University of Tasmania

Harmonic Based Extended Techniques and their Compositional Applications:

An Investigation in New String Techniques

An Exegesis Submitted to

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in partial fulfilment of the requirements for the degree of

Bachelor of Music with Honours (or Bachelor of Music (Elite) with Honours)

by

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November 6, 2019

Declaration

I declare that all material in this exegesis is my own work except where there is clear acknowledgement or reference to the work of others and I have read the University statement on Academic misconduct (Plagiarism) on the University website at `www.utas.edu.au/plagiarism` or in the Student Information Handbook. I further declare that no part of this paper has been submitted for assessment in any other unit at this university or any other institution. I consent the authority of access to copying this exegesis. This authority is subject to any agreement entered into by the University concerning access to the exegesis.

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November 6, 2019

Abstract

This exegesis explores compositional applications of the extended string techniques half-harmonics, subharmonics, and multiphonics. A review of the literature and resources that are readily available to composers will be made to assess what techniques require further investigation and refinement. By researching these techniques and the mechanics behind them, using document analysis, and analysing recordings made, a better understanding of how these techniques can be implemented in my practice will form. As part of both the analysis of techniques and my compositional practice, I assess not only the compositional potential, but also the practicality of techniques. Reviewing the feasibility and notational aspects of the techniques will render the exegesis a practical document to reference for performance and composition. The works that I compose accompanying the exegesis will show idiomatic treatment of the techniques and serve as references as such in the exegesis. The dissemination of the material I research will contribute to the accessibility of new sound possibilities for artists.

Thank you to my supervisor, Matthew Boden, and my teachers Dr. Maria Grenfell and Dr. Scott McIntyre for their help and guidance. I am indebted to my music teachers for inspiring my passion in music, and my peers and friends at UTas who have supported me in my research, and kept that passion alive. My love and thanks go to my partner Claire Farrell*, my family, and my cats Buttercup and Millie for their unconditional support.

∗. Whose cakes, biscuits, and mugs of coffee nourished me, and whose support and words of encouragement kept me sane.

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Introduction

I propose to explore a range of extended techniques that utilise the harmonic series and to assess how they can be used in my, and other people's, creative practice in composition and performance. This exegesis considers the techniques associated with multiphonics, subharmonics, and half-harmonics on string-based instruments. For purposes of brevity, these harmonic-based extended techniques will simply be referred to as 'techniques' throughout the paper, except for when differentiation between standard techniques is needed.

While some techniques such as harmonics are well established and understood, others, such as subharmonics, are still underdeveloped in terms of both repertoire and resources available. The timbral potentials of these techniques are uncharted territories and collectively represent an entire sound world that remains relatively inaccessible to composers.

The exegesis is intended to serve as a useful reference source for artists interested in learning about the mechanics, qualities, and potential implementations of these harmonic based extended techniques. The works that I compose accompanying the exegesis will show idiomatic treatment of the techniques and serve as references as such in the exegesis. This exegesis makes use of hyperlinks throughout to enhance its usefulness as a reference document, and ease of sharing. The dissemination of the material I research will contribute to the accessibility of new sound possibilities for artists.

Chapter 1

Literature Review and Methodology

Literature Review

This study builds on and contributes to the catalogue of resources available to composers interested in implementing harmonic based extended techniques in their practice. The topic of 'harmonic based extended techniques and their compositional applications' is broad, and I will be unable to explore the entire corpus of techniques available to all instruments as this falls outside the scope of this exegesis. This is by design, as certain instruments lack certain facets of research, while others are already well documented, the most obvious example being string harmonics, which are common practice. This broad topic affords a certain level of flexibility to explore what is both novel and feasible given my available resources, all under the unifying theme of harmonic based extended techniques.

Many of the techniques that this study deals with are still in their comparative infancy, especially notationally. As such, engraving the works produced in the course of this study is a more subjective matter, rather than the well-established practice that it normally is due to the lack of a myriad of scores to draw reference from. A review of the available literature makes it clear that attempts have been made to standardise contemporary music notation, but have either fallen short, or are now outdated. Kurt Stone organised an international conference on new musical notation in 1974 in Ghent, Belgium, and then produced the treatise *Music Notation in the Twentieth Century* in 1980 as a result of the conference.[1] This, along with Gardner Read's 1979 *Music Notation*, served as a strong base for the standardisation of music

1. Kurt Stone, *Music Notation in the Twentieth Century* (New York: W. W. Norton & Company, 1980), xiii.

notation, but both are mired by their age and computer-based notation not being widespread.[2] It is therefore unsurprising that both omit the notation of stringed multiphonics, subharmonics, and half-harmonics, the bulk of the research largely postdating publication. Elaine Gould's 2016 book *Behind Bars* immediately became the gold standard of engraving manuals, her decades of notational and editorial experience at Faber Music lending weight to her comprehensive treatise.[3] But the same new techniques are omitted from Behind Bars, with Gould stating:

> 'I have been highly selective in the choice of extended instrumental and vocal techniques included in this book, but it is intended that this should give the reader the facility to create notation for other techniques not in common use.'[4]

Gould's book is less proscriptive than its forerunners, and focuses more on creating a consistent style language, providing the reader with the tools of standardised and codified 'common practice' notation to build new extended technique notation. As such, for all notational aspects, I will be drawing upon the Gould for the philosophy of engraving, if not exact notation, which has the benefit of almost forty years of usage and review against its peers.

Gould provides the tools which Ellen Fallowfield uses to construct a notation method for string multiphonics in her PhD 'Cello Map', the framework of which this exegesis will follow. A detailed, process-oriented review of technique informs the creation of resources which are then analysed.[5] Fallowfield's analysis produced the

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2. Gardner Read, *Compendium of Modern Instrumental Techniques*, 1st ed. (Westport, Connecticut: Greenwood Press, 1993).

3. Elaine Gould, *Behind Bars*, 1st (London: Faber Music, 2011).

4. Gould, *Behind Bars*, iii.

5. Ellen Fallowfield, "Cello Map: A Handbook of Cello Technique for Performers and Composers" (Thesis, University of Birmingham, 2009).

website cellomap.com, a manual of techniques for performers to use. She states that her text maps:

> [...] "actions that a cellist can make" onto "sounds that a cello can produce". In other words, we have tried to reduce the cello and cellist to scales of actions and sounds, and show how cellists can influence sound (loudness, overtone content, pitch...) by their actions (bow speed, contact point, stopping position...). This standpoint is a deliberate move away from providing performers and composers with catalogues of special effects and extended techniques. Instead, we would like to provide information about how the cello works that can serve the imagination of performers and composers.[6]

This approach 'future proofs' her thesis by abstracting the elements into their most base form, showing all of the sounds a cello can make using all of the actions a cellist can perform. While the website is comprehensive, Fallowfield seemingly avoids making any judgement calls on the compositional applications of the techniques that she reviews, and the reader is left to draw their own conclusions on the compositional effectiveness of any given technique. Fallowfield does, however, note that a repertoire gap exists for etudes exploring multiphonics for the cello, and indeed, the entirety of the string family. As part of my practice-led research, it seems fitting to compose a piece that begins to address this repertoire gap.

Bertram Turetzky's book, *The Contemporary Contrabass* was written to exemplify the contrabass as a serious solo and melodic instrument in response to the double bass's underrepresentation in the literature.[7]

He theorised:

> '[...] Concertizing Was The Key, which in the 1950's was impossible mainly due to the lack of literature. I attacked this problem in two directions:

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6. Ellen Fallowfield, "Cello Map," accessed May 31, 2019, `http://www.cellomap.com/`.

7. Bertram Turetzky, *The Contemporary Contrabass*, 1st Edition (California: University of California Press, 1974).

> 1. Locating original contrabass music from the eighteenth and nineteenth centuries, and 2. Commissioning twentieth century music.'[8]

His practice-led research centered on seeking to understand the techniques that contemporary composers could use in solo contrabass repertoire. Turetzky deliberately omitted including any guidance or judgements on notation, or categorisations of the difficulty of the techniques, stating that

> '[. . .] the time between this printing and the second edition will suffice to suggest and select the best notational concepts from a more substantial literature than we possess now.'[9]

The second edition saw Turetzky call for more experimentation with multiphonics, stating:

> 'I know of no music employing string multiphonics [. . .] this is entirely new ground, it remains for composers and performers to build the usable technique.'[10]

The specification of both composers and performers being needed to 'build the usable technique' is peculiar, until one re-examines the context in which Turetzky knew of these techniques. Thus, we might infer that he was attempting to address the situation through commissioning new literature.

Performers and researchers such as Fallowfield are necessary to establish the technique, but it is impossible for a 'usable technique' to be built without composers implementing their research and contributing to a pool of repertoire to show the correct usage of the technique.

Robert Dick's *The Other Flute* was released in 1989, and was notably used as the primary reference for microtonal flute fingerings by John Cage in the preface to

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8. Turetzky, *The Contemporary Contrabass*, vii.

9. Turetzky, *The Contemporary Contrabass*, ix.

10. Betram Turetzky, *The Contemporary Contrabass*, 2nd Edition (California: University of California Press, 1992), 138.

his piece *Music For*.[11] *The Other Flute* is a thorough performance technique manual, presenting each fingering and its resultant multiphonics one after the other, using a chart of descriptions to specify the qualities.[12] It specifies the following: 'exact pitch, ease of response, starting time, stability, dynamic range, timbre, and, if present, noise level, residual tone, and degree of modulation.'[13] While this text focuses more on instruction, it is an efficient system, and sorts the multiphonics into four classes graded by difficulty. From the perspective of a composer, Dick's book provides ample resources on the qualities of each multiphonic, but generic descriptions of their characteristics: enough for a composer to assess whether any given multiphonic is worth investigating with a flautist. While the scope of my research focuses on stringed instruments, Dick's method of cataloguing the qualities is a logical and comprehensive model to follow.

The Contemporary Violin is one of the more recent books in Turetzky's *The New Instrumentation* series.[14] It provides a comprehensive review of various violin techniques, but attempts to shy away from any implication of notational authority, most notably in the section on multiphonics, which seems to contradict rules codified by Gould (though to be fair, the Gould postdates Strange).[15] Fallowfield identified

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11. John Cage, *Music for : Parts for Voice and Instruments without Score (No Fixed Relation), Title to Be Completed by Adding to "Music for"– the Number of Players Performing.* (Henmar Press, 1984), `https://login.ezproxy.utas.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat02831a&AN=UTas.b2468591&site=eds-live`.

12. Robert Dick, *The Other Flute*, Second Edition (New York: Multiple Breath Music Company, 1989), 86–135.

13. Dick, *The Other Flute*, 84.

14. Patricia Strange and Allen Strange, *The Contemporary Violin: Extended Performance Techniques*, 1st ed. (Los Angeles, California: University of California Press, 2001).

15. Strange and Strange, *The Contemporary Violin: Extended Performance Techniques*, 134; Gould, *Behind Bars*, 257–258.

issues with the presentation format of *The Contemporary Violin* in the literature review of her thesis:

> 'The reader will find [information about *col legno battuto*] under the first chapter heading: 'Bowing Technique', the subheading 'Col legno battuto'. Later, chapter three: 'Percussion Techniques' includes the subheading 'The Bow', in which *col legno battuto* is described again.'[16]

Though the scope of my study is significantly smaller in scale, presentation of the findings is paramount to maintain accessibility as a resource. Given that my study focuses on harmonic based extended techniques, an overlap with techniques such as multiphonics is possible, and therefore needs to avoid the structural pitfalls of Strange's layout where information is repeated. Fallowfield's later concern of a need for a balance between subjectivity and level of detail when describing technique and sound is also relevant to both the Strange book and doubly so to the study. These manuals merely describe the qualities of various techniques, whereas my study will be dealing with the compositional applications of the techniques. Taking the extra-musical content such as blending, appropriateness for use in pitch sets, and other aspects of composition into account poses a threat to the usability of my study due to information overload. Marcus Weiss and Giorgio Netti discuss the reasons for limiting their study to extended techniques in the introduction to their book *The Techniques of Saxophone Playing*, stating "It might indeed be conceivable to compile a multi-dimensional "Encyclopaedia of Saxophone Playing" [, however] the demands on presentation and readability would be so complex as to make such a text impractical".[17]

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16. Fallowfield, "Cello Map: A Handbook of Cello Technique for Performers and Composers," 12.

17. Marcus Weiss and Giorgio Netti, *The Techniques of Saxophone Playing* (Kassel: Barenreiter-Verlag Karl Votter, 2010), Introduction.

So far, all of the literature reviewed (with the exception of the Gould and other engraving manuals) has been written either with the performer in mind, or has been written by an instrumentalist. Much of the composer-focused literature is found in the form of orchestration manuals, such as Samuel Adler's *The Study of Orchestration* and Walter Piston's *Orchestration*.[18] Attempting to cover the breadth of the art of orchestration, let alone composition, necessitates the omission of extended techniques. This is the inverse of the issue Weiss and Netti encountered, where their study required an omission of ground-level theory regarding the technical aspects of saxophone playing. Read's *Compendium of Modern Instrumental Techniques* touches upon multiphonics, but delegates to Dick, Thomas Howell, and many of the other books from Turetzky's *The New Instrumentation* series for notation and structure.[19] It becomes apparent that no matter the author, instrument, or technique, the work of packaging extended technique information for composers is left to somebody else. Composers seek to cover the entirety of the craft, while performers seek to cover the entirety of the instrument. Therefore, there is a dearth of resources for composers seeking to incorporate harmonic based extended techniques into their practice. My study addresses this by covering the playability, notation, and implementation of these techniques. Through practice-based research, the exegesis produced by my study will document the process of composing using these techniques, refining the methodology and notation through the creation of several new works. The resulting document will fill a hole in literature aimed at composers by acting as a practical manual for those interested in implementing harmonic based extended techniques in their own practice.

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18. Samuel Adler, *The Study of Orchestration*, Third Edition (New York: W. W. Norton & Company, 2002); Walter Piston, *Orchestration*, First Edition (London: Victor Gollancz Ltd., 1969).

19. Read, *Compendium of Modern Instrumental Techniques*, 160.

Methodology

My research topic "Harmonic Based Extended Techniques and their Compositional Applications" is a review of techniques, and how they can be incorporated in my own practice. As such, it is highly subjective, and the research methodology — largely qualitative — reflects this. Quantitative research, such as the analysis of documents using the same techniques will be used to support subjective claims. Each technique will be reviewed individually, as they are discrete from one another. Because many of the techniques are uncommon or difficult, consultation with players is paramount to undertake a fair assessment of the techniques. Document analysis of technique manuals will augment oral history research into the qualities and attributes of techniques.

To make an educated opinion on the value of a technique, data must first be collected. Compilation of techniques both in isolated, controlled environments, and in context in musical works will allow a full and accurate use of the analytical method on recordings. Examination of techniques in musical context will allow for value judgements to be made about the musical effectiveness of the technique. The recorded data will be treated, and then interpreted and analysed, with the results being implemented in new works.[20] Through this process, my research will feed into my practice.

A holistic approach, taking both the sound possibilities and the player implications ("is this technique too difficult for the average player?", "do I need to write for specific artists if I want to use this technique?", etc.) is necessary to evaluate its overall potential for incorporation in my practice. To overcome this, oral history methodology will be used to gather first-hand experiences and opinions on

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20. Rita Torres and Paulo Ferreira-Lopes, "Multiphonics as a Compositional Element in Writing for Amplified Guitar (2)," *Journal of Science and Technology of the Arts* 4, no. 1 (December 27, 2012): 61–69, accessed May 9, 2019, doi:10.7559/citarj.v4i1.67, http://artes.ucp.pt/citarj/article/view/67.

techniques. In Barnett's "Aspects of Vocal Multiphonics", she conducts several interviews with singers to better understand the way the technique functions from a performer's perspective.[21] Interviewing musicians able to play these techniques will deepen my understanding of the mechanics and technical aspects of implementing these techniques.

