

MICROTONES

APPLICATIONS IN MUSIC COMPOSITION

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In his keynote lecture, musicologist and composer, Bob Gilmore, proposed a question that not too many musicians have raised. He questions the “shelf-life of the term microtonality” arguing that musicians should reconsider the terminology we give this timbral technique¹. However, not many understand the fundamental mechanics of microtonal composition and the plethora of ways in which we can incorporate it in today’s artistic culture. So another may ask if it is valid to argue how we classify it before we have extensively explored its capabilities. Music Composition, as an art form has stood the tests of time. Throughout history, composers have found new and innovative ways to create and manipulate sound. From bones, wood, metal, plastic, and later electronic signal processing, musicians have familiarized and included these new sonic colors into the regular musical practice. With each addition, composers, those who explicitly write new music, were given more tools for creative writing and expression of musical ideas. One such standard is the notion of equal temperament that explains the way in which musicians divide the octave. Today’s standard use of equal temperament, which is utilized by most genres in western culture, is the division of 12 (1200 cents). By taking the smallest musical interval, a semitone (100 cents), and dividing it in half, one will have created a quarter tone (50 cents). This form of influencing the harmonic timbre dives into the field of harmony known as “microtones”. With this basic understanding of micro tonalities, and to further the aural experience of audiences and musicians alike, it is to be evident that microtones are an effective and unique way of expressing musical thought.

The way in which we use and understand these modified intervals is somewhat convoluted and has not been standardized. Adding to this issue, composers and musicians alike cannot agree on what to call this practice. American composer and champion of microtonal composition, Ivor Darreg attempted to categorize this form of new tonality as *Xenharmonic*, which can be derived in Greek as *xenos* or “Strange”². By his definition, Xenharmonic is a classification for musical ideas which do not represent 12

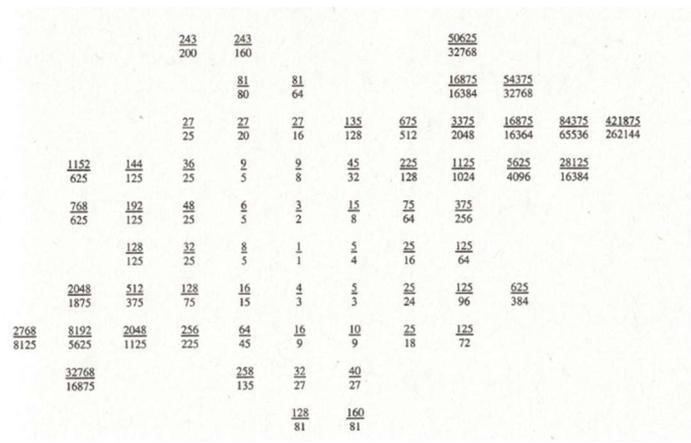
¹ Bob Gilmore, “Microtonality: My Part in Its Downfall” (Keynote Lecture, October 15, 2005).

² Ivor Darreg, “Xenharmonia B’,” May 1974, <https://web.archive.org/web/20120205142523/http://sonic-arts.org/darreg/XHB2.HTM>.

tone equal temperament. Later, Darreg classified microtones as an interval in which it is a quartertone or less than. This creates even more ambiguity in the understanding of such system.

Some may regard microtones as being a novel concept, however such a supposition is further from the truth than one might think. In her master’s thesis for a M.S. in Mathematical Teaching, Laura Smoyer further explains this process of conceptualizing intervals by proportion. The ratios presented by the theorists represent the relation between the original lengths of a string to the new length of a string. Returning to the realm of composers, the 20th century conjured new and unique ways of creating more precise ratios. In his critical analysis of theoretical statements in music, *Genesis of a Music*, composer Harry Partch brings to the forefront ancient ratio based implications of micro tonality in ancient Greece (in particular Archytas and Ptolemy)³. These proportions would include divisions of 28 and of up to 243 creating subtle yet measurable differences in timbre. Advancements into the 20th century led composers and theorists such as Iannis Xenakis and Ben Johnston to conceptualize newer and more extensive ways of formalizing microtonality. In his book *Maximum Clarity and Other Writings on Music*, Ben Johnston demonstrates a way of arranging notes in a hyperchromatic triadic system involving proportional

divisions of up to 262,144⁴. Although the auditory difference from $42187\frac{5}{262144}$ to $42187\frac{6}{262144}$ (see figure 1.0) is nearly impossible to detect, this system gives new complexity to the understandings of microtonal relations as well as providing a unique way of perceiving tonal colors.



