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The Art of Multiphonics: a Progressive Method for Trombone

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THE ART OF MULTIPHONICS: A PROGRESSIVE METHOD FOR TROMBONE

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ABSTRACT

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The Art of Multiphonics serves as a resource for trombone players and teachers wanting to develop multiphonic technique in order to approach the literature for which this technique is required. Its further aims are to provide accurate and relevant information regarding (1) subjective tones and beats, (2) the tuning of multiphonic intervals, and (3) vocal technique. Designed to be accessible to players of intermediate to advanced abilities, this method contains progressively arranged exercises for vocal and split-tone multiphonics.

The first five chapters of the method are devoted to vocal multiphonics and contain individual subchapters that focus on one aspect of the larger section. Sections one and two contain interval studies. Chapter one contains exercises where the sung note lies in unison or above the played note; chapter two contains exercises where the sung note lies in unison or below the played note. Each subchapter found in the first two sections corresponds to specific intervals and begins with the most basic exercise. Following preliminary exercises, each subchapter progresses toward parallel and contrary motion while building on previously established technique. Chapter four begins with a simple part-crossing exercise before advancing to multiphonic flexibility exercises. This chapter also includes subsections devoted to more advanced part-crossing exercises, short-and-

long-range glissandi, and exercises that incorporate all previously learned techniques. The chapter on split-tone multiphonics (chapter five) is placed at the end of the method because this technique is seen less frequently and is more difficult than vocal multiphonics. Split-tone multiphonics is introduced through a series of lip-bending exercises beginning on the second partial.

The appendices include the method with two short practice routines to supplement the player's daily routine. These routines are designed to ensure that continuous progress is made and that previously established technique is not lost. Additional documents found in the appendices include a list of solo literature requiring multiphonics, a subjective tone table, and a beat table.

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Additional thanks and recognition go to my parents, Dr. Paul Thompson and Rev. Clara Thompson for their love, support, and encouragement throughout my education and the writing of this document.

To my sons James and William: Thank you for your patience, love, and understanding as Dad worked and went to Greeley as he finished "trombone school." Finally, to my wife Rheanna: we did it! Without your constant sacrifice, support, and undeniable love, none of this work would have been possible.

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INTRODUCTION

Multiphonic technique has been one of the more popular extended techniques employed by brass players in the music of the twentieth and twenty-first centuries. Interesting to both performers and audience members, this technique has helped to expand the scope of trombone literature. Trombonists Vinko Globokar, Stuart Dempster,[1] and Albert Mangelsdorff have promoted the technique by composing and commissioning new works that require multiphonics. These players could not have advanced the technique had it not been for the players who came before them.

The nineteenth-century trombonist known only by a last name–"Schrade"–was quite good at the technique. So good, in fact, that Hector Berlioz was impressed with his playing:

> The first trombonist, Schrade, who four years ago was a member of the Vivienne concert orchestra at Paris, has undoubted talent. He is thoroughly master of his instrument, revels in difficulties, and produces a magnificent tone from the tenor trombone; I might indeed say tones, for by some inexplicable process he can produce three or four notes at a time, like the young player with whom the musical press has lately been occupied in Paris. Schrade, in a pedal point of fantasia which he performed in public at Stuttgart, caused general astonishment by playing the four notes in the chord of the dominant 7th simultaneously, in this order E flat, A, C, and F. It is for those learned in acoustics for this new

[1] Stuart Dempster, *The Modern Trombone: A Definition of Its Idioms*. Berkeley: University of California Press, 1979.

> phenomenon in the resource of tubes, and it is for us musicians to study it well, and profit by it on occasion.[2]

Schrade was not the first instrumentalist to use multiphonics in pubic. In fact, horn players had been using the technique since the eighteenth century. Antoine-Joseph Hampel (ca. 1710-1771), additionally credited with pioneering the use of hand stopping, is the earliest player known to have used multiphonics. Slightly later, a student of Hampel's, Giovanni Punto (born Jan Václav Stich, 1746-1803) was also known to have used the technique including during performances.

Referring to multiphonics as a "trick," Ferdinand Sordillo (Arthur Pryor Band, 1903-1909) was the first instrumentalist to describe the technique, and described it as singing and playing simultaneously.[3] The use of the word trick, however, does not mean the technique is easy. Sordillo explains:

> While I speak of this as a trick, do not think that it lacks in difficulty or does not require apparent effort or practice. Too many players regard everything too difficult for them to accomplish as a trick and dismiss the subject in this way. The word trick here is used because since chord playing does demand the use of the voice to fill in one of the chordal tones, it can hardly be termed playing.[4]

The mastery of multiphonics, let alone the effort required to successfully maintain the technique, can be challenging, as anyone familiar with the technique can attest.

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[2] Hector Berlioz, *Memoirs of Hector Berlioz; from 1803-1865, Comprising His Travels in Germany, Italy, Russia, and England,* trans. Rachel (Scott Russell) Holmes and Eleanor Holmes, Annot. and rev., Ernst Newman (New York: Dover, 1960), 14.
[3] Sordillo Fortunato, "More Possibilities on the Trombone and Other Brass Instruments," *The Metronome* 41 (15 January 1925), quoted in Green, 21.
[4] Ibid.

How is it possible that triads and seventh chords occur when the player produces two notes? Georg Andreas Sorge's (1703-1778) *Anweisung zur Stimmung und Temperatur* (1744) is the earliest source to describe how chords can be produced:

> How is it then that by playing a fifth 2:3, the subtle shading of a third pitch comes forth and is heard also, and is in fact always an octave lower than the lowest note of the fifth?
> Nature has its lovely interplay in this and demonstrates that in 2:3 the 1 would be missing, and she would gladly wish to include this pitch, in which the order 1:2:3-- c c' g'-- would be complete. Hence it is that a 3 foot Quint [An organ pipe sometimes used with another pipe, tuned a 5th below, to create a note sounding at the difference between the two pipes] makes the pitch thus complete and carries with it a third pitch, which is quite as strong as a soft Gedeckt [an organ stop usually made of wood]. Not only does the fifth do this but also the third, for if one plays a pure major third, there may likewise be heard with it a deeper third pitch, which is present since nature wishes to have 3, 2, and 1 with 5:4. Therefore when 5:4:3, or e'' c' g', is played in tune, yet a fourth pitch comes forth, namely a c with the 2, and indeed when close attention is paid, the fifth C with 1 as well...[5]

Later, in 1754, the celebrated violinist Giuseppe Tartini (1692-1770) wrote a treatise entitled *Trattato Di Musica Seconda La Vera Scienza Dell' Armonia* that, among other things, discusses "terzo tuono," or a third sound. Tartini states, "Let a violinist play simultaneously, with strong and sustained bowing, the following intervals [not listed here for brevity], intoned perfectly. A third sound [is] entirely distinguishable."[6] Tartini explains that his terzo tuono can also be heard when two instruments play together: "The same thing will happen if the stated intervals are played by two violinists five or six paces apart, each playing his note at the same time … There will be the same effect from two oboe players…[7]

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[5] Georg Sorge, *Anweisung zur Stimmung und Temperatur* (Hamburg: 1744), quoted in Reilly, 27.
[6] Fredric Johnson, *Tartini's Trattato Di Musica Seconda La Vera Scienza Dell' Armonia: An Annotated Translation With Commentary* (Ph.D. Diss., Indiana University, 1985), 44.
[7] Ibid.

Of the acoustical texts written in the nineteenth century, one source, Hermann Helmholtz's (1821-1894) *On the Sensations of Tone as a Physiological Basis for the Theory of Music*, not only confirms the existence of the sounds heard by Tartini and Sorge, but also mentions the presence of a new sound. Helmholtz and later acousticians have struggled to determine whether these sounds are physically present, or if they appear due to the way the ear works. Regardless of the physical reality of additional sounds, the fact is listeners can occasionally hear them. When, and how, these sounds are heard has yet to be fully addressed.

There is one final sound to appear that, depending on the interval, can be heard when performing multiphonics: beating. Joseph Sauveur (1653-1716) was the first to discover the occurrence of beats, albeit by accident.

> Sauveur's theory of beats was an incidental result of his search for a reproducible pitch standard. He realized that if the interval between two pitches was known and the period between coincidences of the sound pulses could be measured, then the frequency of the two sounds could be measured.[8]

One will hear a periodic rise and fall in amplitude when closely related frequencies sound at the same time. This rise and fall in amplitude is called a beat; the number of times per second this beat occurs is known as the beat frequency.[9] Musicians should already be familiar with this phenomenon, as tuning in large ensembles can result in the occurrence of beats.

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8 Carlton V. Maley Jr., *The Theory of Beats and Combination Tones 1700-1863*. (New York: Garland, 1990), 17.
9 John Backus, *The Acoustical Foundations of Music*, 2nd ed. (New York: W.W. Norton, 1977), 49.

Considerable confusion may arise if some basic terminology is not established. The terms listed below are seen throughout the document and are, therefore, included in this list.

Beating. When audible, this sound is heard when the two main frequencies are closely related, e.g. A-natural and B-flat. This beating adds interference to the overall sound, thus diminishing the effect of any subjective tones.

Multiphonics. Any two notes sounding simultaneously by a trombone player. There are two types of multiphonics: vocal and split-tone. Vocal multiphonics is the most common form of multiphonics; singing and playing simultaneously will produce this type of multiphonics. Split-tone multiphonics is produced by buzzing the lips into the mouthpiece and instrument, in the manner in which the trombone is traditionally played, at a frequency between two adjacent partials.

Played note. In vocal multiphonics, the played note refers to the note produced in the traditional manner.

Sung note. The note sung through the instrument when performing vocal multiphonics.

Subjective tones. These tones are labeled “subjective” due to the way we, as humans, perceive sound, as some may hear things differently than others. These subjective tones occur as a result of multiphonics. There are two types of subjective tones: differential tones and summational tones.

There are three main types of differential tones, each with its own formula for calculating the frequency. The *quadratic differential tone* occurs at a frequency that is equal to the difference of the two primary frequencies. *The cubic differential tone* is a second order differential tone that comes in two forms: $2(f1) - f2$ and $2(f2) - f1$, where $f1<f2$.

When heard, the summational tone will sound at a frequency that is equal to the sum of the two primary frequencies. There are also two second order summational tones that may be heard when playing multiphonics: $2(f1) + f2$ and $2(f2) + f1$, where $f1<f2$.

Purpose of the Study

Trombonists wanting to develop the multiphonic technique must currently rely on limited resources or the instruction of a private teacher. While the existing literature is helpful to obtain a basic understanding of the technique, these materials are dated and some contain inaccurate or misleading information. Further, these methods do not assist the student with fully mastering the technique. Of the existing literature, one method circulates in print and it does not fully address the needs of students and their instructors. What is lacking in this area is a complete method for learning multiphonics. The purpose of this study, then, is to provide a complete progressive method for learning multiphonics on the trombone.

Scope of the Study

Although many of the proposed exercises can be used and adapted by other brass players, the exercises in this text are written specifically for the trombone. Much has already been done to establish a history of multiphonics on brass instruments, and so, any discussion of historical aspects of multiphonics will not be addressed. Similarly, much of the multiphonic literature has been analyzed to determine similarities and differences between compositions, so any attempt to analyze intervals and subjective tones found in the trombone repertoire is unnecessary. Additionally, although the use of mutes is frequently seen in conjunction with multiphonics in classical avant-garde literature, the wide variety of styles of mutes, manufactures, and the use of different materials makes any analysis of multiphonic muting extend past the scope of this document.

The proposed method, then, will contain information on the acoustical properties of multiphonics and their subjective tones and beats, a discussion of vocal technique as it applies to trombone multiphonics, the tuning of multiphonic intervals, and, finally, newly created, and progressively arranged exercises for the two types of multiphonics.

Solo literature for the trombone containing multiphonics was consulted to ensure that all common multiphonic intervals found in existing literature are addressed. Existing multiphonic literature will also be used to determine whether multiphonic notation found in the trombone literature should be used in the method.

CHAPTER II

REVIEW OF RELATED LITERATURE

Current trombonists do not have access to a single source containing complete and accurate information regarding the multiphonic technique. Existing sources that contain multiphonic instruction either are out of print or not published, are not designed in a progressive manner, contain inaccurate information regarding subjective tones, or do not discuss the acoustical properties inherent in the production of multiphonics.

The following resources have proven to be valuable to the author's research. Resources are grouped into seven categories according to their focus and are arranged alphabetically.

1. Sources consulted but revealed little useful information relative to this topic: resources that seemed promising but were not useful for this study.

2. Dissertations: resources containing general information on multiphonics.

3. Non-trombone specific texts: resources that do not directly address trombone multiphonics but provide insight into multiphonics on other brass instruments.

4. Acoustics and tuning: resources that discuss possible acoustical reasons for subjective tones or address the issue of tuning.

5. Vocal texts: resources containing relevant information for the study.

6. Multiphonic examples and general resources: resources that were not specifically designed to be used as formal multiphonic instruction.

7. Existing methods: resources designed explicitly for the study of multiphonics.

Sources Consulted but Revealed Little Useful Information Relative to This Topic

J. Murray Barbour

Tuning can play a critical role in the hearing and application of multiphonics. The author thought this text by Barbour[1] might contain information on just intonation. While there is a brief discussion of just tuning, the vast majority of the portion on just tuning, unfortunately, consisted of a discussion of various types of historical just tunings. While interesting, historical just tunings are of little importance for trombone multiphonics as the slide and voice can accommodate for any inaccuracies in any given tuning system.

Bob Bernotas

This article[2] yields some interesting findings regarding Dick Griffin's view of multiphonics. For example, he claims that he can sing more than one note at a time. This is not something that many people in the western world can do, let alone while playing a trombone at the same time. Griffin relates most of the discussion to the harmonic series and how it relates to multiphonics. The material presented in this article, although interesting, did not meet the needs of the author's research.

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[1] J. Murray Barbour, *Tuning and Temperament: A Historical Survey*. New York: Dover, 2004.

[2] Bob Bernotas,.Masterclass with Dick Griffin: Multiphonics on the Trombone," *Online Trombone Journal*: http://trombone.org/articles/library/viewarticles.asp?ArtID=85; Accessed 18 December 2014.

R. H. M. Bosanquet

This source by Bosanquet[3], while interesting, provided limited information to the current study. Several experiments are described with their results printed as well. One of the studies concluded that beat notes (something that is still being discussed) are the same as Helmholtz's second order differential tones. Additionally, according to this source, these tones are thought to physically exist and are not subjective in any way.

Charles Culver

In the section on subjective tones, Culver[4] discusses differential tones and summational tones. Within the three pages, Culver recognizes that differential tones are easily heard and summational tones can also be identified. He mentions that summational tones may be easier to hear when the two generating sounds are in a lower register, thus the summational tone will lie within a comfortable hearing range.

Meribeth Dayme and Cynthia Vaughn

Although smaller in scope than Miller's *Structure of Singing*, this text[5] contained a better organizational plan to describe the vocal anatomy. The vast majority of pages are devoted to songs, not text, therefore, the use of this book for this study is somewhat limited.

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[3] R.H.M. Bosanquet, "On the Beats of Mistuned Harmonic Consonances," in *Proceedings of the Musical Association, 8th session*, 13-27. np: Taylor & Francis, (1881-1882).
[4] Charles A Culver, *Musical Acoustics* 4th ed. New York: McGraw-Hill, 1956.
[5] Meribeth Dayme and Cynthia Vaughn, *The Singing Book*, 2nd ed. New York: W.W. Norton, 2008.

Paul Farnsworth

Farnsworth's article[6] had very little in common with trombone multiphonics. The experiments discussed in this article described whether subjects preferred upper or lower notes. Those who preferred the upper notes were actually hearing more of the lower notes. Similarly, those who preferred low notes were hearing more of the higher notes. This study may have an impact on how listeners hear multiphonics and subjective tones.

Trevor Herbert

For a book[7] devoted to the trombone, one would expect to find some rather in-depth information regarding multiphonics, even if the information is rather small. Unfortunately, the information on multiphonics in this source is limited to passing mentions of specific pieces and players who used the technique. Albert Mangelsdorf has three mentions, but no mention of his use of the technique. While Herbert provides an excellent book about the history and development of trombone, it did not assist the author in obtaining information for this study.

Lloyd Jeffress

The experiments explained in the article by Jeffress[8] deal with the missing fundamental effect and how subjects would respond with the fundamental absent from the sound. Overwhelmingly the subjects preferred hearing the octave over any other interval due to its strong relation to the fundamental. While this article addressed subjective tones, it did not meet the requirements for this present study.

[6] Paul R. Farnsworth, "The Pitch of a Combination of Tones," *The American Journal of Psychology 51* No. 3 (July 1938), 536-539.
[7] Trevor Herbert, *The Trombone.* Padstow, Great Britton: T.J. International, 2006.
[8] Lloyd A. Jeffress, "The Pitch of Complex Tones," *The American Journal of Psychology 53* no.2 (Apr. 1940), 240-250.

Robert Marsteller

Marsteller's[9] text does not contain information directly related to trombone multiphonics; however, the note frequency chart is useful as the author based all calculations from this chart.

Steven Michelson

This source[10], directed at public school teachers, provides some advice for using the "head voice." Unfortunately for the study of multiphonics, this article did not provide any useful information.

Brent Jeffery Monahan

Of the three vocal texts consulted for this study, this source[11] does not have the same in-depth information that other sources contain.

Reinier Plomp

The information presented in this source[12] is similar to that found in the other sources reviewed for hearing. Plomp presents the findings of other's research and draws conclusions based on his experience in the field. Most of the topics, while interesting, did not meet the author's research needs.

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[9] Robert Marsteller, *Basic Routines For Trombone*. San Antonio: Southern Music, 1974.
[10] Steven Michelson, "Tone Quality and the Male Voice," *Music Educators Journal 79* no. 5 (Jan. 1993), 27-29 + 71.
[11] Brent Jeffery Monahan, *The Singer's Companion: A Guide to Improving Your Voice and Performance*. Pompton Plains NJ: Limelight Editions, 2006.
[12] Reinier Plomp, *The Intelligent Ear: On the Nature of Sound Perception*. Mahwah, NJ: Lawrence Erlbaum Associates, 2002.

William E. Ross

Although the article by Ross[13] does not directly address the needs of trombonists, it does, however, provide a statement that can motivate and inspire students. Ross states,

> Although many of us are born with the talent to be good and even great singers, few of us are born with technique. Technique must be acquired. It demands that the individual pay particular attention to the details of his vocal production until they are established. Otherwise he will be a slave to his voice instead of his voice being his servant.[14]

William Spottiswoode

While there is some dated, and therefore, in this case inaccurate information, Spottiswoode[15] mainly discussed whether beat tones and combination tones exist. The rolling sensation of beats that can occur during “reverse” multiphonics receives some attention in these meetings. Members of the association mention and briefly discuss the events of beating as follows: audible and countable beats followed by the rolling sensation, followed by little disturbance, until the pitch of the upper note reaches midway between a unison and the octave. From here, the aforementioned beat process occurs in retrograde to the original process. There are many other interesting aspects to this resource including that some members believed the summational tone was a second order beat tone. However, the author did not obtain enough accurate information for this resource to be considered useful for this current study.

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[13] William E. Ross, “The Importance of Good Technique in Singing,” *Music Educators Journal 48* no. 1 (Sep.-Oct. 1961), 91-92, 94-95.
[14] Ross, 91.
[15] William Spottiswoode, “On Beats and Combination Tones,” Proceedings of the Musical Association, 5th sess. (1878-1879), 118-130.

Dennis Wick

Although an excellent source for other trombone related information, this source[16] did not assist the author in furthering his research. Wick provides very little information regarding multiphonics that is not found in other sources. Calling it “magic” and a “freakish effect,” Wick advises students to practice this technique in the same manner one would practice any other form of playing; he advocates for patience and the use of a recording device.

William A. Yost

Fundamentals of Hearing[17] is a textbook for the study of hearing. Topics relevant to this document were the structure of the ear, masking, and subjective attributes of sound. While the text was interesting, the author realized that the information presented in this text went beyond the scope of the author’s proposed method; therefore, little from this resource was useful.

Dissertations

James Max Adams

As an annotated bibliography, this dissertation[18] provides useful information regarding pieces employing extended techniques that may or may not contain multiphonics. Each database entry contains information regarding the date of composition, accompaniment, publication information, and extended techniques used,

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[16] Dennis Wick, *Trombone Technique* 2nd ed. [1984] Oxford: Oxford University Press, 1992.
[17] William A. Yost, *Fundamentals of Hearing: An Introduction* 4th ed. San Diego: Academic Press, 2000.
[18] James Max Adams, *Timbral Diversity: An Annotated Bibliography Of Selected Solo Works For The Tenor Trombone Containing Extended Techniques*. D.A. Dissertation, University of Northern Colorado, 2008.

among others. Multiphonics are mentioned only within a list of extended techniques. Adams' dissertation was helpful in selecting solo literature to review for the purpose of the method.

Michael McKenny Davidson

Davidson's[19] dissertation mentions that there is no standard way for notating multiphonics. This is a valid point, as existing literature shows us that, although composers tend to notate multiphonics somewhat consistently throughout their own compositions, no single notational style prevails.

When writing a method, it may be advantageous for the author to include different notational styles to help prepare students for what they may encounter in the repertoire. After careful analysis, the annotated database section contains useful information regarding intervals used in multiphonic compositions. This method includes all intervals found in Davidson's study, while placing emphasis on the most commonly seen intervals.

Cason A. Duke

This dissertation[20] contains an annotated bibliography of sixty pieces written for trombone which contain some type of theatrical element. Each piece discussed in the dissertation lists the use of any extended techniques, make-up, or costume considerations. Duke also briefly discusses notation, possible playing complications, and gives a rating based on his examination and analysis. Although there is some mention of multiphonics,

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[19] Michael McKenny Davidson, *An Annotated Database of 102 Selected Published Works For Trombone Requiring Multiphonics*. D.M.A. research document, University of Cincinnati College-Conservatory of Music, 2005.
[20] Cason A. Duke, *A Performers Guide To Theatrical Elements in Selected Trombone Literature*. D.M.A document, Louisiana State University, 2001.

this source is lacking a detailed explanation of the use of multiphonics in trombone methods and literature.

Keith Malcolm Green

Green's[21] contribution to this subject deals with the historical aspects of multiphonics. Also seen in other sources is the general avoidance of notating multiphonics in a four-part setting. The examples provided by Green, although interesting and accurate, do not give a complete picture of subjective tones or beats. According to Green, the important trombonists that used multiphonics were Arthur Pryor, Ferdinand Sordillo, "Tricky Sam" Nanton, and Albert Mangelsdorf. Missing from this list of trombonists is Stuart Dempster, Vinko Globokar, and Benny Sluchin, who, besides Mangelsdorf, are four important trombone players who use(d) multiphonics. Of interest to this topic is the discussion of two of Sordillo's notated multiphonic cadenzas. Both cadenzas contain notated subjective tones, although some are notated incorrectly. Sordillo used multiphonics in two ways: parallel major chords and singing above a drone.

In direct relation to this study, Green mentions that Donald Appert's multiphonic method, *A Progressive Study of Multiphonics on the Trombone*, (see page 31) could be used to learn multiphonics, but mentions some caveats of the method: limited mention of combination tones, inaccurate descriptions of subjective tones, and incorrect subjective tones.

[21] Keith Malcolm Green, *The Multiphonic Trombone: Its History, with Analyses of Two Representative Works; Luciano Berio's Sequenza, and Folke Rabe's BASTA*. D.M.A. Thesis, Manhattan School of Music, 1996.

Gary Edwin Moody

This resource[22], as the title suggests, provides information on tuning, however, additional information regarding different types of tuning is also provided. This information proved helpful in learning about just intonation. Additionally, the method portion of the text helped the author in visualizing a possible way to organize a method book.

Milton Lewis Stevens, Jr.

This dissertation[23] discusses new techniques found in selected solo trombone compositions from 1957 to 1970. Of the twenty-five techniques mentioned in this source, multiphonics is the most important technique relevant to this study. Although the focus of Stevens' study seems to be a compilation of effects, rather than an in-depth analysis, some useful information regarding multiphonics is found in this source.

Stevens begins to describe what he believes to be an approach to learning multiphonics, and makes some excellent observations and suggestions related to his approach. To begin the study of multiphonics, Stevens suggests that the player alternate between playing and singing, thus isolating each aspect of the technique. Further isolating one aspect of multiphonic production (the sung note), Stevens suggests to sing the sung note away from the instrument. Like other sources, Stevens seems to advocate for the unison interval to be learned first.

Only the differential tone is mentioned when discussing subjective tones. Stevens believes that any two sounds close in pitch and in similar dynamic compasses will

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[22] Gary Edwin Moody, *A Practical Method for the Teaching of Intonation*. D.A. Dissertation, University of Northern Colorado, 1995.
[23] Milton Lewis Stevens, Jr., *New Techniques Required To Perform Recent Music For The Trombone*. D.M.A. Dissertation, Boston University School for the Arts, 1976.

produce audible subjective tones. Stevens mentions the perfect fifth and major third as two of the better intervals that can produce subjective tones. Based on his analysis of scores, Stevens observes that composers do not seem intent on notating subjective tones; only one of the pieces he analyzed contained a notated subjective tone.

Stevens believes that the trombonist must use a faulty embouchure and overblow the pitch until a raspy sound is heard to produce split-tone multiphonics and that one must "force" their lips to produce this effect.[24] Stevens also mentions that, at least for him, it is easier to split a second partial note than it is to split another partial. Finally, concerning split-tone multiphonics, he seems to believe that any additional notes heard when performing this split-tone multiphonics would be the next pitch in the harmonic series above the principal pitch being played. It is unfortunate that Stevens does not provide proof for his beliefs, as proof of these findings would have supported his theories and greatly benefited the trombone community.

Concerning beating, Stevens mentions that perfect consonances (unison, perfect fourth, perfect fifth, and their octave displacements) do not contain beats, or that the beats present are of small intensity. Relatively consonant intervals like the major and minor third and major and minor sixth produce beats in the low register, but that when played in higher registers, these intervals lose some audible beats. Of the dissonant intervals, Stevens mentions that seconds and sevenths produce the most audibly distinguished beats.

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[24] Ibid.

Other Instrumental Methods

Louis-François Dauprat

Written in 1824, this method provides insight into Parisian scholarly thought on multiphonics. Dauprat[25] only devotes four sentences to multiphonics and views them as unworthy of study. Dauprat writes:

> Those chords that can be produced on certain low notes of the horn by singing along with them, in a head tone, sounds which leave through the nostrils. Young students who are shown how to produce these chords pick up the technique almost immediately. Punto, who performed them much better than anyone who has been involved with them since, has himself avowed that they are both easy and silly. Leave, therefore, to the charlatans these bizarre devices which appeal only to mediocrity, astonish only the ignorant, and repel equally both connoisseurs and true artists.[26]

Although Dauprat's entry on multiphonics does not contain a detailed description of chord production, he does provide some important information.

Dauprat states that multiphonics are produced by playing a low note. One's vocal range is important to consider when writing or playing horn chords. As a male, Dauprat's voice would probably be classified as a low voice type and, as a result, may prefer to "sing along" to a played low note. Dauprat's assumption may come from his experience with the cadenza to Weber's *Concertino for Horn,* as some of the notated chords contain some low notes. Additionally, lower notes provide the player with a greater range to produce the second note necessary for chord production. Finally, Dauprat mentions that multiphoncs can be played on "certain low notes." This statement is intriguing as it appears Dauprat believes that only certain notes can be involved in multiphonics.

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[25] Louis-François Dauprat, *Method for Cor Alto and Cor Basse*. Translated by Viola Roth. Bloomington, IN: Birdalone Music, 1994.
[26] Dauprat, 356.

The second piece of information Dauprat provides is the use of the head tone, or head voice. There are two schools of thought on the head voice: one, that it is an unsupported tone; and two, that the head voice is sung in the falsetto register. Although both types of singing will work, it seems unlikely that Dauprat would advocate for an unsupported tone[27] to accompany the played note. Therefore, Dauprat must be implying that the sung note is higher in pitch than the played note. This implication is the best piece of information provided in his brief section on multiphonics and this statement helps to establish Dauprat as the first brass teacher/player to describe the playing of multiphonics.

Dauprat also states that the sound of the sung note exits the nostrils. It is a fair assumption that Dauprat is referring to the sensation of pressure inside the oral cavity when performing multiphonics, as anyone familiar with this technique knows that the majority of the sound carries through the instrument. So in sum, although Dauprat had a clear bias against the use of multiphonics, he provided some useful information on the subject, even if some facts were incorrect.

Oscar Franz

Oscar Franz[28] mentions multiphonics in his *Complete Method for the French Horn.* Franz calls multiphonics “doppeltöne” (double tones) and, like Kling, feels that multiphonics should not be used in orchestral settings. In addition to providing a copy of the Weber cadenza, Franz provides a multiphonic exercise. Although some of the subjective tones are notated correctly (certain differential tones sounding between the

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[27] It is important to note that in order to produce effective multiphonics, the sung and played notes must be of similar strength.

[28] Oscar Franz, *Complete Method for the French Horn*. Translated by Gustav Saenger. New York: Carl Fischer, 1906.

sung and played notes), like Kling, Franz seems to believe that all subjective tones will sound in-between the sung and played notes. Additionally, most of the subjective tones are displaced by an octave.

Douglas Hill

Hill's[29] *Extended Techniques For The Horn* provides some useful information not seen in his later text, *Collected Thoughts.* Unlike *Collected Thoughts*, this resource uses the term "sing or sung" instead of "hum" to represent the sound coming from the vocal folds. Hill believes that differential and summation tones will theoretically occur when two pitches (found within the same harmonic series) are sung and played simultaneously. He also believes that the use of the beating phenomenon is the most successful application of this technique.

Not mentioned in his other text[30], Hill recommends that vocal notes should be notated in two versions: one for a mid-range male, and another for a mid-range female. Although Hill does not mention how this may affect any subjective tones or beating, having ossia parts for multiphonic passages will allow more accessibility to players of varying voice types.

Of possible significance, Hill suggests to sing the given note with a vowel quality as close to the played note. The use of sung vowels may help to match timbre, and thus, may result in more resonant sounding beats and chords. Additionally, he advocates to use the proper fingering – or for the trombonist, the proper slide position – for the notated chord when possible. This may result in chords that are more resonant; however, further study is needed.

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[29] Douglas Hill, *Extended Techniques For The Horn.* [1996] Miami: Warner Bros., 1983.
[30] Ibid.

Unlike other resources contained in this section of the literature review, Hill's[31] *Collected Thoughts* contains some more recent information regarding the study and application of multiphonics. Hill's knowledge of the technique does not seem to be based on any scientific process, but rather on his own experimentations. This, however, does not discredit any of his useful suggestions. For example, Hill's five-step process to sing and play simultaneously is quite good, and is similar to other methods found later in this literature review: Step 1 is to hum a sustained note in the middle of your vocal range while opening the throat as much as possible. In step 2, one is to play the same note on the instrument that was hummed while opening the throat in the same way. Step 3 allows the player to hum the pitch in the instrument followed by the gradual addition of the played note. Step 4 is the inverse of step 3 (play the note, then add the hummed note). Finally, in step 5, the player should be able to sound both notes together while performing simultaneous crescendos and diminuendos.

Hill briefly mentions that multiphonics were originally used to produce chords, and uses the harmonic series to describe subjective tones. Lastly, Hill mentions that summational and differential tones are only audible when there is a blended and balanced match between the hummed and played note.

Henri Kling

Modern Orchestration and Instrumentation[32] shares a view similar to that of Dauprat: "Taken all in all, whatever is accomplished in this direction is not entirely

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[31]Ibid.

[32] Henri Kling, *Prof. H. Kling's Modern Orchestration and Instrumentation; or, The Art of Instrumentation; Containing Detailed Descriptions of the Character and Peculiarities of All Instruments and their Practical Employment...*, 3rd edition. Translated by Gustav Saenger. New York: Carl Fischer, 1905.

legitimate and the approbation of the really educated or the art-connoisseurs will never be bestowed upon it."[33] Kling seems to believe that subjective tones can only occur between some intervals. Kling also seems to believe that all subjective tones will sound in-between the sung and played notes, as all of his notated subjective tones lie in between the sung and played notes.

Acoustics and Tuning

Edward P. Asmus, Jr.

This study[34] obtained results from forty music majors and non-majors in an effort to see if the quadratic differential tone exists as a physical reality. Data obtained by Asmus indicated that the differential tone was audible around 70 decibels, but starts to decline in its appearance below 40 decibels.

Another study was done with microphones. Here, the primary tones were presented at 70 decibels positioned at the same place. The students were used to determine if the microphones would pickup the differential tone. Asmus hoped that if the microphones and recording equipment were capable of obtaining the differential tone frequency, he could prove the quadratic differential tone was a physical reality. The microphones were able to identify the differential tone, so according to Asmus, the quadratic differential tone was, in fact, a physical reality.

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[33] Kling, 134.
[34] Edward P. Asmus, Jr., "Perception and Analysis of the Difference Tone Phenomenon as an Environmental Event." *Journal of Research in Music Education* vol. 26 no. 2 (Summer 1978), 82-89).

John Backus

Of the acoustic texts, *The Acoustical Foundations of Music*[35], is often mentioned by scholars as a "go-to" resource. Of particular interest to the discussion of subjective tones, are two chapters, "Tone Quality" and "Frequency and Pitch." Backus uses the term "subjective tones" to describe notes that can be heard, but are not physically present in the sound. He further mentions that subjective tones will not appear on a frequency meter. These tones are heard due to the nonlinearity of the cochlea (the spiral-shaped tube in the inner ear containing the sensory organ for hearing) and its related nerve connections.[36]

Sometimes confused with subjective tones, aural harmonics, according to Backus, are a result of the ear adding harmonics to a simple tone (a tone that does not contain harmonics). Discussing subjective tones of simple tones, Backus mentions both differential and summational tones. According to Backus, the ear can hear both aural harmonics and differential tones when combining two simple tones. Discussing summational tones, Backus concludes that these tones do not exist because acousticians after Helmholtz have been unable to reproduce or hear them.

Two terms, the "missing fundamental effect" and "periodicity pitch," are used to describe the combination of complex tones. The missing fundamental effect is described to occur when the ear assigns a fundamental frequency to a complex tone comprised of multiples of the "fundamental" frequency.[37] Backus describes periodicity pitch as the

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[35] John Backus, *The Acoustical Foundations of Music* 2nd ed. New York: W.W. Norton, 1969.
[36] Backus, 124.
[37] Backus, 30.

frequency heard when the difference between two simultaneous pitches is too large to create audible beats.[38]

Gerald J. Balzano

Balzano[39] found that, when identifying intervals, subjects had a harder time identifying closer intervals than more widely spaced intervals.[40] This is important information applicable to the written method. Further implications in regard to writing the method lie in the fact that perfect fourths and fifths are more often confused with each other than the tritone.[41] Additionally, and of direct relevance to this study, is that the major-and-minor second, are easily confused with each other.[42] This knowledge, and the premise that closely spaced intervals are harder to identify, assisted the author in creating the method by limiting these features when possible.

Arthur H. Benade

This source[43] contains information seen in Helmholtz's and Backus' sources, although some different terminology is used. Agreeing with other acousticians, Benade mentions that the mechanical and neurological portions of our ears assist with the hearing of, what he calls "the heterodyne phenomenon." This phenomenon happens when any two frequencies are sounded together. Ordered in the manner in which they are perceived, Benade lists the components of the heterodyne phenomenon as follows: (1) the

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[38] Ibid.
[39] Gerald J. Balzano, "Musical vs. Psychoacoustical Variables and Their Influence on the Perception of Musical Intervals," *Bulletin of the Council for Research in Music Education*, no. 70 (Spring, 1982), 1-11.
[40] Balzano, 1.
[41] Balzano, 2.
[42] Ibid.
[43] Arthur H. Benade, *Fundamentals of Musical Acoustics* 2nd ed. New York: Dover, 1990.

original components; or frequencies; (2) simplest heterodyne components (the second partial of each original frequency, and Helmholtz's differential tone and summational tone), and (3) next-appearing heterodyne components. The aforementioned components, according to Benade, are rarely observed, and can be considered of little musical importance. Of critical importance to this study is the fact that Benade believes Helmholtz's summational tone does in fact exist.[44] Finally, Benade discusses what he terms, "the implied tone," which occurs when any two frequencies have a zero-beat relationship. This implied tone is generally the fundamental and is what Backus referred to as the "missing fundamental effect."

David J. Benson

Benson's[45] text provides a different approach to learn acoustics. While many acoustic texts have some mathematical formulas placed throughout their text, Benson treats math as a way of explaining how music works. He supposes two primary arguments in his section on combination tones. First, that the cubic combination tones of 2(f1)-f2 and 2(f2)-f1 are more important than the traditional summational and differential tones because they are louder and can be heard at softer dynamics than the traditional subjective tones. Finally, Benson believes we cannot hear sound at the beat frequency because there is no place on the basilar membrane that corresponds to the energy created by the beats.

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[44] Benade, 292.
[45] David J. Benson, *Music: A Mathematical Offering*. Cambridge: Cambridge University Press, 2007.

Richard Bowles

Bowles'[46] contribution to multiphonics contains some interesting aspects not found in other sources. The harmonic series is used extensively throughout the article, and is used to find a third additional pitch found as a combination tone from the original pitches. Bowles' third pitch is the same as Helmholtz' summational tone. Although Bowles mentions that a fourth tone can result from multiphonics, his discussion on subjective tones is limited to the summational tone. Bowles mentions that multiphonics are produced by singing and playing (playing one note in the normal fashion and singing a second note of a differing pitch). Additionally, he mentions that the summational tone will appear when the two notes have a proper relationship in the harmonic series. Each example that Bowles provides uses the harmonic series to illustrate his point. Intervals used in the examples include the perfect fifth, tri-tone, major tenth, perfect fourth, and minor sixth. Bowles also includes a list of possible chords produced through the use of multiphonics, but these are not completely accurate. Inaccuracies occur, possibly, because Bowles does not account for the differential tone.

Also mentioned is the use of multiphonics in chorale melodies. Bowles believes that melodies based around the fifth scale degree are the best, melodies around the third scale degree are possible, and that melodies based around the tonic are nearly impossible. Most importantly, Bowles believes that the summational tone is a physical reality and that it is not "just heard by the listener."

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[46] Richard Bowles, "Multiphonics on Low Brass Instruments" *The Instrumentalist* (October 1979), 52-57.

Stephen C. Colley

Colley's[47] system of improving intonation appears like a good system with one caveat: as musicians, we do not play with drones, we play with other human beings. That said, there are many strengths to this system, the first being the systematic approach inherent in the source. Each day the player is to play in a different key, thus working through all major and minor keys to determining where each note "fits" into that particular key. Colley states, "the goal of good intonation is to produce beat-less intervals."[48] While this is possible, the major and minor second will both produce beating against the CD, however, each note will have its own "slot" where the intonation "locks in place." Listing or describing what subjective tones may appear for a given justly-tuned interval would make this, already excellent, source even better.

R. W. Forsyth and R.J. Sowter

The data contained in this resource[49] provided valuable information regarding the existence of combination tones. The photographs, being as they were taken in the late nineteenth century, clearly show periodicity in their experiments. The author has discussed this source in additional detail in the analysis portion of this document.

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[47] Stephen C. Colley, *Tuneup*. (nl: Tuneup Systems, 2004).
[48] Colley, 9.
[49] R. W. Forsyth and R.J. Sowter, "On Photographic Evidence of the Objective Reality of Combination Tones," *Proceedings of the Royal Society of London*, vol. 63 (1898), 396-399.

Evelyn Gough and Genevieve Robinson

This experiment set out to determine whether the Tonoscope[50] could register two separate readings from the voice tube and, further, what subjective tones would appear. This source, although the methodology is slightly flawed (people sung into tubes rather than using a sound mechanism), allowed the author to see if differential tones and summational tones were present in this study, the results of which showed the existence of differential tones but not summational tones.

Herman L. F. Helmholtz

When discussing multiphonics, the earliest and most fiercely debated source is *The Sensation of Tone*. Of significant importance to the present study is Helmholtz's[51] discussion of combination tones. According to Helmholtz, combination tones are heard whenever two notes of different frequencies are justly in-tune and are played with great force. The resulting combination tones will frequently differ from those of the original notes.[52]

Helmholtz defines two types of combination tones. The first, and oldest, form of combination tone is termed the "differential tone." This subjective tone is termed differential because it is equal to the difference of the two original pitch frequencies. Helmholtz mentions that this type of combination tone is best heard when the two frequencies are less than an octave apart. He also mentions that, once one learns to hear

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[50] Evelyn Gough and Genevieve Robinson, "The Tonoscope as a Means for Registering Combination Tones," *The American Journal of Psychology* vol. 31 no. 1 (Jan. 1920), 91-93.
[51] Herman L. F. Helmholtz, *On the Sensations of Tone*. Translated by Alexander J. Ellis. London: Longmans, Green and CO, 1895
[52] Helmholtz,153.

combination tones from two consonant pitches, combination tones from inharmonic pitches can be heard with some ease.[53] Although other differential tones are theoretically possible (by calculating second order, and so on), only the differential tone of the first order is easily heard.[54]

Summational tones are the second type of combination tone identified by Helmholtz and this is where the debate begins for acousticians. Summational tones are equal to the sum of the two original pitch frequencies. These subjective tones are, according to Helmholtz, weaker than differential tones and are, thus, more difficult to hear.[55] Similar to differential tones, the summational tone can form other combination tones and will frequently form inharmonic pitches.[56] Lastly, and after much discussion, Helmholtz believes that combination tones are not a physical reality and are produced in the ear; Helmholtz hypothesizes that combination tones are heard due to the combined vibration of the external vibrating parts of the ear (drumskin and auditory ossicles).[57]

Paul Hindemith

Hindemith's[58] contribution to trombone multiphonics is nonexistent, however, his contribution to his view of combination tones and his theory of interval roots may be of interest to anyone wanting to compose chordal multiphonic music. The idea of interval roots stemmed from what he called "series 2," which, unlike "series 1" evaluates the

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[53] Helmholtz, 154.
[54] Ibid.
[55] Helmholtz, 156.
[56] Ibid.
[57] Helmholtz, 158.
[58] Paul Hindemith, *The Craft of Musical Composition: Book 1 – Theoretical part,* trans Otto Ortmann. New York: Associated Music Publishers, 1942.

distances between various notes, not the relationship between successive notes.[59] Of interest to both this study and music theory is his idea of interval roots. Here, Hindemith believes the ear will determine a chord based on sound analysis, not specific intervals, and that subjective tones should be used to help determine interval roots.

Similar to common practice theory, Hindemith supposes that the subjective tones will assist in determining the chord quality. For example, the interval of the perfect fifth (3:2) in C-Major yields a quadratic differential tone of C, a summational tone of E, and the two original pitches, C and G. It is easy to see that, for this example, there are two C's (root), one fifth (G), and one major third (E), thus creating a C-Major triad in root position, as seen in traditional part-writing where the root of the chord is doubled, and the remaining notes fill in the harmony.

Percival R. Kirby

Kirby's[60] article on multiphonics is an excellent source for anyone wanting to learn to calculate subjective tones. The terms "summational" and "differential" are used in this source to describe subjective tones, and a few of Helmholtz's examples are used as well. Kirby uses the harmonic series to calculate subjective tones instead of using pitch frequencies. He also mentions that a perfectly pure note played on an instrument is practically non-existent.[61] Due to this, any note played on an instrument will be "colored" by its upper partials.[62]

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[59] Hindemith, 57-58.
[60] Percival R. Kirby, "Horn Chords: An acoustical Problem." *The Horn Call* (August 2000), 65-67.
[61] Kirby, 65.
[62] Ibid.

Kirby mentions that subjective tones are theoretically possible but have practical limitations. The steadying of the played note and the compass of the human voice are mentioned as two such limitations. Additionally, “a keen ear and a steady lip” are required to successfully perform multiphonics. Finally, Kirby mentions that chords produced are not in accordance with equal temperament.[63]

Christopher Leuba

This resource[64] aims to help a player improve intonation by increasing the player’s awareness of subjective tones, the harmonic series, and by keeping a note tendency chart. According to Leuba, any interval played at the same time will produce a subjective tone, although he does not specify what type of subjective tone. This subjective tone should reinforce the other notes being played, which can only be accomplished by playing correctly in tune.

Of the more interesting, and far reaching, topics covered in this text is Leuba’s explanation of the minor third. Since a subjective sound will occur every time two notes sound simultaneously–Leuba’s words–the differential tone of a minor triad will result in a note that does not correspond to the notes in the minor triad. Leuba avoids this complication by implying that the newly produced differential tone will act as the root of the chord, thus creating a major seventh chord. Leuba proposes that the “Picardy third” was the result of “undesirable resonances in the environments of large cathedrals.”[65]

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[63] Kirby, 66.
[64] Christopher Leuba, *A Study of Musical Intonation.* [1962] (Vancouver, BC: Prospect Publications, 2004.
[65] Leuba, 12.

Angla Lohri, Sandra Carral, and Vasileios Chatziioannou

This article[66] states that the writers are capable of hearing summational tones, but that they are more difficult to hear than differential tones due to masking effects of the primary frequencies. The authors also believe that summational and differential tones can occur between any two notes. The authors also developed an ingenious device called a "tone matrix" where the matrix will calculate all possible outcomes of combination tones based on a given interval. This type of matrix was helpful in determining the format for some of this author's appendices.

Reinier Plomp

This text[67], while at first mathematically intimidating, is somewhat useful for this study. Both combination tones and beats are discussed in detail. Additionally, ways to produce and cancel (make something inaudible) combination tones are presented. Interesting for a musician, this book may be better suited for someone in the field of acoustics and psychoacoustics.

Otto Stuhlman, Jr.

This brief article[68] provided insight into the decibel levels required to hear combination tones. Harmonics produced from pure tones are subjectively heard when the

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[66] Angla Lohri, Sandra Carral, and Vasileios Chatziioannou. "Combination Tones in Violins," taken from Proceedings of the Second Vienna Talk, Sept. 19-21, 2010, University of Music and Performing Arts Vienna, Austria, 96-99.
[67] Reinier Plomp, *Aspects of Tone Production: A Psychophysical Study*. London: Academic Press, 1976.
[68] Otto Stuhlman, Jr., "The Asymmetrical Response of the Human Ear in Relation to the Problem of Combination Tones," *Bulletin of the American Musicological Society* 5 (Aug. 1941), 19-21).

sounds reach an amplitude of 40 or 50 decibels above the human threshold.[69] Further, after about 90 decibels, odd harmonics begin to become more audible while the even harmonics begin to diminish.[70]

John Sundberg

Sundberg describes what he terms the "voice organ" as consisting of the lungs, larynx, pharynx, and the mouth and nose.[71] This voice organ is the resonating chamber for the vocalist. Aside from briefly describing the vocal anatomy, Sundberg discusses formants, which allow vocalists to sing louder, and with a clearer sense of vowel definition. This resource was useful in the author's research because the formant frequency is described very well.

Edward Titchener

Titchener's[72] text is interesting and informative, with experiments and results related to subjective tones. The subjects were not only able to hear the two types of differential tones, but summational tones as well. Titchener had devised an experiment that allowed the subjects to train themselves into hearing subjective tones, something no one else had been able to do. This research helped the author to better advocate for the existence of summational tones.

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[69] Stuhlman, 20.
[70] Ibid.
[71] John Sundberg, "The Acoustics of the Singing Voice," *Scientific American* (Mar. 1977), 16.
[72] Edward Titchener, *Experimental Psychology: A Manual of Laboratory Practice* vol. 1, "Qualitative Experiments: Part 1, Students Manual." New York: The Macmillan Company, 1901.

Xiaoqin Wang

Wang[73] provides an overview of some pitch recognition theories and provides data to support each theory. Through his analysis, Wang concludes that spectral and temporal processing is unique to the auditory cortex.[74] One theory of pitch recognition is the harmonic template theory where only the first five harmonics are resolved.[75] Another aspect of this theory is that harmonic templates can only function with resolved harmonics, thus any processing must be done before the frequencies reach the template.[76] This article is loosely related to the study of multiphonics, as knowledge of how we, as humans, hear may help to gain a better understanding of subjective sounds.

Glenn White and Kate Grieshaber

This article[77] was written as a reaction to Asmus' article seen earlier in the literature review. White and Grieshaber believe that Asmus's methodology was flawed because of the high likelihood of intermodulation, which just so happens to produce a signal at the differential tone frequency.[78] The authors describe numerous ways intermodulation can occur. They suppose that if all sources of intermodulation could be eliminated no differential tones would exist. White and Grieshaber were unable to locate the differential tone. Unfortunately, the two authors did not include any of their data to

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[73] Xiaoqin Wang, "The Harmonic Organization of Auditory Cortex," *Frontiers in Systems NeuroScience 1* (December),
[74] Wang, 8.
[75] Wang, 6.
[76] Ibid.
[77] Glenn White and Kate Grieshaber, "On the Existence of Combination Tones as Physical Entities," *Journal of Research in Music Education 28*, no. 2 (Summer, 1980), 129-134.
[78] White and Grieshaber, 130.

clarify their findings. Finally, White and Grieshaber recommend that any future research on combination tones be done with complex sounds, as sine tones do not exist in music.[79]

P. M. Zurek and R.M. Sachs

In this article, Zurek and Sachs[80] attempt to prove the existence of combination tones that sound above the generating sounds, something which was of interest to many at the time. A primary problem with distinguishing upper subjective tones is that lower sounds mask upper sounds, thus loud low sounds could eliminate our ability to hear upper subjective sounds. Disregarding upward masking, that is, if masking is limited, Zurek and Sachs found that at times the summational tone was easier to hear than the generating sounds and could be heard at 30 – 40 Db below the generating sounds.

E. Zwicker

Zwicker's[81] research included the dependence on the sound level of the primary notes, the frequency difference, frequency regions, and the addition of a partially masked tone. The results of these experiments revealed clear differences between the two types of differential tones. Zwicker's research into the differing behavior of the two differential tones was very helpful in the author's research.

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[79] White and Grieshaber, 129.
[80] P. M. Zurek and R.M. Sachs, "Combination Tones at Frequencies Greater Than the Primary Tones," *Science, New Series* 205 no. 4406 (Aug. 10, 1979), 600-602.
[81] E. Zwicker, "Different Behavior of Quadratic and Cubic Difference Tones," *Hearing Research 1* (1979), 283-292.

Vocal Texts

Granville Humphreys

Three main ideas can be extracted from Humphrey's brief article[82]. Humphreys mentions that a fixed larynx position would create undesirable sounds, but that if the larynx is allowed to "float" the voice would benefit from the two other positions by obtaining aspects of both positions. The larynx positions in question are the raised larynx, which is more capable of producing smoother and a greater carrying power[83] and the lowered larynx position providing the vocalist with a relativity full volume and a somber timbre.[84]

Peter R. LaPine

This article discussed how the voice works and provides suggestions to keep one's voice healthy. LaPine[85] believes that vocalists can sing without any problems if the correct muscles are contracted upon the support of the expiration, however, he does not describe his own pedagogical approach to breathing. Toward the end of this article, LaPine offers suggestions to keep the voice in good shape. Similar to trombone playing, the vocalist should not ignore painful singing, rest when tired, and sing with good posture.

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[82] Granville Humphreys, "More About the Larynx," *The Musical Times 65* no.978 (Aug. 1924), 693.
[83] Ibid.
[84] Ibid.
[85] Peter R. LaPine, "The Relationship Between the Physical Aspects of Voice Production and Optimal Vocal Health," *Music Educators Journal 94* no. 3 (Jan. 2008), 24-29.

Richard Miller

This resource[86] was invaluable to the author's research as many of the topics discussed in this document were located in this book. Important topics covered in Miller's text are breathing, vowels, and vocal anatomy. This resource would assist anyone in obtaining information for numerous vocal topics.

Darrel L. Teter

Vocalists, their teachers, and most music education students are aware of vocal nodules; they are not to be taken lightly. Trombonists should be sure to take care of their voice, as vocal nodules may occur if the voice is not properly cared for. The best thing one can do when the voice feels stressed or over used is to give the vocal folds rest. Vocal nodules can heal on their own, however, surgery is sometimes needed to remove the hardened callus-like nodule. Following the surgical procedure, Teter suggests that the vocalist use his/her voice as little as possible and eliminate any bad habits that may have led to the nodules in the first place.[87]

Multiphonic Examples and General Resources

Buddy Baker

Baker's[88] method served as the model for what a good method book should contain. The preliminary material, in particular, assisted the author with finding a structure and order upon which a method could be based. Additionally, observing how

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[86] Richard Miller, T*he Structure of Singing: System and Art in Vocal Technique*. New York: Schirmer Books. 1986.
[87] Darrel L. Teter, "Vocal Nodules: Their Cause and Treatment," *Music Educators Journal 64* No. 2 (Oct. 1977), 77.
[88] Buddy Baker, *Tenor Trombone Method: An Approach to Trombone Basics, Warm-up, and Daily Routine for Tenor Trombone With or Without F-Attachment.* Van Nuys, CA: Alfred Publishing, 1983.

Baker interjects commentary throughout the method was helpful in obtaining a visualization of what this author wanted the method book to look like.

Jen Baker

Baker's[89] article on provides an overview of trombone related literature and provides three examples of what she feels are "unique characteristics."[90] These characteristics are mid-range twelfths, which are described as being "clear and open,"[91] low range intervals larger than a twelfth, and singing below the played note. She additionally provides, what she feels are, some of the fundamental aspects of the technique. Baker's article, while short, provided insight into what she viewed as acceptable ranges for all trombonists.

Stuart Dempster

The use of the voice and multiphonics are among many topics covered in this text. Dempster[92] must feel as if they are two of the most important topics, as they are grouped together and are discussed before all other techniques. According to Dempster, the use of multiphonics is one of the most popular extended techniques and, when mastered, can be very successful. Mentioned briefly in this text is singing below a played note, or "reverse multiphonics." Dempster seems to feel that this is more difficult than the traditional way (singing above the played note), but mentions that reverse multiphonics are seen more often than one would think.[93] Sung and played unisons are seen in the first description of

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[89] Jen Baker, "Trombone Multiphonics,"*International Trombone Association Journal 1* (January), 21.
[90] Ibid.
[91] Ibid.
[92] Stuart Dempster, *The Modern Trombone: A Definition of Its Idioms*. Berkeley: University of California Press, 1979.
[93] Dempster, 6.

multiphonics. Dempster suggests that this interval (the unison) be learned once one has learned to use the instrument as a megaphone. Using the trombone as a megaphone is a clever concept, as it allows the student to experiment by sending vocal sounds through the instrument, thus allowing the student to become familiar with sending non-traditional sounds through the trombone.

The use of the unison as the first interval, however, may be problematic for some students, as he or she must deal with irregularities of tone and pitch. Following the unison, Dempster suggests that the student then lower the played note by a quartertone until the interval of a minor second is reached. This, too, may be difficult for students just beginning to develop multiphonics, as this interval creates beats and interference that can be difficult to control for trombonists first learning the technique. Furthermore, the interval of a quartertone may be extremely difficult to produce for someone inexperienced in multiphonics, especially considering Dempster's accurate observation that "the voice will want to vibrate sympathetically with the lip."[94]

Finally, Dempster states that a "breathy lip sound" must be used when playing multiphonics to keep the two sounds relatively equal in dynamics. Rather than advocating to play with a poor sound, Dempster may be suggesting the played note be performed softly to better match dynamics between the sung and played note. Using the interval of the unison again, Dempster provides an excellent exercise to assist the trombonist with matching dynamics between sung and played notes.

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[94] Dempster, 7.

Bruce Fowler

Fowler[95] uses the term “vocal multiphonics” to describe singing and playing simultaneously, and believes the origins of multiphonics are found in early jazz music, as some of these players used “growling” as a special effect. There are fourteen exercises, none of which contain notated subjective tones. Similar to other approaches, the first two exercises focus on singing in unison with the played note. Among the better suggestions Fowler provides is the use of experimentation. Experimentation in the learning approach is excellent, as it allows the student to discover things on his/her own. Similar to Dempster’s approach, Fowler suggests singing and playing a unison, then letting the sung note wander (above and below the played note) looking for natural vibrating combinations that will “lock in.”

Fowler briefly discusses subjective tones (summational and differential tones) and lists some “standard multiphonic jazz licks." Thirteen different combinations of played and sung notes are also provided with notated subjective tones. Unfortunately, not all subjective tones are accurately calculated.

Trevor Herbert

This brief article contains useful information for trombonists wanting to learn multiphonics. Herbert[96] mentions that a basic method should include some experimentation on the student’s part. Although there are no musical examples in the article, Herbert does provide some suggestions to teaching multiphonics. Herbert suggests deciding on two notes that are comfortable to play and sing, and to fully

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[95] Bruce Fowler, “Winds: Vocal Multiphonics.” *Down Beat*, January 1981, 59-61.
[96] Trevor Herbert, “Teaching Notes: Trombone Multiphonics” *Music Teacher* (October 2005), 47.

establish their pitches in the student's mind. He then suggests alternating between the sung and played note, and to sing with an open vowel in the throat. Finally, Herbert suggests that the novice student should focus on pitch accuracy and a continuous flow of air.

Robert Müller

Müller[97] briefly mentions multiphonics at the end of his second book of technical studies and seems to have had only a basic knowledge of subjective tones. Common to method books from this period is the exclusion of differential tones and the displacement of summational tones by an octave. Müller unfortunately followed this trend. Müller also seems to think that the slide position has some effect on subjective tones. While slide position–something beyond the scope of this document–can affect the pitch of the sung note and its overall timbre, it appears Müller believes the placement of the slide has an important role in the multiphonic process. Müller's only exercise consists of a drone played on the trombone above which the voice sings the intervals: perfect fifth, major sixth, and minor seventh.

Jerome Proctor

Not seen in Cornett's original source, Procter's[98] revised edition contains a brief mention of what he calls "simultaneous chords." Similar to other early multiphonic sources, this section is brief and includes one exercise. Procter states that the second sound source should be hummed, and uses the interval of a tenth in his three-measure

[97] Robert Müller, *Studienwerke und Unterhaltungsstücke für Zugposaune* Book II [1901]. Frankfurt: Musikverlag Zimmermann, 2010.
[98] V. Cornett, *Method for Trombone,* revised by Jerome N. Procter. Boston: Cundy-Bettoney, 1937.

exercise.[99] Procter's use of the word "hum" is interesting, as it appears that he does not advocate for singing through the instrument. On closer inspection, however, the words used to describe the vocal sound added to the sound of the instrument are interchangeable, although the term "sing" may be better for acoustical and dynamic reasons. Procter mentions differential tones but not summational tones. This is intriguing because, at least on the trombone, summational tones are often easier to hear than differential tones.

Gardner Read

Read[100] mentions three techniques that are applicable for trombonists: harmonics, microtones, and multiphonics. Like Dempster, Read writes that, realistically two vocal pitches should be indicated so trombonists (Read mentions brass players, but for the purpose of this study I will refer to all brass instruments as trombones), regardless of one's vocal range or sex can play a given multiphonic passage. Apparently, according to Read, a differential tone will occur when the trombonist plays a tenth, but that it is barely audible.[101] Interestingly, Read may believe the tenth is the only interval capable of producing differential tones.

Giancarlo Schiaffini

The Trombone is divided into six sections, each section corresponding to a specific aspect of trombone playing. The section on multiphonics briefly addresses what

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[99] Procter uses the same interval throughout the exercise, changing only the sung and played notes.
[100] Gardner Read, "The Tonal Resources of Wind Instruments: Some Contemporary Techniques," *Music Educators Journal 63* no. 1 (Sept. 1976), 50-55.
[101] Read, 55.

Schiaffini calls “true multiple tones.” According to Schiaffini[102], true multiple tones occur when the trombonist “plays” a pitch that is equidistant between any two adjacent partials on the instrument, e.g. “playing” a “C#/D” in-between the second and third partial notes in first position. The result, according to Schiaffini, will consist of both B-flat and F-natural sounding simultaneously, and are the same notes in the harmonic series chosen for this example. According to Schiaffini, this type of multiple sonority is not very effective unless the notes are sustained for an extended period of time while played at a *mezzo piano* or *mezzo forte* dynamic.

The most commonly applied form of multiphonics, however, is by singing and playing simultaneously. Schiaffini mentions two observations that he has discovered in his own study of the technique: first, the trombone player must resort to “tricks” to be able to sing and play, and secondly, it is not possible to sustain a sung note while playing staccato. The aforementioned observation–that is, sustaining a sung note while playing staccato–is an accurate one. Any attempt to do so will likely frustrate the player. The use of “tricks,” however, to sing and play is not entirely accurate. The trombonist may find it easier to adjust the pressure placed on the mouthpiece while producing multiphonics, but this should not be considered a trick.

Three examples of multiphonics appear in this source, none of which contain notated subjective tones. Schiaffini’s examples provide information regarding playing in parallel fifths, a brief chorale, and a commonly used voice crossing exercise. Aside from a passing mention of subjective tones, these tones and the acoustical reasons behind them are not addressed in this resource.

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[102] Giancarlo Schiaffini, *The Trombone: Increasing its Technical and Expressive Capacities*. Milan: Ricordi, 1982.

Benny Sluchin

Of the material covered in this section, *Practical Introduction to Contemporary Trombone Technique* contains the most relevant and useful information regarding multiphonics. Divided in four sections, the section most pertinent to this discussion is titled “Other Possibilities.” Sluchin[103] provides a few exercises to familiarize the reader with the concept of singing and playing simultaneously, and, while not providing examples for study, provides excellent information regarding the learning process. Sluchin lists three ways that one may begin the study of multiphonics: (1) play, then add the voice; (2) sing, then add the played note; and (3) simultaneous singing and playing. The order in which Sluchin presents all possible scenarios of starting multiphonics seems logical and may be the best way to initially approach the technique. Sluchin also mentions, and notates, sustaining a played note while changing the sung note. Although the reverse is possible (changing the played note above or below the sung note), its most effective use would seem to occur after the trombonist is more familiar with the technique. Additionally, a sustained played note allows the player to experiment with different interval combinations, thus furthering his or her progress in an exploratory manner.

After these exercises, Sluchin stated in 1995 (after two out of the three existing multiphonic methods had been published, reprinted, and, for lack of a better term, “sent out to the masses” that “These exercises explain briefly the way one could proceed. A progressive study material still eludes us.”[104]

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[103] Benny Sluchin, *Practical Introduction to Contemporary Trombone Techniques: 20th Century Excerpts*. Paris: Editions Musicales Européennes, 1995.
[104] Sluchin, 11.

Bill Watrous and Alan Raph

This text contains information regarding various techniques specific to the trombone. Watrous and Raph[105] mention that one must play and sing to create more than one note to sound simultaneously. The authors mention that the played note is often louder than the sung note, and that the played note is often the root of a chord. Watrous and Raph suggest trombonists learn the technique by sustaining a played note and to add the sung note to the played note. Unlike other approaches to learning multiphonics, the authors suggest the use of intervals larger than a third to begin the study of multiphonics; fifths and tenths are the first intervals used in this text.

There is no discussion on why additional notes sound when performing multiphonics. Watrous and Raph state that a third sound will appear if the sung and played notes are in-tune with each other. According to the authors, the third sound is a result of harmonic relationships between the sung and played notes. This text contains fifteen exercises that can be used to familiarize oneself with multiphonics. Subjective tones are notated in many of the examples. Although only one subjective tone, instead of two, is notated per chord, the use of notating subjective tones may assist the trombonist with the correct tuning of intervals. Lastly, Watrous and Raph discuss, briefly, the use of non-chordal multiphonics.

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[105] Bill Watrous and Alan Raph, *Trombonisms: An Extension of Standard Trombone Techniques and an Introduction to Some New Ones*. New York: Carl Fischer, 1983.

Existing Methods

Don Appert

Appert's[106] method contains useful exercises that might assist the trombonist with learning multiphonics. Clear, concise, and accurate, this text is the closest existing method to fill the need of a pedagogical approach to multiphonics. Organized in a manner that minimizes "waves," or beats, Appert's learning sequence is as follows: (1) Unisons, (2) Octaves, (3) Fifths, (4) Fourths, (5) Thirds, (6) Seconds, (7) Tenths, (8) Sixths, (9) Ninths, (10) Glissandi. Each of the intervals used in this method comprises its own section of the method, and each section contains descriptive commentary as to what the student should learn from each chapter.

Although Appert's assertion regarding beats is correct, the student initially learning multiphonics may have difficulties tuning the unison for reasons previously discussed. The perfect fifth (Appert's third learned interval) may be a better starting interval due to the easily recognizable upper subjective tone and the ease at which the student can hear the sung pitch.

One reason this method is less accessible to more trombonists is the order that intervals are learned. For example, major and minor seconds are learned before major and minor sixths and tenths, which are much easier to produce. The minor second is one of, if not the hardest intervals to tune due to the intense sensation of beats felt on the player's embouchure. Similarly, singing below a played note is initially much harder than the reverse. This technique is not discussed, or otherwise mentioned, except for a passing remark, however, the technique is used as early as the nineteenth exercise. To be

[106] Don Appert, *A Progressive Study of Multiphonics on the Trombone*. West Springfield: Trombone Association Publishing of Wsn MA, 1988.

successful with “reverse multiphonics” many students would benefit from some type of preliminary exercise.

Subjective tones are notated in two exercises. Unfortunately for those wanting to learn about subjective tones, little information is provided regarding any pitches that may sound. If arranged differently, and with some modifications and additions, this resource could be a more valuable source for learning multiphonics.

David N. Baker

Of the three published methods, Baker’s[107] *Contemporary Techniques* is the earliest, and was the way the author initially learned to play multiphonics. Of the sixty-plus pages in this volume, fourteen are devoted to multiphonics. While this method contains valuable information, Baker’s approach to learning the technique cannot be considered pedagogically sound for a few reasons. First, subjective tones are not found in this method. The notation of subjective tones, when applicable, will allow the player to adjust the intonation to get the correct subjective tone to sound. The student may learn the technique without the aid of notated subjective tones, but doing so may limit his or her ability to fully understand the complexities of combination tones. Additionally, and similar to other sources, Baker only provides a limited explanation of subjective tones.

Secondly, Baker’s multiphonic method lacks significant written instruction. Although there are a few helpful suggestions, most of the written comments are used to guide the student toward modifying existing material. For a section devoted to learning the technique, written instruction would further enhance what are, already, excellent

[107] David N. Baker, *Contemporary Techniques for the Trombone* vol. 4. New York: Charles Colin, 1974.

exercises. Further, there is no mention of how to play "reverse multiphonics." Baker simply states: "Go back to the beginning of the multiphonic section and reverse the singing and playing roles."

Finally, although the method begins with suitable exercises (perfect fifth exercises progressing to major sixths), the learning sequence may be too advanced for some players. The major seventh is the third interval learned in this method. Although this interval is easily heard, the player initially learning multiphonics may have difficulties tuning this interval due to beating. A more progressive approach would assist the player to gain familiarity and ease of production before introducing intervals that are difficult to tune.

Baker's[108] sixth volume contains no multiphonic instruction; it does, however, provide a way to learn microtones, something needed for this method. Baker's approach seems logical, as he begins with fretted passages to assist with ease of coordination and listening. Unfortunately, the same problems arise in this, incredibly brief, section on microtones that arose in the multiphonic method: there is hardly any written instruction, and the trombonist is expected to make up their own exercises, which is not necessarily a bad idea. This source could be more valuable to trombonists if clear instructions were included, as the difficulty level then diminishes.

[108] David N. Baker, *Contemporary Techniques for the Trombone*, vol. 6. New York: Charles Colin, 1974.

Marc H. LaChance

LaChance's[109] thesis contains information related to combination tones and a method for learning multiphonics. A brief history of multiphonics appears before the method with no analysis of the pieces or related subjective tones and intervals. Most material found in this source consists of a compilation of existing exercises found in other sources, however, a few original exercises are used as supplementary material to further assist the trombonist in learning the technique.

LaChance's method is arranged in the following manner: (1) played and sung notes sounding individually; (2) sung notes added to the played note; (3) simultaneous attack of the sung and played note; (4) sung note moving over a sustained played note; (5) played note moving below a held sung note; (6) parallel movement of both voices; (7) contrary movement of both voices; (8) sung note moving below a played note; and (9) parts crossing while both are in motion.

While this learning order makes sense, there may be some difficulty with arranging a method in this manner. The first difficulty to arise is that, while the intervals chosen for each section are arranged in a progressive manner, the intervals may change from one section to another. This approach may work for some students, whereas simplifying the process by keeping the intervals consistent throughout each section might benefit more players.

The second difficulty is the way in which the exercises progress, moving from simple to intervals that are more complicated quickly. Additionally, there are exercises that, although progressive, may be too difficult for someone learning multiphonics.

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[109] Marc H. LaChance, *Trombone Multiphonics: A Method*. Master's Thesis, College of Bowling Green State University, 1994.

Finally, one comes to the realization that this method contains limited written instruction and only a limited mention of subjective tones. Although there are a few comments related to some exercises, the vast majority of them do not contain information regarding the execution and application of a given exercise. Including more instruction in this method may have made for a more valuable resource; however, most of the exercises borrowed from other sources did not, originally, contain written instructions.

Timothy Myers

For an unpublished resource[110], the exercises contained on this handout are of high quality. Each of the fourteen exercises are progressively arranged and contain the following intervals: unison, major second, minor third, major third, perfect fourth, perfect fifth, major sixth, minor seventh, the octave, and microtones. One beneficial aspect of this handout is the ease in which the player may, if they choose to do so, select exercises at random and not feel lost. This is because all exercises, except one, begin in the same key (B-flat major).

Exercises are arranged in three sections, thus allowing the player to become familiar with one aspect of the technique before moving to a different aspect. The three aspects mentioned are, in order of appearance: (1) moving only the voice, (2) moving only the slide, and (3) moving the voice and slide simultaneously. This approach is excellent, as the player need only focus on one aspect per section of the handout. Also of importance is the starting interval for the first exercise (the perfect fifth) and the separation of the sung and played note. By separating the sung and played note, the player isolates the two main aspects of multiphonics, thus focusing his/her attention to

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[110] Timothy Myers, Untitled and unpublished handout from the 1990 Midwestern Trombone Workshop, 1986.

intonation, sound quality, and conceptualizing the idea of eventually combining the two sonorities.

Due to the scope and the intended audience, this handout cannot be considered a complete progressive method. There is no written instruction or any explanation of the technique, and the acoustical foundations on which subjective tones exist are not addressed. Further, there are perceived gaps in the learning sequence. For example, the dissonant interval of a major second precedes the playing of a unison. Similarly, the minor seventh is introduced before a perfect fourth, which is much easier to tune. “Reverse multiphonics” are notated, however, the exercise introducing the technique may be too difficult for an inexperienced player.

CHAPTER III

METHODOLOGY

The goal of this project was to create a pedagogical method; therefore, the primary research demands included locating existing multiphonic instruction and repertoire. Existing methods of multiphonic instruction are found in Baker's *Contemporary Techniques for the Trombone,* Appert's *Progressive Study on Multiphonics*, Myers' unpublished handout, and LaChance's *Trombone Multiphonics*. The author determined the effectiveness of these methods by practicing the exercises presented in each method. Exercises found to be effective were studied to determine why they were effective. Further, the author attempted to make difficult exercises easier. By looking at the existing methods, the author ensured that any new exercises created were, in fact, newly created. Similarly, exercises that were found to be of little value were analyzed to see how the exercise could have been more efficient. Lastly, the dissertations of Adams (*Timbral Diversity*), Davidson (*Annotated Database of 102 Selected Published Works For Trombone*), and Senff (*Annotated Bibliography of Unaccompanied Solo Repertoire)* provided the author with an abundance of trombone literature to analyze for the purposes of this study. The author consulted the aforementioned sources and the repertoire referenced by those authors to identify notational styles, multiphonic intervals, and singing and playing ranges. No other sources were consulted, as the material found in the three dissertations proved to contain all the information the author needed. Arranged in a progressive manner, the exercise portion of the method contains newly created exercises designed to assist the trombonist master the multiphonic technique with relative ease and is divided into six chapters. Instructional commentary is provided throughout the method and at the beginning of each subchapter. This commentary discusses the section or exercise, why the exercise is important, and how to practice the section or exercise, thus preparing the trombonist for success. The author notated all subjective tones or beats for each of the interval subchapters found in the method.

The first five chapters of the method are devoted to vocal multiphonics and contain individual subchapters that focus on one aspect of the larger chapter. Chapters one and two contain interval studies. Chapter one contains exercises where the sung note lies in unison or above the played note, chapter two contains exercises where the sung note lies in unison or below the played note. Each subchapter found in the first two chapters corresponds to specific intervals and begins with the most basic form of an exercise. Following the preliminary exercises, each subchapter progresses toward parallel and contrary motion while building on previously established technique. Like the first two chapters, chapter three begins with an exercise that introduces the concept in a simple and easy manner before progressing toward more advanced exercises. Chapter four begins with a simple part-crossing exercise before advancing to multiphonic flexibility exercises. This chapter also includes subchapters devoted to more advanced part-crossing exercises, short-and-long-range glissandi, and exercises that incorporate all previously learned techniques.

Chapter five represents the final chapter devoted to vocal multiphonics and is based on the author’s research of healthy voice extension. Exercises found in this chapter will assist the trombonist to further develop their vocal range in order to perform some of the extreme intervals seen in the trombone repertoire.

The chapter on split-tone multiphonics is placed at the end of the method because this technique is seen less frequently in trombone repertoire and is more difficult than vocal multiphonics. Split-tone multiphonics is introduced through a series of lip-bending exercises beginning on the second partial. Only the first and second partials are used to learn this technique, as anything above the third partial is too difficult for many trombonists.

Secondary research demands included locating, analyzing, and applying any new knowledge toward trombone multiphonics. Although the scope of the following research topic is smaller compared to the exercise portion of the method, these supplemental research topics allowed the author to have a better understanding of the multiphonic process. Supplemental research topics included vocal technique, subjective tones and beats, and the tuning of multiphonic intervals.

The author consulted Richard Miller's[1] *The Structure of Singing* and sources cited in the extensive bibliography to study the oral cavity and vowels, vocal resonance, range extension, and vocal health. This resource and the bibliographic entries also assisted the author in learning about the structure, function, and position of the throat, jaw, tongue, and larynx, and to see how vocalists produce tone, breathe, and sustain the vocal sound. This portion of the method stresses similarities between trombone and vocal technique, while determining whether or not any differences between the two techniques would cause harm to the trombonists embouchure or voice.

[1] Richard Miller, *The Structure of Singing: System and Art in Vocal Technique*. New York: Schirmer Books, 1986.

The author also studied subjective sounds produced by vocal and split-tone multiphonics. Limitations to this portion of the study include the fact that not everyone may hear summational tones or differential tones. Due to these limitations, the author uses caution when discussing subjective tones and limits the discussion to include only commonly heard subjective tones. The author used the computer programs Audacity and Raven Lite to perform spectrogram analysis and to record the sound samples used in the study. These tools helped to identify the most commonly heard subjective sounds. Additionally, the frequency table found in John Backus' *The Acoustical Foundations of Music* was helpful in determining audible subjective tones. This source was also beneficial in the study of beating, masking (when the perception of one sound is affected by another sound), and how the human ear works.

