Judge #1, $r = .907$, $n = 20$, $p < .001$ and Judge #2, $r = .943$, $n = 20$,

$p < .001$. As a result, the assessment of student performances was determined to be reliable.

Within the six intact participating bands, two (including one sixth-grade and one seventh-grade band) were randomly assigned to each of three conditions:

- Control Group: This group participated in the pretest and posttest as described above. Following the pretest, participants in this group received an articulation guide sheet that summarized common pedagogical ideas regarding articulation on a brass instrument.
- Exercise Group: Like the control group, this group received an articulation guide sheet at the conclusion of the pretest. In addition, this group practiced the articulation exercises (mid-range and low-range) for five minutes during each band rehearsal in the four-week interval from pretest to posttest. In an effort to mirror the experiences of the pretest and posttest, the exercises were rehearsed at 60 bpm; increases in speed (at intervals of 8 bpm) were based on the director's perception of the ensemble's success during rehearsals.
- Wind-Pattern Group: This group functioned in the same manner as the exercise group, but with one addition: before playing the articulation exercises, this group practiced wind-pattern exercises (described in the literature review) with each increase in tempo, using the rhythms found in the articulation exercises.

Data from the pilot study were analyzed by means of a repeated measures analysis of variance (ANOVA). Between-subject variables included: group (control [n = 28]; exercise [n = 19]; or wind-pattern [n = 22]), instrument played (trumpet [n = 39]; French horn [n = 1]; trombone [n = 16]; baritone/euphonium [n = 9]; or tuba [n = 4]), and grade level (sixth grade [n = 35] or seventh grade [n = 34]). Within-subject variables included test (pretest and posttest) and range (mid-range and low-range). The following results were observed:

- Group: There was not a significant main effect for group, F (2, 57) = .468, p = .628. Mean scores for group are shown in Table 1.

Table 1

Pilot Study Results: Mean Scores for Group

Group	*N*	*M*	*SD*
Control Group	28	82.64	9.01
Exercise Group	19	82.00	12.58
Wind-Pattern Group	22	85.18	9.25

- Instrument Played: It was the intent of the current researcher to compare each of the five brass instruments (trumpet, French horn, trombone, baritone/euphonium, and tuba). However, the small number of French horn (n = 1) and tuba (n = 4) players necessitated a more basic comparison of high-brass (trumpet and French horn [n = 40]) and low-brass (trombone, baritone/euphonium, and tuba [n = 29]). Using these broader categories, there was not a significant main effect for instrument played, F (1, 57) = 2.845, p = .097. Mean scores for instrument played are shown in Table 2.

Table 2

Pilot Study Results: Mean Scores for Instrument Played

Instrument Played	*N*	*M*	*SD*
High-Brass	40	84.65	8.12
Low-Brass	29	81.38	12.26

- Grade Level: There was a significant main effect for grade level (sixth-grade [n = 35] or seventh-grade [n = 34]); the seventh-grade participants outscored the sixth-grade participants, F (1, 57) = 6.827, p = .011. Mean scores for grade level are shown in Table 3.

Table 3

Pilot Study Results: Mean Scores for Grade Level

Grade Level	*N*	*M*	*SD*
Grade 6	35	80.17	9.41
Grade 7	34	86.47	9.95

- Test: There was a significant main effect for test (pretest and posttest) with participants scoring higher on the posttest, F (1, 57) = 45.719, p < .001. Mean scores for test are shown in Table 4.

Table 4

Pilot Study Results: Mean Scores for Test

Test	*N*	*M*	*SD*
Pretest	69	80.64	10.55
Posttest	69	85.91	10.68

- Range: There was a significant main effect for range (mid-range and low-range exercises) with participants scoring higher on the mid-range exercise, $F\ (1, 57) = 56.333, p < .001$. Mean scores for range are shown in Table 5.

Table 5

Pilot Study Results: Mean Scores for Range

Range	*N*	*M*	*SD*
Mid-Range	69	86.43	11.04
Low-Range	69	80.12	10.38

- Interaction Effects: Only one interaction was found to be statistically significant: the three-way interaction between range, instrument played, and group, $F\ (2, 57) = 3.297, p = .044$. On the mid-range exercise, the high-brass outscored the low-brass within all groups (control, exercise, or wind-pattern). This was also true in the low-range exercise with one exception: the low-brass control group outperformed the high-brass control group. Interaction plots are presented in Figures 7 and 8.

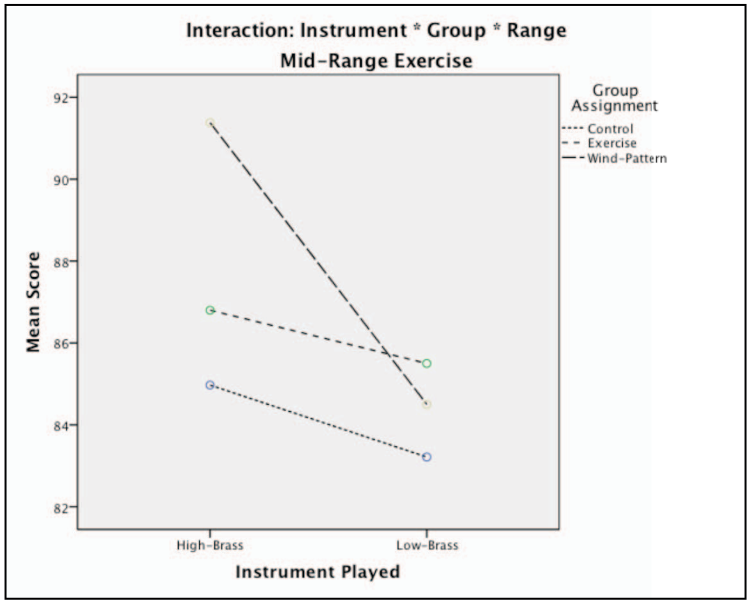

Figure 7. Interaction between range, group, and instrument for the mid-range exercise.

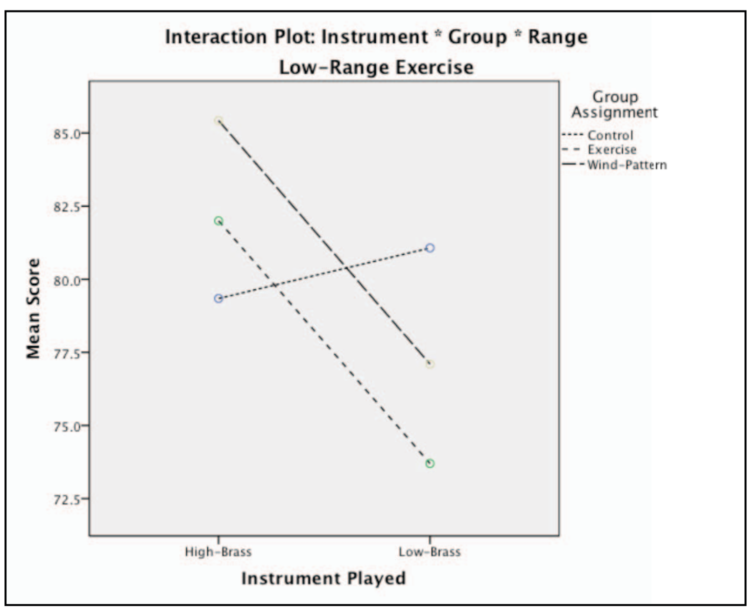

Figure 8. Interaction between range, group, and instrument for the low-range exercise.

To summarize the results of the pilot study, significant differences were revealed for the main effects of grade level (seventh-grade outperformed sixth-grade), range (mid-range scores were higher than low-range scores), and test (posttest scores were higher than pretest scores) on the performance level of young brass students, based on clarity of articulation and accuracy of execution at rapid tempos. No significant main effects were found for instrument (high-brass or low-brass) or group (control, exercise, or wind-pattern). Of all possible interaction effects, only the three-way interaction between range, instrument, and group was found to be significant: on the mid-range exercise, the high-brass outscored the low-brass within all groups (control, exercise, or wind-pattern); this was also true in the low-range exercise with one exception: the low-brass control group outperformed the high-brass control group.

Considerations derived from the pilot study.

The main impetus for the pilot study was to identify teaching strategies that were effective in helping brass students to articulate clearly and accurately at rapid tempos. Yet, as stated above, there was no significant main effect for group. Nonetheless, the pilot study served as a valuable learning experience, providing an informed perspective and methodological foundation for the present investigation. New ideas were generated during the study; these were discussed with participating teachers during a post-experiment meeting. The main points from this discussion have been summarized below.

- The current researcher intended that all participants would practice counting the articulation exercises at various tempos in class during the week prior to the pretest. The inadvertent omission of this step resulted in a general lack of test-readiness in the pretest among all participants. This step is, therefore, considered critical to the success of future research endeavors.

- During the pretest and posttest, participants showed the effects of tongue fatigue. Many students incorrectly played well above the tempo of the metronome in the initial (slow) performances, but were unable to duplicate those speeds when the metronome was actually set to faster tempos. Additionally, participants who were able to articulate at the fastest tempos were required to perform the articulation exercises with more repetitions during the pretest and posttest than did participants who performed the exercises only at slower tempos; these additional repetitions no doubt led to tongue fatigue and influenced the participants' performances at the fastest tempos, which consistently came later in the procedure. An alternate testing protocol with a reduced and consistent number of repetitions should be utilized within future research studies to minimize tongue fatigue and ensure consistency between participants.
- The range of the articulation exercises proved problematic, particularly on the lowest notes of the low-range exercise. A more neutral range should be incorporated in future research studies.
- During the pilot study, it was apparent that a competitive spirit influenced the participants, as they compared scores (metronome markings) upon leaving the pretest room. The design of the pretest must be carefully considered for future research in order to minimize its influence on participant behavior.

- All participants (including those in the control group) received an articulation guide sheet following the pretest. Given the scarcity of information available to young wind players regarding effective articulation techniques, as demonstrated by the examination of full-band method books within the review of literature, this articulation guide sheet may have had an impact on posttest performances within all groups, including the control group; care should be taken to avoid this potential confound in future research studies.
- During rehearsals, participants practiced the articulation exercise as a group during warm-ups. This proved problematic for ensembles that had an unsteady percussion section, resulting in less effective rehearsal time during the treatment period. A means of controlling tempo consistency would increase the reliability of future research studies.
- In order to avoid the development of improper tonguing techniques during the treatment period, participating teachers asked students to stop playing if they could not keep up with the faster speeds of the articulation exercises during band rehearsals; in reality, the students continued to play along with each increase in speed, regardless of their level of success. In future research, a longer treatment period would allow for a more graduated increase in speed during band rehearsals. In addition, the use of a regimented tempo schedule during the treatment period would ensure consistency of approach between groups.
- One of the control groups rehearsed the articulation exercises in class to reinforce the concept of sixteenth-notes. Although this group practiced the articulation

exercise at only one tempo, any use of the articulation exercise within this group nonetheless minimized the intended differences between the control group and the exercise group. Additional efforts must be made to control for similar confounds in future research studies.

- One of the participating teachers acknowledged that she became more aware of articulation as a result of her involvement with the study; as such, she may have unconsciously focused more attention than normal on articulation during rehearsals. Additional efforts must be made to ensure, to the extent possible, that participating teachers do not alter their teaching approaches beyond the parameters of their assigned group conditions in future research studies.
- Due to the time constraints of the pilot study, the posttest occurred at the end of the school year; this generated several potential confounds. First, several bands had finished rehearsing for the school year and were engaged in nonperformance-related activities in class during the posttest period; in addition to creating a difference in testing conditions from pretest to posttest, this may have influenced both the participants' quality of performance and degree of motivation. Second, since band was not required beyond seventh-grade within the participating school district, it is possible that those students who were not continuing in band had, to some degree, shut down at the end of the school year. An alternative schedule should be considered for future research studies.
- One of the participating teachers noted that her seventh-grade control group was the strongest of her classes, while the wind-pattern group was her most

challenging seventh-grade group. This group effect could have countered any tendency of the wind-pattern group to excel, should that strategy have been the most effective. While a larger sample size could help to control for this confound, group effects will exist within any real-world study of this nature.[40]

- During the assessment process, participants' performances of the articulation exercises were evaluated based on clarity of articulation and accuracy of execution at increasing rates of speed; the metronome markings for the fastest successful performances of the mid- and low-range exercises were recorded as the dependent variables for the pretest and posttest. This approach, however, proved problematic, as any determination of *success* was influenced by both the clarity of articulation and the accuracy of execution at each tempo. For example, if the researcher focused on clarity of articulation during the assessment process, a performance might have been considered successful, but if the researcher focused on accuracy of execution, the same performance might have been considered unsuccessful. An alternate method of assessment should be considered that would allow these two components to be considered independently for the purposes of assessment.

[40] Since the time of the pilot study, the current researcher became familiar with analysis of covariance (ANCOVA). Although ANCOVA would have been appropriate for inclusion in the analysis of the pilot study data, due to the challenges enumerated here, the results of the pilot have nonetheless been reported in the manner in which they were analyzed at that time, leaving this more exhaustive and appropriate form of analysis for the present investigation.

In summary, despite the lack of significant differences revealed between groups, the current researcher learned a great deal while carrying out and reflecting upon the pilot study. Many ideas were generated for ways to improve future research on the subject of articulation. This process helped to shape the current study.

Main Experiment

Having summarized the results of the pilot study, a full description of the method for the current study will now be presented. Before commencing, however, it is noteworthy that two changes in protocol took place during the study. First, due to unanticipated events during the collection and assessment of data, a change in protocol was required regarding the specific research questions used in the study. The current researcher submitted a *Change in Protocol Request* form (Appendix B) to the Institutional Review Board (IRB) at the University of Minnesota and was granted approval for the requested change (Appendix C). Second, this change in the research questions subsequently required an alteration of the intended scoring processes for pretest and posttest performances.

In an effort to provide a clear and coherent summary of the current study, only the final version of the research question and scoring processes will be included in the main body of this document; the changes described above regarding the research questions and scoring procedures have been fully detailed in Appendix D. The current researcher acknowledges that some readers could misinterpret this decision as an attempt to hide the associated issues within an appendix. Quite to the contrary, it is the hope of the current researcher that the level of detail included in the appendix will provide a transparent and detailed account of the research study as a whole, while simultaneously facilitating a clear presentation within the main body of this document regarding the processes that were ultimately utilized.

In addition, it is noteworthy at present that sample materials from the current study can be accessed via the University of Minnesota Digital Conservancy as well as ProQuest Dissertations and Theses Online Digital Repository, including (a) copies of the articulation exercise, articulation guide sheet, and signal graph image sheet; (b) audio tracks, including the pretest/posttest accompaniment track, samples of the accompaniment tracks utilized during the treatment period, and recordings of the researcher reading the articulation guide sheet and explaining the concept of wind-pattern exercises; and (c) the articulation video used during the treatment period. These sample materials are intended to clarify the written descriptions within this report and further inform the reader.

Purpose and research questions.

The purpose of the current study was to determine what teaching strategies were most effective in achieving clear and accurate articulation among middle school band students. The specific research question was: Are particular teaching methods more effective than others in helping young wind players to articulate clearly with accurate execution across various tempos?[41] A null hypothesis was assumed, meaning that the researcher predicted no significant differences between the levels of the independent

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[41] See Appendix D for detailed information regarding a change in protocol utilized in the current study with respect to the research questions.

variable (five teaching conditions, including a control group and four treatment groups) concerning the degree to which young wind players articulated clearly with accurate execution across various tempos.

This study was conceived as an experimental pretest/posttest design, a model that aligned with the pilot study. The independent variable included the following five teaching conditions: (a) control group, (b) articulation guide group, (c) practice group, (d) audio model group, and (e) visual model group. Detailed descriptions of each group, including their specific treatment parameters, will be provided later in this chapter. Pretest and posttest scores from the performances of an articulation exercise served as the dependent measures; participants' performances were evaluated based on the clarity of articulation with accuracy of execution at tempos of 60, 80, 100, and 120 bpm. The level of alpha error (α) was set a priori at .05.

Schedule and participants.

The current study was conducted during the Fall Semester 2010. Pretests were conducted during the weeks of September 20 and September 27, 2010.[42] After a 10-week treatment period, which began on October 4, 2010, posttests were conducted during the weeks of December 13 and December 20, 2010.

In working to fulfill the primary purpose of this study, the current researcher chose seventh-grade band students as a suitable population from which to draw a sample;

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[42] The pretest schedule was adjusted slightly to include recording sessions on October 4, 6, and 8, 2010. This deviation from the original schedule will be addressed later within Chapter 3.

based on both the procedures of the pilot study and eight years of personal classroom experience, the current researcher considered seventh-grade students sufficiently new to wind instrument playing (and therefore not yet set in their ways), yet experienced enough to allow for practical testing procedures regarding the investigation of articulation.

During the summer of 2010, seventh-grade band directors from a suburban school district near Minneapolis, Minnesota were invited to participate in this study (invitation letter included as Appendix E). This particular school district was selected partially based on convenience; proximity was an important component in order for the researcher to carry out the in-person pretests and posttests, as well as to assist with and oversee the treatment conditions as needed. Additionally, this school district had a reputation for a thriving music program, thus presenting a large potential sample for the study.

Seven band directors from five middle schools expressed interest (and later agreed to participate) in the study; this resulted in a total of 10 participating seventh-grade bands. Upon receiving formal permission from the Institutional Review Board (IRB) at the University of Minnesota, the school district's administrative office, and the head principal from each participating school, all seventh-grade students within these 10 bands were invited by the researcher to participate in the study. The introductory script (Appendix F), consent form (Appendix G), and assent form (Appendix H) have been included in this document. The IRB did not require the inclusion of parental/guardian signatures on the consent form, since there were no known risks associated with the current study.

In total, 423 of 466 possible seventh-grade wind players (90.8%) from the 10 participating bands participated in the pretest.[43] Scores from 70 participants were eliminated during the assessment process (26 pretest, 44 posttest) for a variety of reasons. First, reed or instrument problems (7 pretest, 1 posttest) prevented eight participants from completing their performances. Second, technical problems during the recording process (2 pretest, 4 posttest) resulted in six unusable recordings. Third, non-tonguing performance problems (12 pretest, 8 posttest) prevented an accurate assessment of 20 participants. For example, some brass players played the exercise starting on a wrong note within the harmonic series (a fact that led to the omission of large sections within their performances); likewise, some flute players did not properly position the mouthpiece on their lips (which resulted in a failure to produce tones in a consistent manner). Fourth, six participants switched instruments during the interim period between the pretest and posttest; this change prevented a reliable within-subject comparison. Fifth, some participants utilized double-tonguing during performances (5 pretest, 8 posttest); despite being a legitimate performance technique on a wind instrument, the inclusion of double-tonguing at fast tempos represented a fundamental difference regarding the method of tonguing utilized. For the five participants who double-tongued on the pretest, double-tonguing represented a between-subjects difference compared to participants who had not received training in this technique; for the eight participants who double-tongued only on the posttest, this same principle applied regarding within-

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[43] Although this study of articulation required only wind players, percussionists participated in the pretest and posttest for the sake of inclusion; their performances were not evaluated or included in the data analyses presented in this report.

subject comparisons between the pretest and posttest. Finally, 17 participants were absent from classes during the posttest period. The elimination of scores from these 70 participants resulted in a set of 353 usable pretest and posttest scores, a number that represented 75.8% of all possible wind players within the 10 participating bands.[44]

Collection of data.