Augmenting the interviews, document analysis will be used on technique manuals that detail the production and quality of techniques. By building off the framework of classification articulated in Robert Dick's seminal *The Other Flute* and adapting it to accommodate a variety of techniques, comparisons across different techniques will be able to be made.[22] Through this, an understanding of the technical and mechanical aspects of the techniques will be gained. Techniques will be assessed on their practicality, ease of use, timbral qualities, and compatibility with my practice. Notation for the techniques varies from composer to composer, and where a common notational standard has not been developed (such as subharmonics), a document analysis of current notational standards will be undertaken, making reference to Gould's seminal text on music notation, *Behind Bars*.[23] Through this, and subsequent consultation with players, development of a consistent and effective notational language can be achieved.

This process of practice-based research will feed into itself, forming a research-based practice as detailed in Hazel Smith and R. T. Dean's "Practice-led research, research-led practice in the creative arts", where the value of it is described as:

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21. Bonnie Mara Barnett, "Aspects of Vocal Multiphonics," *Interface* 6, nos. 3-4 (December 1977): 117–149, accessed May 9, 2019, doi:10.1080/09298217708570239, http://www.tandfonline.com/doi/abs/10.1080/09298217708570239.

22. Dick, *The Other Flute*.

23. Gould, *Behind Bars*.

> the possibility [that] new knowledge . . . may be generated by moving from a stance more accurately seen to move from the 'unknown to the known' whereby imaginative leaps are made into what we don't know as this can lead to critical insights that can change what we do know.[24]

This iterative process will help clearly define the scope of the exegesis, and provide further insight into existing technique, as well as help 'build the new techniques'.

Through the collection of data from a multitude of sources and a range of different methods, it will become evident how harmonic based extended techniques are to be treated idiomatically. By undertaking a holistic review of the techniques including the player's point of view, the qualitative research I perform will enable not only me to incorporate these techniques into my own practice, but future composers that are interested in these techniques.

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24. Hazel Smith and R. T Dean, *Practice-Led Research, Research-Led Practice in the Creative Arts*, OCLC: 643339144 (2009), 48, accessed November 3, 2019, `https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=315978`.

Chapter 2

Assessment of Harmonic Based Techniques and Repertoire

Harmonic based techniques invariably make use of the harmonic series in one way or another. The harmonic series is a sequence of tones in which the frequency of each is an integer multiple of the fundamental frequency. The earliest forms of tuning systems were based around these, but modern instruments are tuned using equal temperament. The pitch of sound on stringed instruments is determined via tension, effecting the speed (and consequently pitch) the string vibrates at. Altering the tension is most commonly achieved via fingerings on the instrument's fingerboard, but bow pressure can also play a part in pitch production (see subharmonics).

The objective categorisation of techniques is a Sisyphean task due to the variability of the techniques, but general guidelines can be made. Dick's categorisation is, in some sense, specific to the flute, as it is based on the instrument's physical properties: altering fingerings can drastically change the resultant sound. While a direct translation to strings is unlikely, his method of partitioning and evaluating each quality will be used to paint a full picture of the technique in chapter 4, using the descriptive prose found in Adler's *The Study of Orchestration*.[1]

To assess techniques, we must first understand these techniques' capabilities, limitations, qualities, considerations, and values. Without references to other composers' works or professional musicians' opinions, any implication of authority on what constitutes as 'idiomatic' writing is baseless. References to other works, and feedback from sightreading sessions with professional musicians will be used to support claims. Where no such references are available, it will be marked as the author's personal opinion. Even without any available references to substantiate my

1. Adler, *The Study of Orchestration*.

compositions as idiomatic, their creation contributes to the literature of the techniques, and thus can be used if not as an example, a warning on what not to do.

All of the techniques covered in this exegesis involve the excitation of a string instrument's string in a non-standard way. A small amount of knowledge of the physics behind these techniques is required in order to understand the methods used to create these techniques. Understanding the conditions under which these techniques are produced will help composers and performers alike realise the techniques' potential accurately and idiomatically.

Strings create sound via the Helmholtz motion, which is a cycle where the string sticks and slips along the bow.[2] Rosin is applied to bows in order to ensure the static friction of the bow is greater than the kinetic friction, allowing the string to stick to the bow better.

Benade describes it as such:

> 'When the bow is placed on the string and drawn to one side, the string sticks to the bow, which pulls it aside until the elastic restoring force produced by the string tension becomes large enough to break the string loose from the bow. It now swings back in much the same way it would after slipping off the plectrum of a harpsichord jack; there is, however, a small amount of damping produced by the rapid (and therefore low-friction) sliding of the string against the steadily moving bow hair. At the end of its backward swing the string will come to rest and then recommence its motion in the direction of the bow velocity'[3]

Typically, the vibration of the string governs the cycle, and therefore the cycle of stick and slip on the bow has the same period as the vibration of the string.[4] Guettler et. al state that two conditions must be met in order to maintain Helmholtz motion;

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2. Joe Wolfe, "Bows and Strings," 2006, accessed October 27, 2019, `https://newt.phys.unsw.edu.au/jw/Bows.html`.

3. Arthur H. Benade, *Fundamentals of Musical Acoustics* (New York: Dover Publications, Inc., 1990), 516.

4. Wolfe, "Bows and Strings."

(1) during the stick phase the bow force must be high enough to avoid premature slipping of the string, and

(2) the bow force must be low enough that the circulating Helmholtz corner can trigger the release of the string at the initiation of the slip phase.

When the bow drags the string too far, raucous motion is produced, which is recognisable as the sound produced by an amateur violinist. Under the right conditions, subharmonics are produced.

For the purposes of brevity, these harmonic-based extended techniques will simply be referred to as 'techniques' throughout the paper, except when differentiation between standard techniques is needed. *Normale* will be used throughout this exegesis to denote an arco bow stroke, with no modifying techniques.

Subharmonics

First discovered by Mari Kimura, subharmonics are a type of overpressure which produces a sound lower than the fundamental.[5] They are also known as Anomalous Low Frequencies (ALFs), but Kimura argues that the predictable nature of them makes the name a misnomer.[6] As such, they will only be referred to as subharmonics in this exegesis. Subharmonics are produced when the bow is drawn across the string with an excessive amount of pressure. The drag of the bow twists the string, creating torsional oscillation. Under the right conditions, these can interact with the string to produce an identifiable pitch lower than the fundamental.[7]

The physics of how subharmonics are produced is not entirely understood as of the time of publication, although many inroads have been made.[8][9] The exact details fall beyond the scope of this thesis as composers and performers simply need to know the methods and characteristics of their production, rather than the science behind it. Thomas Botting describes the technique as "using bow placement, overpressure and a steady stroke to access various partials of the subharmonic series which exists in inverse to the harmonic series, 'beneath' the fundamental as it

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5. Mari Kimura, "How to Produce Subharmonics on the Violin," *Journal of new music research* 28, no. 2 (1999): 178–184, accessed April 11, 2019, doi:https://doi.org/10.1076/jnmr.28.2.178.3118, https://login.ezproxy.utas.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rih&AN=A212434&site=eds-live.

6. Kimura, "How to Produce Subharmonics on the Violin."

7. "Subharmonics.," *New Scientist* 191, no. 2571 (September 30, 2006): 60–60, https://login.ezproxy.utas.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=asn&AN=22720971&site=eds-live.

8. Readers interested in learning more about the physics behind them should find the works of Guettler to be an excellent starting point.

9. Knut Guettler, "The Bowed String: On the Development of Helmholtz Motion and On the Creation of Anomalous Low Frequencies" (Doctorate Thesis, Royal Institute of Technology - Speech, Music and Hearing, 2002), https://pdfs.semanticscholar.org/1d0c/968ee44366cd7d92c63f876be884c9135064.pdf.

were".[10] Subharmonics were initially thought to belong to the undertone series, a reflection of the harmonic series in which the fundamental frequency is *divided* by integers, rather than multiplied.[11] The pitches that can be produced do not necessarily follow any discernible ratio based pattern.[12] Subharmonics, strictly speaking, are not a harmonic based technique, but they remain within the scope of this thesis due to the misinformation surrounding them, and the prevailing similarities with harmonic techniques.

The pedal tones of the woodwind and brass instruments are related to the subharmonics in strings. Both are extended techniques for producing low notes. Pedal notes are established, reliable techniques in the repertoires of brass and woodwind instruments and are notated as regular note. This characterisation does not apply to subharmonics, and comparisons between pedal notes on wind instruments and subharmonics on strings are unlikely to meaningfully advance the discussion.

Subharmonics represent an incredible opportunity for solo string repertoire. On higher pitched instruments, the use of subharmonics can provide harmonic support (particularly in cadenza passages) and extend the range of the instrument. On lower pitched instruments, the use of subharmonics function better as a timbral mechanic, much like overpressure. One of the newest string techniques, subharmonics are still in their comparative infancy, and their notation has not been formalised.

Subharmonics are explored in my works *the veldt*, and *doppelganger*.

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10. Thomas Botting, "Developing a Personal Vocabulary for Solo Double Bass Through Assimilation of Extended Techniques and Preparations" (Thesis, University of Sydney, 2019), 16, `https://ses.library.usyd.edu.au/bitstream/2123/20352/1/botting_ta_thesis.pdf`.

11. Shaahin mohajeri, "Equaldivisionsoflength(Edl) - 240edo," October 25, 2019, accessed October 25, 2019, `https://sites.google.com/site/240edo/equaldivisionsoflength(edl)`.

12. Knut Guettler, "Wave Analysis of a String Bowed to Anomalous Low Frequencies," *Catgut Acoustic Society*, II, 2, no. 6 (November 1994): 8–14, `http://knutsacoustics.com/files/alf-casj.pdf`.

Subharmonics in the literature

One of the most significant contributions to the literature is Kimura's article 'How To Produce Subharmonics', in which she details specific methods in which one can promote the production of subharmonics, making them easier.[13] Notably, she found that older strings are more sympathetic to the production of subharmonics, theorised to be due to the buildup of fats on the string.

Adding twists to the string may also help (or hinder) the production of subharmonics, as shown in Table 2.1.[14]

Table 2.1: Relation between twists in string and resultant subharmonics

	1/2	1	2	3	4	5	6
minor 2nd	x	x					
major 2nd	x	x					
minor 3rd	x	x	x				
major 3rd	x	x	x	x			
perfect 4th				x	x		
diminished 5th					x	x	
perfect 5th	x					x	x
minor 6th							x
octave	x	x	x	x	x		

Possibly the first person to make use of the technique, Crumb described what we know as subharmonics as 'pedal tones'.[15] Crumb makes use of square noteheads and a separate stave for the resultant pitch in *Black Angels*, which makes the

13. Kimura, "How to Produce Subharmonics on the Violin."

14. Kimura, "How to Produce Subharmonics on the Violin."

15. George Crumb, *Black Angels (Images 1) [Music] : Electric String Quartet.* (Peters, 1971), https://login.ezproxy.utas.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat02831a&AN=UTas.b1139221&site=eds-live.

technique clear and readily understandable.[16] They are, however, purely timbral, and no recordings seem to treat them as subharmonics.

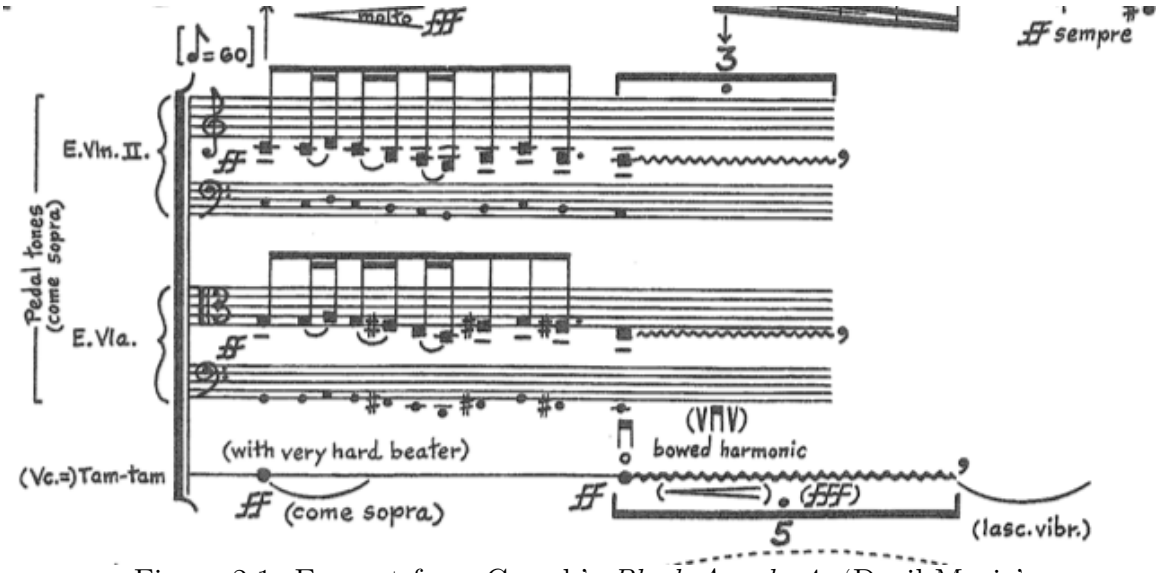

Figure 2.1: Excerpt from Crumb's *Black Angels*, 4. 'Devil Music'

Dejana Sekulic describes subharmonics as:

> [...] a sound that sounds an octave lower than g string. To produce this sound the use of bow is of great importance — the place, speed, and pressure. It is however extremely unsustainable and unpredictable, thus it is difficult to use it much in the compositions.[17]

Sekulic erroneously claims that subharmonics are solely producible on the G string, and can only produce an octave. Kimura's work, and my own experiments on a contrabass show that subharmonics are possible on any string, and octaves, major sevenths, and minor seconds are all readily achievable without specialist practice.[18]

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16. *Black Angels*, in collab. with George Crumb and Cikada Quartet (London: Cala Records, 1995).

17. Dejana Sekulić, "Do You Hear Me?" (Essay, Royal Conservatory Brussels, 2012), 15, `http://dejanasekulic.com/essay-do_you_hear_me.pdf`.

18. Kimura, "How to Produce Subharmonics on the Violin."

Gerard Grisey's *Vortex Temporum* features overpressure, with a subharmonic of specifically a seventh.[19] He notates the subharmonic technique using a triangular filled notehead showing the intended pitch, along with a double down-bow, with an arrow above it, shown in Figure 2.2. Somewhat abstracted out, this hides the intended effect behind symbols, and is slower to sight read.