(Figure 1.0⁵)

³ Harry Partch, *Genesis of a Music*, 2nd ed. (New York, NY: Da Capo Press, 1974).
⁴ Ben Johnston, *Maximum Clarity: And Other Writings on Music*, ed. Bob Gilmore (Urbana, Illinois: University of Illinois Press, 2006).
⁵ *Ibid.*, 49.

Although, major developments in microtonality arose in the middle of the 20th century, one must not dismiss the contributions of post romantic composers such as Béla Bartók and Charles Ives. Hailing from Danbury, Connecticut, Charles Ives was known for his modernist style and his interest in experimental music. In his work, *Three Quarter-Tone Pieces*, Ives utilized the microtonal technique of preparing a piano, tuning one of them a quarter tone higher⁶. Ives’ use of the piano seemed to be effective both conceptually as well as practically. Exploring the use of microtones in string writing, Hungarian composer Béla Bartók utilized quarter tones in his sixth string quartet. Beginning in the third movement *Burletta*, the composer precedes the microtonal section with a violent somewhat primal rhythmic passage. This was the composer’s intent to prepare the audience for the harmonically obscure section later introducing the quarter tone passage at rehearsal 25. Bartók signifies the diminution in pitch by a lowered quarter tone with a down arrow⁷. Although this is a clear form of showing the timbral change, future composers create new ways of signifying quarter tones, which later begs a system of standardization.

Returning to the Greek tradition of discovering innovative expanses of mathematical and musical concepts, Iannis Xenakis was instrumental in furthering 20th century microtonal practices. In his analytical descriptions of the composer’s life and music, Canadian composer James Harley points out Xenakis’ work *Nomos alpha* and its impact in the microtonal idiom, “by treating the smallest intervallic unit... as equivalent to a numerical series of integers,

cyclical rotations and transpositions of selected intervals can be combined to form a “scale,” or specific succession of intervals.⁸” (see figure 1.1).

These pioneers were instrumental in laying the foundation for later exploration of microtonality.

period (12)	0	1	2	3	4	5	6	7	8	9	10	11	12(0)
modulus 3(tr2)			x			x			x			x	
complement 3(tr2)	x	x		x	x		x	x		x	x		x
mod 4(tr0)	x				x				x				x
intersectionA	x				x								x
mod 3(tr1)		x			x			x			x		
comp 3(tr1)	x		x	x		x	x		x	x		x	x
mod 4(tr1)		x				x			x				
intersectionB						x				x			
union: A, B	x				x	x				x			
mod 3(tr2)			x			x			x				x
mod 4(tr2)			x				x				x		
intersectionC			x										

(Figure 1.1⁹)

⁶ Charles Ives, *Three Quarter-Tone Pieces*, ed. George Pappastavrou (New York: C.F. Peters Corp., 1968).

⁷ Béla Bartók, *Sixth String Quartet*, Hawkes Pocket Scores 25 (London: Boosey & Hawkes, 1941).

⁸ James Harley, *Xenakis: His Life in Music* (New York, NY: Routledge, 2004).

⁹ *Ibid.*, 43.

Before one can begin to include this new tonal language within their compositional writing, one must understand the theoretical implications both tangibly and aesthetically speaking. The way in which we divide an octave can be best described as a logarithmic function. Returning to the work of mathematician Laura Smoyer, she continued to further uncover the mathematical functions behind traditional music theory. The way in which we create an equal tempered system is by equally distributing the intervallic content of an octave distance. The standard frequency ratio for equal temperament is as follows, $\sqrt[12]{2}$ ¹⁰. Given this frequency proportion, we can manipulate

and use it to divide the octave by any division we could want.

However, musicians may question what these numbers even

represent. The 2 under the ratio indicates the octave, and 12

signifies the octave divisions. To get find each of the equal

tempered intervals, one must take the frequency ratio and pair it

with its corresponding exponent (see figure 1.2). The way in which

we classify this system can be discussed as either Tone Equal

Temperament (TET) or Equally Divided Octave (EDO).