During the pretest and posttest, participants performed an articulation exercise (Figure 9) designed by the researcher to measure tonguing clarity and accuracy. Performances were accompanied by an audio track during both the pretest and posttest. The researcher created this accompaniment track in an effort to stabilize tempo and rhythm during pretest and posttest performances. The accompaniment track was created in GarageBand® using audio loops (percussion accompaniments), live recordings (count-offs by the researcher), and a synthesized version of the articulation exercise that was inputted by the researcher. The accompaniment track was one-minute and twenty-three seconds in length (1:23). The track began with a two-measure introduction and count-off at a tempo of 60 bpm, followed by the combination of a synthesized rendition of the articulation exercise and a percussion-based accompaniment groove. At the conclusion of the articulation exercise, the same sequence was repeated without pause at 80, 100, and 120 bpm (each including the two-measure introduction and count-off), all within the same audio track. In comparison to the pilot study, the inclusion of this audio track

[44] This calculation is based on the total number of wind players (*N* = 466) within the 10 participating bands at the onset on the pretest.

during pretest and posttest performances provided consistency between participant performances and reduced tongue fatigue by ensuring a shortened assessment procedure.

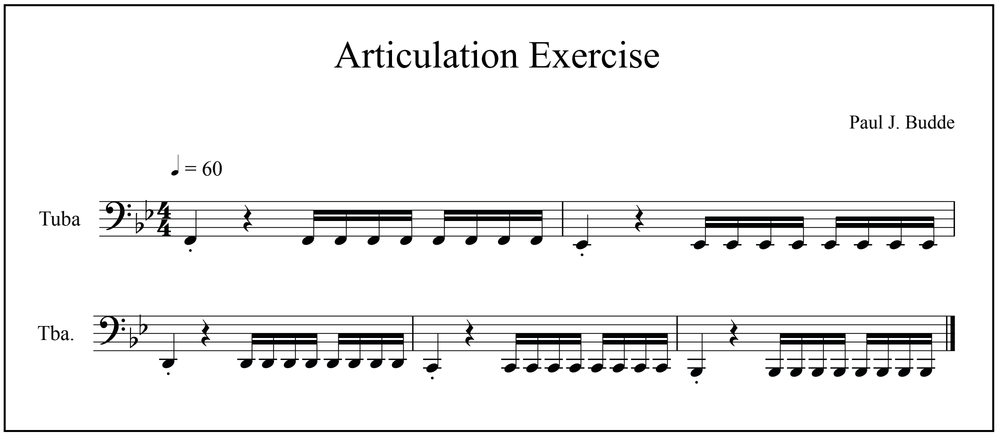

Figure 9. Sample articulation exercise used during the pretest and posttest (tuba).

In order to ensure that participants understood the rhythm of the articulation exercise and were able to change tempos as required during the pretest (and posttest), participants practiced counting (but not playing) the rhythm of the articulation exercise along with the accompaniment track during band in the two-week intermission between the introduction of the study and the onset of the pretest. Although the audio track used during this preparatory procedure was the same track that would be utilized for the pretest (and posttest) performances, participating students were not made aware that this activity was connected to the research study until the onset of the pretest period. This preparatory procedure (counting along with the accompaniment track) was included to minimize the lack of test-readiness encountered in the pilot study.

On the first day of the pretest period for each participating band, participants had their first opportunity to play (rather than count) the articulation exercise along with the audio accompaniment track at the beginning of rehearsal. Next, the researcher explained the procedures to be followed during the recording process. Afterwards, participants were cycled out of rehearsal and directed to a preparation area. While waiting for their turn, participants were able to view a printed copy of the articulation exercise for their instrument and listen to a broadcast of the accompaniment track via an iPod (personal audio player) and portable iPod loudspeaker dock (JBL on stage™ II); this allowed participants to mentally prepare for their performances before they were called upon.

Three separate locations (practice rooms, classrooms, offices, etc.) were utilized within each school for pretest performances, which were recorded for the purpose of assessment at a later time. As such, a portable digital audio recorder (Zoom Handy Model H2) was utilized within each performance site. In addition, a video recorder at each performance site served as a backup in the event of equipment malfunction. Within each of three testing locations, the accompaniment track was broadcast via an iPod; a splitter cable enabled the output from the iPod to be simultaneously broadcast through (a) headphones worn by the participant and (b) a battery-powered portable speaker system (Phillips Model SBA1503). The use of headphones minimized random aural distractions and allowed participants to easily hear the accompaniment track while performing. The external broadcast allowed the audio recorder to capture both the sounds of the performer and the accompaniment track in real time. This configuration allowed the researcher to ascertain whether or not a participant was able to keep up with each increase in tempo when analyzing recordings during the assessment process. A photograph of the equipment utilized for pretest and posttest recordings has been included in Figure 10.

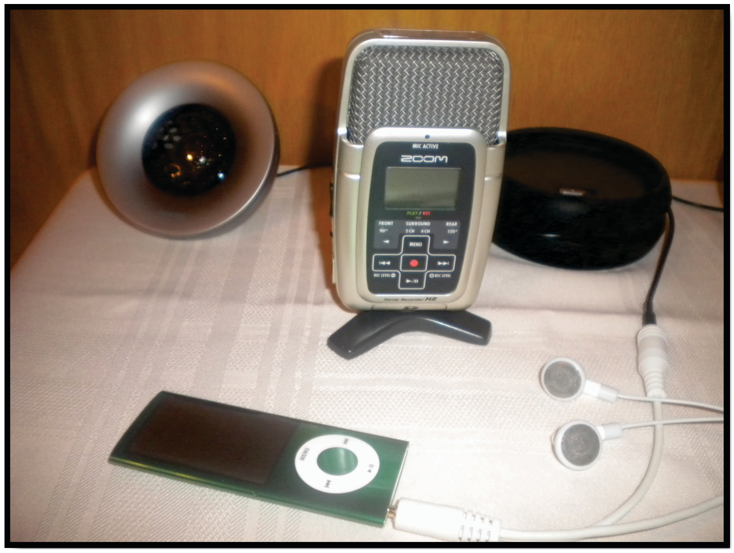

Figure 10. Audio and recording equipment set-up for pretest and posttest recordings.

The researcher's role during the testing procedure was to call each individual into a recording room, announce the participant's five-digit randomized numeric identifier into the recorder,[45] and initiate playback of the accompaniment track when the participant was ready. Once the accompaniment track was started, the researcher left the room and initiated the same sequence of events with the next participant in another testing room. This method of data collection allowed for a highly efficient recording process (up to

[45] This method was used to maintain strict confidentiality concerning the identity of every participant.

three participants performing concurrently) and also gave participants a degree of privacy as they performed the articulation exercise.

The posttest recordings were made in precisely the same manner as the pretest recordings. In the week preceding the posttest, participants practiced counting the articulation exercise during band in the same manner as they had done preceding the pretest; this review was particularly necessary for the groups that did not practice the articulation exercise during the 10-week interval from pretest to posttest.

Upon completion of the pretest and posttest, the researcher cataloged all performances in a database; identifying factors for each participant record included the five-digit numeric identifier, portable recorder number, recording date, and start-time of each performance within a given recording.

Dependent variable.

Within the review of literature, no research study was found that endeavored to evaluate articulation with precisely the same criteria that were utilized within the current study, including both clarity of articulation and accuracy of execution. As such, the current researcher was required to develop a unique assessment protocol. Although this protocol will be summarized below, it is noteworthy at present that the current researcher solicited the advice of professional music educators, including both middle school and high school band directors and collegiate instructors, in order to ensure the validity of the assessment protocol; the ideas from these professional music educators helped the current researcher to develop a draft of the assessment protocol. Next, the current researcher tested the newly devised assessment protocol with the assistance of two additional professional music educators. The current researcher prepared an audio CD that contained pretest performances from 12 participants. This recording was edited to remove unnecessary silence as well as all student verbalizations, leaving only a stream of participant numeric identifiers (in the voice of the researcher) and subsequent performances. These two professional music educators (including one middle school band director and one college music instructor) beta tested the assessment protocol and offered feedback to the current researcher, based on their ability to assess student performances for clarity of articulation with accurate execution across various tempos. The feedback provided by these two music educators was invaluable in helping the current researcher to refine the assessment protocol and ensure its validity as an assessment tool. Having provided a detailed description of this development process, the assessment protocol will now be summarized in detail.

The current researcher evaluated participant performances of the articulation exercise, based on clarity of articulation and accuracy of execution. Clarity of articulation was defined as *having clear definition at the onset of each note*. Accuracy of execution was defined as *the ability to execute the eight 16th-notes (plus the following quarter-note where indicated) precisely in time at the specified tempo*. Despite the inclusion of these two components within the evaluation process, their interconnected nature allowed for the creation of a single Likert-type scale that effectively considered both in combination (a full description of this combination will be provided below). The following prompt was used: *This performance embodies clear articulation with accurate* *execution within the specified tempo*. A continuous scale was used, ranging from 1 (strongly disagree) to 8 (strongly agree).

In order to illustrate the interconnected nature of these two components (clarity of articulation and accuracy of execution) as well as the need for their concurrent consideration within a single Likert-type scale, two fictitious performances will be considered:

- Student A performs the articulation exercise with excellent clarity of articulation and excellent accuracy of execution during a performance at 120 bpm
- Student B performs the articulation exercise with excellent clarity of articulation at 120 bpm, but does so by omitting most of the sixteenth-notes on beats three and four within the articulation exercise. This strategy results in the execution of only three sixteenth-notes where there should be eight

Whereas Student A would be rated at a top score (8 of 8) in the system utilized in the current study, Student B would receive a low score (such as 3 out of 8), which would acknowledge that the performance had a redeeming quality (clear articulation), but did not represent accurate execution of the articulation exercise. Had these two components (clarity of articulation and accuracy of execution) been assessed independently, both Student A and Student B would have received a top score for clarity of articulation. Although these high scores for clarity of articulation would be appropriate within this alternative rating system, the clarity score for Student B would, in fact, represent a performance with clear articulation at a *slow* tempo (since only a few notes were played across beats three and four of the articulation exercise), rather than the actual performance condition (eight 16th-notes on beats three and four, performed at 120 bpm). Thus, due to the interconnected nature of these two elements, the current researcher determined that the combination of clarity of articulation and accuracy of execution within one overall Likert-type scale was the most appropriate means of assessing articulation within any given performance.

Despite the rationale presented above, the consideration of these two components within one rating system warranted careful thought and consideration. In order to ensure consistency of approach during the assessment process, the researcher first considered accuracy of execution, which was viewed by the researcher as the overall determinant of articulation success.[46] As stated previously, accuracy of execution was defined as *the ability to execute the eight 16th-notes (plus the following quarter-note where indicated) precisely in time at the specified tempo*. The score for accuracy of execution, which ranged from 3 (not accurate) to 8 (accurate), was recorded as a *preliminary* score at each tempo. Next, the researcher considered clarity of articulation, which was defined as *having clear definition at the onset of each note*. The researcher adjusted the preliminary score based on the degree of clarity within the performance: for clear articulation, no adjustment was made on the preliminary score; for moderately clear articulation, a one-point deduction was made from the preliminary score; and for unclear articulation, a two-

[46] The three external judges who assisted with reliability testing (to be described in Chapter 4) supported this underlying premise regarding the accuracy of execution as the overall determinant of articulation success.

point deduction was made from the preliminary score.[47] In this way, accuracy of execution acted as the large-scale (macro) means of assessment, while clarity of articulation served to fine-tune (micro) the final rating. As such, a perfect score (8 of 8) required accurate execution throughout (preliminary score of eight) with clear articulation (no points deducted). Likewise, the lowest possible score (1 of 8) required an inaccurate performance (preliminary score of 3) with unclear articulation (two-point deduction). All other scores could be reached by a variety of combinations regarding clarity and accuracy. For example, a score of 6 on this 8-point scale could be achieved in several ways: (a) a performance that was executed with accuracy throughout (a preliminary score of eight), but with unclear articulation (two-point deduction); (b) a performance that was executed with a minor error (a preliminary score of seven) and moderately clear articulation (one-point deduction); or (c) a performance with a more noteworthy error or a few minor errors (preliminary score of six), but with clear articulation throughout (no deduction). Since there were no precedents within the literature reviewed regarding this type of rating system, the current researcher returned to the original prompt (*This performance embodies clear articulation with accurate execution within the specified tempo*) at the end of each individual assessment to ensure that the final score was indicative of a participant's performance, based on clarity of articulation with accuracy of

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[47] It should be noted that other equally valid approaches are possible in arriving at a final score. The current system, however, (a) allowed the researcher to maintain a consistent approach regarding the balance of clarity of articulation and accuracy of execution during the 35-hour assessment-process and (b) reflected the natural assessment process within the mind of the current researcher while listening to performances, a viewpoint that was supported by the three additional expert evaluators who provided an essential reliability check.

execution at each tempo. The researcher found the rating system to be consistently representative, providing a systematic and objective method for rating the performances of the 706 recordings assessed. Appendix I provides a detailed summary of the assessment protocols utilized within the current study.

Separate scores (1 to 8) were recorded for the performances of the articulation exercise at each of four performance tempos (60, 80, 100, and 120 bpm). While these four scores allowed a comparison between groups at each of the four tempos, the current researcher saw no practical significance in doing so. Within a performance-based classroom such as band, a student is expected to be able to play music at various tempos, based on the needs of the music being rehearsed or performed; further, tempo changes are often included within a single piece of music. As such, a teaching method (treatment) that improved articulation only at a specific tempo would be of little practical value in the music classroom; on the other hand, a method that improved articulation skills as a whole might be worthy of implementation in a real-world setting. As such, the sum of the individual scores for each of the four performance tempos provided the most meaningful measure of success regarding clarity of articulation with accuracy of execution across various tempos. Thus, the sum of scores (1 to 8) for each of the four performance tempos (60, 80, 100, and 120 bpm) resulted in a final score (4 to 32) for both the pretest and posttest. These summed scores served as the dependent measures in the current study.

Independent variable.

The independent variable in this study consisted of five teaching conditions that were implemented over the course of a 10-week treatment period. These included: (a) control group, (b) articulation guide group, (c) practice group, (d) audio model group, and (e) visual model group. The treatment parameters for each group are specified below.

Control group.

Participants in the control group ($n = 71$) took part in only the pretest and posttest, as described previously. The inclusion of a control group was intended to represent a traditional (i.e., non-articulation-focused) band classroom to which the four treatment conditions could be compared. A second pretest exercise (which focused on dynamics and intonation) was utilized with participants in this group in an effort to mask the true intent of the research study. The purpose of integrating this masking strategy was to prevent participants in the control group from ascertaining precisely what was being assessed during the pretest, thus minimizing the possibility of a potential threat to validity.

Articulation guide group.

Participants in the articulation guide group ($n = 72$) were supplied with an articulation guide sheet (Appendix A) after the pretest was completed. The articulation guide summarized common recommendations for articulation, based on the ideas found in the literature review, including pedagogical sources, the study of phonetics, and the impact of native language. The inclusion of this group as a separate treatment condition (a) represented a change from the pilot study, in which all participants received an articulation guide sheet upon the completion of the pretest and (b) allowed for an investigation regarding the impact of receiving information about correct articulation techniques, a subject neglected in many full-band method books.

The articulation guide was presented during the first week of the treatment period and reviewed in class by participating teachers every two weeks thereafter (Appendix J). In an effort to control for variance in the approach among the participating teachers, the researcher created the following structured activities:

- Week One: After distributing the articulation guide sheet to all band students, participating teachers in this group played an audio track (2:20) of the researcher reading through the articulation guide, as well as an audio track (1:06) in which the researcher explained the concept of wind-pattern exercises. The script from this wind-pattern-exercises audio track has been included in Appendix K.
- Week Three: Participating teachers asked their students to recall and share as many ideas from the articulation guide sheet as they could (without referring to the guide); their ideas were written as a list on the board at the front of the room. Afterwards, the students reviewed the articulation guide sheet as a class to identify any missing items from their class list related to the topic of articulation.
- Week Five: Participating teachers played a short YouTube video (2:30) in which the researcher reviewed and demonstrated the concept of wind-pattern exercises. This video included demonstrations of what incorrect articulations sound like (including THAH, glottal-stops, and air-starts) in comparison to the recommended approach for articulation (TAH). Finally, the researcher demonstrated the use of an active airstream by blowing into a piece of paper while demonstrating a wind-

pattern exercise; this was included to reinforce the need for an active airstream while articulating.

- Week Seven: Participating teachers reviewed the process of correct articulation based on the articulation guide sheet. Next, they discussed some of the common errors that occurred on the pretest recordings; these included the use of THAH, YAH, HAH, and glottal-stops. Band members were given a chance to try each of these incorrect articulation styles on their instruments to discover how they sounded and felt, after which they returned to the syllable TAH to reinforce the concept of clear articulation.
- Week Nine: Participating teachers reviewed the articulation guide sheet and then led a short discussion regarding what the students learned about articulation during the treatment period.

Practice group.

Participants in the practice group (*n* = 79) functioned in the same manner as the articulation guide group, but included regular articulation practice during warm-ups at the beginning of band rehearsals throughout the treatment period. The pretest/posttest accompaniment track was modified by the researcher (as described below) to serve as a practice tool for band rehearsals during the treatment period. During warm-ups, these audio tracks were broadcast over the stereo speakers in the classrooms of participating bands, which allowed all band members (including percussionists, who played on mallet instruments) to practice along with the accompaniment tracks. This strategy was implemented to minimize the confound of an unsteady percussion section during full-band rehearsals, which had proven problematic in the pilot study.

Separate audio tracks were created that contained a sequence of tempos for the rehearsal of the articulation exercise during the treatment period:

- Audio Track 1: 60 and 70 bpm (1:40);
- Audio Track 2: 60 and 80 bpm (1:35);
- Audio Track 3: 60, 80, and 90 bpm (2:07);
- Audio Track 4: 60, 80, and 100 bpm (2:01);
- Audio Track 5: 60, 80, 100, and 110 bpm (2:26); and
- Audio Track 6: 60, 80, 100, and 120 bpm (2:24).