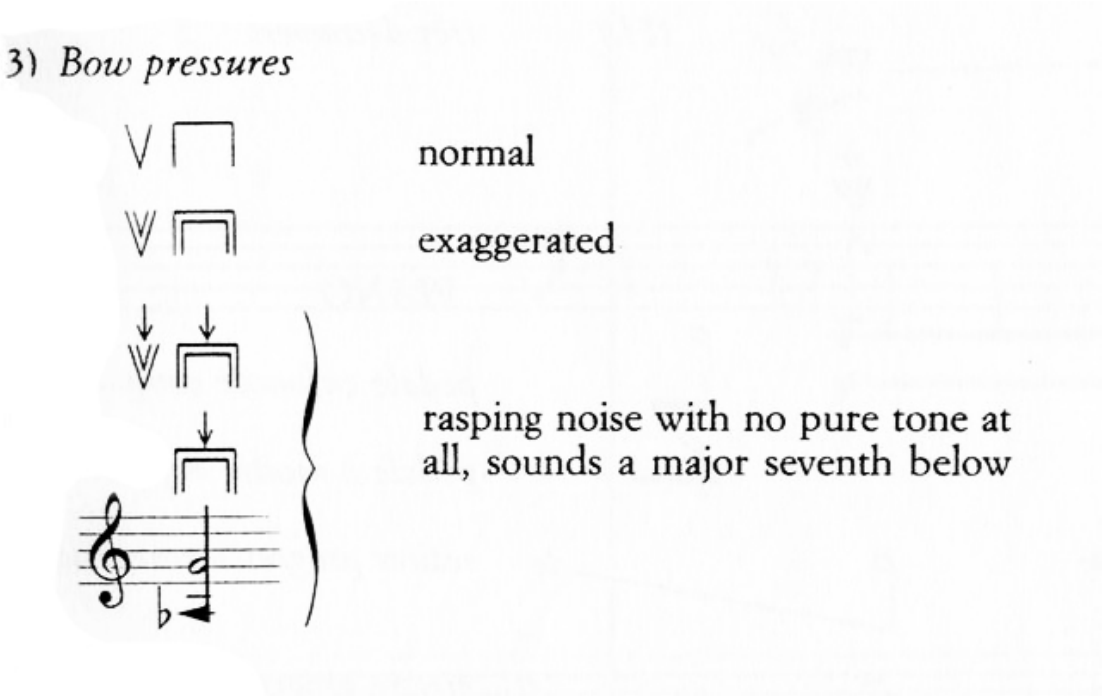

Figure 2.2: Excerpt from Grisey's playing instructions for *Vortex Temporum*.

Kimura's *Gemini* (Figure 2.3) is an example of idiomatic usage of subharmonics on the violin.[20] Kimura's notation practice of using a harmonic denoting the intended pitch below the fundamental is similar to the standard notation of harmonics, which Gould states is to "write harmonics as the player will

19. Gerard Grisey, *Vortex Temporum*.

20. Mari Kimura, *Gemini*, 1992.

finger them".[21] Unfortunately, this method proved somewhat counterintuitive in practice, as the notation was too similar, and caused sight reading issues.[22]

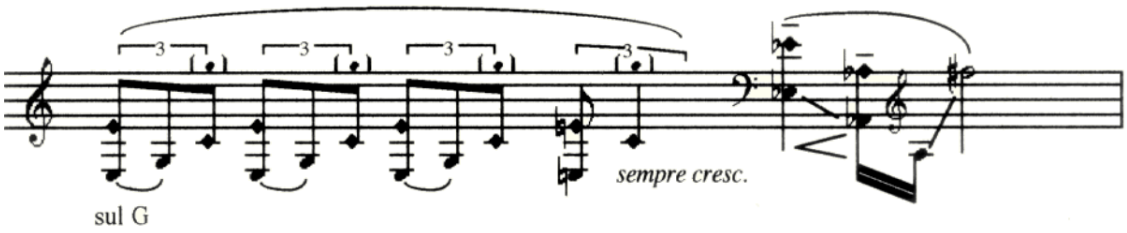

Figure 2.3: Excerpt from Kimura's *Gemini*

The example used on Ashley John Long's website, *The Modern Double Bass* (Figure 2.4) features a square notehead with the intended sound at pitch in a bracketed notehead, with harmonics and a technique line of 'S.H'.[23]

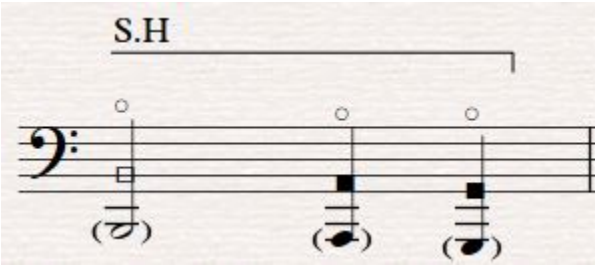

Figure 2.4: Notation of subharmonics from Long's website, The Modern Double Bass

It is the author's opinion that this is somewhat redundant, as just square noteheads with the intended produced pitch would be enough to delineate the technique. The technique line is supernumerary, and it would only be advisable to use it in extended passages of uninterrupted subharmonics. The use of the harmonic to denote the sounding pitch is congruent with the use of circular harmonics.

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21. Gould, *Behind Bars*, 413.

22. *Feedback from Exploratory Session*, in collab. with Angus Appleseed, October 17, 2019.

23. Ashley John Long, "Subharmonics," 2019, accessed September 21, 2019, `https://www.themoderndoublebass.org.uk/subharmonics.html`.

Robert Rowe wrote a work for Kimura, and uses a regular notehead for fingering, with a square bracketed cue sized notehead, as seen in Figure 2.5.[24] *Submarine* uses subharmonics early in the work as a contrast to the higher pitched material. They are referred back to several times, either as a mechanism to further muddy the soundworld created by the digital processing, or to 'clear the palette', the electronic audio cutting out leaving just the authoritative tone of the subharmonic. Rowe makes use of the audio processing, recording the subharmonics and playing them back later; an economical way to use subharmonics, obviating their unreliability. Near the end of the work, Rowe immediately plays back the just-recorded subharmonic, overcoming the limitation of the subharmonic's inability to handle sustained durations through technology. It should be noted that Rowe uses notation that has fallen out of style to notate *normale* harmonics, notating the fingering position with the diamond notehead, and the resultant pitch with a harmonic circle above it. Harmonic circles always denote resultant pitch, and are usually reserved for octave harmonics; the inclusion of the fingering obfuscates the intent.[25]

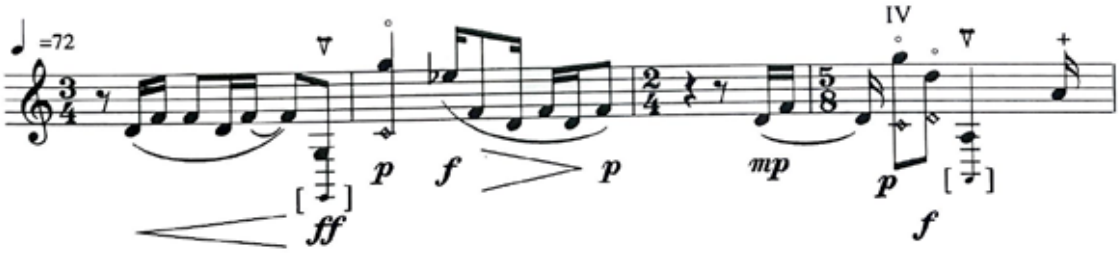

Figure 2.5: Excerpt from Rowe's *Submarine*

24. Robert Rowe, *Submarine*, 1996 (revised 2004).

25. Gould, *Behind Bars*, 420.

Jean-Claude Risset's *Variants*, also written for Kimura, is a work that makes use of both subharmonics and digital processing of live sound.[26] It uses a separate stave for the subharmonics and digital processing, as seen in Figure 2.6.

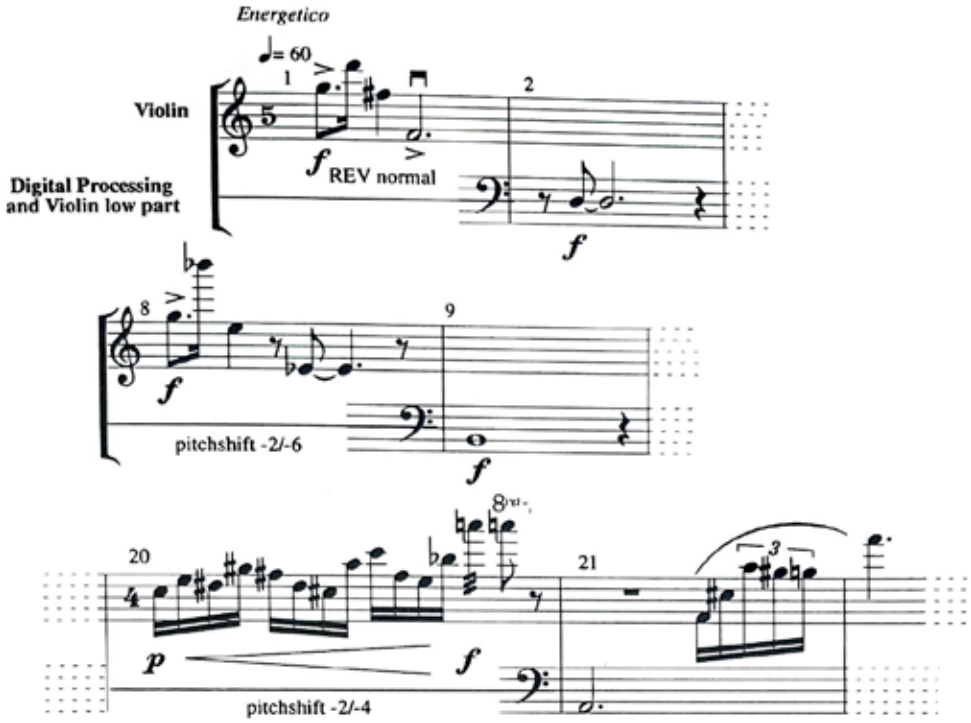

Figure 2.6: Excerpt from Risset's *Variants*

In *Variants*, Risset uses digital processing software to create chords out of singular melodic lines on the violin. This gives the impression of a full string section when the violin is playing fast *normale* passages, and emphasises the raucous, harsh timbre when playing subharmonics. They are used as a timbral device, rather than anything pitch based, with the longest subharmonic going for little more than two seconds, with three subharmonics appearing in the piece in total.

Botting notates subharmonics with a stave for fingering, and two staves for the resultant pitch, which also contains the technique information— the subharmonic

26. Jean-Claude Risset, *Variants*, 1995, `http://composers21.com/compdocs/rissetjc.htm`.

is denoted by 'SH' and a diamond notehead.[27] Apart from the technique text belonging attached to the stave that is performed, this is an acceptable method of showing resultant pitches when subharmonics are used in conjunction with harmonics. Botting's score was included in the appendices of his thesis, but it is unclear if frontmatter was omitted; given that Botting performs the piece personally, it is not unreasonable to assume that the work was written solely for his own practice (and therefore required no explanation of the techniques). This is, however, not acceptable for composers looking to use the technique in pieces performed by other people, and Gould is quite explicit in stating that all extended techniques must be covered in the frontmatter.[28]

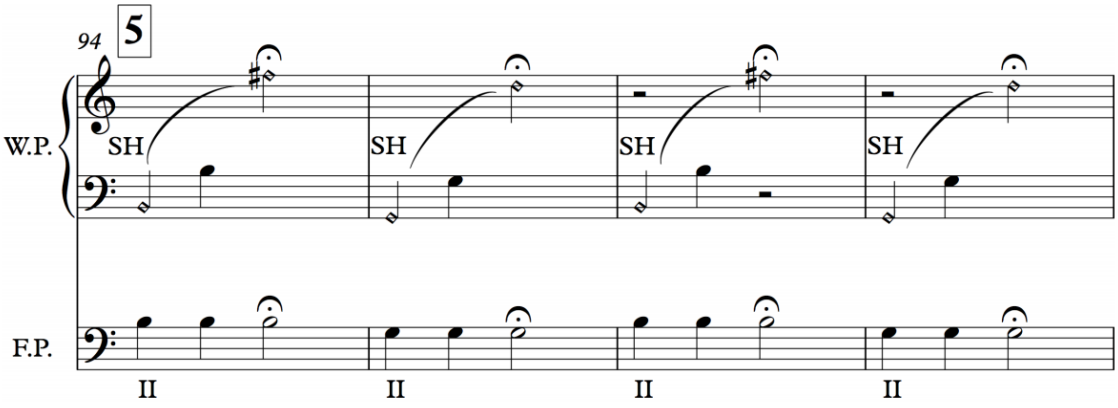

Figure 2.7: Excerpt from Botting's *Heights and Depths* mm. 94–97

This section of movement between subharmonics, *normale*, and harmonics lasts for no more than seventeen bars, but is enough to recognise the compositional potential. The textural movement from rough, gravely subharmonics through to pure harmonics, combined with the ascending pitch material gives a natural wedge shape to the phrase. The effect is more pronounced on the harmonics that result in a major

27. Botting, "Developing a Personal Vocabulary for Solo Double Bass Through Assimilation of Extended Techniques and Preparations," 109.

28. Gould, *Behind Bars*, 494.

third interval and minor seventh at bars 102 and 103 respectively. It then shifts into multiphonics, showing that these techniques can work in quick succession.[29]

Through an examination of the literature, there appears to be a range of different notation methods and levels of understanding of the mechanics of subharmonics.

29. Botting, "Developing a Personal Vocabulary for Solo Double Bass Through Assimilation of Extended Techniques and Preparations," 154–155.

Multiphonics

Multiphonics, also known as split tones, are 'the simultaneous sounding of two or more harmonics on a single string'.[30] For the purposes of this exegesis, they will only be referred to as multiphonics. An acoustical explanation for the production of multiphonics is still lacking[31], although it can be surmised that much like how octave harmonics can withstand a large margin of pitching error in order to activate, several partials' 'tolerance zones' for activation overlap.[32] Multiphonics are most commonly the domain of wind, and occasionally brass instruments, but they are an emerging technique in string writing, Turetzky writing about them in 1974.[33] Multiphonics on stringed instruments are difficult, but with appropriate preparation and notation, are feasible. Production of multiphonics, as with wind instruments, is not guaranteed, and can be dependant on a variety of external factors, including the humidity, make of the instrument, bow used, and other variables that are outside of the control of a composer.

Multiphonics are explored in my piece for violoncello, *liminal*, and contrabass work *the veldt*.

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30. Fallowfield, "Cello Map: A Handbook of Cello Technique for Performers and Composers," 108; Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/the-left-hand.html.

31. For a mathematical model of multiphonic's resultant pitches, an excellent starting point is Caspar Johannes Walter's 'Mehrklänge auf dem Klavier. Vom Phänomen zur Theorie und Praxis mikrotonalen Komponierens' in Mikrotonalität - Praxis und Utopie ed. Cordula Pätold and Caspar Johannes Walter (Maintz: Schott 2014)

32. Fallowfield, "Cello Map: A Handbook of Cello Technique for Performers and Composers," 146; *Feedback from Contrabass Session*, in collab. with Joe Bloggs, October 20, 2019.

33. Turetzky, *The Contemporary Contrabass*, 138.

Multiphonics in the literature

Fallowfield comprehensively explores multiphonic production on the cello in her thesis CelloMap, with video recordings of all possible multiphonics and permutations, including pizzicati.[34] These are isolated, though, and give little indication to the difficulty of the multiphonics, save for some spectral analysis which shows that some multiphonics are more prominent on certain strings.[35] Fallowfield discussed Guettler and Thelin's research into double bass multiphonics, and stated "their calculations and formulas for predicting the outcome of a certain finger position combined with a certain bow position also work in some cases for the cello but matches our measurements only roughly for others".[36] It can be extrapolated that the smaller bodies of the viola and violin have further difficulties.