EQUAL TEMPERAMENT		
<i>Freq. ratio</i>	<i>Decimal</i>	<i>Cents</i>
1	1	0
$\sqrt[12]{2}$	1.0595	100
$(\sqrt[12]{2})^2$	1.1225	200
$(\sqrt[12]{2})^3$	1.1892	300
$(\sqrt[12]{2})^4$	1.2599	400

(Figure 1.2¹¹)

With this in mind, composers can manipulate this equal temperament to new divisions creating 5-TET/5 EDO to 42-TET/42 EDO. The smaller the number of divisions, the easier it is for the human ear to perceive. Note that natural deviations in pitch less than 5 cents is difficult for humans to hear. Because of this, it becomes a valid question to ask at what point in pitch complexity can we use microtones before it becomes practically irrelevant? 5 cents has a frequency ratio of 1.002892, so using the mathematical general root equation, one could argue that $\sqrt[247]{2}$ which produces a frequency value of 1.0028. To put into perspective, that's 247 divisions of one octave compared to the western standard 12 divisions. If not a

¹⁰ Laura Smoyer, "Musical Mathematics" (Master's Thesis, Portland State University, 2005).

¹¹ Ibid.

tangible pitch difference, composers can argue that these small differences serves as a much needed extension of the timbral palate.

The usage of microtones have produced unique and diverse timbral soundscapes. Composer Harry Partch is remembered as one of the pioneers in American experimental music. His contributions to the art of microtonal composition such as his 43 tone scale and numerous creative adaptations in musical instruments have laid the foundation for later composers to build upon. Partch recorded a series of 10 songs each linked to the writings of ancient Chinese poet Li Po. In his short song, *Before the Cask of Wine*, Harry Partch incorporates a 43-tone scale beginning at a ratio of (21/11) to (15/8). The work begins with the title spoken. Immediately the work moves into introductory material with an underlying static microtonal line in the violin. The static line is then transferred to the voice with the violin taking a more rhythmic ostinato line. Throughout the work both the voice and the violin trade motivic places and continue to add more and more harmonic tension with the use of Partch's characteristic microtonal palate.

Student of Henry Cowell and Arnold Schoenberg, Lou Harrison was another American experimental composer who frequently utilized microtonal elements in his works. Originally written for harp and percussion, his work for guitar, *Jahla*, is tuned around just intonation D. For most listeners, they may not hear the minor differences of this tuning system compared to if the work was written in equal temperament, nevertheless the intervallic content is altered and contains microtonal elements throughout. This is an effective way to use microtones in a fashion which may be more palatable for a conservative audience.

Another American composer, Ben Johnston is well known in his work with microtonality. In his collection of the writings of Ben Johnston, composer and musicologist Bob Gilmore stated that, "He is proof... that much of the most inventive and refreshing music of the composers of his generation in the United States was created away from the urban centers."¹² Johnston's *String Quartet No. 5*, is

¹² Johnston, *Maximum Clarity: And Other Writings on Music*.

harmonically grounded in an intonation conceived from the first sixteen partials of the overtone series. In his dissertation on the compositional mechanics of this work, Daniel Huey explains how Johnston utilizes both O-tonality and U-tonality in this work. In particular he states, “The utonal scale is written in descending order to show the symmetrical pairing of the ratios and the cent values compared to the otonal scale. The notation uses Johnston’s symbols.¹³” This work is a good example for the exploration of the ideals of consonance and dissonance within an extended just intonation setting. With this unique set of microtonal repertoire, musicians and composers of today have the opportunity to gain a better understanding and appreciation of this new form of harmonic expression.

Musicians who play on acoustical instruments may find an added difficulty in performing works with intervallic material smaller than a semitone. When composing in a microtonal fashion, one must consider the orchestration constraints that may arise with certain instruments. Czech-native composer Karel Husa, was known for his use of timbral color and his ability to alter and transform a traditional acoustical sound. His sonata for violin and piano is a prime illustration of the way in which he approaches microtonal string writing. Looking at the third movement of his sonata, one can clearly see arrow markings indicating the direction of the quarter tone alteration. In her doctoral dissertation, Mariana Krewer describes in detail some of the competencies required and addressing the initial challenges of this passage. She remarks that the passage is friendlier due to the linear nature of the phrase. However she notes that, “The challenge for the player would be to avoid losing aural sense of the chromatic scale, playing the traditional pitches with their actual sound when requested.¹⁴” This is a valid concern to raise, especially due to the fast and technical nature of this movement.