The inclusion of each these tempos (a) reflected the range of tempos utilized within the pretest and posttest (60, 80, 100, and 120 bpm), while (b) also providing a more graduated increase in speed (including 70, 90, and 110 bpm) for full-band rehearsals during the 10-week treatment period.

Participating teachers were supplied with a weekly schedule that detailed the specific track to be utilized during each week of the treatment period (Appendix J). The inclusion of this tempo schedule constituted a change from the pilot study, in which participating teachers themselves chose the tempos to utilize during rehearsals. Also in contrast to the pilot study, the structured schedule utilized within the current study ensured that all participants (a) experienced an identical approach regarding tempo and playing conditions during rehearsals, (b) had the opportunity to reinforce correct articulation habits by practicing at slow tempos each week, and (c) were challenged by a gradual increase in speed over the 10-week treatment period.

Within each of the audio accompaniment tracks, the articulation exercise was played twice at each specified tempo.[48] During the first run-through at each tempo, a synthesized version of the articulation exercise was sounded along with the percussion-based accompaniment; during this time, participants practiced wind-pattern exercises along with the recording. On the second run-through at each tempo, only the percussion-based accompaniment was included, during which time the participants played the articulation exercise on their instrument. In this way, participants were given the opportunity to (a) focus on correct articulation techniques away from their instrument through the rehearsal of wind-pattern exercises and (b) play the exercise on their instrument at each of the tempos on the audio CD.

Audio model group.

Participants in the audio model group (n = 70) performed the same tasks as the practice group, but utilized a modified set of audio accompaniment tracks. Whereas the accompaniment tracks utilized by the practice group contained a synthesized version of the articulation exercise along with a percussion-based accompaniment, recordings of professional musicians playing the articulation exercise replaced the synthesized sounds within the tracks for the audio model group; the professional musicians included faculty

[48] At the beginning of the treatment period, four repetitions were included within each tempo; this degree of repetition proved to be excessive for both the participating students and teachers. As such, the researcher shortened the tracks between weeks three and four of the treatment period.

members from Gustavus Adolphus College, the University of Arkansas-Fort Smith, and the University of Minnesota.[49] Each professional musician recorded the articulation exercise at one tempo, resulting in the following audio model tracks: trombone at 60 bpm, clarinet at 70 bpm, alto saxophone at 80 bpm, tuba at 90 bpm, oboe at 100 bpm, flute at 110 bpm, and trumpet at 120 bpm. These combinations (instruments and tempos) were determined by the researcher in an attempt to provide balance between woodwind and brass performances as well as high- and low-pitched instruments throughout the treatment period.

The audio tracks within this group were structured in an identical manner as those utilized by the practice group, with the exception that recordings of professional musicians replaced the synthesized version of the articulation exercise. Thus, during the first run-through of the articulation exercise at each tempo, participants practiced wind-pattern exercises along with the performances by the professional musicians within the recordings. On the second run-through at each tempo, participants played the articulation exercise on their instrument.[50]

Visual model group.

Participants in the visual model group (n = 61) functioned in the same manner as the audio model group, but also received computer-generated signal graph (waveform) images of the professionals' model performances, as recorded in the audio model group.

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[49] Some of the faculty performers at the University of Minnesota were also members of the Minnesota Orchestra and Saint Paul Chamber Orchestra.
[50] The audio tracks in this treatment group were shortened in the same manner as those of the practice group between weeks three and four of the treatment period.

These images were gathered via screen capture from the Track Editor window in GarageBand® and were assembled on a summary handout that was distributed to all participants in this group (Appendix L). The handout included images from one full run-through of the articulation exercise as well as a close-up view of one measure from each performance by a professional musician.

During the first week of the treatment period, the researcher attended band rehearsals to explain and discuss the signal graph images found on the handouts (examples of such images will be included later in this chapter). Using a projection of the signal graph handout on an overhead screen, the researcher directed the participants' attention to the onset of the tones (leftmost edge) within the images; the clear articulation produced by the professional models approached that of a vertical line during the onset of tone. Using the whiteboard at the front of the classroom, the researcher illustrated examples of more rounded (and thus less clear) onsets of tone.

All members of the participating bands (both participants and non-participants in the study) were given the opportunity to view their signal graph images during the treatment period; all students chose to explore their signal graph images, regardless of whether they had decided to participate in the study. These experiences were initiated during weeks one, five, and eight of the treatment period and lasted for three to four minutes per participant during each of the three treatments. Because of gaps in the schedule between these three treatments, the current researcher was able to return to the school until 100% participation was achieved during the first two treatments (those beginning on weeks one and five). During the final treatment (beginning on week eight), five total members of the two participating bands (including four participants in the study) were absent from class during treatment days. Because of the proximity of this final experience with the posttest period, additional make-up days were not possible; thus four participants in the study received only two of the three signal graph treatments.

Signal graph images within the treatment period were generated using Audacity® (on a laptop and desktop computer) and FIRe-Field Recorder® (on an iPad).[51] The two computers made use of an external USB microphone that was placed in close proximity to the performers; the iPad required no external microphone. Each of the three treatments within the visual model group will be summarized briefly:

- Week One: During this exploratory treatment, participants were recorded individually and given the chance to examine their signal graph images. After a short performance, the researcher directed the participant's attention to the onset of the tones (leftmost edge) within the signal graph images; whereas the leftmost edge of an unclearly articulated tone tended to be rounded in appearance, the leftmost edge of a clearly articulated tone approached that of a vertical line. After this short discussion, participants were given another chance to record. The signal graph images from one participant's initial and post-discussion performances from the first treatment experience are presented in Figures 11 and 12.[52]

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[51] GarageBand® was used on the two computers at the onset of the first treatment period, but the researcher determined that Audacity® provided more detailed real-time images. As a result, Audacity® was used on both computers during the remaining treatments. This issue is discussed further in Chapter 5.

[52] This type of dramatic change did not occur for all participants, but the sequence of images represents an example of what was possible within this treatment group.

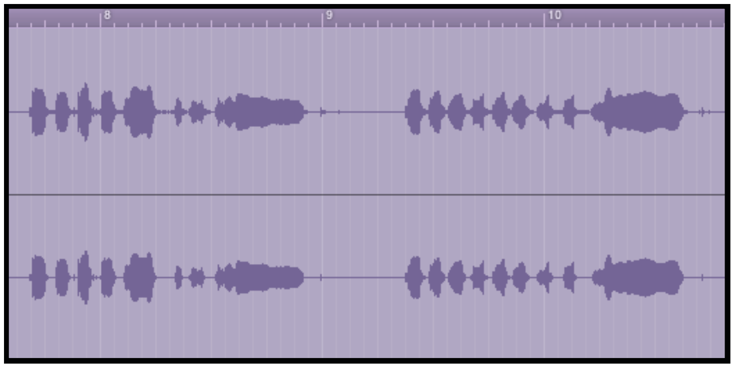

Figure 11. Signal graph images from the initial performance within treatment one.

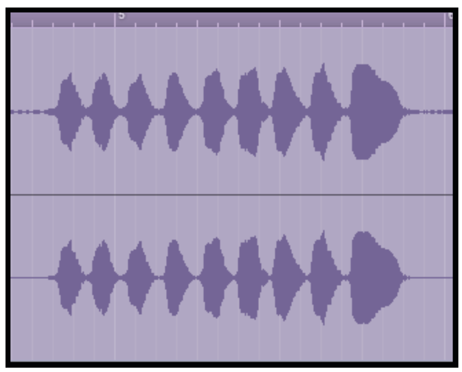

Figure 12. Signal graph images from the post-discussion performance within treatment one.

- Week Five: Participants began by playing a single note at a time, striving to create a clear onset of tone (represented by a vertical line on the leftmost edge of the signal graph representation) as they watched their onscreen images. The researcher circulated between three recording stations to monitor the onscreen images; when participants were articulating clearly on an individual note, the researcher directed them to add additional notes (one at a time) to see if they could maintain clarity of articulation. Finally, participants were directed to increase the speed of their performance while striving to maintain clarity of articulation.

- Week Eight: Participants practiced the articulation exercise along with the pretest/posttest accompaniment track as they viewed their signal graph images. In order to prevent the audio track from interfering with the signal graph images, the accompaniment was broadcast via an iPod with headphones. The researcher once again circulated between three recording stations, focusing each participant's attention on the quality of the attacks, as represented in the signal graph images.

Summary of groups.

As summarized above, a progressive design was used when constructing the various levels of the independent variable. When considering the five teaching conditions utilized within the current study (control, articulation guide, practice, audio model, and visual model), each subsequent strategy added one component to the previous level. For example, the audio model group participated in the pretest and posttest (in the same manner as the control group), received and reviewed information about correct articulation techniques (in the same manner as the articulation guide group), and practiced the articulation exercise along with accompaniment tracks during band rehearsals throughout the treatment period (in the same manner as the practice group); in contrast to the practice group, however, the audio tracks utilized in the audio model group included performances of professional musicians modeling the articulation exercise. Returning to the assumptions and delimitations presented in the opening chapter of this document, an inherent assumption in this design was that any changes found between levels of the independent variable could be attributed to the additional treatment experience of any given group, based on this progressive design. For example, any differences found in the posttest scores of the audio model group in comparison to the previous treatment conditions would be attributed to the addition of the audio model recordings (professional models playing the articulation exercise). Yet, it would be equally noteworthy that the audio model group did not isolate the impact of audio model recordings as a separate and unique strategy. As such, any differences found in the posttest scores of the audio model group (in comparison to the previous treatment conditions) must be considered a result of the inclusion of audio model recordings *in combination* with each of the strategies already included in the previous groups.

Group assignment.

Now that information about each of the groups has been provided, the current researcher will return to a detailed description of the experimental procedure. Ten seventh-grade bands, including five schools and seven directors, participated in the study. Table 6 provides an overview of the assignment of group conditions, participating teachers, and participating schools. This table will be referenced in the subsequent summary regarding group assignment.

Table 6

Group Assignment Summary

Group	Band	Teacher	School
Control Group	1	A	1
Control Group	2	A	2
Articulation Guide Group	3	B	3
Articulation Guide Group	4	C	3
Practice Group	5	D	2
Practice Group	6	D	2
Audio Model Group	7	E	4
Audio Model Group	8	F	4
Visual Model Group	9	G	5
Visual Model Group	10	G	5

Ideally, each of the 10 bands would have been randomly assigned to one of the five groups (control, articulation guide, practice, audio model, and visual model); this option was considered carefully, but was abandoned for practical reasons. When looking at the distribution of bands, Schools 3, 4, and 5 each had two participating bands, which led to a natural pairing of one group assignment for both bands within these schools. This within-school pairing allowed each of the participating band directors to focus on only one teaching strategy during the treatment period and also helped to minimize the likelihood that participants at those schools would learn about the other group conditions in the study. Within the remaining two schools, School 1 had one participating director (Teacher A) and one band, while School 2 had two participating directors (Teacher A and

Teacher D) among three bands.[53] As such, Teacher A was assigned to one group (with one band in both Schools 1 and 2), while Teacher D was assigned to the remaining group (with two bands in School 2). While this meant that School 2 included two group conditions, this was unavoidable, given the three participating bands within that building. The assignment of treatment groups, as described above, resulted in the following groupings, with two bands per condition: Teacher A, Teacher D, School 3, School 4, and School 5. In the end, this strategy for group assignment seemed to be the best choice, given (a) the practical consideration of assigning each of the participating teachers/schools to only one group when possible and (b) the desire to minimize the likelihood that participants would learn about the conditions within other groups during the treatment period. As such, teaching conditions were randomly assigned to each pair of bands (Teacher A, Teacher D, School 3, School 4, and School 5), using the list randomizer at http://www.random.org.

When considering the assignment of groups, Band 2 warrants special consideration. This band was unique in that it existed within the same school as the practice group, but, as a control group, did not receive any treatments. This pairing within one building could result in threats to internal validity, including (a) diffusion of treatments, which occurs when participants learn about differences in treatment conditions between groups; (b) compensatory rivalry, which occurs when participants develop a competitive rivalry based on a perceived lack of special treatment; or (c)

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[53] Teacher A had a split-school teaching assignment and taught seventh-grade band in Schools 1 and 2.

resentful demoralization, which occurs when participants feel demoralized because of a perceived lack of special treatment (Creswell, 2008). The current researcher attempted to control for these possibilities when devising a plan for the current study. First, the researcher did not reveal the purpose of the study to any of the participating bands; participating teachers were asked to do the same. Instead, the researcher told all participants that their teacher was going to instruct them in a way that was *unique* to the other groups, which was true regardless of group assignment. In addition, the researcher included masking techniques during the pretest in the control group, an act intended to conceal the true intent of the study; based on comments from Teacher A at the conclusion of the study, the masking procedures appeared to be successful, as students continued to ask him what the study was about leading into the posttest. The inclusion of a masking technique also reduced the likelihood that participants within the control group would be able to ascertain that they were or were not receiving unique instruction during class. While there is no guarantee that these threats to internal validity were not present, every effort was made to minimize any associated impact.

Consistency of approach.

Throughout the study, the researcher expended considerable effort to ensure consistency among participating teachers in carrying out the tasks assigned to each group. First, prior to the study, the researcher spoke with all participating teachers regarding the importance of consistency. Second, the researcher created a password-protected website for the participating teachers that contained copies of all materials (handouts, audio tracks, etc.) as well as directions for all tasks within each group. This website provided the participating teachers with instant access to pertinent information at any time. Finally, the researcher sent weekly email reminders that contained (a) instructions for each week specific to each group, (b) a reminder about the importance of consistently carrying out the assigned duties within each group, (c) a statement about the importance of not exceeding the parameters within each group, and (d) a request to keep the researcher apprised of any deviations from the plan that had taken place during the previous week.

Despite these precautions, several issues emerged during the course of the study. In the interest of complete transparency, each issue will be described below:

- Scheduling: The pretest was scheduled for the weeks of September 20 and September 27, 2010; the treatment period was scheduled to begin on October 4, 2010. During the process of assembling a pretest schedule, the researcher discovered that five of the 10 participating bands met during either sixth- or seventh-hour within the school day, making it difficult for a single individual to collect data during the intended time frame; this was compounded by the fact that band rehearsals took place every other day. As such, the pretest extended into a third week. One band in the articulation guide group (Teacher B) finished the pretest on October 4, 2010; this seemed to pose minimal disruption to the study, given that it constituted only a one-day discrepancy from the original schedule. In addition, one of the bands needed to conduct the pretest on October 6 and 8, 2010; since this effectively eliminated an entire week from the treatment period for this band, the researcher purposefully chose one of the bands in the control group for this pretest schedule (School 1).

- Initial Recording Session: The first band to record the pretest was from the articulation guide group (Teacher C). There was a five-hour intermission between this first recording session and the second recording session later in the same day. The researcher used this time to catalog performances from the initial recording session, only to discover that the participants were generally unable to perform the articulation exercise in a manner that allowed for a reliable assessment. The original pretest accompaniment track contained a percussion-based groove with which participants performed the articulation exercise at each of four performance tempos. The participants within the initial pretest recording session performed the exercise at fluctuating speeds, resulting in performances that phased in and out of the tempos prescribed on the accompaniment tracks and therefore making an objective assessment impossible. It was noteworthy to the current researcher that, particularly at slower tempos (60 and 80 bpm), this phasing issue occurred without an obvious physical (tonguing) struggle to keep up with the specified tempos. Further, as the tempo of the accompaniment track increased, participants within this first set of pretest recordings often exceeded the previous (slower) performance speeds, despite their performance problems when the tempo was still slow. As such, the current researcher determined that the unsuccessful performances, particularly at slower tempos, were based on an inability to keep time with the accompaniment track rather than an inability to articulate effectively. To remedy this problem, two changes were made in the recording process. First, the current researcher decided to have the participating bands play through the articulation exercise along with the accompaniment track at the beginning of each rehearsal on each day that the researcher arrived to conduct pretest and posttest recordings; in this way, participants would experience appropriate performance tempos before engaging in the individualized pretest recording session. Second, the researcher decided to use an audio track that included both the percussion-based accompaniment groove (as originally intended) *as well as* a synthesized version of the articulation exercise with which the participants could play along. In this regard, the current researcher sought to stabilize both tempo and rhythm during pretest and posttest performances. These changes were implemented immediately. Based on successful pretest recordings later that same day, the researcher decided to (a) maintain these changes throughout the remainder of the pretest (as well as the posttest) and (b) re-record the initial band (Teacher C, articulation guide group) under these new conditions. The latter was done acknowledging the new concerns associated with allowing these students a second opportunity to record their performances; this issue will be discussed within Chapter 5. Upon re-testing this group, the previously found phasing problems were minimized, leaving this group's second-run pretest recording session on par with the other participating bands.

- Pretest Preparations: Teacher A (control group) did not follow protocol in preparing for the pretest. Upon arrival for the scheduled pretest, Teacher A informed the researcher that he had not yet had his bands practice counting the articulation exercise during class. As such, the pretest for this band was delayed to allow time for the prescribed pretest preparations. Upon returning for the rescheduled pretest, the researcher learned that Teacher A had his band play the exercise (rather than count) during the previous rehearsal; this fact was noted, but not viewed as a significant issue, particularly given the decision to have bands play through the articulation exercise as a group at the beginning of rehearsals on pretest dates.

- Masking Procedures: It was the intent of the researcher to include multiple masking procedures within the control group during the pretest in order to conceal the true intent of the study for those participants. Based on the amount of time required for such an endeavor, Teacher A requested that only one masking recording take place; this request was honored. In the end, this decision appeared to be for the best, as it was noted by both the researcher and Teacher A that the students were less willing to record a second time; this effect would have no doubt escalated had further masking tasks been included.
- Delayed Treatments: Teacher B and Teacher C (articulation guide group) did not distribute the articulation guide sheet or discuss articulation during weeks one, two, or three of the treatment period. At the recommendation of the researcher, these teachers caught up to their assigned task schedule during week four of the treatment period. While this resulted in a shortened treatment period for this

group, this seemed to be the best option available. These teachers maintained their scheduled activities for the remainder of the treatment period.

- Error in Weekly Email Instructions: Two of the researcher's weekly email reminders contained an error regarding the audio track to be used by the practice group, audio model group, and visual model group during the treatment period. In the weekly reminder note for November 1, 2010 (week five of the treatment period), the researcher typed "Track 3: 60-80-100," but should have typed "Track 4: 60-80-100." Because of this typo, the participating teachers understandably utilized Track 3: 60-80-90, representing a deviation from the intended schedule, one that resulted in the substitution of the articulation exercise at 90 bpm in place of 100 bpm during full-band rehearsals. This error was replicated when this same typo was copied and pasted into the weekly reminder for November 8, 2010 (week six of the treatment period). It was at this time that the typo was pointed out to the researcher by Teacher G. When considering options, the researcher noted that the assignment for the following week consisted of Track 5: 60-80-100-110. Given that this track included the speed of 100 bpm (the tempo that was missed due to the typo), the researcher decided to simply continue with the remainder of the schedule as planned.