In Strange and Strange's *The Contemporary Violin*, Tracy Silverman compares the sound to electronic feedback.[37] Welbanks compares and contrasts between Fallowfield and Silverman's assessment of the technique, and concludes that Silverman believes that multiphonics are a predominantly left-hand technique, while Fallowfield argues for a more holistic view, with the bow.[38]

Long's 'The Modern Double Bass' website serves a similar purpose as Fallowfield's CelloMap for multiphonics on the double bass.[39] He divides them into

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34. Fallowfield, "Cello Map: A Handbook of Cello Technique for Performers and Composers."

35. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds/frequency-analysis.html.

36. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds/frequency-analysis.html.

37. Strange and Strange, *The Contemporary Violin: Extended Performance Techniques*, 132.

38. Valerie Welbanks, "Foundations of Modern Cello Technique":161–164.

39. Ashley John Long, "The Modern Double Bass," accessed September 2, 2019, `https://www.themoderndoublebass.org.uk/`.

different categories as detailed in Table 2.2, some of which have more information and detail than others.

Type	Description
'Natural' multiphonics	Chart of different fingerings, similar to Fallowfield.
Pizzicato multiphonics	Description of technique, production, and result.
Textural multiphonics	Description of technique, production, result, and considerations.
Multiphonics behind the bridge	Description of technique.
Artificial multiphonics	Chart of different fingerings, similar to Fallowfield.
Percussive multiphonics	Description of technique, production, result, and considerations.
Timbral multiphonics	Description of technique.
Transformative multiphonics	Description and production of technique
Multiphonics through Variations in Finger Pressure	Description of technique, production, result, considerations, and example.

Table 2.2: The different types of multiphonics according to Long

Despite the varying degrees of detail, his work on cataloguing multiphonics is more in depth than many other resources.

Notation of Multiphonics in the literature

It should be noted that multiphonics on strings differ markedly from the multiphonics of wind instruments due to the fingering systems. While wind instruments achieve multiple tones by exploiting the construction of their instrument, string multiphonics are produced agnostic of specific fingerings. As such, the challenges that string multiphonic notation face are different to wind instruments. With no fingering chart necessary (the string being able to be stopped with any finger or tool, and produce the same tone), string instrument multiphonics also have no frame of reference for what sounds can be expected to be produced. String instruments also are not solely monophonic instruments, so notating the resultant multiphonic on the stave produces confusing results. Compounding this issue, string instrument multiphonics are a subset of harmonics, which use a different notehead to denote the fingering pressure difference. This means that any resultant pitches would need to be notated with regular noteheads, to discern the fingering pitch from the

resultant. Therefore, another system of denoting multiphonics must be used, as the existing wind literature is not suited for the purpose.

Strange and Strange discuss multiphonics at length, but lacked the literature necessary to form an opinion regarding their notation, stating that "to our knowledge these string multiphonics have never been notated".[40] They present a potential notation system as seen in Figure 2.8, and justify it thus;

> The effect is a variant of an open harmonic, so it is logical to begin with that symbol- a small circle over the sounding pitch. The timbral characteristics of the multiphonic is a distortion, or breaking up of the various other partials, much like a true *sul ponticello*.[41]

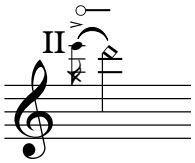

Figure 2.8: Strange and Strange's suggested multiphonic notation.

Buene uses a chart of diamond noteheads with their corresponding intended multiphonic in the score for his work for two double basses, *Blacklight*.[42] It mimics Fallowfield's charts of corresponding nearby quartertones, though the diamond notehead is already used in common repertoire for harmonics, not an extended technique. This has the potential to cause confusion, and could be easily avoided with a symbol or 'M' denoting the special quality of the multiphonic, and Gould warns against such repurposing of existing symbols.[43]

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40. Strange and Strange, *The Contemporary Violin: Extended Performance Techniques*, 132–134.

41. Strange and Strange, *The Contemporary Violin: Extended Performance Techniques*, 134.

42. Håkon Thelin, "Multiphonics on the Double Bass" (Norwegian Academy of Music, 2011), 39–42, `http://haakonthelin.com/multiphonics/uploads/files/4%20Multiphonics/Multiphonics%20on%20the%20Double%20Bass.pdf`.

43. Gould, *Behind Bars*, 494.

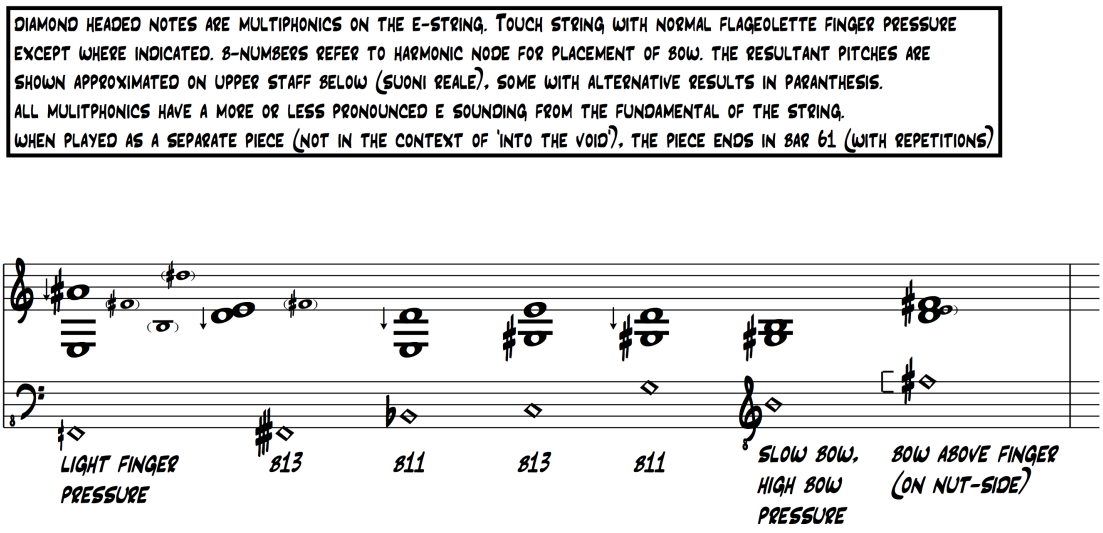

Figure 2.9: Excerpt from Buene's *Blacklight*.

Thelin's thesis on double bass multiphonics states:

> Multiphonics are always notated with the harmonic diamond sign, in tablature notation indicating finger positions rather than musical pitches. I suggest using the symbol M. above or below the note to indicate that it is a multiphonic sound, together with the indication on which string to play the note (in Roman numerals).[44]

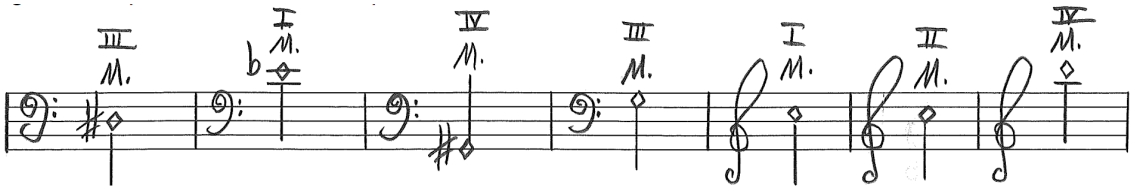

Figure 2.10: Excerpt from Thelin's thesis.

His notation, seen in Figure 2.10, is a somewhat less sophisticated version of Fallowfield's, lacking the tuning information necessary to produce the multiphonic. It should also be noted that Gould warns against technique text being placed below the stave.[45]

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44. Thelin, "Multiphonics on the Double Bass," 6.

45. Gould, *Behind Bars*, 492.

Fallowfield proposes the form of notation seen in Figure 2.11, stating:

> [. . .] it is necessary to indicate both the left-hand finger position and the pitch content. The left-hand finger touches the string above the node of the highest harmonic that contributes to the multiphonic, so the finger position is always that of the highest harmonic in the group. I suggest notating finger position with the rhombus that is usually used for harmonic finger pressure. The pitch of the contributing harmonics could be notated in brackets or on a separate stave. It is necessary to indicate which string the multiphonic should be played on and helpful to use the indication 'M' for multiphonic.[46]

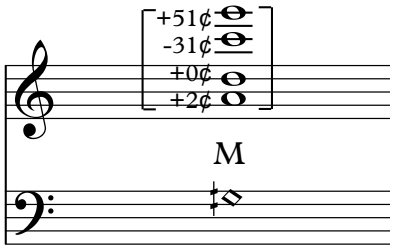

Figure 2.11: Fallowfield's proposed notation.

This notation is effective, although omits the indication of which string the multiphonic should be played on as she specified.

We can see this in practice in Oliver Thurley's work for solo contrabass, *yet another example of the porousness of certain borders*, where he adds another stave showing the intended pitches to be produced.[47]

Thurley embraces the fragility of these multiphonics, and uses their variability as a feature, rather than a hindrance. Slow, quiet transitions between multiphonics, double-stopped harmonics, and other extended techniques make the occasional

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46. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds.html.

47. Oliver Thurley, *Yet Another Example of the Porousness of Certain Borders*, 2014, `http://oliverthurley.co.uk/scores/yaeotpocb-score.pdf`.

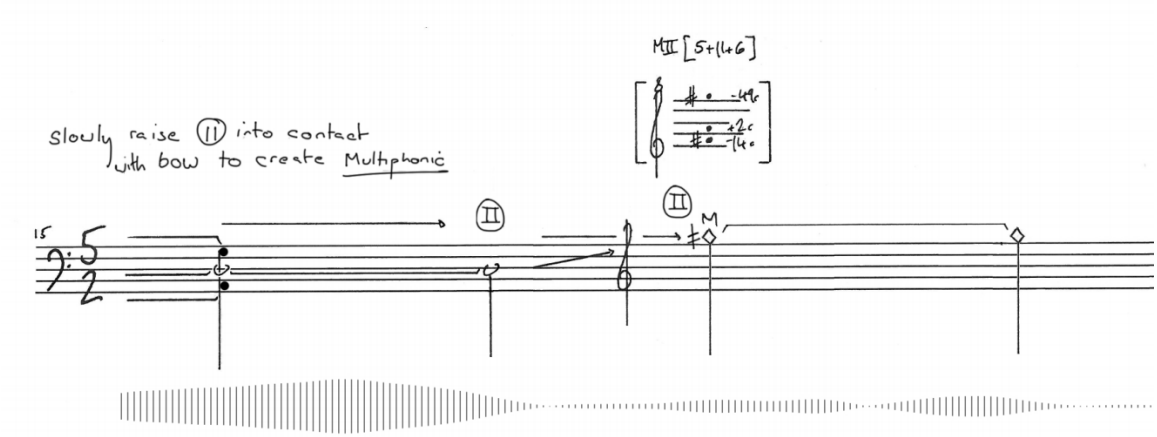

Figure 2.12: Excerpt from Thurley's *yet another example of the porousness of certain borders*

unintentional destabilisation of a multiphonic a point of textural interest, rather than a flaw.

Botting uses a diamond notehead for fingering, and a stave above containing the resultant pitches as diamond noteheads with an 'M' above them, as shown in Figure 2.13.[48]

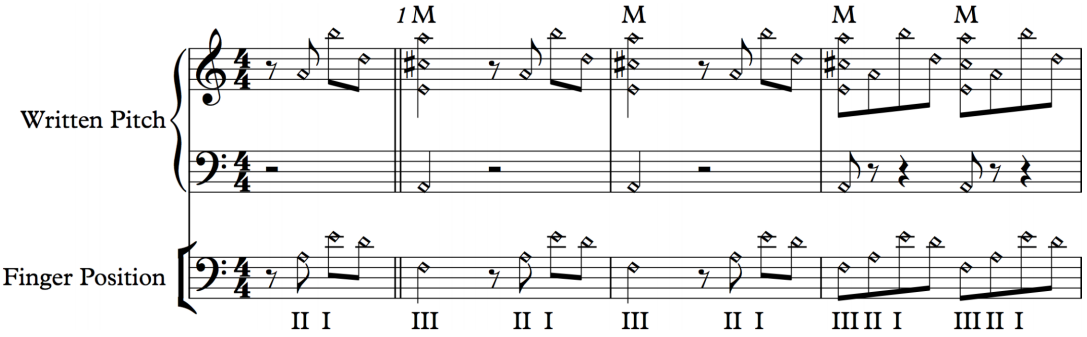

Figure 2.13: Excerpt from Botting's *Study in Harmonics and Multiphonics no. 1*

The *Study in Harmonics and Multiphonics no. 1* repeats the melodic material, and we see that the multiphonic not only slots in as something that can be played at

48. Botting, "Developing a Personal Vocabulary for Solo Double Bass Through Assimilation of Extended Techniques and Preparations," 35.

an *andante rubato*, but we see the bow move across the strings, shifting from D to G to a multiphonic on the A string. It should be noted that Botting produced this notation system without reference to the preexisting works of Fallowfield. This suggests that the use of an 'M' to specify a multiphonic is a relatively intuitive way of conveying the information (preceded, of course, by front matter explaining the technique).

It becomes apparent through the examination of the literature surrounding multiphonics that they are still an emerging technique, but are not shrouded in mystery or disinformation as subharmonics are.

Half-Harmonics

Half-harmonics is a term assigned to the fingering pressure found somewhere in between a regular note and harmonic. The technique is not difficult to produce, and the resultant sound is not dissimilar to the fragility of a multiphonic, producing both the fundamental pitch, and the harmonic. It should be noted that the half-harmonic is a modifying left-hand technique; it can be applied to multiphonics (although the resultant sound would likely be more noise than discernably either of the two techniques), but is not compatible with subharmonics due to the bow pressure needed to produce subharmonics eliminating the possibility of half-harmonics being produced. The terminology has not been formalised, but is most widely known as half-harmonics, although some works describe the technique without ascribing a name.

Half-harmonics are explored in my work for violin, *what are you doing with the humans*.

Half-harmonics in the literature

Half-harmonics, like the other techniques covered in this exegesis, have relatives in the wind and brass literature. Half-fingered and half-valved techniques appear in the respective nomenclature, and share common attributes of speaking poorly with bleedover into partials with the half-harmonic technique. Unlike multiphonics, the mechanical production of the technique is not dissimilar to the wind and brass facsimiles; all three families' respective techniques revolve around pressing almost to the point of a *normale* sound, but not quite, resulting in a pinched sound. Because of this, it is not unreasonable to draw parallels between the half-valved and fingered literature, and half-harmonic literature.

Half-harmonics do not feature heavily in the literature, with the most notable work being Sciarrino's 6 Caprices for solo violin.[49] It should be noted that Sciarrino wrote these in response to Paganini's caprices. They appear to take the same approach to composing in the same philosophy as New Complexicists, in the sense that the written score is the Platonic ideal, and that approximations are all that are expected. This is supported by the fact that many performers play them as harmonics.[50]

Lachenmann also makes use of them, and states it is

> [...] 'important not to produce any harmonics here; the result should be a veiled, almost immaterial and hardly perceptible coloring of the dominating string sound produced by the stopped note'[51]

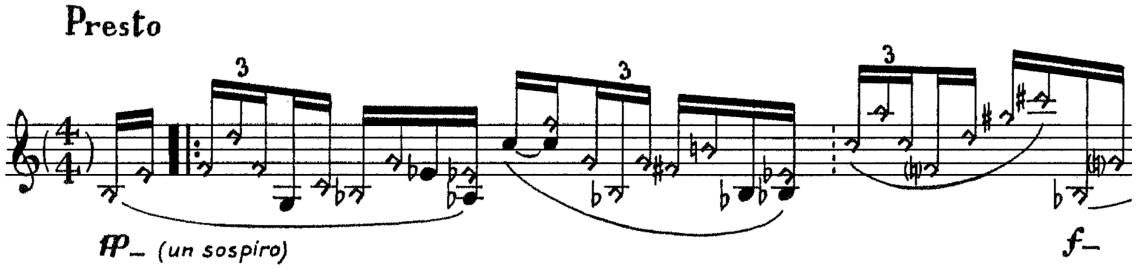

Figure 2.14: Excerpt from Sciarrino's 5th capriccio from *6 Capricci for Violin*

Sekulic adds to this quote, stating in *Do you hear me?* that the stopped note "which, as indicated, is only lightly touched, in conjunction with the flautato bowing" to achieve half-harmonics.[52]

In his work *Es Vee Pea*, Bunk notates half-harmonics with a triangle notehead, and instructs the player to "bow very slow and lightly. The pitch should be fingered

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49. Salvatore Sciarrino, *6 Capricci Per Violino*, 1976.