Another limitation encountered in writing this method was that of the notational element . Both Finale and Sibelius were researched and tried to determine which software best fit the needs of this method. Sibelius was chosen as it could more easily notate non-traditional notation, however, limitations still exist. Although there are numerous ways to notate multiphonics, the author chose to use one notational style throughout this method, so as not to confuse the user.

Finally, multiphonic intervals must be justly in-tune to hear clear and in tune subjective tones and beats. This concept is easily understood but often difficult to execute. Backus' text provides excellent information on just intonation and contained ample information for the study of justly-tuned intervals. Additionally, Christopher Leuba's, *A Study of Musical Intonation,* provided an interesting approach to tuning multiphonic intervals. Other sources were additionally consulted; a description of these sources can be found in the literature review.

CHAPTER IV

ANALYSIS

The use of multiphonics as an avant-garde musical device in the twentieth and twenty-first centuries has helped the trombone to become a more popular instrument among composers. Since 1964, at least 51 compositions for trombone include the use of this technique. This trend shows that composers are increasingly interested in multiphonics, and thus a progressive method for learning the technique should exist. While there are a few existing methods circulating, the method presented in Appendix A is what the author believes to be, a comprehensive approach to learning multiphonics. Some aspects of multiphonics are either briefly mentioned, or dismissed altogether. For example, split-tone multiphonics receive far less attention than vocal multiphonics and are not discussed in most resources. Other aspects of multiphonic technique are also missing. The voice, for example, is not addressed (aside from a description of sung notes) in the majority of resources. What aspects of vocal anatomy and technique can be of use to trombonists? Secondly, to produce subjective tones intervals must be in-tune. What tuning system should be used and how does the trombonist learn to tune intervals and keep them in-tune? Lastly, there are differing views on which subjective tones are audible. Why is it that some trombone players can, depending on the interval, clearly hear summational tones when acousticians either dismiss their existence, or describe them as being far less audible than differential tones? This chapter will address these questions and discuss vocal anatomy and technique, the tuning of multiphonic intervals, acoustics, and data collected from recorded trombone multiphonics.

Vocal Anatomy and Technique

Since the voice plays a major role in vocal multiphonics, it is important to have an understanding of how the voice works, be it specific muscles and their location and function, vowel formation, the creation of sound, or keeping the voice healthy. Information regarding the pharynx, larynx, vocal folds, tongue, and jaw will aid the trombonist to have a complete picture of the vocal apparatus. Vital to learning about these items is the study of the pharynx and its structure and function. The pharynx is a muscular sleeve-like structure that has openings in the nose, mouth, and larynx.[1]

The pharynx is often described as having three separate sections: the oral pharynx, nasal pharynx, and laryngeal pharynx. The nasal pharynx is located between the base of the skull and the soft palate. Consisting of four primary muscles, the soft palate can help the trombonist create vocal sounds that are more resonant. For example, by raising the soft palate, trombonists can avoid nasal sounds, thus allowing for a more resonant sound. Most vocal resonance occurs in the oral pharynx due to the flexibility of the soft palate, tongue, and larynx. The Laryngeal pharynx houses the larynx, among other things.

Sound is created inside the larynx by the vocal folds (commonly miscalled vocal chords). There are two sets of vocal folds: superior, or false, vocal folds and the inferior, or true, vocal folds. Sound occurs when the vocal folds vibrate against each other in a periodic fashion, thus creating a sound at a certain frequency.

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[1] Dayme and Vaughn, 301.

The tongue plays a critical role in vowel and consonant production, and is comprised of several muscle groups. When these muscles work independently, they can draw parts of the tongue downward; when these muscles work together, they help to protrude the tongue. The jaw hangs from the skull by various ligaments and muscles. Although the jaw is primarily used for chewing, it can be used to the trombonists advantage by altering the size of the mouth opening.

Vowels play a key role in the vocal process, as they allow for a sustained sound. While consonances frequently occur in speech and song, the use of vowels predominates vocal music. Richard Miller refers to an acoustic at rest posture that is the "home base" or starting place for all vowels.[2] In this position, the tongue is relaxed, the jaws are separated from each other, the upper and lower teeth are separated, and the lips are parted and unshaped.[3]

Vowels known as "front" or "back" are labeled according to the tongue placement and the perceived change in timbre than the neutral vowels. The vowels [a], [o], and [u] are the most relevant "back" vowels to trombone multiphonics.[4] Back vowels are often described as having a darker timbre than other vowels and the tongue is far in the back of the mouth.

To achieve the [a] vowel, the trombonist lowers the jaw, which allows the tongue to lie flat on the floor of the mouth, and parts his/her lips. The vowel [o] occurs when the lips are separated and somewhat protrude from their normal position. Additionally, the back portion of the tongue is elevated while the front portion is depressed. For [u], the

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[2] Miller, 69.
[3] Ibid.
[4] All vowels could be considered relevant; however, the author chose to include only those that would have the greatest impact on the sound for multiphonics.

back portion of the tongue is greatly elevated, thus creating little room between the tongue and the soft palate.

Contrasting the back vowels, the tongue lies rather far in the front of the mouth for front vowels and is frequently described as having a brighter timbre than the other vowels. Of the most commonly seen front vowels, the vowels [i] and [e] are of most importance to the trombonist. To obtain the [i] vowel, the trombonist places their tongue rather high and close to the front of the mouth. Here, the apex, or tip, of the tongue touches the lower front teeth and the front of the tongue arches toward the roof of the mouth. Since [e] is more closely related to [i] than other vowels, it seems logical to describe the formation of [e] by comparing it to [i]. The [e] vowel has a wider oral cavity and the jaw is a little lower than when using [i]. Additionally, the tongue touches more of the sides of the teeth than in [i].

In conjunction with enunciation, vowels also serve as a second source for vocal resonance. Each vowel has two peaks based on the sound spectrum of a complex sound. These peaks, or formants as they are often called, help to resonate the sound emitted from the vocal folds and produce recognizable vowels as described by Kantner and West,

> All vowels, per se, have resonance but each vowel has its own distinct pattern of resonance that is the result of the number, frequencies, and energy distribution of the overtones present. It is by means of these differences in the overall patterns of resonance that we are able to hear and discriminate one vowel from another.[5]

Each vowel has two formants and the vowel sound is determined by its typical acoustic spectrum, regardless of pitch.[6]

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[5] Miller, 50.
[6] Ibid.

To fully understand the upcoming discussion of formats and their relationship to vowels and resonance, a brief and simple digression on the topic of sound production is necessary. To produce sound, many parts of the body must work together. Similar to a generator, the vocal sound must have three things: a power supply, an oscillator, and a resonator.[7] Here, the lungs act as the power supply, the vocal folds, the oscillator, and the vocal tract acts as the resonator. Therefore, in summary, the lungs move air past the vocal folds creating a periodic sound or wavelength at a fundamental frequency that travels through the vocal tract, thus creating a resonant complex sound containing overtones.

When playing multiphonics, the trombonist has the disadvantage of having to use the same power supply to create two complex sounds – one for the voice, another for the trombone. This creates additional difficulties, as the trombonist must create two separate periodic sounds (vocal and instrumental) while trying to balance the sounds to create the most resonant sounding multiphonic. Balancing the voice and trombone can be difficult initially, but with regular practice, a good balance between instrument and voice can be achieved.

According to Sundberg, there are four or five formants within the vocal tract.[8] The overtones of the fundamental travel across the formants and disrupt the fundamental frequency, thus creating different speech sounds. The closer an overtone is to a formant frequency, the louder the overtone can be heard when it leaves the lips, thus creating a more vibrant sound. If the first formant is far away from the fundamental, the volume will be faint. This can be corrected by changing the size of the jaw opening, which, in turn, adjusts the formant to become in tune with the fundamental, thus increasing the

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[7] Sundberg, 16.
[8] Ibid.

dynamic level. The body of the tongue affects the second formant and the tip of the tongue affects the third formant.

Possibly important to the vocal aspect of multiphonics is the "singer's formant," which can be used to help the trombonist sing, or sound, louder. The singer's formant occurs when the larynx and pharynx have two separate resonance frequencies, and appears between the third and fourth formants. Sundberg states, "the [singer's] format is at an optimal frequency, high enough to be in the region of declining orchestral sound energy but not so high as to be beyond the range in which the singer can exercise good control."[9] Generated by resonance in the vocal tract, this formant requires no additional work by the trombonist[10] and, when employed, creates a much more resonant sound than singing without this formant.

According to Miller, most vocal writing for any voice type is contained within the range of a tenth.[11] To maintain and improve upon previously established range and technique vocalists perform vocalises. Trombonists might improve their vocal skills by singing Bordogni or other well-known vocalises. Vocalises and songs need not be complicated, as the goal of this type of singing is to sing comfortably throughout one's range.

Finally, trombonists should take care to not damage their vocal folds, especially in beginning multiphonic studies, as that is the time to set a foundation for proper singing. There are some easy ways to take care of one's voice when not playing multiphonics or singing. Proper oral hygiene, resting the voice when needed, and avoiding shouting are

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[9] Sundberg, 20-21.
[10] Miller, 55.
[11] Miller, 161.

some ways to help reduce the risk of harming the vocal folds. Additionally, good posture, proper breath support, and correct muscle contraction will allow the trombonist to sing few problems. The trombonist should be sure the breath support system is working properly before multiphonic playing; improper singing technique can, and often does, lead to vocal fold damage. Trombonists should also be aware of some of the lesser-known irritants of the vocal folds, which, if ignored, could also cause harm to the vocal folds. These include throat clearing, excessive coughing, whispering, and consuming alcohol. Finally, if at any time singing becomes painful, the trombonist should stop singing for the day, as this may be the first sign of a problem.

Tuning Multiphonic Intervals

Proper tuning of multiphonic intervals is based on an understanding of just intonation and the ability to apply this knowledge to the instrument. Of the literature reviewed, many authors state that for subjective tones to sound, intervals must be in tune. This seems logical, as mistuned intervals in any context are avoided unless they are explicitly called for in a score. A few of the early sources state that "just" or "pure" intervals are the basis for obtaining subjective tones. Although different tuning systems may yield different subjective tones–a topic beyond the scope of this document–just intonation is used as a basis for tuning intervals in this method, as this tuning is generally accepted to be the most resonant tuning system for multiphonics.

Unlike equal temperament, where each semitone and wholetone are of equal size, just intonation has two different sizes of whole tones that differ by twenty-seven cents (9:8 and 10:9). This may seem as a disadvantage for some, and an undeniable disadvantage for keyboard manufactures, but for instruments like the trombone and the string family, virtually no limitations exist, as these instruments are capable of compensating for this change by adjusting their slide position or finger placement.

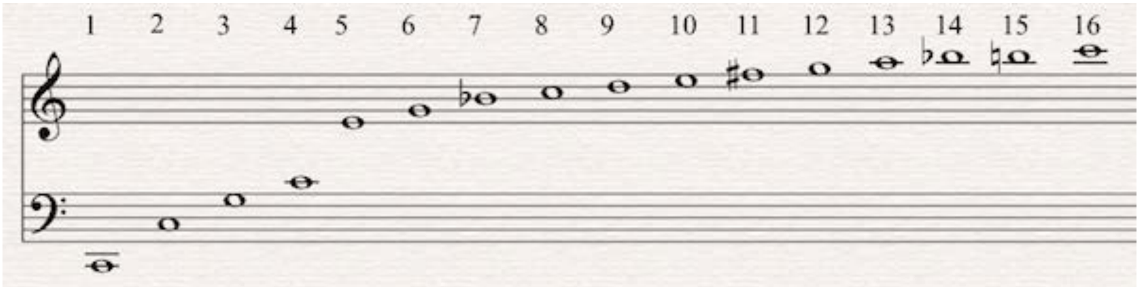
Intervals can be represented by ratios, regardless of the tuning system. Like interval ratios, frequency ratios do not change within a tuning system, however, different tuning systems yield different interval and frequency ratios. The frequency ratios are useful for determining subjective tones. The following table contains frequency ratios in the order in which they are found in the C just diatonic scale (see Table 1).

Table 1. Frequency Ratios of the Just Diatonic Scale [12]

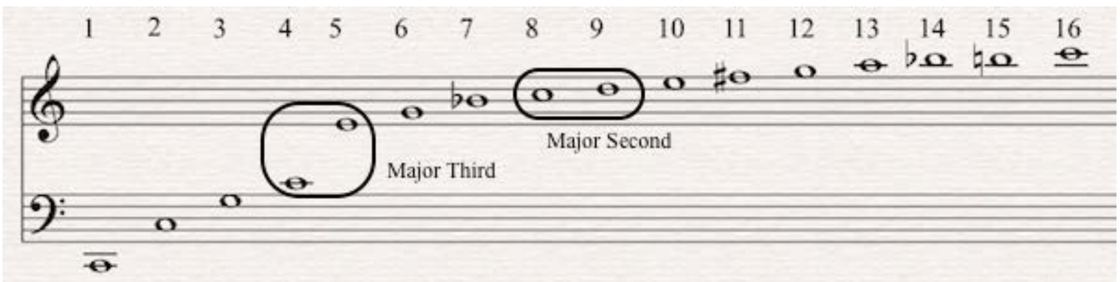
Diatonic Scale	C	D	E	F	G	A	B	C
Frequency Ratio	1	9:8	5:4	4:3	3:2	5:3	15:8	2

The frequency ratios found in Table 1 have an interesting connection to something with which all trombonists should be familiar: the harmonic series (see Example 1). By comparing Examples 1 and 2, one can see the connection between the harmonic series and just frequency ratios.[13] One can also observe that the first ratio (1) corresponds with the first note of the harmonic series or the "fundamental." The second ratio (9:8) corresponds with a major second, found between the eighth and ninth harmonic, the third ratio (5:4), corresponds to a major third, found between the fourth and fifth harmonic. This pattern continues to the end of the diatonic scale.

[12] Backus, 144.
[13] Note that a harmonic series can be built upon any fundamental, but the intervallic relationships found within the series does not change, regardless of the fundamental.



Example 1. The C harmonic series.



Example 2. The relationship between just interval ratios and the C harmonic series.

The question now becomes “how does someone learn to simultaneously sing and play justly-tuned intervals, keep them in tune, and hear subjective tones?” Leuba (*A Study of Musical Intonation*, 2004) recommends that instrumentalists keep a record of each note across the range of their instrument so that the player, when confronted with a passage of music containing an out of tune note, in just intonation, knows how to adjust their instrument to play in tune, thus adapting to their musical surroundings. This approach seems logical, but it does not help trombonists to play or sing justly-tuned intervals when playing multiphonics. Colley (*Tuneup*, 2004), too, recommends the use of what he terms a “note tendency chart,” but additionally advocates for the use of recorded sounds to aid the musician in learning to hear just intervals. While this approach will likely improve one's awareness of just intonation, it is doubtful the musician will hear subjective tones, as the focus of these exercises is to eliminate audible beats (the basis of just intonation), not listen for subjective tones.

Another way to learn to perform justly tuned intervals is to listen for subjective tones, as some intervals can create loud, audible subjective tones. Concerning listening and playing in tune, Backus states:

> It appears that the practical musicians disregard the theorists and play what sounds best, and the centuries-old arguments as to which tuning is best and which scale is most 'natural' are a waste of time.… The fact that the frequencies in the scale can be given exact values does not mean that the musician must play precisely these frequencies; he is free to vary his playing pitch in any way he needs to fit the demands of the music.[14]

That musicians adapt to their musical surroundings shows how versatile the ears are in tuning to others, or, in the case of vocal multiphonics, tuning to oneself. Thus by listening for an expected subjective tone, the trombonist may eventually learn to play justly tuned intervals. The idea of listening for expected subjective tones as a way to improve intonation was tested by Moody (*A Practical Method for the Teaching of* Intonation, 1995) with great success. Junior High age students, university level students, and a professional level player were all able to improve their intonation by listening for a certain pitch.[15] It seems likely that Moody's work could be adapted to assist trombonists to improve intonation and increase their awareness of subjective tones.

Acoustics

Since the topic of acoustics is rather large, this section will only address acoustical principals and ideas that are in direct relation to trombone multiphonics.

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[14] Backus, 150.
[15] Moody, 98.

Unlike some discussions on acoustics where reading can become laborious, tiresome, and dry, the author will attempt to present the information in a manner that is both pertinent and easy to understand. Topics in this section include the hearing mechanism (how we hear), subjective sounds, and an analysis of multiphonic data.

The Hearing Mechanism

Before learning about various subjective tones and other sounds, the author felt necessary to provide a foundation for how we, as humans, observe sound. Our ears never truly "hear" anything; instead, our brain tells us what we are hearing. By describing the process in which our ears and brain function together, we will have a better understanding of our auditory system and how it effects our perception of sound and subjective tones.

The ear is divided into three sections (outer, middle, and inner). The three sections of the ear work together to provide the illusion of hearing. Here, vibrations enter the outer ear, go through the eardrum and vibrate the middle ear, which then sends vibrations to the inner ear. The basilar membrane is found in the inner ear and plays a crucial role in the hearing process. Covered in roughly thirty thousand nerve endings,[16] the basilar membrane has specific spots for each frequency. When too much pressure from incoming vibrations are applied to the opening of the inner ear, the excess pressure vibrates the basilar membrane at specific spots, thus sending information regarding a specific pitch or pitches to the brain.[17] The amplitude quickly diminishes once it reaches its specific spot

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[16] Backus, 88.
[17] Backus 89.

on the basilar membrane before it is removed by nerve endings and sent to the brain for further processing,[18] thus our brains tell us what we hear.

Subjective Sounds

Numerous subjective sounds occur during multiphonic production, some are audible while others are not (not everyone will hear these sounds, hence the term "subjective sounds"). Subjective sounds come in numerous forms and vary in amplitude and audibility depending on the balance between the sung note and played note, the interval produced, and the type of multiphonic used (vocal or split-tone), among others. Subjective sounds can be grouped into three distinct, yet similar, categories: tones from "pure" tones, tones from trombone multiphonics, or "complex tones," and noise. Rumbles, beats, and split-tone multiphonics, depending on how you hear–more on this later–all fall under the category of noise. Cubic differential tones, quadratic differential tones, "the missing fundamental," sub harmonics, virtual pitch, and summational tones all fall under the multiphonic and pure tone categories, however it seems easier to hear subjective sounds from complex sounds. Subjective sounds from complex sounds may, in fact, be heard more easily than pure tones because of the added harmonic palate seen in complex sounds. Table 2 provides a visualization of each category and their corresponding subjective sounds.

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[18] Backus, 90.

Table 2. Subjective Sounds

Pure Sounds	Complex Sounds	Noise
Quadratic differential tone f1-f2 where f1< f2.	Quadratic differential tone f1-f2 where f1< f2.	Rumbles
Summational Tone f1+f2	Summational Tone f1+f2	Beats
Cubic Differential Tone 1 2f1-f2	Cubic Differential Tone 1 2f1-f2	Split-Tone Multiphonics
Cubic Differential Tone 2 2f2-f1	Cubic Differential Tone 2 2f2-f1	
Aural Harmonics		
The Missing Fundamental, Virtual Pitch, Sub Harmonics	The Missing Fundamental, Virtual Pitch, Sub Harmonics	

"f" = frequency.

Summational Tones

Although the differential tone has received the most attention from acousticians and some brass players, summational tones have been under constant scrutiny since their discovery. Both acousticians and early trombonists appear to agree that summational tones do not exist; early trombone sources notate differential tones, not summational tones, however, later trombone sources, although rarely notated, mention only the existence of summational tones. This is a curious situation, as many trombonists claim to hear clear, audible summational tones.

According to Backus, summational tones do not exist because no one besides Helmholtz has been able to hear them.[19] At first, Backus' comment seems to avoid the question of summational tones altogether, however, in scientific disciplines, most theories will not be accepted or confirmed until they can be reproduced on a consistent basis by members of the scientific community. In opposition of Backus, Benade states:

> A great deal of confusion exists in the literature, caused chiefly by the almost-universal tendency of scientists and musicians to talk interchangeably about single-component sounds and those made up of a set of harmonics. Another cause for misunderstanding arose from ignorance or neglect of masking and the distractions produced by the other, unclassifiable heterodyne components that are generally present. Helmholtz' essentially correct physics regarding these new tones was challenged for many years because of the experimental fact that the perception of summation tones by our ears is not normally possible, even though their components are detectable within the ear.[20]

Clearly, Benade views summational tones as a reality and not imaginary.

Zurek and Sachs found that the most common reason for the inability to hear subjective tones above two primary frequencies was due to masking, as the lower frequency tones mask the higher frequencies. At times during their research, the summational tone was the most audible subjective tone, not the differential tone, something that must have surprised the scientific community. Additionally, summational tones were found to be audible at thirty-to-forty decibels below the two primary generating tones. With lower generating frequencies than before, Zurek and Sachs were still able to hear summational tones, but they were more difficult to locate due to upward masking (low frequencies masking higher frequencies). This study of summational tones shows that masking could be the reason why summational tones, and possibly differential tones, are less audible for some people.

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[19] Backus, 124.
[20] Benade, 273-274.

The final supporting evidence of summational tones provides photographic evidence. Forsyth and Sowter[21] set out to prove the existence of differential and summational tones. After taking initial photos of the rubber bands in a steady state (see Figure 1), Forsyth and Sowter preceded to take photos of the rubber bands to document the response to a 64 Hz tuning fork (see Figure 2), the slamming of a door (see Figure 3) and a unison (see Figure 4). They also took photos of the differential tone (see Figures 5 and 6), and the summational tone (see Figures 7, 8, and 9).

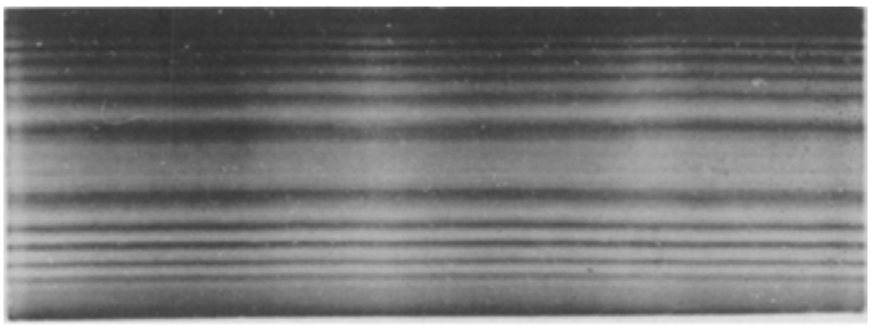

Figure 1. Steady-state rubber bands.

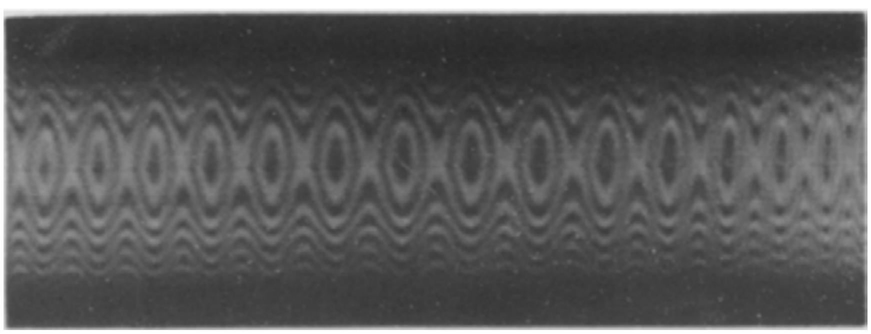

Figure 2. 64 Hz tuning fork response.

[21] Forsyth and Sowter, 396.

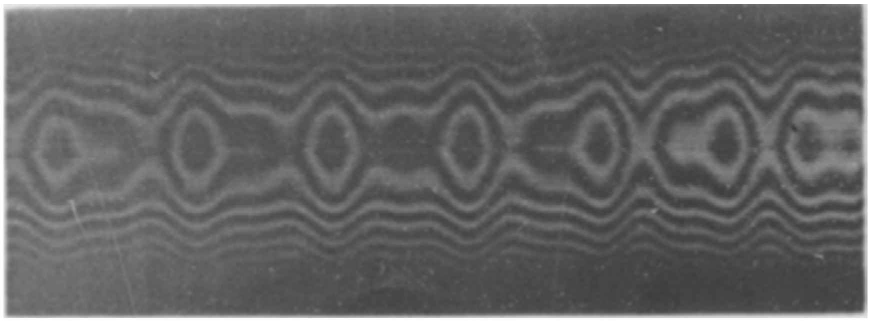

Figure 3. Slamming a door response.

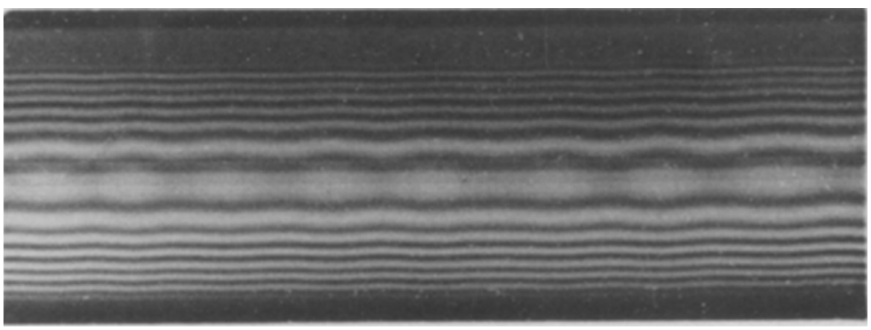

Figure 4. Unison between a 256 Hz tuning fork and a siren tuned to 256 Hz.

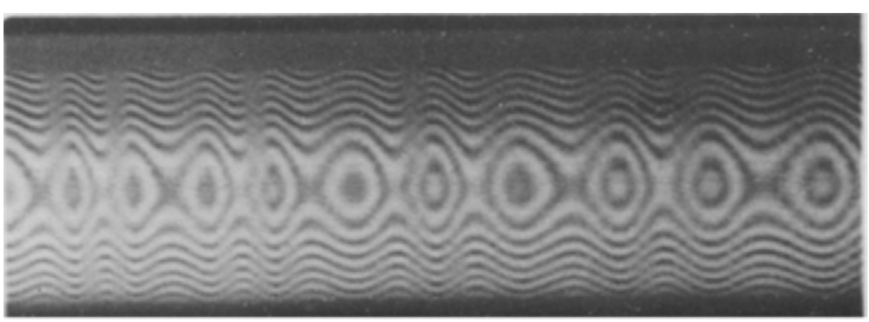

Figure 5. Differential tone 1.

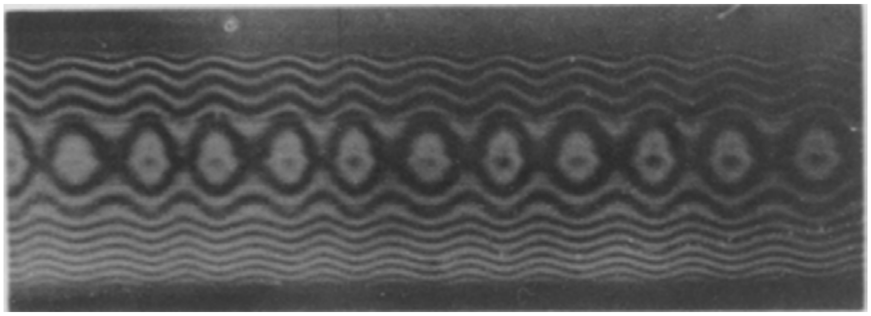

Figure 6. Differential tone 2.

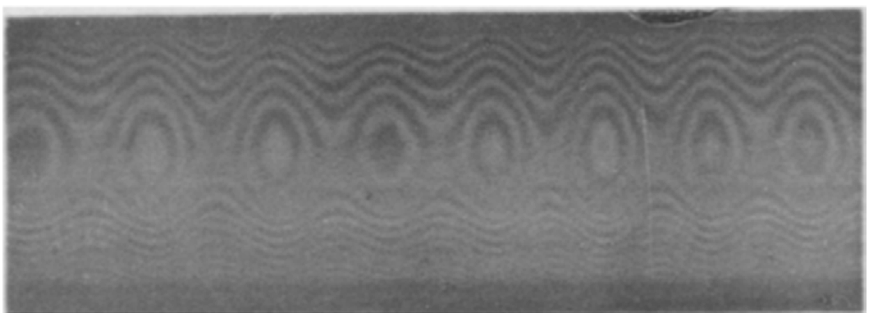

Figure 7. Summational tone 1.

Figure 8. Summational tone 2.

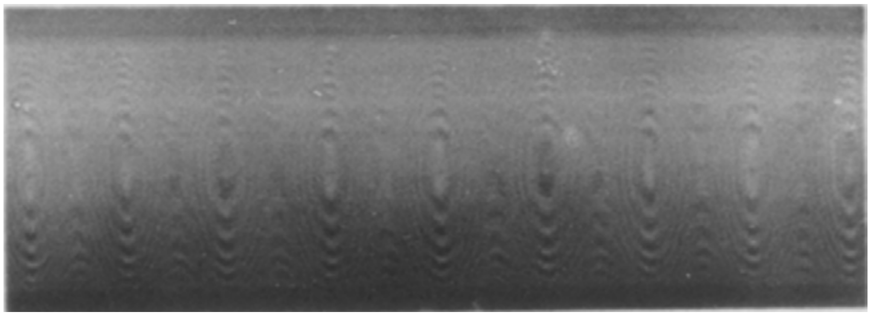

Figure 9. Summational tone 3.

Forsyth and Sowter's experiment show that, a relatively simple mechanism is capable of producing and documenting the periodic movement of rubber bands. The movement of the rubber bands proved the existence of both summational tones and differential tones. If rubber bands are capable of producing complex, periodic movement, why, then, would the sounds from trombone multiphonics be any different?

Differential Tones

Unlike summational tones, which are rarely mentioned or dismissed altogether, the differential tone has a long historical background and is mentioned and accepted far more frequently than the summational tone. Similar to the summational tone, some people are unable to hear differential tones. This could be due to the frequency of the tone being below one's hearing range, that one is not "trained" to listen for such tones, or that something else beyond the scope of this dissertation, is interfering with the ability to hear differential tones. Since awareness of differential tones has existed for more than three centuries,[22] it seems un-necessary to discuss here, their existence or restating what has previously been reported numerous times.

[22] Reilly, 27.

There are two types of differential tones, the first being the quadratic differential tone. Here, the difference between the frequencies is calculated and the result is known as the quadratic differential tone.[23] Cubic differential tones, on the other hand, are second order differential tones and have two similar formulas: 2(f1) – f2 and 2(f2) – f1. This type of differential tone is not thought to originate at the same location of the quadratic differential tone. Zwicker states:

> The quadratic difference tone and the cubic difference tone are *not* [Zwicker's emphasis] produced by the same source although they interfere with each other. The cubic difference tone seems to be produced within or very close to the frequency selective mechanism [basilar membrane] in the inner ear near the sensory cells but still within the stage of the analogue oscillations. The quadratic difference tone, however, seems to be produced before the frequency-selective mechanism, maybe in the inner ear or at least without frequency selectivity.[24]

Paul Hindemith was so intrigued by differential tones that he developed a concept called "interval roots" or "series 2' based on differential tones. Hindemith writes:

> We have learned two lessons from our consideration of the combination tones–the proof of the invertibility of interval, and the determination of the relative value of the intervals. A third awaits us.
>
> If one of the tones of the directly produced interval is doubled, either in the unison or in a lower octave, by a combination tone, this accretion of strength gives the upper hand over its partner.
>
> In intervals in which such doublings occur, the constituent tones are thus not of equal value. Rather, the tone strengthened by such doublings is to be regarded as the root of the interval, and the other as its subordinate companion. Numerous experiments have convinced me that the feeling that one tone of an intervals has more importance than the other is just as innate as the ability to judge intervals exactly–everyone hears the lower tone of a fifth as the principal tone; the ear cannot be persuaded to attribute primary importance to the upper tone. Yet I have never found in any treatise the statement that intervals have roots–a curious circumstance, since this fact is of primary significance for the

[23] The author will continue using the term quadratic differential tone, and stop using "differential tone," as it may cause confusion throughout the remainder of the document.
[24] Zwicker, 291.

> hearing and evaluation of harmonic intervals, and since its acoustical basis is so easily established.[25]

Hindemith's statement that "everyone hears the lower tone of a fifth as the principal tone"[26] shows he was aware that other people can hear differential tones and that there is a possibility for their use in composition. The idea of interval roots is intriguing, as it could lead to a new type of musical analysis, however, it appears Hindemith was not aware of summational tones, thus eliminating the possibility of three additional notes (first and second order summational tones) which may or may not affect the outcome of the analysis.

Although Hindemith and many others claim to hear differential tones, others struggle to hear them or do not hear them at all. Early in the twentieth century (1901-05), Titchener created experiments for more than one hundred of his psychology students to determine if they could hear subjective tones. In his *Manual of Laboratory Practice*, Titchener describes the procedures of each experiment so thoroughly that he, no doubt, knew his students could hear subjective tones. Titchener states:

> E [subject 1] takes tubes marked 1 and 5 (major third) [5:4], and sounds each two or three times over, in order to accustom O's [subject 2] ear to the pitch of the generating tones. Then after a preparatory signal, he sounds (a) the lower tone by itself, for a couple of seconds, and (b), with as little interruption of continuity as possible, the two tones together. At the moment when the higher tone is added, a difference-tone is produced which lies two octaves below the lower of the primary tones.… The tone is of moderate loudness and is so much louder in pitch than the *l* [lower frequency] of the tubes that O should find it easily recognizable. The experiment must, however, be repeated, until O is entirely satisfied with his introspections.[27]

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[25] Hindemith, 68.
[26] Ibid.
[27] Titchener, 41.

Titchener, thus, describes a way to train someone to hear the quadratic differential tone. Providing the subject with multiple attempts to hear the differential tone allows the subject to become familiar with the sound of the differential tone. Additional studies by Titchener were done in a similar manner, but trained the listener to hear what he calls the second differential tone, although it is actually the cubic differential tone and the summational tone. Titchener, however, did not seem to be interested in the outcome of his subjects ability to hear subjective tones–probably because he knew of their existence and, thus, assumed everyone would hear them– but rather, was interested in which intervals were most pleasing. Titchener's order of preferred intervals is major third, minor third, major sixth, minor sixth, perfect fourth, octave, tritone, perfect fifth, major second minor seventh, major seventh, and minor second. That both thirds and their inversions were the most pleasing intervals for the subjects is not surprising, as these intervals are seen in tonal music more frequently than the other intervals.

Noise and Other Phenomenon

Having discussed subjective tones, it is time to turn our attention toward more remote and, thus, more subjective sounds.

Beats

Although beating is not subjective, its place as a resultant sound lies in the noise category because it creates a disturbance in the sound. Beating occurs when two differing frequencies sound simultaneously. The resultant sound wave is calculated by finding the average frequency (1/2[f1 + f2]) and will vary at the beat frequency (f2 – f1, where f2 is greater than f1).[28] When the two frequencies are close together, a third sound, in

[28] Backus, 50.

combination with the two original frequencies, can be heard.[29] For example, if frequencies of 440 Hz and 444 Hz sound together, a listener will hear a frequency of 442 Hz that beats four times per second.

The ability to count beats is dependent on the distance between the frequencies. When the beat frequency is between 5 and 15 Hz, the beats occur too rapidly to hear individual beats and the observer simply hears a "rough, rolling sensation."[30] This sensation could also be described as a rumble or machine gun like sound. Since the threshold for hearing individual beats ends at 5 Hz, it is safe to assume that beats can be counted when the beat frequency is between 1 Hz and 4 Hz. This type of audible beat can occur when playing unisons, octaves, and microtones.

Other Phenomena

Sometimes confused with the summational tone, aural harmonics are a result of our hearing process turning a pure tone into a complex sound.[31] While an aural harmonic may coincide with the frequency of a summational tone, it differs in origin: the summational tone is generated by two pure or complex tones, the aural harmonic is generated by a single pure tone.

The "missing fundamental effect," first termed by John Backus, occurs when the hearing mechanism provides the ear with a fundamental frequency that is not present in the original sound. Other names for this pitch are "periodicity pitch" (Backus)[32] "virtual

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[29] Benade, 240.
[30] Benade, 240.
[31] Backus, 123.
[32] Ernst Terhardt, "The Concept of Musical Consonance: A Link Between Music and Psychoacoustics," *Music Perception: An Interdisciplinary Journal 1* No. 3(Spring, 1984), 287.

pitch" (Terhardt)[33] and residue pitch (Terhardt).[34] This effect can occur organically, as in rootless voicings in jazz music,[35] or synthetically in a lab. Amazingly, the fundamental can still be heard by removing harmonics up to the 20th harmonic.[36]

Throughout this study of resultant sounds, differing opinions on the existence of audible and physical sounds have been discovered. Upon careful examination, it appears that, at a minimum, listeners can be trained to hear summational and differential tones, regardless of the sound origin. This theory can be supported by the evidential research for both types of subjective tones. While beating will occur, it will most often be seen in trombone literature as a timbral effect, although some pieces do call for a specific number of beats to be heard. Lastly, the subjective nature of virtual tones, missing fundamentals, etc., only adds to the color palate available to the listener who is capable of hearing such things.

Multiphonic Data

Thus far, the author has discussed the theoretical possibilities of trombone multiphonics; this section will provide analytical data about the acoustical nature of multiphonics as it pertains to subjective sounds. The data collected in this section was invaluable to writing the method book and provides additional avenues for further research. This section does not address split-tone multiphonics, as the number of pieces that contain vocal multiphonics far outnumber the ones that use split-tone multiphonics.

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33 Ernst Terhardt, "Music Perception and Sensory Information Acquisition: Relationships and Low-Level Analogies," *Music Perception: An Interdisciplinary Journal 8,* No. 3 (Spring, 1991), 226.

34 Terhardt, Concept of musical consonance, 287.

35 Robert Ehle, discussions with author, University of Northern Colorado, October 2009-Decemer 2014.

36 H. Fastl and E. Zwicker, *Psychoacoustics: Facts and Models*, 3rd ed. (Berlin: Springer Verlag, 2007), 121.

Additionally, obtaining consistent recordings reflecting the technique are difficult to find, and any subjective sounds were different for each recording.

Procedures and Equipment

The author recorded traditional and reverse multiphonics for the common multiphonic intervals (unison-perfect twelfth) three times, and chose the best sounding recording to use during the analysis. For this study, the best sounding recording is defined as the recording in which no extraneous noise was present in the sound and both the sung and played note were played in tune. Recordings were done using an Apogee USB MiC 96K microphone, saved as Audacity files, and exported as .wav files for use in Raven Lite.

Data Obtained from Raven Lite

Raven light, a free program from the Cornell Lab of Ornithology, proved to be an invaluable resource in analyzing the recorded data.[37] This program allowed the author to view spectrograms of each interval and adjust various settings until the frequencies with the most power appeared. Power is observed in the spectrograms by dark lines, which represent the likelihood of a sound at that particular frequency being audible. The author was interested in which subjective tones would be recognized and chose six subjective tones to look for (in all cases f2 represent the higher frequency). f1+f2 (Helmholtz's summational tone, or what the author has termed the quadratic summational tone), 2f1+f2, and 2f2+f1 (what the author has termed cubic summational tones), f2-f1 (Tartini's tone, or the quadratic differential tone), and 2f1-f2, and 2f2-f1, the two most commonly used cubic differential tones.

[37] The author wishes to acknowledge Dr. Paul Thompson at the University of Wisconsin-Madison for providing information about this software.

Three conclusions were drawn from this data. The first being most, if not all, expected subjective tones are seen on spectrographs for both traditional and reverse multiphonics. Secondly, traditional multiphonics (singing above the played note) frequently contain more harmonics than reverse multiphonics, and, finally, reverse multiphonics provide for a more complex sound than traditional multiphonics.

The author chose two intervals to represent the data collected and to confirm the accuracy of the previous paragraph. Through comparison of traditional and reverse multiphonics, it can be shown that certain intervals, regardless of how they are played, will look similar. Other intervals may only show an outline of the interval.

The augmented eleventh (an octave plus a tritone) is one such interval. By comparing Figures 10 and 11, it is seen that the reverse multiphonic shows the outline of the interval, having a more complex sound than when it is played traditionally. When played traditionally, additional harmonics are evident in the sound. After viewing the figures, it should be apparent that the reverse form still maintains the integrity of the interval, while the traditional augmented eleventh contains more harmonics. The arrows indicate any similarities.

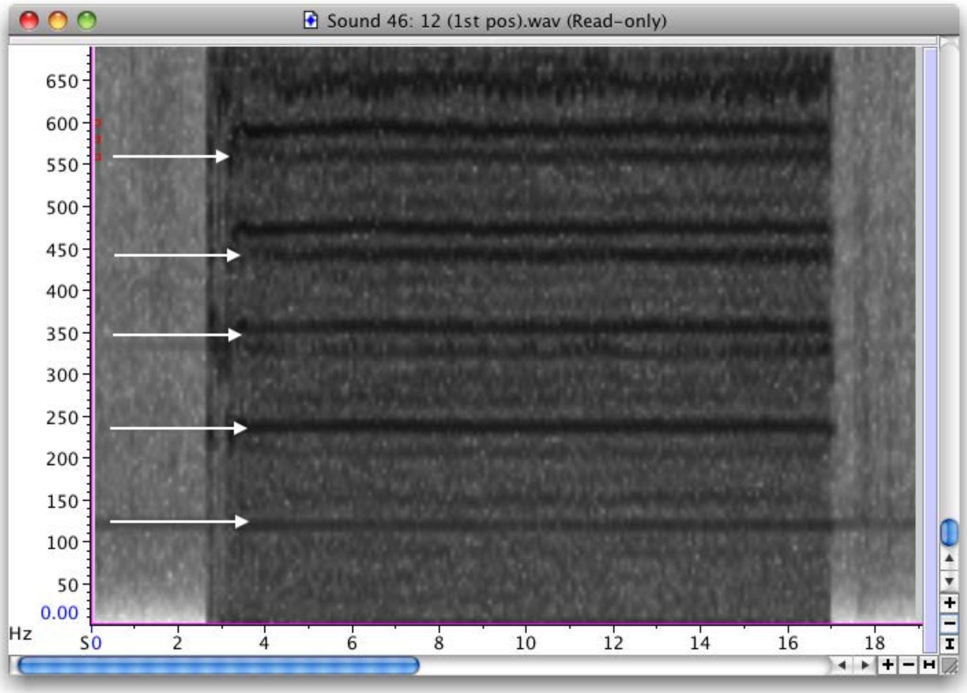

Figure 10. Traditional augmented eleventh.

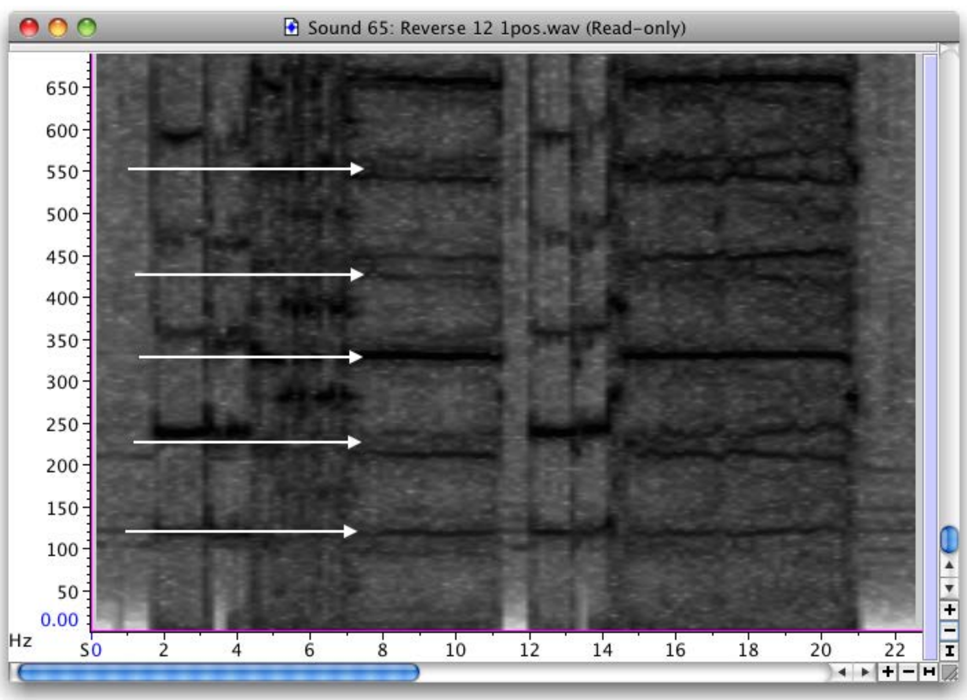

Figure 11. Reverse augmented eleventh.

Not all intervals behave in the same way, however. The spectrographs for the traditional and reverse major-third are almost identical, the only difference being the contrast level of the traditional major-third, which is of no importance to this study (see Figures 12 and 13). The similarities between the two figures are amazing. Almost every frequency seen on the traditional major third is seen in the reverse form as well.

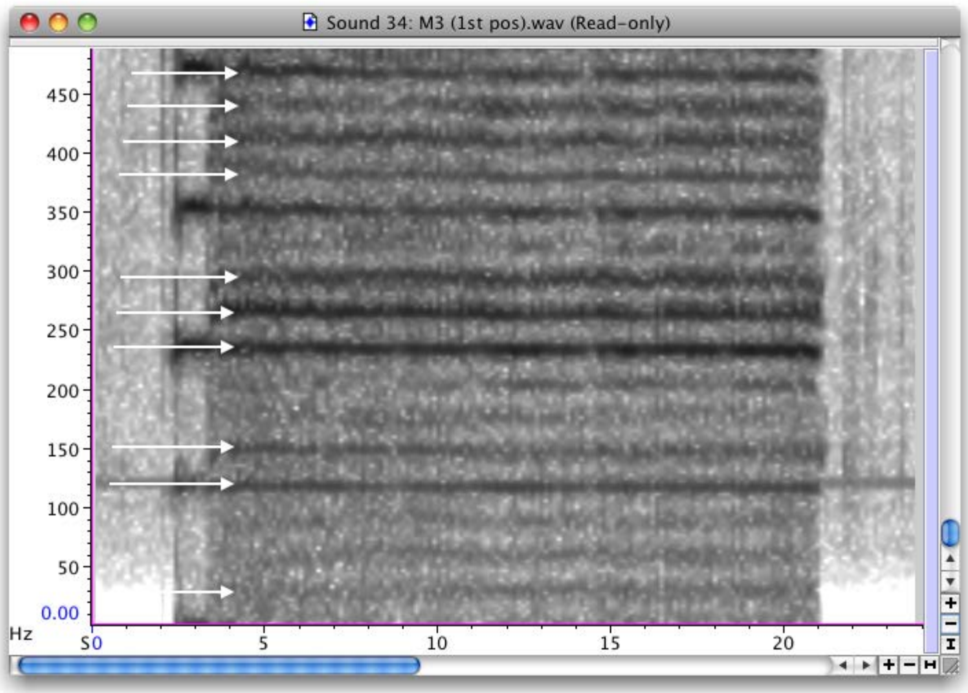

Figure 12. Traditional major-third.

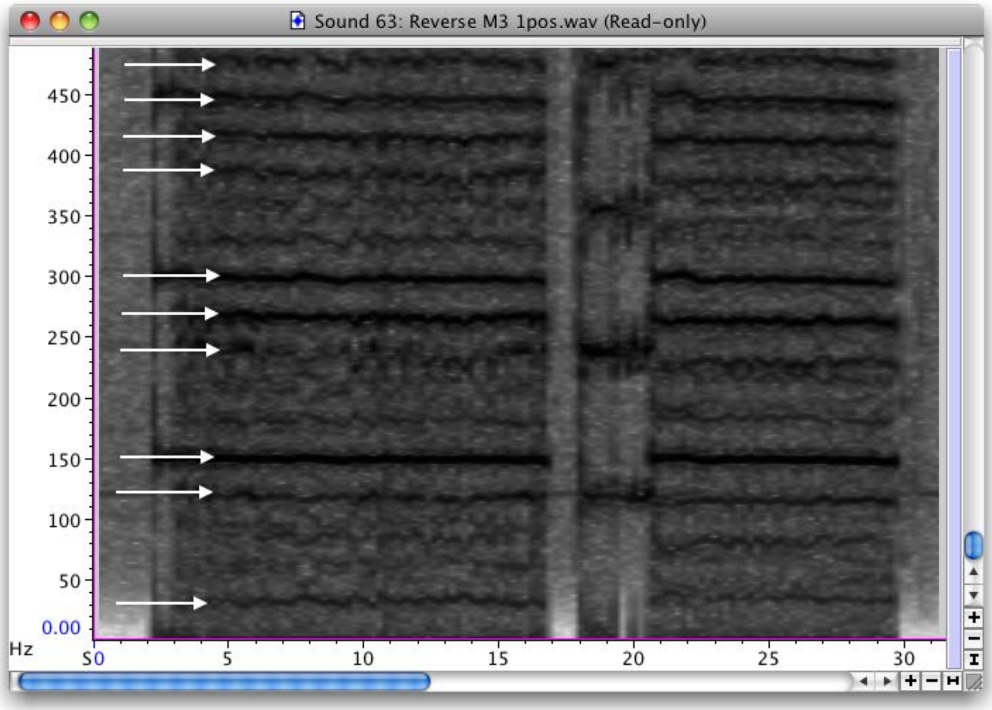

Figure 13. Reverse major-third.

Writing the Method Book

In writing this method book, exercises were originally composed by hand, checked for accuracy by playing them, and then placed into Sibelius for final formatting. This section will detail organization of the method book, information chosen for inclusion, and, finally, a description of the split-tone multiphonics section.

Organization of the Method

Wanting to compose a method that was accessible for players of intermediate to advanced abilities, the method book is organized in a manner in which information can be easily accessed, yet arranged in a progressive manner in which no gaps exist in the learning sequence. The method contained in Appendix A begins with an introductory page followed by preliminary exercises, textual information, and the multiphonic exercises. Since the trombonist is playing so early in the method, the author feels that the student will be more likely to read the information presented following the preliminary exercises. Each section of the method (e.g., perfect fifths, major sixths, etc.) begins with the most basic form of an exercise for that particular interval before progressing to more difficult exercises within that section.

Choosing Information to Present in the Method

The textual portion found at the beginning of the method includes information on vocal technique, acoustics and intonation, and general comments regarding the use of the method. Not wanting to overwhelm the trombonist with information, only information that was crucial toward the development of the technique was chosen. For example, information regarding the hyoid bone or an in-depth analysis of how we, as humans, hear was not included in the method.

Explanation of the Learning Sequence

Following the introductory text, the method is divided into five chapters: interval studies 1 (singing above a played note), interval studies 2 (singing below a played note), part crossing, range extension, and split-tone multiphonics. The method is progressively arranged so that the trombonist is able to transition from each exercise with increasing confidence. Interval studies 1 begins with the unison, which was chosen due to its ease of production following the preliminary exercises found at the beginning of the method. The perfect fifth is the second interval the trombonist will learn; only perfect fifths and unisons are found in this section of the method. Likewise, section three contains only octaves, perfect fifths, and unisons. By focusing on a limited number of intervals in each section, the trombonist is able to build a foundation upon which other intervals can be learned successfully.

Chapter 2 – Interval Studies 2 is presented in a similar manner, although this chapter contains exercises that have the sung note below the played note. Following a preliminary exercise for learning this technique, the exercises progress much like the previous chapter where each section builds upon previously established technique. Following chapter 2 is a chapter on part-crossing (chapter 3). This chapter combines everything the trombonist has learned thus far in the method, yet still begins with the most basic form of a part-crossing exercise. The range extension portion (chapter 4), like the previous chapter, builds upon previously established technique. Exercises used in this chapter include scales and arpeggios, as this is a good way to increase multiphonic range. Finally, Chapter 5 includes exercises to learn split-tone multiphonics. Of the five chapters, this chapter is the shortest for many reasons, the first being that extensive use of this technique could cause harm to a players embouchure. Additionally, the subjective sounds, if any, are so subjective that it may frustrate the trombonist, however, the exercises used are of some benefit to the player.

Appendix A represents the culmination of the author’s work on multiphonics. The method is progressively arranged, contains information regarding vocal technique, acoustics, tuning, as well as general commentary throughout the method to assist the trombonist.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

At this time, no single pedagogical source contains a complete, progressive approach to learning trombone multiphonics with comprehensive information regarding all aspects of the technique. The question has been asked why someone should study, learn, or practice multiphonics and the answer has always been the same: learning and playing multiphonics may improve breath control, embouchure stability, and aural skills. Further, important works for trombone include the use of this technique, and its use in contemporary literature is growing.

How, one might say, does learning this technique aid in the development of better breath support, embouchure stability, and aural skills? Breath support is further developed because the air required to sustain multiphonics must pass two (instead of one) points of resistance: the vocal folds and the embouchure. Embouchure stability is improved, particularly, when the trombonist plays and sings intervals that are close to each other. In producing the minor second, for example, it is difficult to keep the played pitch still, thus requiring a stable embouchure, particularly the corners. Lastly, aural skills may be greatly improved because the trombonist is likely singing more than he/she had been in the past. If practiced on a regular basis, the interval training further develops one's sense of intervallic relationships.

Findings, Interpretations, and Recommendations

Vocal Anatomy and Technique

Of the information presented in chapter four, the information regarding vowel formation, vocal folds and breathing are helpful to trombonists. By thinking of breath and sound as one entity, the trombonist will have an easier time obtaining freer and more relaxed breathes. The calmness associated with free and relaxed breathing helps avoid unnecessary tension in the neck and pharynx area, will allow for a clear tone during multiphonics, and a relaxed state of mind during normal playing.

Knowing just a little bit about the vocal folds will help trombonists avoid making bad choices like shouting or overexerting the voice during practice. I recommend starting with no more than ten minutes a day on multiphonics, even after enough stamina has been developed to perform a piece of extended length

The knowledge of vocal formants is also helpful for trombonists, as singing loudly while playing is quite difficult. By keeping the larynx in a “floating position,”–i.e. not fixed–the trombonist has a greater chance of singing with a formant. Additionally, trombonists should attempt to adjust their jaw to bring the sung pitch closer to a formant, thus making the sung note louder. With that said, it is unnecessary for trombonists to think about formants and frequencies while playing. Instead, the player should experiment with the amount of mouthpiece pressure, the placement of the larynx, and the distance between the jaws to sing more easily and possibly louder. It is also possible to sing within the trombone’s formant to attempt to match tone quality, but this is beyond the scope of this document. Additionally, and, again, beyond this scope, is the possibility of aligning slide positions with the sung note, so the sung note lies within the harmonic series of the slide position, thus having the possibility of an easier and louder vocal sound. These are just some ways trombonists can more easily achieve a good dynamic balance between sung and played notes.

Finally, the use of vowels will greatly assist the trombonist to obtain various tone colors when performing multiphonics. Knowing the specific vowels one has at their disposal does not mean that one vowel is optimum for all people or in every multiphonic situation. This is not to say vowels are to be chosen at random, rather, the trombonist should make a conscience decision as to why they have chosen a particular vowel. To perform well, the trombonist should focus on good posture, proper breath support, a relaxed pharynx and neck, and singing and playing with a good sound regardless of which vowel has been chosen. All of this should eventually become subconscious.

Tuning Multiphonic Intervals

Using just intervals is vital for most subjective tones to sound, and it is crucial to know how each interval sounds when justly tuned. This knowledge may additionally assist trombonists to quickly adapt to intonation problems, if/when they occur. When practicing multiphonics, listen for the expected subjective tones. Once you obtain the desired result, gradually adjust the pitch of either the played or sung note to hear what happens to the subjective tones when the interval is not justly tuned. Do they disappear, change, or stay the same? Once the trombonist understands what happens when their justly-tuned interval is slightly out of tune, tuning adjustments may be made quickly and accurately.

Acoustics

Since the brain tells us what to hear, is it not a fair assumption to believe that if we expect to hear something, we will hear it? It is the author's view that both types of summational tones, both types of differential tones, missing fundamentals, virtual pitches, etc. can all be heard, but one must know what to listen for. Finally, the presence of second order summational tones can be heard by listeners and seen in spectrographs, therefore, there are two types of summational tones. The author will use the same terminology used for differential tones for summational tones. Quadratic summational tones are equal to the sum of both frequencies. Cubic summational tones are equal to 2(f1) – f2 and 2(f2) – f1. Using the same terminology for both types of subjective tones avoids any unnecessary confusion.

Multiphonic Data

Based on the data found in chapter four, it is evident that subjective tones exist and can become quite powerful when performed. Reverse multiphonics create a different timbre from the traditional technique. The author supposes this occurs because the voice and played note conflict with inner harmonics based on the position of the slide. For example, if the slide is placed in fifth position, the G-flat/F-sharp harmonic series will dominate over a sung B-flat, with its own set of harmonics. This allows for cross-contamination between the two harmonic series with G-flat attempting to override the sung B-flat. This theory requires further research, however, the author recommends trombonists experiment with slide position and sung pitches. An easy example showing the interference of sung notes by a given slide position can be demonstrated by singing any note through the trombone while moving the slide between first and seventh positions (higher pitched notes tend to highlight the interference slightly better than low notes, although low notes highlight a change in pitch rather well). It is virtually impossible to sustain the pitch without it "bumping" as the slide moves, nor is it possible to have the pitch sung at the same frequency for the duration of the experiment.

Suggestions for Further Research

The most controversial theory, it seems, is that everyone has the ability to hear subjective tones. A systematic training system that teaches people to not only hear these tones, but to learn how to better interpret the signals from our brains would be beneficial to anyone interested in learning to hear subjective tones. This system could be modeled after Titchner's experiments, but Moody's intonation method could also be adapted to help people identify subjective tones. Teaching someone how to interpret auditory brain signals is a completely different study, and well beyond anything that has been done before.

Mongolian-Tuvan Kargyraa, or throat singing, allows one to sing two notes at once and is quite impressive. This technique is done around the world and is based on the harmonic series. Applying this technique to trombone multiphonics could produce some interesting results, and further research on the combination of these two techniques could possibly benefit the trombone community.

Another topic that could be researched is vowel and trombone formants. How are they related and, if they are, could they be used to form some type of super formant, thus allowing the trombonist to produce a larger sound?

Data obtained from the recorded samples shows that, overall, reverse multiphonics create more complex sounds than traditional multiphonics. Why is this, and could alternating, while using the same interval, between traditional and reverse multiphonics create a new form of multiphonic composition?

Mutes also affect the trombone sound. How can trombonists incorporate mutes into their technique, and how would it affect the sound quality? Would it be possible to change the subjective tone based on a specific mute or mute placement?

Although it seems doubtful that a change from yellow brass to rose brass, or a change in bell thickness or diameter, would change any subjective tones, it may be possible that an instrument's material or design could highlight certain subjective tones. To what extent, if any, does an instrument's material and design affect subjective tones?

Lastly, depending on the sung note, the slide position can, at times, interfere with the sung note so much that it is incredibly difficult to sing certain notes in certain slide positions. Why does this happen? Is it a result of conflicting harmonic series between the sung note and slide position, or is something else interfering with the sung note?

Summary and Conclusion

The topics addressed in this document establish the groundwork for a method book, confirm the existence of subjective tones, and provide options for further research. What can we as trombonists do now that we know subjective tones really exist? We practice knowing exactly what to listen for, because guessing is no longer necessary (see appendix B for a subjective tone chart). The misunderstanding and lack of support for multiphonics by early brass pedagogues led to the mystique of this technique. Difficulties for acousticians, players, and teachers who may have been interested in this technique arose, as the people who could perform multiphonics did not want to share their secret. Had the early instrumentalists who used multiphonics been more forthcoming, and teachers more open-minded, perhaps there would be more acceptance of this technique today, and the technique more advanced than it currently stands. It is the author's hope that this method helps to further legitimize multiphonics, increase awareness of subjective tones, and further advance the technique of the trombone.

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APPENDIX A

THE ART OF MULTIPHONICS: A PROGRESSIVE METHOD FOR TROMBONE

The Art of Multiphonics: A Progressive Method for Trombone

Matthew W. Haislet

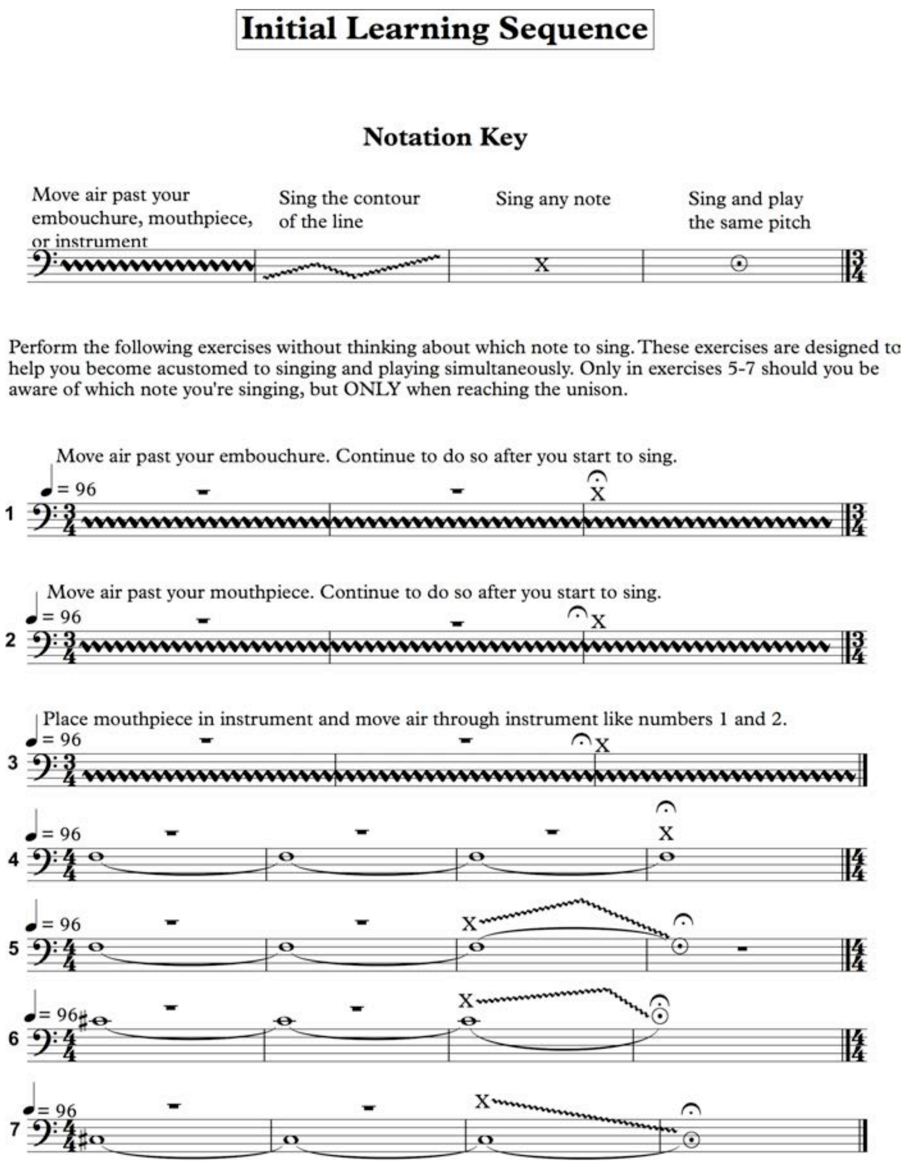
INTRODUCTION

This method is intended for players of intermediate to advanced abilities and can be used to introduce and master multiphonics, or used to further one's study of the technique. Upon completion of the method, the trombonist will have a firm grasp of the technique, thus allowing him/her to pursue the performance of multiphonic literature. Further, the author hopes this method helps to advance the technique to a new level of sophistication and expressiveness. The exercises contained in this method are arranged progressively and cover roughly ninety-five percent of the existing trombone literature. This method represents a current, progressive approach to learning trombone multiphonics.

Table of Contents

FIRST SOUNDS – INTRODUCTORY AND EXPLORATORY EXERCISES

In these exercises you will learn to (1) sing through your embouchure, mouthpiece, and instrument, (2) add a sung pitch to a sustained note, (3) adjust the pitch of the sung note, and (4) sing and play in unison. These exercises should be done each day before your multiphonic practice. You may find it helpful for exercise 1 to place your hand four to six inches in front of your mouth to ensure that you are singing with a breathy sound, as you should feel a constant flow of air on your hand.



VOCAL TECHNIQUE

Too often, the trombonist learns multiphonics without really thinking about what they are doing when they sing through the instrument. Unfortunately, this can lead to injuries and does not help with continued progress. There are some things that are common to both vocal technique and trombone playing, as well as a few items the trombonist can borrow from vocalists that can help make the multiphonic process both easier and more pleasant sounding.

To understand vocal multiphonics, the trombonist must have a solid understanding of the vocal process. This begins with correct posture and proper breath support. Any deviation from good posture can cause tension throughout the body, thus making your job harder. Because air is vibrating at two different locations (the vocal folds and the embouchure), air becomes increasingly important, more so than regular trombone playing, so proper breath support is vital to your success. This support comes from staying relaxed as you inhale and by lifting the air up and out, which allow the lower abdominal muscles to contract upon exhalation. At no time should your chest drop, as this signifies a loss of compression. Keep the breathing process free and relaxed.

Just as important as breathing, it is crucial that you have a free and relaxed neck area. One cannot sing with a good sound if the vibrations created in the vocal folds are restricted as they travel toward the instrument. Common restrictions found in the beginning stages of the learning process are: (1) the throat is too tight. (2) The shoulders interfere with inhalation. (3) Playing too loudly and (4) Fear of making a mistake. The throat often becomes constricted when the breathing process is not free and relaxed, or by attempting to sing outside one's given range. Too often, especially in younger students, the shoulders become part of the inhalation process. While the shoulders will move upon inspiration, their movement is not conscience, but will move as a result of expansion. Playing loudly at any time will diminish the effect of subjective tones and cause the back of the throat to narrow. Finally, fear of making a mistake will often lead to tension throughout the body, thus making it difficult to sing with an open throat. Do not worry about making mistakes, as they tell you what you need to work on. If you make the same mistake twice, analyze why it happened and make a plan to ensure that you no longer make that mistake. Often, this requires a tempo reduction.

The use of vowel manipulation can help you obtain the sound you want. This method will not tell you how to sound, it will provide you with the tools needed to create your own multiphonic sound. The vowels most commonly used in multiphonics are [ˆ], [ə], [a], [o], [u], [i] and [e]. The following is a suggested learning sequence with a description of the sound and mouth placement of each vowel.

1) [ˆ] sounds like the “u” in up; the tip of the tongue touches the bottom of the front teeth and the back of the tongue is *slightly* elevated.
2) [ə] sounds like the “a” in ahead; the tip of the tongue touches the bottom of the front teeth and the back of the tongue is *slightly* elevated.
3) [a] sounds like the “a” in task. Here, the tongue lies on the bottom of your mouth and the draw drops slightly from where it was for [ə].
4) [o] sounds like the “o” in note; the middle portion of the tongue is *slightly* elevated and the tip of the tongue is elevated *slightly* but lies in a fairly neutral position.

5) [u] sounds like the “u” in nook; the back portion of the tongue is elevated and the tip protrudes down toward the lower teeth.

6) [i] sounds like the “e” in keen; similar to [u], the tip of the tongue touches the lower teeth, but it is closer to the gum line, and the back portion of the tongue is higher in the mouth than [u].

7) [e] sounds like the “a” in chaos; the tip of the tongue touches the front teeth and the back of the tongue is *slightly* elevated.

TIPS FOR KEEPING YOUR VOICE HEALTHY

1. Stop if, you feel pain or discomfort in your voice.

2. Rest when needed.

3. Avoid shouting.

4. Perform with proper posture and breath support. I recommend sitting, as most of our playing, as trombonists, is done sitting. Sitting also has the added benefit of better inspiration, thus making the return of air easier.

5. Avoid clearing your throat.

6. Avoid excessive coughing and whispering.

8. Avoid alcohol and cigarettes, as both are bad for the vocal folds.

ACOUSTICS AND INTONATION

At some point when you worked on the preliminary exercises, you may have come across some sounds that you may or may not have been expecting. Some of these sounds are called subjective tones because they occur as a result of the multiphonic process. This chapter will discuss the types of sounds you can expect to encounter when playing multiphonics and how you can get the most out of these sounds by accurately tuning them. There are six types of subjective sounds: quadratic summational tone, Cubic summational tone, quadratic differential tone, cubic differential tone, beats, and missing fundamentals.

1) The quadratic summational tone is equal to the frequency of the sung and played notes, represented as f1+f2.
2) The cubic summational tone is equal to 2(f1) + f2 and 2(f2) + f1
3) The quadratic differential tone is equal to the difference between the two frequencies, represented as f2-f1, where f2 ≥ f1.
4) The cubic differential tone is represented by 2(f1) - f2 and 2(f2) - f1
5) Beats occur when any two frequencies are close together. For our purposes, beating occurs for intervals less than a perfect fourth, when you approach a unison or octave from either direction, or play a mistuned interval.
6) The missing fundamental occurs when a sound is heard that is equal to the fundamental frequency, but it is not actually being played.

Tuning becomes increasingly important when working on multiphonics, as having a mistuned interval will result in the subjective sound being inaudible, or the subjective sound will not be what you expected, e.g. A-flat instead of A-natural. Be sure to know how much adjustment is needed for each interval (see Table 1). Note that the compound intervals will need the same adjustment as their simple counterpart.

Table 1. Adjustments from Equal Temperament to Just Intonation.

INTERVAL	ADJUSTMENTS FROM EQUAL TEMPERAMENT NEEDED TO FORM JUST INTERVALS
Unison	none
Minor Second	+ 12 cents
Major Second	+ 4 cents
Minor Third	+ 16 cents
Major Third	- 14 cents
Perfect Fourth	- 2 cents
Tritone	- 17 cents
Perfect Fifth	+ 2 cents
Minor Sixth	+ 14 cents
Major Sixth	- 16 cents
Minor Seventh	- 4 cents
Major Seventh	- 12 cents
Octave	None

GENERAL COMMENTS REGARDING THE USE OF THIS METHOD

The exercises contained in this text will allow the trombonist to master the multiphonic technique through the use of easy to advanced exercises and etudes that are progressively arranged. To get the most out of this resource, (1) practice the material daily, (2) perform the “”First Sounds” page before moving to the method portion each day, (3) do not be afraid of mistakes and wrong notes, as they are part of the learning process, (4) always play with your best sound, and, finally, (5) stay relaxed.

Although some exercises will be out of your current playing and/or singing range, the exercises should be performed in successive order. Do not simply “move on to the next one” because an exercise is hard (keeping in mind your playing and singing range). Record yourself often. Better yet, listen to those recordings; do you hear any subjective tones? If so, what are they, and do they match the notated subjective tones? I suggest playing both parts (sung and played lines) a few times before trying to add the voice and instrument together. Doing so helps with ear training and allows you to be better prepared for any difficult passage. Isolate difficult passages to their most basic form, e.g. just play the interval on the trombone without singing. Step two: play the interval with the instrument and voice. Step three: add the interval to what you’ve already learned.

I have found multiphonics to be incredibly useful in my playing as it (1) helps with ear training, (2) helps to maintain proper posture and air support, and finally, (3) I have found that working on multiphonics greatly improves embouchure control.

The exercises found in this method will help you gain familiarity with the most common intervals seen in the trombone repertoire. Ordered from easiest to advanced exercises, avoid the temptation to skip ahead, as skipping ahead may lead to poor habits, so please, do not move on to the next exercise until the current exercise can be performed with ease.

Suggestions for success:

(1) Play with your best sound.

(2) Listen carefully to the pitch of both the played and sung notes. Use a tuner when necessary.

(3) At times, it will be helpful to play the sung part before attempting to play the entire exercise.

(4) If you are stuck on a particular exercise, work up each interval slowly. After you can play each interval in an isolated setting, try playing two intervals back to back, then three, and so on, until you can complete the exercise with ease.

(5) Use a recording device and listen back in between exercises. Doing so will give your face and voice the chance to relax and you will be able to have a better understanding of how you sound.

(6) If at any time you experience pain or discomfort in the voice or embouchure, stop. Attempting to play through pain will not help you further your studies; in fact, it will often hold you back, so rest when needed.

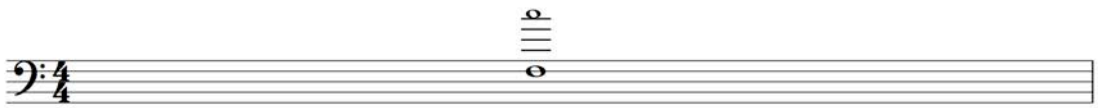
Interval Studies I – Singing Above a Played Note

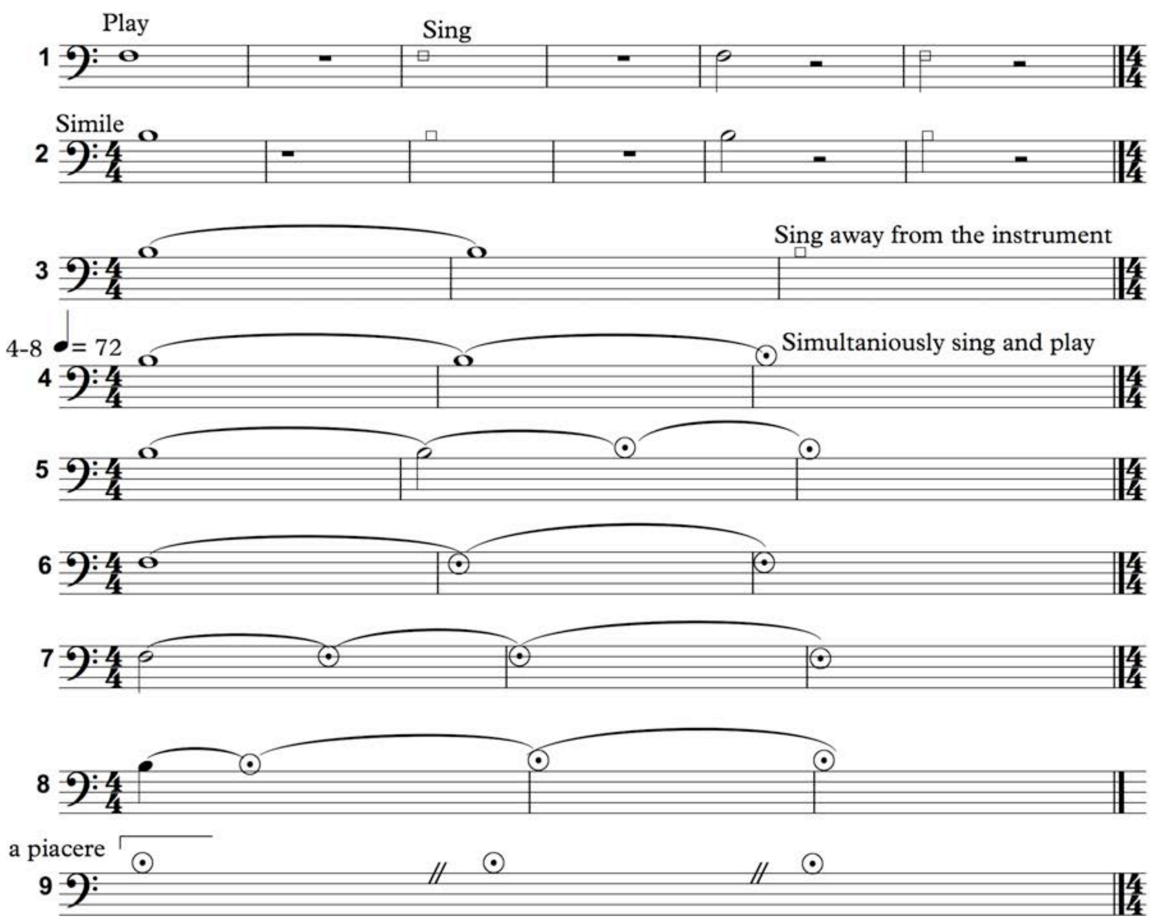
The Unison

The following exercises are designed to help you gain familiarity with multiphonic technique. If you find unisons too difficult at this time, move to perfect fifths and then return back to unisons after learning the perfect fifth, as either of these intervals are excellent starting intervals. Doing the preliminary exercises found earlier in the method on a daily basis will help with unisons as well.