Given the inclusion of seven teachers, five schools, and five treatment conditions, real-world problems were bound to occur in a study of this nature. Despite the deviations summarized above, the vast majority of processes within the study were carried out precisely according to plan. The use of an audio accompaniment track, recording equipment, and multiple recording rooms during the pretest and posttest resulted in a highly efficient recording process, provided consistency between participants, facilitated a degree of privacy for participants during the recording process, and resulted in quality audio recordings suitable for reliable assessment. The pretest masking procedures utilized for the control group appeared to be successful based on feedback from Teacher A. Throughout the treatment period, the current researcher maintained consistent communication with participating teachers via weekly email reminders, telephone conversations, and a password-protected website; these sources of information served to keep the treatment procedures on track with only those exceptions noted above. The articulation guide sheet, along with structured classroom activities (including the researcher's explanations via audio recordings and a YouTube video), provided a high degree of consistency regarding the manner in which articulation was addressed between all groups. The use of accompaniment tracks and a regimented tempo schedule during the treatment period eliminated the issues of inconsistency that emerged during the pilot study. Finally, participating students were cooperative and receptive to the processes, based on the observations of the current researcher as well as comments from participating teachers. As such, the current researcher considered the pretest, treatment period, and posttest to be successful, paving the way for valid and reliable results.

Overview of statistical analysis.

Upon the completion of the assessment process, the scoring procedure underwent reliability testing performed by three external judges, who rated a random sample of 35 pretest and posttest performances. Spearman's Rank Order Correlation (rho) was used to compare the researcher's assessment scores with those of the three external judges. A strong positive correlation existed between the scores of the researcher and all three external judges. The reliability testing will be summarized in detail in Chapter 4.

In addition to this check of reliability, additional preliminary checks were conducted on the 353 pairs of pretest and posttest assessment scores to ensure that there were no violations of the assumptions of normality, linearity, homogeneity of variances, and homogeneity of regression slopes within the overall sample. Although the Kolmogorov-Smirnov statistic indicated that the assumption for normality was violated, the large sample size ($N = 353$) within the current study far exceeded 30 participants, a number beyond which the violation of normality is sufficiently minimized (Pallant, 2007). No other violations of assumptions were present.

In order to compensate for differences in mean pretest scores between the five teaching conditions (including a control group and four treatment groups), a one-way, between-groups ANCOVA was conducted to compare the degree to which young wind players articulated clearly with accurate execution across various tempos. The dependent variable consisted of scores from the posttest performance of an articulation exercise. The scores from a pre-intervention performance (pretest) of the same articulation exercise constituted the covariate.

The steps for carrying out ANCOVA were based on the approaches described by Pallant (2007) and Field (2005). Data were analyzed via IBM SPSS Statistics Version 19 (Release 19.0.0) using a Macintosh computer. A detailed description of the data analyses utilized within the current study will be included in Chapter 4.

Summary

The current study was guided in part by both the procedures and findings from a pilot study conducted at the University of Minnesota (Budde, 2008). Seventh-grade wind players ($N = 353$) served as the participants in this experimental pretest/posttest study, which was carried out during the Fall Semester 2010 near Minneapolis, Minnesota. Pretests were conducted during the weeks of September 20 and September 27, 2010.[54] After a 10-week treatment period, which began on October 4, 2010, posttests were conducted during the weeks of December 13 and December 20, 2010. Despite careful planning and implementation, real-world procedural issues emerged during the treatment period; the researcher addressed these issues in a manner that minimized their impact on the study. With the exception of those aspects explicitly enumerated within this chapter, the procedures of the current study were carried out according to plan. As such, the current researcher considered the pretest, treatment period, and posttest to be successful, paving the way for valid and reliable results.

The purpose of this study was to determine what teaching strategies were most effective in achieving clear and accurate articulation among middle school band students. The specific research question for the study was: Are particular teaching methods more effective than others in helping young wind players to articulate clearly with accurate execution across various tempos? A null hypothesis was assumed, meaning that the researcher predicted no significant differences between the levels of the independent

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[54] The pretest schedule was adjusted slightly to include recording sessions on October 4, 6, and 8, 2010, as summarized previously within the current chapter.

variable (five teaching conditions, including a control group and four treatment groups) concerning the degree to which young wind players articulated clearly with accurate execution across various tempos. The level of alpha error (α) was set a priori at .05.

The independent variable in this study consisted of five teaching conditions that were implemented over the course of a 10-week treatment period. These included: (a) control group, (b) articulation guide group, (c) practice group, (d) audio model group, and (e) visual model group. Each group carried out tasks according to the specifications outlined within this chapter.

During the pretest and posttest, participants performed an articulation exercise at four tempos (60, 80, 100, and 120 bpm); the researcher assessed each tempo separately, using an 8-point Likert-scale. In order to assess a participant's overall performance, based on clarity of articulation with accuracy of execution across all tempos, the sum of these four scores served as the dependent measure for both the pretest and the posttest. This approach aligned the study with real-world considerations in the music classroom, where students are expected to be able to articulate effectively at various tempos.

As a means of reliability testing, three external judges rated a random sampling of 35 pretest and posttest performances. Spearman's Rank Order Correlation (rho) was used to compare the researcher's assessment scores with those of the three external judges. A strong positive correlation existed between the scores of the researcher and all three external judges. In addition to this check of reliability, additional preliminary checks were conducted on the 353 pairs of pretest and posttest assessment scores to ensure that there were no violations of the assumptions of normality, linearity, homogeneity of variances, and homogeneity of regression slopes within the overall sample. Although the Kolmogorov-Smirnov statistic indicated that the assumption for normality was violated, the large sample size ($N = 353$) within the current study far exceeded 30 participants, a number beyond which the violation of normality is sufficiently minimized (Pallant, 2007). No other violations of assumptions were present.

In order to compensate for differences in mean pretest scores between the five teaching conditions (including a control group and four treatment groups), a one-way, between-groups ANCOVA was conducted to compare the degree to which young wind players articulated clearly with accurate execution across various tempos. The dependent variable consisted of scores from the posttest performance of an articulation exercise. The scores from a pre-intervention performance (pretest) of the same articulation exercise constituted the covariate.

The procedures utilized within the study have been thoroughly summarized in order to provide a transparent and detailed account of the current study, including rationales for the decisions that were made in preparing for and implementing the procedures utilized therein. Chapter 4 will include detailed information about the analyses included within the present study. A discussion regarding the differences found between groups (including both statistical and practical significance) will be presented in Chapter 5.

Chapter 4 – Results

The purpose of the current study was to determine what teaching strategies were most effective in achieving clear and accurate articulation among middle school band students. The specific research question was: Are particular teaching methods more effective than others in helping young wind players to articulate clearly with accurate execution across various tempos? During pretest and posttest recording sessions, participants performed an articulation exercise at four tempos (60, 80, 100, and 120 bpm); the researcher assessed each tempo separately, using an 8-point Likert-scale. In order to assess a participant's overall performance, based on clarity of articulation with accuracy of execution across various tempos, the sum of these four scores served as the dependent measure for both the pretest and the posttest. This approach aligned the study with real-world considerations in the music classroom, where students are expected to be able to articulate effectively at various tempos.

Preliminary Checks

Upon the completion of the assessment process, the scoring procedure underwent reliability testing through the inclusion of three external judges. Judge #1 was a professional musician (trombone) and college music teacher; Judge #2 was an active performing musician (trumpet) and former high school band director; and Judge #3 was an active performing musician (saxophone) and middle school band director. These three external judges were not associated with the pilot study or the development of the assessment protocol used in the current study. The current researcher trained the judges regarding the use of the 8-point Likert-scale that was incorporated during the assessment process; practice examples were conducted, and discussions took place until all judges were comfortable with the assessment procedure.

Using the participants' five-digit numeric identifiers, 35 performances were selected using the list randomizer at http://www.random.org, including 18 pretest and 17 posttest recordings. Although this random sampling of 35 performances represented only 5.0% of the 706 recordings (353 pretests and 353 posttests), the process of assessing these performances required approximately three hours. The researcher deemed this a sizable contribution by the external judges, one that appeared comparatively small only because of the large sample size within the current study.

For the purposes of reliability testing, the researcher created an audio CD for each of the three external judges; each CD contained the recordings from the 35 randomly selected performances, as described above. The performances within these recordings were edited to remove unnecessary silence as well as all student verbalizations, leaving only a stream of participant numeric identifiers (in the voice of the researcher) and subsequent performances. The utilization of these individual CDs allowed the external judges to listen to each performance repeatedly as needed, replicating the manner in which the current researcher assessed performances. The order of performances was randomized uniquely for each of the three CDs in an effort to control for possible order effects. Each external judge recorded assessment scores on a separate spreadsheet, which listed the participant numeric identifiers in order from low to high; only the numeric identifiers for the 35 randomly selected participants scored during the reliability testing procedure were included on this spreadsheet. During the assessment process, each external judge listened for the numeric identifier in the recording, identified the appropriate row on the spreadsheet based on the numeric identifier, and entered scores accordingly. The accurate entry of scores for each external judge was confirmed at the moment of the final assessment, based on an appropriate match of the numeric identifier announced on the assessment CD and that of the remaining row on the spreadsheet.

Upon completion of the reliability assessment process, the scores from each of the three external judges were transferred to the researcher's computer for the purpose of analysis. The relationship between the researcher's assessment scores and those of the three external judges was investigated. Preliminary analyses were performed to test for violations of the assumptions of normality, linearity, and homoscedasticity; within this random sampling of 35 performances, the assumption of normality was violated. As such, Spearman's Rank Order Correlation (rho) was used to compare the researcher's assessment scores with those of the three external judges; this non-parametric correlation test can be utilized when a violation of assumptions is present in the data (Pallant, 2007). A strong positive correlation existed between the scores of the researcher and Judge #1, $r_s = .87$, $n = 35$, $p < .001$; Judge #2, $r_s = .88$, $n = 35$, $p < .001$; and Judge #3, $r_s = .82$, $n = 35$, $p < .001$. Field (2005) and Pallant (2007) identified a correlation of ± 0.1 as a small effect, ± 0.3 as a medium effect, and ± 0.5 as a large effect. All r_s (rho) correlation values within the current reliability measure were .82 or higher, placing them well above the threshold for a large effect. The clear level of agreement between the scores of the current researcher and the three additional expert judges on the 35 randomly selected participant performances confirms the reliability of the current researcher's assessment of student performances.

In addition to this check of reliability, additional preliminary checks were conducted on the 353 pairs of pretest and posttest assessment scores to ensure that there were no violations of the assumptions of normality, linearity, homogeneity of variances, and homogeneity of regression slopes within the overall sample. The Kolmogorov-Smirnov statistic indicated that the assumption of normality was violated. Pretest and posttest histograms are presented in Figures 13 and 14. Pallant (2007) stated, "With large enough sample sizes (e.g. 30+), the violation of this assumption [normality] should not cause any major problems" (p. 204). The sample size within the current study far exceeded 30 participants; the pretest and posttest each included 353 participants. No other violations of assumptions were present.

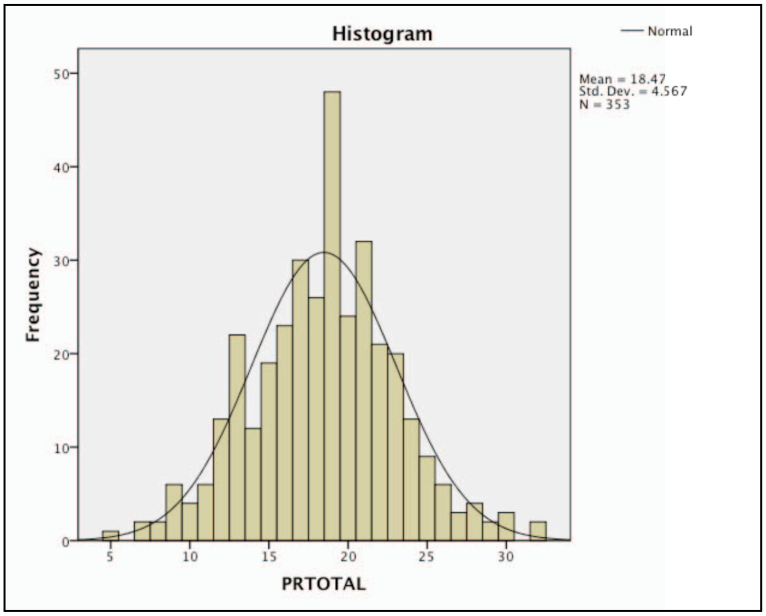

Figure 13. Histogram of pretest scores.

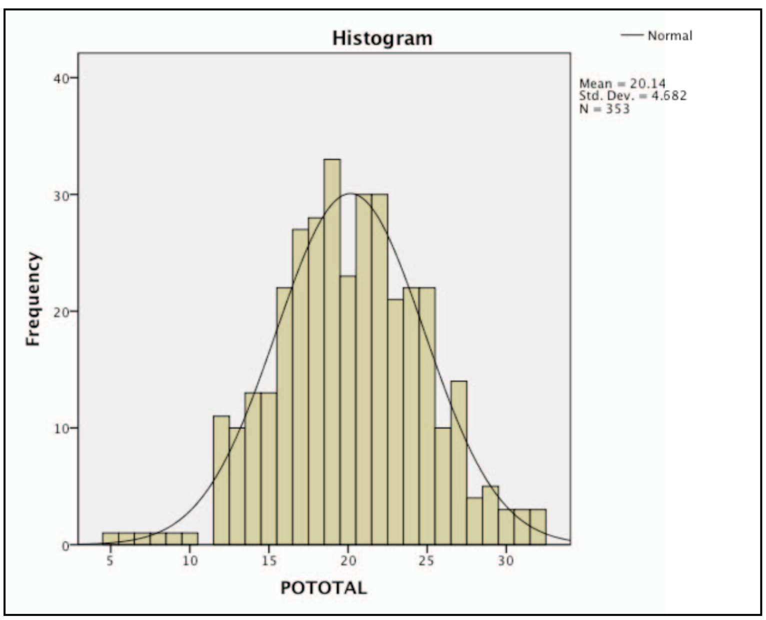

Figure 14. Histogram of posttest scores.

Statistical Analysis Utilized

The current researcher originally intended to analyze data using a mixed between- and within-subjects analysis of variance (ANOVA), as had been done in the pilot study. However, upon the completion of the assessment process, sizable differences were found in mean pretest scores between the five groups. These differences reflected varying levels of performance prior to treatment conditions. Mean and standard deviation scores from the pretest by group are presented in Table 7.

Table 7

Mean Pretest Scores for Group

Group	*N*	*M*	*SD*
Control Group	71	18.49	4.15
Articulation Guide Group	72	19.86	5.31
Practice Group	79	17.96	4.54
Audio Model Group	70	18.54	4.25
Visual Model Group	61	17.38	4.16

An inspection of these scores revealed that the spread of mean pretest scores between the highest (articulation guide) and lowest (visual model) scoring groups was 2.48 within a 28-point range (scores from 4 to 32). The mean pretest score for the highest scoring group (articulation guide) surpassed the second highest scoring group (audio model) by 1.32; this difference between adjacent groups (1.32) represented 53.2% of the overall range (2.48) between groups. The differences between groups were especially noteworthy when considering the manner in which participants were assigned to treatment conditions within the study. Given the structure of music programs within the public school system, the use of intact bands presented the best option for group assignment. Yet, this quasi-experimental approach allowed for the possibility of differences between groups regarding articulation instruction and training prior to the onset of the treatment period.

Pallant (2007) recommended the use of an analysis of covariance (ANCOVA) when intact groups (such as classes of students) are utilized within a pretest-posttest design. ANCOVA includes the use of a pre-intervention test that is used as a covariate, thus controlling for pre-existing differences between groups when analyzing the results of a post-intervention test. Pallant's recommendation aligned with the assignment of groups within the current study, during which intact seventh-grade bands were assigned to five groups. The differences in pretest means found between groups underscored the need to utilize the pretest scores as a covariate during data analysis.

In order to compensate for differences in mean pretest scores between the five teaching conditions (including a control group and four treatment groups), a one-way, between-groups ANCOVA was conducted to compare the degree to which young wind players articulated clearly with accurate execution across various tempos. The dependent variable consisted of scores from the posttest performance of an articulation exercise. The scores from a pre-intervention performance (pretest) of the same articulation exercise constituted the covariate. The steps for carrying out ANCOVA were based on the writing of Pallant (2007) and Field (2005). Data were analyzed via IBM SPSS Statistics Version 19 (Release 19.0.0) on a Macintosh computer.

Results of Data Analysis

After adjusting for the covariate, there was a significant main effect for group (control, articulation guide, practice, audio model, and visual model) regarding the degree to which young wind players articulated clearly with accurate execution across various tempos, F (4, 347) = 10.652, $p < .001$, partial eta squared = .109. Mean and standard deviation scores for the posttest, as well as the estimated marginal means and standard error, are presented in Table 8. The mean scores and estimated marginal means for the posttest are presented graphically in Figure 15. Estimated marginal means represent an adjustment from the raw posttest means, based on pre-existing differences found between groups within the covariate (pretest scores). As a result of this adjustment, the estimated marginal means facilitate a comparison between groups based on an equal starting point. The estimated marginal means within the present analysis were based on a covariate (pretest) mean score of 18.47. Effect size, or strength of association, indicates the relative magnitude of the differences between means. Partial eta squared is one such measure of effect size, one that "indicates the proportion of variance of the dependent variable that is explained by the independent variable" (Pallant, 2007, p. 208). The scores for partial eta squared range from 0 to 1, with .01 representing a small effect size, .06 representing a medium effect size, and .138 representing a large effect size. The results of the current study indicated a partial eta squared value of .109, which, according to the scale presented above, represents a medium effect size.