50. *Feedback from Exploratory Session*.

51. Helmut Lachenmann, *Musik Für Streichquartett*, 1972, foreword.

52. Sekulić, "Do You Hear Me?," 28.

with a bit more pressure than a harmonic, but the string should not touch the fingerboard. The result will be a quiet scratchy sound blended with a faint and unstable pitch".[53]

In her thesis on extended viola techniques, Kwok describes half-harmonics as producing "a "flutey" sound, similar to that of *sul tasto* and a natural harmonic".[54]

In his piece *The Plate of Transition Nourishes the Chameleon Appetite*, Applebaum uses the half-harmonic technique with a half-filled diamond notehead, describing it as being 'fingered lightly to produce noisy, semi-uncontrolled pitch'.[55]

Dimpker takes half-filled diamond noteheads found in Pröve's *Firebird*, and compares it with Kagel's notation in his Streichquartett I/II.[56] Dimpker notes the metrical disadvantages that half-filled diamonds have, but fails to note that regular harmonics overcome the same issue with little fanfare. The subject of transitions between half-harmonic and harmonic, and half-harmonic and *normale* is discussed, with the conclusion that:

> the transition from half-harmonic pressure to harmonic pressure, and vice versa, could be requested by using two notes of the same pitch (one for the half-harmonic and one for the harmonic stops) and connecting them by means of a legato slur.[57]

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53. Lou Bunk, *Es Vee Pea*, 2002, http://www.loubunk.com/scores/Es%20vee%20Pea%20Bunk.pdf.

54. Sarah Wei-Yan Kwok, "Breaking the Sound Barriers : Extended Techniques and New Timbres for the Developing Violist" (University of British Columbia, 2018), accessed May 30, 2019, doi:10.14288/1.0365754, https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0365754.

55. Mark Applebaum, *The Plate of Transition Nourishes the Chameleon Appetite*, 1992.

56. Christian Dimpker, "Extended Notation: The Depiction of the Unusual" (University of Plymouth, 2012), 120–121, https://pearl.plymouth.ac.uk/bitstream/handle/10026.1/3184/2013Dimpker10320048PhD.pdf?sequence=3&isAllowed=y.

57. Dimpker, "Extended Notation: The Depiction of the Unusual," 121.

This is contrary to what Gould suggests stating "transitions between one technique and another takes a solid line with an arrowhead."[58] Dimpker also specifies that half-harmonics 'are not limited to the nodes and hence the natural harmonics, but may be executed on all fingerboard positions'.[59]

We begin to see that the characteristics of half-harmonics are relatively consistent throughout the literature, and although the terminology and descriptions of the resultant sound varies, there is a general consensus on what the sound should be. There is not, however, as much consensus with regards to the notation of half-harmonics, and the binary nature of the technique seems to work against its favour, resulting in new forms of notation being constructed rather than composers using existing literature's notation to form a standardised notation system for half-harmonics.

Notation of half-harmonics in the literature

Perhaps the most straight-forward technique covered in this exegesis, notation for half-harmonics have just a single variable of finger pressure to convey in notation. The use of standard notation, modified to reflect the idea that the technique fits in 'half way between' two well established techniques (normale and harmonics) would be ideal, conforming to Gould's ideology of maintaining uniformity.

58. Gould, *Behind Bars*, 493.

59. Dimpker, "Extended Notation: The Depiction of the Unusual," 121.

Chapter 3

Compositions and Implementation of Techniques

My folio of works comprises of four pieces: *doppelganger*, for solo viola, *the veldt*, for solo contrabass, *liminal*, for solo cello, and *what are you doing with the humans*, for violin. These works all deal with different facets of the techniques that I have researched in this exegesis. Through the process of practice-based research and reflection on the implementation of these pieces, it is hoped that a clear identity of idiomatic treatment of these techniques will emerge. Shortcomings are still valuable data points due to the lack of information readily available about the treatment and usage of these techniques. It is envisaged that these works are to be used as etudes, both for musicians as testing grounds for the capabilities of the techniques, and for composers seeking to study scores to better understand how to implement these techniques in their own works. Through the process of journalling my compositional intent, it will become clear what the function of each piece is. Comparisons and contrasts to pre-existing literature and works will support the acceptance of the techniques as idiomatic. I worked with several instrumentalists proficient in their instruments at a professional level, but were unfamiliar with the techniques. They sight-read the works, and provided feedback on the writing, the technique, and how to better produce the techniques. Participants intimately familiar with the techniques were not approached both due to their unavailability, and because players unfamiliar with the techniques better fit the purpose of this exegesis: to inform composers and performers unfamiliar with the techniques to the point where they are able to accurately replicate the techniques.

Because these were sight-reading sessions, and due to the scope of the research, the names of the participants have, by agreement, been altered to preserve their anonymity.[1] Their pseudonyms and instruments are as follows:

- Angus Appleseed — viola
- Jane Smith — cello
- Joe Bloggs — contrabass

Due to the scope of this exegesis and time constraints, it was not possible to obtain recordings of each piece in full. Excerpts have been recorded where possible, and are supported by examples of other works from the literature, and instructional videos that support the idiomacy of the treatment of the techniques. As the goal of the exegesis is to produce a practical document that future composers can refer to, the entirety of the scores are included in the appendices of this exegesis. To aid the reader in referencing the relevant document quickly, hyperlinks are provided initially to the corresponding scores. Excerpts are provided for further references to the scores.

what are you doing with the humans

what are you doing with the humans is a solo work for violin that explores half-harmonics. It is a non-programmatic work, and the title was inspired by a question that my supervisor posed to me while I sought ethics approval for the exegesis. Half-harmonics are perhaps one of the simplest techniques to achieve, produced by applying finger pressure halfway between that required to create a harmonic, and a *normale* sound. The scale of finger pressure is detailed in Table 3.1.

The one-dimensional nature of this facet of the techniques leaves little variability in the implementation of the technique. Thus, *what are you doing with the humans* explores the relationship between half-harmonics and other finger pressures.

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1. This is because the participants had limited rehearsal time, and the techniques are not representative of their normal playing.

Table 3.1: Finger Pressure & Resultant Sound

Finger pressure	Result
Open	Fundamental
Touching	Harmonic
More pressure	Half-harmonic
Fingerboard	Normale

Rapid change between half-harmonics, regular harmonics, and *normale* makes the work an exercise in finger control, as well as an introductory work to half-harmonics. Below, I demonstrate the rapid changes of the half-harmonics in mm. 5 of *what are you doing with the humans*.

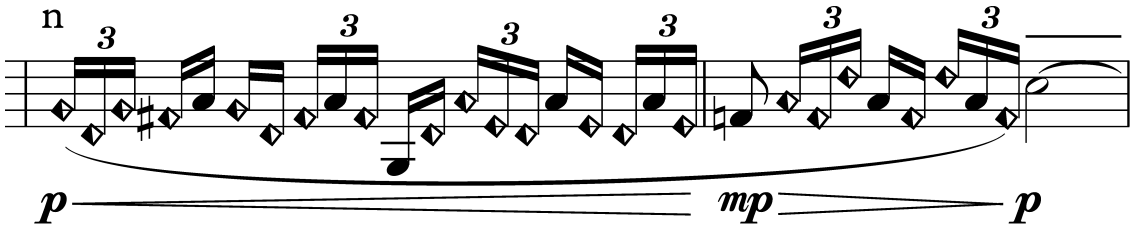

Figure 3.1: Excerpt from *what are you doing with the humans*

In mm. 27–32, I use the D string to provide additional available harmonics; the fifth D string harmonic, octave D string harmonic, and a fourth artificial harmonic using a stopped A are all readily available underneath the violinist's fingers. Thus, the difficulty is not in the fingering on the fingerboard, but the quick changes between harmonic, half-harmonic, *normale*, and artificial harmonic. Through this facet of eliminating needless complexity, the work serves as an etude targeting specifically the production of half-harmonics.

what are you doing with the humans takes inspiration from Sciarrino's fifth Caprice, and serves as a stepping stone to the more difficult work.[2] In practice, the pitch content of my work was obscured by the noisy texture of half-harmonics,

2. Sciarrino, *6 Capricci Per Violino*.

rendering large portions of it as noise. With the knowledge that properly performed, the harmonic content would be obscured, I leant into this, writing in a more tonal style than I do usually.

I opted to omit specific string instructions for the majority of the work, as this work is at a difficulty level where players should be able to make intelligent decisions over which strings to use. Where a natural harmonic is desired specifically, and not an artificial harmonic, the fundamental has been notated with a small notehead in parentheses.

As the technique is available on both nodal points, and non-nodal points (i.e. the technique is not limited to the fingering positions of harmonics on each string), I wanted to clearly delineate this with a section comprised of half-harmonics that do not excite any harmonics. The timbre of these non-nodal half-harmonics is darker than the others, and they are more difficult to speak.

I explore the inverse of this, playing on nodes to bring out the harmonic content as seen in Figure 3.2. Here, *normale* open string notes (for the most part) signal the end of the use of the string; in this way, the player will learn how to make the half-harmonics speak properly while moving the bow to different strings.

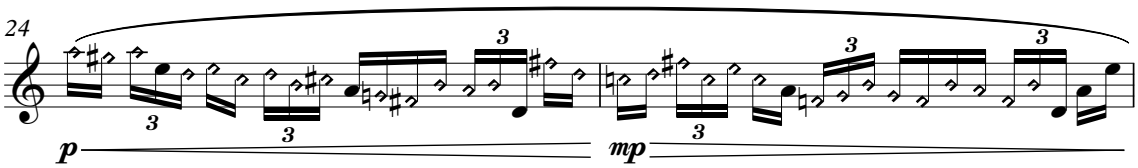

Figure 3.2: mm. 24 of *what are you doing with the humans*

Another facet of half-harmonics that I wanted to explore was the timbral aspect of them, bar 27 shown in Figure 3.3. Similar to a multiphonic in their rich harmonic content, half-harmonics do not have the purity of tone that regular harmonics have, and are more often a type of multiphonic, as evidenced by

Fallowfield's example.[3] I explore the interplay of half-harmonics, regular harmonics, and *normale*, double stopped minims and semibreves slowly changing from one mode of pressure to another. In this way, violinists that play *what are you doing with the humans* will become familiar with different modes of pressure played concurrently.

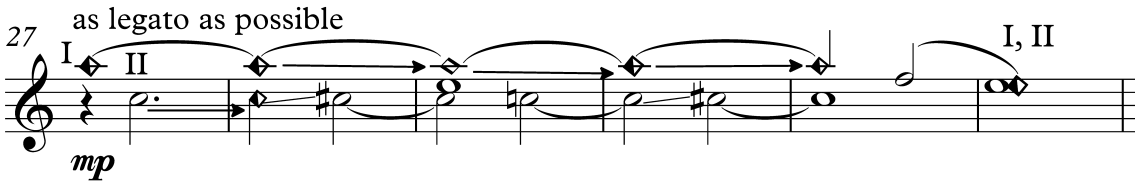

Figure 3.3: Excerpt from *what are you doing with the humans*

Notationally, the rapid changes between half-harmonics and other techniques were an ideal testing ground for different notation types. Notably, the issue of half-filled diamond noteheads not having any distinction between crotchets and minims is not an issue due to the bulk of the work dealing in smaller divisions of the beat.[4] The considerations of how to best notate half-harmonics are discussed further in section 4.

Ultimately, I opted to implement the half-filled diamond noteheads, finding them to most accurately present the information in a way that was unobtrusive, and built upon pre-existing notation. It should be noted that this is contrary to the opinion set out in Dimpker's seminal thesis on notation, *Extended notation. The depiction of the unconventional*, but conforms to Gould's opinion on the matter.[5]

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3. *Cello Map - Half Harmonics Example* (Basel: Academy of Music, January 11, 2013), `https://vimeo.com/57219720`.

4. Which is to say, that the connection of stems make the timing obvious for quaver and smaller noteheads, regardless of the notehead.

5. Dimpker, "Extended Notation: The Depiction of the Unusual," 120–121; Gould, *Behind Bars*, 61.

doppelganger

doppelganger is a piece for solo viola, written to explore the lower register of the viola using subharmonics juxtaposed with upper harmonics. The pitch distance between subharmonics and harmonics sidestep the viola's usual role occupying the middle register.

Findings of *doppelganger*

Workshopping an early draft of *doppelganger* with Angus, I found that subharmonics came fleetingly, and were prone to 'jump back' to the fundamental.[6] This resulted in a rewrite, redirecting the focus of the technique as a more textural element. As such, I amended the score to treat subharmonics largely as a 'special effect', and not ascribe importance to their pitched content.

A second workshop with Angus was more productive, and we found that the subharmonic technique spoke much more readily with a slower bow speed, combined with a consistent amount of pressure.[7] We found that the A string of the viola did not respond nearly as readily to the technique, to the point of being unusable. The D and G strings both spoke acceptably, but due to the pressure required, often resulted in unwanted double-stopping. The C string spoke very freely, with the technique coming readily. Contrary to Fallowfield stating 'It is very difficult to sustain the tone, which often has a high noise component', we found that with practice, the subharmonic was able to stabilise to the point of it being usable for longer sustained notes.[8]

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6. *Feedback from Exploratory Session*.

7. *Feedback in Sightreading Session*, in collab. with Angus Appleseed, October 23, 2019.

8. Fallowfield, "Cello Map: A Handbook of Cello Technique for Performers and Composers," http://www.cellomap.com/index/the-string/plucking-striking-and-bowing-the-string/how.html; *Cello Map - Example 24* (Basel: Academy of Music, January 11, 2013), `https://vimeo.com/57219720`; *Feedback in Sightreading Session*.

To 'ease the player into' the technique, *doppelganger* begins with an open C string, which drones for a few seconds before crescendoing while moving the bow towards the fingerboard and slowing the bowing speed down, shown in Figure 3.4. The pressure used to play *sul ponticello* is the same as the pressure needed to play

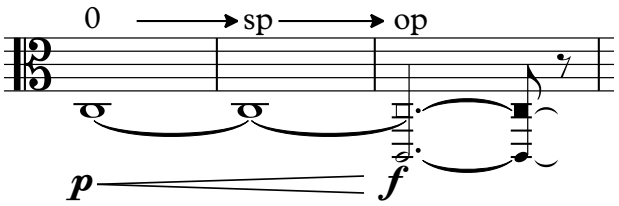

Figure 3.4: mm. 1–3 of *doppelganger*.

subharmonics, priming the player to only need to concentrate on the bow speed and location on the string.[9] This technique of applying the thought process of playing *sul ponticello*, but actually playing near the fingerboard appears to be an ideal way to guide players unfamiliar with the technique into achieving it without lengthy in-person demonstrations.[10]

liminal

liminal is an exploration in multiphonics, but is not strictly an etude. I wanted to explore multiphonics as I explored half-harmonics in the piece section 3. Unfortunately, while workshopping with Sarah, I found the non-binary nature of multiphonics precluded this from being a possibility.[11] I discovered several facets of the technique that were not previously discussed in the literature found in Fallowfield's work.[12]

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9. *Feedback in Sightreading Session*.