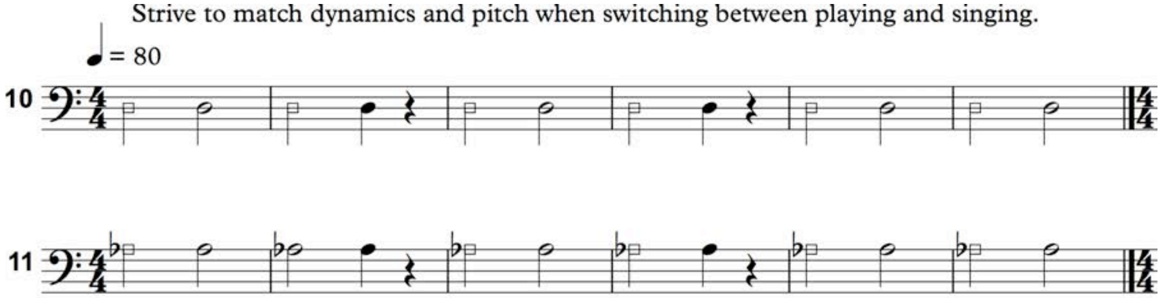
Suggestions for success: (1) Practice playing then singing some of the more advanced exercises. Doing so will help you to better hear the melodic line. (2) Attempt to sing louder than you can play. By thinking this way, you will have a better chance of matching dynamics. (3) Work to eliminate beats by adjusting one part at a time (playing or singing).

Although the same note is played and sung, there is one subjective tone that occurs with this interval: a perfect twelfth (see below).

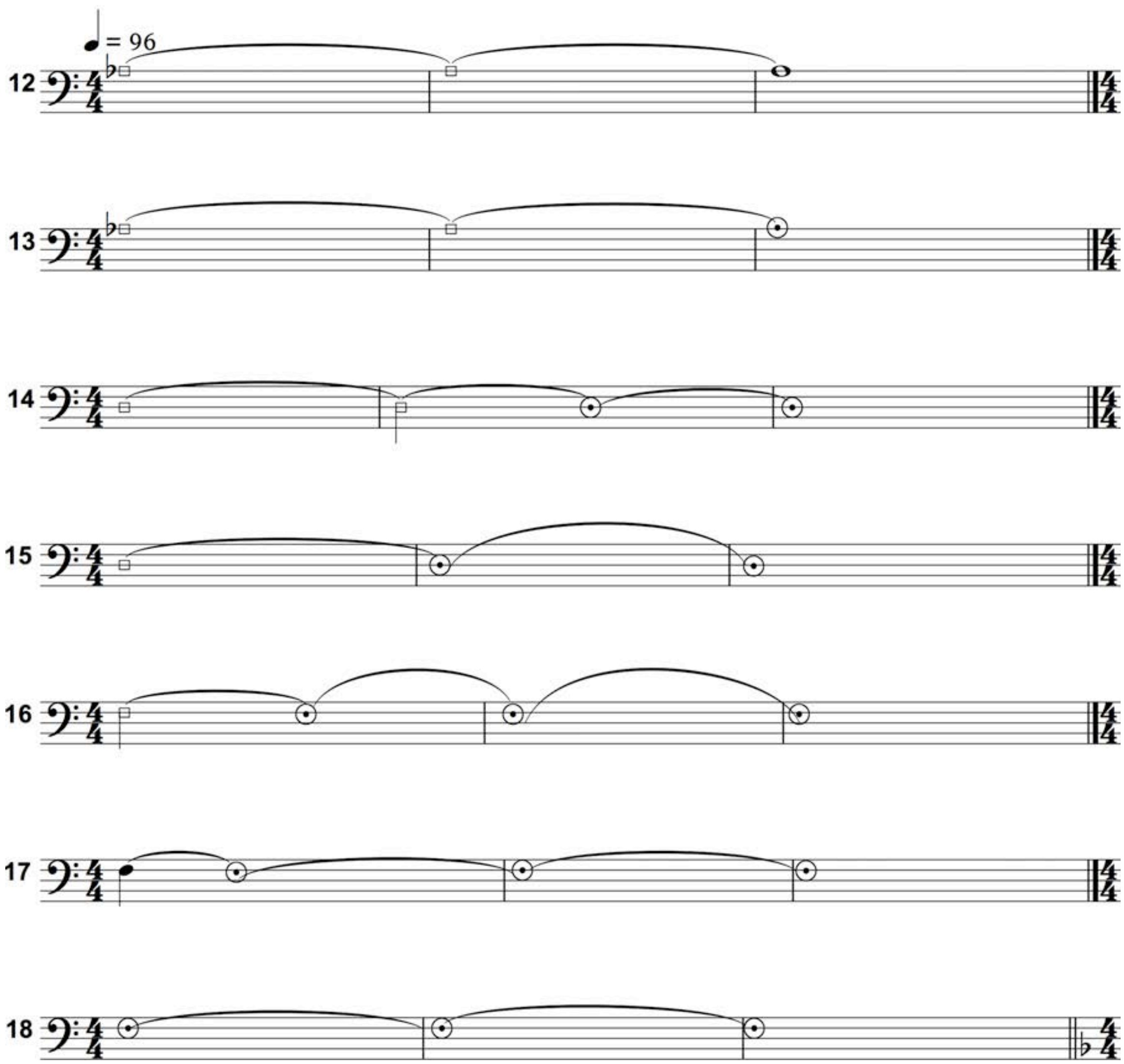




Strive to match dynamics and pitch when switching between playing and singing.



Exercises 12-18 are used to develop multiphonic attacks.

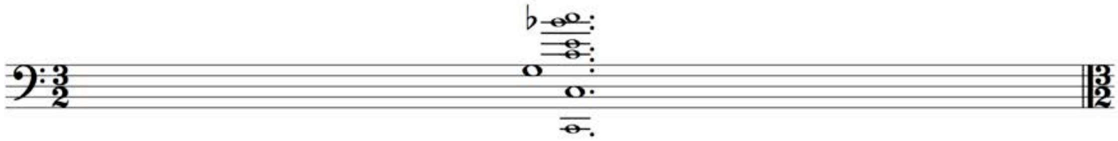


Perform only the exercises within your vocal range. Play with your best sound and be sure to keep your airstream consistent. <u>All exercises are to be played and sung simultaneously.</u>

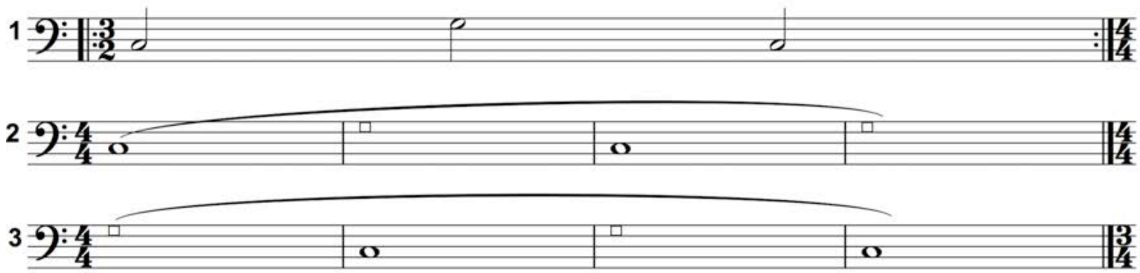
The Perfect Fifth

Similar to the unison, the perfect fifth is relatively easy to master as your fundamentals begin to improve. These fundamentals will improve by doing the preliminary and introductory studies before each multiphonic practice session and by working through this method on a regular basis. Unlike the unison, the voice and trombone are further apart so tuning becomes a little easier. Tips for success: (1) Remember to lower this interval by two cents to play a justly-tuned perfect fifth. (2) Record yourself and listen back to see if you hear any subjective tones. If you are able to hear any additional tones, write them down and (3) strive to have any subjective tones sound, as this interval, and the major-and-minor sixth, are some of the easier intervals to hear subjective tones.

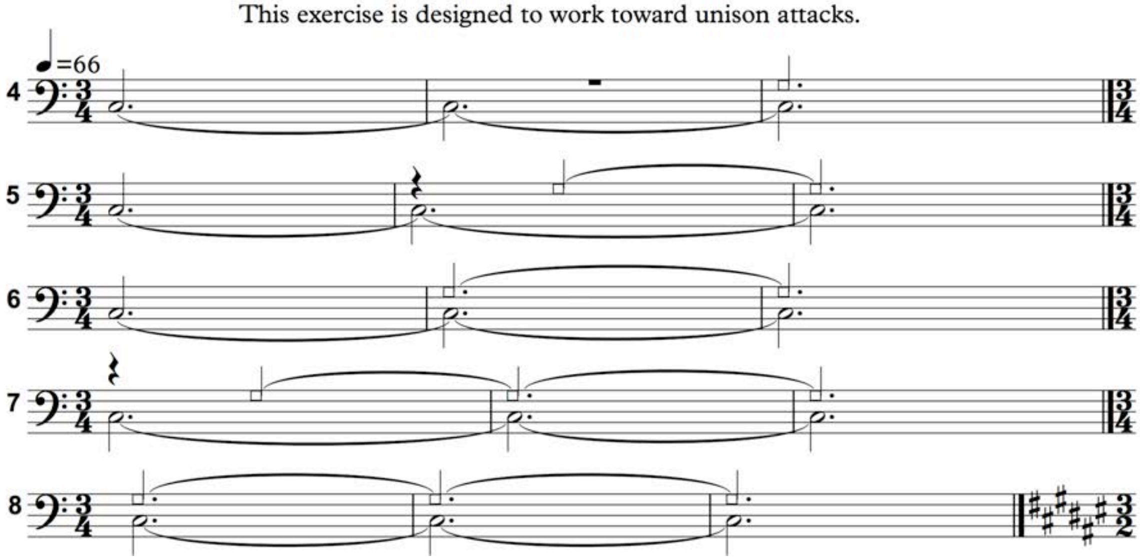
Subjective tones seen in the perfect fifth: an octave appears below the bottom note, while an octave, a major tenth, minor fourteenth, and a fifteenth appear above the bottom note (see below).



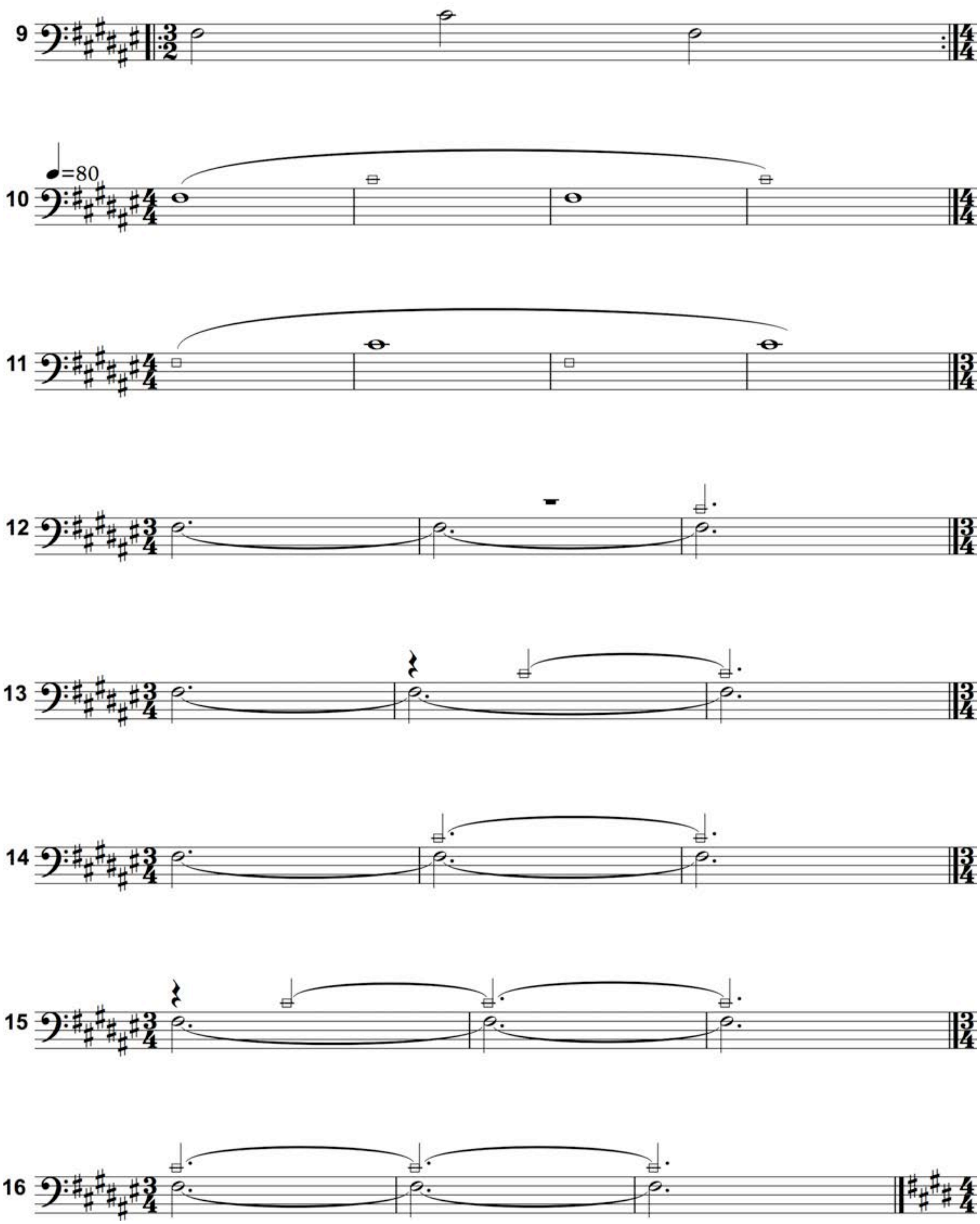
Repeat exercise 1 three times, each time taking a bar of rest before playing the exercise again. Play this exercise slowly and listen to the sound of the interval.



This exercise is designed to work toward unison attacks.

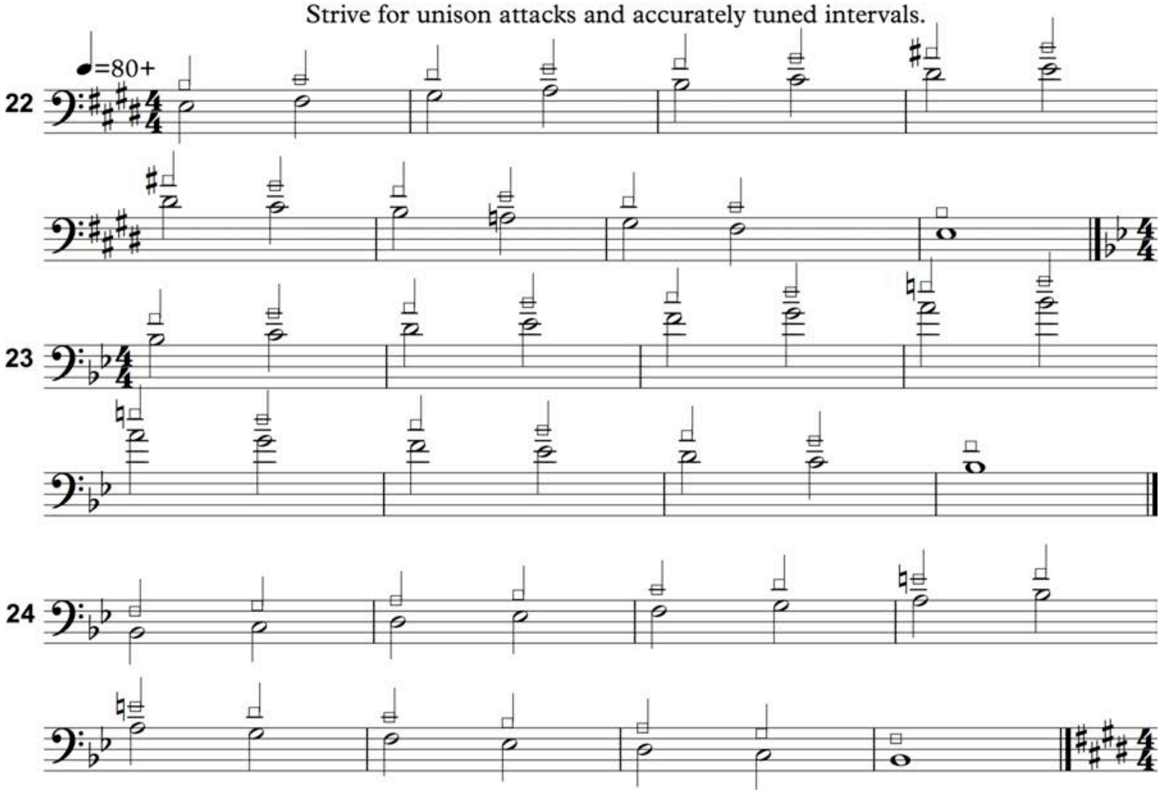


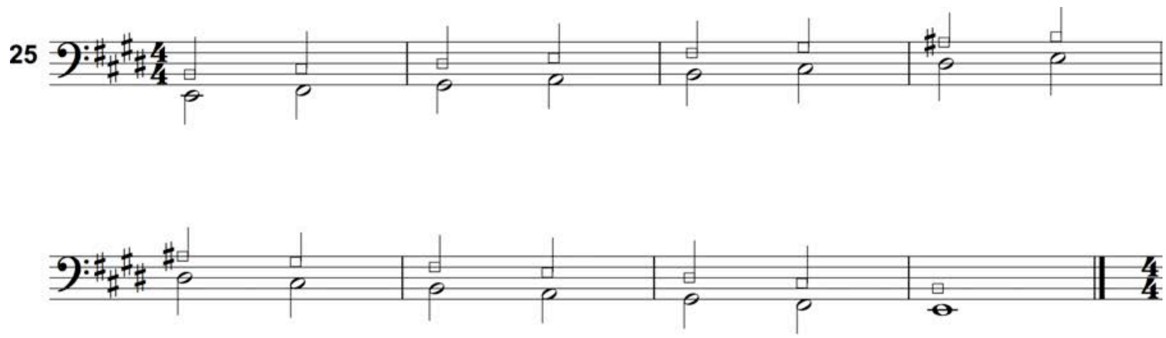
Repeat exercise 9 three times, each time taking a bar of rest before repeating.
Play this exercise slowly and listen to the sound of the interval.



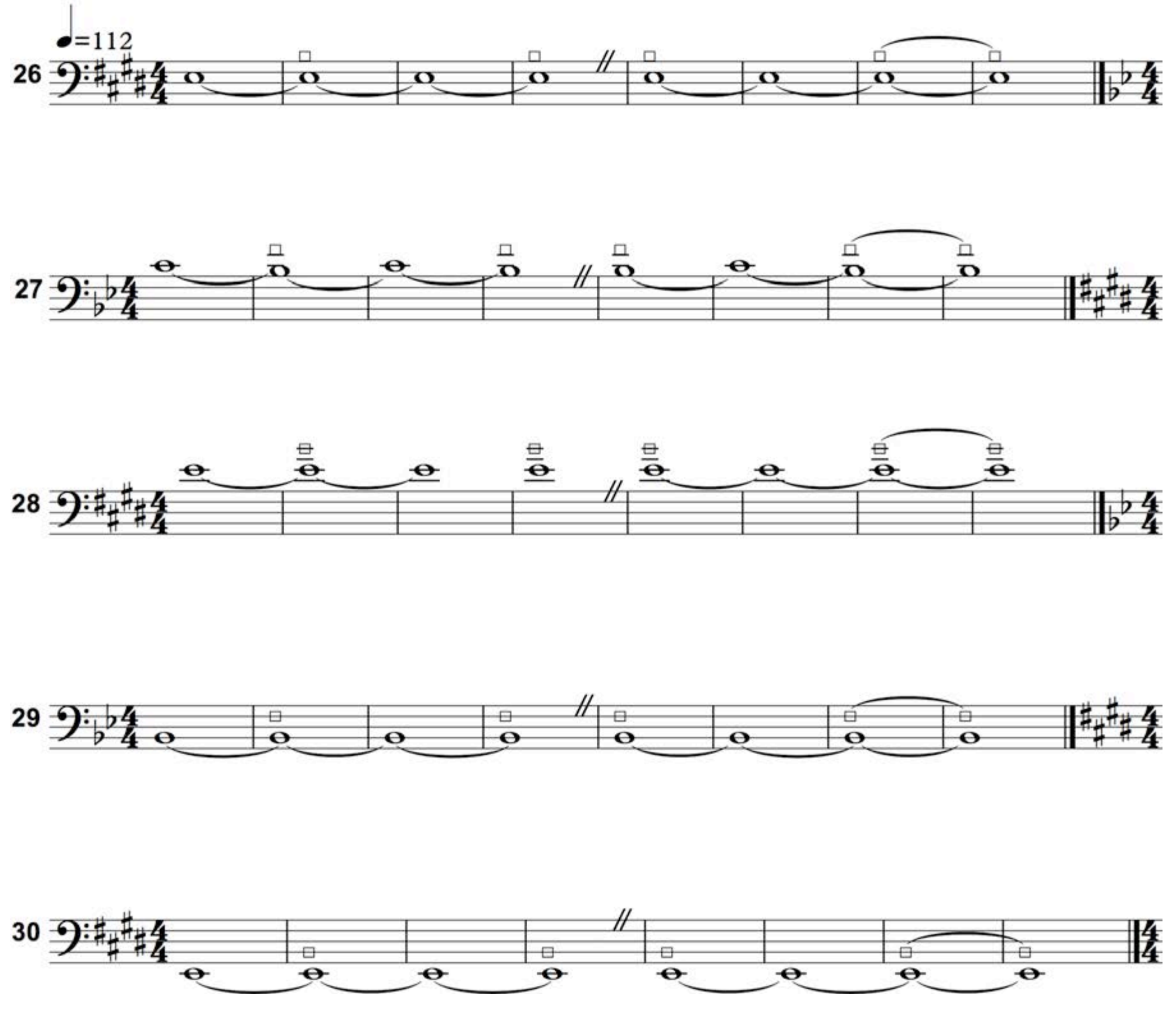
Only play the exercises you can play correctly. Do not attempt exercises that are too difficult for you (too high or too low). Play with your best sound. At times, attempt to sing louder than you're playing.

Strive for unison attacks and accurately tuned intervals.

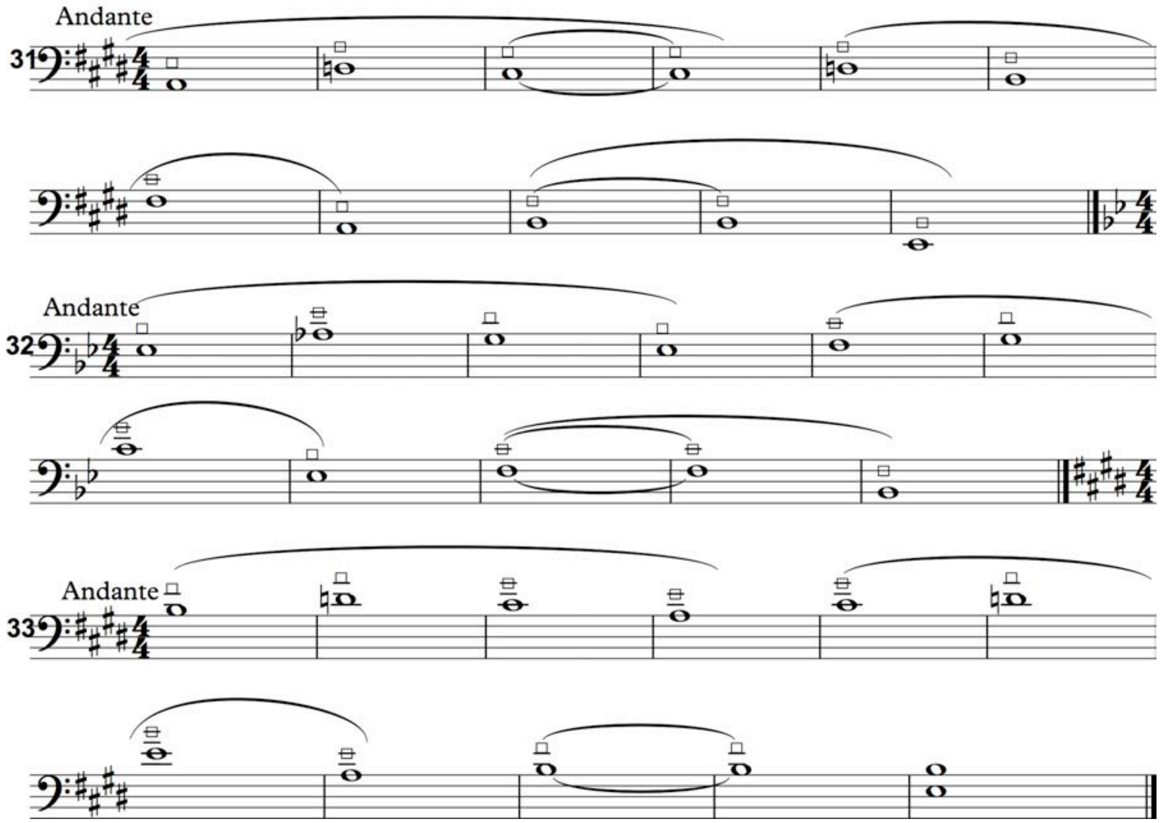




Exercises 26-30: pause briefly at the caesura, then proceed to the remainder of the exercise.



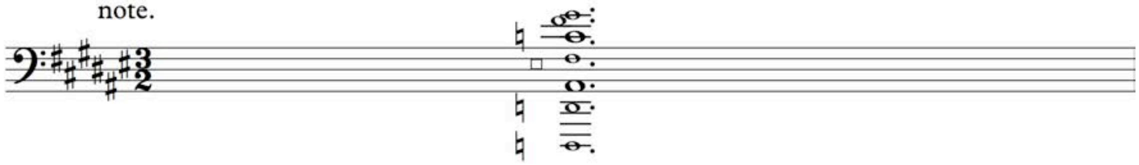
Only play exercises within your playing and vocal range. Remember to go back and learn the unison if you started with the perfect fifth.



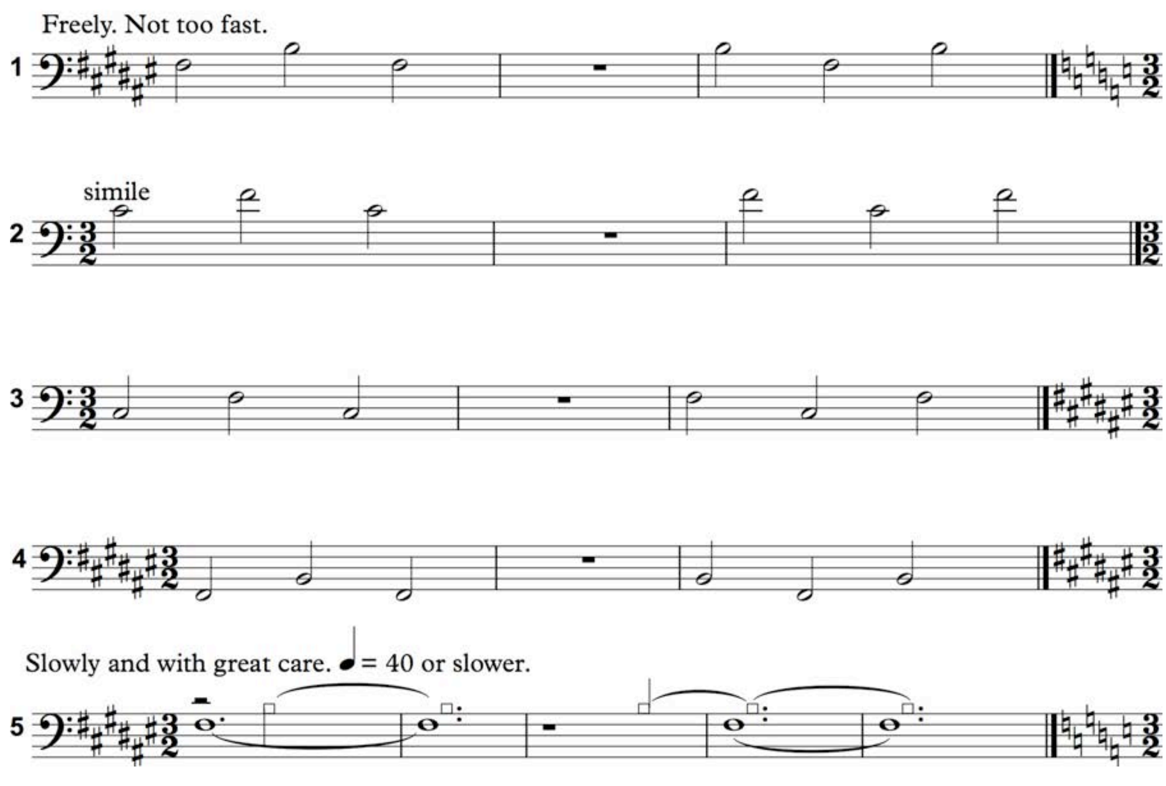
The Perfect Fourth

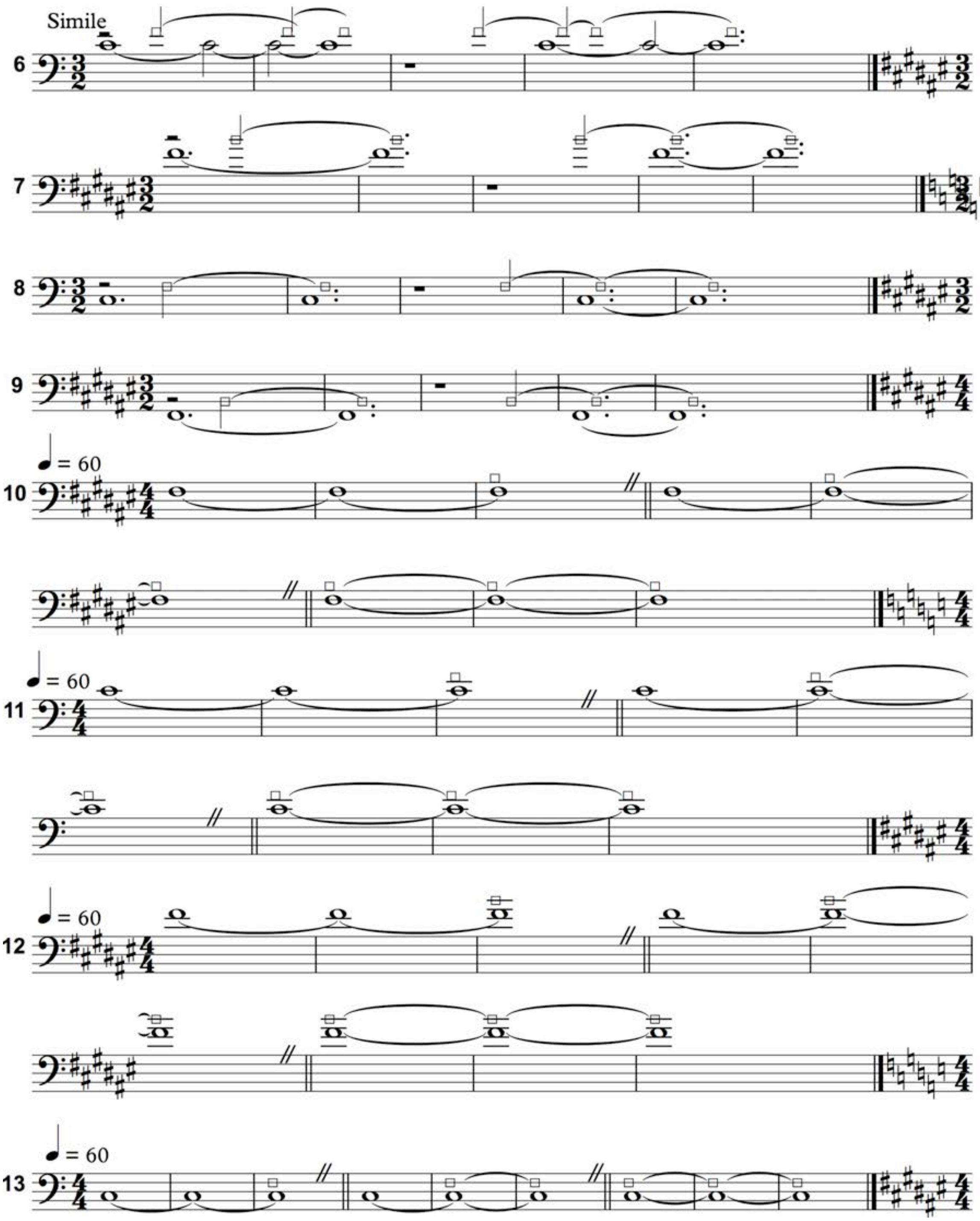
The perfect fourth is the first interval you will learn where beating can be felt on the lips. This beating is not strong, however, it is noticeable enough that it could cause some additional difficulty. Here are a few suggestions to assist with learning the perfect fourth: (1) Play the first four exercises with a light flutter tongue, as doing so will help you become accustom to the beating sensation felt on your lips. (2) Remember that the just perfect fourth is lower than the perfect fourth in equal temperament by two cents. (3) The voice should make any necessary pitch adjustments, as it is easier to control at this point in your development of the technique. Eventually you will learn, through trial and error, to adjust the pitch of the played note as well as both "voices" simultaneously.

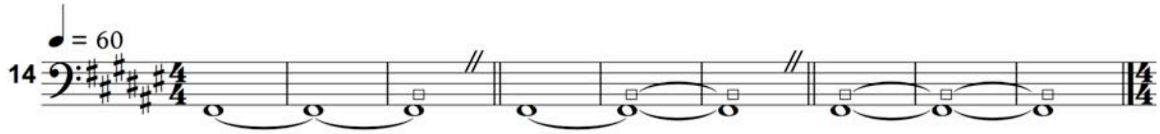
The following subjective tones may be heard when performing perfect fourths and are notated below: A perfect twelfth and perfect fifth are seen below the bottom note, while a major sixth, minor tenth, major thirteenth, and a major fourteenth lie above the bottom note.



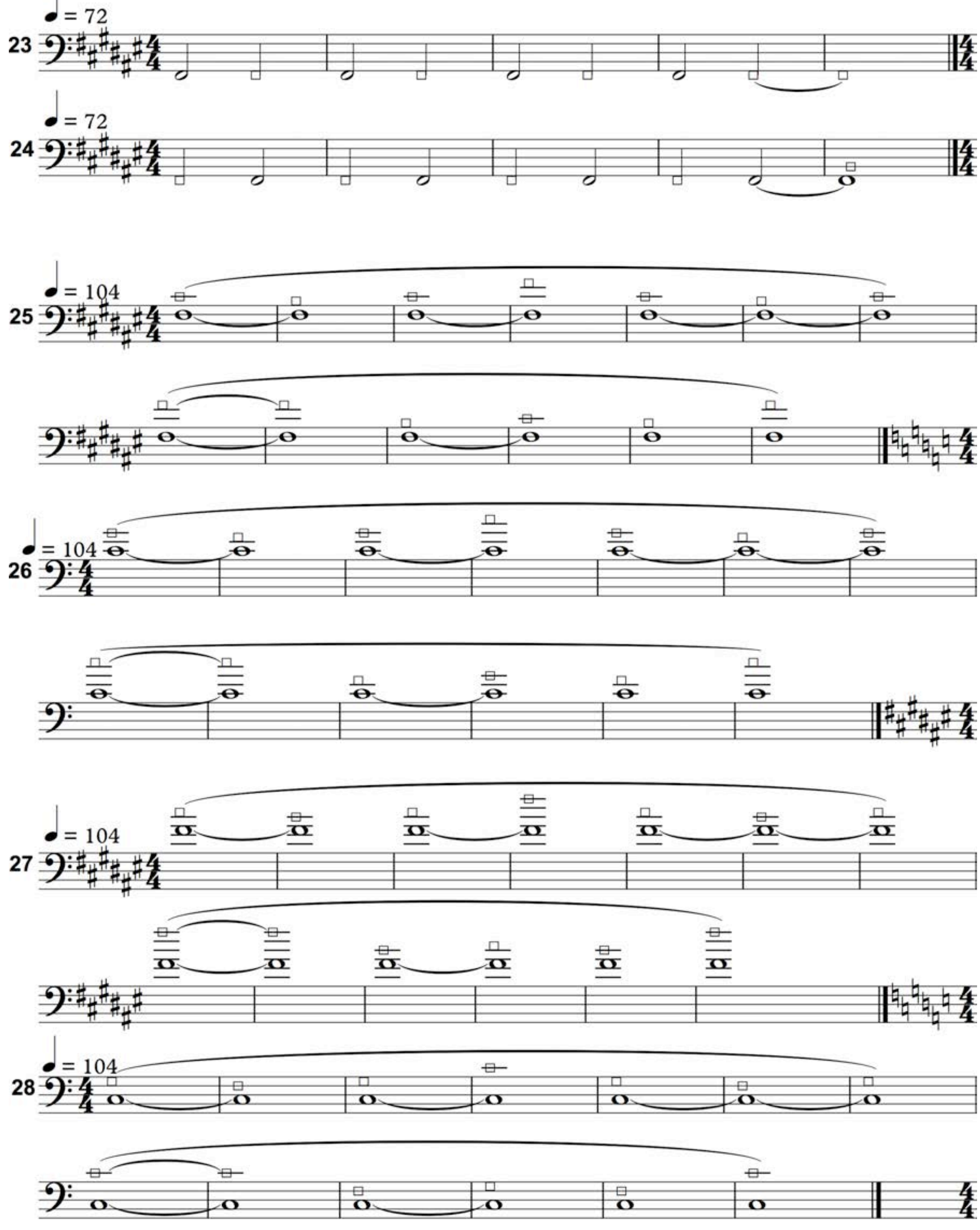
Exercises 1-4 should be played and sung; first play the exercise, then sing it.




Simile
6
7
8
9
= 60
10
= 60
11
= 60
12
= 60
13



Some of the remaining exercises may be beyond your current playing and or singing range. DO NOT attempt to play or sing higher or lower than you can, as this often leads to bad habits. Only play the exercises in which you have complete control of your voice, embouchure, and sound.


= 72
23
= 72
24
= 104
25
= 104
26
= 104
27
= 104
28

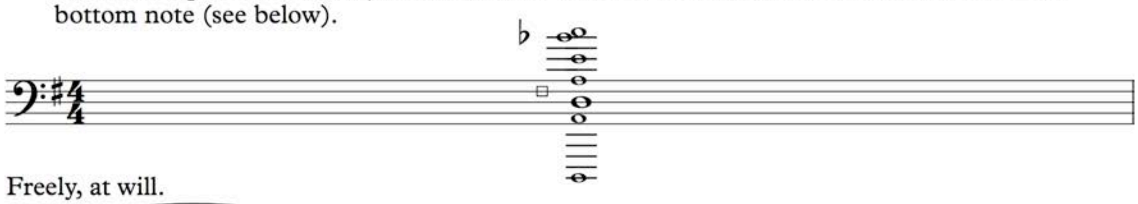

= 104
29
= 80
30
= 80
31
= 80
32

The Major Third

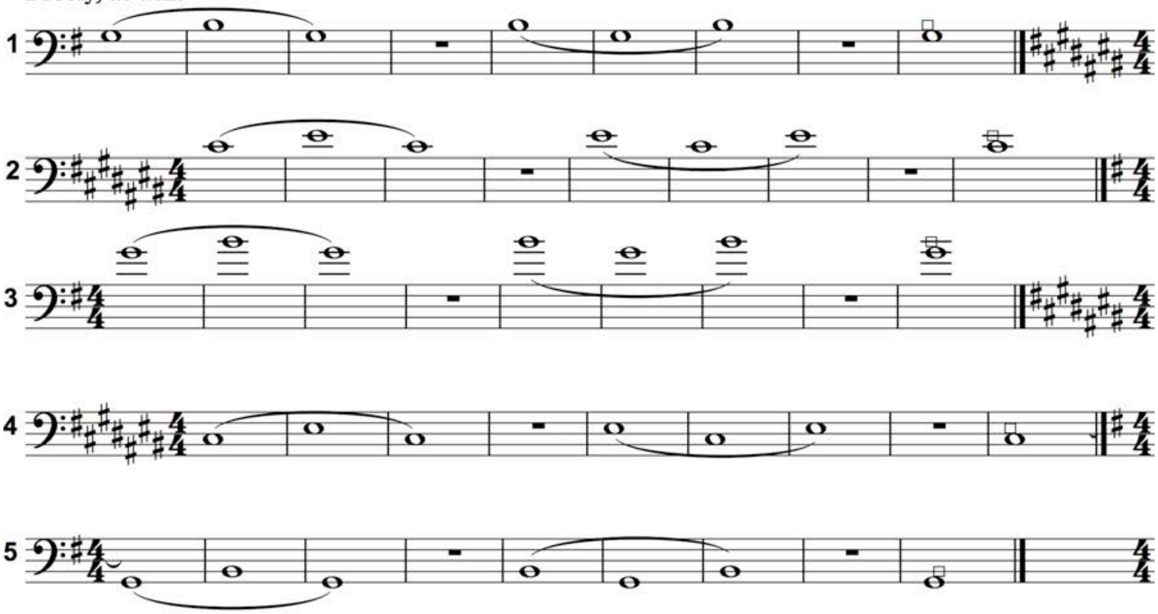
When mastered and played correctly, the major third can be one of the more satisfying intervals to perform. At first, the interval sounds rough due to interference from beating, however, if you learn to match dynamics of the sung and played note, the beauty of the interval can be heard.

Suggestions for success: (1) Attempt to perform each exercise and etude with matching dynamics between the sung and played note. (2) Listen for the quadratic difference tone (the root) heard below all properly tuned major thirds. (3) Finally, practice moving from the fourth scale degree to the third in various keys, as doing so will help you to gain more familiarity with this interval.

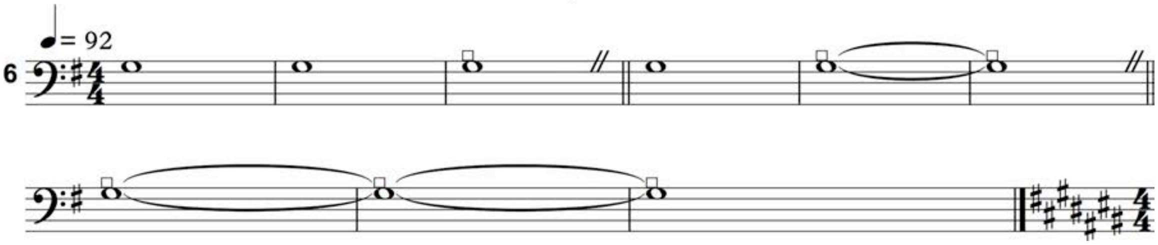
Subjective tones for the major third include a fifteenth and perfect fourth below the bottom note, and a perfect fifth, major ninth, minor thirteenth, and a minor fourteenth above the bottom note (see below).

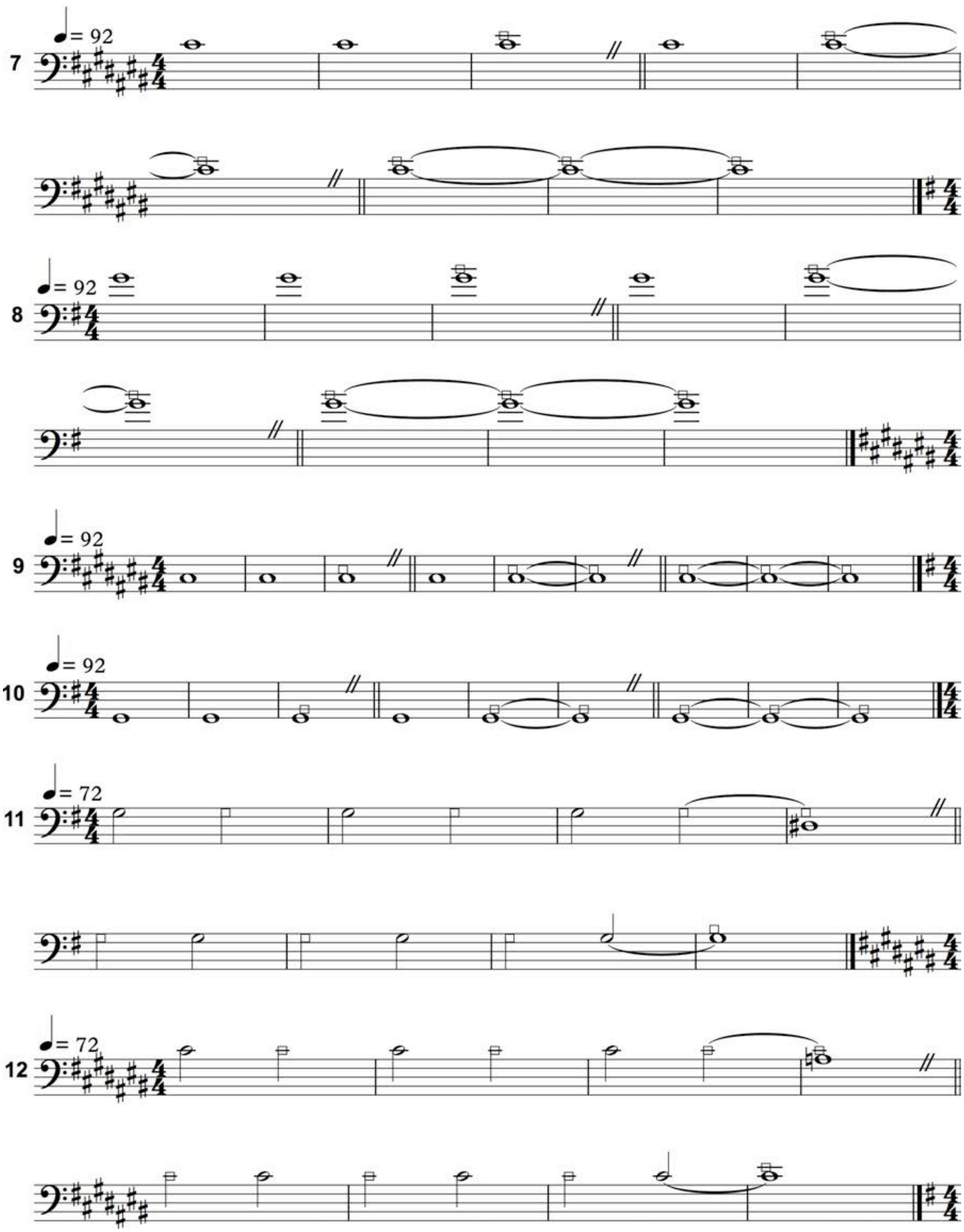


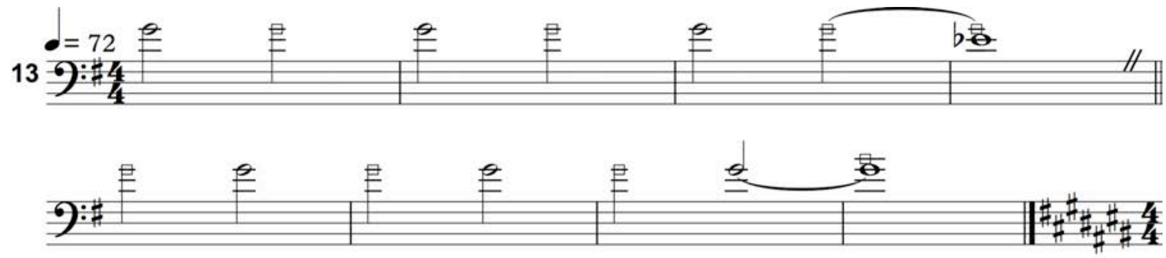
Freely, at will.



Pause briefly at each caesura.

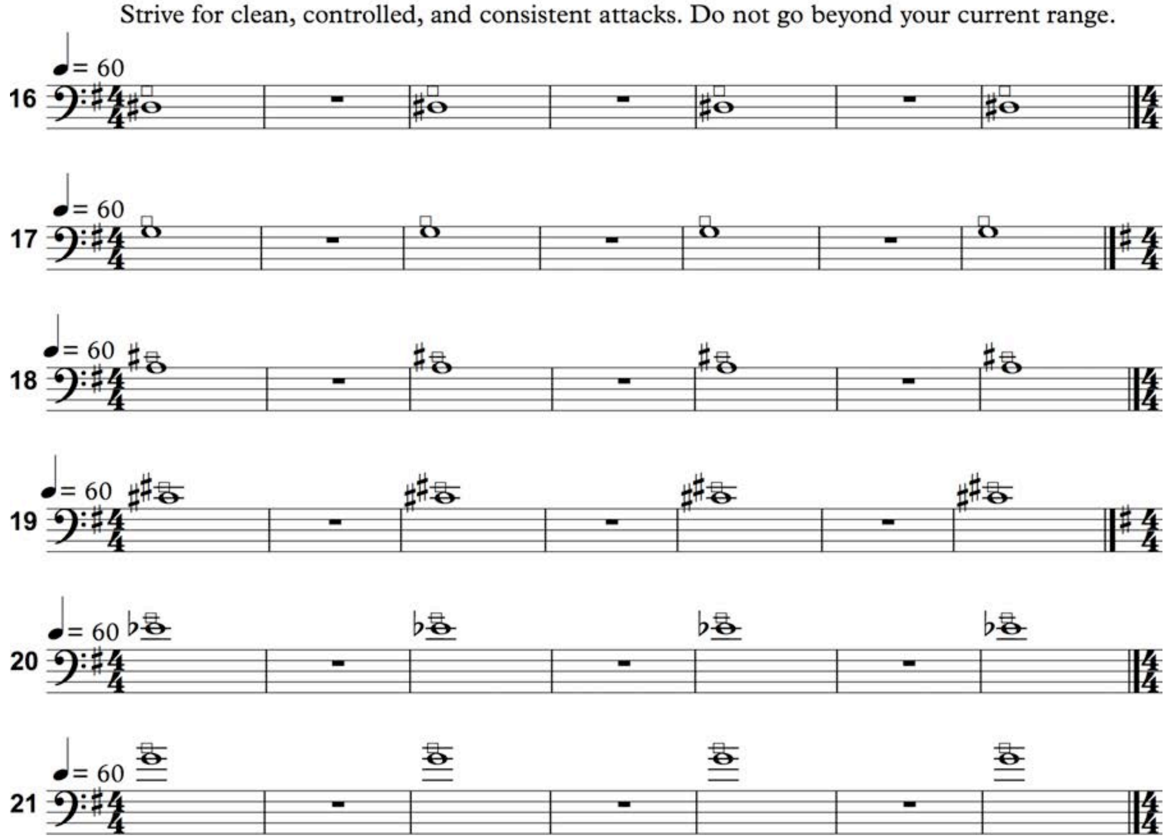



= 92
7
= 92
8
= 92
9
= 92
10
= 72
11
= 72
12



Work toward smooth transitions between sung and played notes.

Strive for clean, controlled, and consistent attacks. Do not go beyond your current range.



Sing and play with your most beautiful sound, making sure to stay within your range.

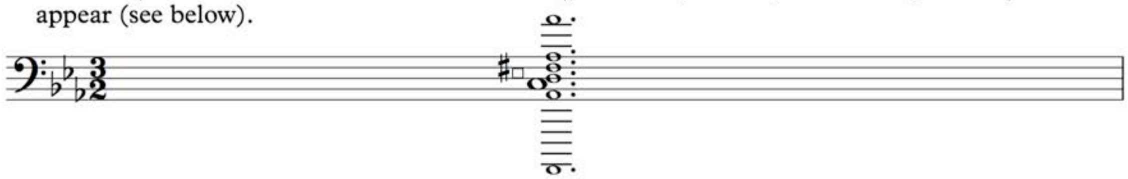

Andante
30
Allegro
31
Allegro moderato
32
Andante
33
Allegro
34

The Minor Third

The minor third is a little more challenging, initially, than the major third, however, your mastery of the major third will help you learn this interval. The additional difficulty occurs because of more beats or interference than the major third.

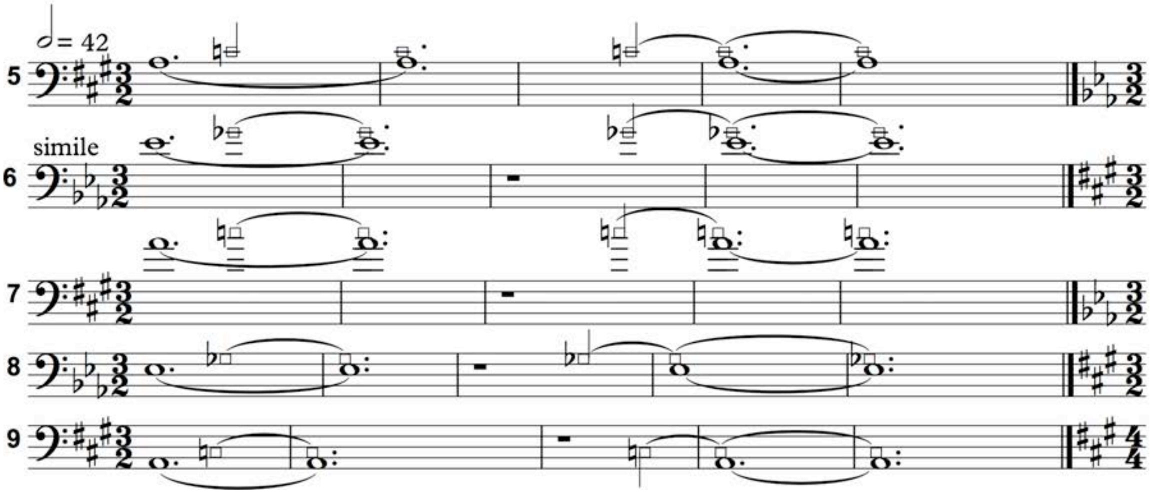
Remember to, initially, (1) Occasionally try to sing the top note louder than the played note. This will help you to better hear the interval and also assist in tuning. (2) Practice moving between major-and-minor thirds throughout the range of your voice and instrument. (3) Record and listen back to ensure that you are playing a true minor third. Remember, you need to (4) raise the this interval by 16 cents to have a justly-tuned minor third.

Subjective tones for the minor third: below the bottom note you will find a major seventeenth and a major third. Above the bottom note a major second, tritone, minor sixth, and major thirteen appear (see below).

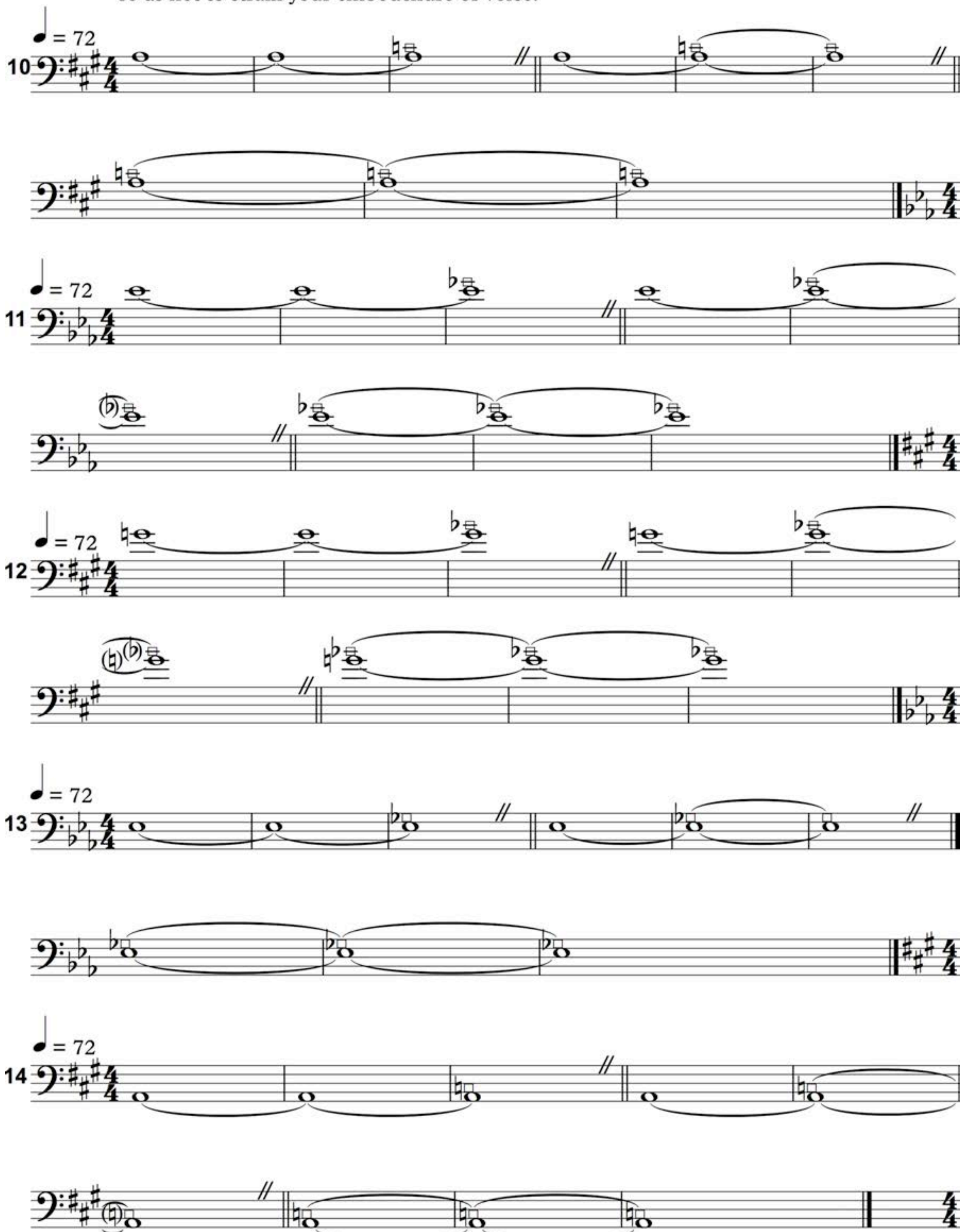


First play exercises 1-4, then sing through your instrument the notes indicated.

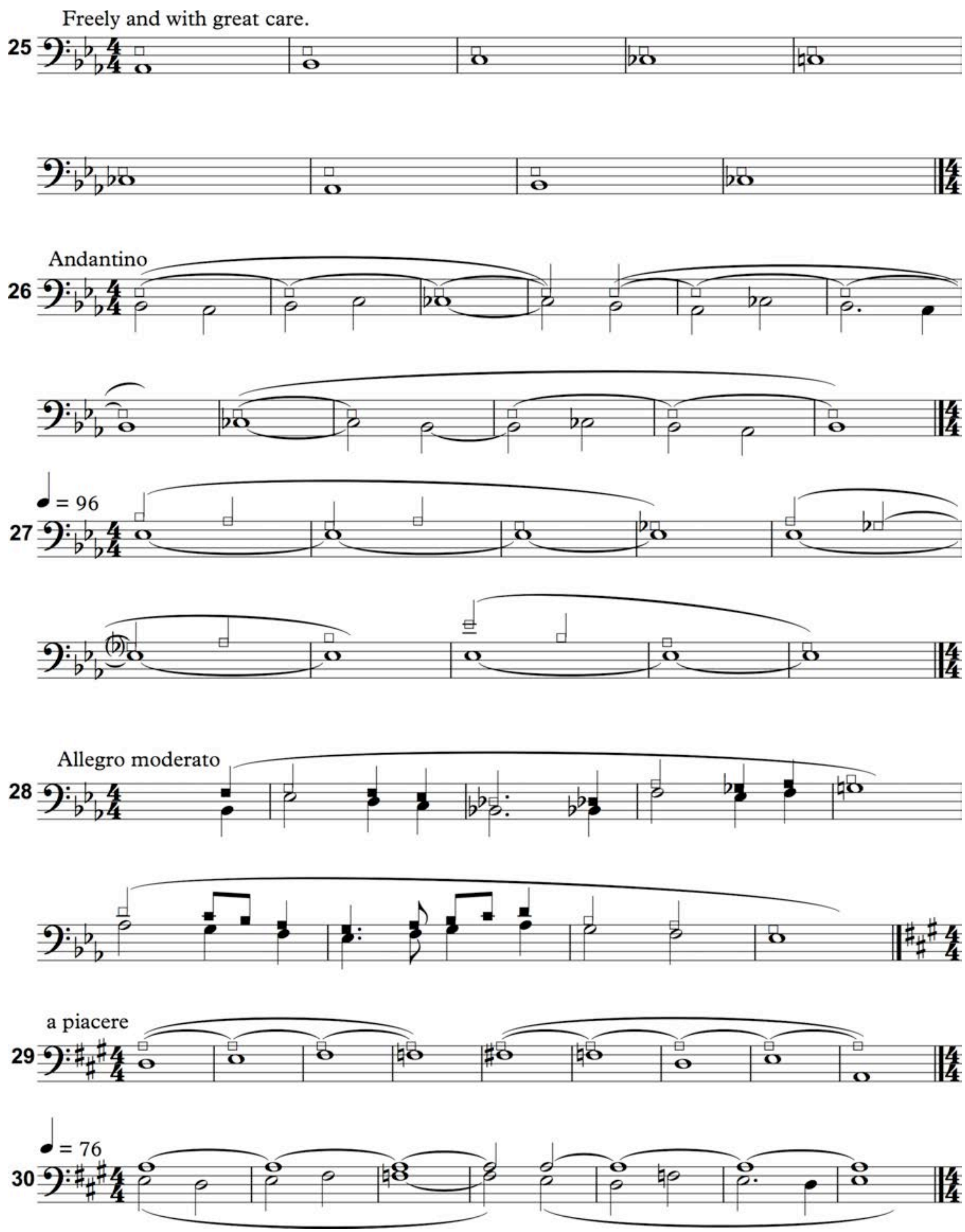
Listen for accurate intervals and tuning of the minor third.



Pause briefly following each caesura. Be sure to stay within a comfortable range, so as not to strain your embouchure or voice.



Strive for a continuous sound and accurate intervals.

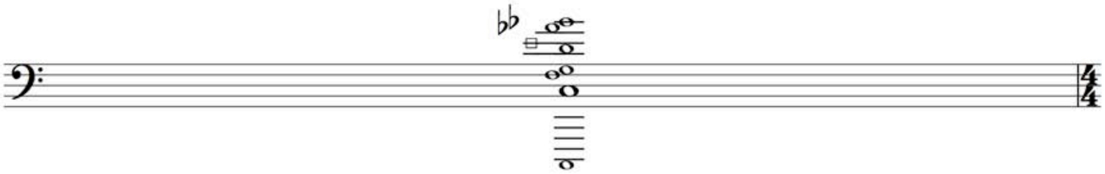

Freely and with great care.
25
Andantino
26
= 96
27
Allegro moderato
28
a piacere
29
= 76
30


Andante
31
♩ = 80
32
Moderato
33

The Major Tenth

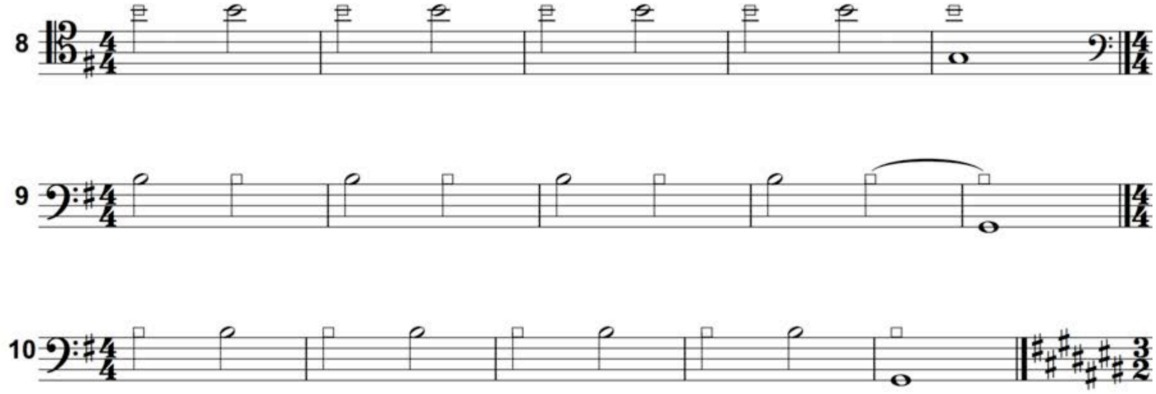
The compound equivalent of the major third varies from its simple form, as the beating sensation is not as strong as the major third. Tips for the major tenth: (1) Use the octave and major third as guide tones. Later, use the perfect eleventh in combination with the octave and major third to help you better hear the interval. (2) To obtain a justly-tuned major tenth, the sung note must be lowered by fourteen cents. (3) Practice this unfamiliar technique by attempting to sing louder than the played note so that you can hear the sung note clearly. (4)Lastly, DO NOT attempt exercises that are too high or too low for you.

Subjective tones for the major tenth: a fifteenth below the bottom note and a perfect fourth, perfect fifth, major ninth, minor thirteenth, and minor fourteen above the bottom note.

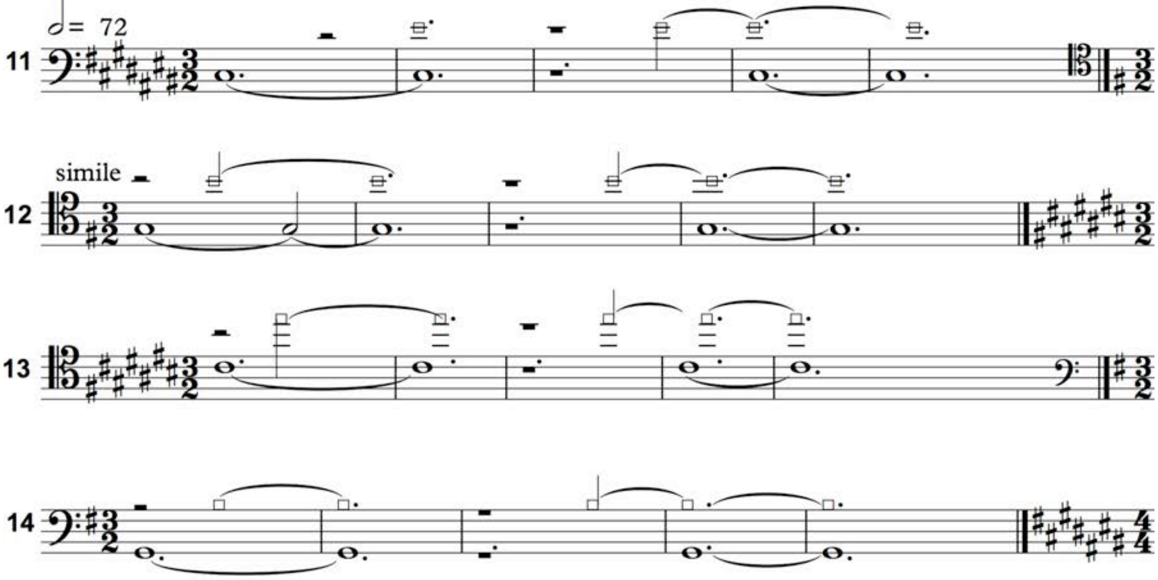


Pause briefly after each caesura.

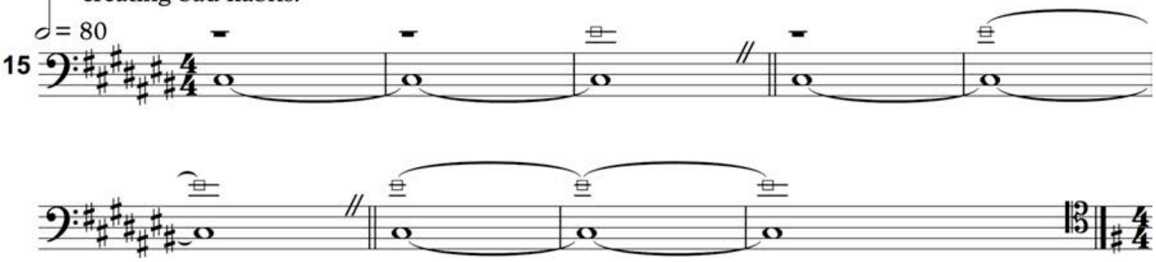
Avoid any interuption in sound.

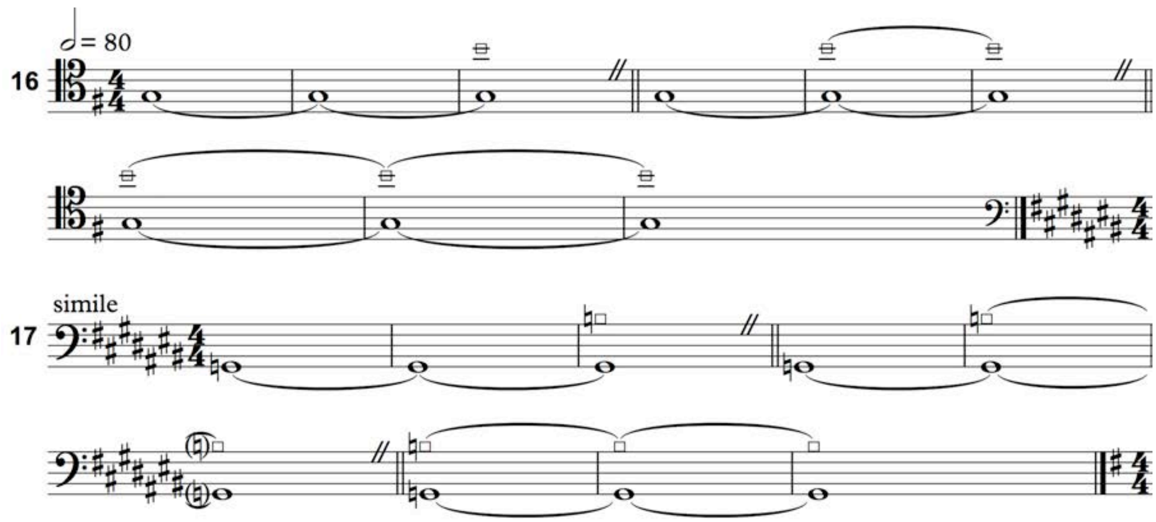


Be sure to keep the back of your throat relaxed and open.



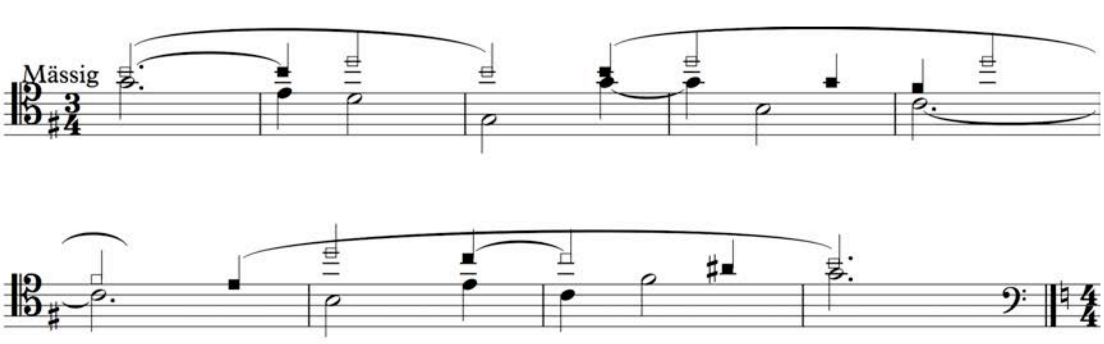
Exercises 15-17 should be played with at least one measure of rest following each caesura. Do not ascend or descend past your current range and rest when tired. Playing out of your range and playing while tired often leads to bad habits. Do not make your job harder by creating bad habits.

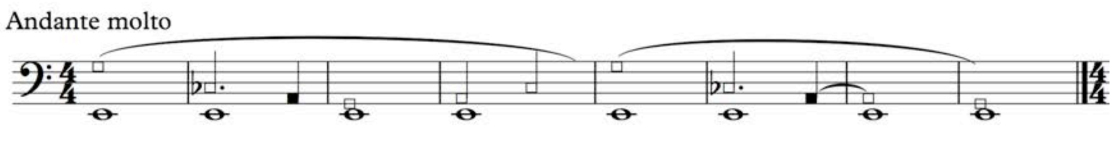




Perform as many etudes as possible while staying within a comfortable range. You will notice that etudes are repeated in two keys and in various registers throughout the trombone and voice. This is done purposely to allow you to become familiarized with multiphonics throughout the range of the instrument. Stay relaxed and play musically.