¹³ Daniel Huey, “Harmony, Voice Leading, and Microtonal Syntax in Ben Johnston’s String Quartet No. 5” (PhD. Dissertation, University of Massachusetts Amherst, 2017), https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1924&context=dissertations_2.

¹⁴ Mariana Krewer, “Extended Techniques for Intermediate Violin Students” (DMA Dissertation, Louisiana State University and Agricultural and Mechanical College, 2018), https://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=5204&context=gradschool_dissertations.

Wind players often can manipulate the speed of their air however, this may create more variations in microtonal perception. Exploring the microtonal capabilities of the saxophone as a microtonal instrument, Sean Mac Erlaine discusses the various orchestrational and practical concerns in his master's dissertation. One important aspect to understand about Mac Erlaine's research is in regard to how the microtones are being conceived. Most research focuses on the strict written out compositional idiom however, Mac Erlaine focuses on ways in which improvising musicians can utilize microtones. He suggests that one must have a deep study in microtonal ear training, more specifically the 24-note octave¹⁵. As a saxophonist, Mac Erlaine gives educated critiques in the way in which one should approach microtonal playing on the instrument. Techniques such as cross fingering, pitch bending, and physical adjustments to the instrument are all feasible methods to providing an improved microtonal landscape. However these techniques are not only unique to the saxophone, one must consider the extended techniques of other instruments and the ways in which they can be used effectively.

In their journal article for Plainsound Music Editions on the *Tuneable Intervals on Horn, Tuba, and Trumpet*, Canadian composer Marc Sabat and English composer Robin Hayward lay out the measurable microtonal valve combinations for brass instruments¹⁶. In their work, they discuss how one can properly approximate certain pitches with alterations to the instrument tuning. Not dismissing the tenor trombone, the composers provided a system in understanding the 45 equal divisions between C and B \flat . Although practical constrictions still exist, composers can utilize these sounds to create a homogenous and natural color.

The sonic representation of microtones can be easily experienced in an auditory sense. However, the way in which composers signify these minute distinctions in tonal color have not yet been standardized. This has the possibility of creating confusion between performers, in the interpretation of

¹⁵ Seán Mac Erlaine, "Microtonality as an Expressive Device: An Approach for the Contemporary Saxophonist" (Dublin Institute of Technology, 2009).

¹⁶ Marc Sabat and Robin Hayward, "Towards an Expanded Definition of Consonance: Tuneable Intervals on Horn, Tuba and Trombone," 2006.

these minute differentiations in sound, as well as future composers with which notational system they employ. Composer Gardner Read was able to compile a collection of ways in which composers notated microtones. Discussing the feasibility of current microtonal notation systems, Read states that “The problem of finding a logical and pragmatic microtonal notation... is not a pressing concern for these composers.¹⁷” However without a standardized set of ways in which composers write, can often cause confusion and lost time during rehearsals. Especially in the rapidly changing modern musical world, time is money. One solution has been presented in the OpenMusic (OM) composer’s book by Alain Bancquart, Carlos Agon and Moreno Andreatta. This new and more simplified way is somewhat limited however, it takes on a more practical approach. By creating specific divisions (up to 8 equal divisions) of the semitone, they were able to devise a system which better signify these specific microtones¹⁸. It would behoove composers to normalize the way in which they represent microtonal writing. This will provide a less convoluted approach to microtonality and give a clearer consensus for how they should be performed.

It is human nature that the things in which are new and challenging to understand, will not be initially widely accepted. Thus is the same with microtonal writing and the way composers have developed it. According to a study conducted by two music professors Freya Bailes and Mary Broughton in conjunction with the MARCS Institute for Brain Behavior and Development’s Roger Dean, participants rated microtonal sounds as being, “rough and less liked than consonant intervals.¹⁹” However, the way in which they conducted this experiment leaves some room for concern on a scientific level. For one, the sample size was somewhat small and only included 20 participants (divided between 10 musicians and 10 non musicians). To access more accurate results, the study should have included more demographics as well as a larger range of age. It may be that microtones are less appealing to the public

¹⁷ Gardner Read, *20th-Century Microtonal Notation* (New York: Greenwood Press, 1990).

¹⁸ Alain Bancquart, Carlos Agon, and Moreno Andreatta, *The OM Composer’s Book*, ed. Gérard Assayag (Paris: IRCAM-centre Pompidou, 2006).