10. *Feedback in Sightreading Session*; *Feedback from Contrabass Session*.

11. *Feedback from Cello Sightreading Session*, in collab. with Jane Smith, October 18, 2019.

12. Fallowfield, "Cello Map."

For each pair of nodes that produce multiphonics, the lower of the two is easier to pitch due to the logarithmic correlation between string length and pitch; that is to say, because the gaps between semitones are correlationally larger as the pitch lowers, the pitching can be more precise.

Double-stopped multiphonics are feasible, but because the angle of attack can impact the partials the multiphonic produces, the shift between single strings and double stopping can stop the multiphonic from speaking clearly. Aurally, double stopped multiphonics seem to be more effective with the *normale* note on a lower string than the multiphonic.

the veldt

Inspired by the eponymous short story by Ray Bradbury, *the veldt* is a composition for solo contrabass that explores both multiphonics and subharmonics in the context of a soundworld; the musical language is derived from the harmonic series, exploiting the resonance of the bass to maintain a drone.[13] Similarly like the plot of Bradbury's work, this world is filled with danger but also beauty. This is reflected in my work in the use of subharmonics and multiphonics; difficult and fragile techniques that can break at a moments notice. My intent with Veldt was to create a harmonic language and space that the performer was able to 'roam around' in, and features several sections of improvisation or stochastic aleatory based around the harmonic series, representing the possibilities of the veldt.

Findings of *the veldt*

Writing for contrabass, I found subharmonics came most easily on the G string. This was confirmed in a workshop with Joe, although he was able to produce

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13. Ray Bradbury, "The Veldt," in *The Illustrated Man* (New York: Doubleday & Company, 1951), 256.

subharmonics on all other strings, too. Subharmonics on the lower strings did not speak as well, and it was difficult to discern the lower frequency's shifts. Because of this, *the veldt* uses the technique as a textural tool, rather than a melodic device.

Working with Joe, he identified the need for subharmonics to be played closer to the fingerboard than normal. He theorised that the tension being weaker as the contact point moved away from the bridge, closer to the middle, made it easier to produce subharmonics via the raucous motion.[14] A second stave displaying the music notated at actual pitch was necessary, as shown in Figure 3.5. In contradiction of

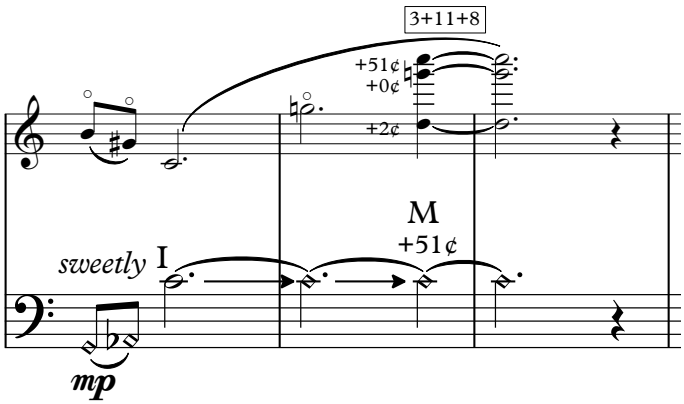

Figure 3.5: excerpt from *the veldt* showing the *suono reale* stave.

Gould's recommendations, I opted to notate the *suono reale* in treble clef, rather than treble transposed down an octave.[15] This is because the multiphonics activate partials well above those usually expected, resulting in the advice not being relevant. To maintain ease of playing, I use similar fingerings across the strings to aid in the pitching of multiphonics, as seen in Figure 3.6.

14. *Feedback from Contrabass Session*.

15. Gould, *Behind Bars*, 423.

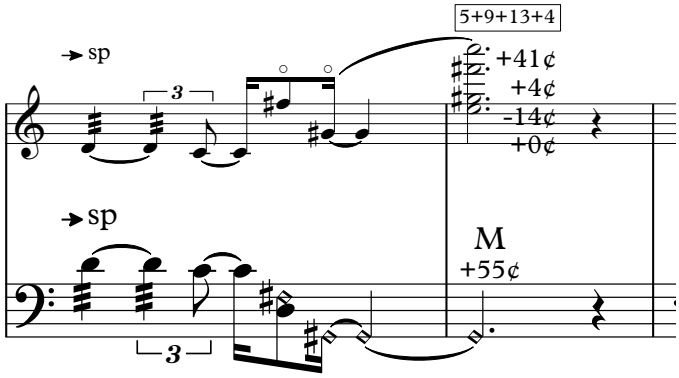

Figure 3.6: Excerpt from *the veldt*.

Chapter 4

Findings and Research Implications

In this chapter, my findings are presented as an instructive manual for composers and performers interested in using the techniques. Because my folio of works has some degree of overlap in usage of techniques, this chapter will deal with each technique, rather than be a review of findings from each piece singularly.

Due to the limited number of permutations of these techniques, the Dick model of categorisation will not be discussed due to its limited applicability and the notational challenges of these techniques.[1] It will also take into account how common the technique is, as well as notational challenges.

Notation

If a composer wishes to use a technique once off, or in sparing amounts, plain English text explaining the technique and what is desired of the player is adequate..[2] For all other cases where a technique is required more than once, composers should include the technique in the frontmatter of the work.[3] If a technique uses a new symbol or notehead, this should be reflected in the frontmatter. Where possible, composers should retain the same clef for both fingered and sounding pitches.[4]

Composers would do well to include a description of the desired sound, and method of production, as shown in the frontmatter for each of my works.

- Subharmonics:

1. Dick, *The Other Flute*.

2. Gould, *Behind Bars*, 494.

3. Gould, *Behind Bars*, 494.

4. Gould, *Behind Bars*, 422.

  - *doppelganger*
  - *the veldt*
- Multiphonics:
  - *the veldt*
  - *liminal*
- Half-harmonics:
  - *what are you doing with the humans*

Subharmonics

Subharmonics are a difficult technique that lend themselves to solo works, or works where they can be brought to the forefront. They produce a sound lower than the fundamental through precise control of torsional oscillation, which usually produces the sound of an amateur string player's heavy handed, slow bowing. The timbre of overpressure can vary, but is identifiably pitched, and typically is somewhat nasal. Subharmonics are notably different to overpressure, but bleed over into non-pitched overpressure is common. This, plus the difficulty in their execution, makes them unsuitable for melodic content.

Several different intervals are available as subharmonics and a myriad of factors feed into which are easily replicable. As a rule, octaves come most easily, with minor seconds, major sevenths, and perfect fifths coming after that.[5] Composers should be aware that producing the specific pitch is not *necessarily* guaranteed. Subharmonics are unable to be performed *laissez vibrer*, as the pitch returns to the fundamental as soon as the bow is no longer in contact with the string.[6] Due to the pressure needed, subharmonics are most comfortable at least *mezzo-forte* or louder,

5. Kimura, "How to Produce Subharmonics on the Violin."

6. *Feedback from Exploratory Session*.

although quieter subharmonics are possible. Sympathetic resonances from the other strings are common at higher volumes. Playing on the two inner strings is slightly harder due to the angle of attack being restricted to not inadvertently play double-stopped notes.[7]

Composers looking to use this technique should be aware that instrumentalists will need copious amounts of practice and guidance in order to fully and reliably realise this technique.

Notation of Subharmonics

Subharmonics require both a fingered pitch, and an intended resultant pitch to be conveyed to the player, as well as some form of indication that it is a subharmonic. This can be done through a variety of ways, including technique text (i.e. 'S.H.' as Long suggests), or using a different notehead.[8]

Gould suggests several practical methods of communicating resultant pitch, as a "small [black] notehead [without a stem] in brackets directly above or after the fingered pitches", an ossia stave with the resultant pitches above, or notated in a footnote using a cue stave.[9] She states "wherever possible, retain the same clef for both fingered and sounding pitches", though this is sometimes impractical.[10] The use of a second stave is seen in Figure 2.6.[11] Extrapolating from the use of the circular harmonic signifying at-pitch harmonics, we can apply the same method to subharmonics, as seen in Figure 4.1.

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7. Welbanks, "Foundations of Modern Cello Technique," 99.

8. Long, "Subharmonics."

9. Gould, *Behind Bars*, 421.

10. Gould, *Behind Bars*, 422.

11. Risset, *Variants*, It should be noted that Risset's notation omits a fingered pitch, which is not recommended.

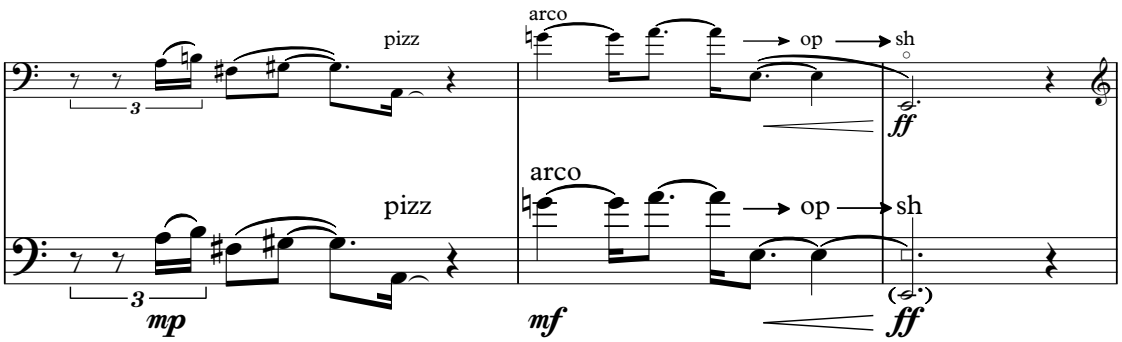

Figure 4.1: Excerpt from *the veldt* showing subharmonics notation.

Observations on techniques

- Rope core strings produce more harmonics, but are more difficult to produce subharmonics with.
- Strings with a single or nylon core make the technique easier, due to their low tension.[12]
- Players may find that subharmonics are easier on older strings.[13]
- They may also find that adding twists to the string may also help, or hinder the production of subharmonics, as shown in Table 2.1.[14]

Botting notes that experimentations with octavic subharmonics yielded a pitch slightly flatter than an octave. He states:

> I developed a left hand finger technique whereby I rotate my hand slightly clockwise, pivoting on the finger stopping the string, which has the effect of sharpening the subharmonic enough to be more in tune with the fundamental.[15]

12. Welbanks, "Foundations of Modern Cello Technique," 99.

13. Kimura, "How to Produce Subharmonics on the Violin."

14. Kimura, "How to Produce Subharmonics on the Violin."

15. Botting, "Developing a Personal Vocabulary for Solo Double Bass Through Assimilation of Extended Techniques and Preparations," 111.

To 'find' the subharmonic, an excellent method to practice is to play *sul ponticello* at a *forte* dynamic on an open string, and then move towards the fingerboard, keeping the pressure but slowing the bowing speed down. Subharmonics are easier to find at nodal points[16], particularly the 6th node (closest to the bridge).[17] Bow pressure should be totally consistent throughout the bowing stroke; rather than the tapered start and finish of *normale*, players should imagine a more binary stop and start, beginning and ending on the string. The bow hair should remain flat throughout the stroke, in order to to exert the maximum amount of pressure.[18] Different bow positions on the string can make different subharmonics speak more easily.[19]

Instrument specific considerations for subharmonics

Subharmonics may be easier to produce on the contrabass with a lighter bow, preferably a cello bow, or alternatively a French style bow.[20] Conversely, violin and violas may benefit from the use of a heavier bow.[21] The A string of the viola appears to be particularly resistant to producing subharmonics, although this may vary from instrument to instrument.[22] The tension of the string appears to impact the feasibility

16. Points at which the string is divided into fractional ratios, such as 1/3.

17. *Feedback in Sightreading Session*.

18. Kimura, "How to Produce Subharmonics on the Violin."

19. Kimura, "How to Produce Subharmonics on the Violin."

20. Long, "Subharmonics."

21. *Feedback in Sightreading Session*.

22. *Feedback in Sightreading Session*.

enormously; 13 inch violas may have more success producing subharmonics on the A string than 18 inch violas.[23]

Works featuring subharmonics

- Mari Kimura — ALT in three movements for solo violin (1992)
- — Gemini for solo violin (1993)
- — 6 Caprices for subharmonics for solo violin (1997)
- — JanMaricana (for subharmonics) for solo violin (2016)
- Joshua Burel — Sonata No. 2 for violin and piano 'Subharmonics' (2011)
- Jean-Claude Risset — Variants (1995)
- Robert Rowe — Submarine (1996)

Multiphonics

Multiphonics are fragile, and require much practice to execute reliably. Despite this, they can be used to achieve harmonies that are not otherwise achieveable through double-stopping, and lend themselves well to drawn out or slow passages of music. Multiphonics' exact pitching makes them ideal for music that uses ratios, microtones, or tone rows. Multiphonics are easier to achieve on larger instruments, due to the need for precise ratio-based fingering to achieve the resonance of multiple partials.[24]

The open string (or first partial) can be activated as part of a multiphonic.[25] The second partial (octave harmonic) is *never* produced in a multiphonic

23. *Feedback in Sightreading Session*.

24. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds/frequency-analysis.html.

25. Welbanks, "Foundations of Modern Cello Technique," 161.

Notation of Multiphonics

Much has been written about multiphonics, and they are a well established technique in woodwind writing. The notation between them differs, though; precise fingering charts above resultant pitches do not translate precisely into string writing.[26] Fallowfield states:

> To notate 'pure' multiphonics accurately in a score, however, it is necessary to indicate both the left-hand finger position and the pitch content. The left-hand finger touches the string above the node of the highest harmonic that contributes to the multiphonic, so the finger position is always that of the highest harmonic in the group. I suggest notating finger position with the rhombus that is usually used for harmonic finger pressure. The pitch of the contributing harmonics could be notated in brackets or on a separate stave. It is necessary to indicate which string the multiphonic should be played on and helpful to use the indication 'M' for multiphonic.[27]

Below, I have notated the permutations of what Fallowfield has described, and will let the reader draw their own conclusion as to which is most appropriate. Her example omits the necessary string, but Gould suggests several different options; the inclusion of the corresponding string number (i.e. 'I', 'IV'), the usage of Italian (i.e. 'sul E', 'sul G'), or by notating the fundamental on the stave, using "a small bracketed black notehead (regardless of duration) for the open string and for the first note only of a tied harmonic."[28] In Figure 4.2, we see the specific cents tuning for the fingered note, contrasted with Figure 4.3, which uses quarter tones to convey the relevant pitching data, both with a *suono reale* stave indicating the sounding pitch above.

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26. The relation between string and woodwind multiphonics is discussed more in-depth in chapter 2.

27. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds.html.

28. Gould, *Behind Bars*, 418.

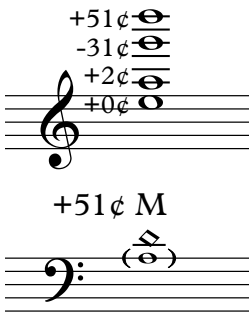

Figure 4.2: Multiphonic notation with cents

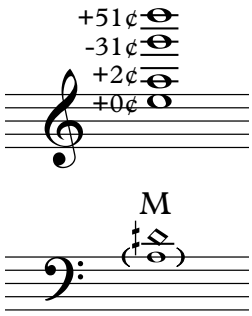

Figure 4.3: Multiphonic notation with quarter tones

While Figure 4.2 is more precise, the horizontal space usage is greater than that of Figure 4.3; if using text to specify which string to use, it may quickly become cumbersome to read.