Andante molto
21
Allegro moderato
22
Mässig
23
Andante molto
24
Allegro moderato
25

26 

27 

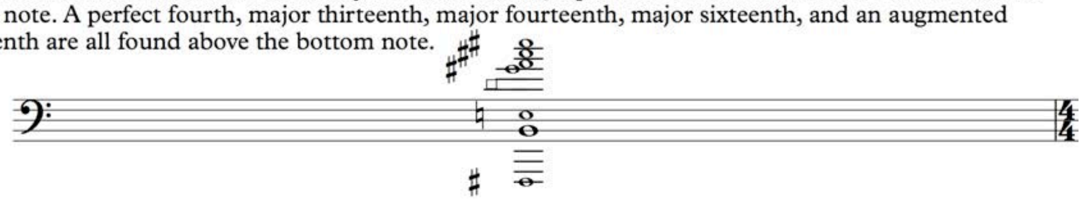
28 

29 

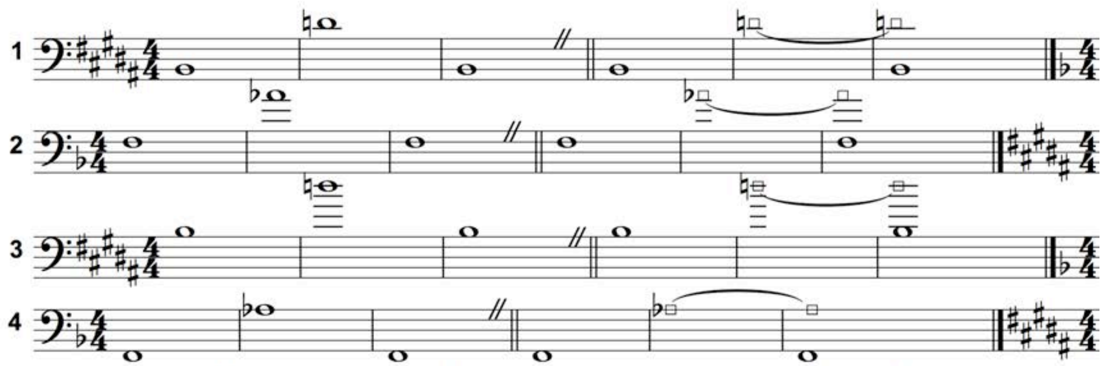
The Minor Tenth

Unlike the minor third, the minor tenth does not contain beats that affect your perception of sound, nor do the beats grossly interfere with the sensation of playing. Similar to the minor third, use the major tenth as your guide note to help you locate this interval. Focus on maintaining the sung voice as it tends to drift flat and lie somewhere between the minor tenth and major ninth. Tips for mastery and success: (1) The minor tenth is sixteen cents sharper than the equally tempered interval, therefore, you will need to raise the sung note by sixteen cents to obtain a justly-tuned interval. Since beating does not interfere with embouchure sensation, playing softer becomes easier. (2) To play softer and sing louder, use slightly less mouthpiece pressure than you would when playing normally. (3) Record yourself and listen for a consistent sung note and subjective tones.

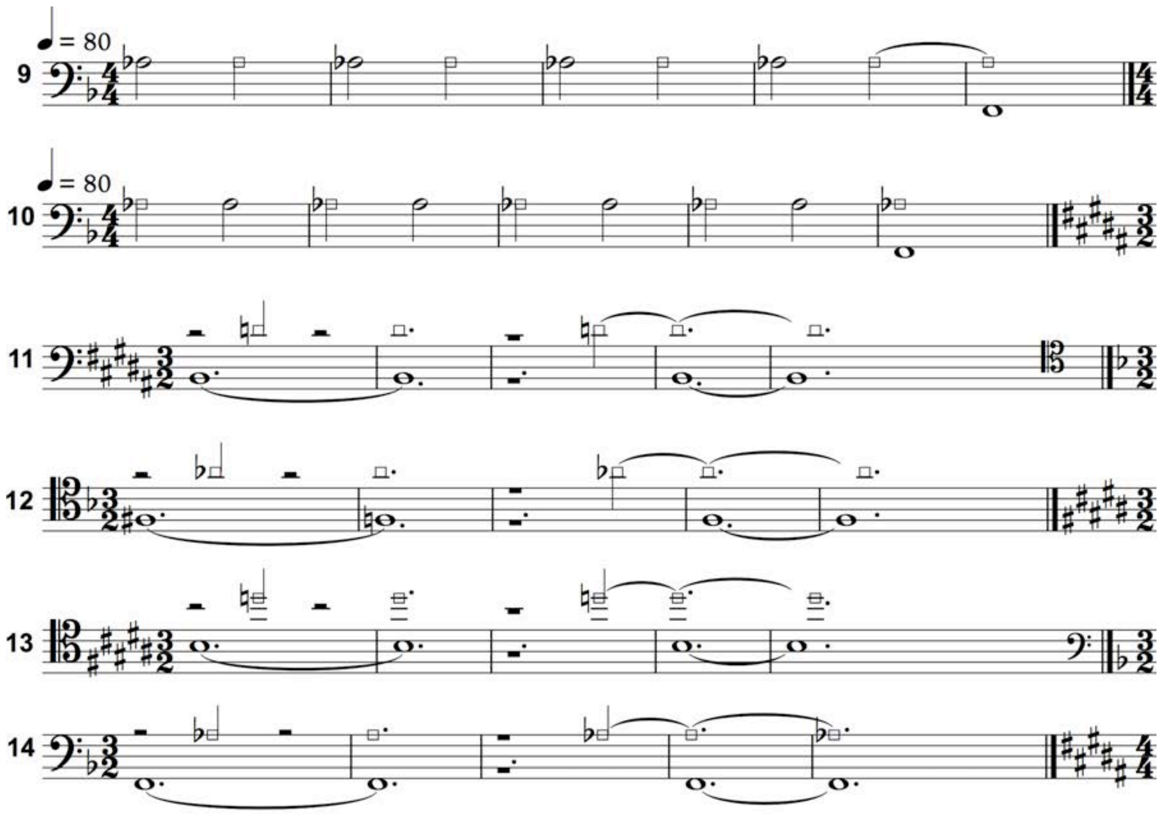
Subjective tones for the minor tenth: as you can see below, a perfect eleventh lies underneath the bottom played note. A perfect fourth, major thirteenth, major fourteenth, major sixteenth, and an augmented eighteenth are all found above the bottom note.



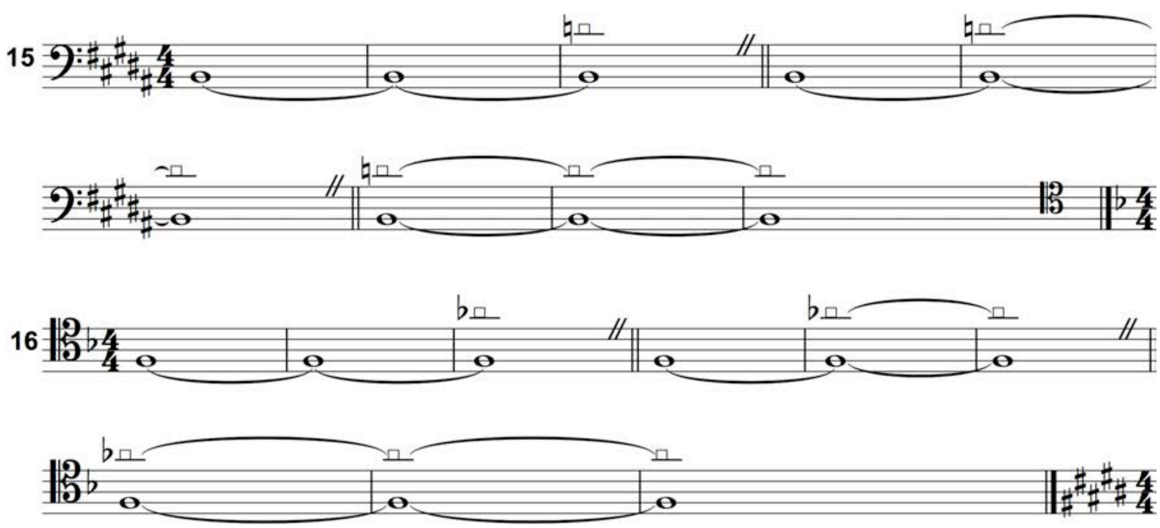
Pause briefly after each caesura.

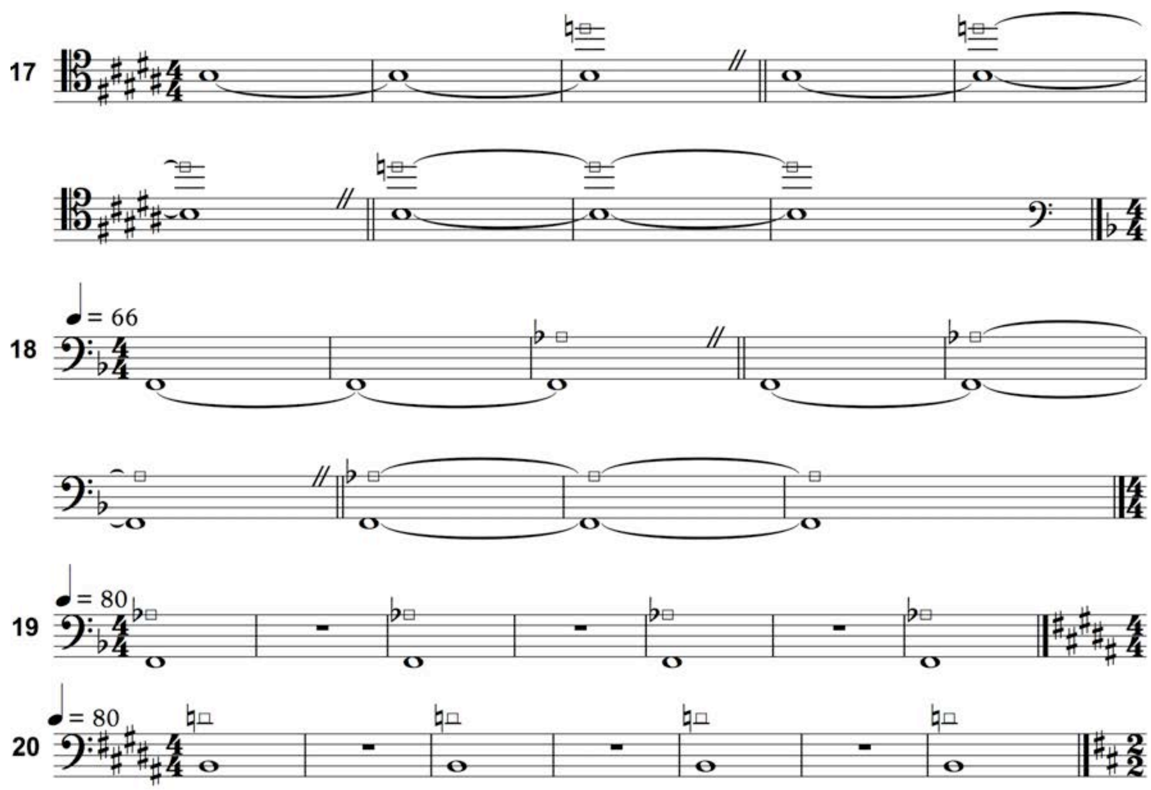


For exercises 5-14, work on blend and balance between the trombone and voice. Match dynamics and try not to bump either note when switching between voice and trombone. Only play exercises you can do with ease.



For exercises 15-18, pause for one measure after each caesura. Use the time you are not playing to hear the note you are about to sing and only play exercises within your range.





Select from the following pages appropriate etudes based on your playing and singing range. Do not, at any point, go beyond this range while learning multiphonic technique. Stay relaxed, breathe easy, and listen for potential subjective tones. Observe phrase markings as much as possible.


Monoton und langsam mit zunehmender Leidenschaft
23
Grave
24

= 76
25
Monoton und langsam mit zunehmender Leidenschaft
26
Grave
27

= 76
28
Monoton und langsam mit zunehmender Leidenschaft
29

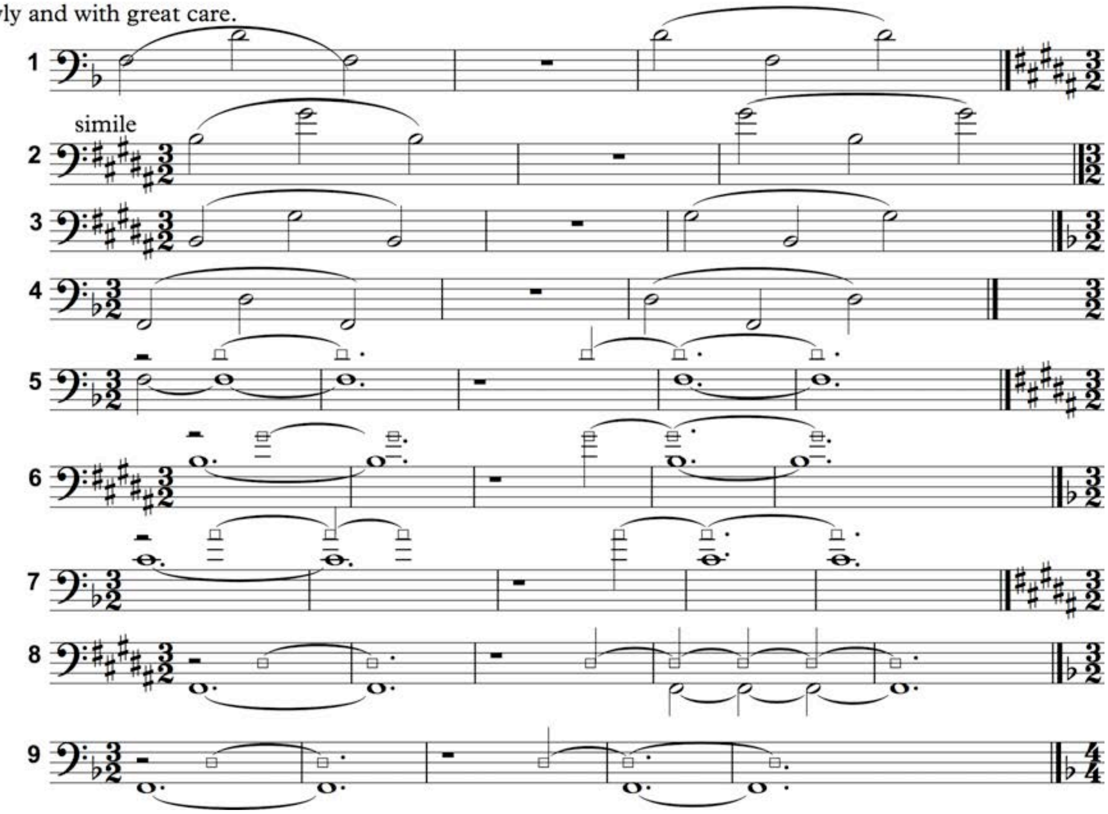
The Major Sixth

Although you will feel beats on your embouchure, these beats are not felt as strongly as the perfect fourth and both types of thirds. Since the aforementioned intervals have already been learned, the presence of beats should not distract you. Like the perfect fifth, the major sixth, as well as the minor sixth (next interval), have subjective tones that are easier to observe than other intervals. Tips for learning and mastering the major sixth: (1) Listen for subjective tones as you play. (2) These tones can appear if you play justly-tuned major sixths. To do so <u>the sung voice should be lowered by twelve cents.</u> (3) Use a tuner to help you visualize the lowered sung note. (4) Begin by playing the sung note on the trombone, being sure to play with your best sound and do not bend the pitch down with your embouchure (move the slide to do this).

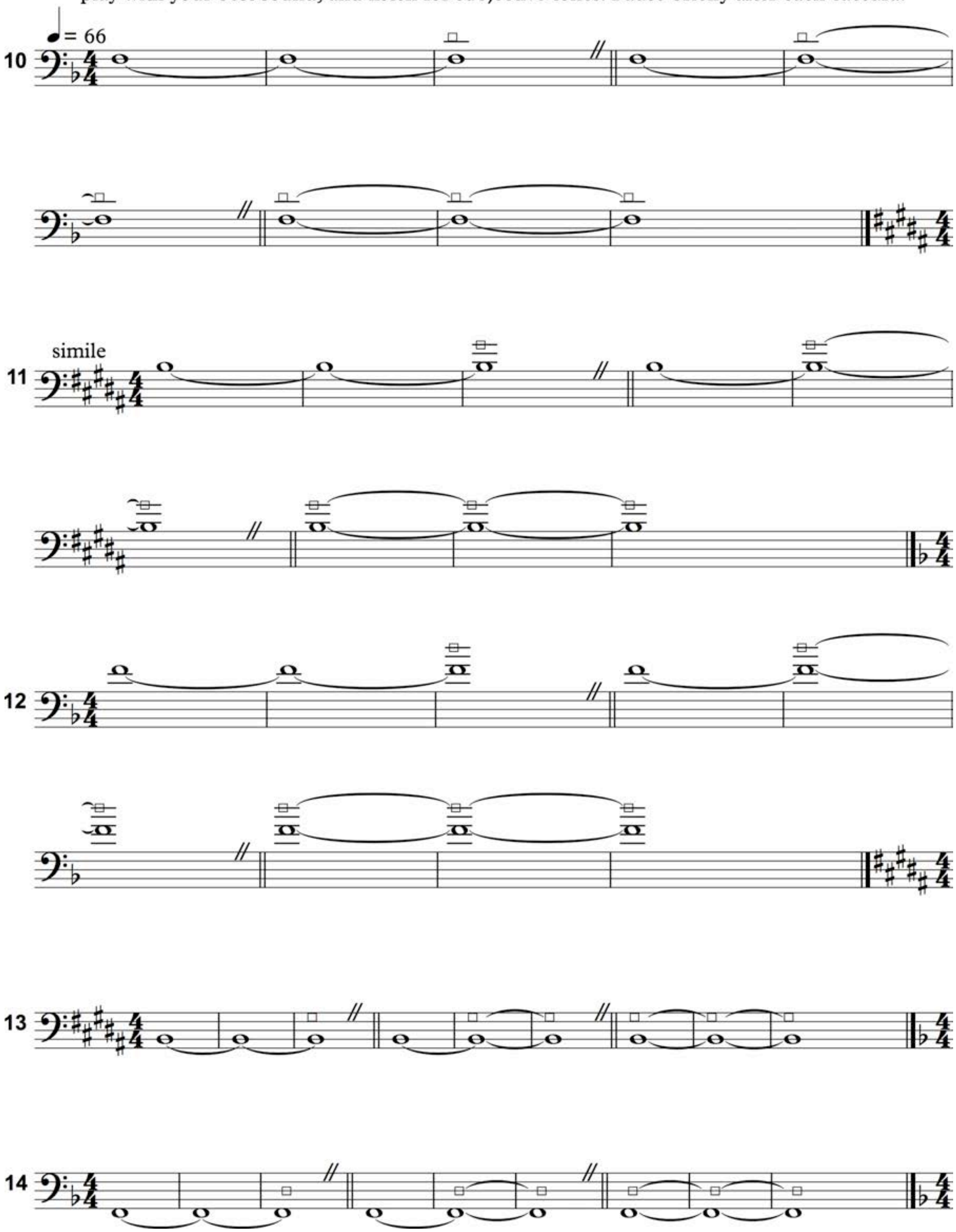
Subjective tones for the major sixth include a perfect twelfth and perfect fifth below the bottom note, and a minor sixth, minor tenth, perfect eleventh, and a major fourteenth are found above the bottom note.

First play the exercises, then sing through your horn the notes indicated. Do not go past your multiphonic range, as it tends to cause problems with the voice and embouchure.

Slowly and with great care.



Play all exercises that lie within your multiphonic range (exercises 10-15). Stay relaxed, play with your best sound, and listen for subjective tones. Pause briefly after each caesura.



Play as many exercises as you can correctly, with ease, and within your range (exercises 16-24).

Perform all remaining exercises that are within your vocal and playing range. Do not strain your voice or play too high. Eventually, you may be able to perform more of these exercises once you have increased your range (both high and low), but for now, stay within your range to insure the multiphonic process is as accurate as possible. Pushing range will not help you become more accurate, especially while learning this technique.


Andante
29
Andantino
30
Moderato
31

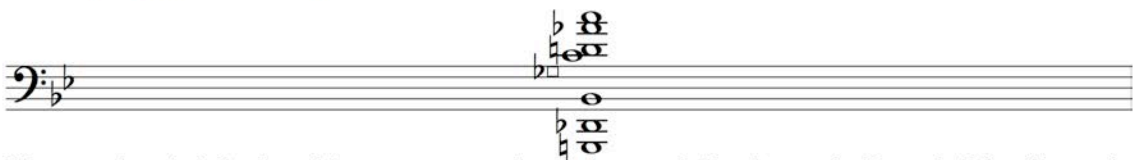

Andante
32
Andantino
33
Moderato
34
Andante
35


Andantino
36

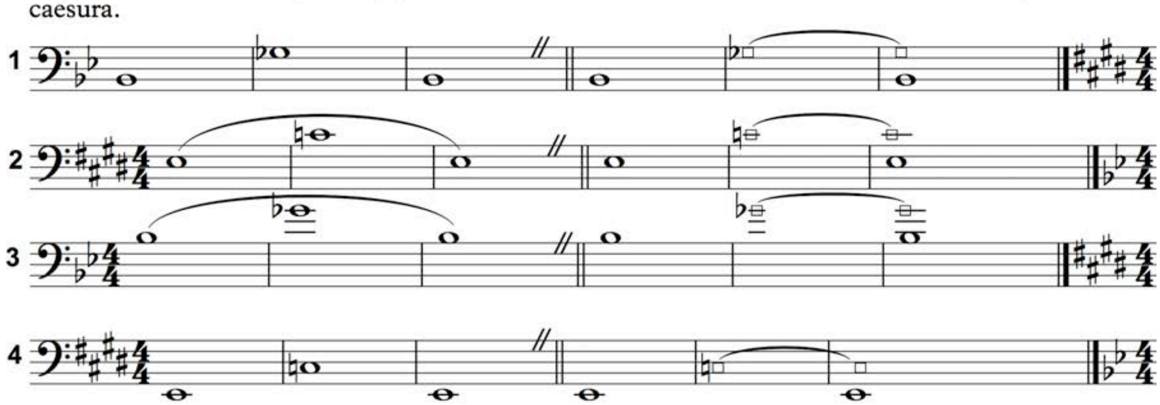
The Minor Sixth

Unlike the major sixth, the minor sixth can be difficult to place. Beating associated with this interval add to its difficulty, however, once one is able to hear a clear minor sixth the difficulty level drops significantly. If you struggle with this interval, try moving from major sixth to minor sixth and back again. I have found that using the major sixth as a reference point works better than the perfect fifth, as ascending half-steps tend to be more difficult to hear than descending half-steps. Tips for success: (1) from time to time, spot-check your intervallic accuracy with a tuner remembering that (2) the minor sixth must be raised by fourteen cents to obtain a just minor sixth. (3) Finally, practice some of these exercises with an air attack. Doing so provides an excellent opportunity to have the air, voice, and embouchure work together. Once you have mastered the air attack, add the tongue back into the equation.

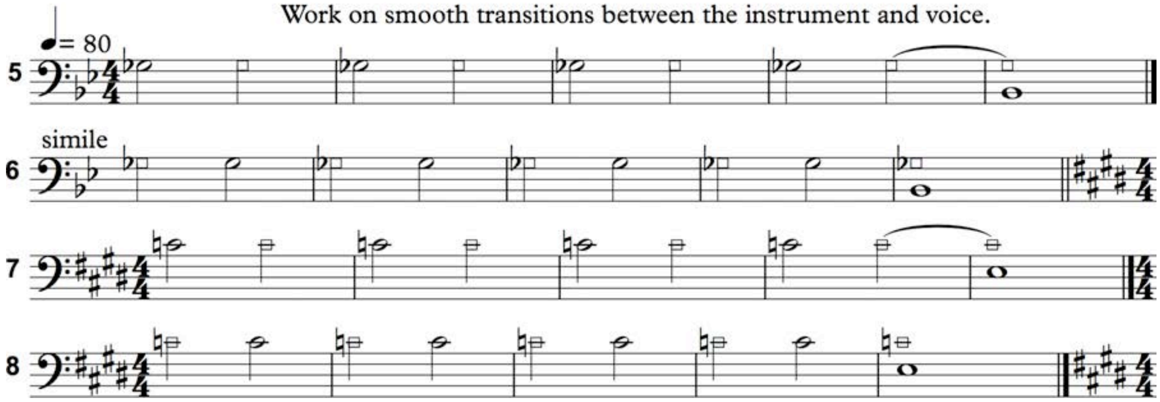
Subjective tones for the minor sixth: a major tenth and major sixth lie below the bottom note; a major ninth, major tenth, minor fourteenth, and minor sixteenth can be found above the bottom note (see below).

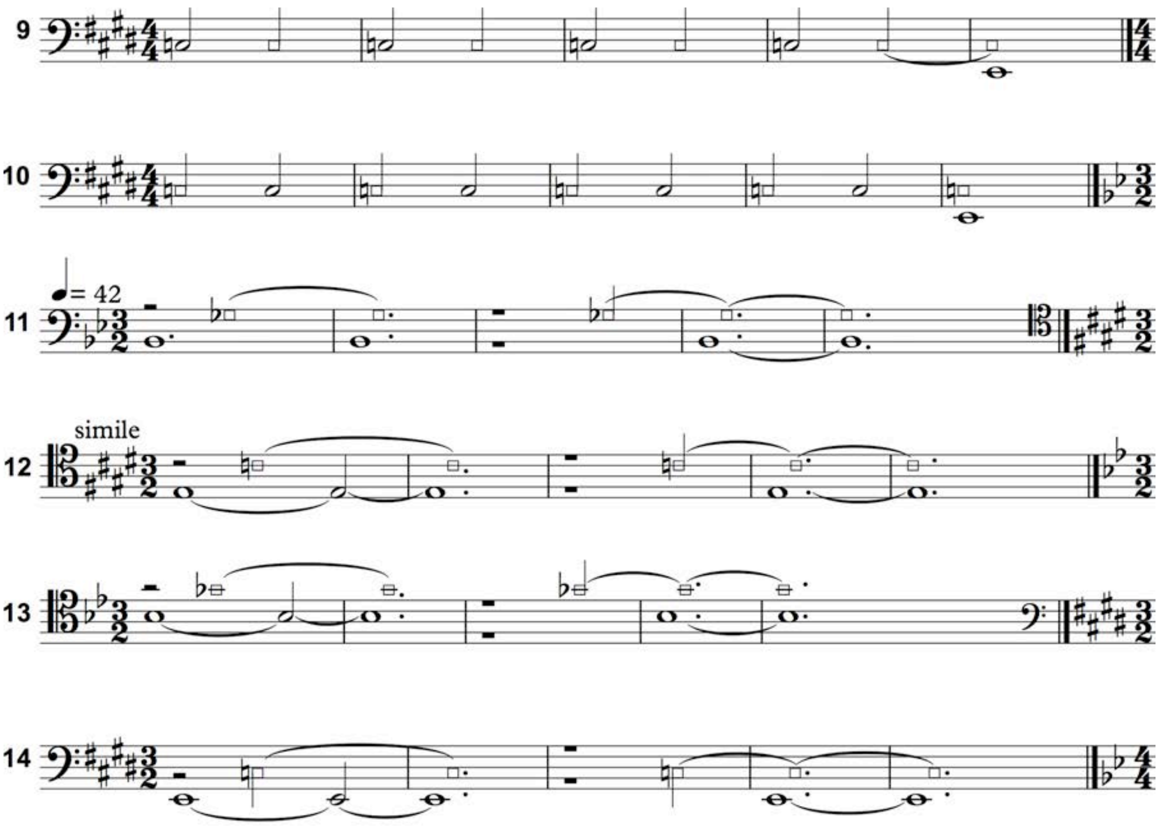


Play exercises 1-4 slowly, taking great care to have clean and clear intervals. Pause briefly after each caesura.

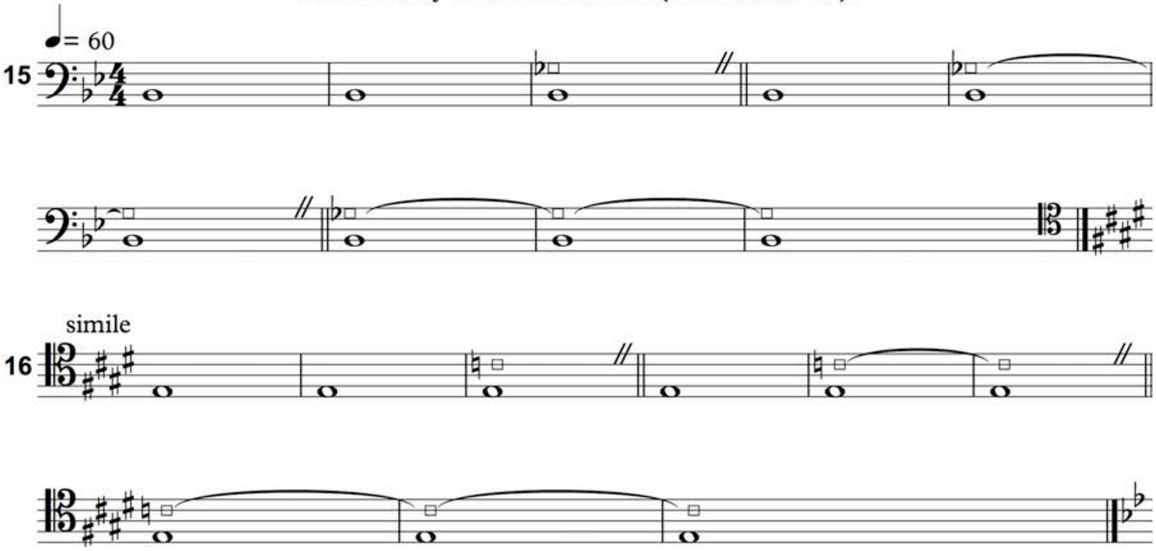


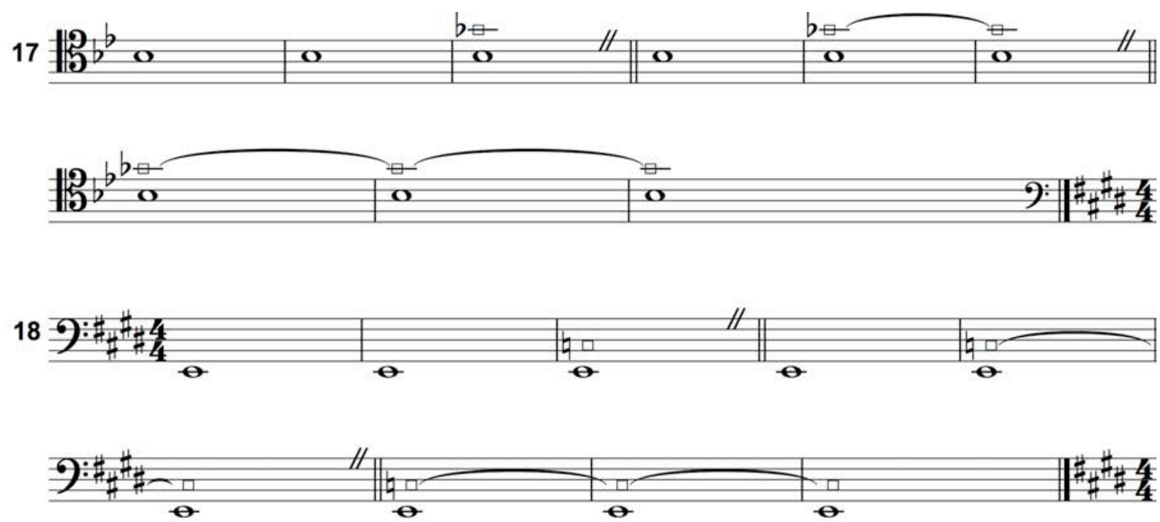
Work on smooth transitions between the instrument and voice.





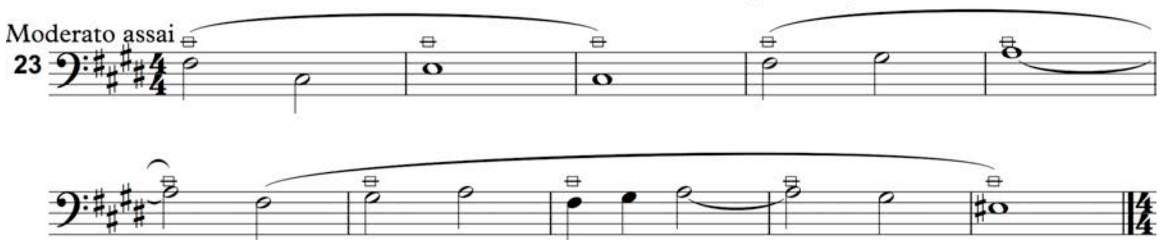
Pause briefly after each caesura (exercises 15-18).





Strive for clean, unison attacks.

Perform all etudes that lie within your range.




Allegro moderato
24
Andante
25
rit.
a Tempo
Adagio
26


Allegro moderato
27
Andante
28
rit.
a Tempo
Adagio
29

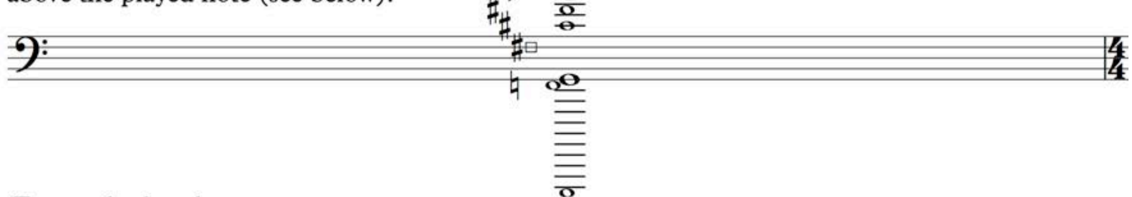

Allegro moderato
30

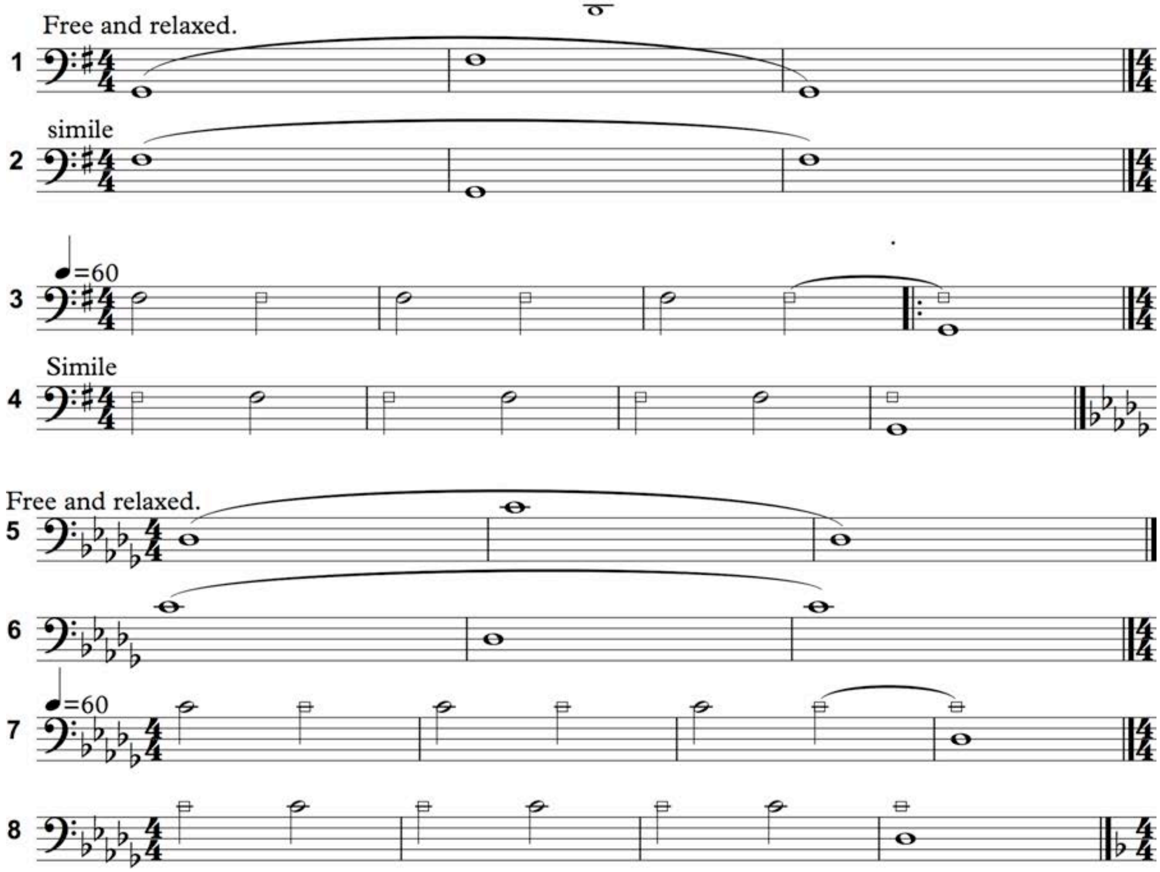

Andante
31
a Tempo
rit.

The Major Seventh

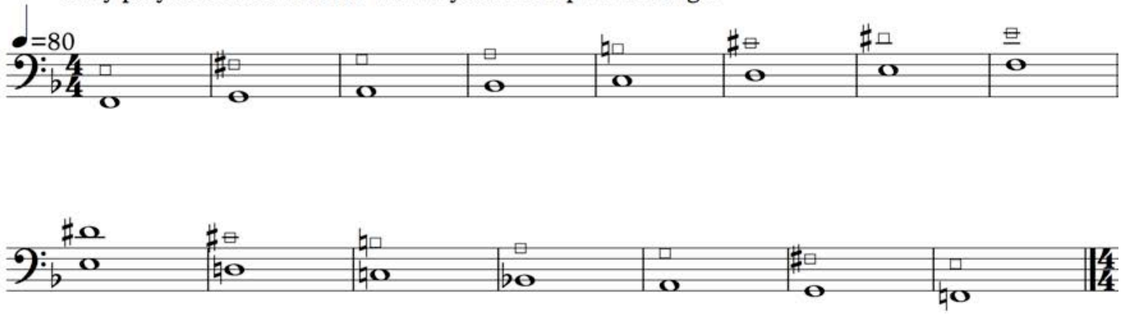
When played with similar dynamics and justly tuned, the major seventh can be very effective. Initially, matching the dynamics of the sung and played note will be difficult. Attempt to sing louder than the played note, as this will help you learn to match dynamics by feel and sound. Tips for successful learning and application of the major seventh: (1) Use the octave as your guide note. Practice moving between the octave and major seventh whenever you have issues with this interval. (2) Avoid the distraction of beats on your lips and in your ears. Do this by actively listening for correct intonation. (3) The just major seventh varies from the equal tempered equivalent by twelve cents and can be adjusted by lowering the sung note. At times you may have difficulty hearing the sung note which happens because the played note is too loud. (4) Apply less mouthpiece pressure to help you play softer, thus allowing the sung note a better chance to resonate.

Subjective tones found with the major seventh include a twenty-second and major second below the bottom note; an augmented eleventh, major fourteenth, and a minor seventeenth are found above the played note (see below).





At first, perform exercises 9-12 out of time, making sure the major seventh is justly tuned. Once each exercise is fully established, gradually increase the tempo to performance speed. Only play exercises that fall within your multiphonic range.

9


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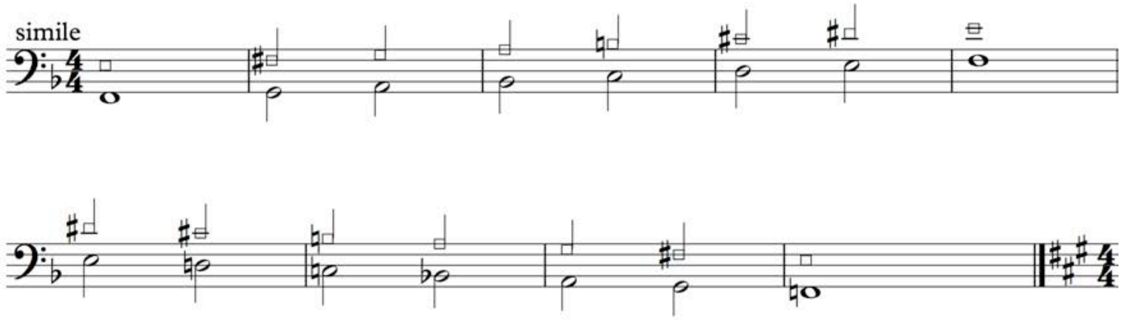

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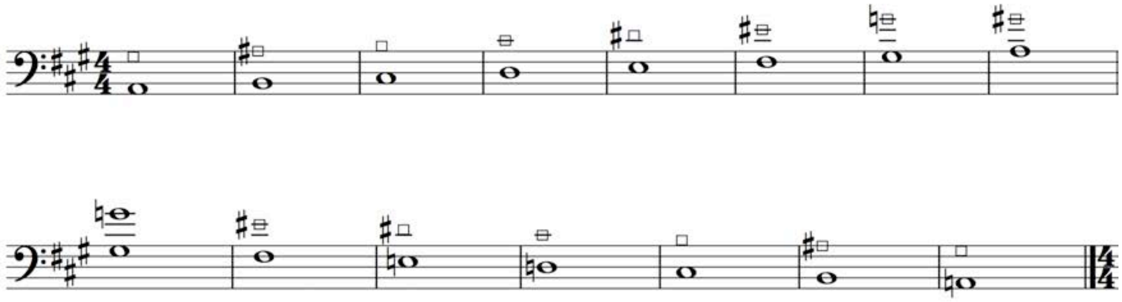


12


Choose from the following etudes those that lie within your multiphonic range.
Stay relaxed and play with your best sound.

Adagio con moto

16

Adagio con moto

17


Andante
18
Moderato
19

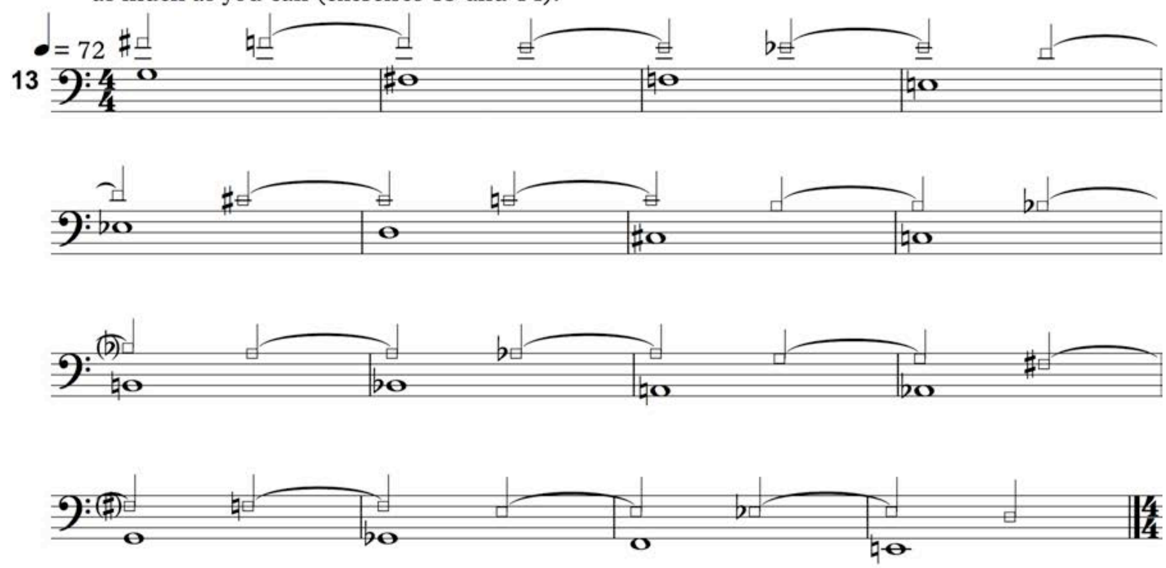
The Minor Seventh

The minor seventh, like the major seventh, contains beats which can make tuning difficult. The minor seventh's subjective tones can be easier to hear than the major seventh. Listen carefully as you proceed through this interval. Tips for success: (1) Because the minor seventh can be hard to hear, use the major sixth interval as a guide to locate the minor seventh. (2) If you find this interval to be too challenging, practice moving between the major sixth and the minor seventh. (3) The just minor seventh is four cents flatter than its equal tempered counterpart. (4) Use a recording device and a tuner to help with tuning. (5) Remember to take breaks. Don't pound away at these exercises, as you could develop bad playing habits. Play with ease and your most beautiful sound.

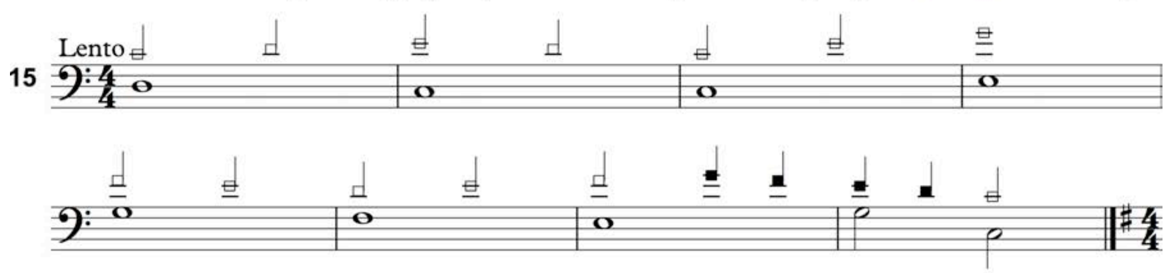
Subjective tones for the minor seventh: a major seventeenth and major third lie below the bottom note, while a major tenth, augmented eleventh, major fourteenth, and major sixteenth are found above the bottom note (see below).

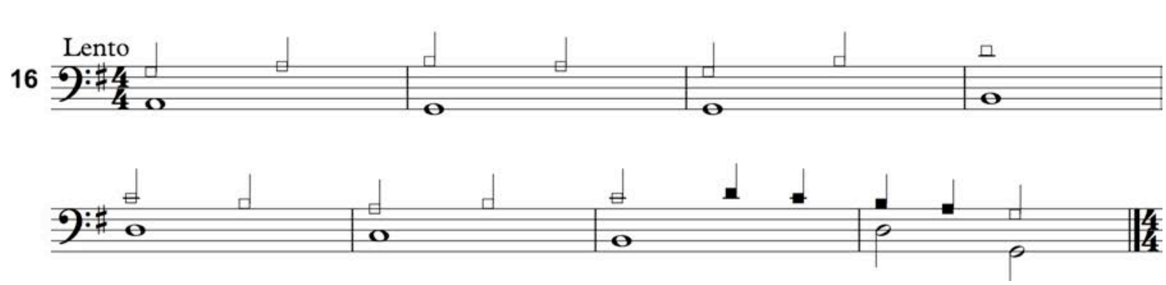
Perform only exercises in which you have complete control of your air, voice, and instrument. If necessary, skip measures that are unplayable and master what you are capable of playing.

Only play the notes that lie within your range. Skip measures if necessary, but complete as much as you can (exercises 13 and 14).



Of the remaining etudes, play only those in which you do not go beyond a comfortable range.






Adagio
17
Adagio
18
Adagio
19

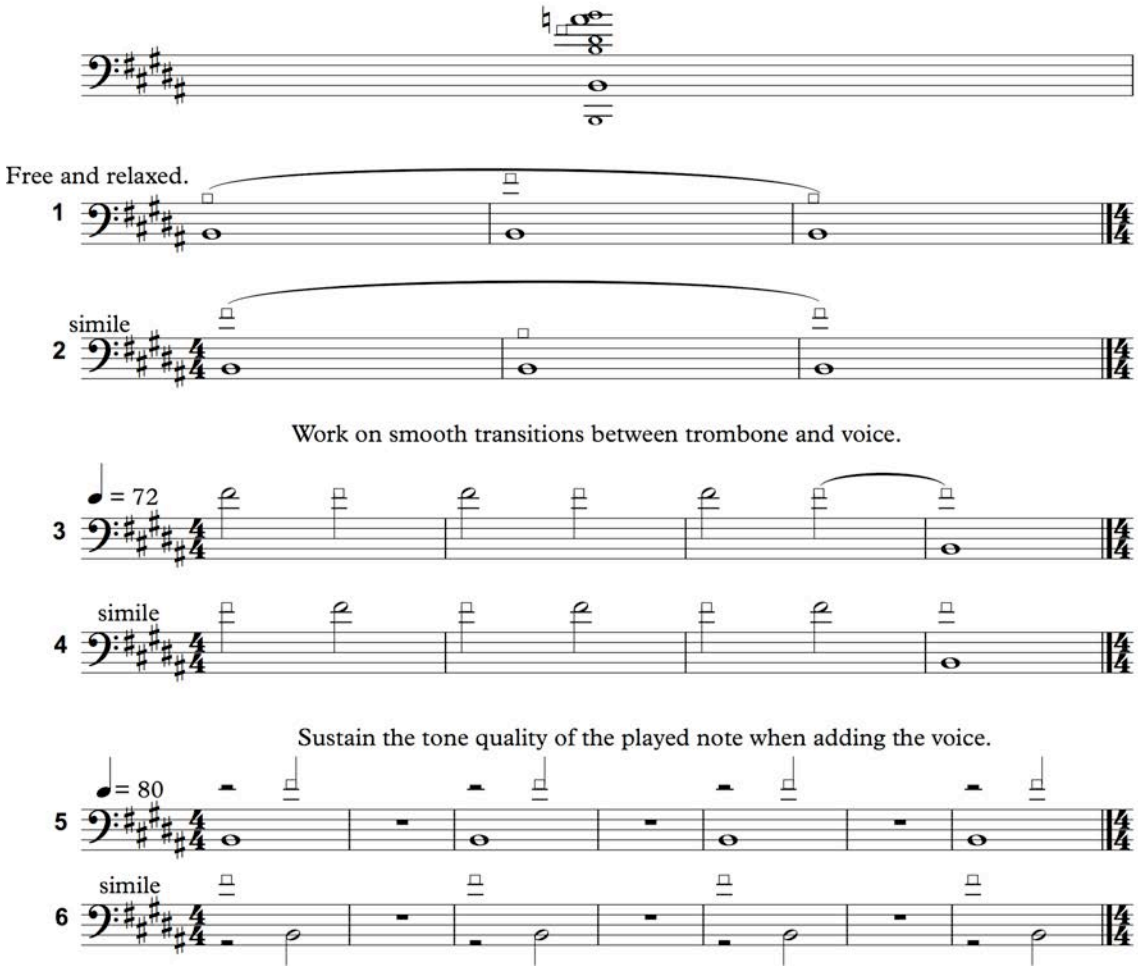

Adagio
20
Moderato
21
Moderato
22

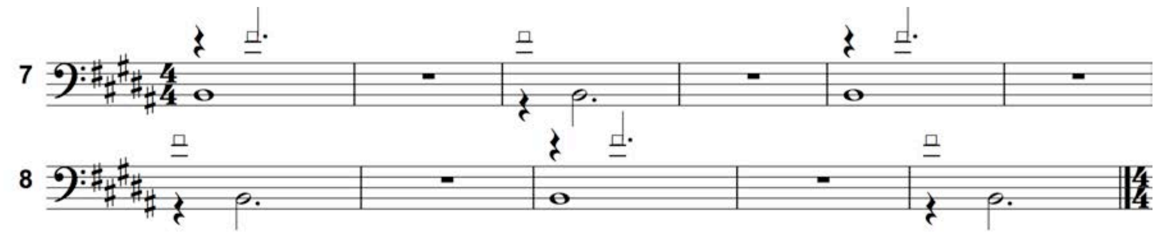

23
Moderato

The Perfect Twelfth

Play free, open, and musically. Focus on the sound of the interval and stay as relaxed as possible. This interval should be relatively easy to learn and hear because we hear the simple interval of a perfect fifth on a regular basis. Tips for a successful learning experience: (1) Keep the back of the throat relaxed. This will happen for one of three reasons (a) the student is trying to sing too high, (b) too loudly, or (c) the student's tongue is too far back in the mouth. One of these issues could cause problems, but multiple issues signify some assistance from a private teacher, as there may be another way to better approach trombone fundamentals. (2) Be sure you can feel the sides of your tongue toward the middle and front part of your mouth. (3) If you feel your tongue begin to move back, listen for how the sound quality changes and attempt to remember the sensation in the event the tongue slips again. Please do not go beyond your multiphonic range.

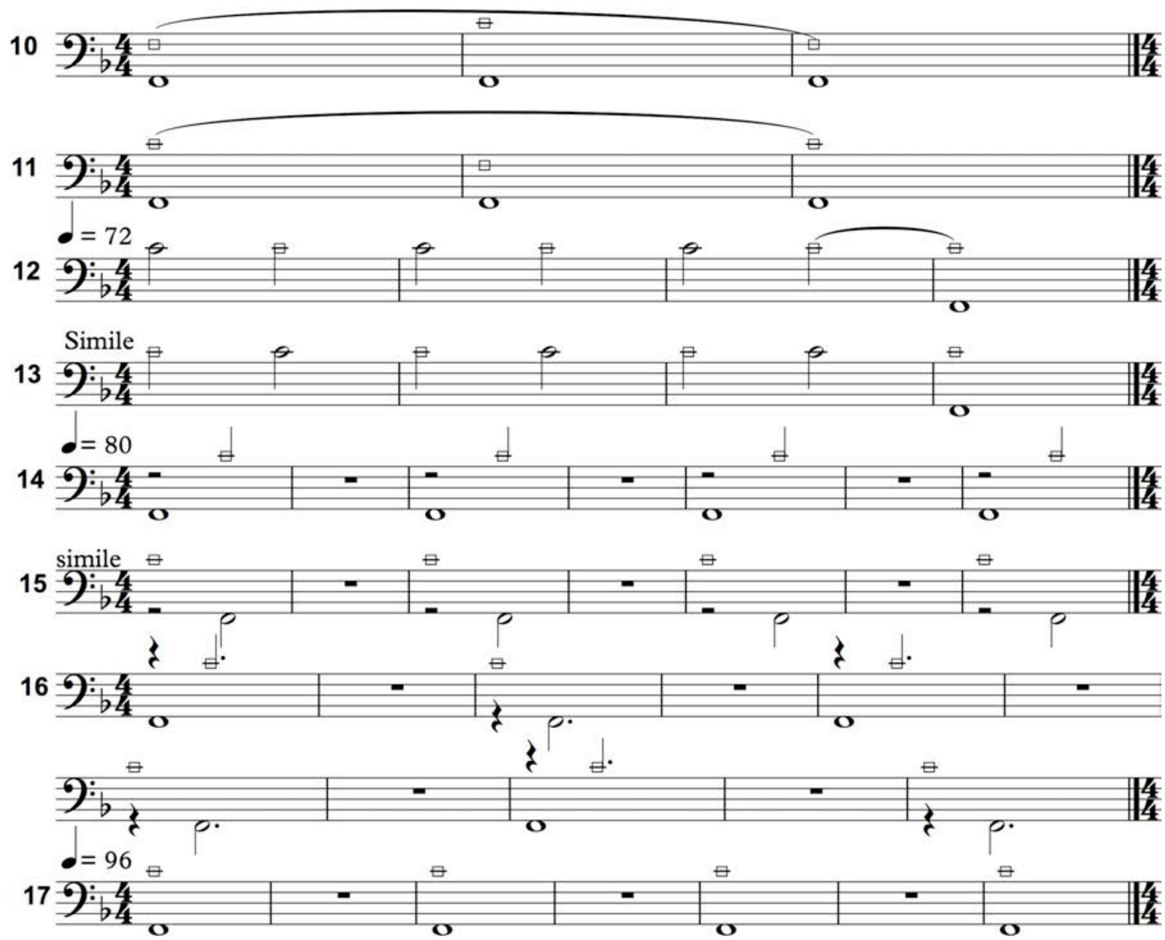
Subjective Tones for the perfect twelfth: an octave is located below the bottom note, an octave, major tenth, minor fourteenth, and a fifteenth found above the bottom note.





Strive for consistent and unison attacks. At times, it may be beneficial to practice this exercise without the tongue.

Perform exercises 11-17 in the same manner as 1-10.



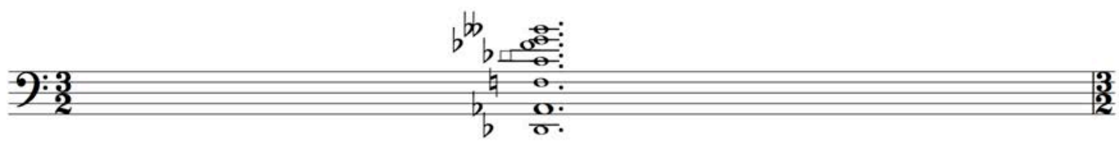
Listen to your body. Stop playing immediately if your embouchure or voice starts to hurt, as permenant damage can happen due to poor playing and singing habits. I advise you to limit your multiphonic practice time and to omit exercises that are out of your range.


Free, and flowing
25
Allegro moderato
26
Moderato cantabile
27
Adagio assai
28
Andante e gravità
29

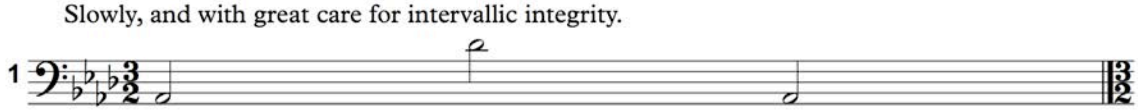
The Perfect Eleventh

The perfect eleventh shares some similarities to the perfect fourth. Fist, a perfect eleventh is simply a perfect fourth plus an octave. Second, similar subjective tones are found in both intervals. Half of the subjective tones in each interval are found in the other. Finally, the same adjustment needed for the justly-tuned perfect fourth is the same for the perfect eleventh. Here are some suggestions I find will help you in this interval section and throughout the method: (1) When accurately tuned, the perfect eleventh has far fewer beats than the perfect fourth, but it can also make tuning more difficult. Tuning can difficult because the perfect fourth lies in between the third and fifth scale degrees, which just happen to be two of the most important notes in tonal music. Therefore, (2) use the perfect twelfth as your guide tone. (3) A justly-tuned perfect eleventh is two cents lower than the equally tempered perfect eleventh. (4) Take breaks when needed. Like your playing endurance, you will have to build up your multiphonic endurance. This is done by daily effective multiphonic practice. (5) Be sure to watch and listen for signs of overexertion in the voice, embouchure, neck, and shoulders.

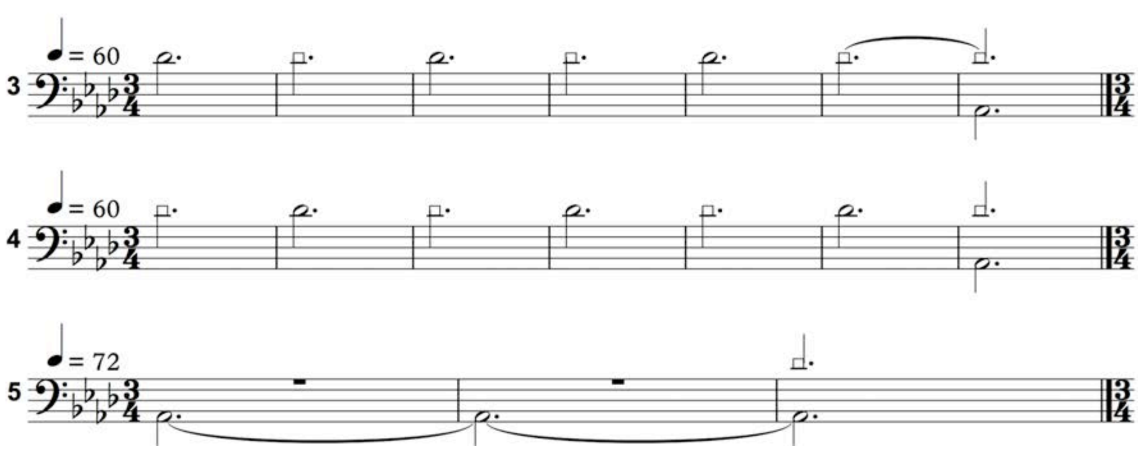
Subjective tones for the perfect eleventh include a perfect fifth below the bottom note and a major sixth, minor tenth, major fourteenth, minor sixteenth, and a minor twentieth above the bottom note.

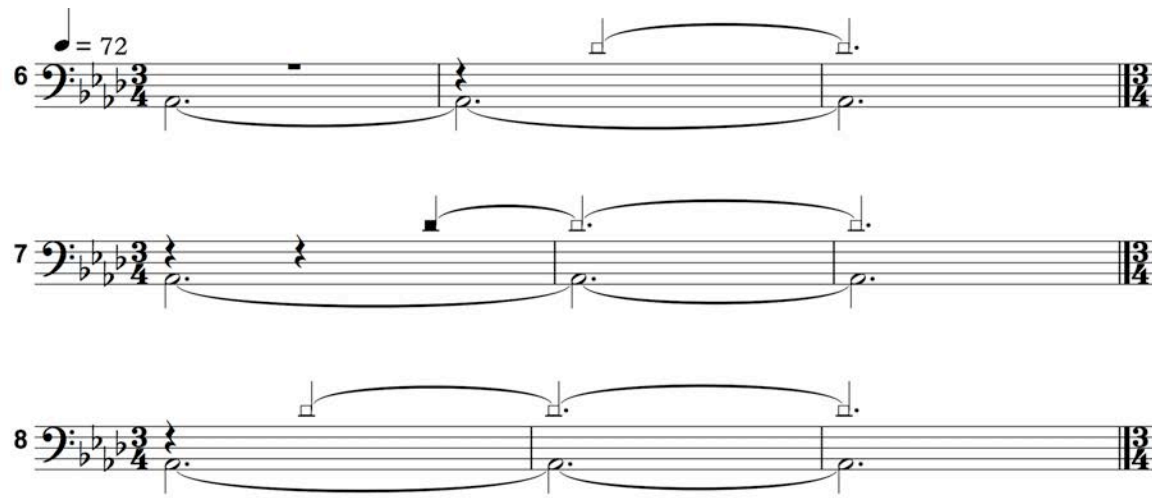


Slowly, and with great care for intervallic integrity.



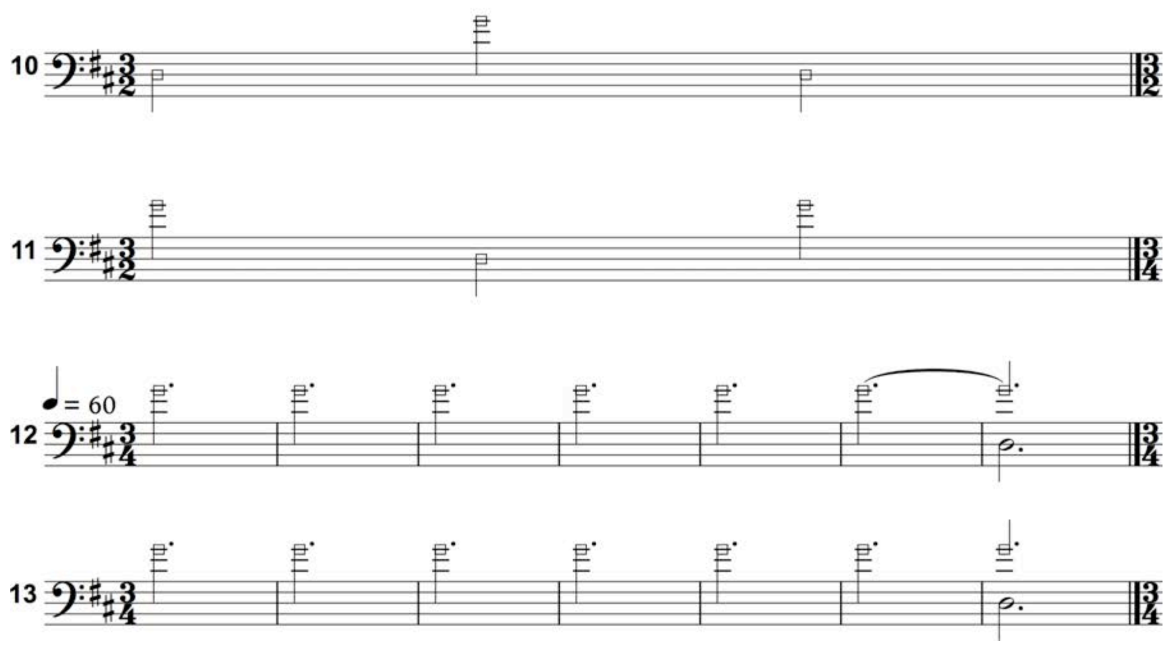
Try to make the transition from trombone to voice as smooth as possible. Likewise, the transition between voice and trombone should be incredibly smooth and, ideally, unnoticeable.

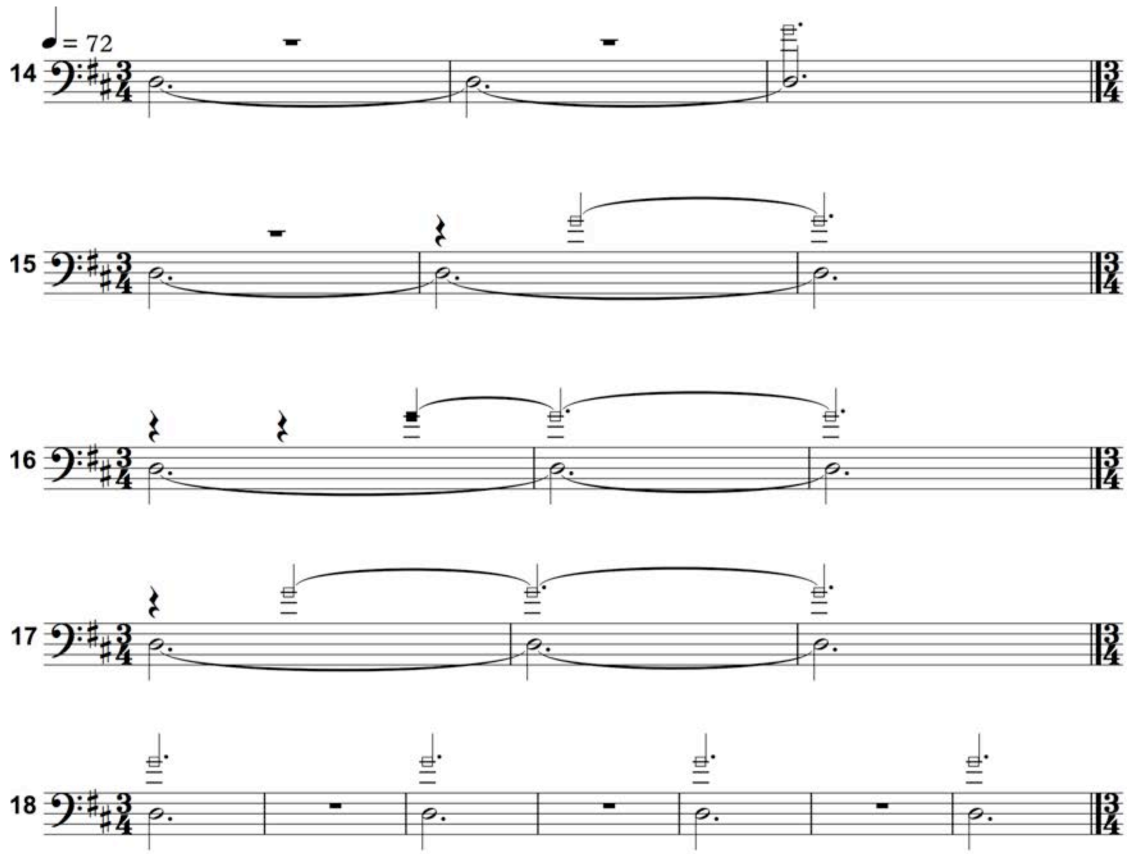




Perform this exercise twice. Use air attacks the first time and the tongue the second time.

Play exercises 10-18 in the same manner as 1-9.





You may find that moving the bottom note up an octave before staring exercises 19 and 20 makes the perfect eleventh interval easier to hear. Stop playing when an exercise goes beyond your range. Count measures of rest and enter as the exercise is once again within your range.

Some of the following etudes may not fit within your range. Do not play these. Instead, find etudes that will better address your needs. If an etude fits in your range but has some notes that are too high or too low, omit those notes and pickup once the sung line is within your range.

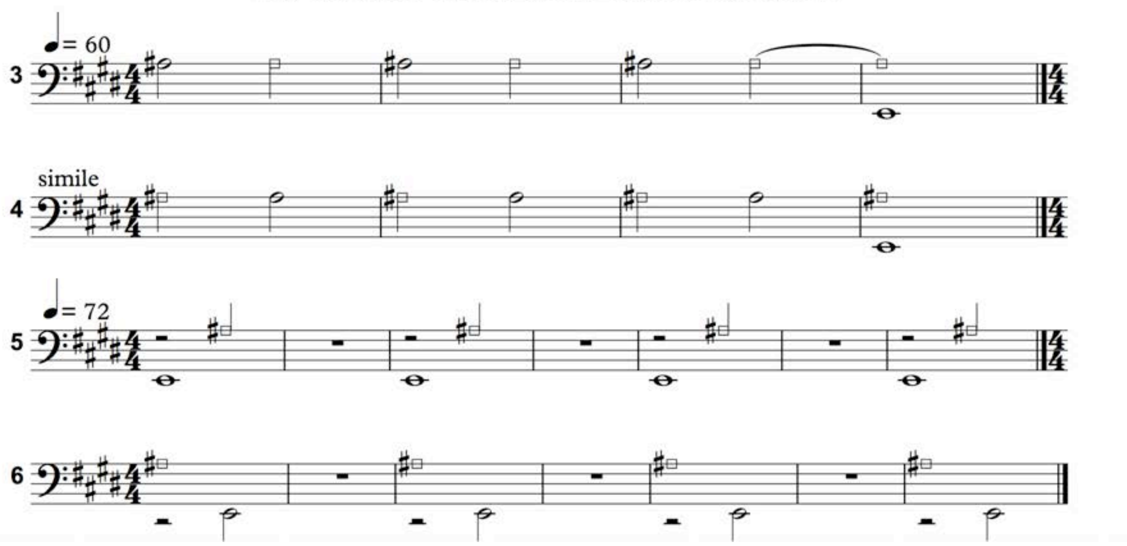

Andante cantabile
24
Moderato assai
25
Adagio
26

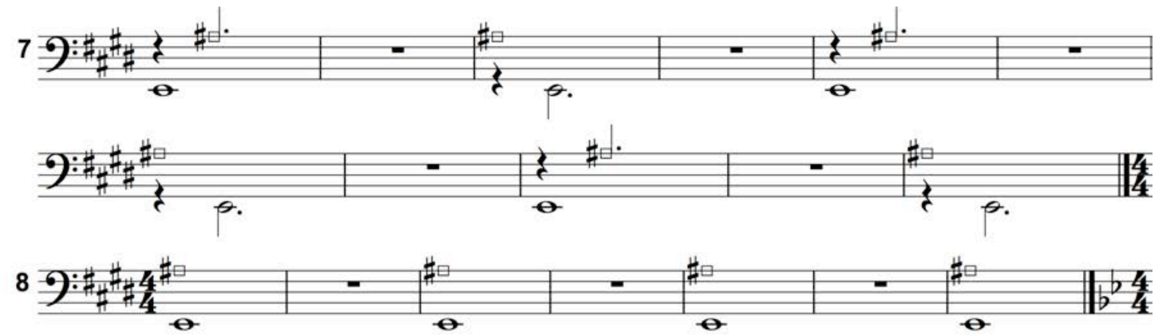
The Augmented Eleventh

Think of the augmented eleventh as being similar to the tritone, but with the augmented fourth located up an octave. Although the augmented eleventh and the tritone are similar sounding, the beating felt on the lips is less intense with this interval than it is with the tritone. Here are some suggestions I find will help you learn and master the augmented eleventh: (1) When accurately tuned, the augmented eleventh has far fewer beats than the tritone which can make tuning more difficult. (2) Use the perfect twelfth as your guide tone. (3) A justly-tuned perfect eleventh is seventeen cents lower than the equally tempered augmented eleventh. (4) Do not rush through these exercises. Instead, take your time, record yourself, and listen back to be sure that you are (a) playing with your best sound, (b) playing/singing in tune, (c) matching dynamics, and (d) moving accurately from one interval to the next.

Subjective tones for the augmented eleventh include a minor third below the bottom note and a major seventh, major fourteenth, minor seventeenth, and a major twentieth above the bottom note.

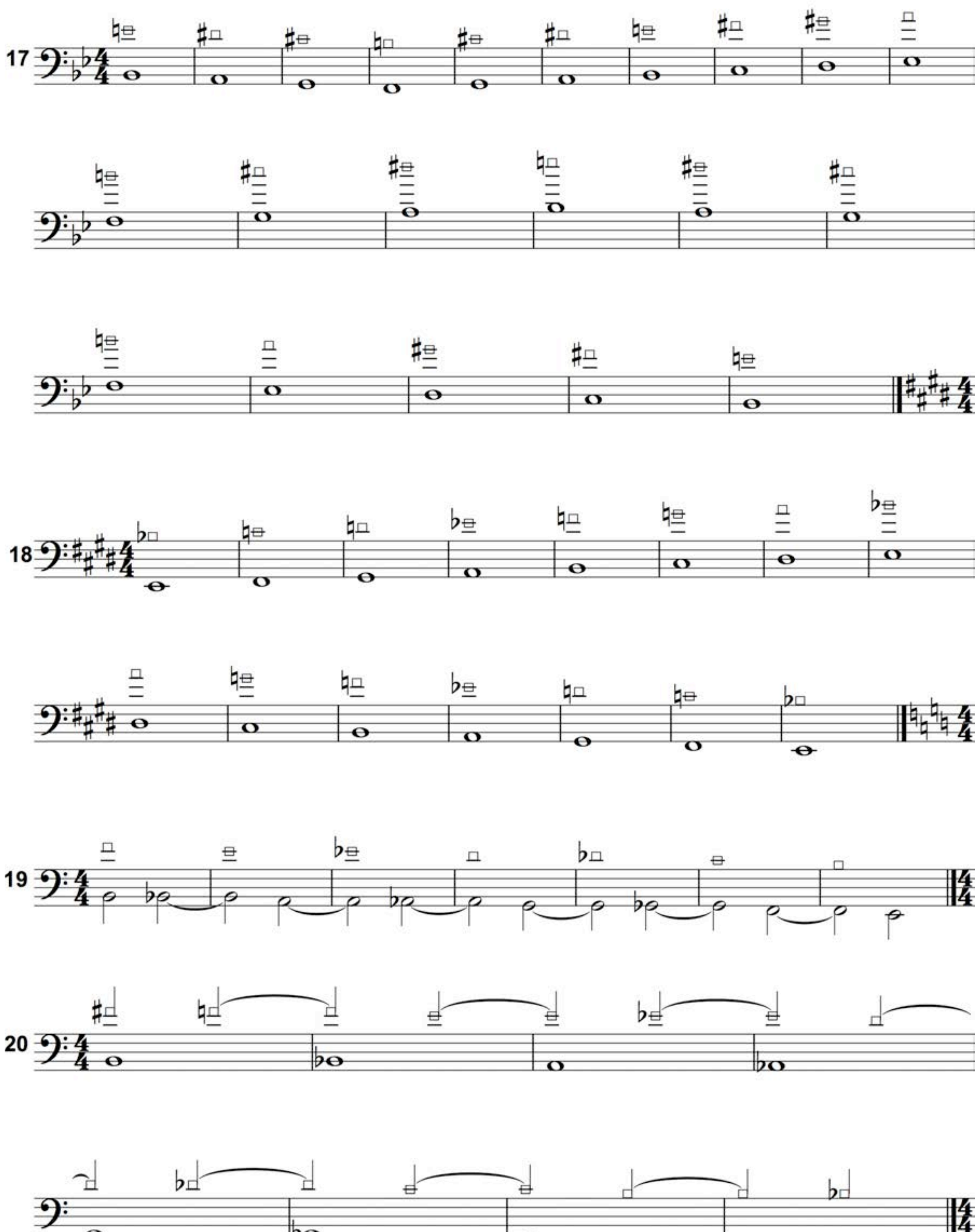
Play exercises 3-7 as smooth and connected as possible.