¹⁹ Freya Bailes, Roger T. Dean, and Mary C Broughton, “How Different Are Our Perceptions of Equal-Tempered and Microtonal Intervals? A Behavioural and EEG Survey,” ed. Lutz Jaencke, *PLOS ONE*, August 18, 2015, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4540280/>.

ear, however it could quite possibly be a cultural phenomenon. More research needs to be taken to fully understand the social corollaries with microtonal music.

Microtonal writing can be used as an effective means of musical expression. It can provide moments of intensity while serving as an aleatoric harmonic scheme. There are contextual considerations which could not be discussed due to brevity. Once such contemplation is in regards to electronics and its modern day usage in creating microtonal effects. In addition to the discussion of differed temperament, one such musician who is exploring the realms of changing temperament mid work is Jacob Collier. Unfortunately, this cannot be further elaborated on. Other considerations include the programmability of works which involve microtonality to a non-musically trained audience. More discussion can aid in the complete and full understanding for how microtonality can be used in a full ensemble context. However, microtones are here to add timbral diversity and additional sound colors. Within the world of academic composition, with students and educators who are curious to study more closely intricate soundscapes, it is quite possible that this harmonic language can find a permanent home.

BIBLIOGRAPHY

Ayers, William. "Structural Properties and Compositional Processes in Microtonal Equal Temperaments." PhD Diss., University of Cincinnati, 2018.

Recently completed, this dissertation by Dr. Ayers, will serve as a modern take on varying settings of tone equal temperament systems. This work focuses on numerous forms of microtonality however, concludes that microtonal equal temperament (especially 19-tone and 31-tone) is the most effective use of microtones in modern musical composition. This work will be used as a modern argument opposing quarter tones.

Bancquart, Alain, Carlos Agon, and Moreno Andreatta. *The OM Composer's Book*. Edited by Gérard Assayag. Paris: IRCAM-centre Pompidou, 2006.

This source gives some context into the history and applications of microtonal music. It gives a standardized way of notating microtones. This will aid in the discussion of how composers should represent this harmonic conceptualization. Taking time to elaborate on possible electronic applications of microtones, this can also be used to present a further discussion on the applications of a digital audio system.

Bartók, Béla. *Sixth String Quartet*. Hawkes Pocket Scores 25. London: Boosey & Hawkes, 1941.

Hungarian composer, Béla Bartók was very experimental in the way in which he approached harmony. The Burletta in the third movement of his Sixth String quartet shows us this trait as the composer uses quarter tones to add extra tension in the harmonic texture. The paper will include an excerpt showing the composer's use and notation of these quarter tones.

Besada, José L. "Flamenco, Fractals, and the Refigured Past: Three Creative Paths for Implementing Microtones in Contemporary Spanish String Quartets." *Perspectives of New Music* 55, no. 1 (2017): 5–39.

In discussion about the way in which we use microtones, this article helps composers understand ways and practices in which they can utilize these harmonic tools. Moreover, this article provides a broader point into the way in how one can write in Spanish inspired style. This paper is more focused on using this information as an addition to the discussion of microtonal string writing. The cultural context is irrelevant.

Brook, Taylor. "Synergy of Form, Rhythm, and Orchestration in Three Microtonal Compositions." DMA Diss., Columbia University, 2018.

In her doctoral dissertation, Dr. Taylor Brook explores the use of microtones and how they affect considerations in the form, rhythm, and orchestration. This research is extremely helpful in the understanding how other composers have been influenced by this harmonic language as well as some deliberations in ways which microtonal instruments should be approached. Also, this will further the discussion in certain percussive techniques in regards to microtonality.

Carpenter, Hoyle. "Microtones in a Sixteenth Century Portuguese Manuscript." *Acta Musicologica* 32 (1960): 23–28. <https://doi.org/10.2307/931819>.

Tracing back to the mid-sixteenth century, renaissance composer Thomas Morley's contributions to early microtonal composition are explored in this document. This will be used show how early the practical use of microtones was. Also this text will provide further discussion into the compositional styles of other renaissance composers, considering this microtonal direction.

Cope, David. *New Music Composition*. New York, NY: Schirmer Books, 1977.

Exploring the realm of microtonal composition, David Cope provides a comprehensive analysis of the creative techniques of twentieth century composers such as Julian Carrillo, Charles Ives, and Krzysztof Penderecki to name a few.