Gould's advice for resultant pitch for harmonics, which has been applied to subharmonics can also be applied to multiphonics as evidenced in Figure 4.5 The ossia staff, or *suono reale* if necessary for the entirety of the work[29], can have the multiphonics notated as a rhythm, as seen in Figure 4.4.

Further simplifications can be made if there is no clef change, making it possible to omit the 'M' technique text denoting it as a multiphonic.

There are several ways of denoting the same (or similar) information; because multiphonics notation is cumbersome, there is often a deficit of either vertical or

29. *suono reale* should be full sized, while ossia staves are 3/4 sized.

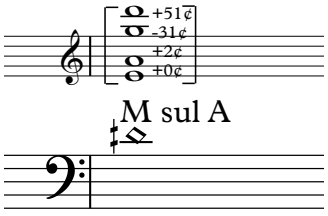

Figure 4.4: Multiphonic notation using an ossia line

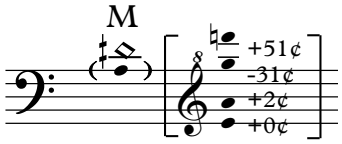

Figure 4.5: Multiphonic notation on one line

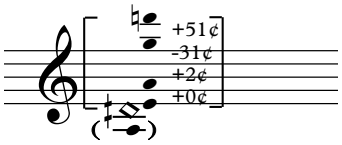

Figure 4.6: Multiphonic notation in one clef

horizontal space. However, with the flexibility of each element, there should be a method of notating multiphonics idiomatically that can be implemented in every score that makes use of them.

Observations on techniques

- Multiphonics should be played closer to the bridge than one would normally play them.[30]
- Overly high and low bow pressure can limit the lower partial content of resultant multiphonics.
- Faster bow speed favours higher partials over lower partials, and similarly, slower bow speed favours lower partials over higher.

30. Fallowfield, "Cello Map."

- Moving the contact point closer to the bridge yields more noise content and favours lower partials, until the contact point is very close to the bridge, where it produces a clearer sound and favours higher partials over lower partials.[31]
- Multiphonics containing higher partials require a lighter and faster bow stroke, closer to the bridge than multiphonics that have lower ranges of partials.[32]

To first find a multiphonic, Welbanks and Fallowfield both recommend playing the harmonics individually.[33] Then play the harmonic with the highest resultant pitch. Use a slower bow stroke with higher pressure and closer to the bridge, and slightly lighter finger pressure.

Instrument specific considerations for multiphonics

Multiphonics are easier on large instruments, as more precise pitching is possible with the longer strings. Composers should be aware that of the pair, the multiphonic node closer to the bridge can be harder to produce because of this fact. 'Artificial' multiphonics are possible, although much more difficult.[34]

Works featuring multiphonics

- Mari Kimura — 6 Caprices for subharmonics for solo violin (1997)

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31. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds.html.

32. Welbanks, "Foundations of Modern Cello Technique," 165.

33. Welbanks, "Foundations of Modern Cello Technique," 167.

34. Knut Guettler and Håkon Thelin, "Bowed-String Multiphonics Analyzed by Use of Impulse Response and the Poisson Summation Formula," *The Journal of the Acoustical Society of America* 131, no. 1 (January 2012): 772, accessed May 28, 2019, doi:10.1121/1.3651251, http://asa.scitation.org/doi/10.1121/1.3651251.

- Andrew Greenwald — On Structure (2a) — for clarinet, violin, and cello (2010)
- Stefano Scodanibbio — composed e/statico (1980)
- Håkon Thelin — oibbinadocS (2004)
- — Glasperlenspiel (2010)
- Michael Liebman — Sonata for double bass, movement 2: Legato sonore (2001)
- Kaija Saariaho — Lichtbogen (1986)
- Kimmo Hakola — Thrust, Rubato (1989, rev. 1991)
- Eivind Buene — 'Blacklight' (2019)
- Fernando Grillo — 'Fluvine' (1974)

Half-harmonics

Half-harmonics are produced via left-hand finger pressure that is halfway between that of a harmonic and a *normale* sound produced when the string is pressed to the fingerboard. The pitch content is sharpened slightly, and the overtone content is relatively weak.[35] Half-harmonic stops are not limited to the nodes and hence the natural harmonics, but may be executed on all fingerboard positions, as well as executed as 'artificial' harmonics.[36] Half-harmonics are what many would interpret as notes that 'fail to speak'.

35. Welbanks, "Foundations of Modern Cello Technique," 113.

36. Dimpker, "Extended Notation: The Depiction of the Unusual," 127.

Notation of Half-harmonics

Half-harmonics can be notated in one of several ways (see Figure 4.7 for examples of both the crotchet and semibreve notation of each), but regardless of the chosen symbol, the notation should be described in the performance notes.

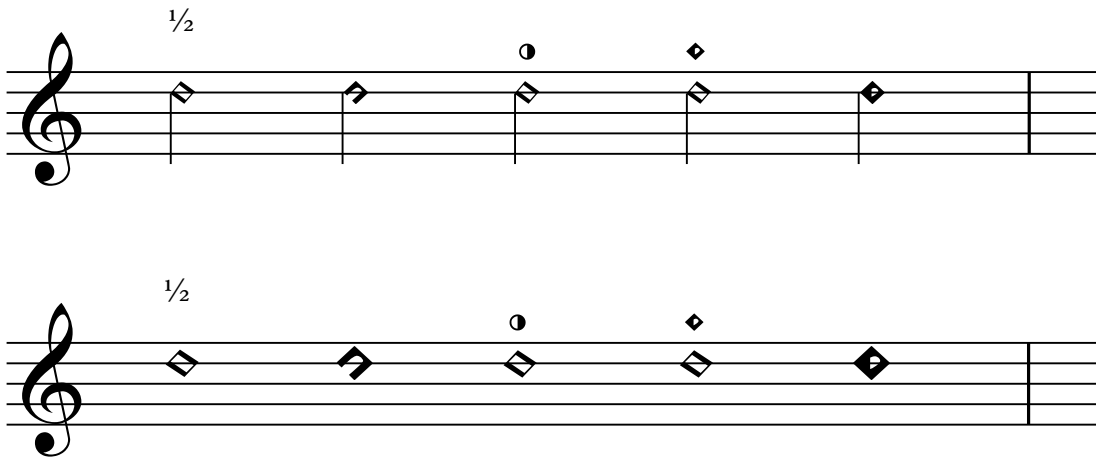

Figure 4.7: Half-harmonic notation examples

The simplest method, using text rather than a graphic may produce good results, as seen in Figure 4.8. No scores appear to use this method, despite it being the only example able to convey more precise ratios of finger pressure as Fallowfield states is possible.[37]

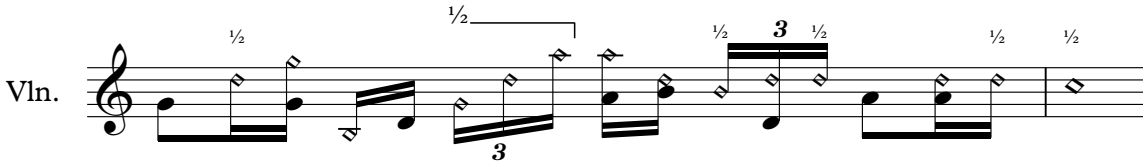

Figure 4.8: Half-harmonic displayed with text

37. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds/other-multiple-sounds.html.

The second and last of the examples in Figure 4.7 do not have discrete noteheads for crotchets and minims like regular diamond noteheads. As such, if there is rhythmic ambiguity, rhythms should be clarified above the stave as normal. The second example, as seen in Sciarrino's *Six Capricci for Violin* (Figure 2.14) shows the ambiguity of this. The 'slant' of the regular harmonic notehead is opposite to the unfinished diamond, going from up to down, helping distinguish it.

The third example unfortunately is not without issues, either; (*normale*) harmonics denoted with a circle are exclusively for the resultant pitch.[38] While half-harmonics do produce the notated pitch, rapid transitions between half-harmonics and *normale* harmonics using half-filled circles may cause confusion due to the translation between a symbol that denotes pressure needed and a resultant harmonic respectively, as illustrated in Figure 4.9, which is the notation used for half-depressed valves on brass instruments.[39] This is compounded by the circle notation's inability to handle harmonics that fall well outside the range of the staff (i.e. major 3rd and minor 3rd harmonics), resulting in a need for at least two types of notation; circular half-harmonics, and diamond noteheads for problematic *normale* harmonics.

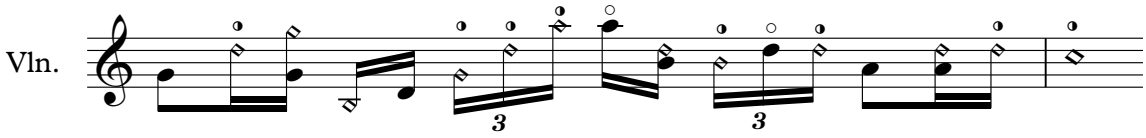

Figure 4.9: Half-harmonic circular notation

The fourth example of notation displayed in Figure 4.10 is a non-standard symbol, and also suffers the same issues that plague the previous example.

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38. Gould, *Behind Bars*, 419.

39. Amy K Cherry, *Extended Techniques in Trumpet Performance and Pedagogy*, OCLC: 912250760 (2009), 85.

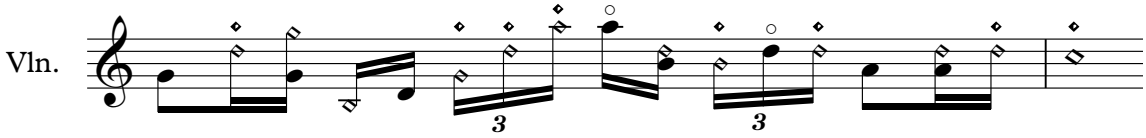

Figure 4.10: Half-harmonic diamond symbol notation

Compare this with Figure 4.11 and Figure 4.12, which is an example of Sciarrino's half-empty notation as seen in Figure 2.14.

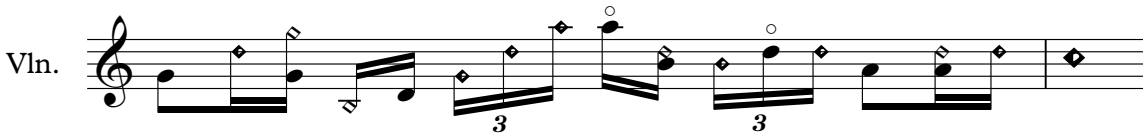

Figure 4.11: Half-harmonic half-filled notehead

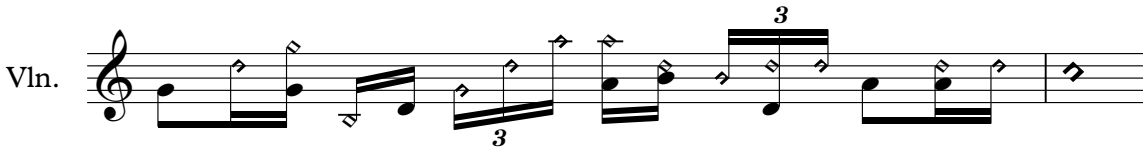

Figure 4.12: Half-harmonic half-empty notehead

Observe that neither the half-filled notehead as depicted in Gould and Figure 4.11, nor the Sciarrino style half-empty notehead as seen Figure 4.12 are available in modern versions of Sibelius or Dorico as of the time of writing.[40] The flagship Standard Music Layout Font (SMuFL), Bravura, includes the half-harmonic circle as depicted in Figure 4.9, but is only available on Dorico and the Sibelius port of Bravura, Norfolk.[41]

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40. Gould, *Behind Bars*, 424.

41. W3C Committee, "Standard Music Font Layout (SMuFL)," March 5, 2019, `https://w3c.github.io/smufl/gitbook/`.

Observations on techniques

Half-harmonics are pitched slightly sharp, and so should be fingered accordingly flat to compensate for this.[42]

Works featuring half-harmonics

- Robert Rowe — Flood Gate (1989)
- Salvatore Sciarriono — 6 Capricci for violin (no. 5) (1976)
- Helmut Lachenmann, Gran Torso
- Trevor Bača — Al-Kitab Al-Khamr (2015)
- Claudio Pompili — Scherzo Alla Francescana (1990, revised 1994)
- Mary Bellamy — Transference (?)
- Sam Park — The Colour of Light (2010)
- Jack Symmonds — Hell Is Murky (2018)
- Mark Applebaum — The Plate of Transition Nourishes the Chameleon Appetite (1992, revised 1994)
- Henrik Deneren — seals II (2014–15)
- Ramteen Sazegari — Slate Representative (2015)

42. Welbanks, "Foundations of Modern Cello Technique," 113.

Impact and Further Research

This exegesis will help inform other artists interested in implementing these techniques. Compositionally, the scope of this exegesis has been limited to the techniques appropriate for solos, and no research into how the techniques fit into ensemble works has been attempted. The exact mechanics of the production of subharmonics and multiphonics are still poorly understood, and would benefit from further research. Further research into the way the techniques react to artificial harmonics, the difference between the two nodal points for multiphonics, and the methods for producing different intervals of subharmonics is needed for a holistic understanding. The analysis and cataloguing of the qualities of each multiphonic and subharmonic would contribute further to the ideal of idiomatic writing for the techniques.

Conclusion

It is apparent that the literature surrounding these techniques is still in its infancy, with few sources of authority due to the niche nature of the techniques. In this exegesis, the documentation of the existing literature and findings from the implementation of the techniques establishs a baseline for treating these techniques, which others can build upon. Through the gradual adoption of these techniques, a standardised notation will form, and further advance the acceptance of these techniques in modern literature.