Table 8

Mean Posttest Scores and Estimated Marginal Means for Group

Group	*N*	Posttest Mean	*SD*	Estimated Marginal Posttest Mean*	Std. Error
Control Group	71	18.80	4.23	18.785	.344
Articulation Guide Group	72	20.42	5.25	19.308	.345
Practice Group	79	19.82	4.81	20.228	.327
Audio Model Group	70	21.56	4.07	21.499	.347
Visual Model Group	61	20.18	4.62	21.052	.373

**Covariates appearing in the model are evaluated at the following value: Pretest = 18.47.*

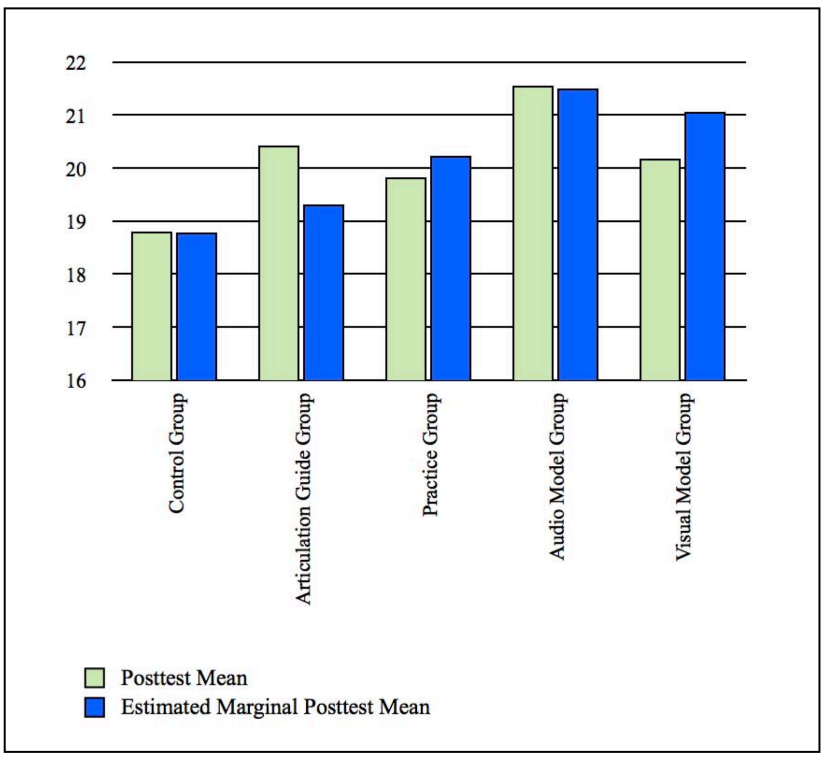

Figure 15. Mean posttest scores and estimated marginal means for group.

Given the statistically significant differences found between groups on the estimated marginal means for posttest scores, the current researcher investigated further to ascertain more information about these differences. Pairwise comparisons were computed based on the estimated marginal means for posttest scores; adjustments for multiple comparisons were conducted via Bonferroni, as recommended by Field (2005). Statistically significant differences were found between the following groups:

- The practice group outscored the control group, $p = .025$.
- The audio model group outscored both the control group, $p < .001$, and the articulation guide group, $p < .001$.
- The visual model group outscored both the control group, $p < .001$, and the articulation guide group, $p = .007$.

No other significant differences were found between groups.

Summary

After adjusting for differences between groups within pretest scores, there was a significant main effect for group (control, articulation guide, practice, audio model, and visual model) regarding the degree to which young wind players articulated clearly with accurate execution across various tempos. Pairwise comparisons revealed significant differences between groups, including: (a) the practice group outperformed the control group, (b) the audio model group outperformed both the control group and articulation guide group, and (c) the visual model group outperformed both the control group and articulation guide group. A discussion of these differences (including both statistical and practical significance) will be presented in the final chapter of this document, along with specific implications for band directors as well as recommendations for future research.

Chapter 5 – Discussion

Summary

The purpose of the current study was to determine what teaching strategies were most effective in achieving clear and accurate articulation among middle school band students. The specific research question for the study was: Are particular teaching methods more effective than others in helping young wind players to articulate clearly with accurate execution across various tempos?[55] Seventh-grade wind players ($N = 353$) served as the participants in this experimental pretest/posttest study, which was carried out during the Fall Semester 2010 near Minneapolis, Minnesota.

The independent variable in this study included five teaching conditions that were implemented over the course of a 10-week treatment period. These included:

- control group: participated in only the pretest and posttest, but included masking activities to minimize the possibility of potential threats to validity
- articulation guide group: participated in the pretest and posttest and also received and reviewed information about correct articulation techniques throughout the treatment period
- practice group: participated in the pretest and posttest, received and reviewed information about correct articulation techniques, and practiced the articulation

[55] See Appendix D for detailed information regarding a change in protocol utilized in the current study with respect to the research questions.

exercise along with accompaniment tracks during band rehearsals throughout the treatment period

- audio model group: participated in the pretest and posttest, received and reviewed information about correct articulation techniques, and practiced the articulation exercise along with accompaniment tracks during band rehearsals throughout the treatment period; in contrast to the practice group, the accompaniment tracks utilized in the audio model group included performances by professional musicians modeling the articulation exercise
- visual model group: participated in the pretest and posttest, received and reviewed information about correct articulation techniques, practiced the articulation exercise along with accompaniment tracks (which included performances by professional musicians modeling the articulation exercise) during band rehearsals, and had the opportunity to view computer-generated signal graph images of their sounds (as well as those of the professional models) during the treatment period

During pretest and posttest performances, participants played an articulation exercise at four tempos (60, 80, 100, and 120 bpm); the researcher assessed performances at each tempo separately, using an 8-point Likert-scale. In order to assess a participant's overall performance, based on clarity of articulation with accuracy of execution across various tempos, the sum of these four scores (ranging from 4 to 32) served as the dependent measure for both the pretest and the posttest.

As a means of reliability testing, three external judges rated a random sampling of 35 pretest and posttest performances. Spearman's Rank Order Correlation (rho) was used to compare the researcher's assessment scores with those of the three external judges. A strong positive correlation existed between the scores of the researcher and all three external judges.

In addition to this check of reliability, additional preliminary checks were conducted on the 353 pairs of pretest and posttest assessment scores. Although the Kolmogorov-Smirnov statistic indicated that the assumption for normality was violated, the large sample size ($N = 353$) within the current study far exceeded 30 participants, a number beyond which the violation of normality is sufficiently minimized (Pallant, 2007). No other violations of assumptions were present.

In order to compensate for differences in mean pretest scores between the five teaching conditions (including a control group and four treatment groups), a one-way, between-groups ANCOVA was conducted to compare the degree to which young wind players articulated clearly with accurate execution across various tempos. The dependent variable consisted of scores from the posttest performance of an articulation exercise. The scores from a pre-intervention performance (pretest) of the same articulation exercise constituted the covariate. After adjusting for the covariate, there was a significant main effect for group (control, articulation guide, practice, audio model, and visual model) regarding the degree to which young wind players articulated clearly with accurate execution across various tempos, F (4, 347) = 10.652, $p < .001$, partial eta squared = .109.

Given the statistically significant differences found between groups, the current researcher investigated further to ascertain more information about these differences.

Pairwise comparisons were computed based on the estimated marginal means for posttest scores; adjustments for multiple comparisons were conducted via Bonferroni, as recommended by Field (2005). Statistically significant differences were found between the following groups:

- The practice group outscored the control group, $p = .025$.
- The audio model group outscored both the control group, $p < .001$, and the articulation guide group, $p < .001$.
- The visual model group outscored both the control group, $p < .001$, and the articulation guide group, $p = .007$.

No other significant differences were found between groups.

Additional Considerations

Before discussing the results of the current study, two topics will be explored: (a) the decision to allow participants within the initial pretest recording session to redo an unsuccessful first recording experience and (b) the inclusion of two intact bands within each of the five groups. These two topics will be addressed separately, including the rationales behind the decisions made by the researcher as well as possible implications based on these decisions.

Redo of the initial pretest recordings.

As described within Chapter 3, the current researcher observed that participants within the initial pretest recording session (articulation guide group) were generally unable to perform the articulation exercise in a manner that allowed for a reliable assessment; after making changes to the testing procedures, the current researcher allowed these 25 participants to redo their pretest performances.

When considering the results of the current study, it is noteworthy that the articulation guide group, which included the 25 participants who were allowed a second chance to record the pretest, outscored all other groups, based on mean pretest scores. This led the current researcher to carefully reconsider the decision to allow students in this group an opportunity to re-record the pretest. Upon reflection of this issue throughout the duration of the study, several considerations were noteworthy to the current researcher. First, participants within this group were not aware that they would redo their pretest recording until the beginning of the class period during which the second recording took place. As such, these students had no incentive to improve their pretest score in the intermission between these two consecutive band rehearsals. Second, given the mean difference scores from pretest to posttest (mean difference of 2.56) within the groups that included regular articulation practice (practice, audio model, and visual model) over a 10-week treatment period, it seemed unlikely to the current researcher that a sizable change in mean scores would occur between two consecutive band rehearsals, particularly when the participants were not aware that they would be retested during the following rehearsal. Third, at the conclusion of the study, the researcher compared the scores of (a) students in the articulation guide group who re-recorded their pretest performances with (b) students in the articulation guide group who recorded only once during the pretest. As can be seen in Table 9, participants who re-recorded the pretest did, in fact, have a higher mean pretest score than those in the articulation guide group who recorded the pretest only once. This difference in mean scores, however, was not surprising to the current researcher. In this regard, the 25 participants who re-recorded their initial pretest performance (11 flute, 11 clarinet, 2 alto saxophone, and 1 French horn) constituted a more homogenous group than did the 47 participants in the articulation guide group who recorded the pretest only once (5 flute, 10 clarinet, 2 bass clarinet, 5 alto saxophone, 1 tenor saxophone, 1 baritone saxophone, 11 trumpet, 2 French horn, 5 trombone, 1 euphonium, and 4 tuba). Further, the music typically found in band literature for upper woodwind sections (which made up the majority of the group that re-recorded the pretest) is generally more technically demanding than that of the music found in instrument sections that perform the role of the bass voice (which were included solely within the group who recorded the pretest only once); this difference represented a pre-experiment advantage for the more homogenous group that re-recorded the pretest in comparison to the more heterogeneous group that recorded only once. Further, participants who re-recorded their pretest performances had a greater difference in mean scores from pretest to posttest than did those who recorded only once, a result that would seem unlikely to the current researcher if the pretest scores were inflated as a result of the opportunity to re-record the pretest. Finally, when considering the pretest scores for the articulation guide group as a whole (rather than the two subsets compared above), the participating teachers within the articulation guide group provided an alternative rationale that could account for the higher mean pretest scores in the articulation guide group in comparison to the remaining four groups. As will be summarized later in this chapter, the teachers in the articulation guide group stated to the current researcher, both before and after the treatment period in the current study, that rhythm and tonguing were perennial pedagogical focal points within their band program. Despite the anecdotal nature of these comments, they nonetheless provided a reasonable explanation for the higher mean pretest scores found within the articulation guide group in comparison to the remaining group conditions. Given the rationale provided above, the current researcher determined that the decision to re-record the pretest for participants within the initial unsuccessful recording session was justifiable and was likely to have had a negligible impact on the results of the study.

Table 9

Comparison between Articulation Guide Group Participants

Group	Pretest Mean	Posttest Mean	Difference Score
Participants (articulation guide group) who re-recorded their pretest performance	20.68	21.32	0.64
Participants (articulation guide group) who recorded the pretest only once	19.43	19.94	0.51

Nesting within each group condition.

A second issue that warrants attention is nesting, based on the inclusion of two bands within each of the five groups utilized in the current study. Although the inclusion of intact bands presented the most practical manner of carrying out a real-world study of this nature within the public schools, one that was representative of the authentic learning environments within which music education takes place, such a design necessarily included nesting within each group condition, since each group consisted of two intact bands with unique experiences and teaching conditions prior to the treatment period (Table 6). Given that the purpose of this study was to investigate the possible impact of five teaching conditions on participants' performances, the estimated marginal posttest means were based on the mean pretest scores for each of the five teaching conditions, rather than each of the 10 individual participating bands. For the practice group and visual model group, the two intact bands within each group were housed in the same school and had the same participating teacher; as such, these groups represented the lowest degree of concern for the current researcher regarding the impact of nesting. Despite this lower level of concern, nesting was, in fact, most obvious to the current researcher within the visual model group, in which one of the two participating bands exhibited behavior and performance problems throughout the treatment period, as communicated to the researcher by the associated participating teacher. Next, the articulation guide group and the audio model group each included two teachers (within one school) per group condition, a circumstance that increased the current researcher's level of concern regarding nesting, since the inclusion of two teachers increased the likelihood of pre-study experiential differences between the two intact bands within each group. Finally, the control group consisted of intact bands that, despite having the same teacher, were housed in two separate schools; again, the diversity of experiences between these two bands within separate school environments increased the current researcher's level of concern regarding nesting.

The current researcher acknowledges the presence and possible impact of nesting within the current study. Yet, given the constraints of conducting a real-world study of this nature within the public school system, the current researcher maintains that the research design utilized within the current study was both necessary and appropriate. Further, given the necessity of incorporating intact bands in the current study, the use of multiple intact bands within each of the five groups may, in fact, provide a more balanced representation of a typical band classroom. Whereas the tendencies of a single band would be fully unchecked when utilizing only one band in each group condition, the inclusion of more than one intact band per group condition may provide a means of checks and balances within each group.

Findings Based on Statistical Analysis

When considering the overall design of the current study, a progressive approach was utilized among the five teaching conditions (control, articulation guide, practice, audio model, and visual model); beginning with the articulation guide group, each subsequent group added to the treatments found within previous levels. For example, the audio model group performed the articulation exercise during the pretest and posttest (in the same manner as the control group), received and reviewed information about articulation (in the same manner as the articulation guide group), and practiced the articulation exercise during warm-ups in band rehearsals (in the same manner as the practice group), but additionally made use of audio tracks during the treatment period that included performances of professional musicians modeling the articulation exercise. This progressive design lends itself to a group-by-group comparison in order to consider those treatment conditions that effectively helped young wind players to improve their articulation skills.

Articulation guide group.

The current researcher will begin by comparing the group conditions that featured the lowest degree of intervention: the control group and the articulation guide group. These groups were distinguished by the dissemination of information about articulation, which was supplied to participants within the articulation guide group and reviewed throughout the treatment period. Based on mean posttest scores, the articulation guide group outperformed the control group, but this difference did not achieve a level of significance. As such, the inclusion of information (alone) about articulation did not make a significant difference in the performance of young wind players regarding clarity of articulation with accuracy of execution across various tempos.

In this regard, it is noteworthy that the full-band method books analyzed within the current study often included information about articulation (albeit in a limited capacity), but rarely included specific and regularly occurring exercises designed to improve articulation skills. The lack of a statistically significant difference when comparing the articulation guide group to the control group within the current study suggests that the approach incorporated within many full-band method books, namely supplying only information about articulation (albeit limited in scope), is not sufficient for helping young wind players to develop articulation skills.

Practice group.

Upon reaching the next level of treatment, the practice group included regular articulation practice during warm-ups in band rehearsals throughout the treatment period.

Based on mean posttest scores, the practice group outscored the articulation guide group, but this difference did not achieve a level of significance. However, the practice group did perform significantly better than the control group, $p = .025$. The significant difference revealed when comparing the practice group and control group indicates that the articulation skills of young wind musicians improve when both practice time and information about articulation are included as components of music instruction. Moreover, although the remaining group conditions will be discussed below, it is noteworthy that the audio model group and visual model group, which likewise included regular articulation practice during band rehearsals, also significantly outperformed the control group. This common result (a significant difference from the control group) among groups with a common treatment condition (regular articulation practice) underscores the importance of regular articulation practice, in combination with information about articulation, within band rehearsals.

It should be noted at present that the articulation exercise rehearsed by the practice group (as well as the audio model group and visual model group) during the treatment period was the same exercise that was performed during the pretest and posttest. The past experiences of the current researcher have shown that articulation skills generally transfer between musical selections, provided that (a) other factors, such as range and dynamics, are comparable between selections and (b) the student understands the rhythm pattern being performed. This assumption was supported by post-experiment comments (summarized later in this chapter) in which the participating teachers noted improvements in articulation during the performance of non-study-related music rehearsed during full-band and within private lessons. Nonetheless, the transference of tonguing skills between various exercises was not directly addressed within the design of the current study; this must be considered when interpreting the significant results for the practice group, audio model group, and visual model group in comparison to the control group. This topic will be further addressed as an avenue for future research.

Audio model group.

Moving to the next treatment level, the audio model group incorporated the use of audio tracks that included performances of professional musicians playing the articulation exercise, thus providing an aural model for the participants within this group. Based on mean posttest scores, the audio model group outperformed the practice group, but this difference did not achieve a level of significance. However, the audio model group significantly outperformed both the control group, $p < .001$, and the articulation guide group, $p < .001$. Further, although the remaining group condition will be discussed below, it is noteworthy at present that the visual model group, which included the same audio tracks with professional aural models, also significantly outperformed both the control group and the articulation guide group; this common result (a significantly higher level of performance in comparison to the control group and the articulation guide group) among groups with a common treatment condition (aural models) underscores the importance of modeling, in combination with providing information about articulation and regular articulation practice, during band rehearsals.

Additionally, it is notable that the aural models within the current study were provided via audio recordings. The statistically significant levels of enhanced articulation performance within groups that contained recordings of professional musicians modeling the articulation exercise would suggest that audio recordings are a viable manner in which articulation modeling can be accomplished within band rehearsals.

Visual model group.

The outcome for the visual model group was unique among all treatment conditions. When comparing the mean posttest scores for all previous groups in this progressive study design, each successive treatment condition led to an increase in mean posttest scores, based on clarity of articulation with accuracy of execution across various tempos (although these differences did not achieve a level of significance). However, this trend did not continue with the visual model group, which engaged in the greatest number of articulation-related activities during the treatment period within the current study. While the posttest mean for the visual model group was higher than those of the control group, articulation guide group, and practice group, it was lower than that of the audio model group (although this difference did not achieve a level of significance). Nonetheless, the visual model group significantly outperformed both the control group, $p < .001$, and the articulation guide group, $p < .007$. However, since no additional significant differences were found beyond those already achieved with the audio model group, no further claims can be made about the impact of visual models regarding the articulation skills of young wind players.

Summary of findings based on statistical analysis.

Based on the progressive design utilized in the current study, the treatment conditions that resulted in the maximum degree of difference included a combination of (a) information about the process of articulation via an articulation guide sheet that was reviewed throughout the treatment period, (b) regular articulation practice during band rehearsals throughout the treatment period, and (c) aural models through the inclusion of recordings by professional musicians playing the articulation exercise. The current researcher recommends the combination of these three elements for inclusion within band rehearsals in order to improve the articulation skills of young wind musicians. The implications from these findings will be explored later in this chapter.