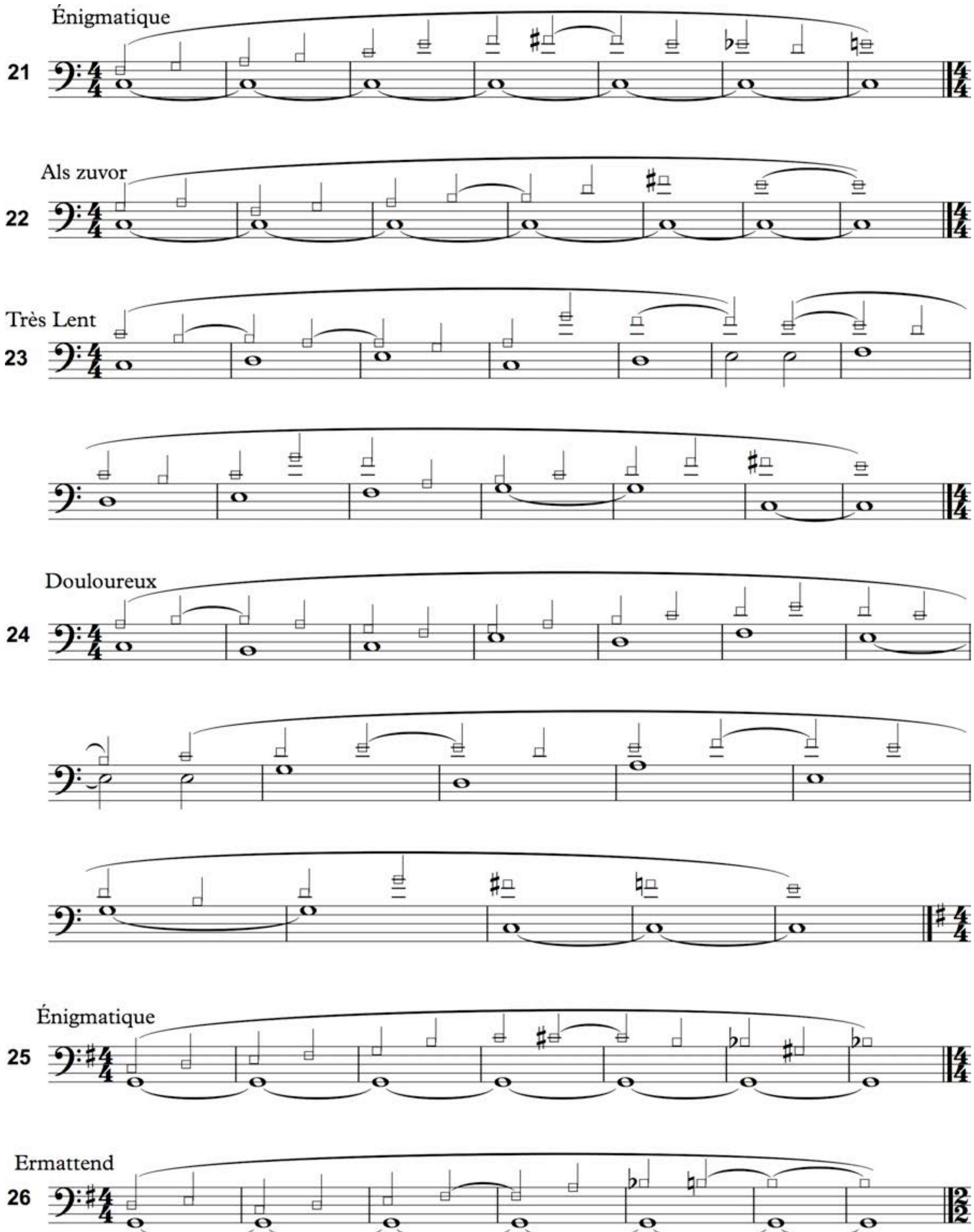




Exercises 9-16 should be played slowly and in a steady tempo. Listen for accurate intervals.

Play exercises 17-20 slowly and in a steady tempo.

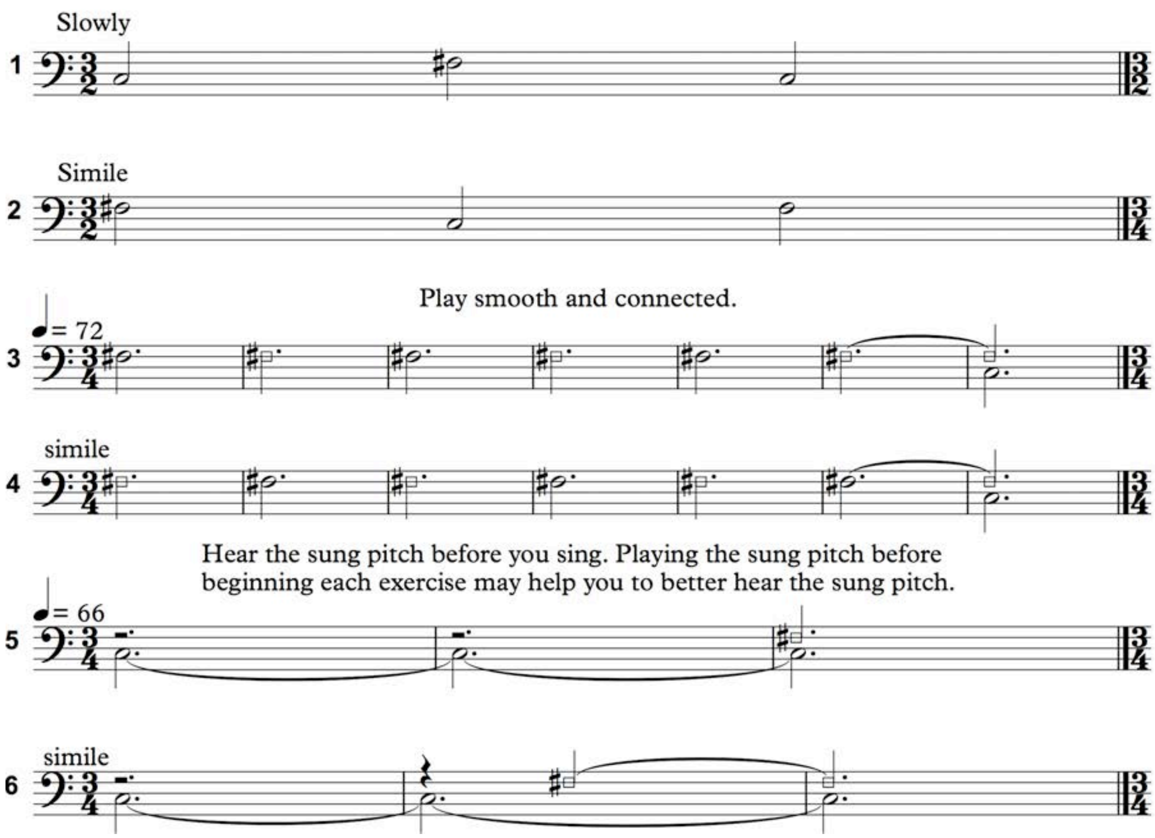


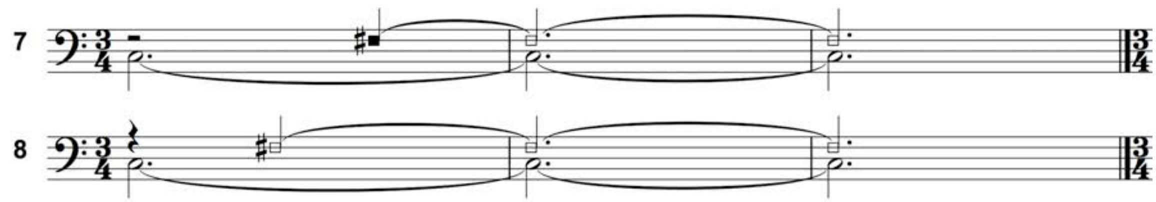

Énigmatique
21
Als zuvor
22
Très Lent
23
Douloureux
24
Énigmatique
25
Ermattend
26

The Tritone

The tritone can be difficult to hear when performing multiphonics, however, the use of tritone relationships throughout this method should help you to gain familiarity of this interval. Similar to the perfect fourth and major third, the tritone contains beats that can easily be felt on the lips. Tips for successful learning: (1) Avoid the temptation to be distracted by the beating sensation and listen for the quality of the interval. (2) Practice slowly moving from perfect fifths and fourths to the tritone. (3) Strive to match the dynamic of the trombone with your voice. Doing so will help to hear the interval better.

Subjective tones for the tritone: a major seventeenth, minor seventh and a major second are found below the bottom note, while a major second, major sixth, minor tenth, and a major fourteenth are found above the bottom note (see below).



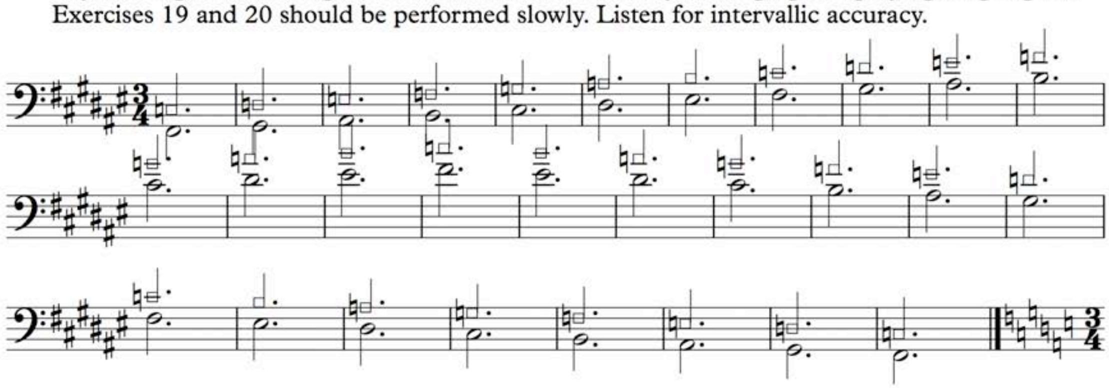


Match dynamics and work on clean, unison attacks of the voice and trombone.

Play exercises 10-18 in the same manner as exercises 1-9.

Go as high and low as possible with ease and without strain. Stop when you reach the extremities of your range and start again when the exercise reaches your singing and playing range again. Exercises 19 and 20 should be performed slowly. Listen for intervallic accuracy.

19



20

Exercises 21 and 22 move between tritones and perfect fifths. Listen for the change in timbre and strive to make as much contrast as possible between the intervals. Play these exercises slowly.

21

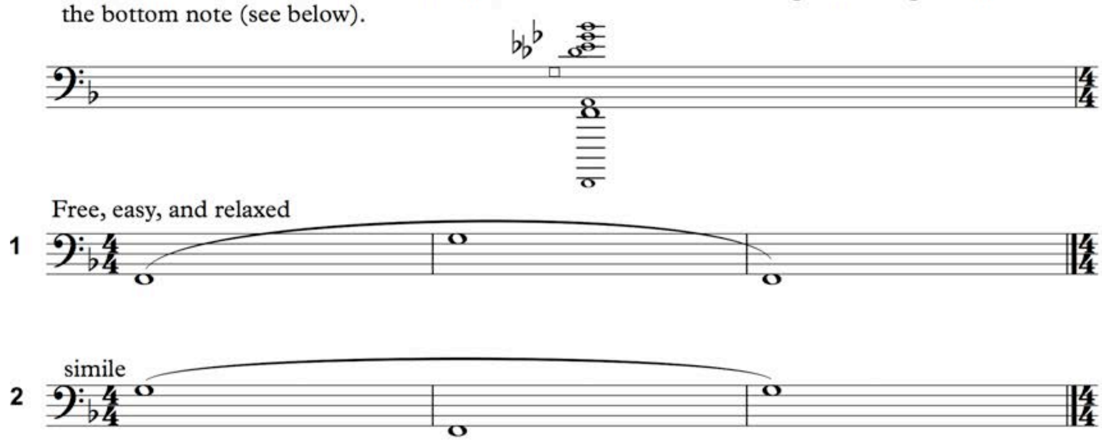
22


Andantino
23
Larghetto
24
Bewegt
25
Andantino
26
Larghetto
27
Bewegt
28

The Major Ninth

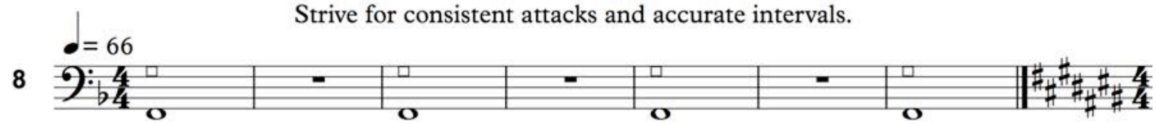
Tuned accurately, which is not complicated, the major ninth can create a sensation of a "rolled" sound. This timbre can be heard by the various subjective tones that are addressed below. When played softly, the effect is greatly enhanced which can make some subjective tones sound louder than others when played at a louder dynamic. Beats are heard and felt, however, the sensation on the lips is not as great as you experienced with the tritone and minor third. Tips for success: (1) To have a chance of hearing subjective tones, the voice must be lowered by four cents. (2) Use the octave as a guide note to help hear where to place this interval. Remember, the major ninth is simply an octave above a major second, so (3) think of this interval as a major second but with a greater timbral palate. Finally, (4) if this interval is, or becomes, problematic, practice playing scales by playing the tonic note on trombone and sing the scale up to the ninth, holding the ninth as long as possible.

Subjective tones for the major ninth include a fifteenth below the bottom note and a major third, minor thirteenth, minor fourteenth, minor sixteenth, and an augmented eighteenth above the bottom note (see below).



Aspire to have no breaks in the sound while learning exercises 3-7 and 11-15, as the goal of these exercises is to have smooth transitions between notes and accurately-tuned intervals. Slow down the tempo if needed, and try to have a similar quality of sound between the trombone and voice.

Strive for consistent attacks and accurate intervals.



Play exercises 9-16 in a similar manner as exercises 1-8.

Listen for clean attacks and accurate intervals. At times, pause to check your intonation with a tuner to verify you are raising the sung note by four cents. Play exercises 17-20 slowly, with your best sound, and free of tension in you neck, shoulders, face, and as you breathe. Playing with good posture (I recommend sitting) provides you with the best opportunity to perform at your best with the least amount of effort.

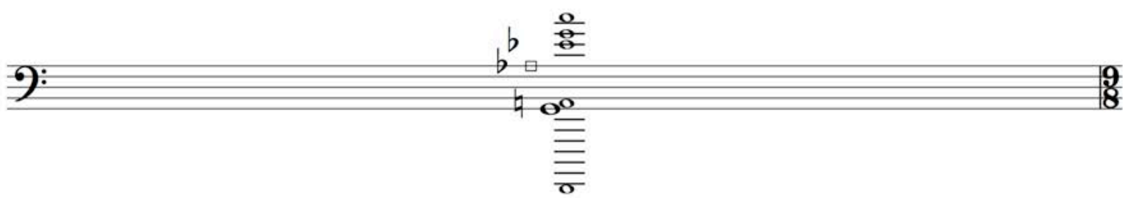
Choose from the following etudes those that lie within your multiphonic range. Use the phrase markings as a guide for breathing, however, if you need a breath before the end of a phrase, chose a musically appealing spot to do so. Play full value notes and breathe on the upbeats. Look up unknown terms and write down their definition in the text.

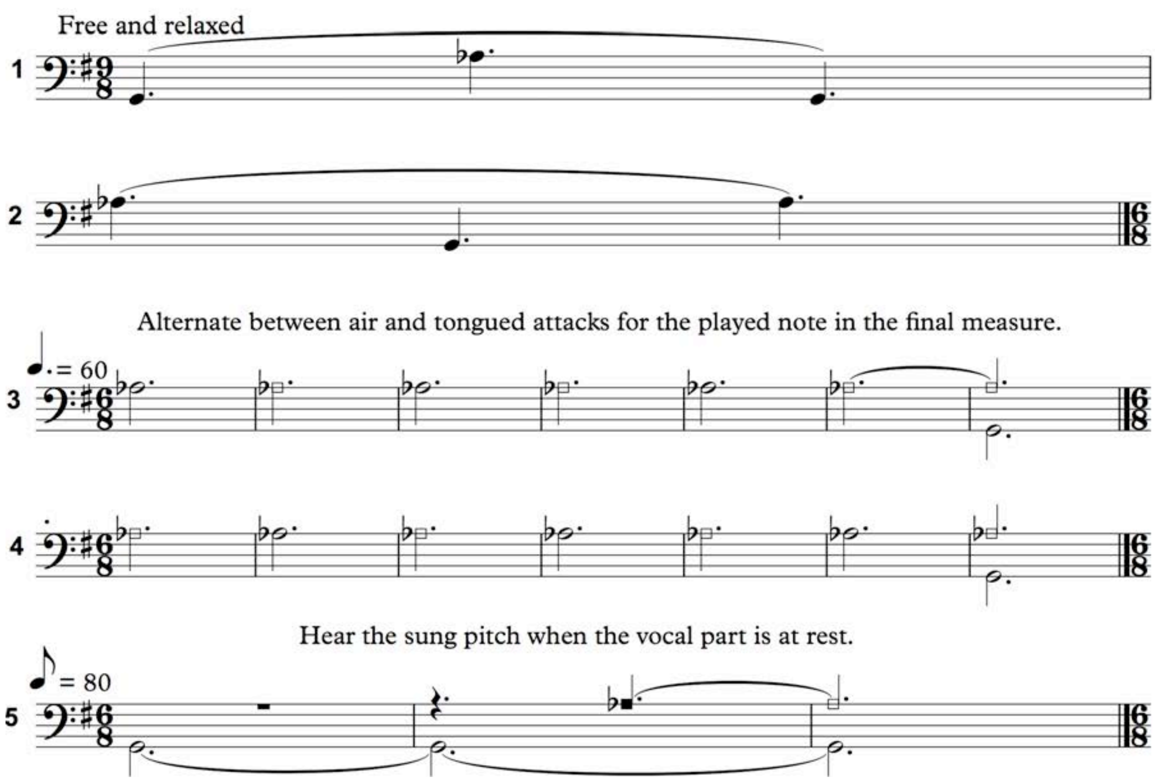

Larghetto
26
Langsam
27
Andante ma non troppo
28
Lieblich
29
Mässig
30

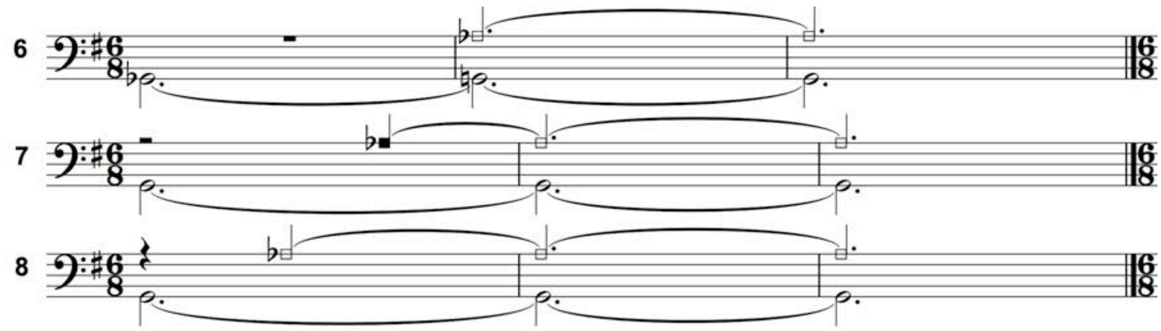
The Minor Ninth

Of the intervals learned thus far, the minor ninth may be the most difficult to master. There are three main obstacles to overcome before mastering this interval. First, you are trying to play a minor second (one of the most difficult intervals to learn) plus an octave. Second, although there is less noticeable beating felt on the embouchure, the beating makes holding the vocal note in tune for an extended period of time quite challenging. Lastly, matching dynamics is difficult as intervals increase in size. Additionally, there is not a useful guide tone to assist with placing the minor tenth. With that said, here are a few tips to help you master the minor ninth. (1) Use mouthpiece pressure to your advantage. By using less mouthpiece pressure, you will find it much easier to play softer and have the vocal note sound louder. Experiment for yourself, but for most people, only a minute change in pressure is needed for this "trick." (2) Learn the sound of this interval. Be able to sing, whistle, or aurally identify a minor ninth. (3) Playing minor ninths against a drone, piano, or another trombonist will greatly help in learning to hear this interval. Finally, (4) <u>this interval needs to be raised by twelve cents</u>, compared to the tempered interval, to obtain a justly-tuned minor ninth.

Subjective tones for the minor ninth include a major sixteenth below the bottom note and a major second, minor thirteenth, a fifteenth, and a perfect eighteenth above the bottom note (see below).

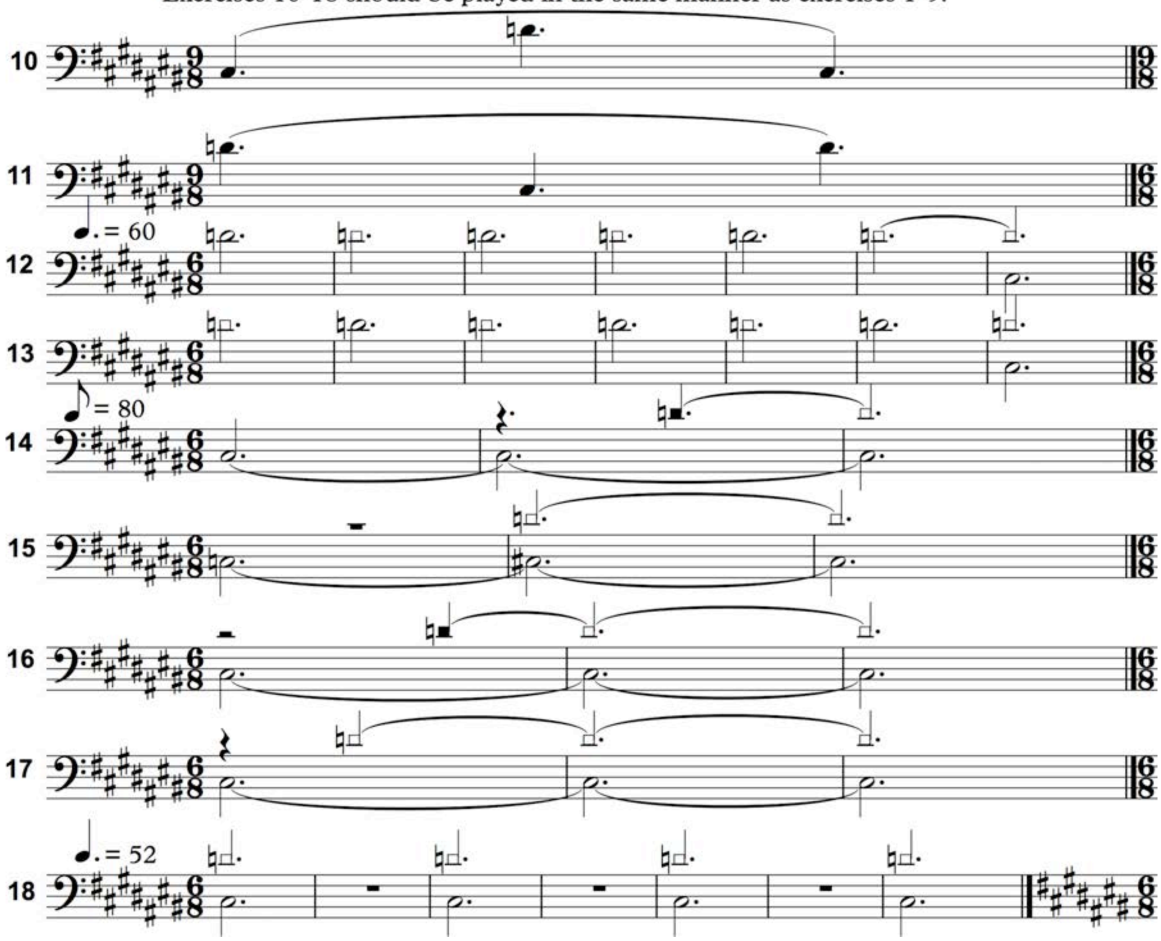




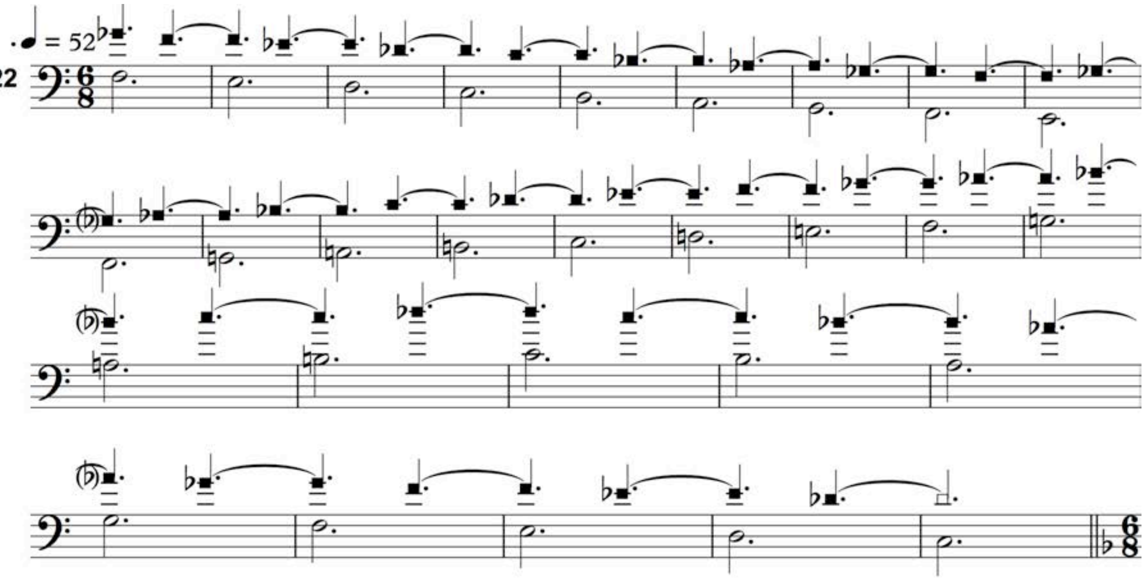


Repeat this exercise as needed. Strive for instant sound from both the voice and trombone.

Exercises 10-18 should be played in the same manner as exercises 1-9.

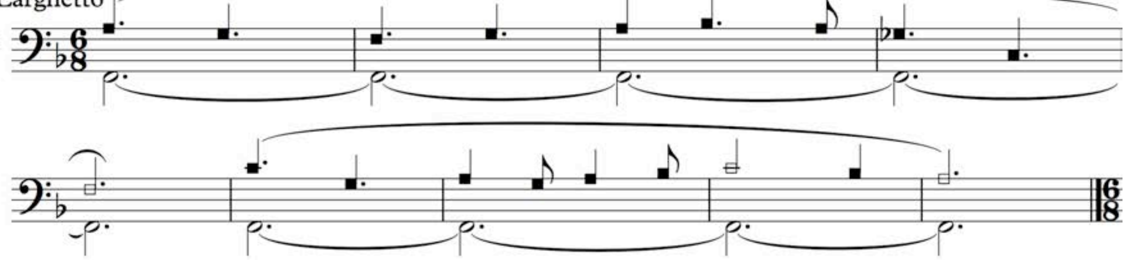


Exercises 19-22 contain some high sung pitches. Do not overexert yourself by playing outside your comfort level. Breathe where needed and use five different attacks: (1) Air attacks, both combined with the voice and alone before the trombone enters, (2) Tongued attacks, both combined with the voice and alone prior to the vocal entrance, (3) begin with the voice and add the trombone to the vocal sound, (4) Start with an air attack on the trombone, then add the voice, and, lastly, (5) begin with a tongued attack before adding the voice.

22


The following etudes should be played with great care, as vocal lines contain more leaps in this section than in previous sections. Play both lines on the trombone before attempting to put both "voices" together. Isolate any challenging passages and work them up to tempo slow to fast. Stay relaxed, breathe easy, and stay within your multiphonic range. Play all exercises that lie within your range.

Larghetto

23


Adagio

24

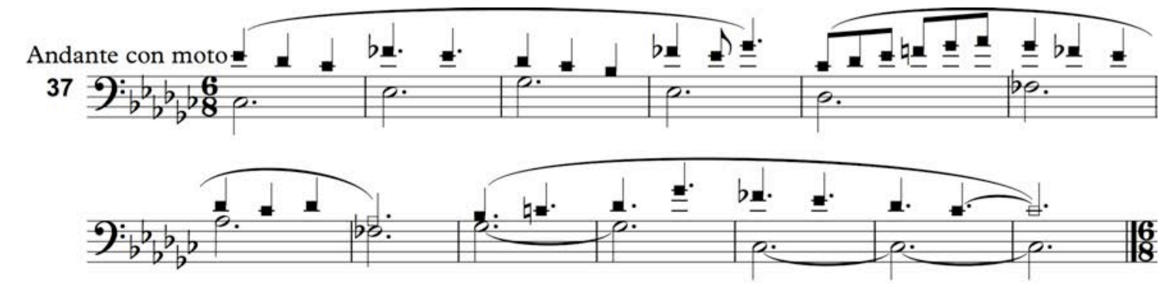

Andante con moto

25



Lento ma non troppo
26
Larghetto
27
Adagio
28
Andante con moto
29
Lento ma non troppo
30

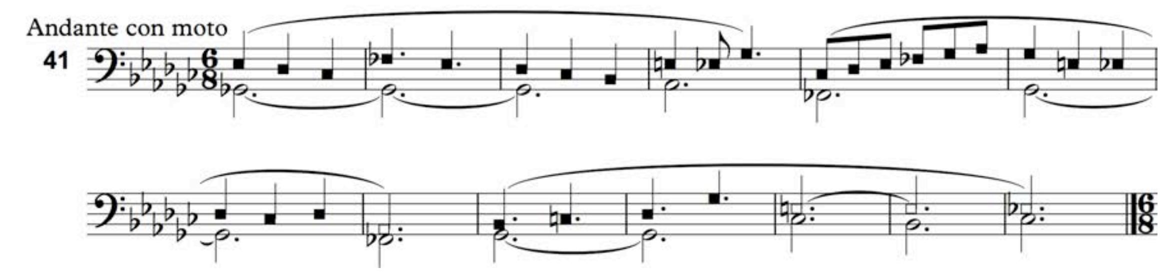

Larghetto
31
Adagio
32
Andante con moto
33
Lento ma non troppo
34
Larghetto
35
Adagio
36


Andante con moto
37


Lento ma non troppo
38


Larghetto
39


Adagio
40


Andante con moto
41

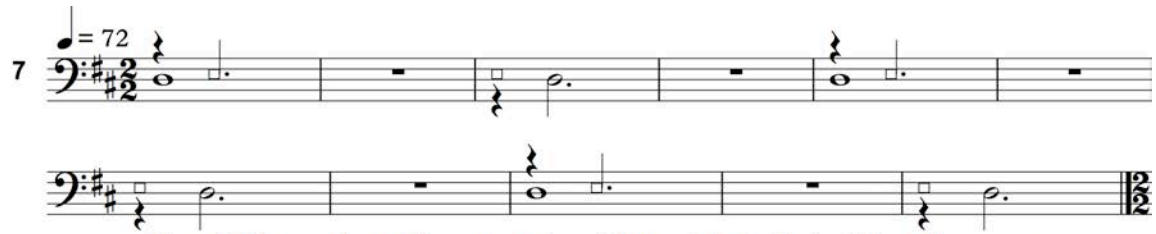

Lento ma non troppo
42

The Major Second

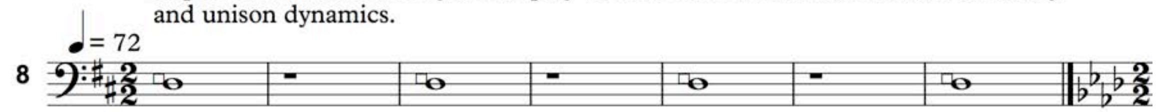
The major second is one of the more challenging intervals to learn, so take your time with these exercises. The beating phenomenon adds to the difficulty of this interval, but playing exercises 1 and 2 with a slight flutter tongue may help you become accustomed to the sensation felt on the lips.

Suggestions for success. (1) Listen for a clear major second interval. This can be accomplished by (2) playing the lower note softer than the sung note. Eventually you will want to have the same dynamic for both notes so that you can (3) listen for subjective tones. (4) To do this, you will need to be an active listener while you practice; imagine yourself sitting in the audience and listen as closely as you can. (5) <u>The justly-tuned major second is four cents higher than an equal-tempered major second</u>.

Subjective tones include: a twenty-second and a major second below the bottom note, and a major sixth, minor seventh, an octave, and a perfect nineteenth are seen above the bottom note.



Repeat this exercise until you can play with consistent attacks, intervallic accuracy, and unison dynamics.



Perform exercises 9-16 in the same manner as exercises 1-8.

Play with great care, exercises 17-20. Be sure to stay within your range, listen for possible subjective tones, and play accurately-tuned major seconds. Remember, raise the vocal part by four cents to obtain a justly-tuned major second. Use a little less mouthpiece pressure to help the sung note sound louder.


= 72
20
Andante moderato
21
Adagio
22
Larghetto
23
Largo
24

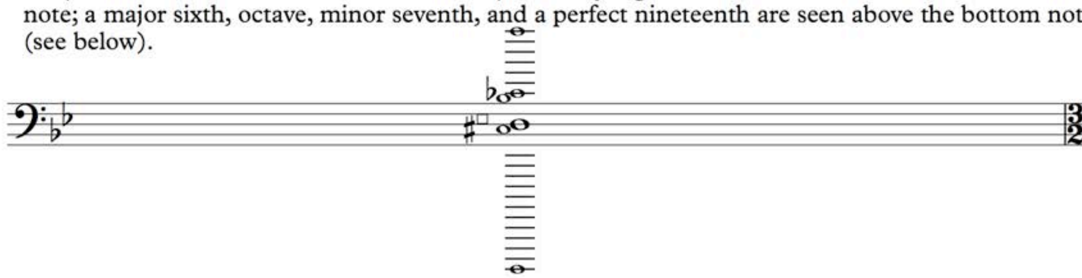

Moderato
25
Adagio
26
Larghetto
27
Largo
28

The Minor Second

Playing minor seconds creates intense beats that can make it difficult to control pitch. These beats are easily heard and are felt on your lips. This is the primary reason the minor second is difficult to master. If the beating is extremely problematic to learning this interval, try playing with a slight flutter to help simulate the feeling of beating

Suggestions for success: (1) Keep your embouchure steady; strive to keep your corners firm as you learn this interval. (2) Initially, play the bottom note as soft as you can, doing so allows you to better hear the interval and allows the sung note to be easily heard. (3) Try starting some exercises with the sung note, others with the played note. (4) As with other difficult intervals, using less mouthpiece pressure often yields good results and helps the vocal note to sound louder. (5) Finally, the justly-tuned minor second is twelve cents wider than the equally-tempered interval. Raise the voice to adjust to just tuning.

Subjective tones for the minor second: a major twenty-eighth and a minor second lie below the bottom note; a major sixth, octave, minor seventh, and a perfect nineteenth are seen above the bottom note (see below).



Use exercises 1 and 2 to help you hear the minor second interval. Play these exercises in just intonation. Use a tuner to help you visualize the justly-tuned minor second.

Notice the slide position markings located at the beginning of each exercise, as they are to be used throughout the entire exercise. Work on sustaining the voice while "breaking away" from the unison. If you have an F-attachment, be sure to use the valve in exercise number three, otherwise, use seventh position. Play these exercises slowly.

Again, notice the slide position markings for exercises 6 and 7. Sing all F's in second position to familiarize yourself with singing the sung note in a different position. Here, the difficulty lies in the fact that you are attempting to sing a note that does not lie within the harmonic series of the given position. Do your best to match pitch and timbre between the played and sung notes.

6 

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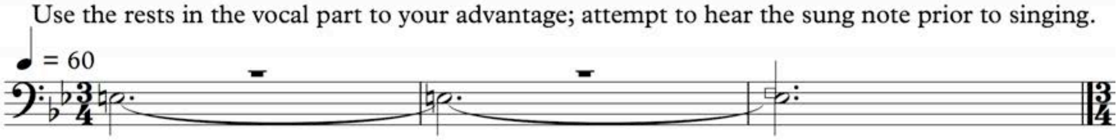
Use the rests in the vocal part to your advantage; attempt to hear the sung note prior to singing.

8 

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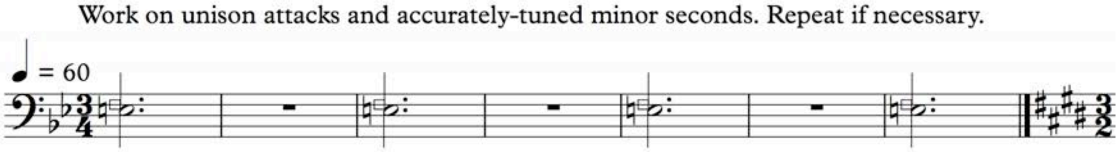
Work on unison attacks and accurately-tuned minor seconds. Repeat if necessary.

12 

Exercises 13-24 should be played in the same manner as exercises 1-12.

13 

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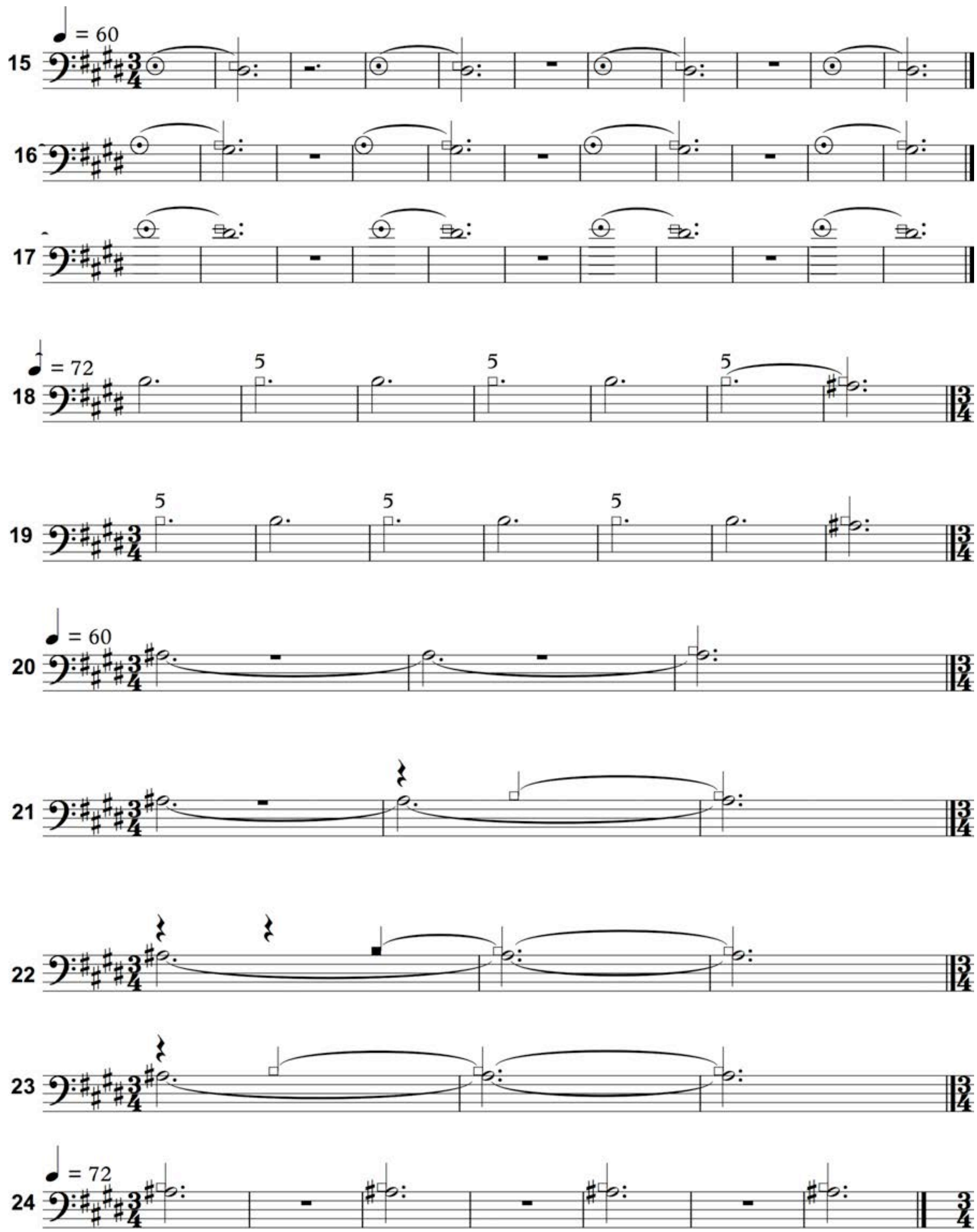

= 60
15
16
17
= 72
18
5
5
5
19
5
5
5
20
= 60
21
22
23
24
= 72

Use exercises 25-28 to firmly establish the minor second in your ear. It may be beneficial to play these exercises slowly and out of time before playing them at the indicated tempo. As with all other exercises found in this method, play as many exercises as you can with ease and control. Do not go beyond your range and, if necessary, omit measures that lie beyond your range.


= 88
29
= 66
30
= 72
31
= 96
32
= 60
33
= 96
34
= 80
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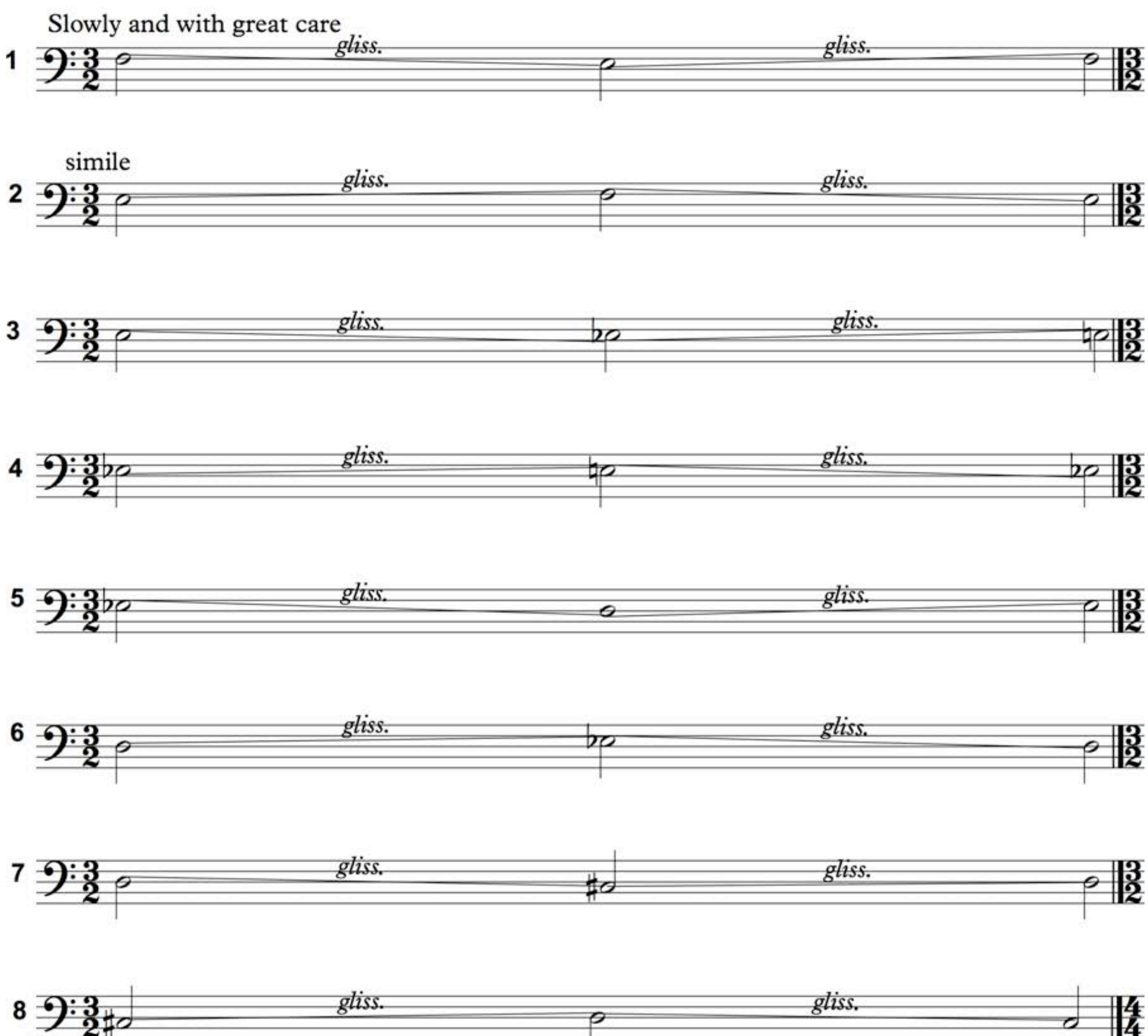
The etudes on this page are fairly challenging. Be sure to play each "voice" on the trombone prior to playing each etude. Once you are able to clearly hear each "voice," begin to add the trombone and voice together. Begin with slow tempos (half-time) and gradually increase the tempo until the indicated tempo is reached. Observe phrase markings as much as possible, but breathe when needed.

Quarter Tones and Indeterminate Intervals

In Exercises 1-8, you will learn to hear quarter tones by performing slow glissandi. You will hear the quarter tone twice each exercise; once at the middle of the descending gliss, and again in the middle of the ascending gliss. These exercises are to be performed unsung on the trombone.

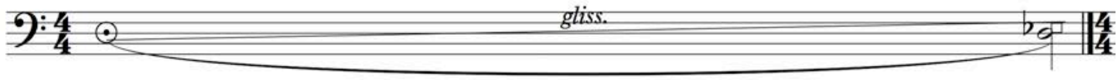
Tips for completing this section of the method: (1) Have fun and play with your best sound. (2) Don't worry about playing completely accurate quarter tones in the beginning. The idea here is to introduce you to the subject so that you have a solid framework to work with once the exercises become more challenging. (3) Each quarter tone has two guide tones a half-step away from each other. Use this to your advantage and listen for three notes: the starting note, quarter tone, and the final note, or half-step. This type of slow practice, especially on the first few exercises will greatly improve your chances for success.



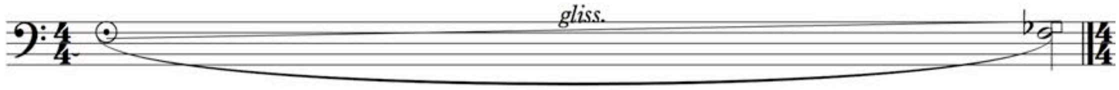
STOP

Do not continue until you can identify where the quarter tone lies and can hear it clearly.

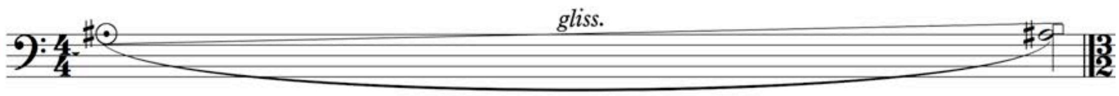
Listen for the location of the quarter tone in the following exercises. At times, try to stop on the quarter tone so as to hear where it lies in relation to the starting note.

9 

Play this exercise starting on sixth and first positions.

10 

Play this exercise starting on fifth and first positions.

11 

STOP

Move on to the following exercises only after you
are able to consistently hear and place quarter tones.

In exercises 13-18 you learn to (1) gliss to the quarter tone, (2) sustain the quarter tone interval, and (3) reach the minor second interval. Play these exercises SLOWLY, as doing so provides you with the best opportunity for immediate success.

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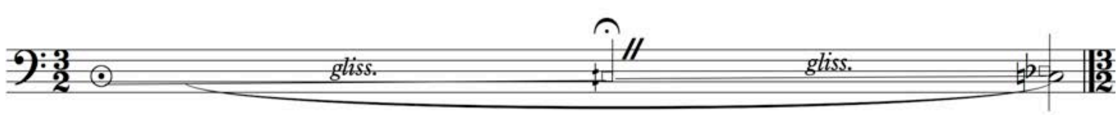
16 

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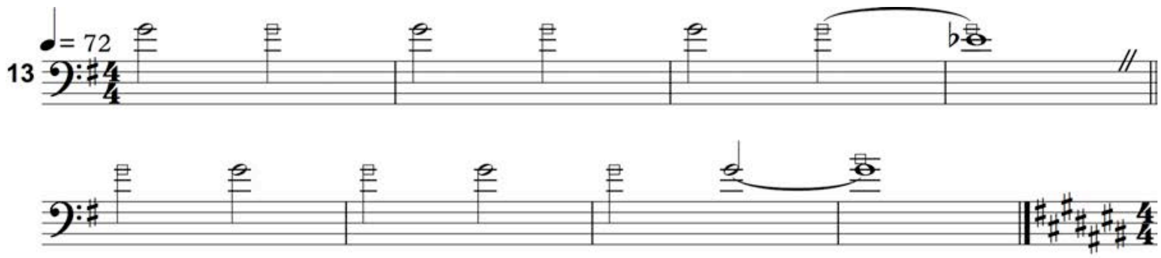
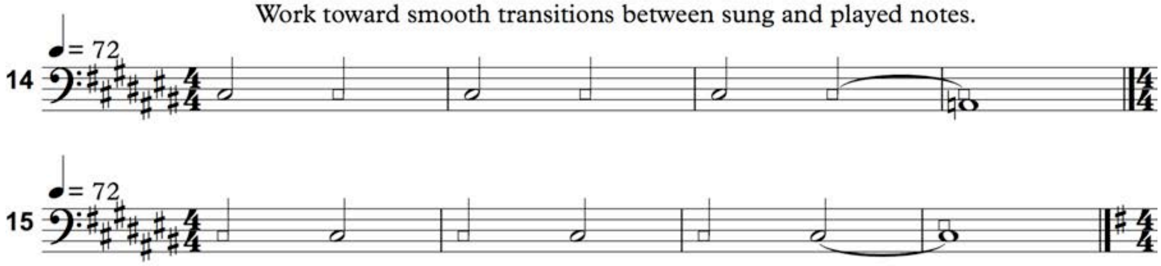
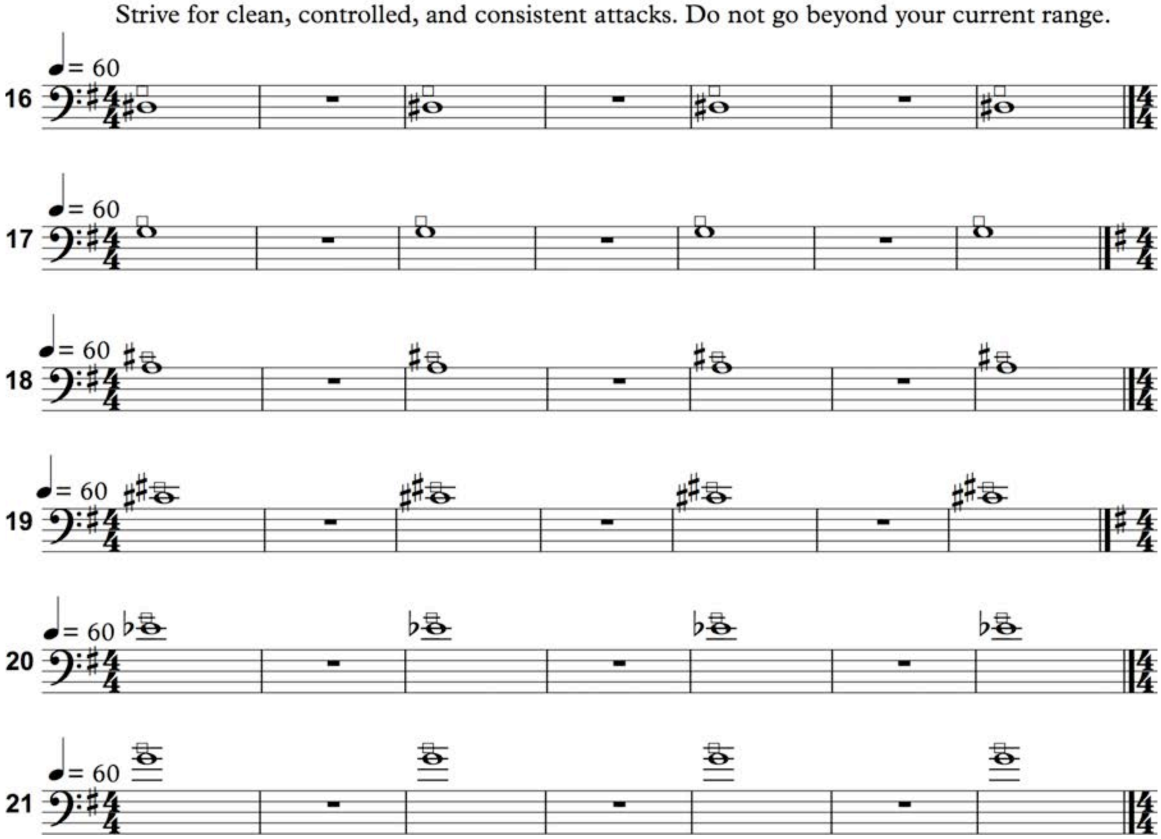


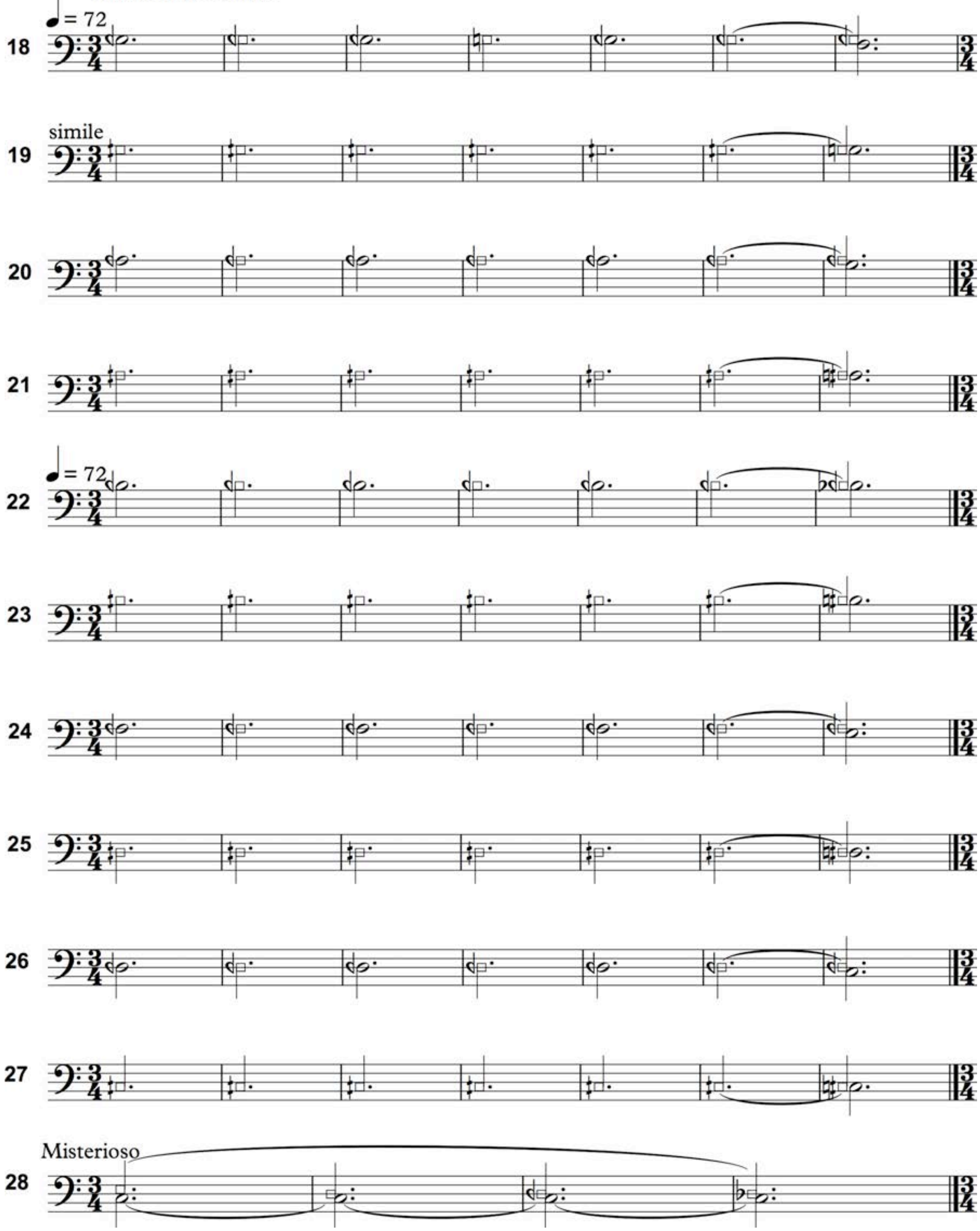
Work toward smooth transitions between sung and played notes.



Strive for clean, controlled, and consistent attacks. Do not go beyond your current range.



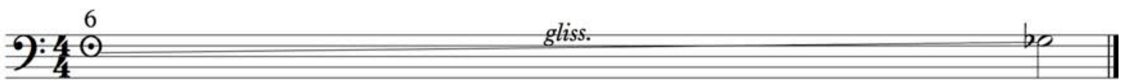
Check your initial pitch with a tuner before proceeding with each of the following exercises listen actively for subjective tones and sounds and the quality of each interval. Breathe on the barline if necessary.



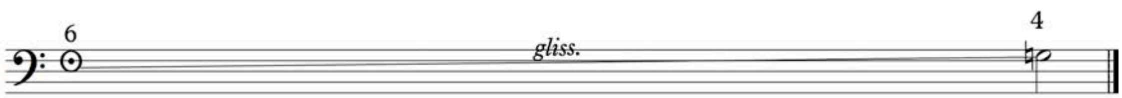
INTERVAL STUDIES II – SINGING BELOW THE PLAYED NOTE

Initial Exercises

Keeping the sung note constant and steady, slowly move the slide from sixth position to 5th position.

1


As the exercises become more difficult, the played note may drop to the third partial. Do not be discouraged if this happens; move the slide slower and keep your embouchure steady. A slow slide and a firm, but relaxed, embouchure will assist in mastering these exercises.

2


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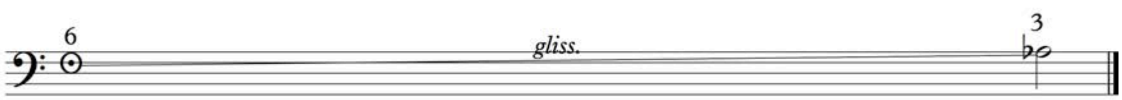

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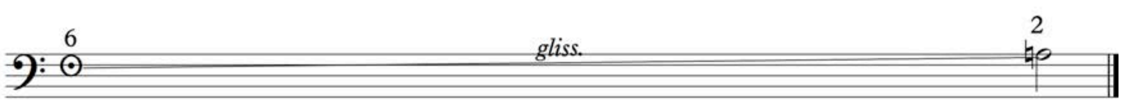

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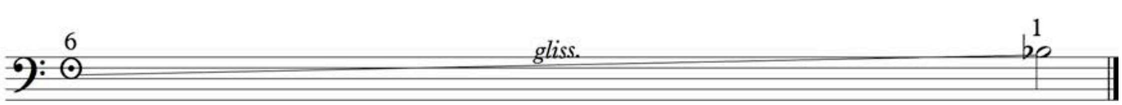
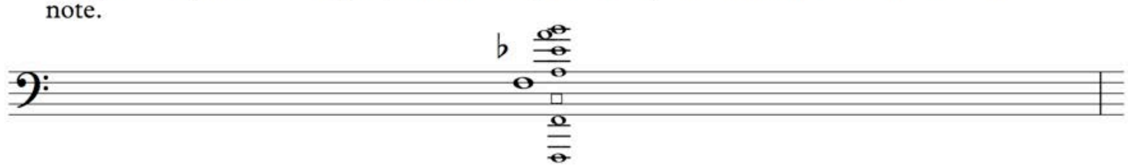


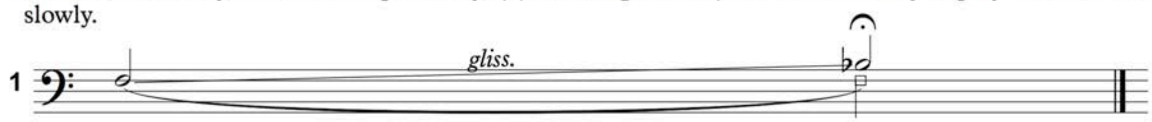
The Reverse Perfect Fourth

The reverse perfect fourth will initially feel like there are more beats than the traditional version. This beating is not very strong, however, it is noticeable enough that it could cause some additional difficulty. Here are a few suggestions to assist with learning the reverse perfect fourth: (1) Play the first four exercises with a light flutter tongue, as doing so will help you become accustom to the beating sensation felt on your lips. (2) Remember that <u>the just perfect fourth is lower than the equally-tempered perfect fourth by two cents</u>.
(3) The voice should make any necessary pitch adjustments, as it is easier to control at this point in your development of the technique. Eventually you will learn, through trial and error, to adjust the pitch of the played note as well as both "voices" simultaneously.

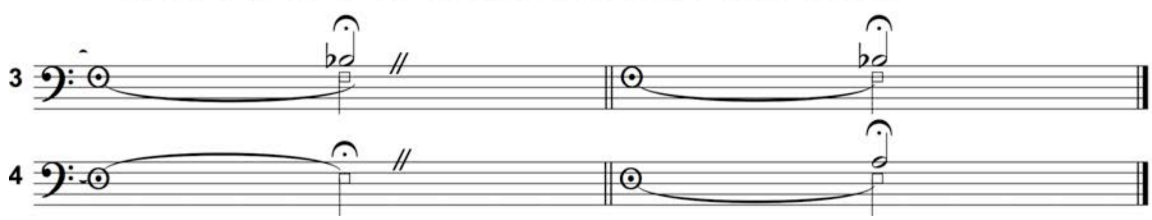
The following subjective tones may be heard when performing perfect fourths and are notated below: A perfect twelfth and perfect fifth are seen below the bottom note, while a major sixth, minor tenth, major thirteenth, and a major fourteenth lie above the bottom note.



Play the glissandi exercises free in time. Although some of the later notated glissandi are not "true," as they require crossing a partial, they are still effective exercises for reverse multiphonics. If you find a "false" glissandi, figure out what position(s) and partial(s) you will use. Write these down so you don't forget how to play them. These exercises are good for (1) Air support, (2) tuning of the final interval, and lastly, and most importantly, (3) listening for subjective sounds as you play each exercise slowly.



Moving from a unison to the reverse perfect fourth can feel similar to a lip slur. Strive to make the transition to the fourth partial as smooth as possible. Exercises 3-6 should be performed free from time. Pause briefly after each caesura.



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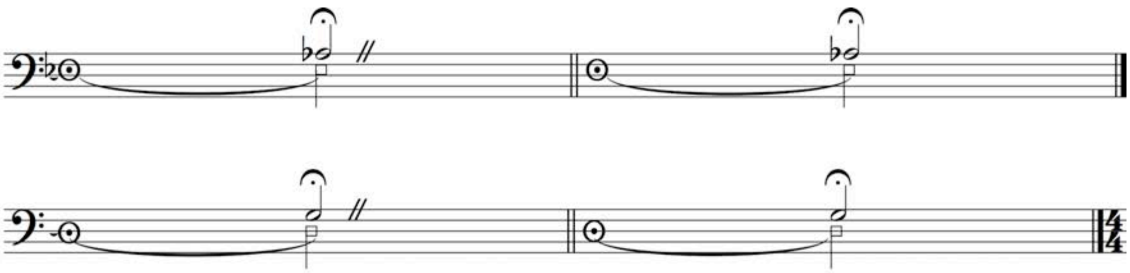

<u>Play each exercise a minimum of two times.</u> The first time use a breath attack, as it is easier to add the played note in the final measure this way. The second time use a tongued attack. Strive to sustain the sound when switching between voice and instrument. Hear the final played note in your head as you play each exercise.

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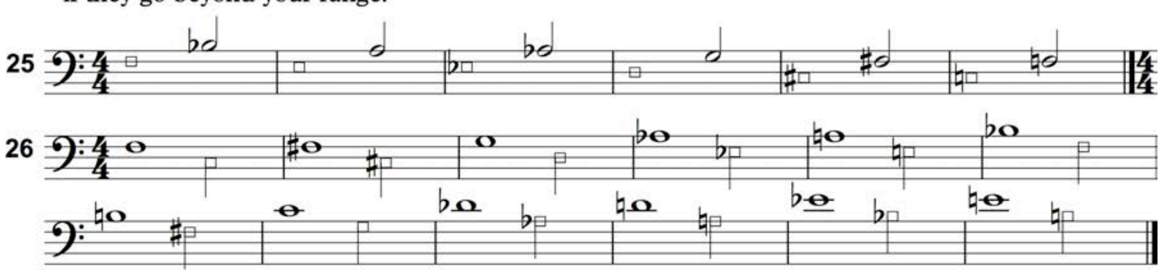
Play from the following exercises, those in which you can play with ease. Do not attempt exercises that are beyond your range. If an exercise is too difficult, play it at a reduced tempo and use air attacks to assist in performing the final played notes. The purpose of these exercises is to (1) play accurate reverse intervals, (2) learn to blend and balance the voice and instrument in a new way, and (3) familiarize yourself with the sound of the reverse perfect fourth.

If you find the following exercises too challenging, try using air attacks or play each note on your instrument prior to starting each exercise.

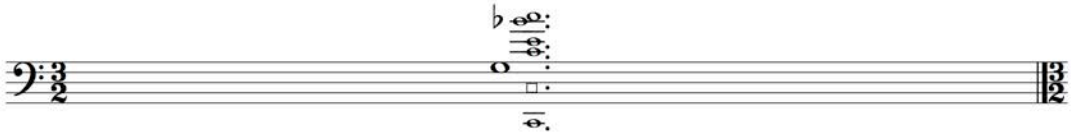
Slowly, and with a good sound. Breathe where needed. Omit any part of the following exercises if they go beyond your range.



The Reverse Perfect Fifth

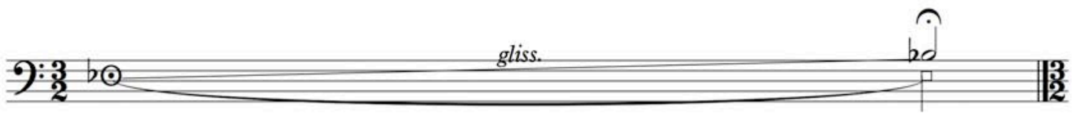
Similar to the perfect fourth, the perfect fifth is relatively easy to master as your fundamentals begin to improve. These fundamentals will improve by doing the preliminary and introductory studies before each multiphonic practice session and by working through this method on a regular basis. The voice and trombone are further apart than they were for the perfect fourth so tuning becomes a little easier. Tips for success: (1) Remember to lower this interval by two cents to play a justly-tuned perfect fifth. (2) Record yourself and listen back to see if you hear any subjective tones. If you are able to hear any additional tones, write them down and (3) strive to have any subjective tones sound, as the reverse perfect fifth is one of the easier intervals to hear subjective tones.

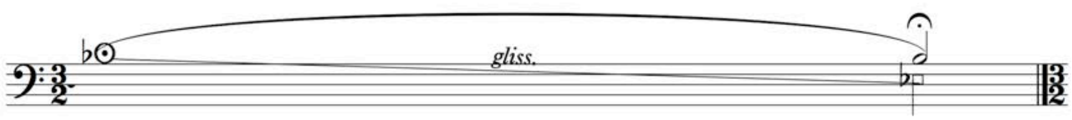
Subjective tones for the reverse perfect fifth: an octave appears below the bottom note, while an octave, major tenth, minor fourteenth, and a fifteenth appear above the bottom note (see below).



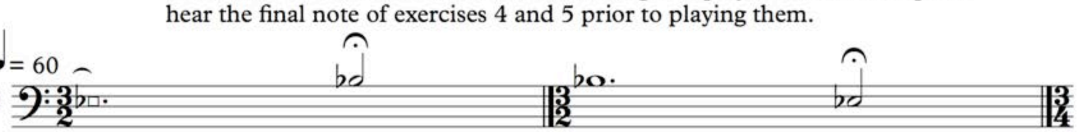
Exercises 1-3 should be played free of tension, in a relaxed tempo, and with your best sound. Play any "false" glissandi to the best of your ability and write down where you plan to switch positions/partials, as the goal of these exercises is to hear reverse perfect fifths.

1 

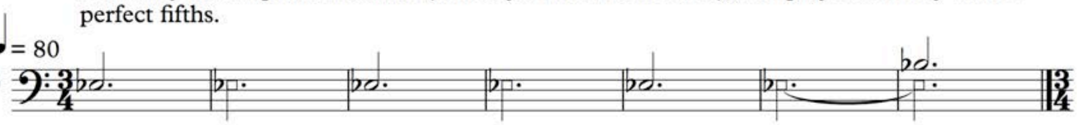
2 

3 

Work on blend and balance between the sung and played notes. Attempt to hear the final note of exercises 4 and 5 prior to playing them.

4 & 5 

While playing exercises 6 and 7, try to match dynamics between sung and played notes, avoid any interruption in sound (unless you need to breathe), and play accurately-tuned perfect fifths.

6 

7 

Exercises 8-13 are intended to help you learn to add a played note above a sustained sung note, and to add a sung note below a sustained played note. As you progress through the exercises, the time you have before you add a note diminishes, thus making each exercise more difficult. Work on hearing the added pitch while sustaining the sung or played note.

8 & 9 

10 & 11 

12 & 13 

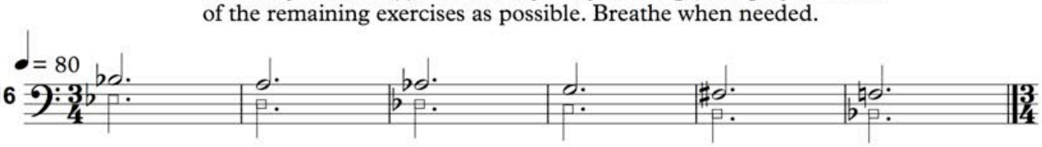
Strive for unison attacks. Repeat this exercise at least once, then choose a different perfect fifth and play this exercise two additional times with your chosen pitches.

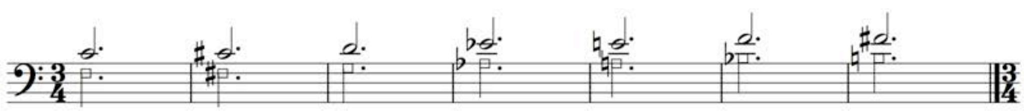
14 

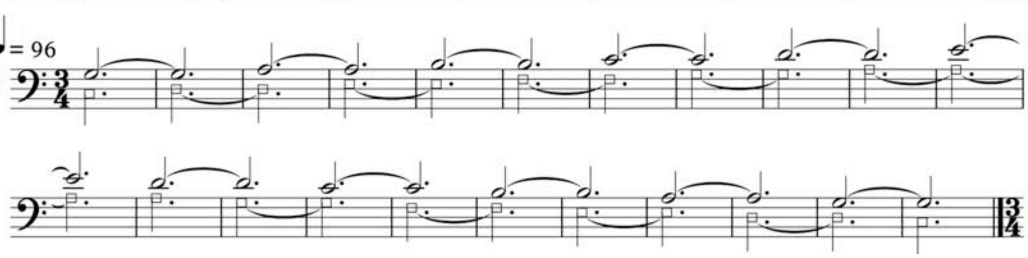
Listen for the difference in sound, timbre, and subjective tones as you alternate between perfect fifths and fourths.

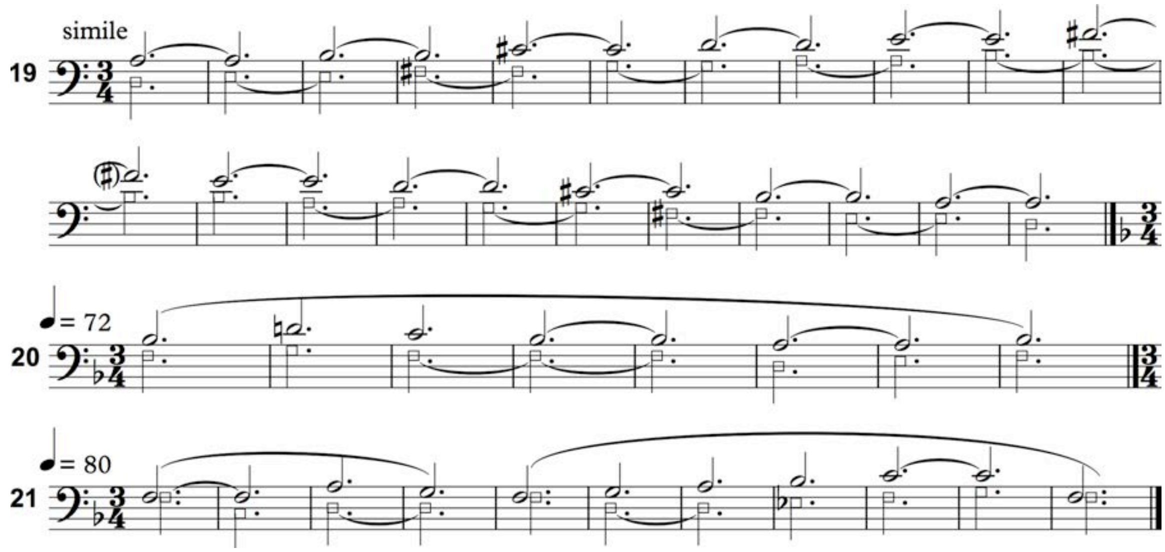
15 

Omit any measure(s) that are beyond your range, but play as much of the remaining exercises as possible. Breathe when needed.