Cope, David. *New Music Notation*. Dubuque, IA: Kendall/Hunt Publishing Company, 1976.

Former professor of composition at Miami University, David Cope gives the reader a lens into the compositional practices of experimental composers. This resource will be used to show the notational techniques of previous microtonal musicians as well as a jumping off point to show how they compare to modern notation.

Cornelis, Olmo, and Joren Six. "Sound to Scale to Sound, a Setup for Microtonal Exploration and Composition." *International Computer Music Conference, Proceedings*. Ghent University, Department of Art, Music and Theatre Sciences, 2012.

Giving a new way to compose in a microtonal fashion, this presentation provides a possible solution to producing such sounds. Using a system software called *TARSOS*, the authors were able to produce microtonal signals through three different means. This will help to offer new avenues into this area of musical composition.

Darreg, Ivor. "Xenharmonia B'," May 1974. <https://web.archive.org/web/20120205142523/http://sonic-arts.org/darreg/XHB2.HTM>.

In this article, American composer, Ivor Darreg explains a concept of Xenharmonic music or music, melodies, and harmonic content which does not sound like the traditional 12 tone structure. Darreg expresses clearly in this article that xenharmony is separate from microtonality, as he later argues that microtones can be regarded as only quarter tones and/or smaller. This will be used to begin the discussion of what microtones are and how composers and artists alike classify them.

Donahue, Thomas. *A Guide to Musical Temperament*. Lanham, MD: Scarecrow Press, 2005.

Musician and instrument builder, Thomas Donahue explores the complexities of equal temperament. This text is to be used as a reference for explaining equal temperament as well as to understand some of the mathematical concepts behind this system of division between octaves.

Fox, Christopher. "Hybrid Temperaments and Structural Harmony: A Personal History."
Contemporary Music Review 22 (2003): 123-39.
<https://doi.org/10.1080/0749446032000134779>

This article is an account of the author's experience with microtonal composers ranging from differing equal temperament systems, quarter-tonal/sixth-tonal systems, to hybrid tuning systems. Providing scores and musical examples, this entry will help to provide more context into the microtonal compositional styles of modern composers such as John Cage and James Tenney.

Freya Bailes, Roger T. Dean, and Mary C Broughton. "How Different Are Our Perceptions of Equal-Tempered and Microtonal Intervals? A Behavioural and EEG Survey." Edited by Lutz Jaencke. PLOS ONE, August 18, 2015.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4540280/>.

Studying the way in which we perceive these two types of tonal systems, this study helps to show us how musicians and non-musicians process them. The findings in the report can serve as a possible rebuttal in the use of such microtonal methods.

Gann, Kyle. *Two Creatures*. Germantown, NY: Unpublished, 2018.

Former student of Ben Johnston and Morton Feldman, Kyle Gann's work *Two Creatures* is written for a microtonal accordion. This score will be used to discuss the modern use of microtones with unconventional instruments.

Gilmore, Bob. *Harry Partch: A Biography*. New Haven, CT.: Yale University Press, 1998.

Exploring the life and legacy of Harry Partch, this work also focuses on conceptual practices of the composer. It will be useful to include the composer's viewpoints towards observations on O-tonality and U-tonality. This source will also be used to show how the composer devised such methods by giving visual figures with commentary.

Gilmore, Bob. "Microtonality: My Part in Its Downfall." Keynote Lecture presented at the UK Microfest 1, Edinburgh, UK, October 15, 2005.

In his presentation, musicologist and educator Bob Gilmore expressed his concern not for the sustainability of microtonal music, however the way in which microtonality is perceived. Often paired with adjectives such as "otherness" and/or "strangeness", Gilmore explains that although the use of these colors is "here to stay", he hypothetically asks where the future of microtonality will be and should we even continue to classify this practice as microtonal. This is very helpful for understanding where modern musicologists stand on microtones and to begin the discussion of where it fits in the broader picture of music history.

Harley, James. *Xenakis: His Life in Music*. New York: Routledge, 2004.

The cello work, *Nomos Alpha*, by Iannis Xenakis is an example of how the Greek composer was able to utilize Byzantine musical systems in a microtonal practice. Coining the term "sieves", this work uses this *sieve* system built from both quarter tones and three-quarter tones.

Ives, Charles. *Three Quarter-Tone Pieces*. Edited by George Pappastavrou. New York: C.F. Peters Corp., 1968.