Post-Experiment Discussion with Participating Teachers

At the conclusion of the posttest, the current researcher met with participating teachers (January 12, 2011) to discuss the study. The researcher prepared several questions to discuss with participating teachers, but also left an opportunity for an open-ended discussion at the end of the meeting. Teacher C (articulation guide group) was unable to attend this meeting, but responded to the same set of questions via email. The responses within her email reply, which was returned to the current researcher in advance of the aforementioned group discussion, were read to the remaining teachers as a starting point for each question during the in-person discussion. In addition, Teacher G (visual model group) was unable to attend this meeting, but met with the researcher later that same day. The current researcher shared with Teacher G the responses from the group discussion as well as the email reply from Teacher C. The responses from the participating teachers that are most pertinent for the present discussion will be summarized below. A full summary of the ideas presented by participating teachers (both in-person and via email) has been provided in Appendix M.

Two participating teachers indicated that articulation issues were a perennial concern within their band programs. In her email reply, Teacher C (articulation guide group) stated, "so many sixth-graders [come] in not tonguing at all - or throat tonguing, puff tonguing, etc." She went on to state, "Our emphasis on correct tonguing, I think, spills over to the kids who do tongue, improving their tonguing also…. [We] are very focused on this area of playing. Everything else is dependent on it." Teacher B (articulation guide group) concurred, stating, "We have so many incoming sixth-graders that don't tongue at all. You can't play if you don't tongue, at a certain point." Though anecdotal in nature, these statements by participating teachers within the articulation guide group are noteworthy for several reasons. First, these comments support an underlying premise of the current research study: articulation problems are widespread among young wind musicians and need to be addressed as such. Second, Teacher C indicated that tonguing was a pedagogical focal point for the teachers within the articulation guide group. In addition to the statement presented above from her email reply, Teacher C discussed this same issue in an informal (and unsolicited) conversation with the researcher before the treatment period began. Based on the elevated mean pretest scores for the articulation guide group, the pedagogical focal point on articulation within this band program appears to have had a positive impact on student performance levels, providing further evidence that music teachers need to devote attention to tonguing in order to help young wind musicians to improve their articulation skills. Additionally, this pedagogical focal point underscores the need to use pretest scores as a covariate within the current study, as summarized in Chapter 4. Finally, the pedagogical focus on articulation must be considered when interpreting the results of the current study, since the treatment condition of the articulation guide group, which consisted only of providing information about articulation to the participants, aligned with a pedagogical focal point already in place within this band program.

Next, participating teachers in the practice group, audio model group, and visual model group shared with the researcher that they noted improvements within their bands that they attributed to the treatment conditions for their assigned groups. Teacher D (practice group) stated, “Even with the [lower-achieving] kids, that was really where you noticed a significant difference, because they just didn’t do anything before. [We] noticed a difference in lessons as well.” Teacher E (audio model group) indicated that she expected to see an improvement on the posttest, based on the improvement that she observed during rehearsals. Teacher F (audio model group) stated, “In band, with that repetition, even the low[-achieving] kids start to pick it up and follow everyone else.” Finally, Teacher G (visual model group) indicated that he “definitely” noticed improvement during the treatment period regarding the quality of articulation during rehearsals. Based on these comments, the participating teachers within the practice group, audio model group, and visual model group observed that, according to their own independent assessments (outside the context of the experimental research design of the present study), their bands had improved on articulation during the treatment period. These comments (a) matched the statistical findings in the current study, in which each of these group conditions showed significant improvement in comparison to the control group and (b) revealed that a level of practical significance was also attained through the inclusion of the treatment conditions within these groups. Practical significance can be thought of as having real-world (i.e., practical) value beyond the statistically significant differences that are determined through data analysis. In this regard, effect size is typically included within reported findings. As summarized in Chapter 4, the results of the current study indicated a partial eta squared value of .109, which represents a medium effect size; this value suggests that a degree of practical significance was achieved as a result of the treatment conditions, a finding that aligns with the comments made by participating teachers, as summarized above. As such, it would appear that the treatments utilized within these groups have real-world value.

Finally, the improved articulation skills evident in the results of the current study appear to have lasted beyond the treatment period. Teacher F (audio model group) stated, "We're getting back to regular lessons now [one month later], and we increase tempos, and a lot of the kids still had [improved articulation] from the study. It was still evident that it hadn't gone away." Teacher G (visual model group) added, "Even now [one month later], as we work on rhythm issues, now we can focus on the rhythm, since tonguing is less of an obstacle to deal with. Rhythm mistakes happen, but they are clean now." These comments by participating teachers provide further evidence of the practical significance that accompanied the treatment conditions in the practice group, audio model group, and visual model group within the current study, since the noted improvements in articulation skills appear to have lasted beyond the conclusion of the treatment period, as indicated by the participating teachers assigned to these three conditions.

Implications

Given the statistical and practical significance summarized above, the current study has implications for band directors regarding effective ways in which to teach articulation to young wind players. Each component included within the treatment conditions that resulted in the maximum level of articulation improvement (namely the combination of information about articulation, regular articulation practice, and the inclusion of aural models) will be addressed below in an effort to provide specific information and teaching strategies for band directors.

Information about articulation.

Participants in the current study received an articulation guide sheet that was developed by the current researcher based on the study of phonetics, native language, and music pedagogy, as summarized within the review of literature. Although articulation is a fundamental component of wind instrument performance, most full-band method books contain little or no information regarding how to effectively use the tongue during articulation on a wind instrument. The most thorough method books analyzed within the review of literature included limited information about articulation, generally within the introductory pages; two books additionally included videos within a CD-ROM that contained both spoken information and performance demonstrations regarding articulation. Yet, even in this best-case scenario (written information about articulation along with a video demonstration), the current researcher questions the extent to which the introductory materials and CD-ROM are actually utilized within performance-dominated band rehearsals.

With this in mind, the current researcher challenges band directors to introduce information about articulation to young wind musicians from the onset of band instruction and to review this information regularly throughout the duration of music study. Information about articulation could be disseminated during full-band rehearsals, as was done in the current study, as well as within small group sectionals or private lessons. The current researcher maintains that insights from the study of phonetics as well as the impact of native language must be incorporated in any discussion about articulation in order to (a) provide accurate information about the use of the vocal models typically associated with articulation and (b) address the widely divergent needs of the students within any given classroom. Given the prevalence of articulation problems among musicians of all ages, the dissemination of accurate and inclusive information is critical for the development of young wind players.

Regular articulation practice.

The addition of articulation practice during band rehearsals, in combination with information about articulation, significantly improved the articulation skills of the young wind musicians in the current study. Unfortunately, the experiences of the current researcher suggest that most band directors focus on performance-oriented goals during band rehearsals, such as the accurate execution of rhythms and pitches, at the expense of important pedagogical issues upon which quality wind instrument performance is dependent. For example, when working on a rhythm-based exercise, band directors often focus on the correct execution of the rhythm pattern itself, but do not concurrently address the issue of quality articulation, a subject for which a rhythm-based exercise provides an ideal means for the exploration thereof. This approach is mirrored within full-band method books, which feature progressively more challenging musical ranges and rhythm patterns, but rarely provide a structured manner in which the fundamentals of wind instrument performance, such as articulation, are addressed. Only one full-band method book analyzed within the review of literature contained exercises throughout the book that were specifically designed to improve tonguing (Elledge & Haddad, 1992). It is, therefore, typically up to the individual band director to create a structured approach to improving articulation skills within band rehearsals.

The current researcher acknowledges that band directors are faced with large numbers of students and short class periods. As such, the tendency to focus on correct rhythms and pitches within rehearsals is certainly understandable. In this regard, it is important to note that the time spent rehearsing articulation during the treatment period of the current study was minimal (the articulation tracks lasted between 1:40 and 2:26), yet resulted in improved articulation skills that achieved a level of statistical and practical significance. Further, the past experiences of the current researcher suggest that rehearsal time spent on the fundamentals of wind instrument playing, including articulation, impacts performance in general, rather than being limited to a specific exercise or piece of music. The post-experiment discussion with participating teachers added powerful classroom-based commentary in this regard, such as when Teacher G (visual model group) expressed that tonguing was no longer an issue when working on rhythm exercises during band, even one month after the conclusion of the treatment period (as quoted above). This comment supports the current researcher's assertion that time spent on fundamentals, particularly the study of articulation, is time well spent.

A structured approach to teaching articulation within warm-ups should be included regularly within band rehearsals. This articulation practice could include an approach similar to the procedures utilized during the current study. Likewise, band directors could utilize tonguing-focused rhythm patterns while working on scales; these could be adjusted per the specific needs of any given ensemble. Regardless, the current researcher recommends that band directors include articulation exercises at slow tempos as well as increasingly challenging speeds, as was the case during the current study; this approach allows students to focus on correct articulation techniques (at slower speeds), while also developing the ability to articulate rapidly (through the inclusion of increasing tempos). Finally, as a tubist and former public school band director, the current researcher recognizes that the music rehearsed and performed within public school band programs does not provide equitable challenges for all instrument sections in many regards, including articulation. The significant difference found between the practice group and control group within the current study accentuates the need for band directors to provide articulation training and challenges for all students, regardless of instrument played.

Modeling.

The addition of aural models, in combination with information about articulation and regular articulation practice, led to the maximum level of improvement within the current study. This finding regarding the benefits of aural models has implications for the band director. Although several full-band method books contain CDs with professional musicians performing the exercises within these books (Feldstein & Clark, 2001, 2002; Froseth, 1997; O'Reilly & Williams, 1997; D. A. Sheldon et al., 2010), the models provided within these CDs are not focused specifically on developing articulation skills.[56] While it could be argued that these performances nonetheless provide models of quality articulation, the current researcher questions whether students focus on this specific element of wind instrument performance (articulation) when listening to recordings of exercises for which articulation is not the primary objective.

As such, the current researcher challenges band directors to provide modeling, whenever possible, that is specifically focused on the development of articulation skills. While an ideal scenario would include quality modeling on all wind instruments, the current researcher acknowledges that this is largely impractical, given the instrument-specific specialization of many music educators. Nonetheless, modeling is an important component of teaching, specifically for developing articulation skills in young wind players. Band directors should include this strategy to the maximum degree possible within their classrooms. The current researcher recommends the use of call-and-response

[56] Two additional full-band method books contained CDs with synthesized performances of the exercises provided (Pearson, 2004b; Sueta, 1999); however, these synthesized performances do not provide an aural model of quality articulation on a wind instrument.

activities that are specifically focused on the development of articulation skills and include both slow and progressively increasing tempos.

Future Research

As demonstrated in the review of literature, there is a paucity of empirical investigations focusing on articulation, particularly regarding the most effective ways to teach young wind players how to articulate correctly. It is the hope of the current researcher that this study will lead to more informed teaching practices regarding effective ways to help young wind players to improve their articulation skills. At the same time, the current researcher recognizes that additional studies are needed to further ascertain the most effective ways in which to teach articulation. Based on the current study, including both the main experiment and the review of literature, this researcher recommends several avenues for future research. Each will be summarized below.

Investigation of articulation syllables.

The current study included the use of the articulation syllable TAH as a model, based on the study of phonetics, native language, and music pedagogy. Yet, the review of music pedagogy sources revealed conflicting theories regarding the most effective articulation syllables to be utilized. As such, the current researcher proposes an investigation regarding the use of the most commonly recommended articulation syllables (including TEE, TOO, TAH, and TOH as well as DEE, DOO, DAH, and DOH) to ascertain whether they have an impact on the quality of articulation during performance on a wind instrument.

Such studies could compare various vowel sounds, as recommended by music pedagogues, to determine possible differences (a) between instruments, including whether vowels that utilize a low tongue position are most effective for low-pitched instruments and vowels that utilize a high tongue position are most effective for high-pitched instruments; (b) within instruments at various pitch levels, to investigate whether vowels that utilize a low tongue position are most effective for the low-range and vowels that utilize a high tongue position are most effective for the high-range within any given instrument; and (c) between tense and lax vowels, to investigate whether the degree of tension incorporated during the formation of specific vowels has an impact on the quality of articulation among young wind players. Likewise, /t/ and /d/, which were the most commonly recommended consonants within the review of music pedagogy sources, could be investigated to compare their effectiveness (a) between various wind instruments; (b) between the upper and lower registers within specific wind instruments; (c) for particular musical styles (such as legato, staccato, accented, etc.); and (d) to ascertain whether the use of /d/, which is voiced in the English language, leads musicians to phonate during articulation on a wind instrument. In each case, such investigations would provide empirical evidence to support or disprove the commonly held beliefs and strategies recommended within the music sources investigated during the review of literature.

Native language.

Each of the studies suggested within the preceding investigation of articulation syllables should be additionally focused through the lens of native language to investigate the possible impact of differences between languages regarding articulation on a wind instrument. Of particular interest in this regard, the use of lax versus tense vowels is especially apropos, given the tendency of many non-native-English speakers to replace lax vowels with tense vowels. Similarly, the current researcher recommends a future study that investigates the impact of relaxation techniques, such as the those summarized by Lindberg-Kransmo (2002), on the articulation skills of young wind players, particularly non-native-English-speaking musicians. Finally, the current researcher recommends a study that includes the use of computer-generated signal graph images, specifically with non-native English-speaking students, since these images provide tangible and clear feedback regarding the onset of tone during performance on a wind instrument, but do so in a way that is not language-dependent. The past experiences of the current researcher, including interactions with "John" (as described within the summary of native language), have shown that the use of signal graph images can help young wind players to become aware of articulation problems when verbal descriptions and articulation syllables prove unsuccessful; this tactic is particularly relevant when language differences might otherwise impede progress, such as when utilizing vocal models as the primary means of working on articulation. This line of research, focused on the impact of native language, would provide evidence regarding the most effective ways to teach articulation to non-native-English-speaking students, a topic that received minimal attention within the sources investigated during the review of literature.

Articulation syllables versus wind-pattern exercises.

Haynie (1967) found differences in tongue position when comparing spoken vowels and performance on a wind instrument. However, he noted that the use of unvoiced attacks, which the current researcher interpreted as the equivalent of wind-pattern exercises, revealed tongue positions that matched those used for articulation during wind instrument performance. Still, Haynie's study was observational in nature, rather than an experiment that compared the results of each approach. As such, the current researcher recommends an investigation that compares two unique practice groups: one that utilizes wind-pattern exercises and one that utilizes spoken articulation syllables as the models for articulation. In this way, Haynie's findings could be investigated regarding potential differences between these two strategies.

Airflow and articulation.

The current study isolated articulation as a fundamental skill of performance on a wind instrument. The current researcher acknowledges, however, that clear and accurate articulation on a wind instrument is necessarily dependent on quality airflow. As such, a future research study should investigate possible differences in the quality of articulation among young wind players between the following practice groups: (a) one group that practices only the specific articulation exercises during the treatment period and (b) one group that practices the articulation exercises while concurrently working on specific breathing exercises (such as the wind-pattern exercises incorporated within the current study or other more general breathing exercises). Such a study would determine whether a pedagogical focus on airflow has a direct impact on the quality of articulation skills for young wind players.

Slower tempos.

The current study utilized four performance tempos (60, 80, 100, and 120 bpm) within the pretest and posttest recordings; this range of tempos was also incorporated during the treatment period. During the assessment of posttest recordings, the current researcher observed a tendency of some participants to lock their tongues at faster tempos, resulting in an immediate cessation of quality articulation. As such, the current researcher recommends an investigation during which one group includes a smaller range of performance tempos (60 to 80 bpm) during the treatment period (but maintains pretest/posttest tempos ranging from 60 to 120 bpm), while a second group maintains a larger spread of tempos (60 to 120 bpm) during both the treatment period and pretest/posttest performances. Such a study would provide empirical evidence to determine whether a more aggressive tempo rehearsal schedule, such as that used during the current study, can lead participants to lock their tongue at faster tempos, a tendency that was observed by the current researcher during posttest assessments and one that aligns with the concerns presented by Cochran (2004).

Transferability of articulation skills.

The current study utilized a single articulation exercise during the pretest and posttest as well as during rehearsals throughout the treatment period. As previously stated, the past experiences of the current researcher have shown that the skills required for quality articulation on a wind instrument generally transfer between comparable musical selections. Nonetheless, this premise was not specifically addressed within the design of the current study. As such, the current researcher recommends a future study that investigates this assumption, namely that articulation skills are not dependent on the specific exercise being performed, provided that the musical selections are comparable. Such a study could include two separate practice groups: (a) one that includes a single articulation exercise that is used for the pretest and posttest as well as during the treatment period (as was done in the current study) and (b) one that utilizes one articulation exercise for the pretest and posttest along with a separate (unique) articulation exercise (or exercises) during the treatment period. Likewise, more authentic performance experiences could be incorporated during the treatment period. These could include technical etudes and melodic lines that provide specific articulation challenges, possibly drawn from solo literature or concert music. Such a study would determine the extent to which improvements in articulation are transferable between performance experiences.

Aural models.

Given the significant differences found when comparing the audio model group to both the control group and articulation guide group, the use of aural models warrants further investigation. Within the current study, aural models were provided via audio recordings. While this method of presentation facilitated the inclusion of professional models on seven distinct instruments, this process nonetheless lacked a sense of personal connection, including the visual images of musicians as they performed the articulation exercise. As such, the current researcher recommends a future study that compares the impact of aural models via audio recordings with in-person (live) modeling, provided by the band director (or guest musicians), in order to investigate potential differences between recorded and in-person modeling regarding the quality of articulation among young wind players.

Visual models.

The current study incorporated the use of computer-generated signal graph images to ascertain whether visual models help students to improve their articulation skills. Although significant differences were revealed when comparing the visual model group to both the control group and articulation guide group, these same significant differences were found between the audio model group and both the control group and articulation guide group. Based on the progressive design of the treatment conditions (described previously), no additional claims, beyond those already associated with the audio model group, can be made regarding the addition of visual models within the current study.

Reflecting upon the signal graph treatments utilized within the current study, the process of working individually with each participant proved to be more time-intensive than this researcher had originally anticipated. The signal graph treatments necessarily included multiple computer stations in separate rooms, allowing up to three participants to concurrently view their computer-generated images. While the use of multiple stations did serve to streamline the treatment process, it also resulted in an unsupervised experience for participants as the researcher alternated between rooms. It was apparent to the current researcher that the seventh-grade participants within this study were frequently off-task when the researcher was not directly present. As such, the current researcher recommends a future study during which the investigation of signal graph images takes place within a teacher-supervised learning environment, such as an individual lesson setting. In this way, the focus of participating students would be maintained to a higher degree than was possible within the current study, which would in turn lead to more reliable data regarding the possible impact of this treatment condition.