16 

17 

18 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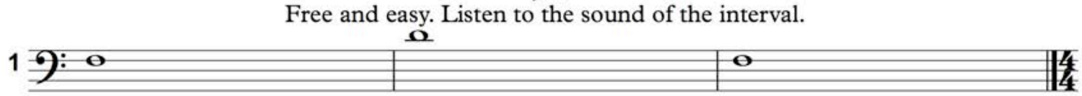
The Reverse Major Sixth

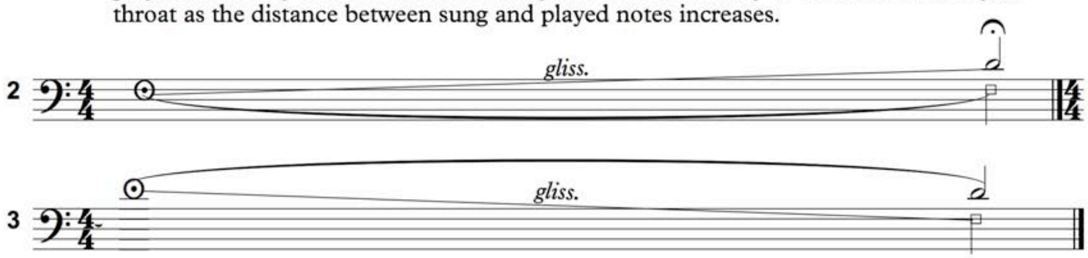
Although you will feel beats on your embouchure, these beats are not felt as strongly as the perfect fourth. The major sixth and minor sixth (next interval), contain easily heard subjective tones for some people. For others, a strong "rolling" sensation is heard. Listen closely as you play and try to determine what subjective tones or sounds you hear. Tips for learning and mastering the major sixth: (1) Listen for subjective tones as you play. (2) These tones can appear if you play justly-tuned major sixths. To do so, the sung voice should be lowered by twelve cents. (3) Use a tuner to help you visualize the lowered played note, and eventually learn to hear this adjustment. (4) Begin by playing the sung note on the trombone. Be sure to play with your best sound and do not bend the pitch down with your embouchure (move the slide to do this).

Subjective tones for the major sixth include a perfect twelfth and perfect fifth below the bottom note, and a minor sixth, minor tenth, perfect eleventh, and a major fourteenth are found above the bottom note.

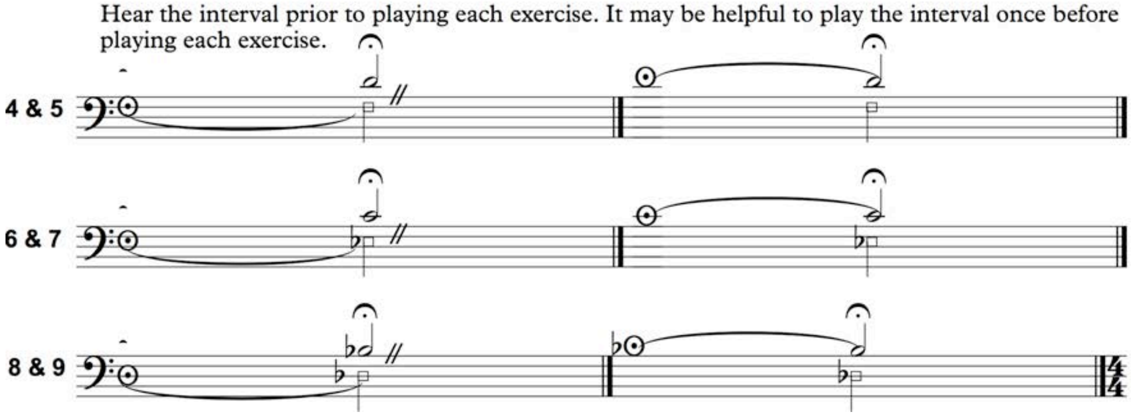
Free and easy. Listen to the sound of the interval.



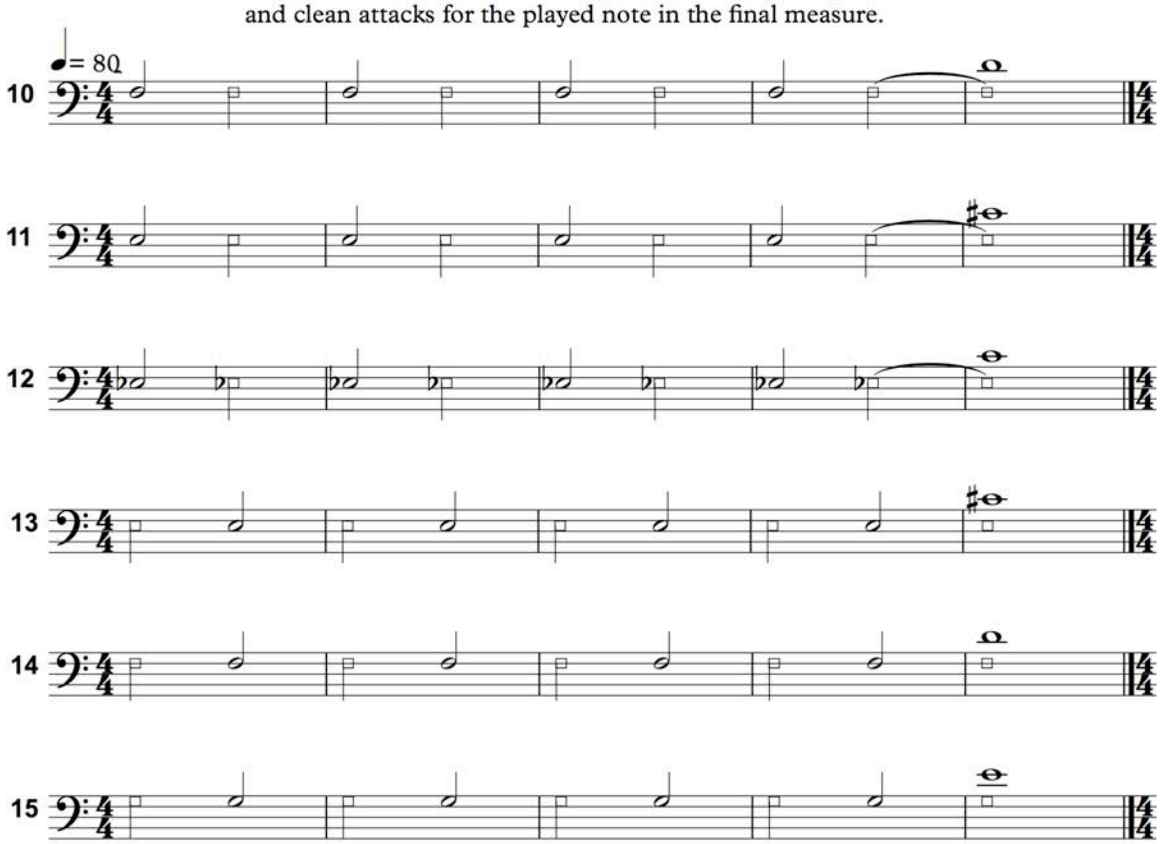
Perform the "false" gliss found in exercise 2 to the best of your ability. Here, the goal is not to play proper glissandi, but to gradually increase the distance between the sung and played note. Play exercises 2 and 3 slowly. Avoid the tendency to close the back of your throat as the distance between sung and played notes increases.



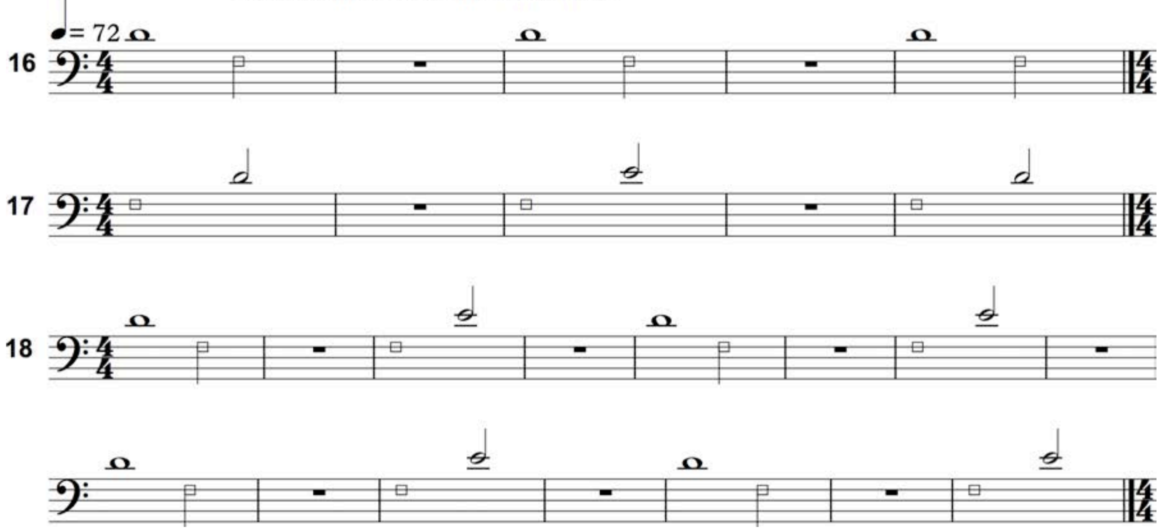
Hear the interval prior to playing each exercise. It may be helpful to play the interval once before playing each exercise.



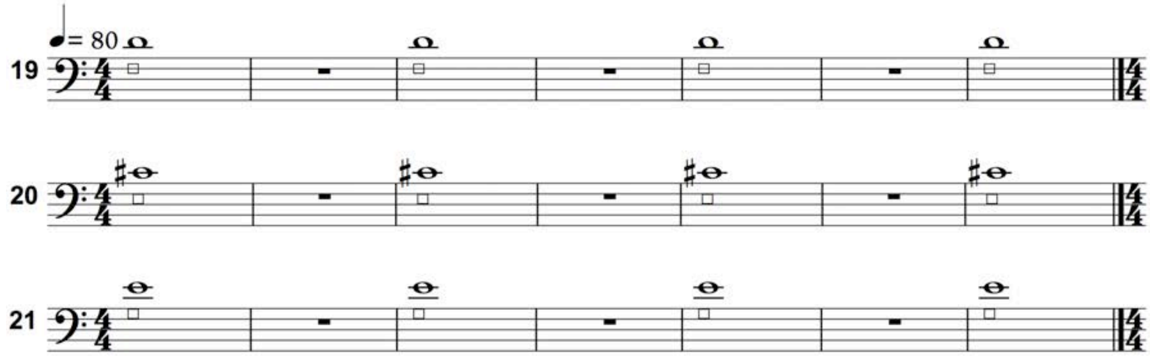
Work toward an inaudible change between sung and played notes
and clean attacks for the played note in the final measure.



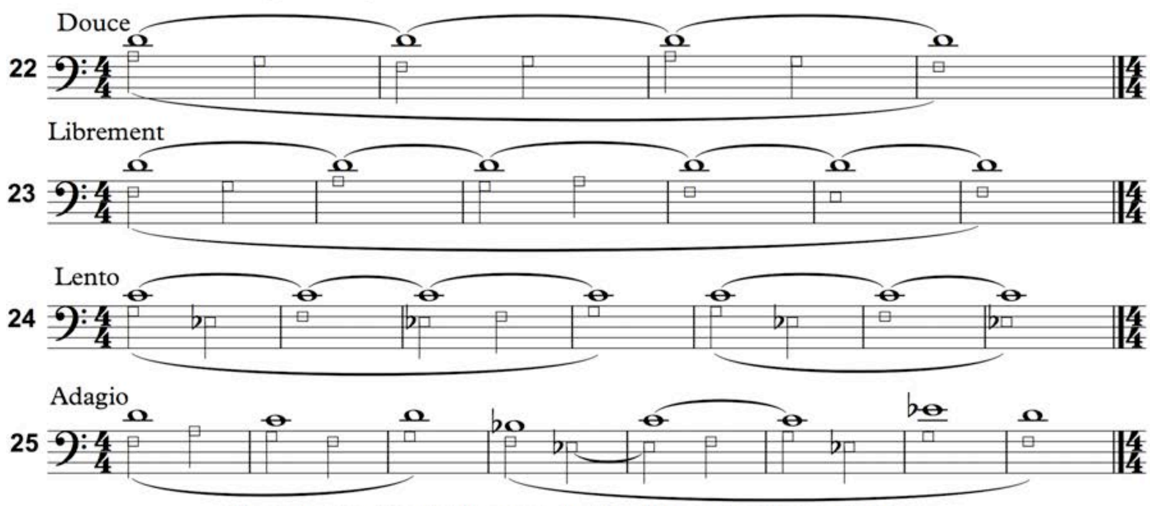
Work on blend and balance between the sung and played note.
Focus on how this interval sounds and feels; attempt to remember
how this interval sounds and feels.



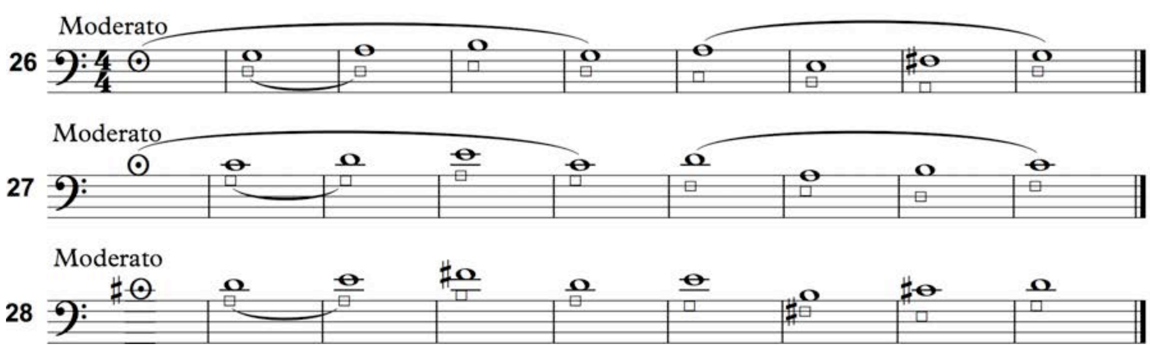
Practice exercises 19-21 in four different ways. (1) Begin with the sung note, then add the trombone. (2) Begin with the played note, then add the voice. (3) Play as notated, but use an air attack. (4) Play as notated and use tongued attacks.



Learn the following etudes to help you combine the reverse major sixth with previously learned reverse intervals.



Exercises 26-28 are the same, but in different registers and keys. Perform the exercises that are within your range and comfort level, and omit any measure(s) that are beyond your range.




Poco allegro
24

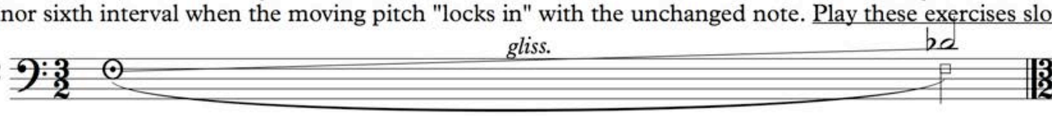
The Reverse Minor Sixth

Unlike the reverse major sixth, the reverse minor sixth can be difficult to place. Beating associated with this interval adds to its difficulty, however, once one is able to hear a clear minor sixth (away from the instrument), the difficulty level drops significantly. If you struggle with this interval, try moving from major sixth to minor sixth and back again. I have found that using the major sixth as a guide tone works better than the perfect fifth, as ascending half-steps tend to be more difficult to hear than descending half-steps. Tips for successful learning and mastery of the reverse minor sixth: (1) from time to time, spot-check your intervallic accuracy with a tuner remembering that (2) <u>the minor sixth must be raised by fourteen cents</u> to obtain a justly-tuned minor sixth. (3) Lastly, take your time with these, and all exercises. Pushing speed or range will not help in your multiphonic development; only slow, concentrated, and consistent practice will yield good results.

Subjective tones for the minor sixth: a major tenth and major sixth lie below the bottom note; a major ninth, major tenth, minor fourteenth, and minor sixteenth can be found above the bottom note (see below).

As with previous glissandi exercises, do your best to play as much of the glissando as possible. The focus of exercises 2 and 3 is to (1) Learn to hear the reverse minor sixth and its relationship to other intervals as you play the ascending glissandi. (2) Learn to sustain a sung note while the played note ascends to a given interval. (3) Finally, these exercises help to develop awareness of just intonation, as the ascending glissando is an excellent way to hear when a note or interval is in-tune. You will hear when you reach the minor sixth interval when the moving pitch "locks in" with the unchanged note. <u>Play these exercises slowly.</u>

2



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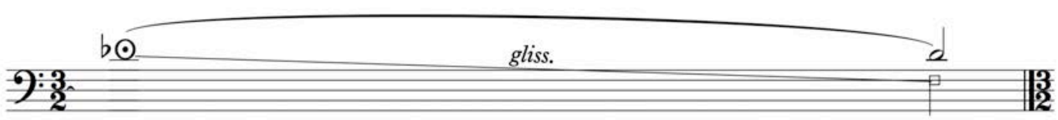
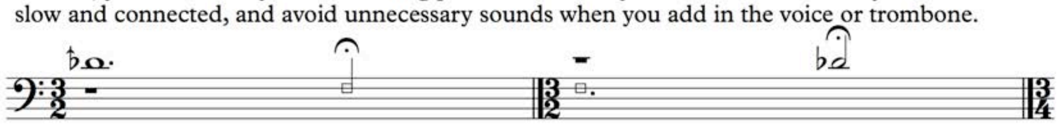


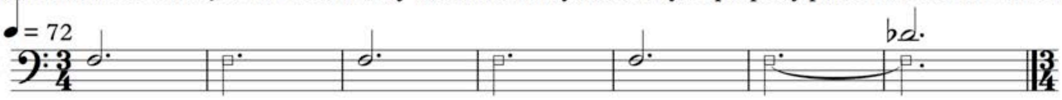
Exercises 4 and 5 are designed to further develop your awareness of the minor sixth interval, as there is no assistance from a glissando to help you hear when the interval is accurately tuned. Instead, you have to rely on the starting pitch to accurately locate the interval. Play these exercises slow and connected, and avoid unnecessary sounds when you add in the voice or trombone.

4 & 5



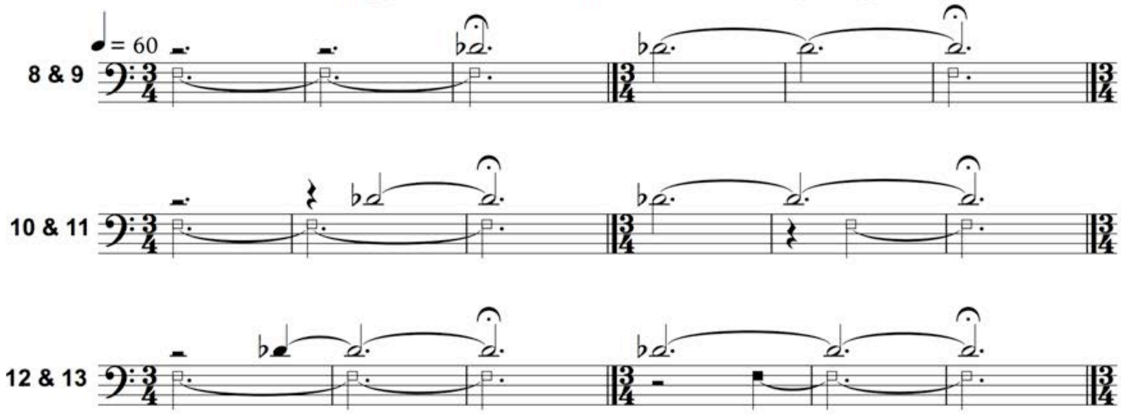
Play exercises 6 and 7 with a continuous sound. Breathe if needed, but do not breathe after the penultimate measure, as the breath may interfere with your ability to properly place an accurate interval.

6

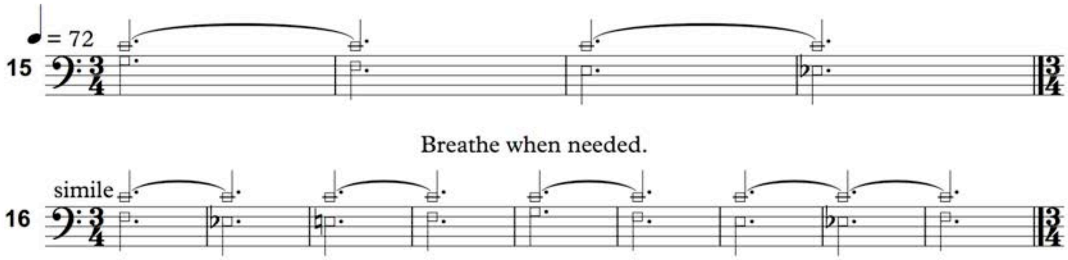


7

Use the rests found in exercises 8-13 to your advantage. Try to hear the added note throughout the duration of each exercise. Playing the added note prior to beginning each exercise will help you to better hear the added note once you begin the exercise.



Focus your attention on (1) playing unison attacks, (2) playing accurately-tuned intervals, and, finally, (3) learning how this interval sounds and feels. Play this exercise until you can play the entire exercise correctly three times in a row.



Only perform the intervals in exercises 17 and 18 that you can do comfortably, with ease, and with your best sound. Do not push your range at this time; the chapter on range extension contains exercises to help further develop your range. Breathe when needed and on the upbeat prior to the barline.


18"
4"
gliss.
gliss.
19
Müdigkeit
20
Festlich
21
Festlich
22
Allegro Moderato
23

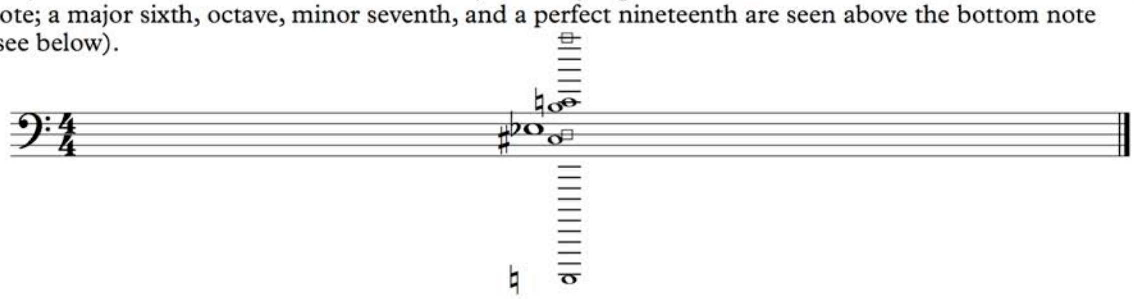

Poco allegro
24

The Reverse Minor Second

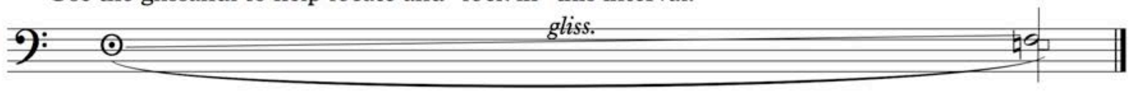
Playing minor seconds creates intense beats that can make it difficult to control pitch. These beats are easily heard and are felt on the lips. This is the primary reason the minor second is difficult to master, however the reverse minor second is far easier than the traditional minor second. If the beating is extremely problematic to learning this interval, try playing with a slight flutter tongue so as to simulate the feeling of beating. This should also help you to become accustomed to the beating sensation.

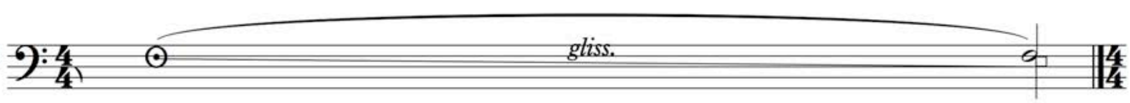
Suggestions for success: (1) Keep your embouchure steady; strive to keep your corners firm as you learn this interval. (2) Initially, play the bottom note as soft as you can, as doing so allows you to better hear the interval and allows the sung note to be easily heard. Additionally, (3) use less mouthpiece pressure to help keep both notes steady. (4) Try starting some exercises with the sung note and others with the played note. (5) Remember, the justly-tuned minor second is twelve cents wider than the equally-tempered minor second.

Subjective tones for the minor second: a major twenty-eighth and a minor second lie below the bottom note; a major sixth, octave, minor seventh, and a perfect nineteenth are seen above the bottom note (see below).



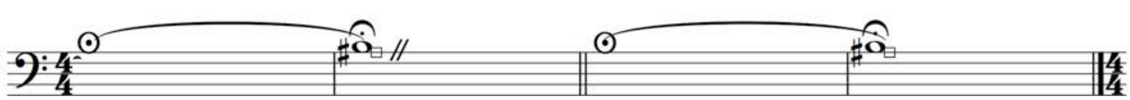
Play exercises 1 and 2 slowly to become accustomed with the sound of the minor second. Use the glissandi to help locate and "lock in" this interval.

1


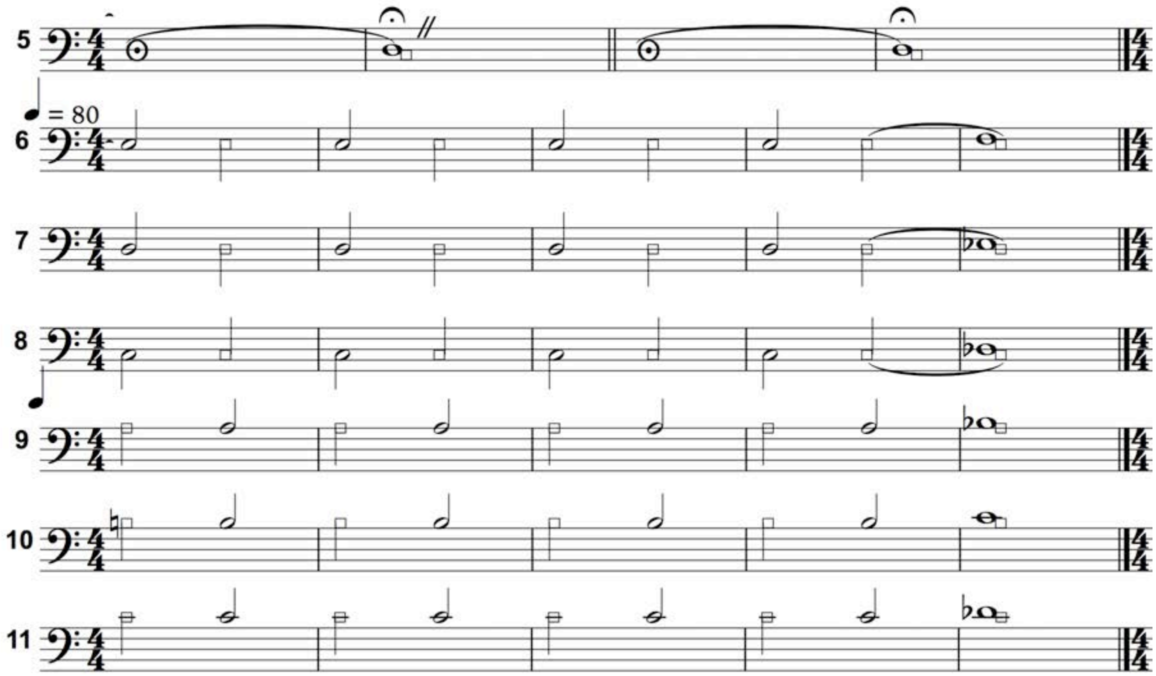
2


Use exercises 3-5 to work on control of the played note. Here, the played note tends to drift flat in an attempt to reach a unison with the voice. Do not let this happen. Instead, start by focusing on the pitch of the played note. Later, once you have developed more control of the played note, focus your attention on the sung note, making sure that the intervallic relationship between the sing and played note is accurate. Take at least one measure of rest after each caesura.

3

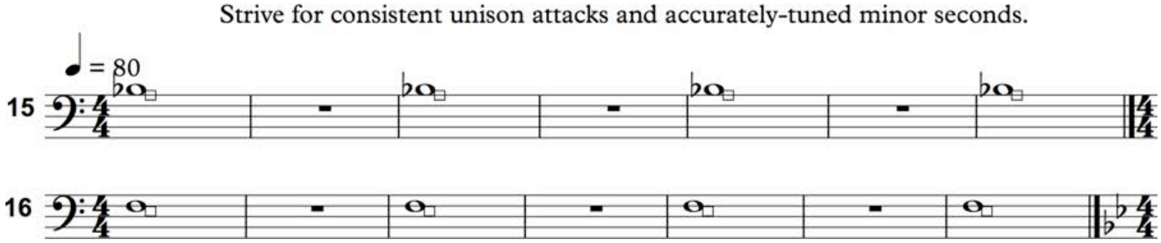

4


Exercises 6-12 are intended to develop consistent tone quality while switching multiphonic "voices." Additionally, these exercises help to further develop the reverse minor second. Try to hear the final sung note throughout the duration of each exercise.



Use exercises 12-14 to work on blend and balance of the two notes. Use the rests to your advantage by attempting to hear the added note before it is played or sung.

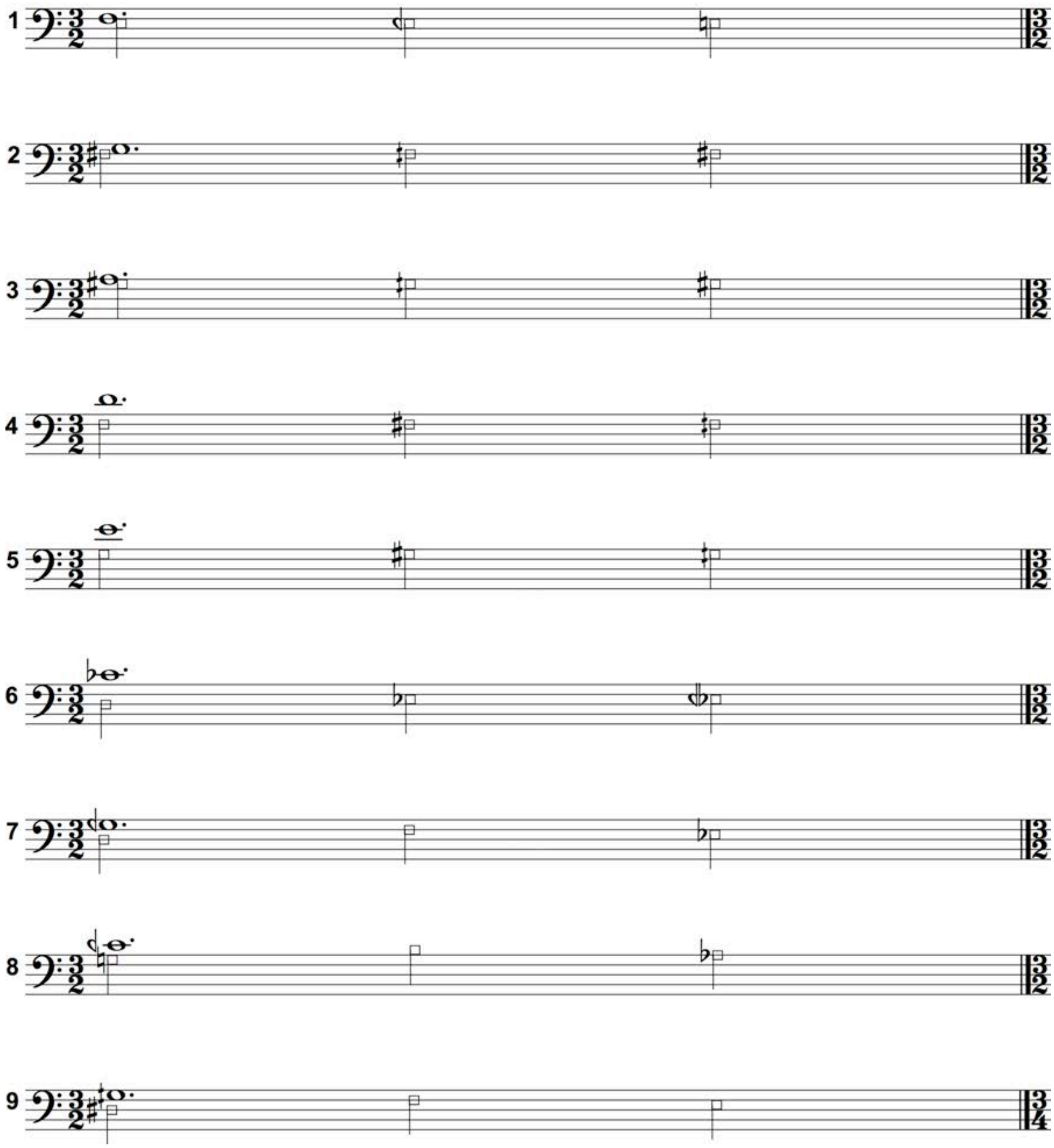
Strive for consistent unison attacks and accurately-tuned minor seconds.



Play all etudes that lie with your multiphonic range. If you find that most of the material in this section is too hogh or too low for you, I reccomend transposing these exercises to different keys and octaves.

Reverse Microtones

Your study of microtonal intervals from the previous chapter and your work on the reverse minor second will assist you in easily mastering reverse microtones. Of the individual intervalic exercises, this microtonal section is the shortest due to the ease of production.



Breathe when needed.

Andante con moto

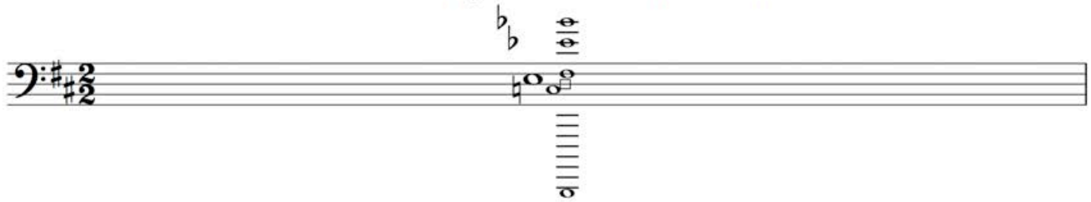
Breathe when needed.

The Reverse Major Second

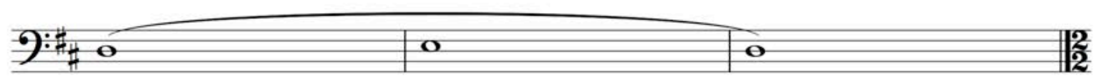
The reverse major second is one of the more challenging intervals to learn, so take your time with these exercises. The beating phenomenon adds to the difficulty of this interval, but playing exercises 1 and 2 with a slight flutter tongue may help you become accustomed to the sensation felt on the lips.

Suggestions for success. (1) Listen for a clear major second interval. This can be accomplished by (2) playing the lower note softer than the sung note. Eventually you will want to have the same dynamic for both notes so that you can (3) listen for subjective sounds.

Subjective tones include: a twenty-second and a major second below the bottom note, and a major sixth, minor seventh, an octave, and a perfect nineteenth are seen above the bottom note.



Play slowly, and with a full, resonant sound. Try singing Exercises 1 and 2 after you have played them. Do not sing lower than you can comfortably, in tune, and with a good sound.

1


2

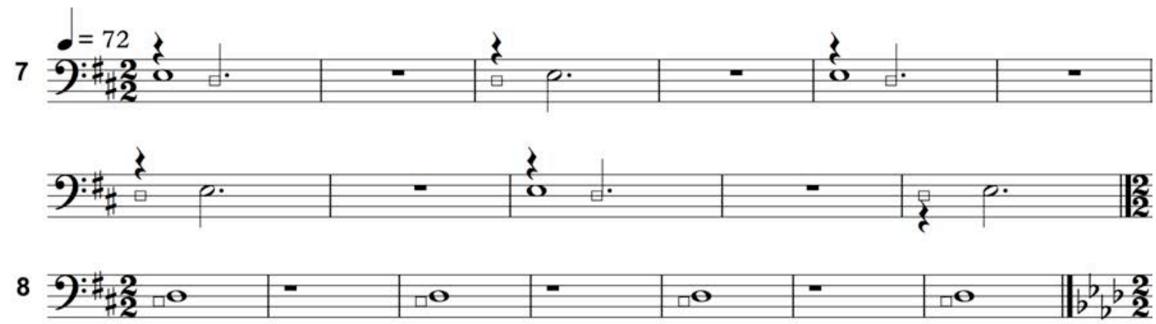

Exercises 3-16: strive to match tone quality as you switch between singing and playing.

3


4

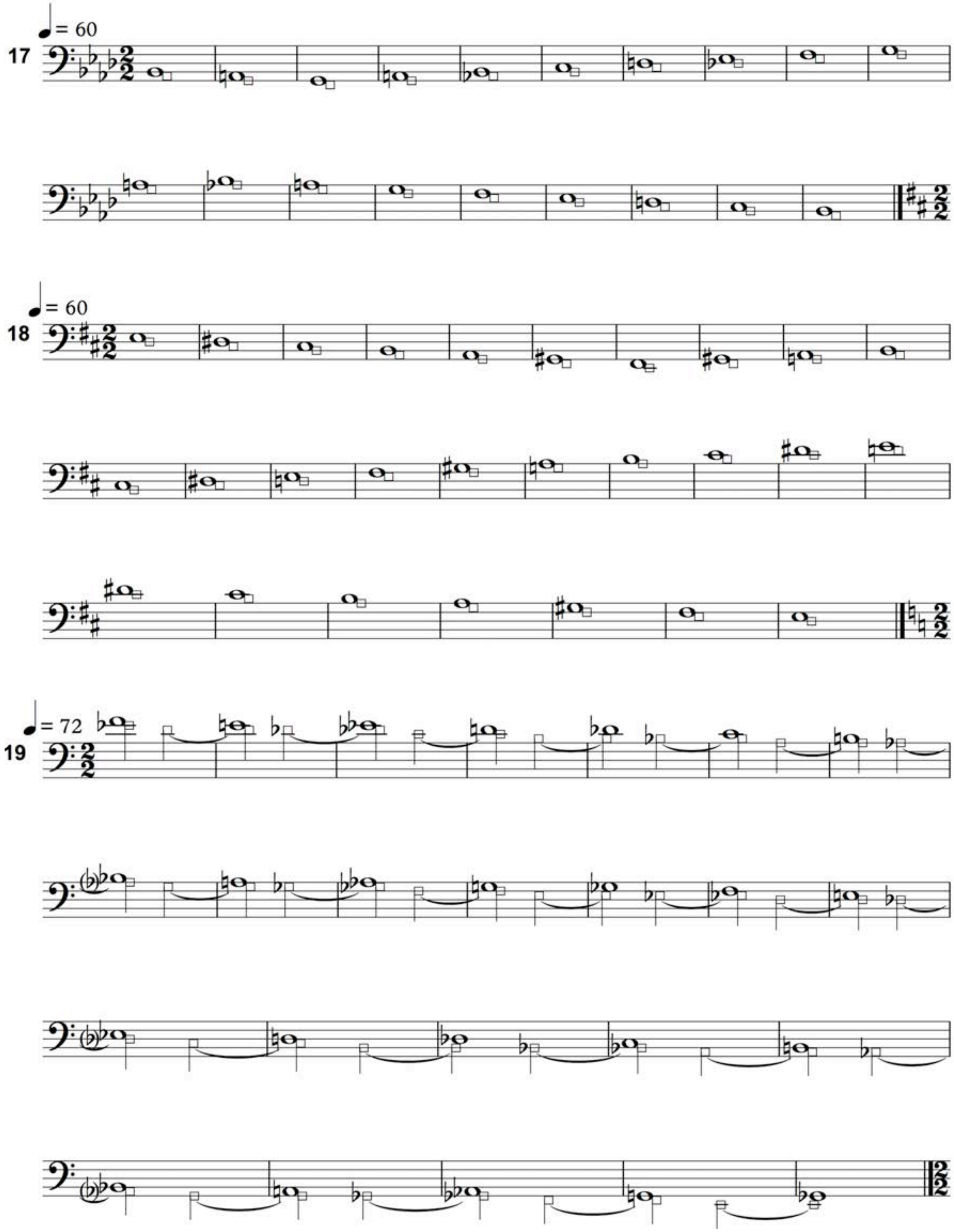

5


6

Play exercises 9-16 in the same manner as exeercises 1-8.

The scale-type passages found in exercises 17-20 are excellent for working on intervallic consistency. Breathe when needed and do not sing or play above or below your multiphonic range.



The following pages contain three short etudes written in various keys. Play every etude that is within your range. If the majority of the etude is within your range, but a few notes are too high, or too low, omit that note and continue performing the etude. Look up any unknown terms to help establish tempos for each etude.

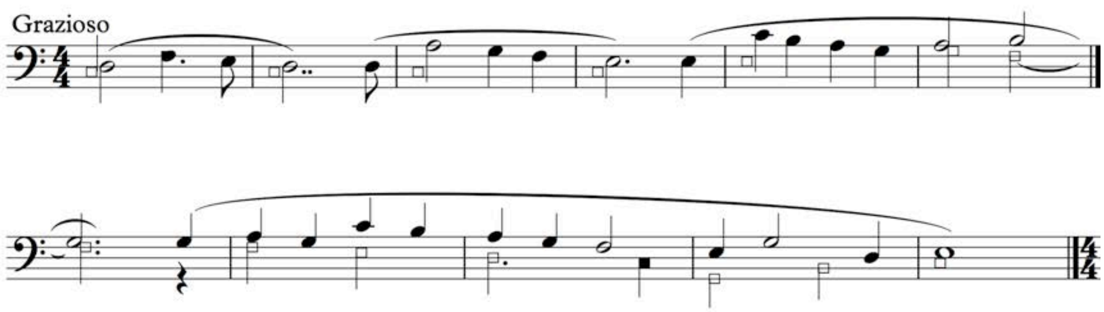

Grazioso
24
mit Überzeugung
25
Lento epico
26
Grazioso
27
mit Überzeugung
28
Lento epico
29

30

mit Überzeugung

31

Lento epico

32

Grazioso

33

mit Überzeugung

34

Lento epico

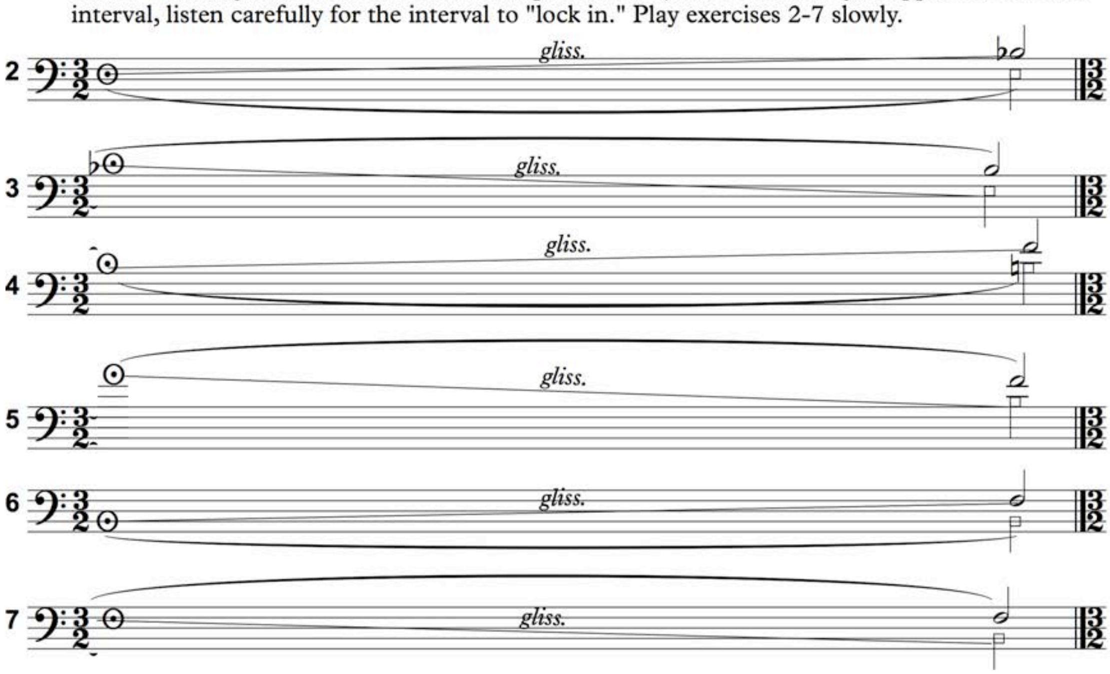
The Reverse Tritone

The tritone can be difficult to hear when performing multiphonics, especially in the reverse form. Similar to the perfect fourth, the tritone contains beats that can easily be felt on the lips. Tips for successful learning: (1) Avoid the temptation to be distracted by the sensation of beats and listen for the quality of the interval. (2) Practice slowly moving from perfect fifths and fourths to the tritone. (3) Strive to match the dynamic of the trombone with your voice. Doing so will help to better hear the interval.

Subjective tones for the tritone: a major seventeenth, minor seventh and a major second are found below the bottom note, while a major second, major sixth, minor tenth, and major fourteenth are found above the bottom note (see below).

Free and easy. Pause briefly after the caesura.

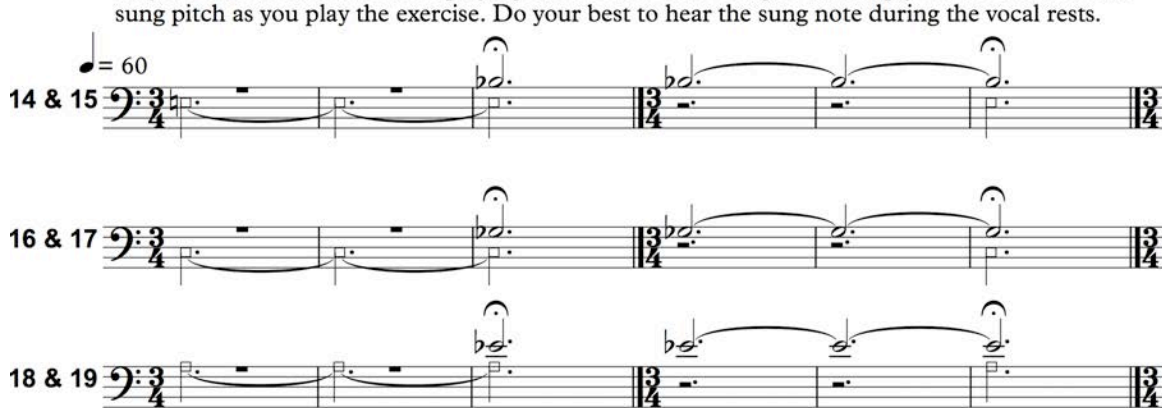
Work on playing the sustained note in tune throughout each exercise, making sure that, once the tritone is reached, the interval is justly tuned. Listen for subjective tones. Do you hear a subjective tone change pitch as the distance between notes increases, or is nothing heard? Record yourself and listen back for possible subjective tones. As you approach the final interval, listen carefully for the interval to "lock in." Play exercises 2-7 slowly.



Play exercises 8-10 free from tension and in a moderate tempo. Pause briefly after each caesura.

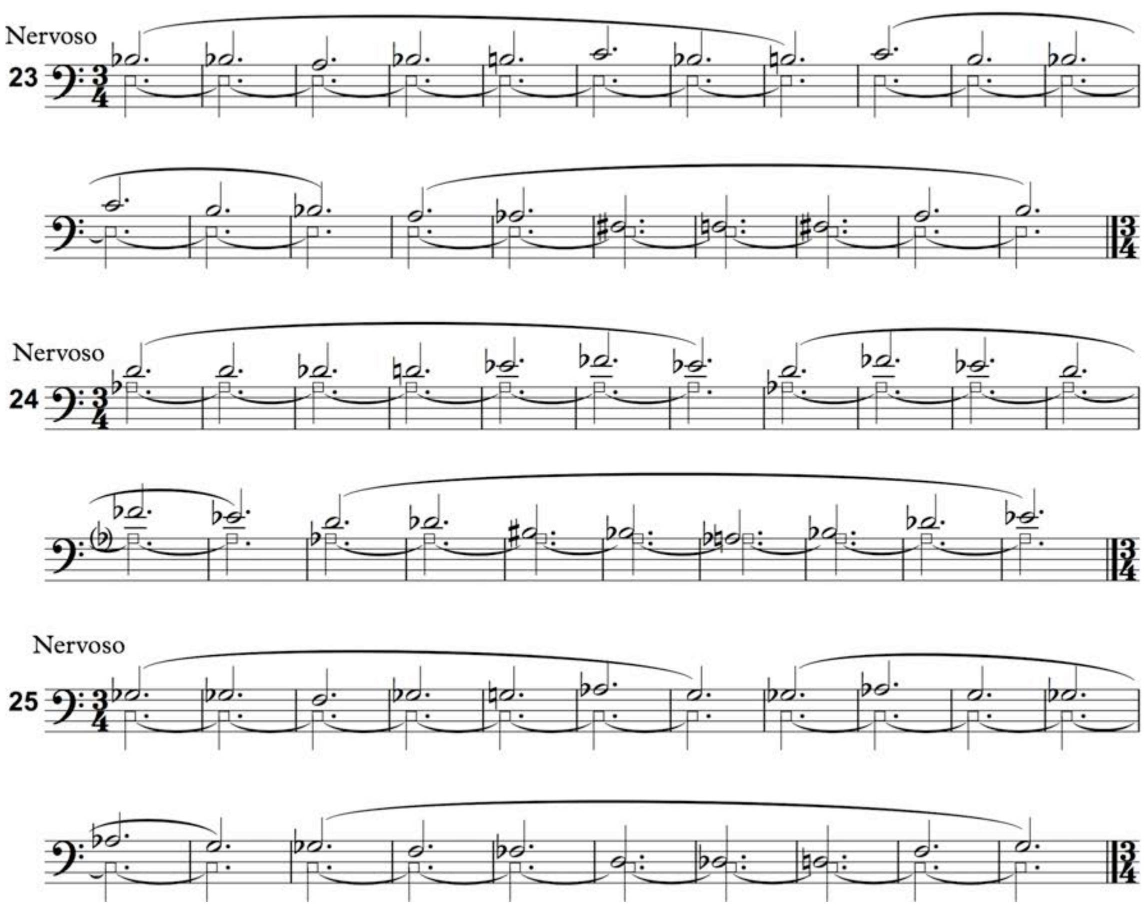
Strive for smooth transitions when changing from trombone to voice and vice versa.
When the tritone interval is reached, try to vary the dynamics of the multiphonic "voices."
Do this by performing crescendos and decrescendos in both the vocal and trombone parts.

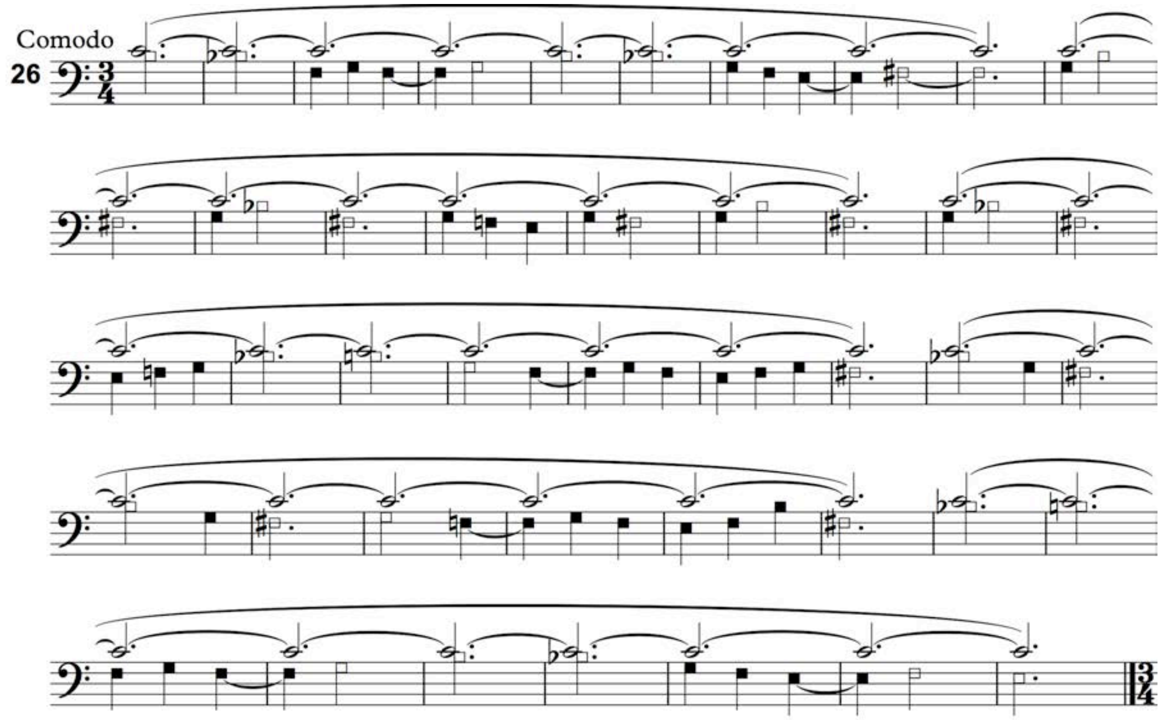
Play the tritone interval before playing exercises 14-19. Doing so will help you to better hear the sung pitch as you play the exercise. Do your best to hear the sung note during the vocal rests.

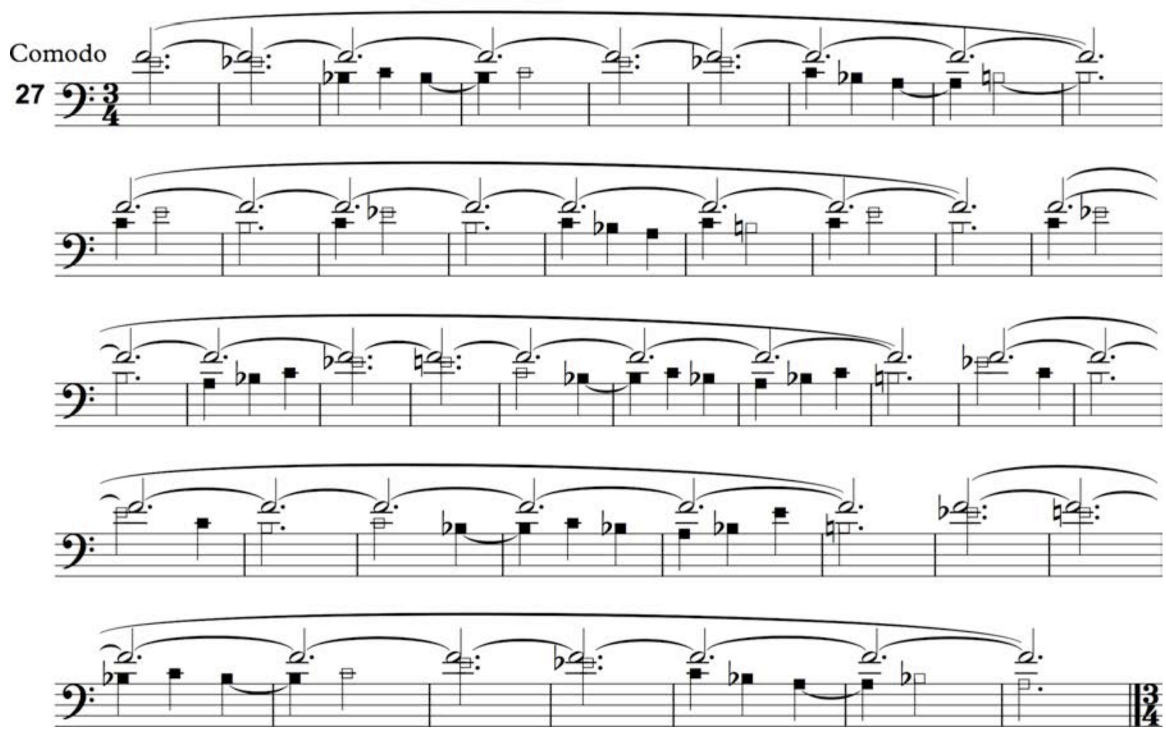


At this point in the method, you should be able to play exercises 20-22 with clean and consistent attacks even though the reverse tritone is a new interval. <u>Play each tritone prior to playing these exercises</u>, as this will help you to hear the interval, thus giving you the best chance for success.

Play as many of the following etudes as possible. If the entire etude is out of your range, skip the etude, otherwise omit any measure(s) that you are unable to play. Do your best to follow the phrase markings, but breathe if needed at a musically appropriate spot.




Comodo
26


Comodo
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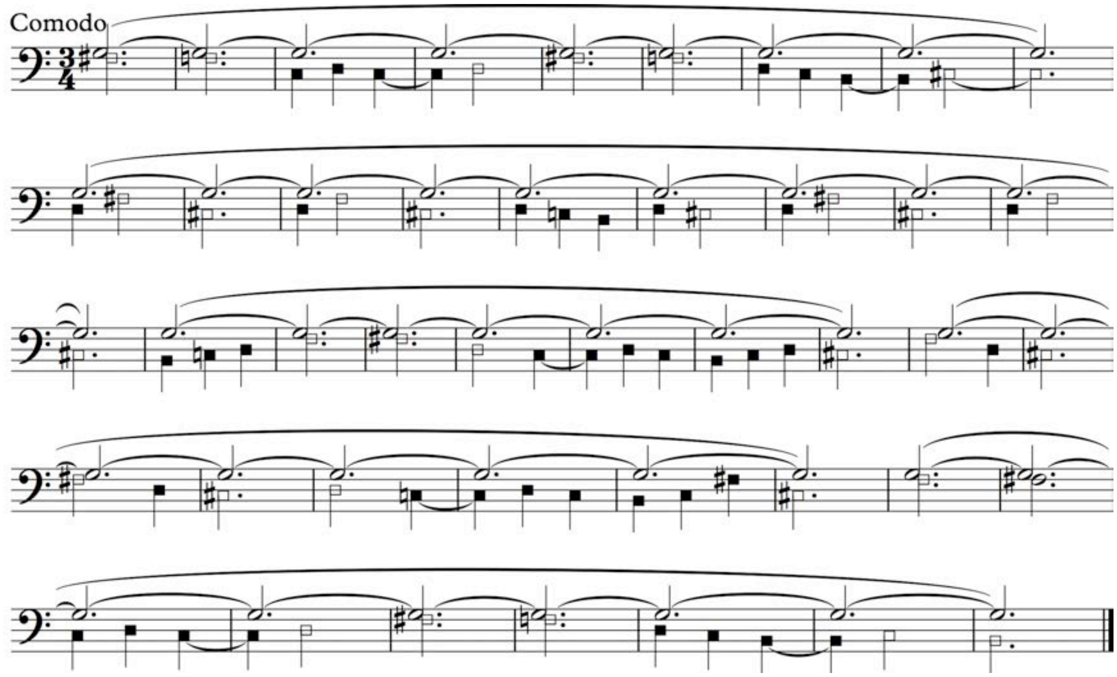
28

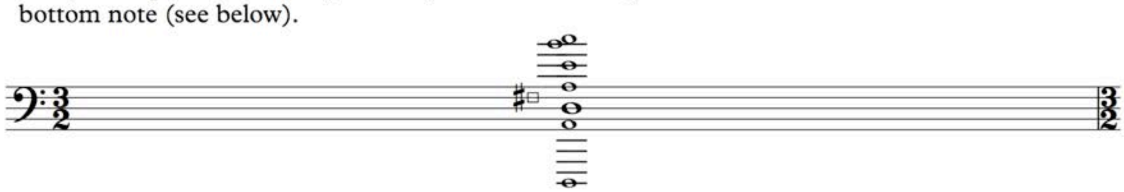


The Reverse Major Third

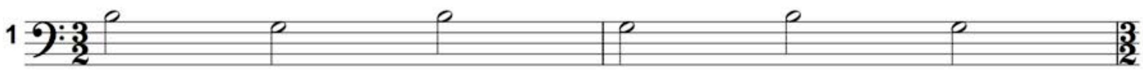
Your mastery of the traditional major third will assist you with this interval. Remember, if the beating sensation is troublesome, practice a variety of music using a flutter tongue to further familiarize yourself with the sensation.

Tips for success: (1) Use the perfect fourth as your guide tone. Practice moving between these two notes may help you to better hear this interval. 2) Rest when tired. There is no need to rush through exercises. Take your time and always play with your best sound. (3) Record and listen back to insure that you are playing a just major third. Remember, you need to (4) <u>raise this interval by 14 cents to have a justly-tuned major third.</u>

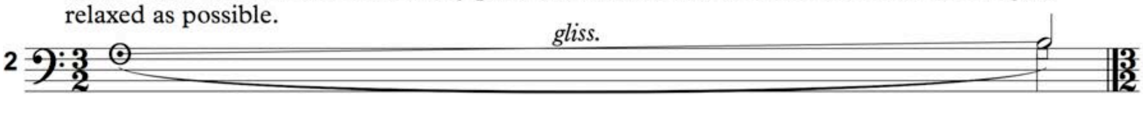
Subjective tones for the major third include a fifteenth and perfect fourth below the bottom note, and a perfect fifth, major ninth, minor thirteenth, and a minor fourteenth above the bottom note (see below).

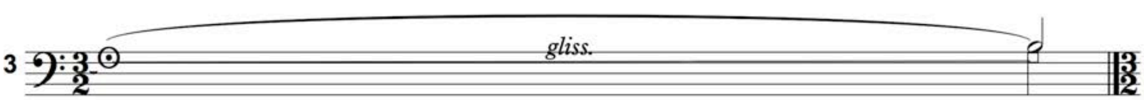


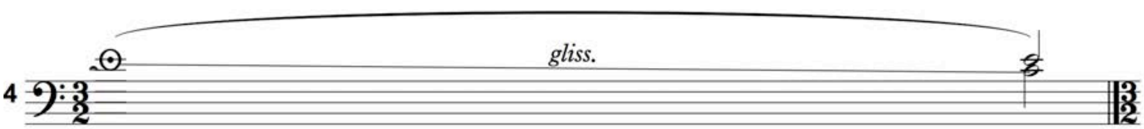
Take care and listen for the adjustment to just intonation. Do not rush.

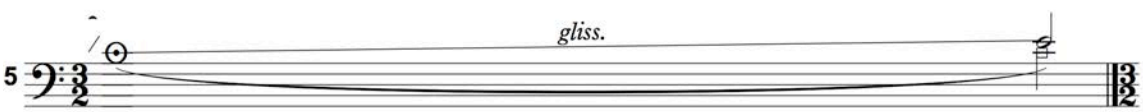


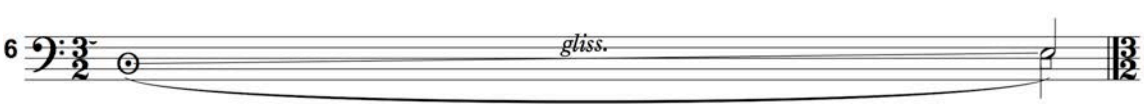
Exercises 2-7 are intended to help you sustain either the sung or the played note while the other "voice" moves. Work on steady pitches for both the voice and trombone and stay as relaxed as possible.











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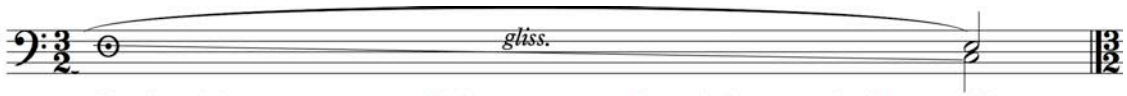
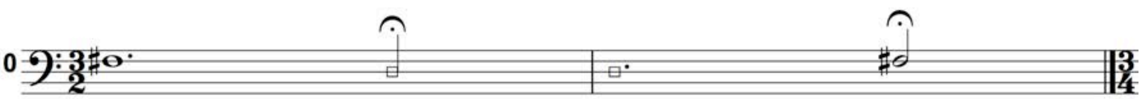


Slowly, taking great care to add the new note to the existing sound without making the new note "bump," or otherwise disrupt an uninterrupted stream of sound. Be sure to rest briefly after each caesura.

8

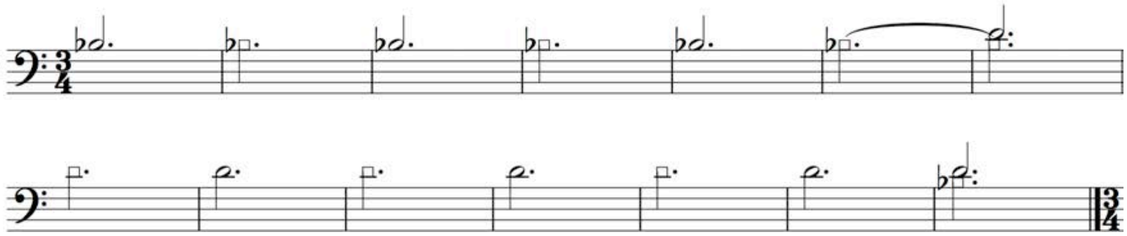

9


10


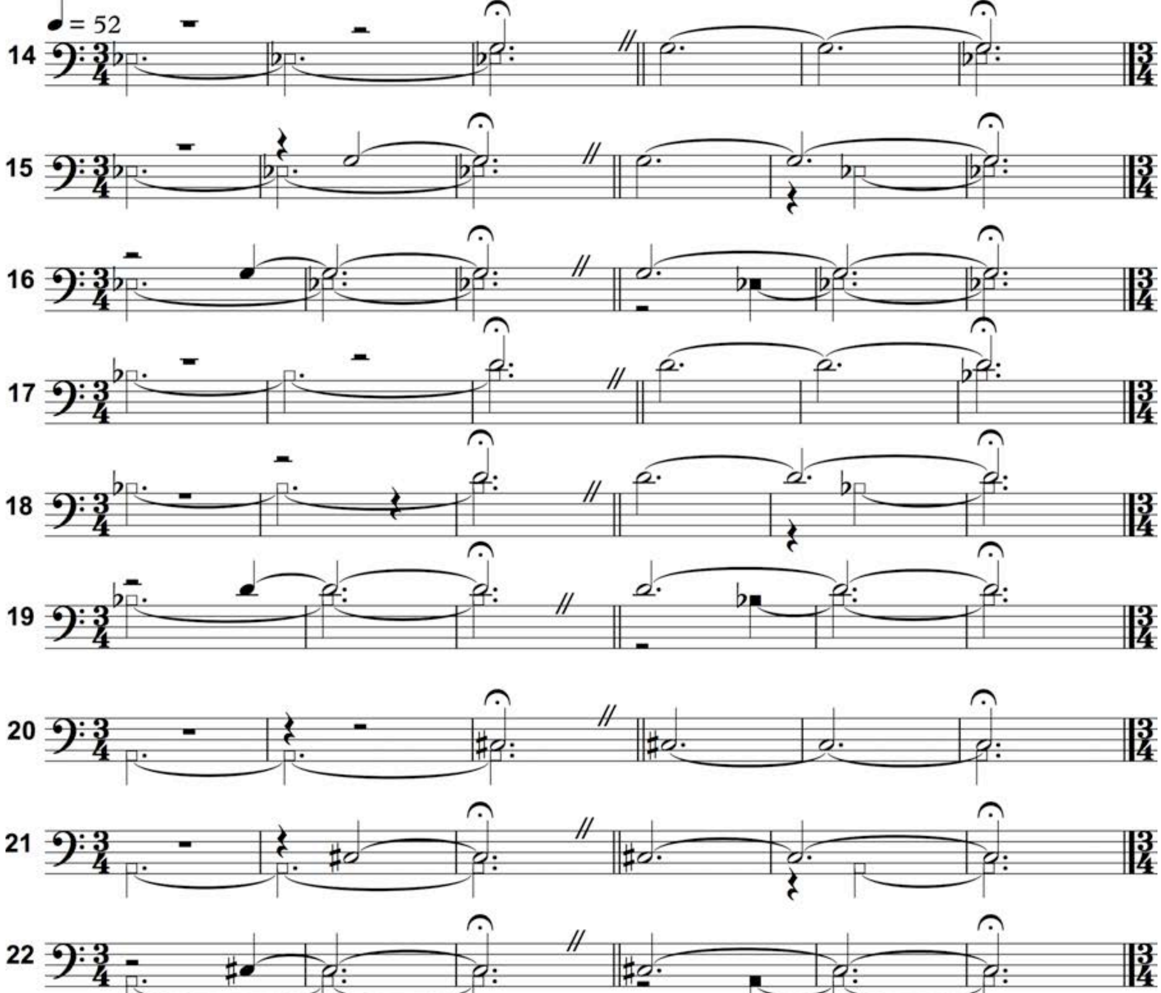
Work for smooth transitions between each note and a clean, clear interval in the final measure of exercises 11-13.

11


12


13


Play the notated interval before playing exercises 14-22. As the exercises progress, the time between the initial note and the new note diminishes. Attempt to hear the final measure as you play each exercise. Take your time, pay careful attention to intonation, and rest briefly after each caesura.



Play exercise 23 at least two times before advancing to exercise 24. At no point in this method should you proceed to the next exercise without having fully mastered the previous exercise. If you feel that you need additional time with this exercise, practice the exercise using major thirds of your choice. Attempt to play each major third with clean, unison attacks.

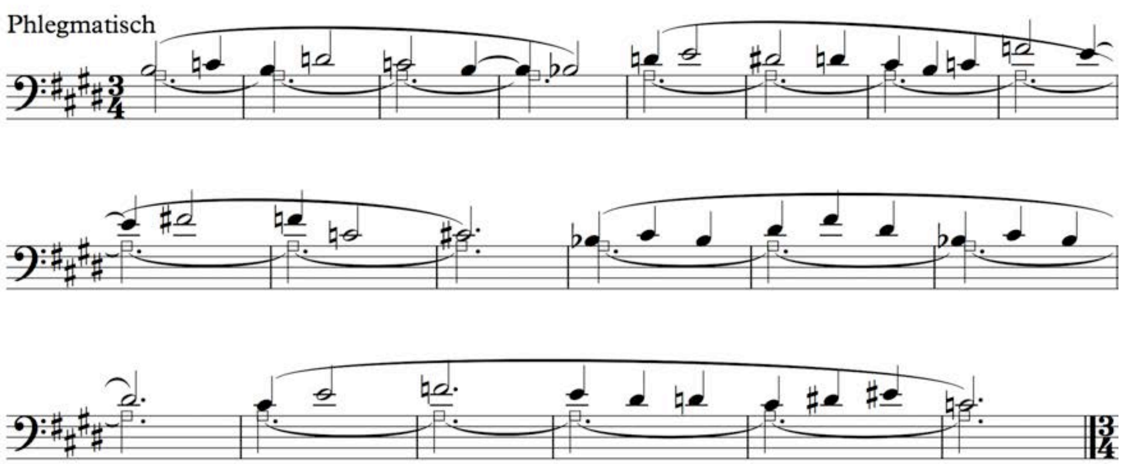
In exercises 24 and 25, breathe when needed and on the upbeat prior to the barline.

Play from the following etudes, those that are within your multiphonic range. Remember to (1) Play with your best sound. (2) listen and adjust for subjective tones, and (3) stay relaxed throughout each etude. Look up any unknown terms to help establish the style and tempo of each etude.

Phlegmatisch

Andante

28


29


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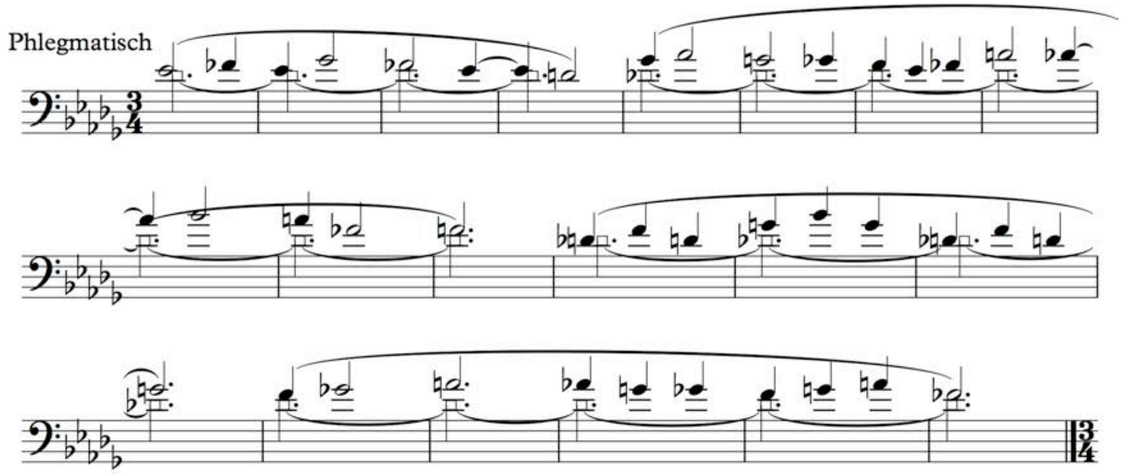
31


32


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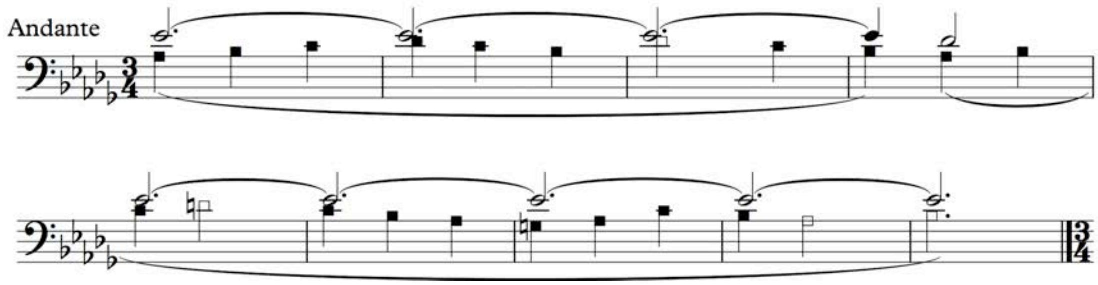



Andante assai
34

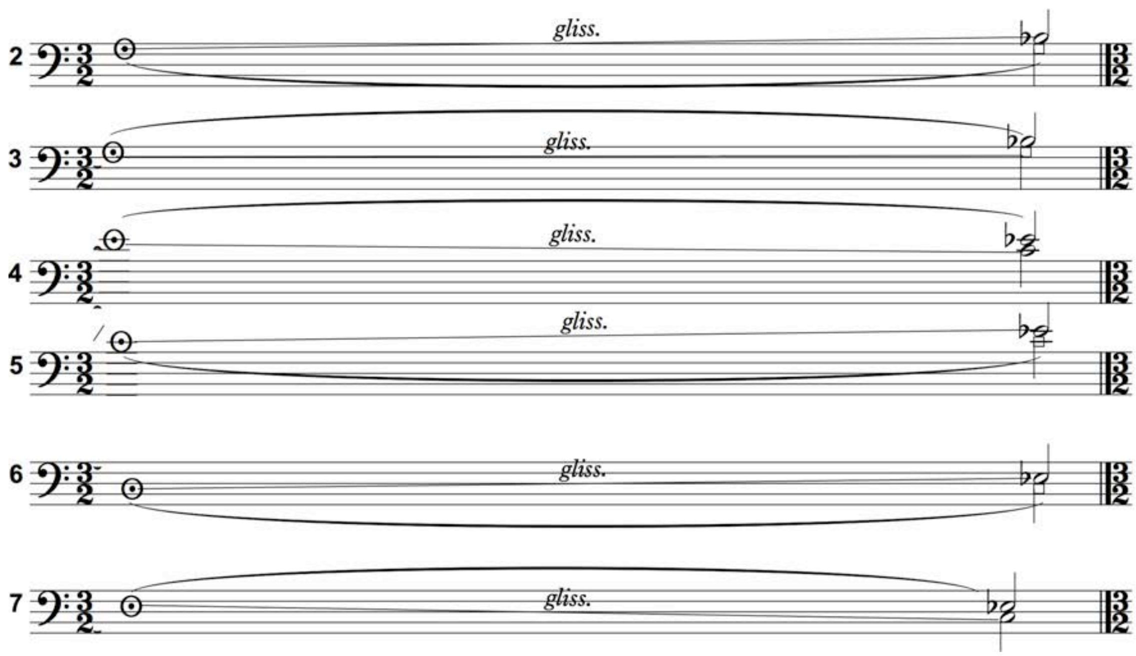
The Reverse Minor Third

The reverse minor third is more difficult to execute than when it is played traditionally. Two things make this interval more difficult than its traditional counterpart: (1) Beats are felt more strongly on the lips, thus making tuning a larger issue and (2) you are trying to sing at the same dynamic as the played note, which is often easier to hear because it is of a higher frequency. There are, however, things we can do to put ourselves in a better situation. Tips for successfully learning the reverse minor third: (1) Try eliminating some of the mouthpiece pressure you are using, as this often enables you to play a little softer. (2) Play really, really, soft. Practice some of these exercises without the voice at dynamics softer than mezzo piano. (4) <u>Raise the this interval by 16 cents to have a justly-tuned minor third.</u>

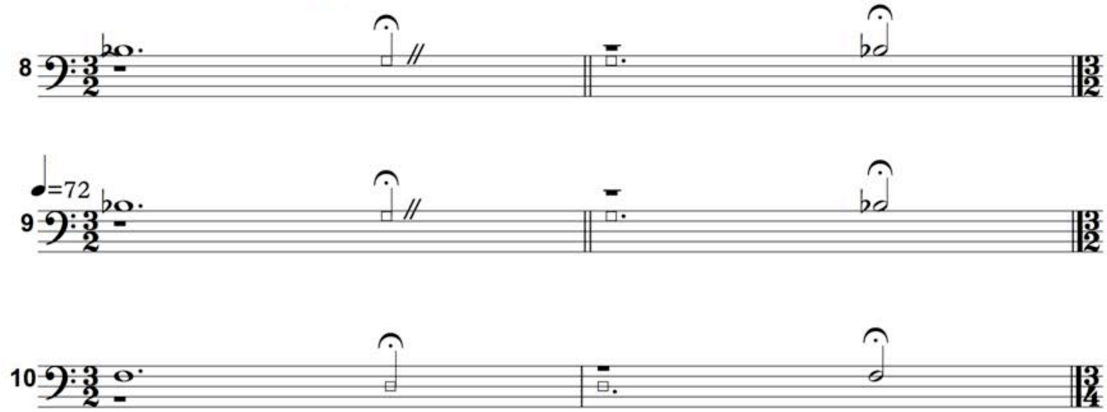
Subjective tones for the reverse minor third: below the bottom note you will find a minor seventeenth and a major third. Above the bottom note a major second, tritone, major sixth, and major thirteenth appear (see below).