The piano does not have the agility to adjust its tuning in the middle of a work such as a wind or string instrument. However that did not discourage composer Charles Ives from writing a suite for two pianos. This work contains three fairly short pieces for one piano tuned to the standard 12 tone equal temperament while the other tuned a quarter tone higher. This creates a brighter more brittle sound and adds unique harmonic color.

Johnston, Ben. *Maximum Clarity: And Other Writings on Music*. Edited by Bob Gilmore. Urbana, IL: University of Illinois Press, 2006.

Prolific microtonal composer, Ben Johnston, provides the reader unique perspectives on microtones, and their role in a more explorative understanding of traditional theory. This material will be used to introduce his concepts on microtonality, extensions of just intonation, and its role in how we perceive music.

Krewer, Mariana. "Extended Techniques for Intermediate Violin Students." DMA Diss., Louisiana State University and Agricultural and Mechanical College, 2018.
https://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=5204&context=gradschool_dissertations.

When working with microtones, classical musicians may be unfamiliar with how to approach certain situations. In her DMA dissertation, Mariana Krewer further discusses some of the competencies as well as complications with microtonal violin performance. The author also provides further discussion in how young violinists can prepare for these extensions on technique through simple to understand technical exercises.

Mac Erlaine, Seán. "Microtonality as an Expressive Device: An Approach for the Contemporary Saxophonist." Master's Thesis, Dublin Institute of Technology, 2009.

Exploring the abilities of the saxophone, this master's dissertation brings to light the microtonal nuances available to the instrument. This information will be used to provide potential solutions to approximations in microtonal performance. Additionally, this will offer examples of how previous composers wrote for the instrument.

Partch, Harry. *Genesis of a Music*. 2nd ed. New York, NY: Da Capo Press, 1974.

The American composer and theorist, Harry Partch was a pivotal figure in experimental music composition. His book *Genesis of a Music*, is filled with information on how he perceived of intonation and proportions. I intent to use this source as a reference to the microtonal practices and concepts of Harry Partch.

Read, Gardner. *20th-Century Microtonal Notation*. NY: Greenwood Press, 1990.

Capturing the multiple ways in which composers have indicated the use of microtones, Gardner Read's book on 20th century microtonal notation will be used to show the convolutions in the

representation of microtones. Not having a standardized form of conceptualizing this system, may have caused a resistance from using them.

Sabat, Marc, and Robin Hayward. "Towards an Expanded Definition of Consonance: Tuneable Intervals on Horn, Tuba and Trombone." Plainsound Music Edition, Berlin, Germany, 2006.

Using microtones can become challenging for acoustical musicians. With this in mind, composers should consider how brass instruments can approach these techniques. This article provides in depth detail on the ways in which horn, tuba, and trombone players approach extended tonal situations such as U-tonal concepts and microtonal tunings.

Smolka, Martin. "My Experience with Microtones." Glissando, 2011.
<http://en.glissando.pl/text/my-experience-with-microtones/>.

In his brief article about the writer's personal experiences with microtonal composition, Martin Smolka describes some of the challenges in which he came across while writing in this style. This will help aid in the discussion of creative timbral solutions in regards to microtonal composition.

Smoyer, Laura. "Musical Mathematics." Master's Thesis, Portland State University, 2005.

Venturing away from a traditional artistic perspective, Laura Smoyer's Master's Thesis helps to explore and explain the mathematical ramifications of equal temperament. This material is very useful for the introduction of intervallic ratios. The author's work also gives mathematical arithmetic formulas for understanding microtonal theory.

Ulman, Erik. "Some Thoughts on the New Complexity." *Perspectives of New Music* 32, no. 1 (1994): 202–6. <https://doi.org/10.2307/833163>.

As musicologists have attempted to conceptualize microtones in the historical sense, there are arguments for and against the association of microtonal music with the New Complexity movement. This article serves as an argument against the new complexity movement and can commence a discussion into how we classify music which is occurring presently.

Von Gunden, Heidi. *The Music of Ben Johnston*. Metuchen, NJ: Scarecrow Press, Inc., 1986.

Exploring the musical life of American composer, Ben Johnston, Heidi von Gunden provides excerpts as well as sketches showing the artist's process of creativity. This resource will be utilized to explore the creative capabilities of Johnston's practice of microtonal composition as well as providing this paper further visual examples and concepts.