In addition, a more precise method of visual representation is needed regarding the use of computer-generated signal graph images. Within the current study, the software program GarageBand® was originally utilized, but abandoned due to the low quality graphic presentations displayed onscreen during participant performances. The level of detail within the images provided by GarageBand® increases once a recording is stopped. However, this necessitates a reflective, rather than real-time, viewing experience in order to obtain the most detailed images. Given the time constraints within the current study, this stop-and-start approach was not practical. As such, the researcher switched to Audacity® after the first treatment procedure. Audacity® provided more detailed real-time images, but proved to be less consistent when depicting the signal graph images; within performances, the images produced onscreen would occasionally change in appearance, despite a seemingly consistent performance, and then return to the original format (again with no apparent change in performance attributes). A software program that provides a consistently high level of detail within the signal graph images and does so in a manner that makes real-time viewing practical would aid in this line of research. As such technologies become available, they should be incorporated into future research designs in order to more fully investigate the potential of this treatment strategy.

Participant feedback.

Within the current study, no information was gathered directly from the student participants regarding their perspectives on the study. Future research studies should include feedback directly from the student participants, including: (a) their perceptions regarding possible improvements in articulation skills, (b) the extent to which any perceived improvements in articulation skills carried over to non-study-related performance activities, and (c) the degree to which any perceived improvements in articulation skills impacted their attitude regarding performance on a wind instrument. Further, the participating students' perceptions regarding possible improvements in articulation skills could be compared to the assessments of the researcher in order to determine the degree to which young wind players are aware of and can accurately assess their own articulation skills.

Longitudinal study.

The current researcher has found that the ability to articulate clearly and accurately impacts most aspects of performance on a wind instrument. The personal teaching experiences of the current researcher suggest that students who struggle with articulation become frustrated with wind instrument playing in general and, as such, lose their motivation to continue in band. With this in mind, the current researcher recommends a longitudinal study to investigate the long-term impact of success (or lack thereof) regarding articulation skills within the early stages of music instruction. For example, when the seventh-grade participants in the current study reach high school, a follow-up study could investigate whether or not these students continued to participate in their school band program. Specifically, this researcher would be interested in comparing the retention rate of students who struggled with articulation during their early years of music instruction (such as the lowest one-fourth of posttest scores within the current study) with the students who excelled during their early years of music instruction (such as the upper one-fourth of posttest scores in the current study). In this way, a future research study could investigate the association between articulation skills during the beginning stages of music instruction and future retention in a public school band program.

Concluding Remarks

Given both the prevalence of articulation problems found within wind musicians of all ages and the lack of attention devoted to the subject of articulation within full-band method books, it is up to the individual band director to (a) review articulation strategies on regular basis, (b) provide opportunities to practice tonguing on a regular basis, and (c) give students the opportunity to learn from the aural models of professional-level performances that are focused on articulation. Based on the results of the current study, the combination of these strategies is critical for the development of successful young wind players. It is the hope of the current researcher that this study will (a) provide direction for band directors who seek to improve this fundamental aspect of performance on a wind instrument and (b) serve as a springboard for future research to enhance our understanding in this area of study.

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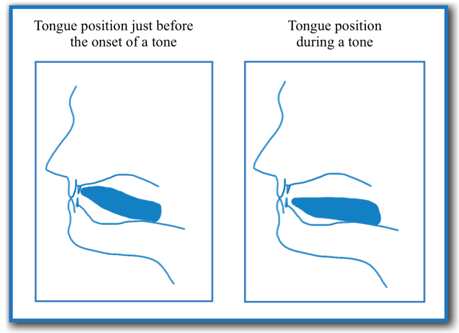
Appendices

Appendix A - Articulation Guide Sheet

Tonguing Guide for Performers



Tonguing (or articulating) is done to add clarity and accuracy to the beginning of a tone. During articulation, the tongue acts as a release valve for the air stream.

To tongue on a wind instrument, touch the tip of your tongue near the top of the back side of the front teeth (or the tip of the reed for most woodwind instruments). As the tongue is pulled down and back, a carefully-timed and steady airstream will result in a clean and clear start to the musical tone.[1]

Correct tonguing can be achieved by imitating sounds used in speech; TAH is an effective model. The vowel /ɑ/ (as in *pod*) uses a relaxed tongue and open oral cavity.[2] A gentle /t/-sound provides clarity to start a tone.[3]

Be sure that the use of TAH is unvoiced (the vocal cords should not sound) and is immediately followed with a steady flow of air (such as TAAAAAAAAH). By holding a piece of paper vertically in front of your mouth, you can check to make sure that you are using good airflow; the paper should be blown (and suspended) away from your mouth.

Here are some additional ideas to consider:

- Move only the tip of the tongue; keep the rest of the tongue relaxed, low in the mouth.
- Keep your throat open and uninvolved - a yawn is a great model for openness.
- Use a mirror to make sure that your jaw and face are not moving when you articulate.
- Wind Patterns are an effective way to practice tonguing away from your instrument. An audio sample can be heard at www.houseoflowaire.com - click on *Dissertation Study.*
- Do not move your tongue between your teeth, as this will cause the lips to stop vibrating.
- Do not vocalize as you articulate - listen carefully for any additional sounds.

Most importantly, let your ears guide you to a tonguing style that is clean and accurate!

---

[1] Although the word *attack* is used to describe the onset of a tone, this often results in over-tonguing and should thus be avoided.

[2] The study of phonetics suggests that /o/ (as in TOH) creates a tense approach to the tongue and jaw; /ɑ/ (as in TAH) is a more lax approach.

[3] Care should be used with the /d/ sound - this can result in the phonation (vibration) of the vocal cords just before the onset of a tone.

Appendix B – Change in Protocol Request

University of Minnesota

Change In Protocol Request

Route this form to: See instructions below.	**Rev:** Jan 2010

Instructions:
Use this form when submitting change requests on IRB protocols. This form is for use when the changes are initiated by the PI. Do not use this form to respond when changes are requested by the IRB. Please do not use this form when responding to changes requested in a stipulation letter.

1. Submit this form to the Human Research Protection Program:

U.S. Mail Address:
Human Research Protection Program
MMC 820
420 Delaware St. SE
Minneapolis, MN 55455-0392

Campus Mail:
Human Research Protection Program
MMC 820
Minneapolis Campus

Deliver to:
D-528 Mayo Memorial Building
Minneapolis Campus
8-4:30, M-F

IRB Protocol Information

IRB Study Number:	**1008S87635**
Current Principal Investigator:	**Paul J. Budde**
Primary Title:	An Analysis of Methods [originally "Methodologies"] for Teaching Middle Band Students to Articulate
Submission Date	2/8/2011 (the IRB study number was assigned on August 17, 2010)

Indicate the type of change/addition and attach all applicable documents:

☐ Protocol Amendment: Version , Dated
☐ Revised Investigator Brochure: Version , Dated
☐ Recruitment Changes/Advertisements
☐ Notice of Closure to Accrual
☒ Change(s) to Study Procedures
☐ Other:

1. **Briefly summarize the change(s). For protocol amendments, do not say "See summary of changes provided with amendment." Rather, summarize the nature of the significant revisions.**

In the original write-up for the IRB, the following statement was made:
"The purpose of my dissertation study will be to determine what teaching strategies are most effective in achieving clean and accurate articulation amongst middle school band students. Independent variables will include five teaching strategies used (groups specified in 6.3). Pretest and posttest scores from a playing exercise will serve as the dependent measures.
Specific research questions will include: 1) Are particular teaching methods (specified in 6.3) more effective in helping young musicians to articulate cleanly at various tempi? 2) Are particular teaching methods (specified in 6.3) more effective in helping young musicians to articulate accurately at various tempi?"

I would like to consolidate these two research questions into the following single question:
"Are particular teaching methods more effective in helping young wind players to articulate cleanly and accurately at various tempos?"

2. **Describe the rationale for the change(s):**

During the assessment process (I listened to over 400 7th-graders performing the articulation exercise), I ran into an unexpected performance tactic as the students played the articulation exercise at various tempos. At faster tempos, a sizable number of participants played a series of notes slowly (rather than all eight sixteenth-notes in tempo). This allowed them to play their notes very cleanly (research question #1), and thus resulted in an assessment score for clarity that was highly inflated in comparison to participants who made every every effort keep up with the fast tempos.

As such, I believe that the most accurate way of assessing the performances in the current study is to combine these two research questions into the single question specified above.

With this approach, the same two criteria (clarity and accuracy) are utilized in the assessment, but they would be looked at in combination rather than as separate entities. This combined score seemed to represent the quality of articulation at an appropriate level within the assessment process.

Should you approve this change, I will include information about the need for this alteration in my final paper, as I believe that this is important to note for future research in this area.

3. In your opinion as principal investigator, how will these changes affect the overall risk to subjects in this study?

There is no change of risk involved. This change would simply result in an alteration to the way that scores are assigned to pretest and posttest performances (which are already completed).

4. Do the changes to the study prompt changes to the consent form(s)?

☒**No.** ☐ **Yes.**

If yes, attach a copy of the revised consent form(s) with changes tracked or highlighted as well as a clean copy. Use this space to further describe consent form changes if necessary:

[signature] 2/15/2011

Principal Investigator's Signature **Date**

Appendix C - IRB Approval Letter for Change in Protocol

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Human Research Protection Program
Office of the Vice President for Research

D528 Mayo Memorial Building
420 Delaware Street S.E.
MMC 820
Minneapolis, MN 55455

Office: 612-626-5654
Fax: 612-626-6061
E-mail: irb@umn.edu or ibc@umn.edu
Website: http://research.umn.edu/subjects/

02/17/2011

Paul J Budde
17638 Fair Isle Path
Farmington, MN 55024

RE: "An Analysis of Methodologies for Teaching Middle School Band Students to Articulate"
IRB Code Number: **1008P87635**

Dear Dr. Budde:

The Institutional Review Board (IRB) has received your response to its stipulations of February 10, 2011. Since this information satisfies the requirement set by the IRB, final approval for the change in study procedures as described in the change in protocol form dated February 8, 2011 and involving the consolidation of two research questions.

For your records and for grant certification purposes, the approval date for the referenced project is September 1, 2010 and the Assurance of Compliance number is FWA00000312 (Fairview Health Systems Research FWA00000325, Gillette Children's Specialty Healthcare FWA00004003).

As Principal Investigator for this study, you are required by federal regulations to inform the IRB of any proposed changes to your research that will affect human subjects. Changes should be reviewed and approved before they are initiated. Unanticipated problems and adverse events should be reported to the IRB as they occur. Research projects are subject to continuing review and approval.

Upon receipt of this letter you may institute the changes. If you have any questions, please call the IRB office at 612-626-5654.

We have created a short survey that will only take a couple of minutes to complete. The questions are basic, but will give us guidance on what areas are showing improvement and what areas we need to focus on:

https://umsurvey.umn.edu/index.php?sid=97893&lang=um

Sincerely,

Christina Dobrovolny, CIP
Research Compliance Supervisor
CD/ks

CC: Scott Lipscomb

Appendix D - Changes in Protocol

During the current study, two related changes in protocol were required, based on unanticipated events during the collection and assessment of data. These changes were not described within the main body of the document, as the inclusion therein would reduce the clarity of the narrative regarding the protocols that were ultimately utilized within the study. However, in an effort to provide thorough documentation regarding all aspects of the current study, these changes have been summarized below.

Research Questions

Based on experiences from the pilot study (Budde, 2008), the current researcher originally identified clarity of articulation and accuracy of execution as separate components within the current study, allowing each to be considered independently during the assessment process. As a result, the original research proposal submitted to the Institutional Review Board (IRB) at the University of Minnesota included two research questions:

- Are particular teaching methods more effective than others in helping young wind players to articulate clearly across various tempos?
- Are particular teaching methods more effective than others in helping young wind players to articulate accurately across various tempos?

The articulation exercise (Figure 9) that was performed during the pretest and posttest included eight 16^{th}-notes on beats three and four of each measure; this exercise was performed at 60, 80, 100, and 120 bpm by all participants. During performances, most participants reached a tempo that was faster than they could execute successfully; yet, given the nature of the testing procedures, participants were instructed to continue playing until reaching the end of the accompaniment track. This resulted in a wide range of performances. For example, at faster speeds, some participants sacrificed clarity as they strained to keep up with the fastest tempos; this strategy often resulted in a low score for both clarity of articulation and accuracy of execution. Alternatively, other participants simply played a lesser number of notes (at a slower rate of speed) within counts three and four of each measure of the articulation exercise; this strategy often resulted in a high score for clarity of articulation and a low score for accuracy of execution. Yet, the high score for clarity of articulation within this approach represented a performance with clear articulation at a *slow* tempo (since only a few notes were played across beats three and four of the articulation exercise), rather than the actual performance condition being assessed (the performance of eight 16th-notes at a fast tempo). Thus, the assessment scores were influenced by the manner in which participants attempted to play the exercise, particularly when speeds were reached beyond which they were capable of executing successfully. As a result, the validity of isolating these two components (clarity of articulation and accuracy of execution) during the assessment process was called into question.

In response, the current researcher determined that a combination of these two elements (clarity of articulation and accuracy of execution) would be the most appropriate means of assessing the overall quality of articulation within a given performance, one that reflected the interconnected nature of these two components.

Within a given performance, this manner of assessment differentiated (a) participants who articulated clearly and accurately, (b) participants who articulated either clearly or accurately, and (c) participants who articulated neither clearly nor accurately. As a result, the original research questions (listed above) were combined into one, namely: Are particular teaching methods more effective than others in helping young wind players to articulate clearly with accurate execution across various tempos? In order to formally request permission to consolidate the two research questions into one, the current researcher submitted a *Change in Protocol Request* form (Appendix B) to the Institutional Review Board (IRB) at the University of Minnesota; the IRB approved the requested change (Appendix C).

Scoring Procedures

The consolidation of the research questions described above subsequently required an adjustment to the manner in which performances were assessed. The scoring procedures that were ultimately incorporated into the current study are fully summarized within the main body of this document.

Appendix E - Email Invitation to Participating Teachers

To 7th Grade Band Directors in ISD [school district number]:

I am working on my Ph.D. in Music Education at the University of Minnesota. Next fall, I enter the final portion of my degree: the dissertation. I am hoping to work with 7th grade band directors and students in ISD [school district number].

For some time, I have been interested in finding a more effective way to teach tonguing to young band students; this will be the focus of my dissertation. During the Spring Semester 2008, I conducted a pilot study that is similar to what I am proposing here. A write-up about that pilot study (as well as more information about my dissertation study) is available at http://www.houseoflowaire.com - click on Research Studies.

Here is an overview:

- The study will take place during the Fall Semester 2010.
- Near the beginning of the school year, students in the study will play a short pretest exercise to assess the clarity and accuracy of their tonguing. At the end of the study, the students will play the same exercise for the posttest.
- In the period between the pretest and posttest, the students will work on a tonguing exercise as a part of warm-ups during band (3-5 minutes each class). Each participating teacher will be randomly assigned to one of five teaching methods for working on tonguing. The goal of the study is to see if there are differences in the students' performance level, based on clarity of articulation with accuracy of execution, as the result of the assigned teaching methods.
- At the completion of the study, I will share the results with each of you (and your students) so that you can see how different teaching strategies affected the students' performance level, based on clarity of articulation with accuracy of execution.

It is very important to note that this study would in NO WAY be a reflection of your teaching skills; rather, it is a study of the effectiveness of randomly assigned teaching methods. Your participation would be done anonymously for the purposes of any publications/presentations. A typical write-up for a project of this nature would be something like: "Participants included students from six suburban middle schools in the upper Midwest."

I should also point out that I am responsible for making this project go. I will supply all materials and photocopies, etc. I will provide you with specific instructions for your assigned teaching method. I will do all testing and scoring. Your role would be to spend 3-5 minutes at the beginning of class working on tonguing.

Finally, it is important that the students are NOT aware of this for now. In order to minimize potential confounds, I will supply carefully worded information to the students at the beginning of the school year.

At present, my question for each of you is this: Would you be willing to participate in my dissertation study? Please let me know as soon as possible so that I can plan accordingly (there's a lot of paperwork for me to complete, including formal permission from your principals among other things). Thanks much for your consideration!

Appendix F - Introductory Script

"My name is Paul Budde. I am working on my Ph.D. in Music Education at the University of Minnesota and teach tuba/euphonium at Gustavus Adolphus College. I am planning to conduct a study this fall with middle school band students to look for better ways to teach music. I would like to invite you to participate in my study.

"If you agree to be in this study, I will ask you to play a couple of short exercises on your instrument. As you play, I will record your performance so that I can review it afterwards. I'll also video record your performance as a backup; only I will have access to the video, which will be destroyed once the study is all done.

"After I am done recording everyone, you will have band just like you always do, but I will ask your teacher to work with your class in a specific way. In December, I'll come back and ask you to play the same exercises again so that I can compare your playing to what you did at the beginning of the study.

"That's it!

"It is totally up to you if you would like to be a part of this study. If you agree to do the study, but change your mind, you are free to stop at any point. I want you to be completely comfortable with each and every part of being involved. You are always welcome to ask me any questions - I'll give you my phone number and email address.

"I would like to ask you to take two forms home to discuss with your parents. If you are willing to be a part of this study, we'll start the week of September 20th.

"Thanks for allowing me to come into your class today and for assisting me in this research. Your participation will help teachers to better understand the learning process for middle school band students.

"Do you have any questions? [researcher will respond to any questions] If you think of any questions after I leave, you may contact me at [phone number] or by email at [email address]."

Appendix G - Consent Form

To the Parents/Guardians of Independent School District [school district number] Seventh-Grade Band Students:

Your child is invited to be in a research study for middle school band students. Your child was selected as a possible participant because of his/her involvement in one of the middle school bands within ISD [school district number] where this study will take place. Please read this form and ask any questions you may have before agreeing to allow your child to be a part of this study.

This study is being conducted by:

Paul J. Budde, Ph.D. Candidate in Music Education at the University of Minnesota

Background Information:

The purpose of this study is to compare several teaching approaches for middle school musicians. The intent of this study is to identify effective ways to teach young musicians, thus improving music education.

Procedures:

If your child participates in this study, the researcher will ask him/her to do the following things:

All participants will perform a couple of short exercises on their instrument at the beginning of the study. These performances will be recorded so that the researcher can review them as needed; scores from these performances will serve as the pretest for the study. A video recording of all performances will serve as a backup; only the researcher will have access to the video, which will be destroyed once the study is all done.

Following the initial testing, participants will have the opportunity to practice during band class as they normally would; participating teachers will implement a specific teaching approach as assigned to their band. In December, each participant will once again perform the same exercises for the researcher as spelled out above; scores from these performances will be recorded as the posttest. At the conclusion of the study, the researcher will examine pretest and posttest scores to determine if any particular teaching method proved to be more successful than the others.

Risks and Benefits of being in the Study

There are no known risks associated with this study.

If a particular teaching method is found to be effective, the middle school band directors in ISD [school district number] will be informed so that they can incorporate the use of that method into their teaching practice.

Compensation:

There is no compensation associated with this study.