Play exercise 1 free of time and actively listen to the intervallic relationship between each note.

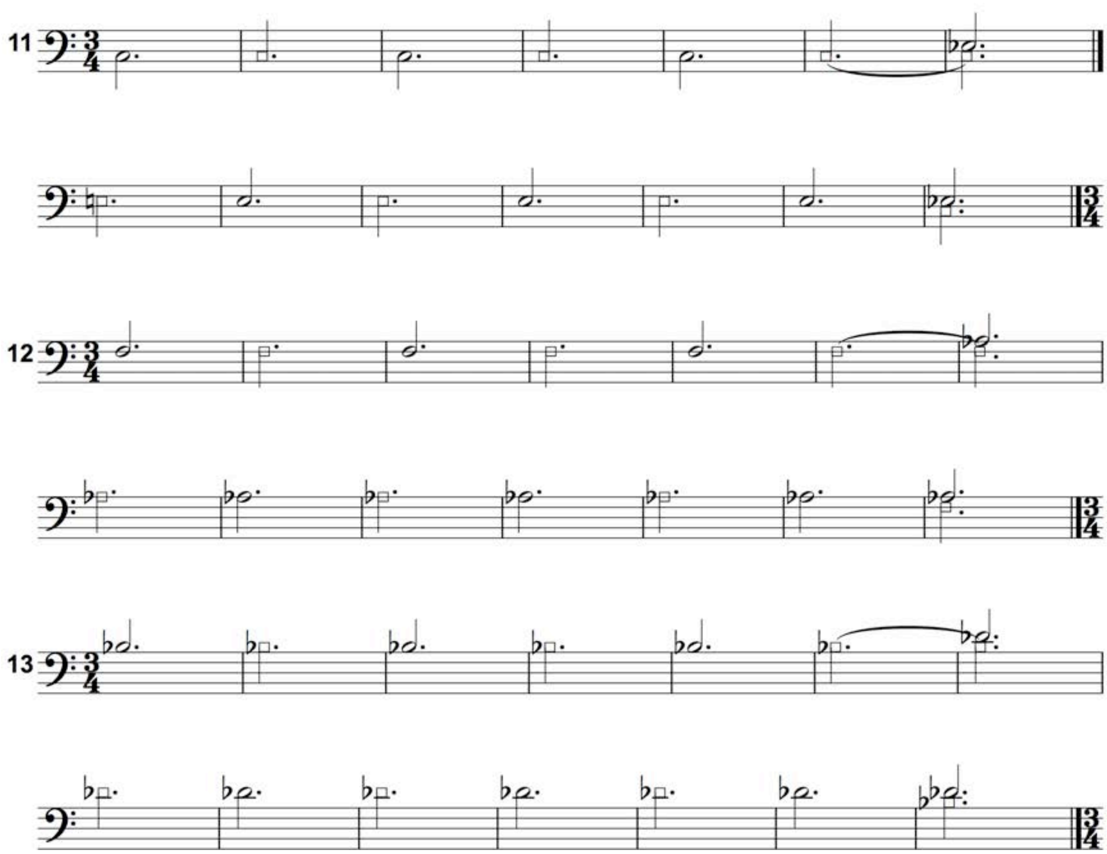
Work on keeping the sustained note in tune, as both the voice and trombone have a tendency to drift outward to a major third, or inward toward a major second. Use a tuner if needed, but by now you should be using your ears more than your eyes to tune intervals. Remember, do not worry about trying to play the glissandi found in exercises 2-7 with exact precision, as the goal of these exercises is to use the glissando to help locate the justly-tuned minor third. Play these exercises slowly to help you listen for accurate intonation.



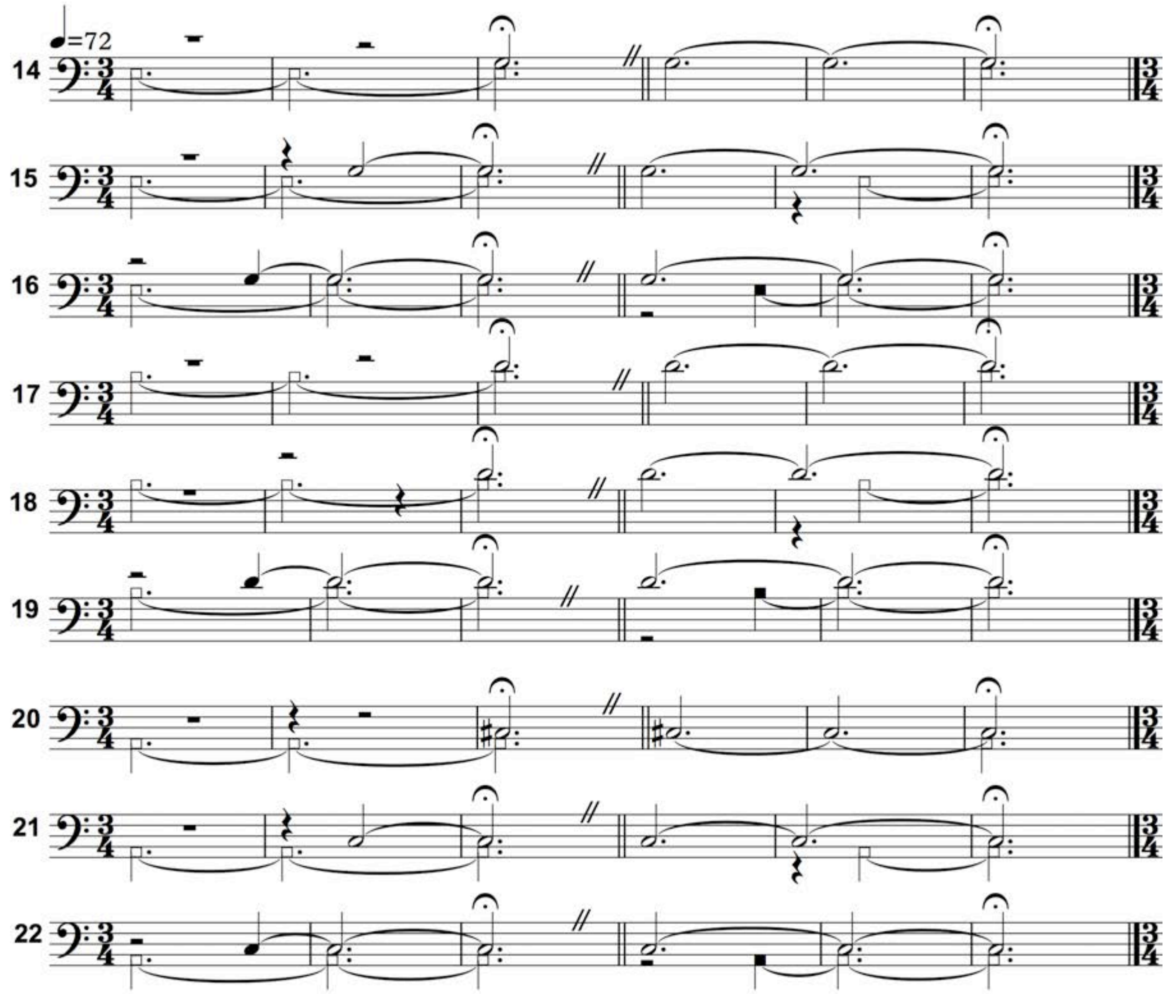
Pause briefly after each caesura. Hear the interval of the minor third before playing exercises 8-10. It may be beneficial to play the interval on the trombone before beginning these exercises.



Goals for exercises 11-13: (1) Play and sing with your best possible sound. (2) Play a clear, justly-tuned minor third, and (3)work to eliminate any blemishes in the sound when changing from sung to played note.

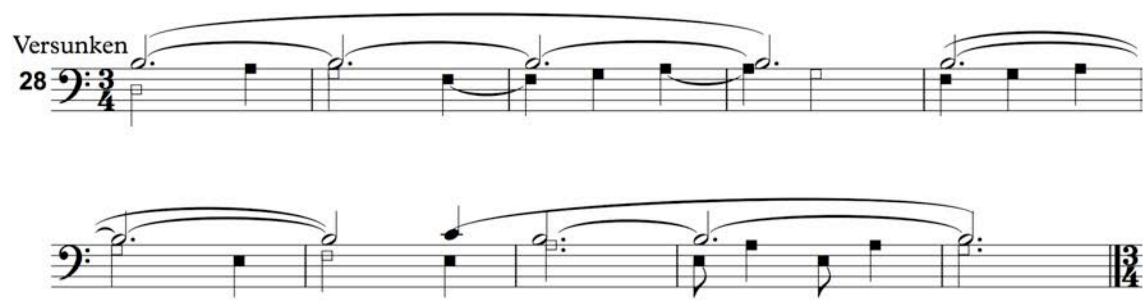


Be sure to rest after each caesura and when you become tired. Strive for accurate intervals and attempt to hear the final measure of each exercise as you play.



Work on instantaneous sound from both multiphonic voices. Repeat these exercises until you feel comfortable with the tuning and unison attacks of this interval. If necessary, choose additional minor thirds to work on unison attacks.

The remaining pages contain some foreign terminology. Be sure to look up any terms you are unaware of, and write them down in the score. These terms help you determine the style or tempo of the piece. Do your best to observe the phrase markings. Make each of these etudes unique and musical.



mit freudiger Bewegung

30

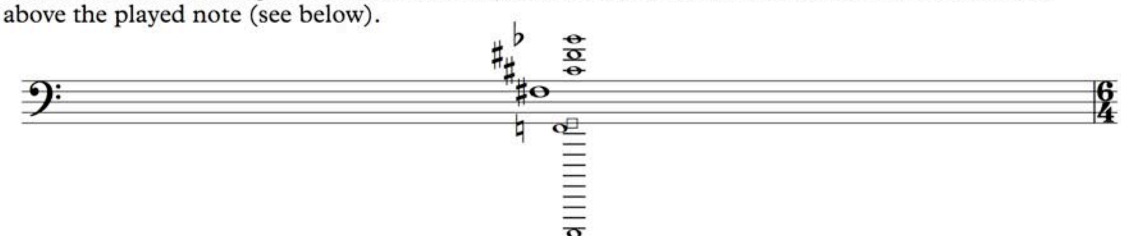
mit freudiger Bewegung

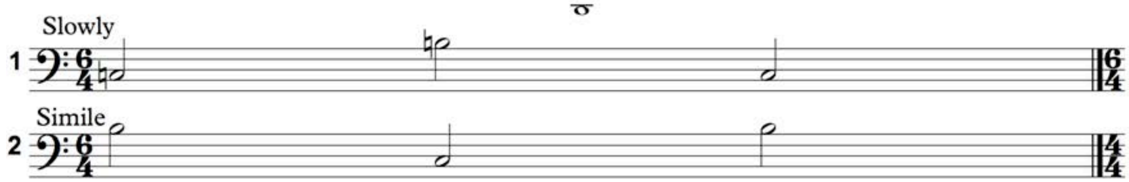
31

The Reverse Major Seventh

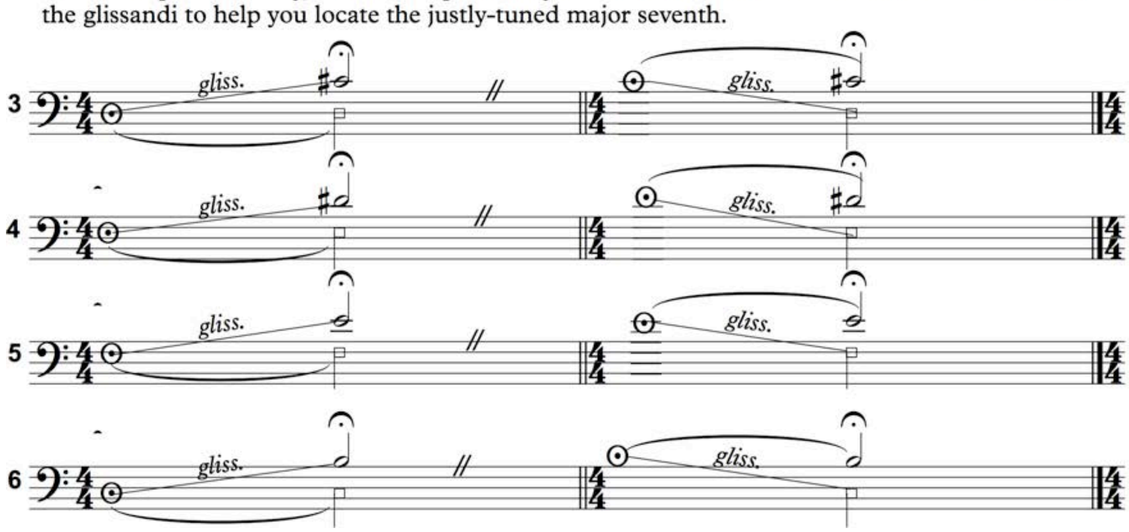
When played with similar dynamics and justly tuned, the reverse major seventh can be very effective. Initially, matching the dynamics of the sung and played note will be difficult, as you are singing well below the played note. Attempt to sing louder than the played note, as this will help you learn to match dynamics by feel and sound. Tips for successful learning and application of the major seventh: (1) Use the octave as your guide note. Practice moving between the octave and major seventh whenever you have issues with this interval. (2) Avoid the distraction of beats on your lips and in your ears. Do this by actively listening for correct intonation. (3) The just major seventh varies from the equal tempered equivalent by twelve cents and can be adjusted by lowering the sung note. At times you may have difficulty hearing the sung note. This happens because the played note is too loud. (4) Apply less mouthpiece pressure to help you play softer, thus allowing the sung note a better chance to resonate.

Subjective tones found with the major seventh include a twenty second and major second below the bottom note; an augmented eleventh, major fourteenth, and a minor seventeenth are found above the played note (see below).





As the distance between trombone and voice increases, the tendency for poor playing habits increases as well. Be sure to stay relaxed in the neck, throat, embouchure, and shoulders, as these are frequently the most common problems associated with reverse multiphonics. Play exercises 3-6 slowly and out of time. If you are tired when you begin this interval section, it is in your best interest to put this away, or work on previously learned intervals. Rest after each caesura and use the glissandi to help you locate the justly-tuned major seventh.



Exercises 7-19 are intended to help you gain control and, eventually, master the reverse major seventh. I reccomend playing the final measure of a given exercise before playing the entire exercise. Once you have the sound of the major seventh in your ear, play through the exercise and keep the sound of the interval in your ear throughout the exercise.

= 72
17
18
= 72
19
Adagio
20
Moderato
21

Choose one of the remaining etudes, as they are challenging and long. Choose the etude that best fits your range and abilities. Omit any note(s) that may lie beyond your range. Although these etudes do not contain barlines, you should still play with a steady beat. Play both "voices" prior to learning the etudes and select a tempo that is both musically appropriate and within your abilities.

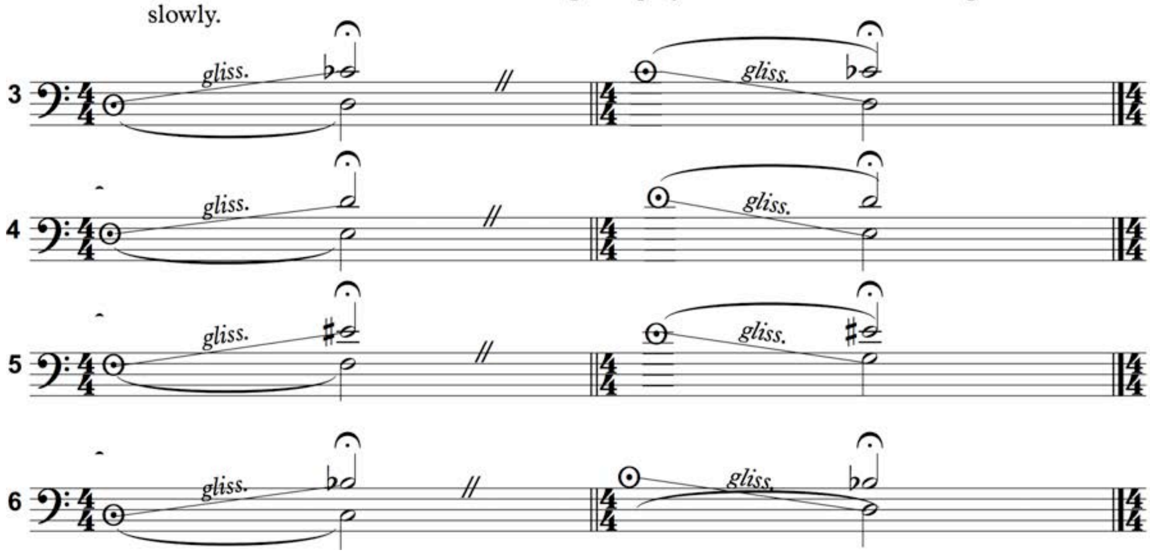

Avec enthuousiasme
23

The Reverse Minor Seventh

Similar to the major tenth, the reverse minor seventh is challenging due to the distance between sung and played notes and the beating phenomenon. Listen carefully as you proceed through this sub-section. Tips for success: (1) Use the major sixth as a guide to locate the minor seventh. (2) If you find this interval to be too challenging, practice moving between the major sixth and minor seventh. (3) The just minor seventh is four cents flatter than its equal tempered counterpart. (4) Use a recording device and a tuner to help with just intonation. (5) Remember to take breaks. Don't pound away at these exercises, as you could develop bad playing habits. Play with ease and your most beautiful sound.

Subjective tones for the minor seventh: a major seventeenth and major third lie below the bottom note, while a major tenth, augmented eleventh, major fourteenth, and major sixteenth are found above the bottom note (see below).

As with other similar exercises, use the glissandi, even the "false" ones, to gradually increase the distance between the sung and played notes. Do the following exercises slowly.



Exercises 7-19 help develop (1) Clean and accurate intervals, (2) Staggered entrances, (3) Simultaneous entrances, and (4) A solid framework for which you can continue to build your multiphonic skills. Make sure that you stay within your range.

Perform all remaining exercises that are within your range and omit any note(s) or measure(s) that lie outside of your range. Some of the etudes do not contain barlines. This is to help you become accustomed to reading a different type of multiphonic notation.


Zuversichtlich
21
Zeit lassen und stürmisch
22


Lagnoso
23
3


Cadenza
24

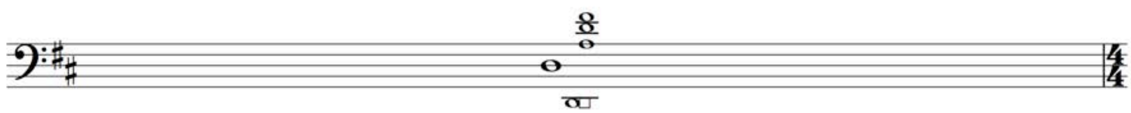

Commosso
25
Moqueur
26
Morboso e lesto
27


Nostalgico
28
Schwermütig
29
Adagio meravigliato
30

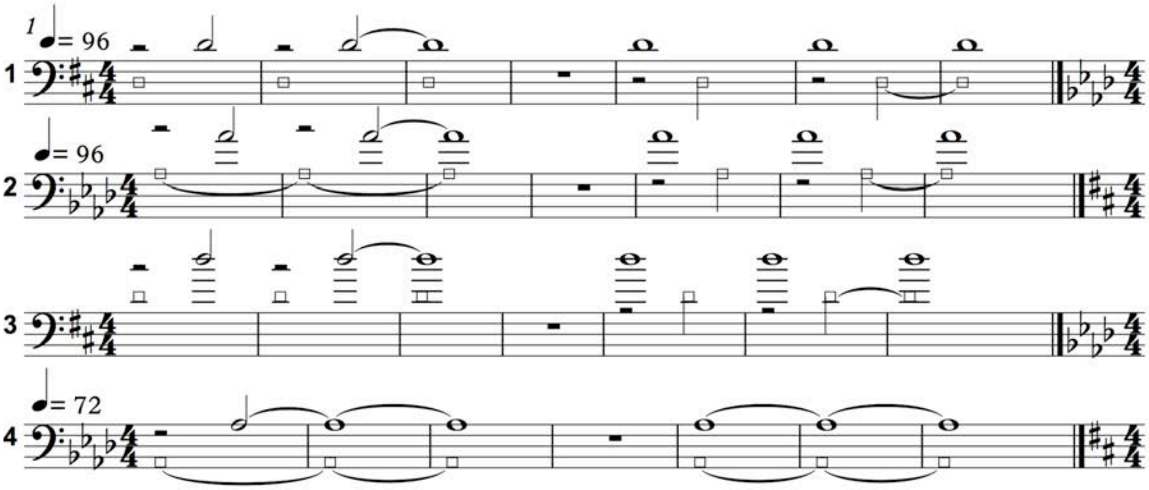
The Reverse Octave

Like the perfect fourth and fifth, the reverse octave is one of the most easily learned intervals. Exercises in this portion of the method will help you to hear the interval and its relationship to previously learned intervals. Tips for mastery and success: (1) Closely related intervals include the unison and perfect fifth. If you find the octave difficult to hear, (2) Spend additional time on the first few exercises. (3) Try playing octaves with another trombonist and listen for the quality of sound and any subjective tones you may hear.

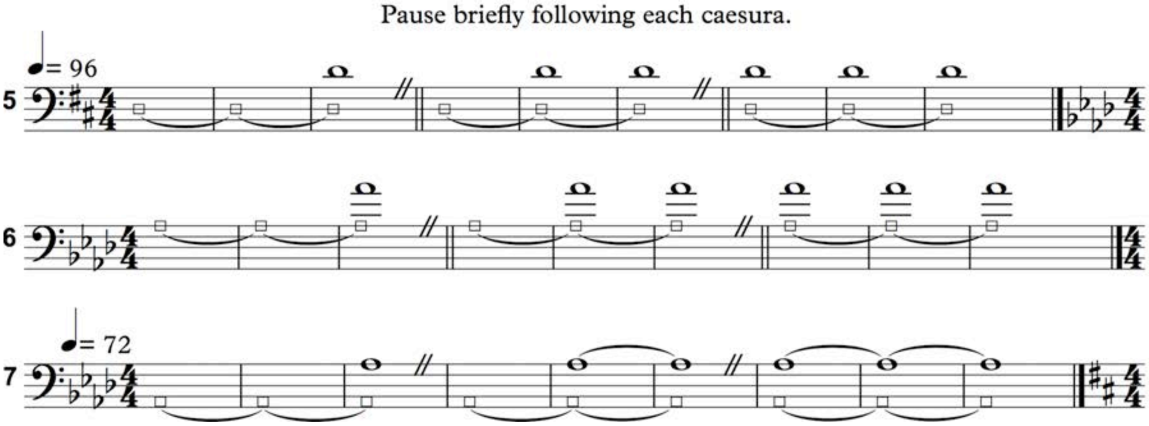
Subjective tones for the octave include a unison, perfect twelfth, a fifteenth, and a major seventeenth above the bottom note (see below).

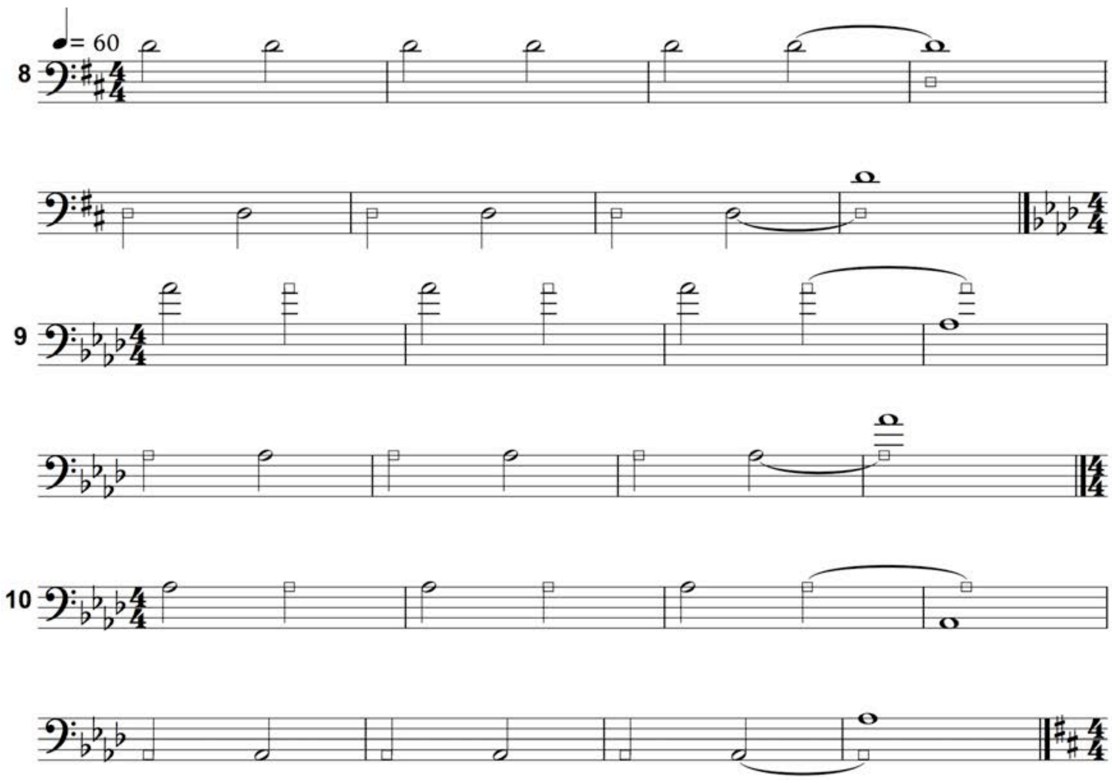


Some of the exercises on the next two pages contain high played and/or low sung notes. Remember to stay relaxed, keep the air moving, and avoid tension in the neck and shoulders. Doing so will greatly help your study of multiphonics. Only play the exercises that are within your range.

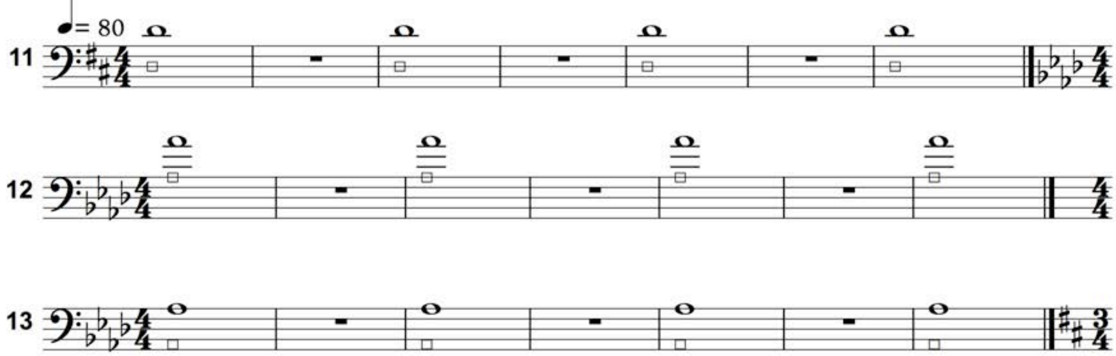


Pause briefly following each caesura.





Work on clean, unison attacks.



Play from the following etudes, only those you can play with ease. Do not attempt to go beyond your playing or vocal range. Over time, you will develop more facility and master this technique, thus allowing you the ability to play most anything you choose.


= 92
15
16
17
18
19
⊙ = Sing and play in unison
= 60
20
21
= 60
22
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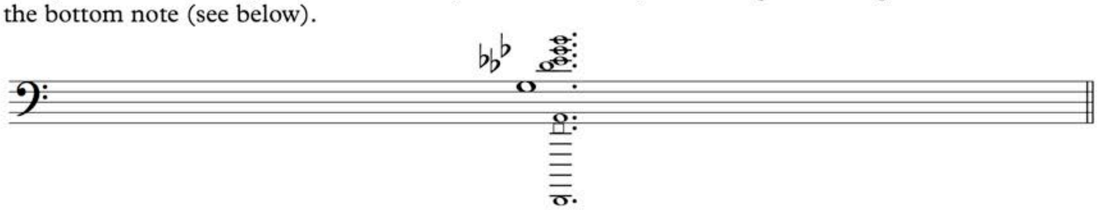
35

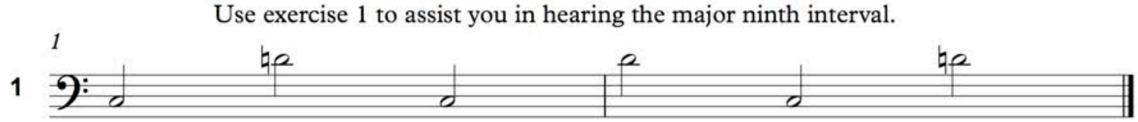
The Reverse Major Ninth

Tuned accurately, which is not complicated, the reverse major ninth can create a sensation of a "rolled" sound. This timbre can be heard by the various subjective tones that are addressed below. When played softly, the effect is greatly enhanced which can make some subjective tones sound louder than others at a louder dynamic. Beats are heard and felt, however, the sensation on the lips is not as great as you experienced with the tritone and minor third. Tips for success: (1) To have a chance of hearing subjective tones, the voice must be lowered by four cents. (2) Use the octave as a guide note to help hear where to place this interval. Remember, the major ninth is simply an octave above a major second, so (3) think of this interval as a major second but with a greater timbral palate. Finally, (4) if this interval is, or becomes, problematic, practice playing scales by playing the tonic note on trombone and sing the scale down to the ninth, holding the ninth as long as possible.

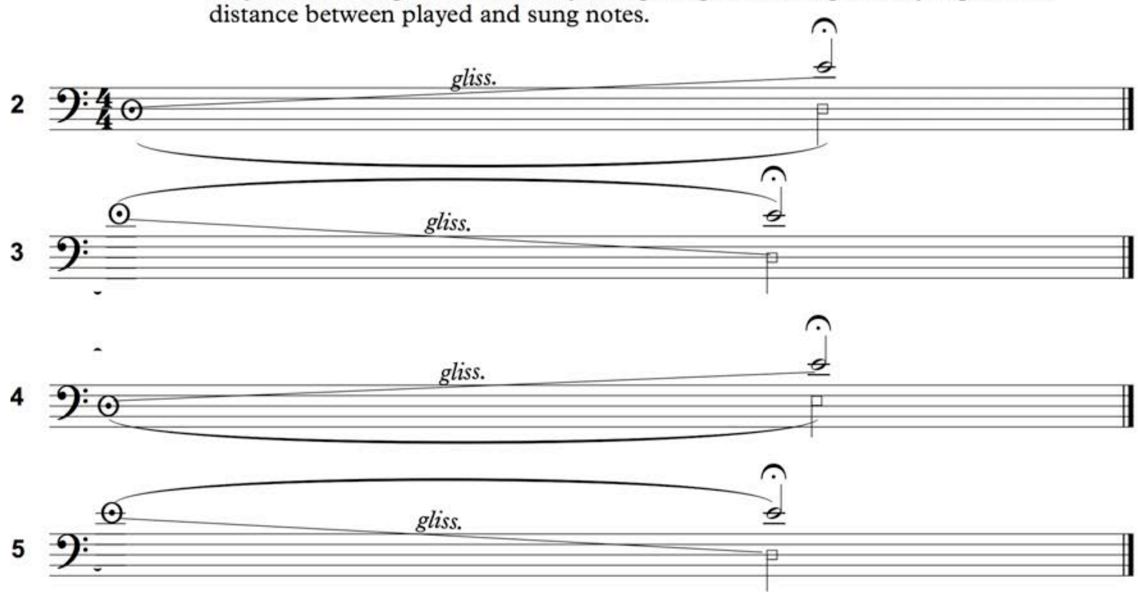
Subjective tones for the major ninth include a fifteenth below the bottom note and a major third, minor thirteenth, minor fourteenth, minor sixteenth, and an augmented eighteenth above the bottom note (see below).

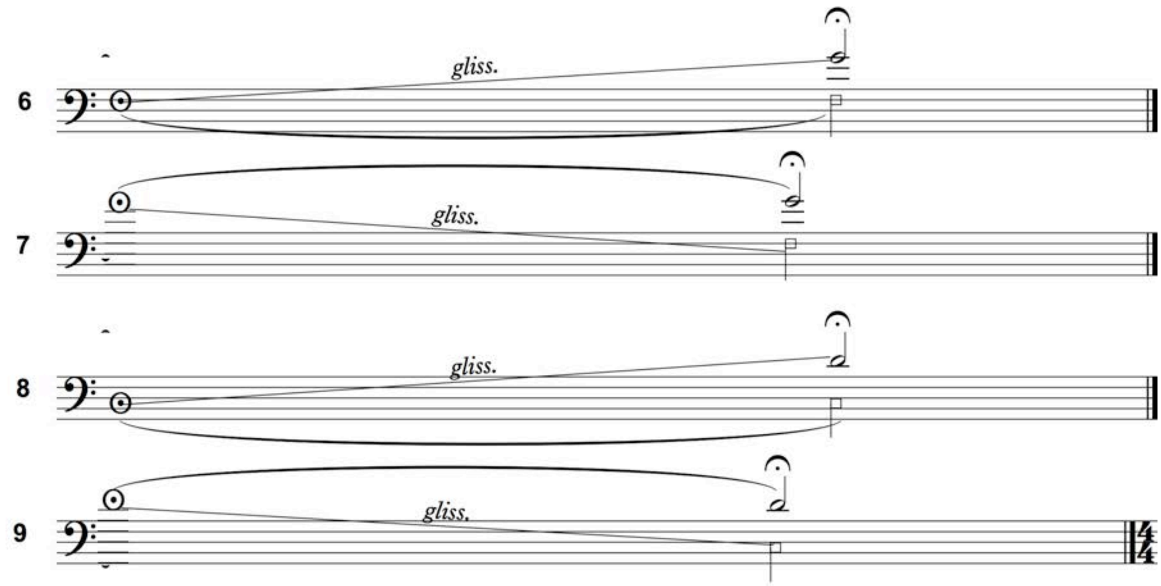


Use exercise 1 to assist you in hearing the major ninth interval.



Play the following exercises slowly, using the glissandi to gradually expand the distance between played and sung notes.





Work on smooth transitions and similar dynamics between sung and played notes.
Play nice, pretty sounds while staying within your playing and singing range.


16
17
18
19
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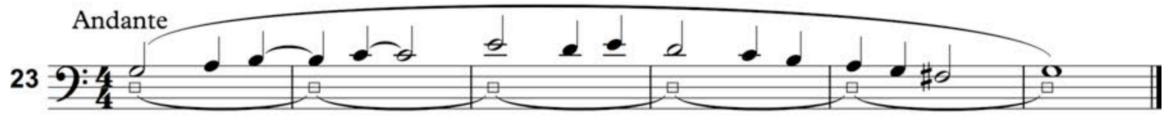
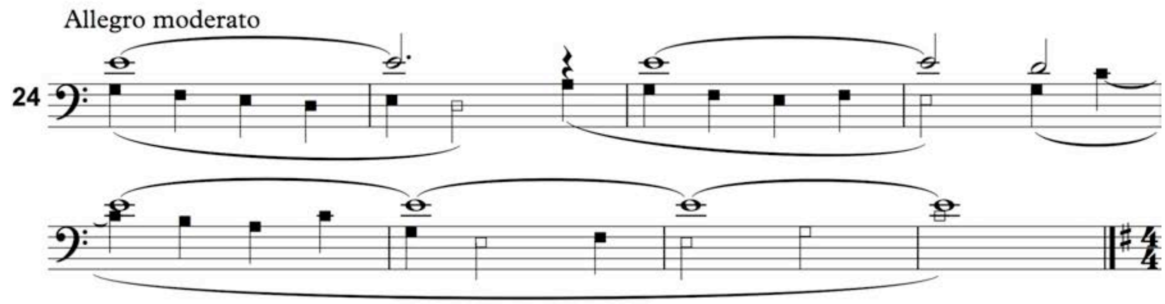
21
= 72
22

Play as many of the following etudes that are within your range. Observe the phrase markings to the best of your ability, but breathe when needed at musically appropriate spots.

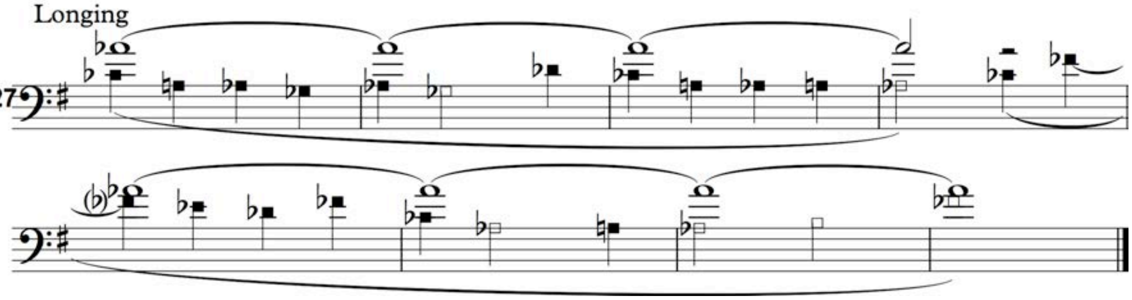




Free and melodious.

26 

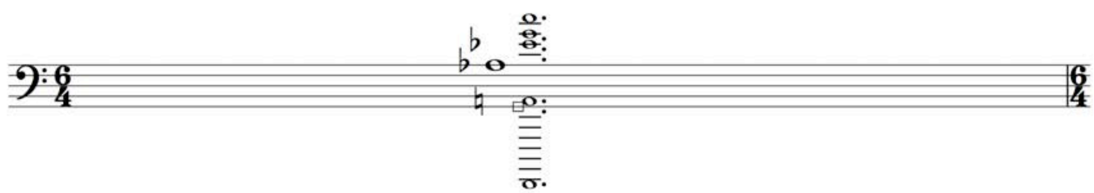
Longing

27 

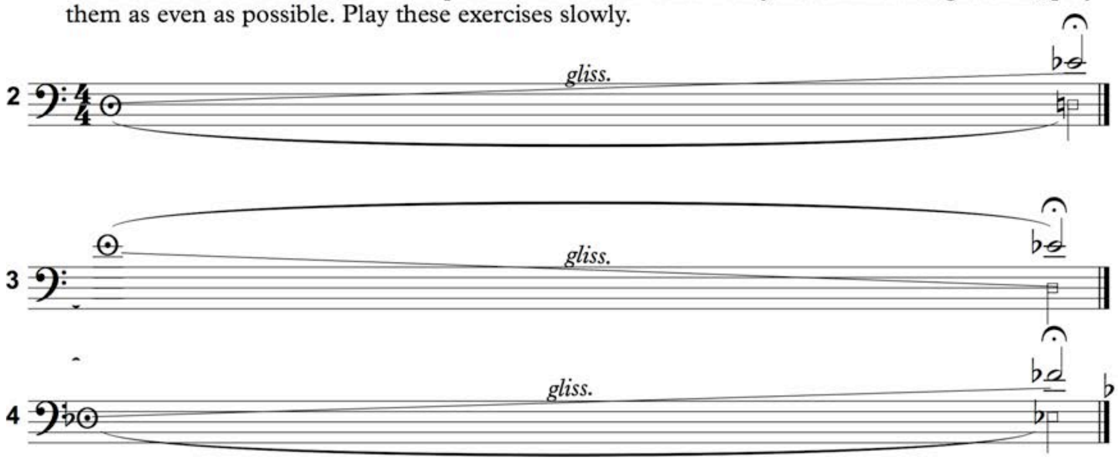
The Reverse Minor Ninth

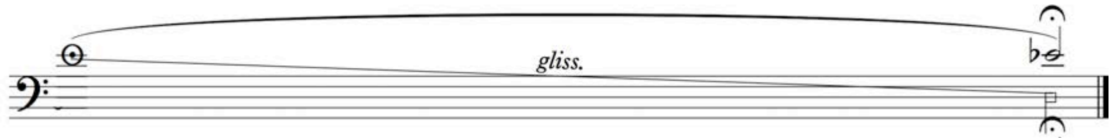
Of the intervals learned thus far, the reverse minor ninth may be the most difficult interval to master. There are three main obstacles to overcome before mastering this interval. There is no useful guide tone to help place the minor ninth, so take plenty of time learning how this interval sounds and feels. Here are a few tips to help you master the minor ninth. (1) Use mouthpiece pressure to your advantage. By using less mouthpiece pressure, you may find it easier to play softer and have the vocal note sound louder. Experiment for yourself, but for most people, only a minute change in mouthpiece pressure is needed for this "trick." (2) Learn the sound of this interval. Be able to sing, whistle, or aurally identify a minor ninth. (3) Playing minor ninths against a drone, piano, or another trombonist may help you to better hear this interval. Finally, (4) the just minor ninth is twelve cents wider than the equally-tempered minor ninth. Use your voice to adjust for this difference, not the slide.

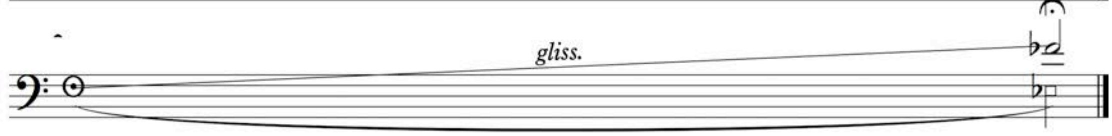
Subjective tones for the minor ninth include a major sixteenth below the bottom note and a major second, minor thirteenth, a fifteenth, and a perfect eighteenth above the bottom note (see below).

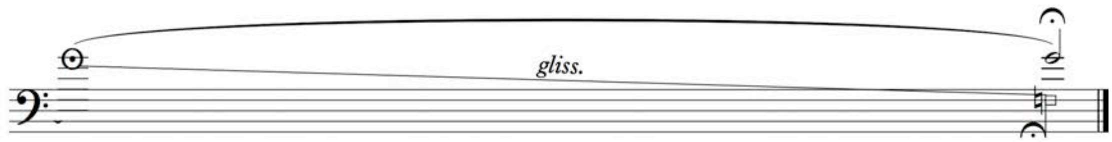


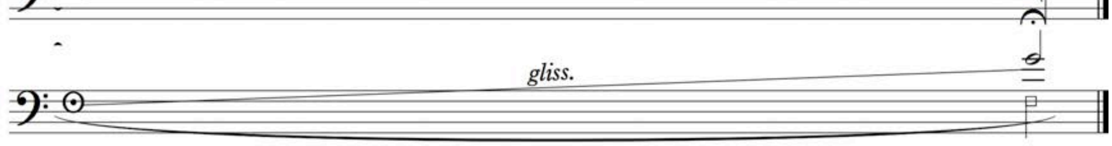
The goal of this exercise is to reinforce the sound of the minor ninth while gradually increasing the distance between the two multiphonic "voices." Do not worry about the false glissandi; play them as even as possible. Play these exercises slowly.

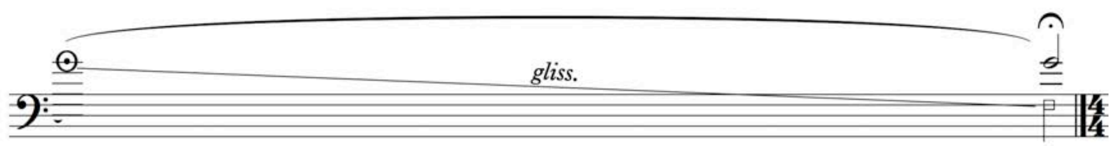


5 

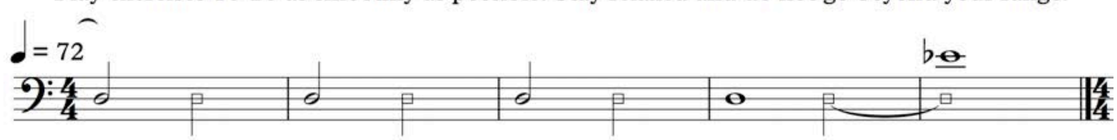
6 

7 

8 

9 

Play exercises 10-20 as smoothly as possible. Stay relaxed and do not go beyond your range.

10 

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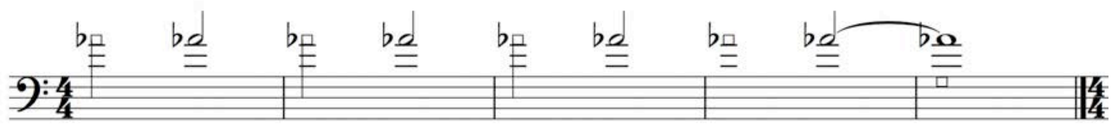
13 

14 


= 72
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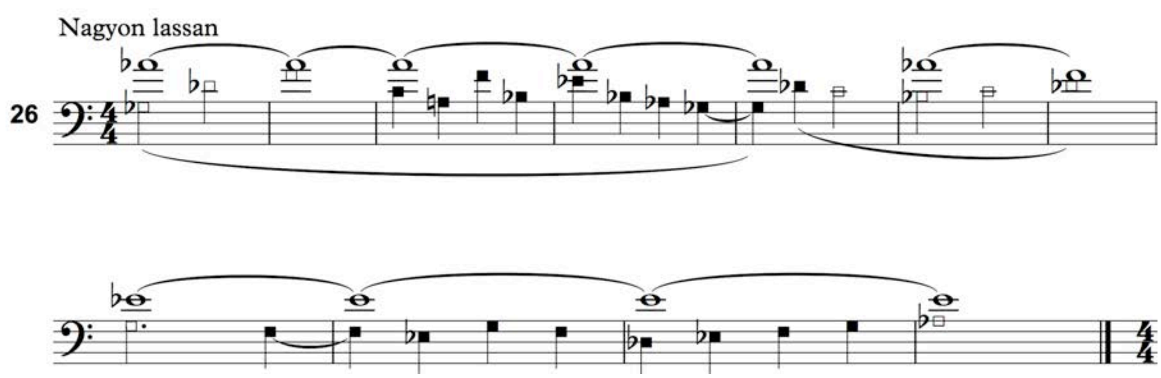
= 72
22

Play all etudes that are within your range.

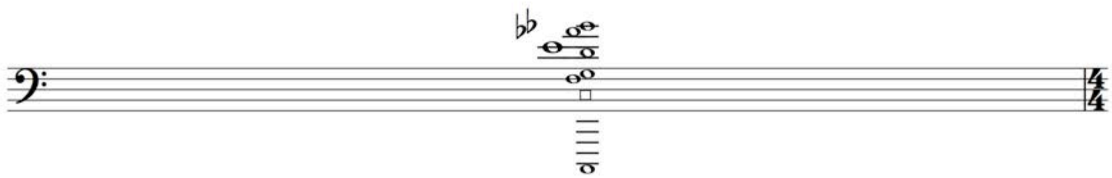



Forwährend
27

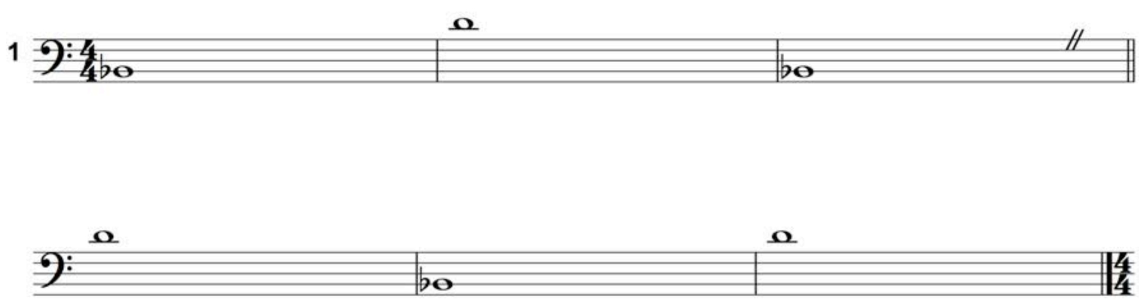
The Reverse Major Tenth

The compound equivalent of the major third varies from its simple form as the beating sensation is not as strong as the major third. Tips for the major tenth: (1) Use the octave and major third as guide tones. Later, use the perfect eleventh in combination with the octave and major third to help you better hear this interval. (2) To obtain a justly-tuned major tenth, the sung note must be lowered by fourteen cents. (3) Practice this unfamiliar technique by singing louder than the played note so that you can hear the sung note clearly. (4)Lastly, do not attempt any exercises that are out of your range.

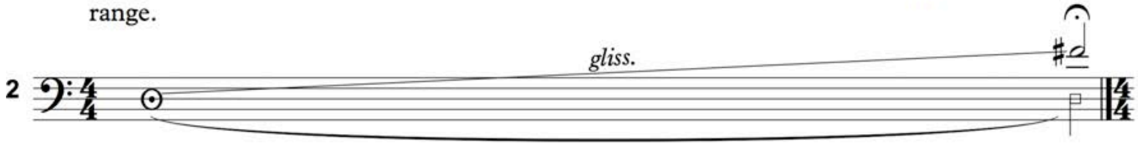
Subjective tones for the major tenth: a fifteenth below the bottom note and a perfect fourth, perfect fifth, major ninth, minor thirteenth, and minor fourteen above the bottom note.

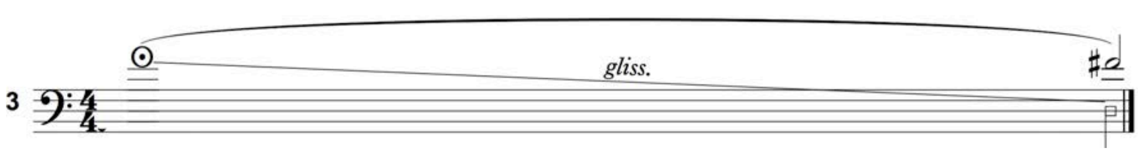


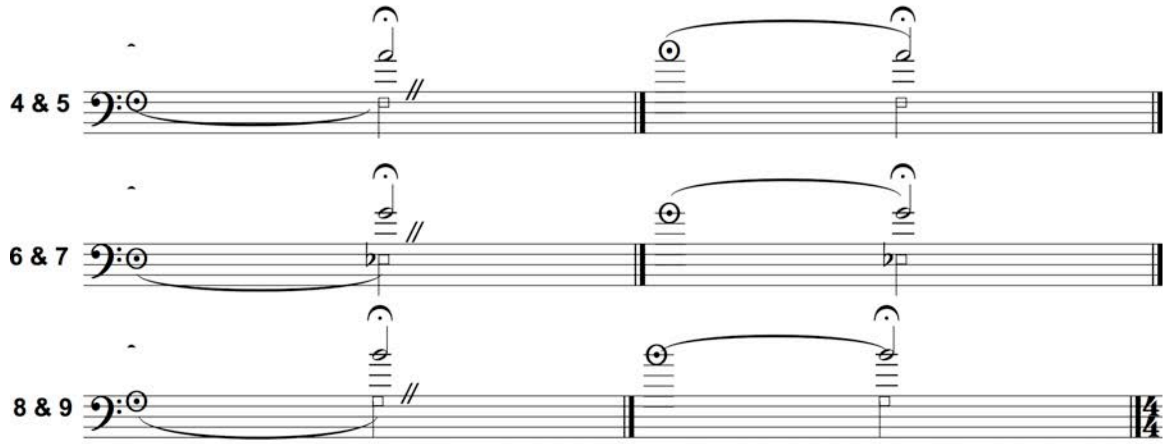
Use exercise 1 to familiarize yourself with the sound of the major tenth. Pause briefly at the caesura in measure three.



Play exercises 2 and 3 slowly. Focus on maintaining the sung pitch throughout the glissandi. If needed, transpose these exercises to different keys to better fit your singing and/or playing range.







Strive for an uninterrupted sound when switching between trombone and voice.
Additionally, attempt to hear the major tenth interval as you play each exercise.


16
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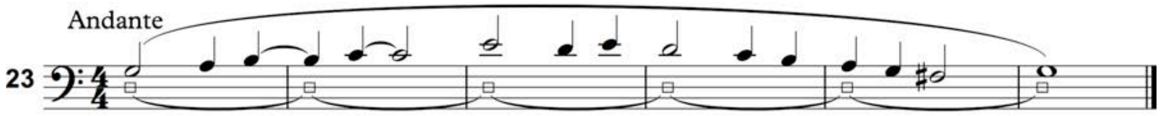
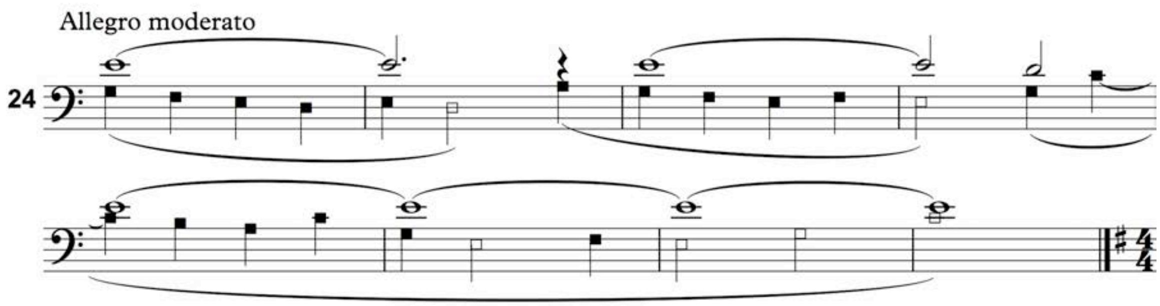
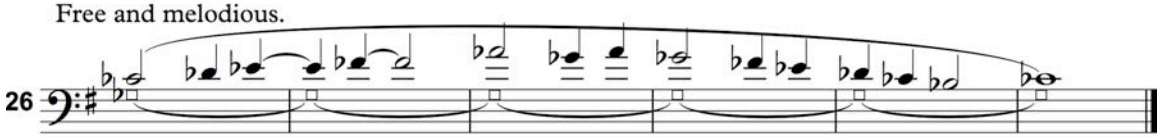
21
= 72
22

Play as many of the following etudes that are within your range. Observe the phrase markings to the best of your ability, but breathe when needed at musically appropriate spots.

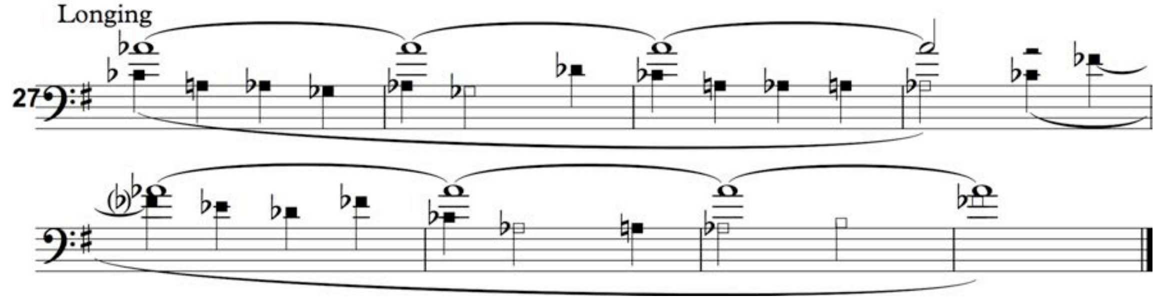




Free and melodious.



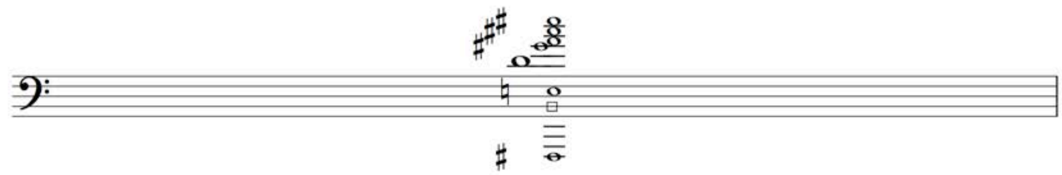
Longing



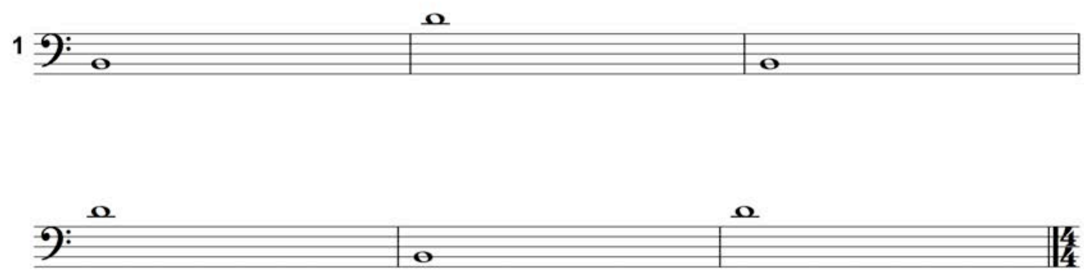
The Reverse Minor Tenth

Unlike the minor third, the minor tenth does not contain beats that affect your perception of sound, nor do the beats interfere with the sensation of playing. Use the major tenth as your guide note to help locate this pitch. Focus on maintaining the sung voice as it tends to drift flat, often lying somewhere between the minor tenth and major ninth. Tips for mastery and success: (1) The just minor tenth is sixteen cents sharper than the equally tempered interval, therefore, you will need to raise the sung note by sixteen cents to obtain a justly-tuned interval. (2) To play softer and sing louder, use slightly less mouthpiece pressure than you would when playing normally. (3) Record yourself and listen for a consistent sung note and subjective tones.

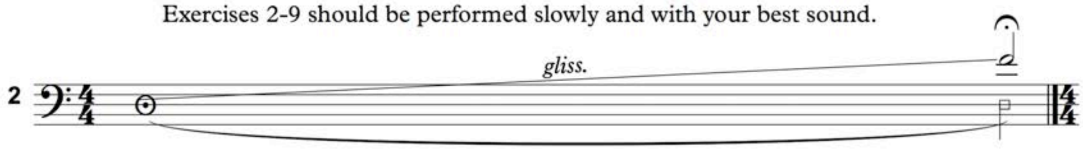
Subjective tones for the minor tenth: as you can see below, a perfect eleventh lies underneath the bottom note. A perfect fourth, major thirteenth, major fourteenth, major sixteenth, and an augmented eighteenth are all found above the bottom note.

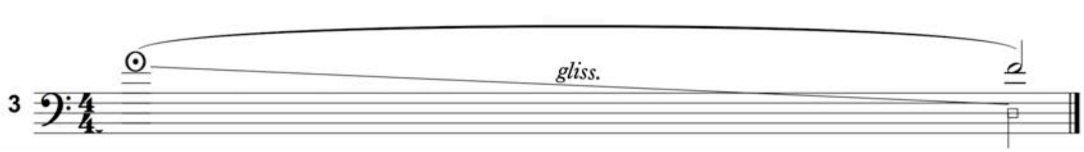


Listen for the quality of the interval. Go slowly.

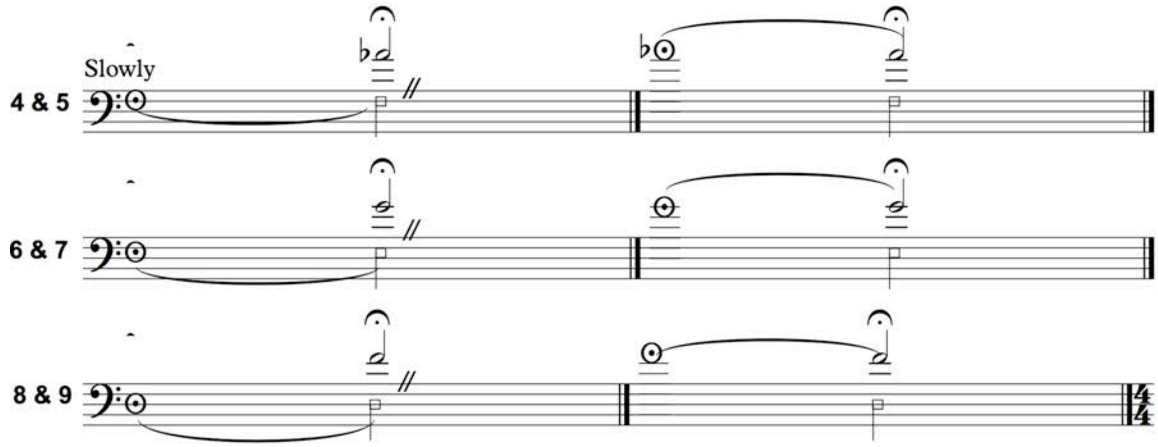


Exercises 2-9 should be performed slowly and with your best sound.



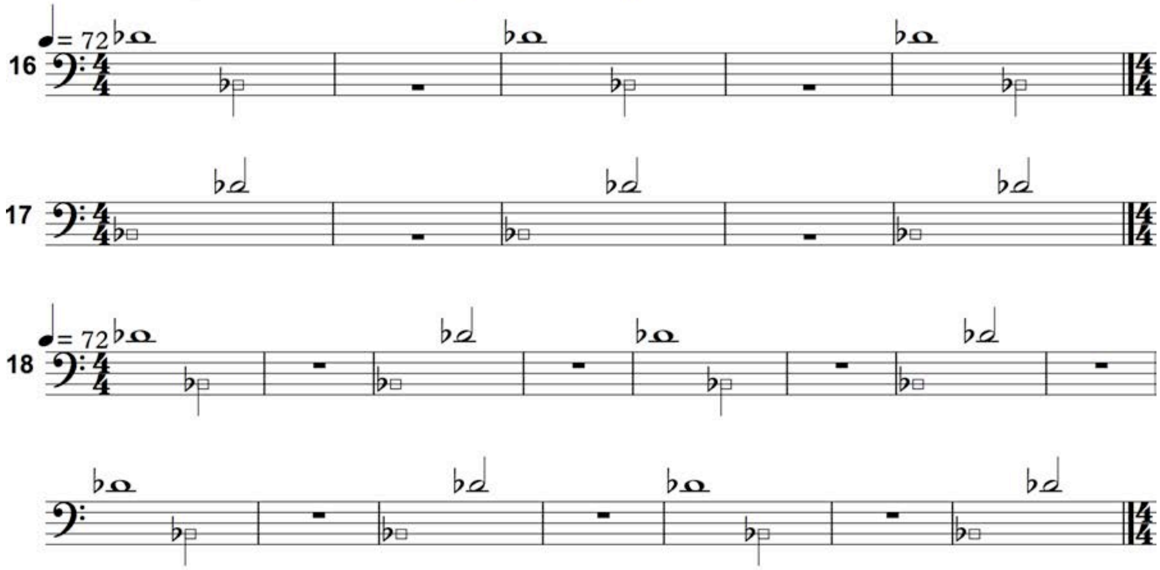


Stay relaxed, play with your best sound, and attempt to hear the "added note" throughout each exercise. Pause briefly after each caesura.

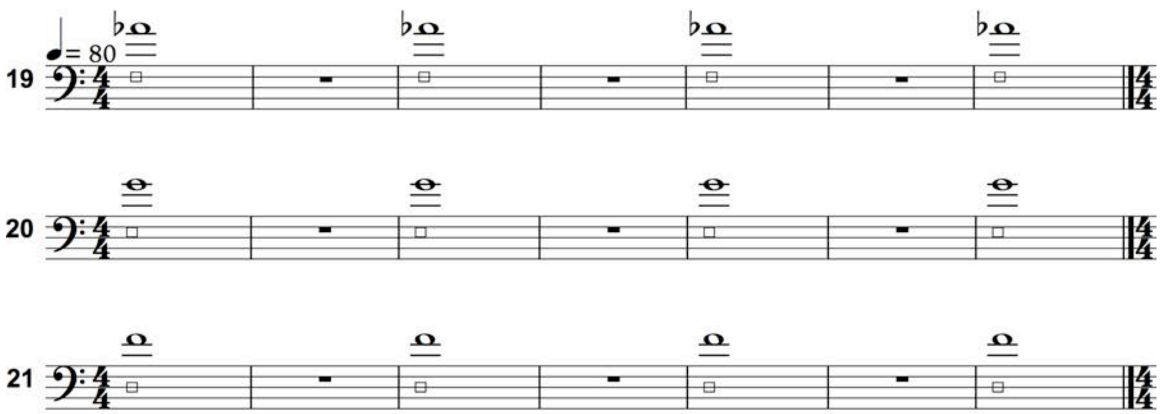


Continue to work on hearing the added note while playing each exercise as smooth and connected as possible. Only play exercises that are within your range.

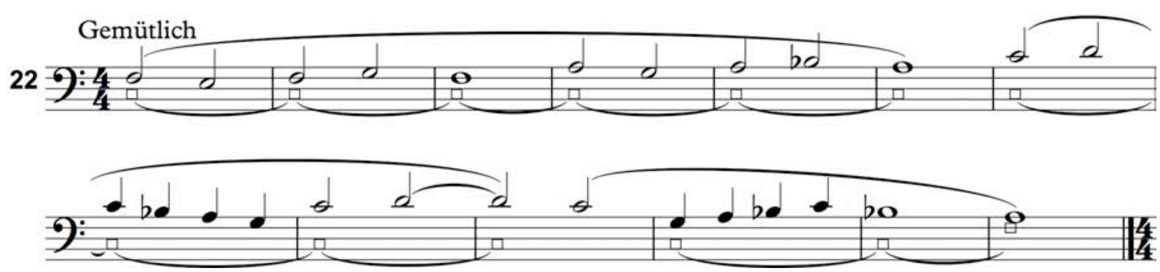
Strive for accurate intervals and seamless integration of sung and played notes.
Transpose these exercises to a minimum of one additional key.



These exercises are used to develop clean, unison attacks. It may be helpful to play each interval prior to starting each exercise.



Play all etudes, but omit any sung note(s) that are beyond your range.



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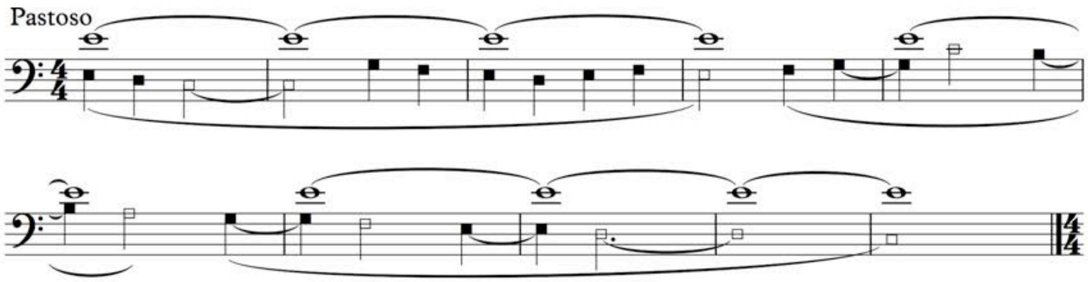


24


Cadenza
25

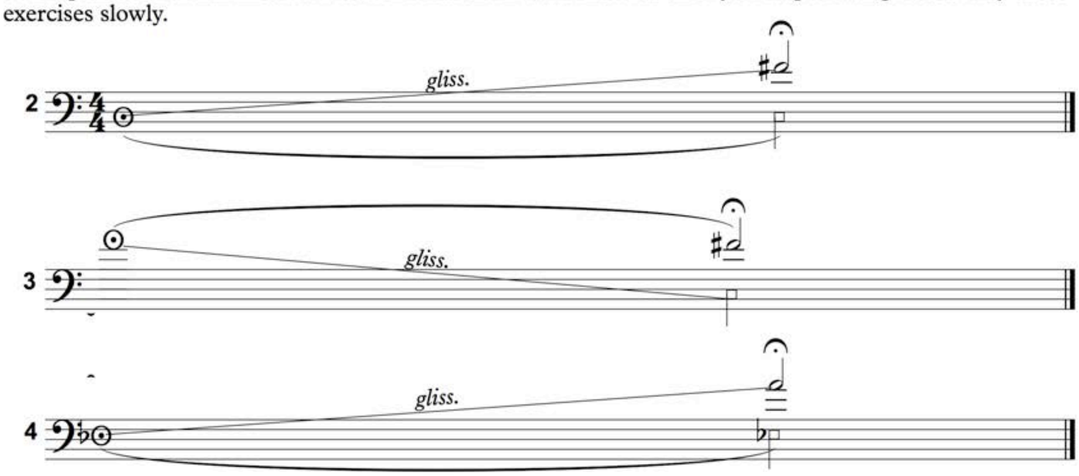
The Reverse Perfect Eleventh

The perfect eleventh shares some similarities to the perfect fourth. Fist, a perfect eleventh is simply a perfect fourth plus an octave. Second, similar subjective tones are found in both intervals. Half of the subjective tones in each interval are found in the other. Finally, the same adjustment needed for the justly-tuned perfect fourth is the same for the perfect eleventh. Here are some suggestions I find will help you in this chapter : (1) The perfect eleventh has fewer beats than the perfect fourth, but these beats can also make tuning challenging. Tuning can be difficult because the perfect fourth lies in between the third and fifth scale degrees. Therefore, (2) <u>use the perfect tenth as your guide tone.</u> (3) <u>A justly-tuned perfect eleventh is two cents lower than the equally-tempered perfect eleventh.</u> (4) <u>Take breaks when needed.</u> Like your playing endurance, you will have to build up your multiphonic endurance which is accomplished by daily effective multiphonic practice

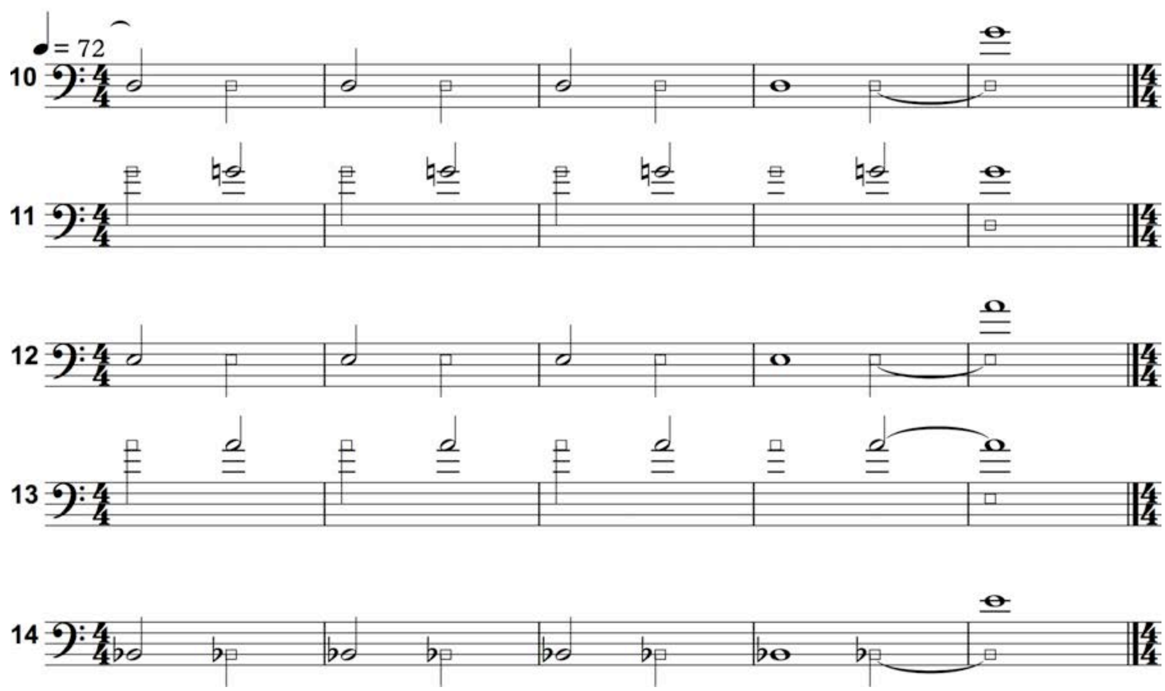
Subjective tones for the perfect eleventh include a perfect fifth below the bottom note and a major sixth, minor tenth, major fourteenth, minor sixteenth, and a minor twentieth above the bottom note.

Freely and with great care. Rest for at least one measure at the caesura.

The following glissandi exercises are used to further develop (1) independence of the voice and trombone, (2) increasing distance between sung and played notes, and (3) tuning. Use your ears to help find the location of the perfect eleventh interval. You will hear an in-tune interval once you stop hearing beats. Play these exercises slowly.



As you play the following exercises, work toward seamless transitions between sung and played notes. Try to hear the final interval or the "added note" as you play each exercise. Play all exercises that are within your singing range.

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♩ = 80
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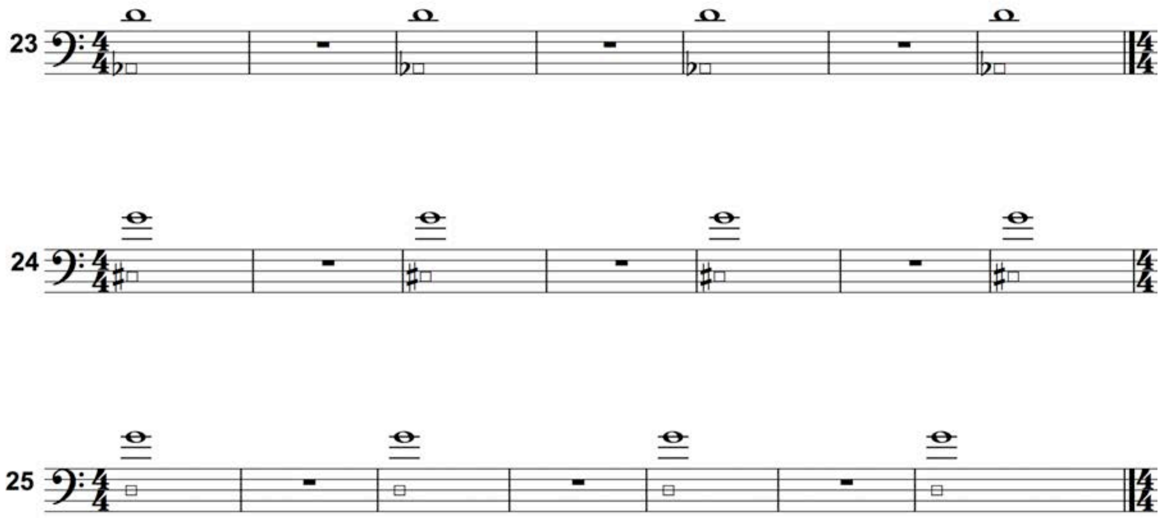
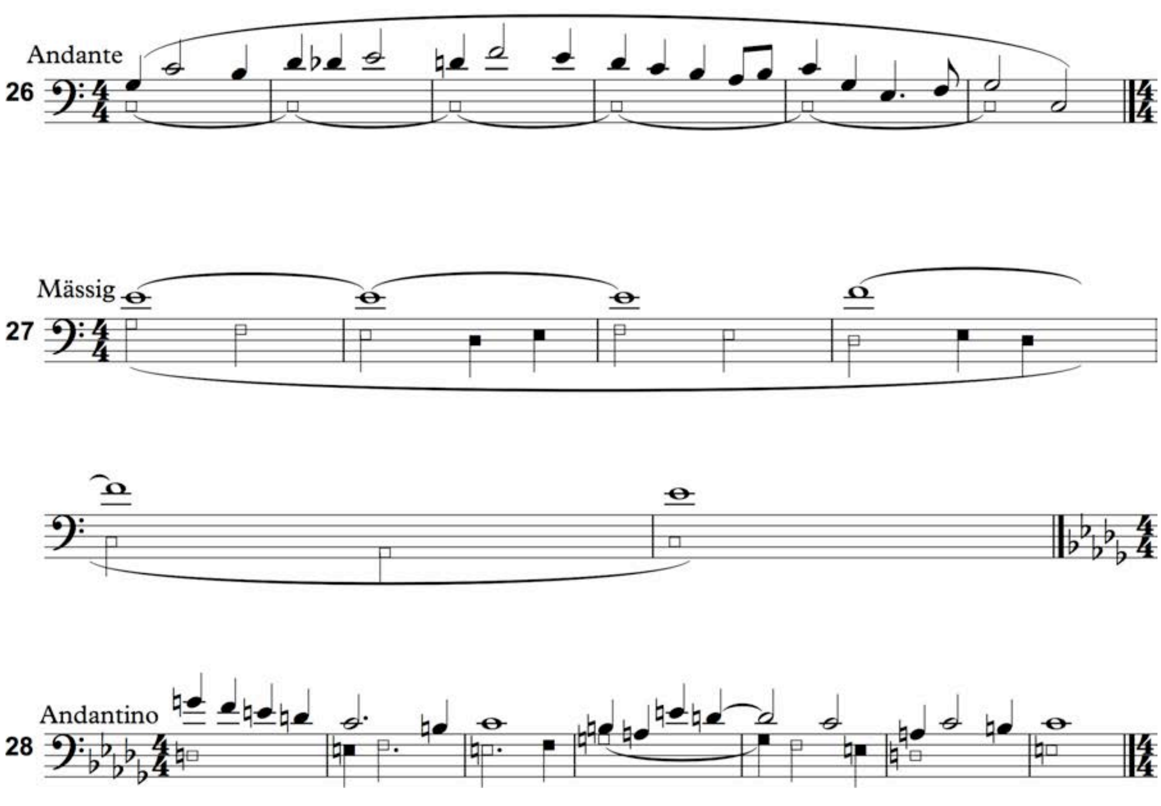
♩ = 96
22

Strive for accurately-tuned intervals, clean, unison attacks, and unison dynamics.



Play all etudes that are within your range. If necessary, omit any note(s) that are too low to sing.

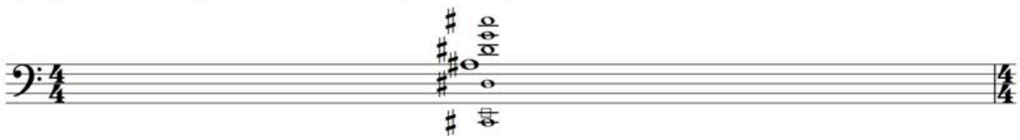



Allegro con Moto
29

The Reverse Augmented Eleventh

The reverse augmented eleventh is more challenging than the traditional augmented eleventh because the roles of each "voice" have switched. Unlike traditional multiphonics, where larger intervals are easier for most people, reverse multiphonics become increasingly harder the larger the interval. Here are some suggestions for the reverse augmented eleventh: (1) Do not rush through these exercises. Instead, take your time, record yourself, and listen back to be sure that you are (a) playing with your best sound, (b) playing/singing in tune, (c) matching dynamics, and (d) moving accurately from one interval to the next. (2) When accurately tuned, the augmented eleventh has fewer beats than the tritone which can make tuning more difficult. (3) <u>A justly-tuned perfect eleventh is seventeen cents lower than the equally-tempered augmented eleventh.</u>

Subjective tones for the reverse augmented eleventh include a minor third below the bottom note and a major seventh, major fourteenth, minor seventeenth, and a major twentieth above the bottom note.



Slowly

1 

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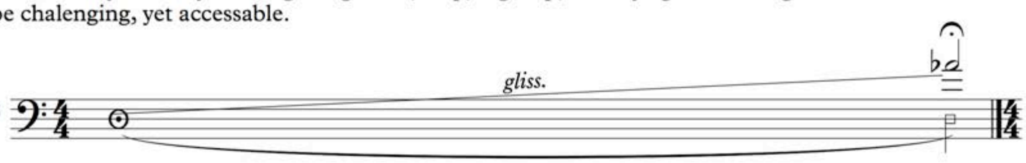
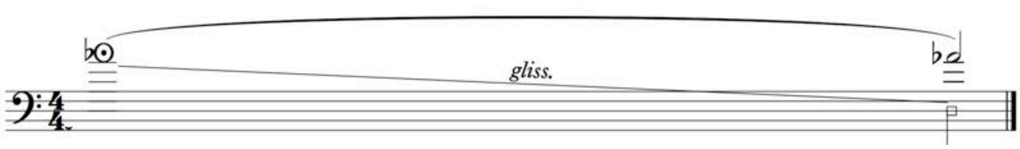
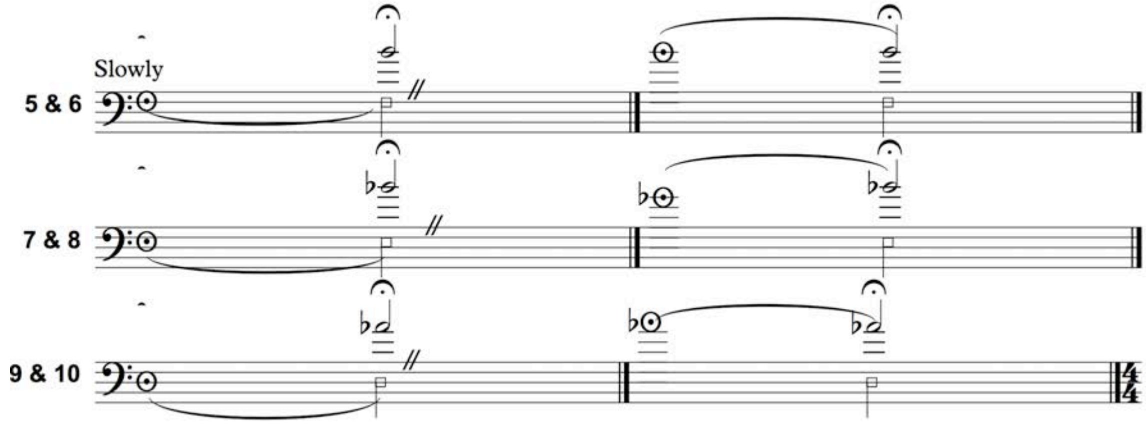
Play exercises 3 and 4 slowly. Be sure to stay relaxed as the distance between the sung and played notes increase. If you find yourself getting tense, stop, regroup, and try again. These glissandi exercises should be chalenging, yet accessable.

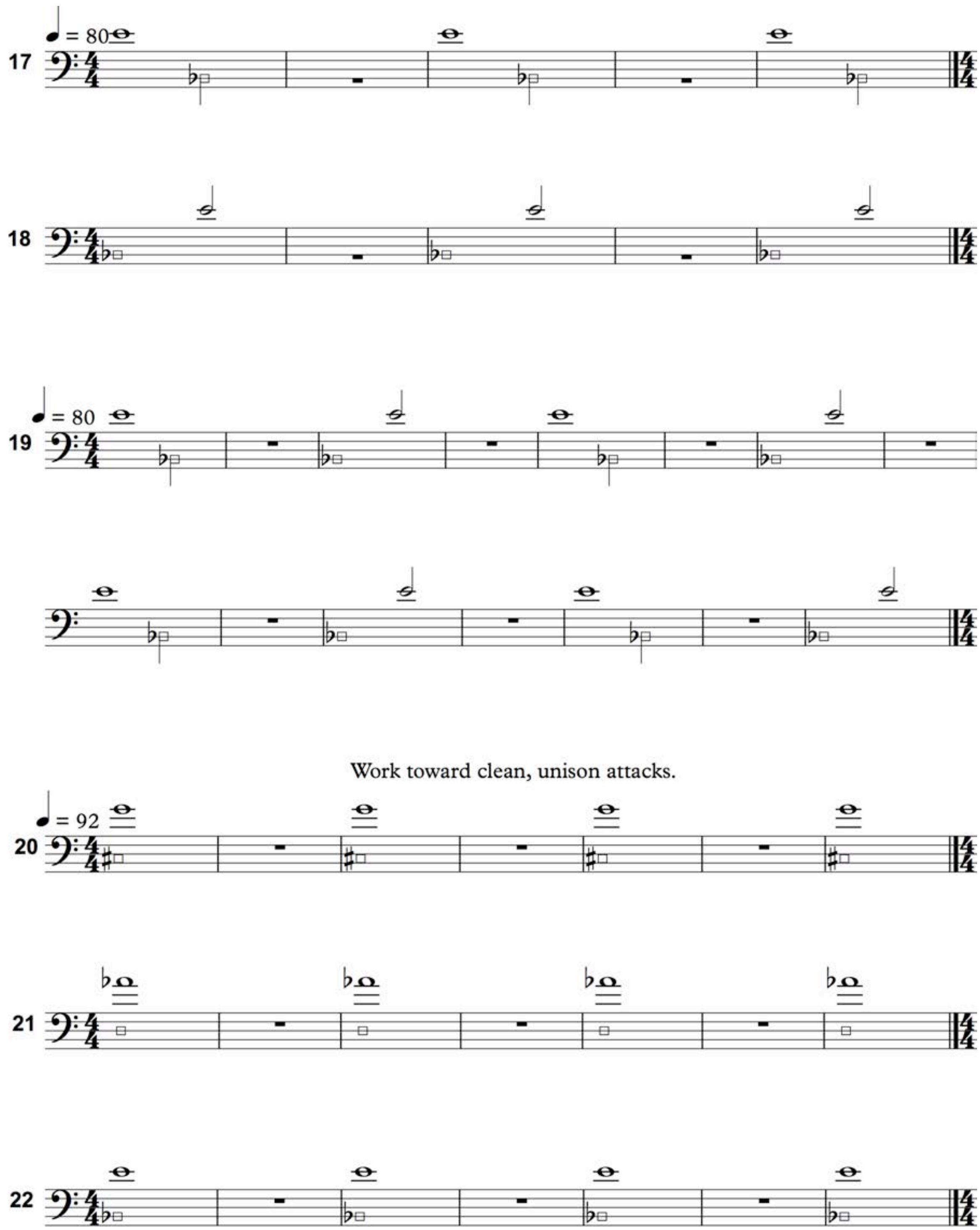
3 

4 

Pause for at least one measure after each caesura (Nos. 5-10).



Strive to play the high note of each exercise with ease. Do this by keeping your throat, sholders, and upper torso as relaxed as possible. Keep the corners of your embouchure firm throughout each exercise, as doing so will assist with the clairty and quality of the played note. Nos. 11-22


♩ = 80
17
18
♩ = 80
19
Work toward clean, unison attacks.
♩ = 92
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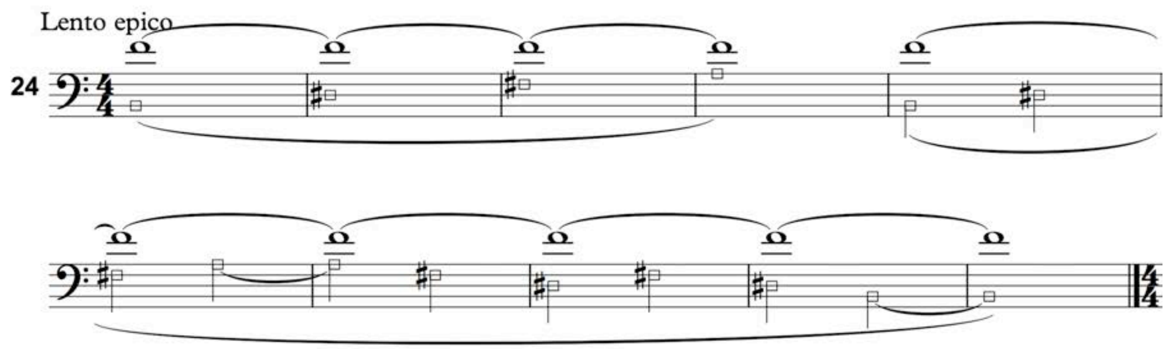
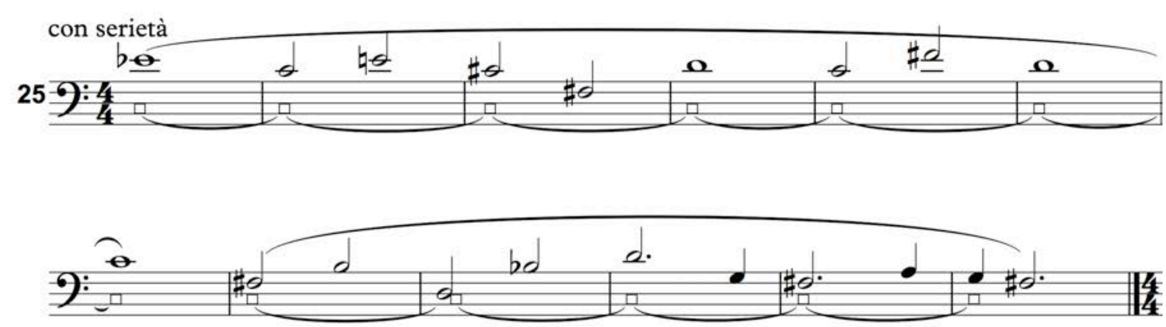
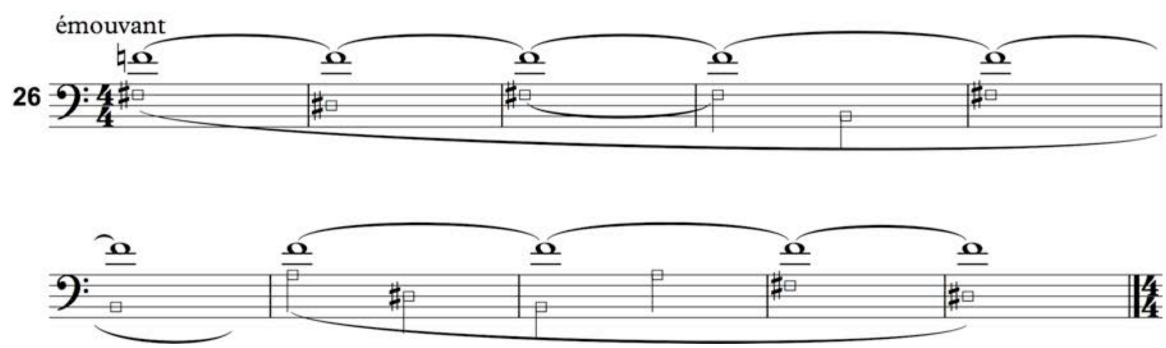
21
22

Play all etudes that are within your range. If necessary, omit any note(s) that are beyond your range.







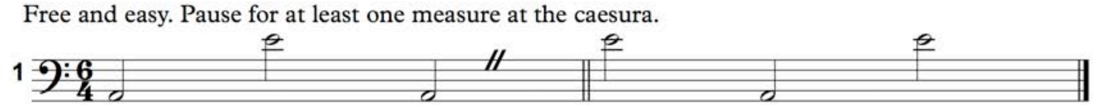

Moderato
27
Moderato
28
Moderato
29

The Reverse Perfect Twelfth

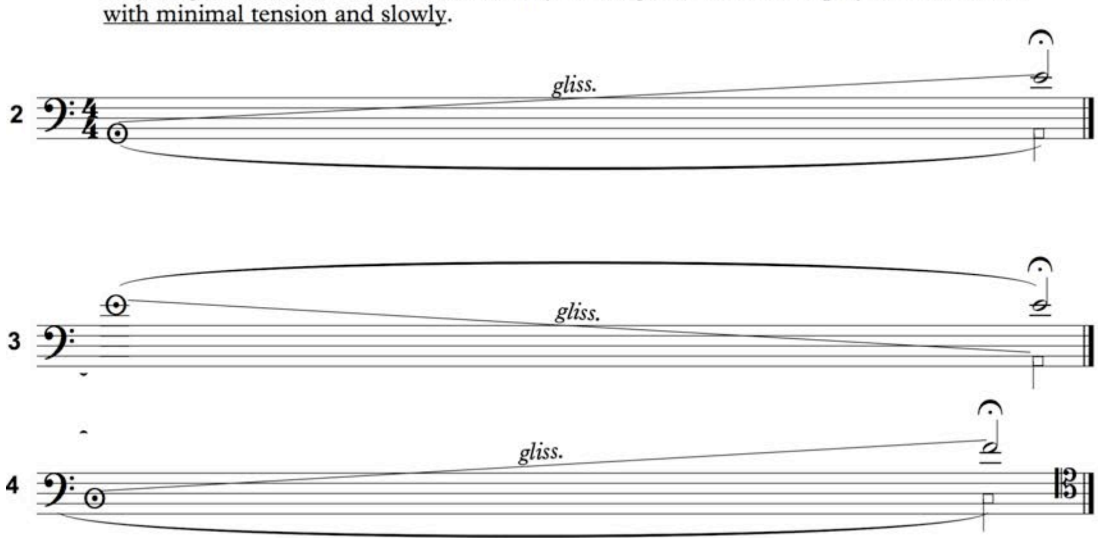
Play free, open, and musically. Focus on the sound of the interval and stay as relaxed as possible. This interval should be relatively easy to learn and hear because we hear the simple interval of a perfect fifth on a regular basis, however, when played in inappropriate keys for students (stay within your range!) trombonists will often want to tighten the back of the throat. Tips for a successful learning experience: (1) Avoid tightening the throat. Throat tightness will happen for one of three reasons (a) the student is trying to sing too high, (b) too loudly, or (c) the student's tongue is too far back in the mouth. (2) Be sure you can feel the sides of your tongue toward the middle and front part of your mouth. (3) If you feel your tongue begin to move back, listen for how the sound quality changes and attempt to remember the sensation in the event the tongue slips again. (4) Do not go beyond your multiphonic range, as doing so can cause harm to your voice and embouchure. (5) Keep the corners of your embouchure gentile, yet firm, as playing with loose corners will make most of these exercises incredibly difficult.

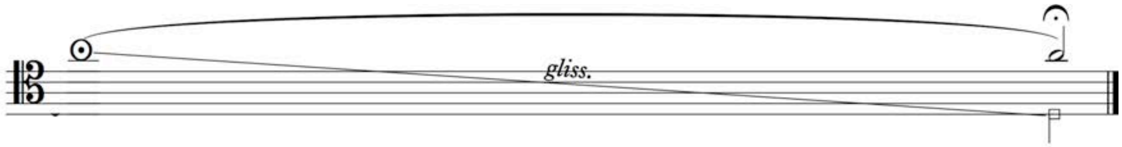
Subjective Tones for the reverse perfect twelfth: an octave is located below the bottom note, an octave, major tenth, minor fourteenth, and a fifteenth are found above the bottom note.

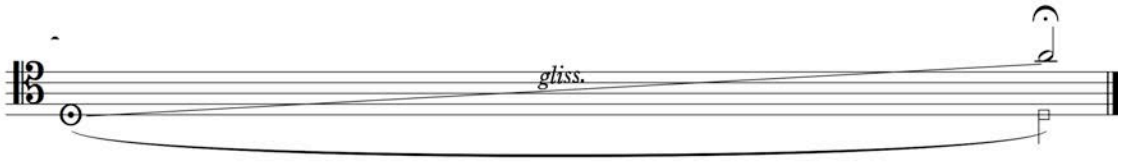
Free and easy. Pause for at least one measure at the caesura.

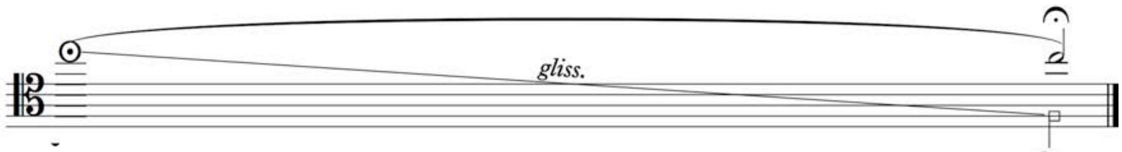


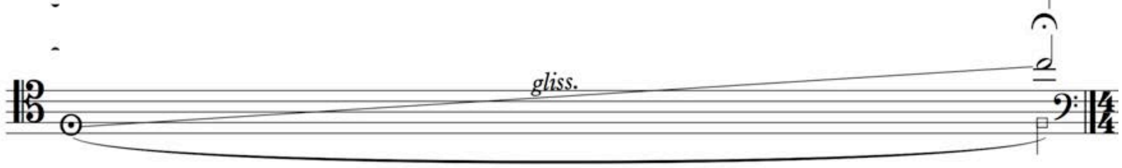
Play all glissandi exercises that are within your range. Remember to play these exercises with minimal tension and slowly.



5 

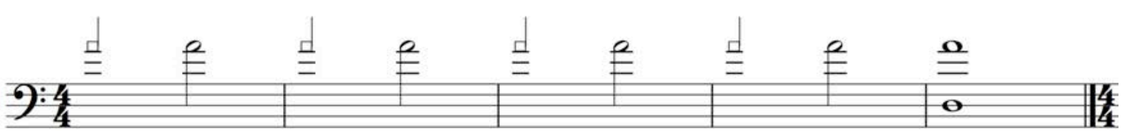
6 

7 

8 

Hear the final measure (the interval or the "added note") as you play each exercise. Strive for (1) justly-tuned intervals, (2) connection between sung and played notes, and (3) unison dynamics.

9 

10 

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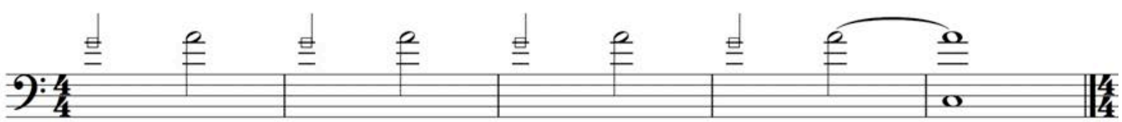
12 

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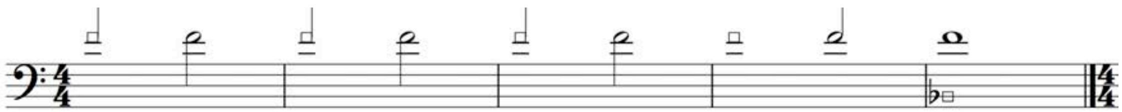
14 

Continue to work on tuning and unison dynamics, but focus on adding the new "voice" to the sustained note. Here, allow the entrance of each new voice to add color to the existing note while maintaining the pitch and sound of the first note.

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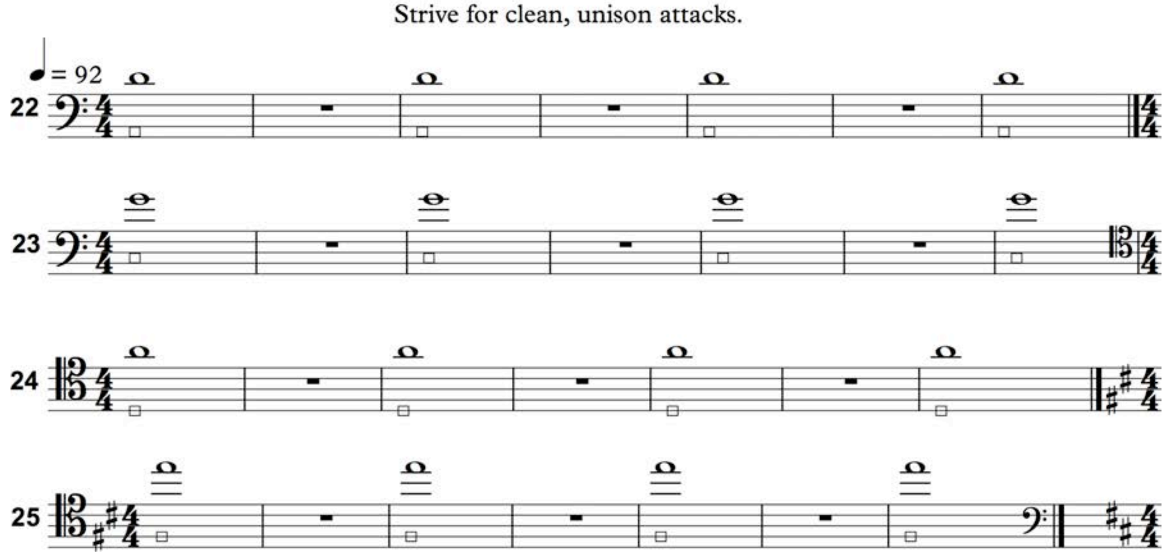
Strive for clean, unison attacks.



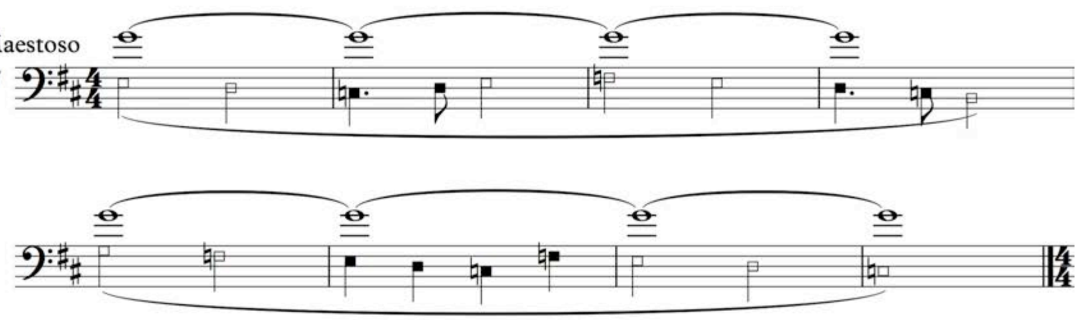
Play all etudes that are within your range and omit any note(s) that may be out of your range.

Spirited, dance-like

26

Maestoso

27



Mässig

28


Spirited, dance-like
29
Maestoso
30
Mässig
31


Spirited, dance-like
32
Maestoso
33
Mässig
34

Part-Crossing

Only go as high or as low as you can comfortably and with a good sound. If you need to skip some exercises, do it. It's better to wait until you're able to perform most of the exercise before trying the entire thing.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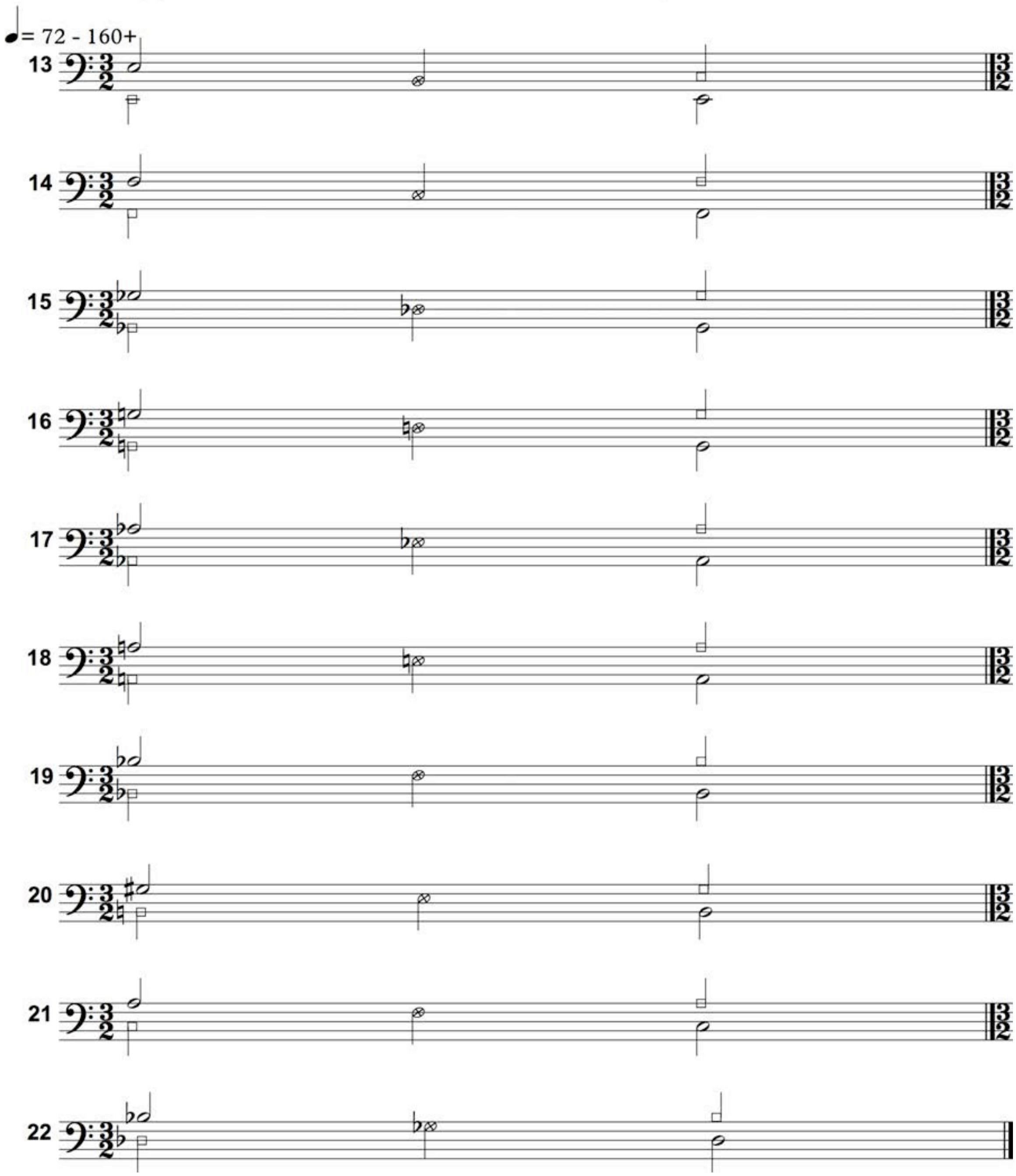
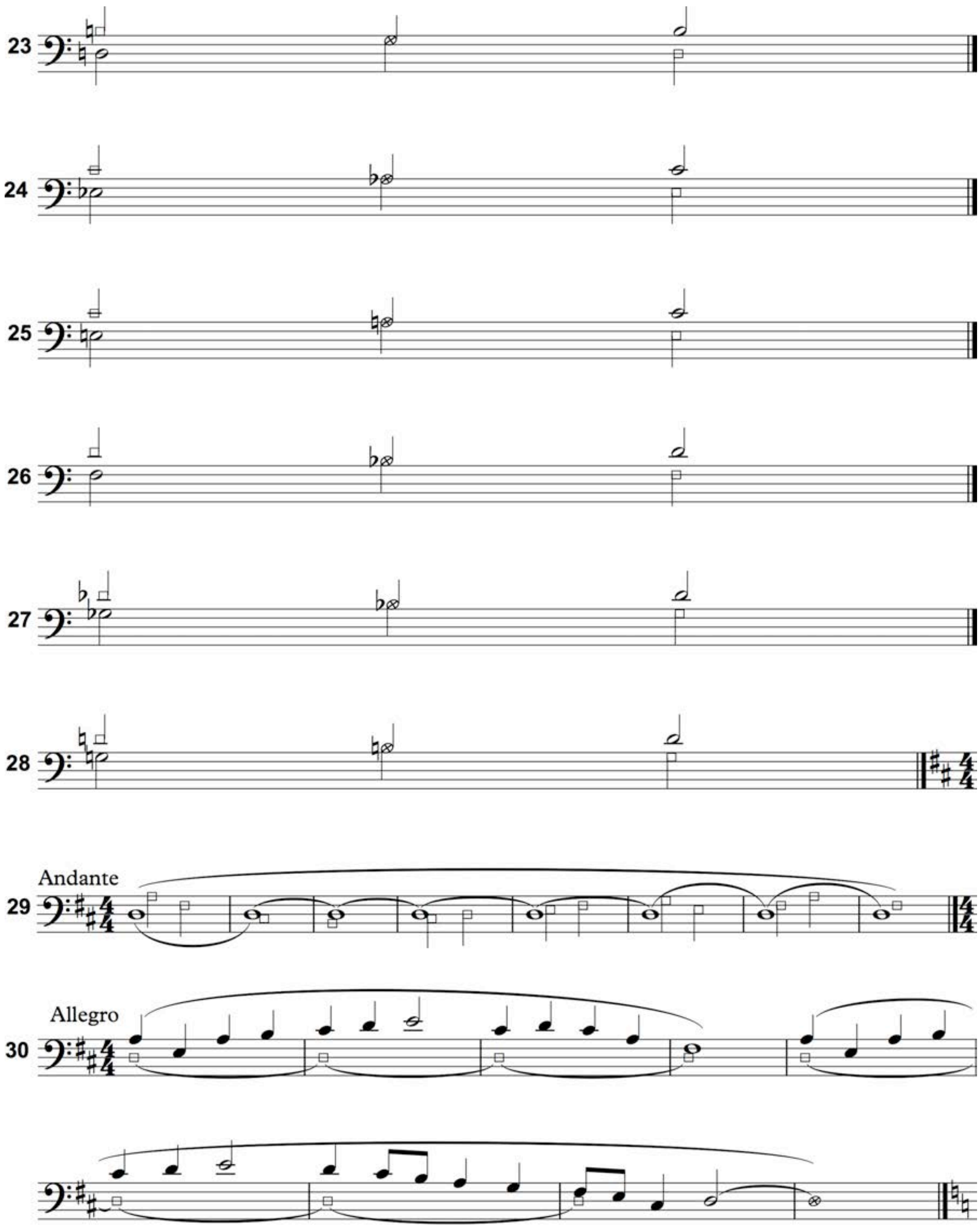
Lip Slur Multiphonics

Only play the exercises that are within your range. The goal of these exercises is to: (1) Be able to switch multiphonic voices within a single harmonic series. (2) Be able to ascend and descend both the trombone and voice with ease. (3) Be able to ascend the trombone line without closing the back of the throat.

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Andante
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Allegro
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Look closely at this etude. Throughout this etude you will see there are no barlines and that each "voice" is not always heard. Accidentals carry throughout each stave, returning back to "C" at the beginning of each system. Play as much of the following etude as possible, so omit any note(s) that are beyond your range. There is no tempo indication, however, this etude should be played in strict time.

31


Glissandi

This exercise is originally difficult, but by practicing it correctly, you can have great success with this technique.

To get started, simplify the problem down to its most basic form. Here, you're trying to move two voices in opposite directions and have them reach the origin of the other at the same time. By selecting key intervals to listen for (like the unison, fifth, fourth, or major third) you will help yourself greatly improve your chances of succeeding in this material.

Play, then sing.

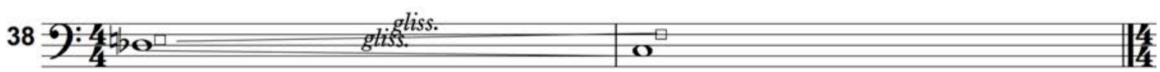
32

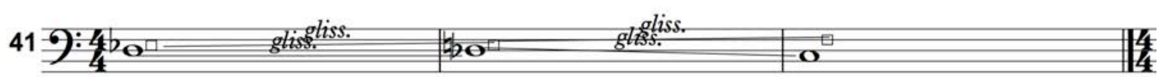

33

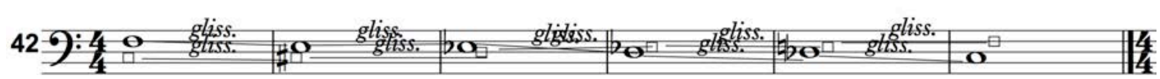

Now isolate the first semitone sequence and listen for the change in timbre. Play this slowly.

Isolation of the next two semitone pairs. Repeat three times

Continue to add the remainder of semitone pairs once you have mastered each exercise. Go slowly!







Additional Slur Exercises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63


Expanding Your Range

This portion of the method will provide the trombonist with exercises to help expand their range. As trombonists we need a way to (1) expand the upper and lower limits of our multiphonic range, (2) do so in away that assists the us with other aspects of trombone playing, and (3) does so in way that allows us to play comfortably.The exercises in this chapter contain major scale drills. These exercises could, of course, be used as a template for further study with different scale forms.

If it's an odd day, start on Number 1; if it's an even day, start on Number 2. Continue the ascending scales and arpeggios until you have reached your highest note. Begin the descending major scales immediately following the ascending form, thus allowing your embouchure a better chance to recover faster. Similar to the ascending form, play odd-numbered scales on odd days, and even-numbered scales on even days. <u>Play each exercise in unison with the voice.</u>


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= 72+
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Split-Tone Multiphonics

What are they, and how do you play them? The split-tone technique involves sending two separate sound waves generated by the lips, thus emitting extraneous sounds. Just like in vocal multiphonics, each pitch in the split-tone should be close in amplitude/dynamic to each other.

So… how do I play these?
The answer is easier than it sounds. To perform split-tone multiphonics, you must play the pitch that is exactly between any two adjacent partials, or in other words, you're attempting to play a note that does not exist, hoping the horn will "split" your lips apart and provide two separate frequencies to travel the length of the trombone.

What will I hear when I play split-tone multiphonics? You will hear one of four things. (1) Nothing extra. (2) The two adjacent partials. (3) A sense of something extra being heard, but unidentifiable. (4) A rolling sensation.

A NOTICE OF CAUTION: Do not spend more than five to ten minutes a day on these exercises, as they may promote bad habits regarding embouchure placement, mouthpiece pressure, and the possibility of this technique entering into your "traditional" playing unintentionally.

Lip Bends. Start in first position and gradually loosen the lips to obtain the desired pitch. Repeat as necessary. Eventually strive for hitting the desired pitch without bending. Play these exercises slowly.

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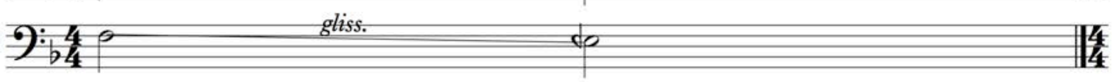

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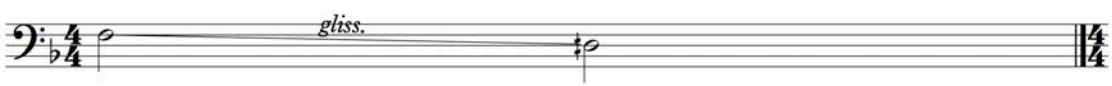

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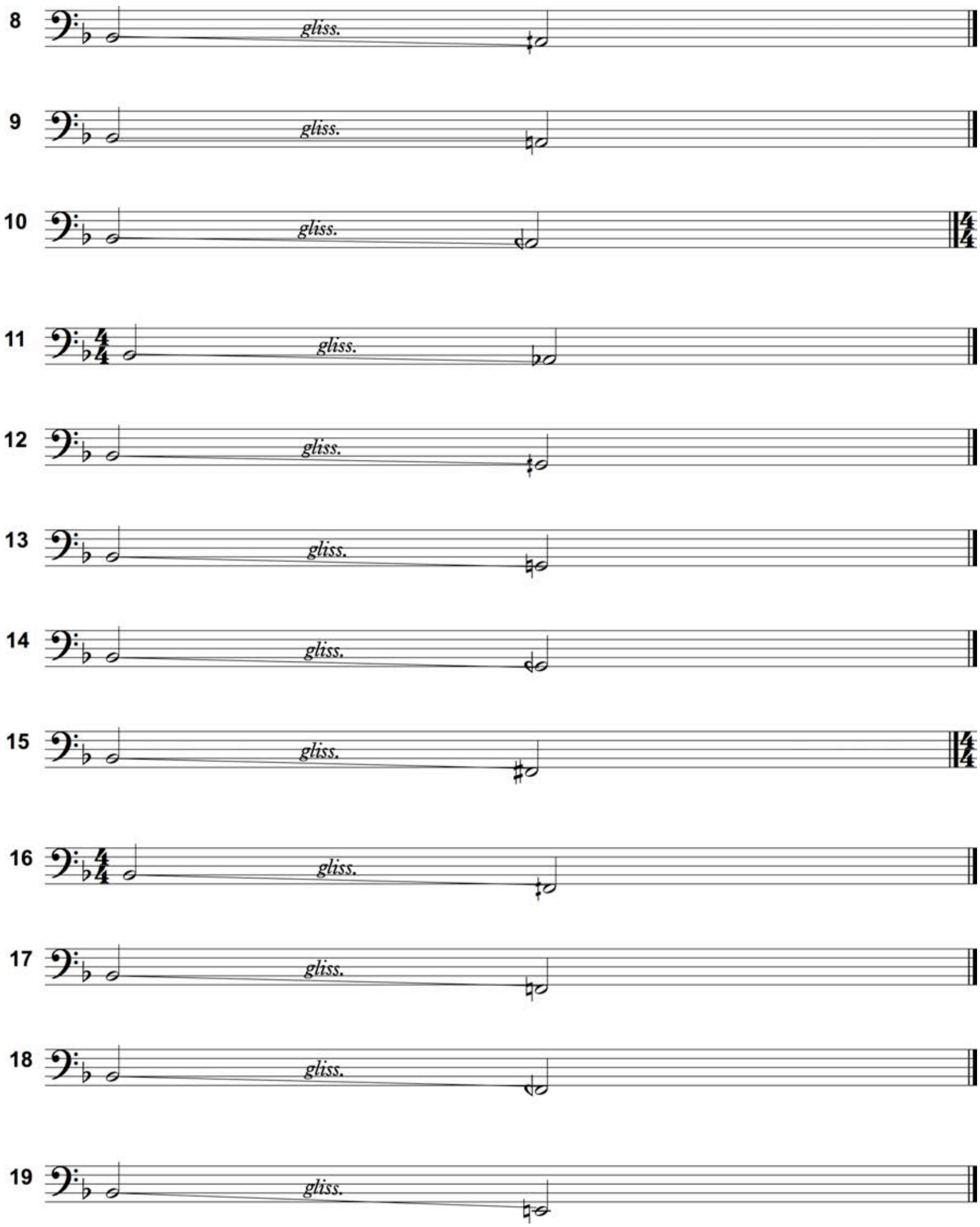
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gliss.
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gliss.
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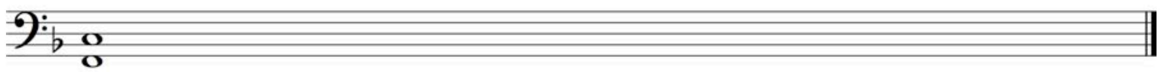
gliss.

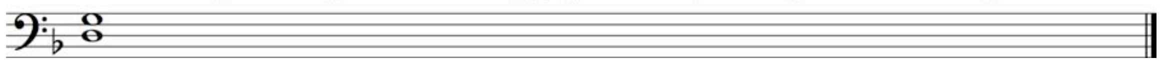
When they appear in solo literature, they are often notated by the two notes in the harmonic series adjacent to the split note. For example, the following exercise is asking for a quarter-tone flat D played in first position.

Sixth position (partials 3 and 4); played note equals D-quarter-tone sharp.

Sixth position (partials 2 and 3); played note equals A-quarter-tone flat.



Fourth position (partials 3 and 4); played note equals E-quarter-tone sharp.



Six Day Multiphonic Rotation

The following pages contain exercises that can be added to your daily routine. This particular variation takes you through all learned material in six days. Play the introductory exercises found earlier in the method before starting each session. Play the glissandi exercises twice and slowly. For the split-tone exercises, bend the pitch down until the split-tone is found and repeat two times. Then, play the split-tone without bending three times. If you are having difficulty with split-tone multiphonics, then play five lip bends (total) instead of trying for the initial attack. Play each multiphonic slur exercise twice; once as written, once with reversed multiphonic roles.

DAY 1

Traditional perfect fifth

Reverse octave

Reverse minor ninth

Reverse minor second

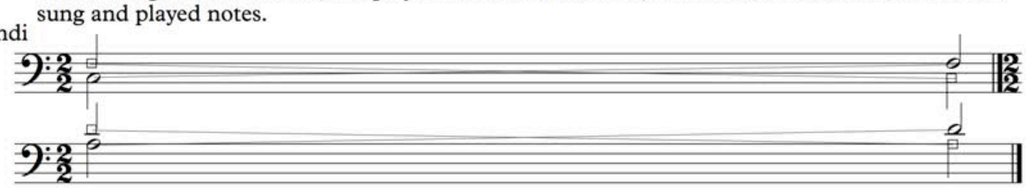
Reverse minor seventh

Traditional perfect twelfth

Reverse minor sixth

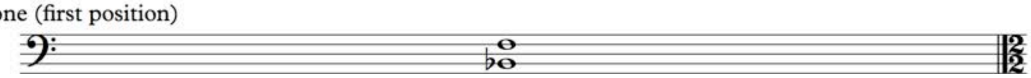
Select one glissandi exercise, but play it two times; first time, as written, second time, switch the sung and played notes.

Glissandi



Do three lip bends followed by three split-tone attacks.

Split-tone (first position)

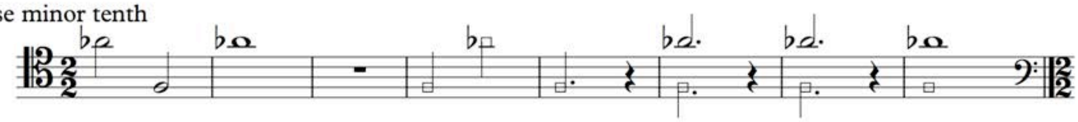


DAY 2

Reverse perfect fourth

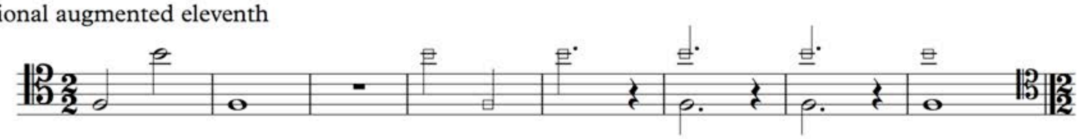
Traditional major second

Reverse minor tenth

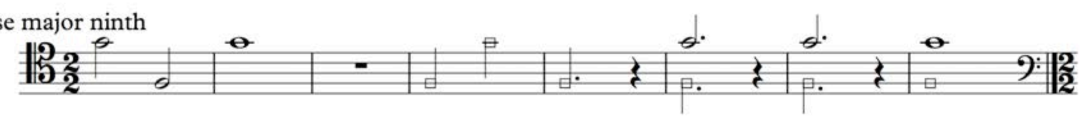


Reverse minor third

Traditional augmented eleventh



Reverse major ninth

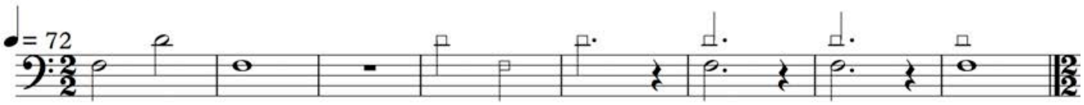


<u>Play this two times.</u> The <u>first time, play as written</u>; the <u>second time, switch the sung and played notes.</u>

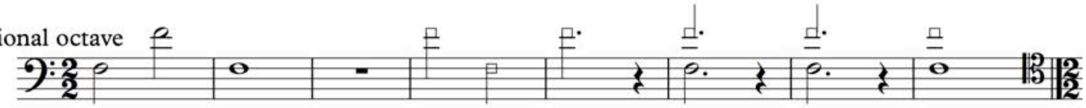
Multiphonic lip slur

DAY 3

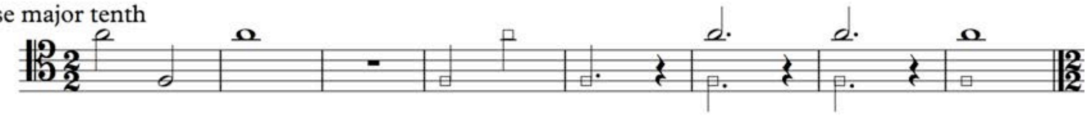
Traditional major sixth



Traditional octave



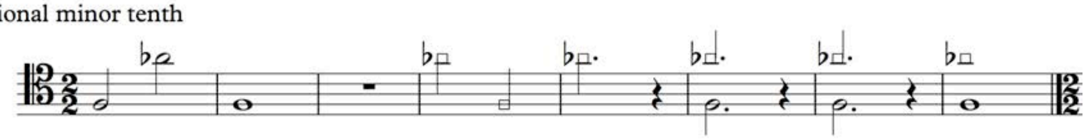
Reverse major tenth



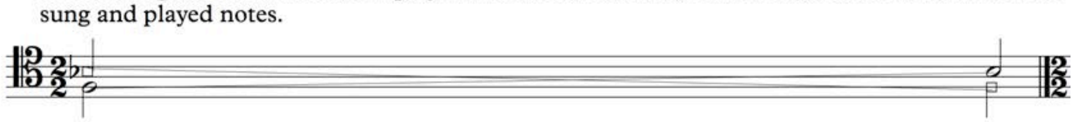
Reverse tritone

Traditional major seventh

Traditional minor tenth



Select one glissandi exercise, but play it two times; first time, as written, second time, switch the sung and played notes.



Do three lip bends followed by three split-tone attacks.

Split-tone (sixth position)

DAY 4

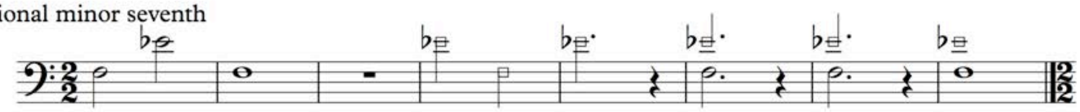
Reverse perfect fifth

Traditional major ninth

Reverse perfect eleventh

Reverse minor third

Traditional minor seventh



Traditional minor sixth

Play this two times. The first time, play as written; the second time, switch the sung and played notes.

Multiphonic lip slur

DAY 5

Traditional perfect fourth

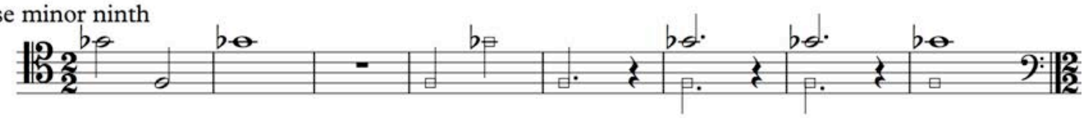
Reverse major second

Reverse augmented eleventh

Traditional tritone

Reverse major third

Reverse minor ninth

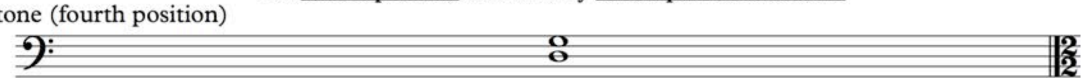


Select one glissandi exercise, but play it two times; first time, as written, second time, switch the sung and played notes.

Glissandi

Do three lip bends followed by three split-tone attacks.

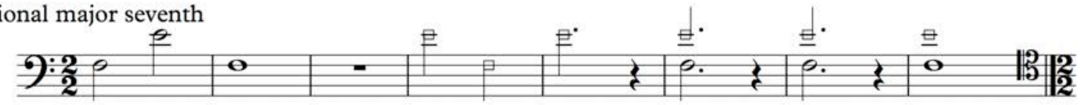
Split-tone (fourth position)



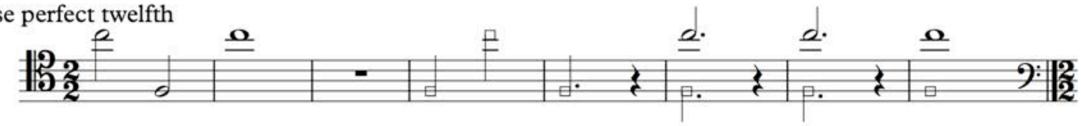
DAY 6

Reverse major sixth

Traditional major seventh



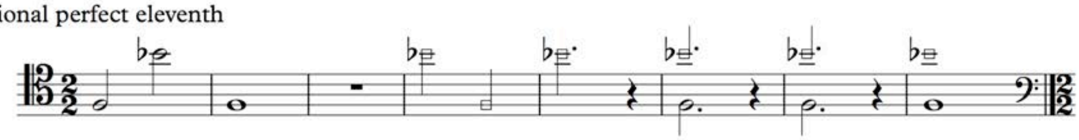
Reverse perfect twelfth



Reverse minor second

Traditional major third

Traditional perfect eleventh



Play this two times. The first time, play as written; the second time, switch the sung and played notes.

Multiphonic lip slur

Twelve Day Multiphonic Rotation

The following pages contain exercises that can be added to your daily routine. This particular variation takes you through all learned material in six days. Play the introductory exercises found earlier in the method before starting each session. Play the glissandi exercises twice and slowly. For the split-tone exercises, bend the pitch down until the split-tone is found and repeat two times. Then, play the split-tone without bending three times. If you are having difficulty with split-tone multiphonics, then play five lip bends (total) instead of trying for the initial attack. Play each multiphonic slur exercise twice; once as written, once with reversed multiphonic roles.

DAY 1

Traditional perfect fifth

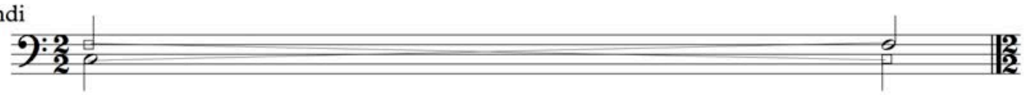
Traditional major ninth

Reverse minor third

Reverse major second

Select one glissandi exercise, but play it two times; first time, as written, second time, switch the sung and played notes.

Glissandi



DAY 2

Traditional minor tenth

Reverse major third

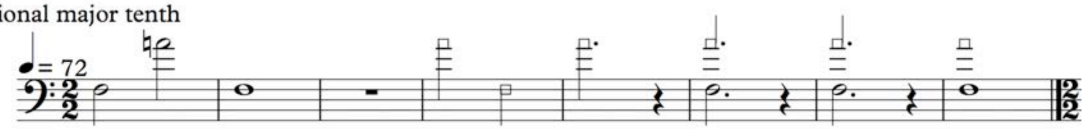
Reverse minor sixth

Multiphonic lip slur

<u>Play this two times.</u> The <u>first time, play as written</u>; the <u>second time, switch the sung and played notes.</u>

DAY 3

Traditional major tenth

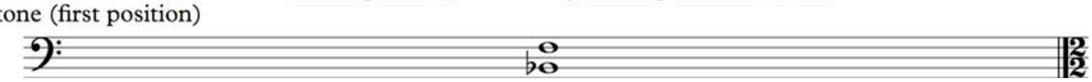


Reverse perfect fourth

Reverse major sixth

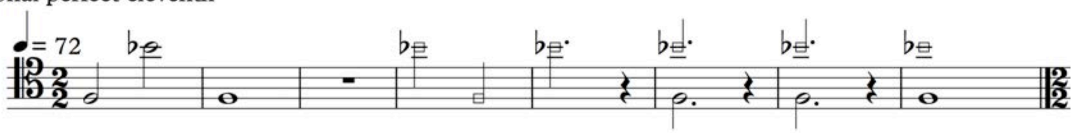
Do <u>three lip bends</u> followed by <u>three split-tone attacks.</u>

Split-tone (first position)



DAY 4

Traditional perfect eleventh



Reverse major second

Reverse minor seventh

Select one glissandi exercise, but play it two times; first time, as written, second time, switch the sung and played notes.

DAY 5

Traditional octave

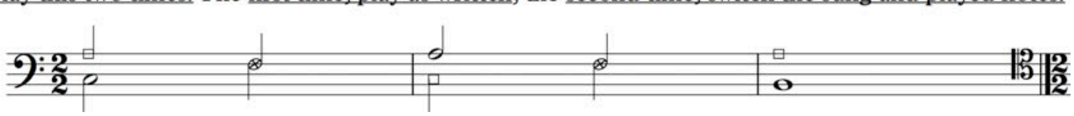
Traditional augmented eleventh

Reverse major seventh

Traditional tritone

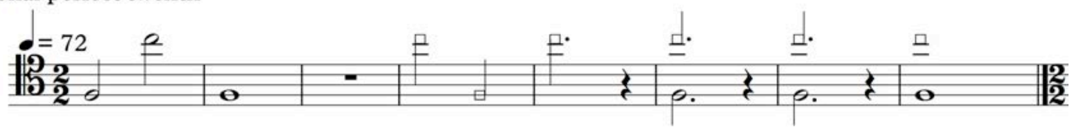
Multiphonic lip slur

Play this two times. The first time, play as written; the second time, switch the sung and played notes.



DAY 6

Traditional perfect twelfth

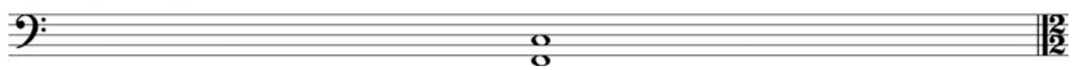


Traditional major second

Reverse minor ninth

Do three lip bends followed by three split-tone attacks.

Split-tone (sixth position)

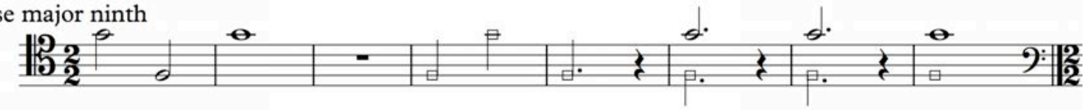


DAY 7

Reverse perfect fifth

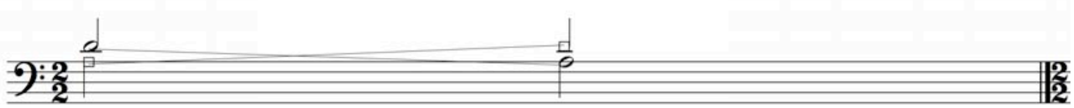
Traditional minor third

Reverse major ninth



Select one glissandi exercise, but play it two times; first time, as written, second time, switch the sung and played notes.

Glissandi



DAY 8

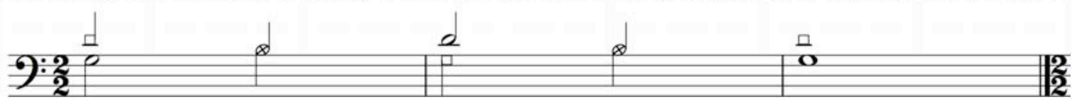
Traditional minor sixth

Reverse tritone

Reverse minor tenth

Multiphonic lip slur

Play this two times. The first time, play as written; the second time, switch the sung and played notes.



DAY 9

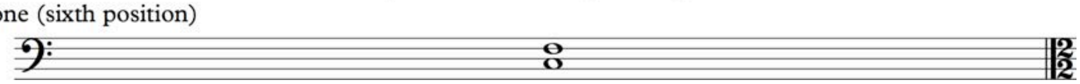
Traditional major sixth

Traditional major third

Reverse major tenth

Do three lip bends followed by three split-tone attacks.

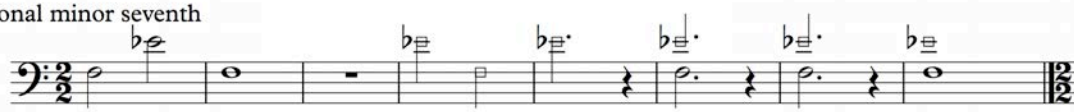
Split-tone (sixth position)



DAY 10

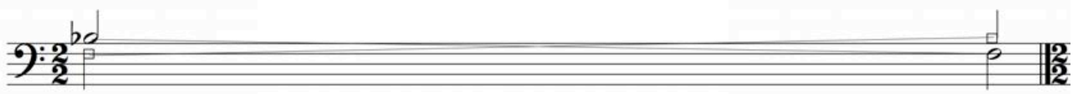
Reverse octave

Traditional minor seventh



Reverse perfect eleventh

Select one glissandi exercise, but play it two times; first time, as written, second time, switch the sung and played notes.



DAY 11

Traditional major seventh

Traditional minor third

Reverse augmented eleventh

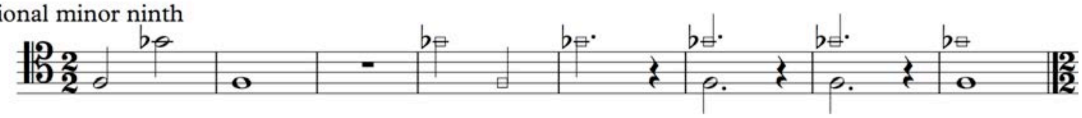
Multiphonic lip slur

Play this two times; the first time, play as written, the second time, switch the sung and played notes.

DAY 12

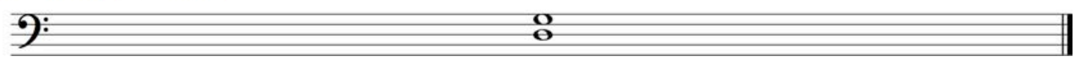
Traditional perfect fourth

Traditional minor ninth



Reverse perfect twelfth

Split-tone (fourth position)



APPENDIX B

SUBJECTIVE TONE CHART FOR LEARNED INTERVALS

The chart below contains the following abbreviations and symbols:

- + = the note is found above the lowest note
- - = the note is found below the lowest note

Interval	Notes added in relationship to the lowest note.
Unison	_+P12
Minor Second	_-M28, -m2, +M6, +m7, +8va, +P19
Major Second	_-22, -M2, +M3, +m9, +m13
Minor Third	_-M17, -M3, +M2, +TT, +M6, +M13
Major Third	_-15, -P4, +P5, +M9, +m13, +m14
Perfect Fourth	_-P12, -P5, +M6, +m10, +M13, +M14
Tritone	_-M17, -m7, -M2, +M6, +m10, +M14
Perfect Fifth	_-8va, +8va, +M10, +m14, +15
Minor Sixth	_-M10, -M6, +M9, +M10, +m14, +m16
Major Sixth	_-P12, -P5, +m6, +m10, +P11, +M14
Minor Seventh	_-M17, -M3, +M10, +Aug11, +M14, +M16
Major Seventh	_-22, -M2, +Aug11, +M14, +m17
Octave	_+Unison, +P12, +15, +M17
Minor Ninth	_-M16, +M2, +m13, +15, +P18
Major Ninth	_-15, +M3, +m13, +m14, +m16, +Aug18
Minor Tenth	_-P11, +P4, +M13, +M14, +M16, +Aug18
Major Tenth	_-15, +P4, +P5, +M9, +m13, +m14
Perfect Eleventh	_-P5, +M6, +m10, +M14, +m16, +m20
Augmented Eleventh	_-m3, +M7, +M14, +m17, +M20
Perfect Twelfth	_-8va, +8va, +M10, +m14, +15

APPENDIX C

BEAT CHART FOR LEARNED INTERVALS

The following chart lists the number of beats per second for each interval when justly tuned. Asterisks identify intervals that beat strongly when playing multiphonics.

Interval	Beats Produced
Unison	0 bps
Minor Second*	55 bps
Major Second*	55 bps
Minor Third*	55 bps
Major Third*	55 bps
Perfect Fourth	55 bps
Tritone	116.11 bps
Perfect Fifth	55 bps
Minor Sixth	165 bps
Major Sixth	110 bps
Minor Seventh	220 bps
Major Seventh*	385 bps
Octave	-55 bps
Minor Ninth *	433.89 bps
Major Ninth *	275 bps
Minor Tenth	226.11 bps
Major Tenth	110 bps
Perfect Eleventh	275 bps
Augmented Eleventh	605 bps
Perfect Twelfth	110 bps

APPENDIX D

LIST OF TROMBONE REPERTOIRE CONTAINING MULTIPHONICS ARRANGED BY DATE

1964

Hughes, Robert *Anagnorisis:* A Ballet

1965

Austin, Larry *Changes: Open Style*

Traulsen, Palmer: *Trombone Humoresque*

1966

Berio, Luciano *Sequenza*

Childs, Barney: *Music for Trombone and Piano*

Druckman, Jacob: *Animus I* for Trombone and Tape

Erickson, Robert: *Ricercar à 5*

Grahn, Ulf: *Pour Quatre*

Globokar, Vinko: *Accord*

1967

Alsina, Carlos Roqué: *Trio*

Erickson, Robert: *General Speech*

Stibilj, Milan: *Condensation*

1968

Du Bois, Robert: *Music for a Sliding Trombone*

Globokar, Vinko: *Discours II*

Heinke, James: *Music for Trombone and Percussion*

Kroeger, Karl: *Toccata*

Schwartz, Elliot: *Signals:* for Trombone and Contrabass

1969

Alsina, Carlos Roque: *Consecuenza* op. 17

Krenek, Ernst: *Five Pieces: for Trombone and Piano*

1970

Beale, James: *Mushroom Piece*

Imbrie, Andrew: *Three Sketches*

Kubin, Rudolf: *Koncert pro Pozoun a Orchestra*

Moryl, Richard: *Swallows*

Sandstrom, Sven-David: *Disjointing: for Trombone Solo*

Schwartz, Elliot: *Options I*

1971

Bischoff, John: *Olives*

Chaynes, Charles: *Impulsions*

Clark, Thomas S.: *Night Songs*

Erb, Donald: *"…and then, toward the end…"*

Grahn, Ulf: *Tensta Emotions*

1972

Celona, John Anthony: *Multiphony III*

Dedrick, Christopher: *Prelude and March*

Del Monaco, Alfred: *Syntagma for Trombone Solo (B Version)*

Kraft, William: *Encounters IV: Duel for Trombone and Percussion*

Kondo, Jo: *Out*

Moryl, Richard: *Chambers no. 1:* for Trombone, Tape, and Film or Slide and/or Lights

1973

Aitkin, Robert: *Kebyar*

Fulkerson, James: *Trombone Concerto*

Powell, Morge: *Incabado*

1974

Brink, Philip: *Exegesis*

Cervetti, Sergio: *Concerto for Trombone*

McCulloh, Bryon: *Concertino for Large Trombone and Small Orchestra*

Udow, Michael: *Acoustic Composition #2 For James Fulkerson and His Tenor Trombone*

Vazzana, Anthony: *Tre Monodie*

1975

Buss, Howard: *Camel Music*

Felder, David: *Nexus*

Fulkerson, James: *Co-ordinative systems no. 9*

Gaburo, Kenneth: *Cantilena Four*

Globokar, Vinko: *Res/As/Ex/Ins-pirer*

Heider, Werner: *D.e. Memorial*

Reynolds, Roger: *"…From Behind the Unreasoning Mask"* for Trombone, Percussion, and Tape

1976

Erb, Donald: *Concerto for Trombone and Orchestra*

Asia, Daniel: *Dream Sequence*

Hartley, Walter S.: *Sonorities III*

Nieman, Alfred: *Tongs and Bones*

Hutcheson, Jere: *Wonder Music IV*

Rieunier, Jean-Paul: *Silences*

Harris, Roger: *Women go to Heaven and Men go to Hell*

1977

Bon, André: *Canzone*

Bornefeld, Helmut: *Lituus*

Buckley, John: *"Why Not" Mr. Berio*

Kavanaugh, Patrick: *Debussy Variations* (No.13)

Hutcheson, Jere: *PASSING PASSING PASSING*

1978

Campo, Frank: *Commedie*, op. 42

Anderson, T.J.: *Minstrel Man*

Fulkerson, James: *Stations, Regions, and Clouds III*

Barnekow, Deborah: *The Kraken*

Appert, Donald: *Dialogue*

Erb, Donald: *Mirage*

McCulloh, Byron: *Protagony*

1979

Larsen, Libby: *Bronze Veils, after Morris Louis*

Fulkerson, James: *From the Last Few Pages*

Fulkerson, James: *Stationary Fields… Moving Fields*

Appert, Donald: *Query*

Huber, Nicolaus: *presente*

Kühnl, Claus: *5 Episoden*

Yuhas, Dan: *Episodes*

Everett, Thomas: *Natural "D"*

1980

Hofmann, James: *Hot Potatoes*

Nordheim, Arne: *Hunting of the Snark*

Borden, Lawrence: *The Conditions of a Solitary Bird*

1981

Nicholson, Geoprge: *Slide Show*

Heussenstamm, George: *TrombOnly, Op. 59*

Schafer, R. Murray: *Music for Wilderness Lake*

1982

Rabe, Folke *Basta*

Bergsma, William: *Blatant Hypotheses:* for Trombone and Percussion

Braun, Peter: *Jericho--die fallenden Mauern*

Coppens, Claude ∑*kiaï (Skiai):* for Trombone and Percussion

Fulkerson, James: *In Quest of Silence*

Kucharzyk, Henry: *Imagination (Yes)*

1983

Hübler *Am Ende des Kanons:* Music con(tro)versa für Posaune und Orgel

Hübler, Klaus: *Cerca*

Dubrovay, Laszlo: *Solo No. 2: Harsonara*

Kehrberg, Robert: *Tautophonic*

1984

Owen, Jerry: *Dialog IV, to me*

Istvan, Lang: *Libero*

Fulkerson, James: *Mini Concerto*

Knopoff, Steven Peters: Projection

1984

Kenny, John: Sonata for Unaccompanied Trombone

1985

Schindler, Allan: *Eternal Winter*

Tessier, Roger: *Scene*

1986

Erb, Donald: *The Rainbow Snake*

Elias, Joel: *Preludes*

Kenny, John: "Sonata for Tenor Trombone"

Wolking, Henry: *Seven Vignettes*

Hovland, Egil: *Cantus V*, Op. 120

1987

Siekmann, Frank: *Episodes*

Dusapin, Pascal: *Indeed*

Pehrson, Joseph: *Approaches*

Haug, Halvor: *Essay*

1988

Blokker, Kees: *Four Different Pieces*

Globokar, Vinko: *Kolo*

Blank, William: *Esquisse*

White, John: *Dialogues for Trombone and Piano*

1989

Xenakis, Iannis: *Keren*

Hekster, Walter: *Wave of Light*

Bacley, Wayne: *Ronald McDifficult*

Ford, Andrew: *Tuba Mirum*

Sandström, Jan: *Concerto for Trombone and Orchestra*

1990

Schudel, Thomas: *Dialogues*

Chaves, George: *Trombonics*

Sandstöm, Jan: *Short Ride on a Motorbike*

1991

Powell, Kit *Suite:* for Solo Tenor Trombone

Globokar, Vinko *Prestop II:* pour trombone et électronique

Cosma, Edgar: *Concerto*

1992

Walter, Stefan Johannes: *Agonie*

1993

James, Kevin: *Good Friday*

Klein, Joseph: *Goblin Market*

1994

Vayo, David: *Eight Poems of William Carlos Williams*

Aho, Kalevi: *Symphony No. 9*

Sandström, Jan: *Don Quixote Trombone Concerto No. 2*

Kenny, John: *Sonata for Alto Trombone*

Young, David L.: *loris 25*

Trussell-Cullen, Lauren: *The Devil's Dervish*

Klein, Joseph: *Pathways: Opposing Forces*

1995

Carter, Elliott. Trans Sluchin: *Gra*

Mabry, Drake: *9.28.85*

1996

Große-Schware, Heman: *Rezitativ*

Swiridiff, Susanne: *Zeitstimmen*

1997

Lesley, Simon: *The Two Terrible Trombones*

Lipkis, Larry: *Harlequin*

Rivas, Diogènes: *Ricercare II*

1998

Buss, Howard: *Boom Time*

Oehring, Helmut*: Philipp*

Sandström, Jan: *A Scottish Play*

Wilby, Philip: *Rauch*

Klein, Joseph: *Leviathan*

1999

Sichel, John: *Waltz of the Underworld Manicurists*

Walshe, Jennifer: *they could laugh smile*

2000

Frith, John: *Ode to a Happy Bunny*

Lynn, Brian: *Doolallynastics: A Brief Torture for Unaccompanied Trombone*

Lesley, Simon: *Three Sketches in the Form of a Sonata*

2002

Edwards, Brad: *Blue Wolf*

Stockhausen, Gabriel: *Poe Songs*

2003

Repar, Patricia: .breathing.bones.mobile.mind

Globokar, Vinko: *Eppure si muove: für einen Dirgierenden Soloposaunisten und Elf Musiker*

Keenan, Paul: *A Field of Scarecrows*

Lesley, Simon: *The Two Terrible Trombones*

UNDATED

Reuter, Fritz: *Suite for Trombone Alone* Op. 23

Ervin, Karen: *Obiter Dictum*

POSSIBLE

Fulkerson, James: *Patterns XI*

Kagel, Mauricio: *Atem*

Rabe, Folk: *"All The Lonely People"*