Confidentiality:

All records for this study will be kept completely confidential; students will be supplied with a unique numeric identifier to maintain anonymity. Research records will be stored securely; only the researcher will have access to the records. Recordings will be used as a means to check pretest and posttest results; only the unique numeric identifier will be recorded. A video recording of all performances will serve as a backup; only the researcher will have access to the video, which will be destroyed once the study is all done. In any report of findings, no information will be included that would indicate the identity of the participants.

Voluntary Nature of the Study:

Participation in this study is voluntary. The decision for your child to/not to participate will not affect his/her current or future relations with the University of Minnesota or the schools within ISD [school district number]. If your child does participate in this study, he/she is free not to answer any question or withdraw from the study at any time with out affecting those relationships.

Contacts and Questions:

The researchers conducting this study are: Paul J. Budde.

You/your child may ask any questions you have now. If you have questions later, **you are encouraged** to contact Paul Budde at the University of Minnesota, either by phone at [phone number] or via email at [email address]. In addition, participants may also contact Dr. Scott Lipscomb, who is the advisor for this study. Dr. Lipscomb can be reached at [phone number] or via email at [email address].

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research

Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; [phone number].

You will be given a copy of this information to keep for your records.

Because there are no known risks associated with participation in this study, a signed consent form will not be utilized. If you do not want your child to participate in the study, please contact the primary researcher prior to Friday, September 17, 2010. Participation in the pretest and posttest exercises will serve as consent to participate in this study.

Appendix H - Assent Form

To Independent School District [school district number] Seventh-Grade Band Students:

My name is Paul Budde. I am working on my Ph.D. in Music Education at the University of Minnesota and teach tuba/euphonium at Gustavus Adolphus College. I am planning to conduct a study this fall with middle school band students to look for better ways to teach music. I would like to invite you to participate in my study.

If you agree to be in this study, I will ask you to play a couple of short exercises on your instrument. As you play, I will record your performance so that I can review it afterwards. I'll also video record your performance as a backup; only I will have access to the video, which will be destroyed once the study is all done.

After I am done recording everyone, you will have band just like you always do, but I will ask your teacher to work with your class in a specific way. In December, I'll come back and ask you to play the same exercises again so that I can compare your playing to what you did at the beginning of the study.

That's it!

It is totally up to you if you would like to be a part of this study. If you agree to do the study, but change your mind, you are free to stop at any point. I want you to be completely comfortable with each and every part of being involved. You are always welcome to ask me any questions - my contact information is listed below.

By playing the exercises for me, you are agreeing to be a part of this study. No one will be mad at you if you don't participate or even if you change your mind later. It's totally up to you.

In Music,

Paul J. Budde
Ph.D. Candidate - Music Education
University of Minnesota
[email address]
[phone number]

Appendix I – Assessment Protocol for Rating Pretest and Posttest Performances

An 8-point Likert-type scale will be utilized to assess participant performances at each of four performance tempos (60, 80, 100, and 120 bpm). The sum of these four scores (resulting in a range from 4 to 32) will be used as the dependent measure for pretest and posttest performances.

Preliminary Score: Accuracy of Execution

Accuracy of Execution will be defined *the ability to execute the eight 16th-notes (plus the following quarter-note where indicated) precisely in time at the specified tempo*. Issues of tuning, articulation style (legato, staccato, etc), and tone quality will not be included. Points will not be deducted for minor issues of pitch accuracy (such as forgetting to change pitch on the first beat of the measure or occasionally landing on a wrong partial or using an incorrect fingering), although participants who play incorrect notes throughout will not be assessed. In the event that a student shows a lack of understanding regarding the rhythm pattern of the articulation exercise at the opening of the exercise, assessment should begin at the point where understanding becomes evident. Points will not be deducted for omitting the last note of the rhythm pattern if the remaining notes were executed in tempo.

Accuracy of execution will be rated based on the following scale: 3 (inaccurate performance) to 8 (accurate performance). This score will represent a *preliminary score* at each tempo.

Scoring Adjustment: Clarity of Articulation

Clarity of Articulation will be defined as *having clear definition at the onset of each note*. For the sake of this assessment, no distinction will be made for a student who articulates in a noticeably incorrect manner (such as a glottal-stop or air start), as this goes beyond the scope of this study.

Using the preliminary score (as described above) as a starting point, an adjustment will be made, based on the clarity of articulation within the performance. The following scale will be used: clear articulation (no adjustment to the preliminary score), moderately clear articulation (one-point deduction from the preliminary score), and unclear articulation (two-point deduction from the original score).

Sample Assessment:

A final score of 6 on this 8-point scale could be achieved in several ways: (a) a performance that was executed with accuracy throughout (a preliminary score of eight), but with unclear articulation (two-point deduction); (b) a performance that was executed with a minor error (a preliminary score of seven) and moderately clear articulation (one-point deduction); or (c) a performance with a more noteworthy error or a few minor errors (preliminary score of six), but with clear articulation throughout (no deduction).

Appendix J - Dissertation Study Schedule:

Dissertation Study Schedule:

Please use the following schedule for the Fall 2010 Dissertation Study on Articulation. It is very important that you follow this exact schedule throughout the study. Please do not deviate in any way.

From group to group, there is an additive approach to the tasks involved. Moving from left to right on the chart below, each subsequent group incorporates the plan of the previous group(s) (to the left). For example, whereas the Articulation Guide Group will follow only the steps listed in that column, the Practice Group and Audio-Model Group will follow their tempo instructions as well as the Articulation Guide schedule, and the Visual-Model Group will follow all three columns.

Week of:	Articulation Guide Group	Practice Group and Audio-Model Group	Visual-Model Group
Sept. 6 and Sept. 13	Introduction to the study - consent and assent forms go home during this time. Practice COUNTING the articulation exercise along with the accompaniment track (use Performance Track (pretest/posttest) - With Solo Line). Please DO NOT have the students play the exercise during this period - count only.		
Sept. 20 and Sept. 27	Pretest takes place - no other duties this week		
Oct. 4	Introduce Articulation Guide Sheet	♩ = 60/70	Begin Round 1 - Visual Images
Oct. 11		♩ = 60/80	
Oct. 18	Review Articulation Guide Sheet	♩ = 60/80/90	
Oct. 25		♩ = 60/80/90	
Nov. 1	Review Articulation Guide Sheet	♩ = 60/80/100	Begin Round 2 - Visual Images
Nov. 8		♩ = 60/80/100	
Nov. 15	Review Articulation Guide Sheet	♩ = 60/80/100/110	
Nov. 22		♩ = 60/80/100/110	Begin Round 3 - Visual Images
Nov. 29	Review Articulation Guide Sheet	♩ = 60/80/100/120	
Dec. 6		♩ = 60/80/100/120	
Dec. 13 and Dec. 20	Posttest takes place - no other duties this week		

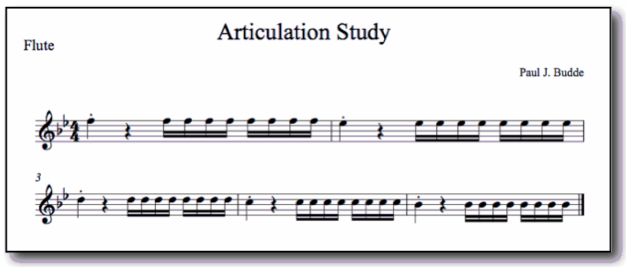
If you have any questions, please email me [email address]. Thank you for participating!

Appendix K – Script from Wind-Pattern Exercise Audio Track:

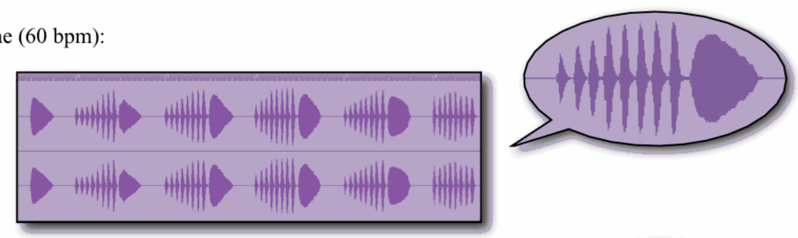
"The use of wind-patterns is an easy way to practice articulating away from your instrument. To do a wind-pattern, simply use a TAH syllable with a great airstream behind it, like this [demonstration]. In this way, you can take a simple song, such as *Twinkle Twinkle Little Star*, and practice it as a wind-pattern [demonstration]. You can also easily work on articulation exercises in the same way. Here's an example [demonstration with metronome on]. For more information on articulation, please visit www.houseoflowaire.com."

Visual-Images Group - Dissertation Study

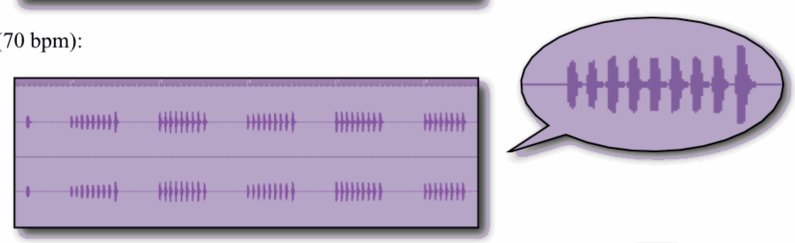
The exercise below was performed and recorded by outstanding teachers/musicians at Gustavus Adolphus College, the Minnesota Orchestra, the University of Arkansas-Fort Smith, and the University of Minnesota. Computer-generated signal graph images from those recordings can be seen below.



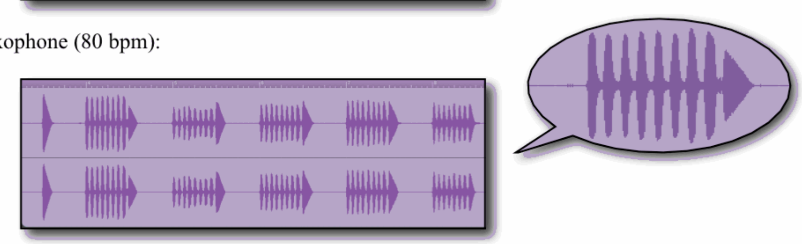
Trombone (60 bpm):



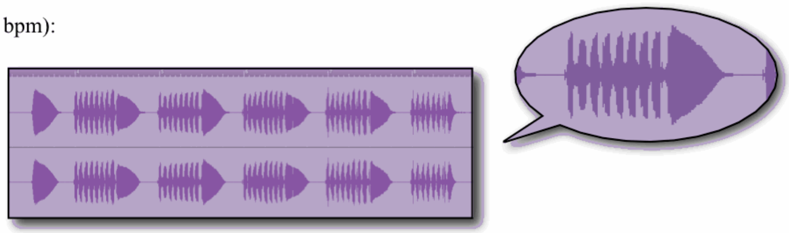
Clarinet (70 bpm):



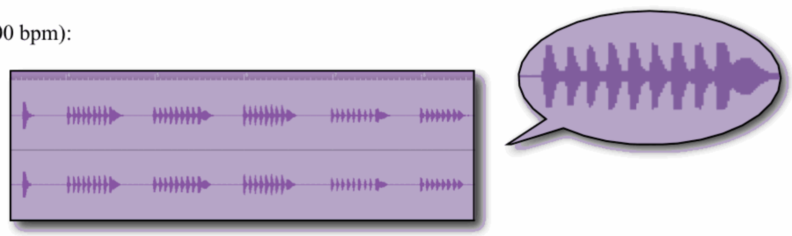
Alto Saxophone (80 bpm):



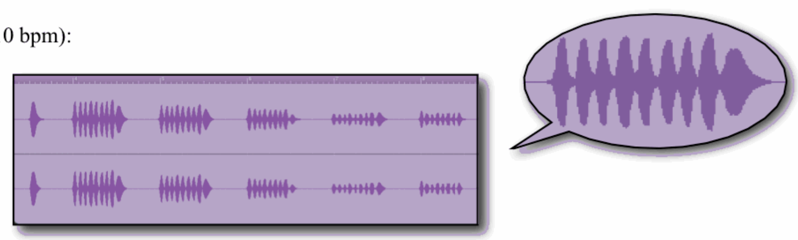
Tuba (90 bpm):



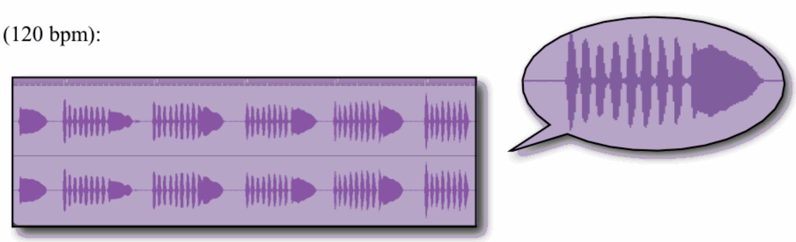
Oboe (100 bpm):



Flute (110 bpm):



Trumpet (120 bpm):



Appendix M - Post-Study Discussion with Participating Teachers

At the conclusion of the posttest, the current researcher met with participating teachers (January 12, 2011) to discuss the study. The researcher prepared several questions to discuss with participating teachers, but also left an opportunity for an open-ended discussion at the end of the meeting. Teacher C (articulation guide group) was unable to attend this meeting, but responded to the same set of questions via email. The responses within her email reply, which was returned to the current researcher in advance of the aforementioned group discussion, were read to the remaining teachers as a starting point for each question during the in-person discussion. In addition, Teacher G (visual model group) was unable to attend this meeting, but met with the researcher later that same day. The current researcher shared with Teacher G the responses from the group discussion as well as the email reply from Teacher C. A summary of this discussion, including the corresponding email reply, has been included below.

Question #1: How did the participating bands compare to your typical seventh-grade bands?

> Responses to this question included: (a) weaker than normal (Teacher C [articulation guide group] and Teacher F [audio model group]); (b) typical to somewhat weaker than normal (Teacher B [articulation guide group], Teacher E [audio model group], and Teacher G [visual model group]); (c) typical (Teacher D [practice group]); and (d) stronger than normal (Teacher A [control group]).

From these responses, five of the seven participating teachers described their bands as *weaker than normal* or *typical to somewhat weaker than normal*.

Question #2: What positive/negative impacts did you notice as a result of the study?

Comments were generally positive from all participating teachers. Several comments focused on general teacher pedagogy. Teacher E (audio model group) indicated that the use of the articulation exercise (and audio CD) helped to establish a routine at the beginning of rehearsals; she stated, “Turn on the CD, and they knew what to do.” Teacher D (practice group) indicated that the inclusion of the study at the beginning of the year helped to direct attention to the fundamentals of playing, of which articulation was “high on the list of things to be addressed.” Several teachers cited improved student confidence. For example, Teacher F (audio model group) stated, “We’re getting back to regular lessons now, and we increase tempos, and a lot of the kids still had [improved articulation] from the study. It was still evident that it hadn't gone away.” Teacher G (visual model group) concurred, stating, “Even now [one month later], as we work on rhythm issues, now we can focus on the rhythm, since tonguing is less of an obstacle to deal with. Rhythm mistakes happen, but they are clean now.” Only two concerns were identified. Teacher C (articulation guide group) felt that the timing of the study (beginning of the school year) created challenges, since there were so many things to attend to; she stated, “It would have been much easier for us if the study began in January when our bands were settled in and the next concert months away.” Teacher G (visual model group) noted that the repetition of the articulation exercise sometimes led to "subconscious performing," but indicated that this disappeared with each increase in tempo.

Question #3: Were you able to notice any progress in your students' articulation skills?

Responses were positive, particularly in the groups that practiced the articulation exercise during class. Teacher E (audio model group) indicated that she expected to see progress on the posttest, based on the improvement that she could hear during rehearsals. Teacher D (practice group) stated, "Even with the [lower-achieving] kids, that was really where you noticed a significant difference, because they just didn't do anything before. [We] noticed a difference in lessons as well." Likewise, Teacher F (audio model group) stated, "In band, with that repetition, even the low[-achieving] kids start to pick it up and follow everyone else." Teacher G (visual model group) indicated that the use of graduated practice speeds was helpful. Teacher C (articulation guide group) indicated that she had seen improvement in articulation, "but we couldn't tell if that was because of the study or because of our emphasis on tonguing in lessons and band rehearsals."

Question #4: What were the students' reactions to the study?

Teacher A (control group) indicated that students "were wondering what it was all about, especially with all the cloak and dagger of hiding what we were testing." Such a statement would seem to indicate that the masking strategies employed within the control group were effective. Teacher D (practice group) stated, "Initially, they really enjoyed it. When it continued on, like anything else with repetition, they wanted to know if they really needed to work on it again, but that only happened at the end, not the beginning or the middle." Teacher G (visual model group) indicated that the students were "generally pretty positive. Seventh-grade is hard to read. It was all non-verbal, but they were willing to go and do what needed to be done. They were either positive or neutral." Additionally, Teacher G indicated that the audio CD had become a class "theme song" of sorts that helped to get kids back on track during rehearsal.

Question #4: What went/didn't go well for you as you carried out your assignment within the study?

Comments were once again generally positive in nature. Teacher D (practice group) stated, "Once we got settled in and it didn't take so much time at the start of the rehearsals [due to the shortened audio tracks incorporated between weeks three and four in the treatment period], it went beautifully. It was very un-intrusive." Teacher B (articulation guide group) felt that discussions regarding the physiology of tonguing were helpful, as most students "never thought about it in that depth." Teacher F (audio model group) singled out the YouTube video (in which the researcher discussed and demonstrated wind-pattern exercises, including the use of a paper to check airflow) as being especially effective; he indicated that the students were excited to try this for themselves afterwards. On the other hand, Teacher G (visual model group) indicated that the study was more disruptive to rehearsals than he had anticipated, since students regularly left class to explore their own signal graph images; yet, he indicated that he would do the study again without hesitation. A follow-up question in this regard led to a proposal that individual lesson times might provide a less disruptive means of incorporating individualized experiences for future studies.

At the conclusion of this set of questions, the researcher opened the floor for any additional thoughts about the study. Teacher F (audio model group) indicated that the audio model CD (with recordings of seven professional musicians performing the articulation exercise) was beneficial for the students; he stated, "Everybody hears differently. Having the different [professional models] on the CD - high, medium, and low [instruments] - let kids hear that 'I can get myself to sound like that.'" Additionally, Teachers B and C (articulation guide group) indicated that articulation problems were a perennial issue in their band program. Teacher C stated, "so many sixth-graders [come] in not tonguing at all - or throat tonguing, puff tonguing, etc…. Our emphasis on correct tonguing I think, spills over to the kids who do tongue, improving their tonguing also…. [We] are very focused on this area of playing. Everything else is dependent on it." Teacher B stated, "We have so many incoming sixth-graders that don't tongue at all. You can't play if you don't tongue, at a certain point."