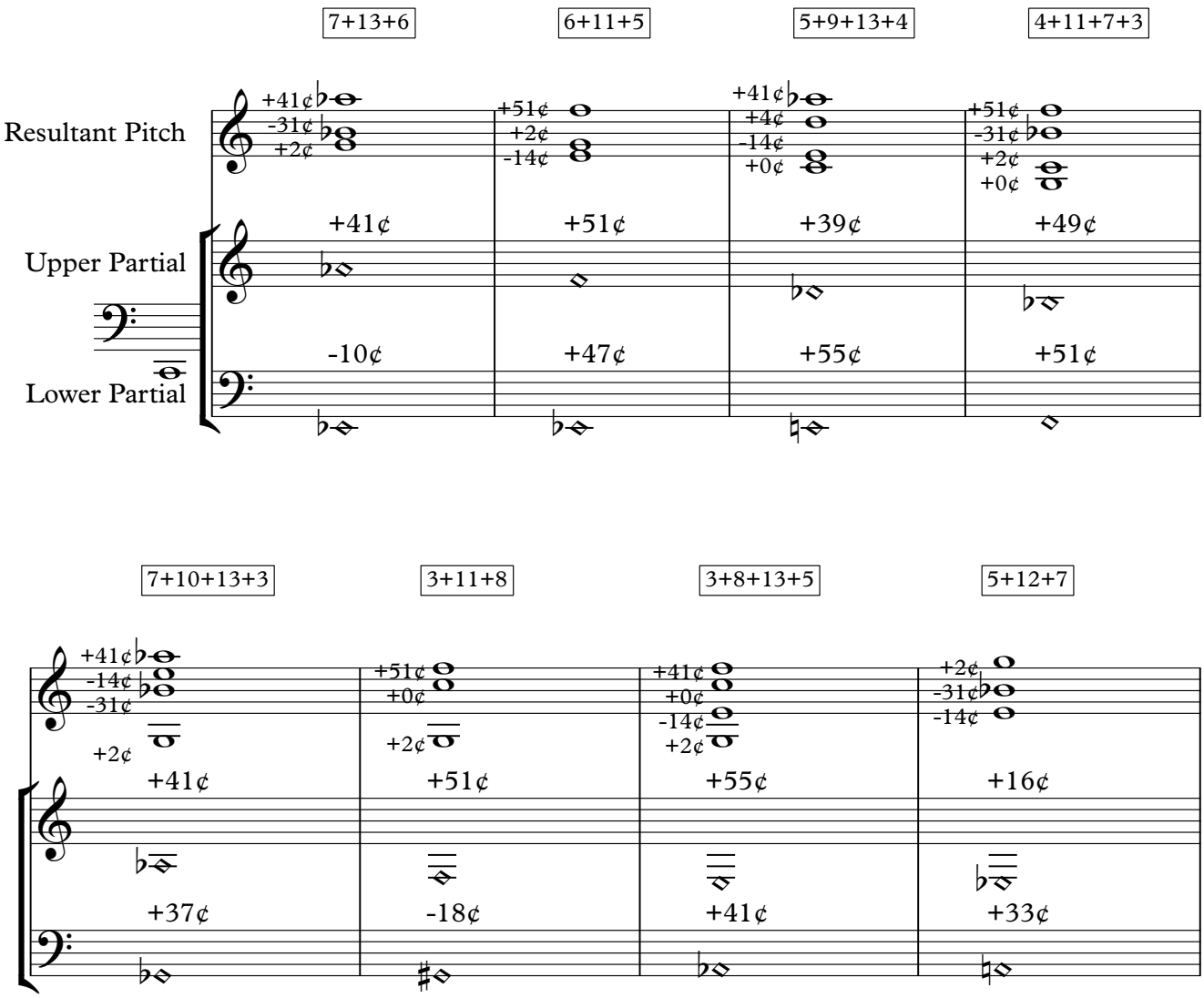
Appendices

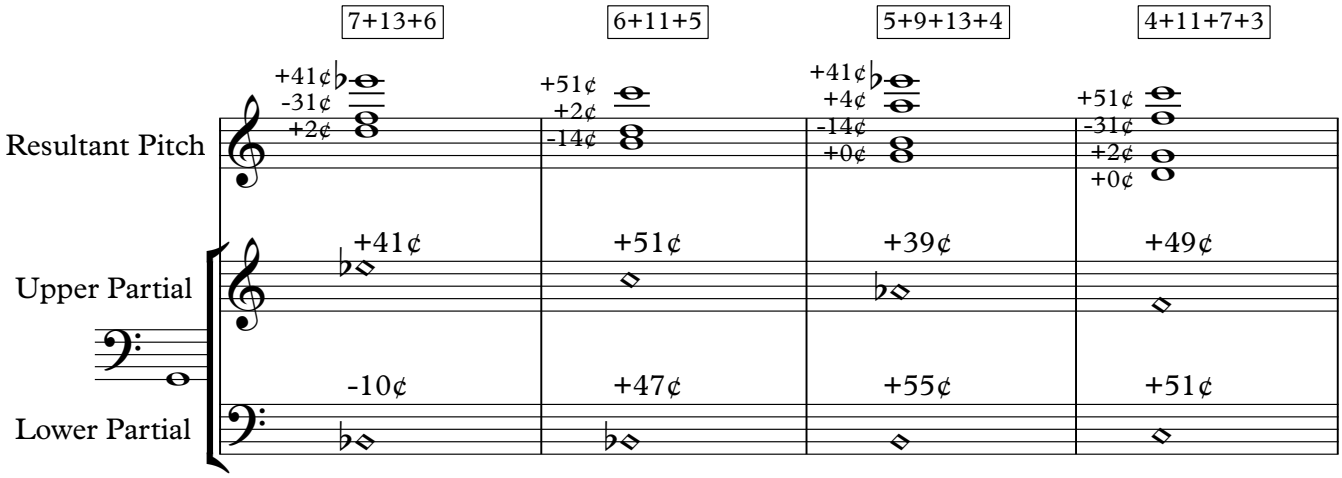
Appendix A

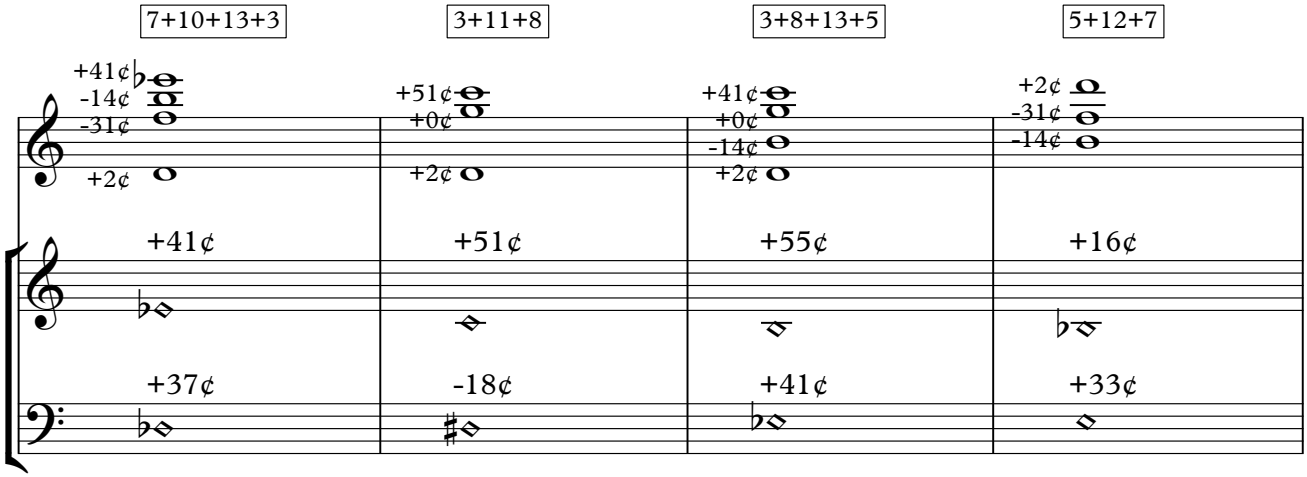
Multiphonic Fingering Chart

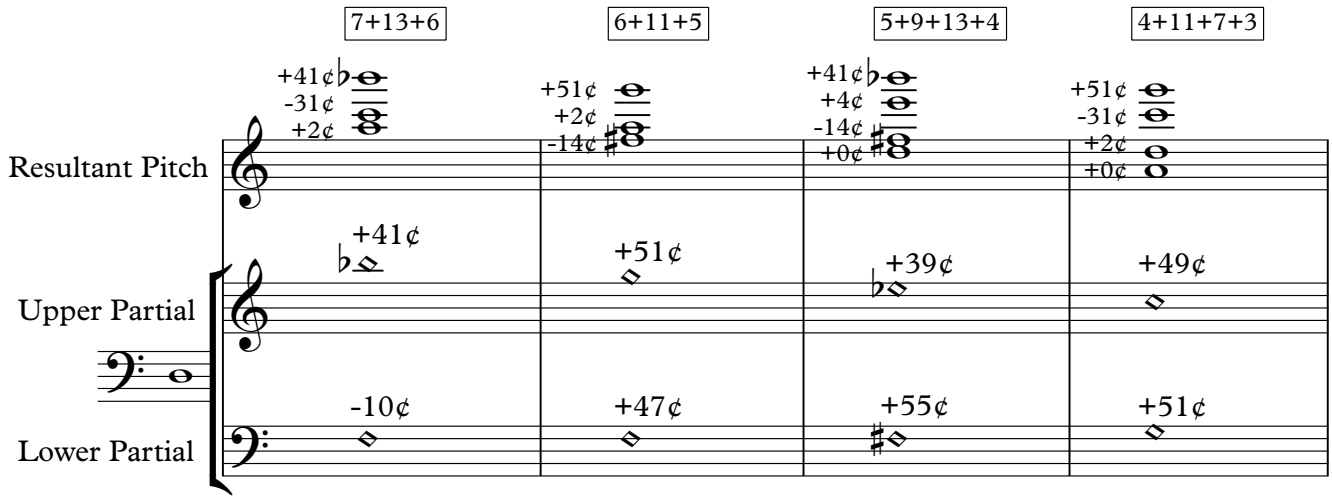
Adapted from Fallowfield's website CelloMap, which as of time of publication, is not currently online.[43] This shows the two nodes where multiphonics can be produced, and the resultant pitch for both of them. It includes the tuning in cents, and the partial ratios (i.e. 7+13+6). It should be noted that this is a fingering reference tool, and not to be used for notation (see section 4 for notation of multiphonics.)

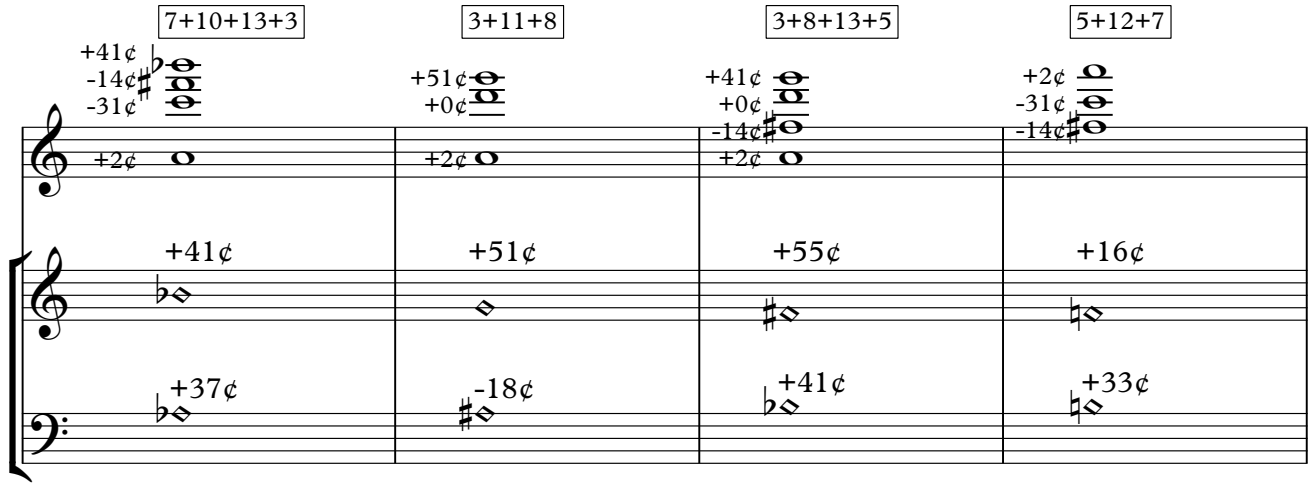
43. Fallowfield, "Cello Map," http://www.cellomap.com/index/the-string/multiphonics-and-other-multiple-sounds/fingeringcharts.html.

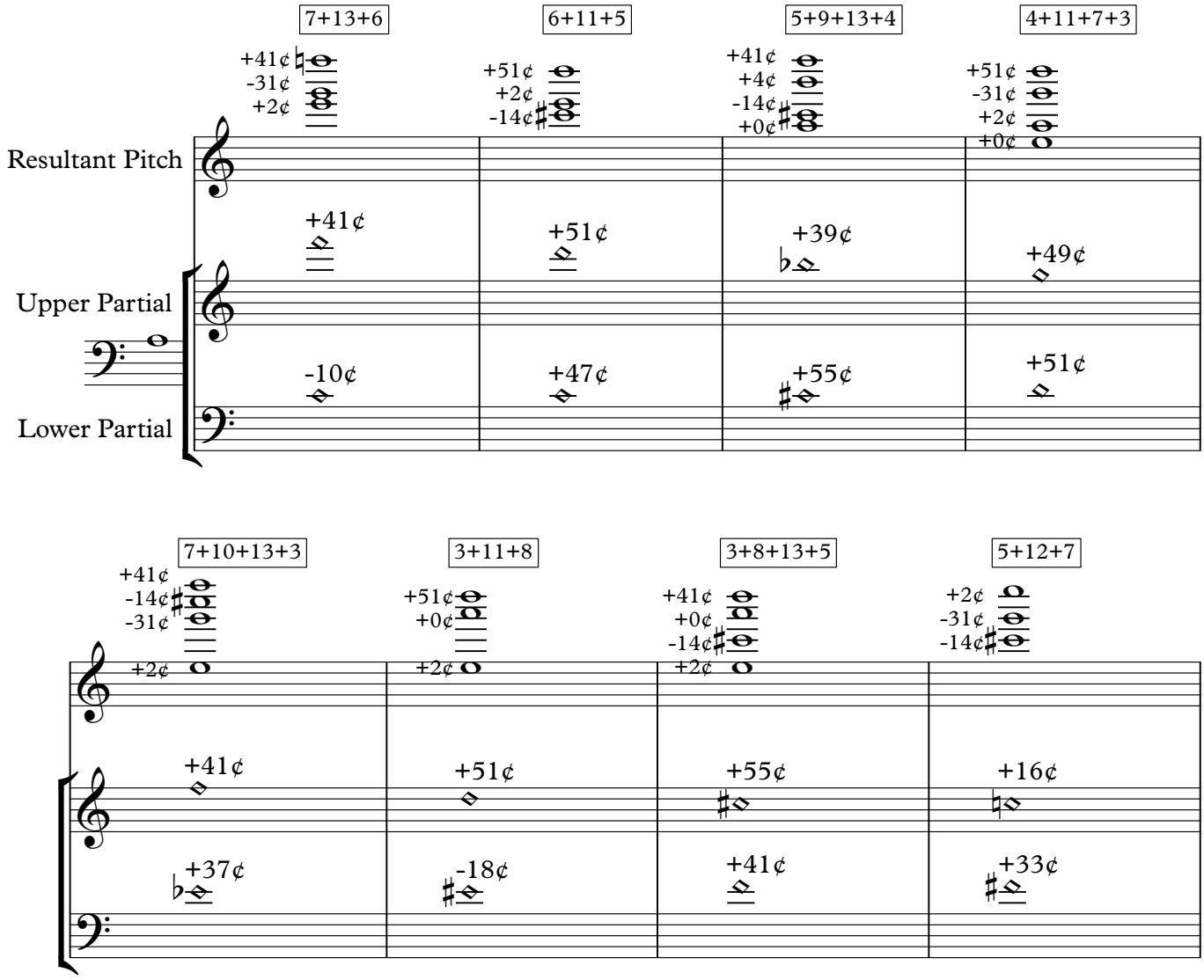

7+13+6
6+11+5
5+9+13+4
4+11+7+3
Resultant Pitch
Upper Partial
Lower Partial
+41¢
-31¢
+2¢
+51¢
+2¢
-14¢
+41¢
+4¢
-14¢
+0¢
+51¢
-31¢
+2¢
+0¢
+41¢
+51¢
+39¢
+49¢
-10¢
+47¢
+55¢
+51¢
7+10+13+3
3+11+8
3+8+13+5
5+12+7
+41¢
-14¢
-31¢
+2¢
+51¢
+0¢
+2¢
+41¢
+0¢
-14¢
+2¢
+2¢
-31¢
-14¢
+41¢
+51¢
+55¢
+16¢
+37¢
-18¢
+41¢
+33¢

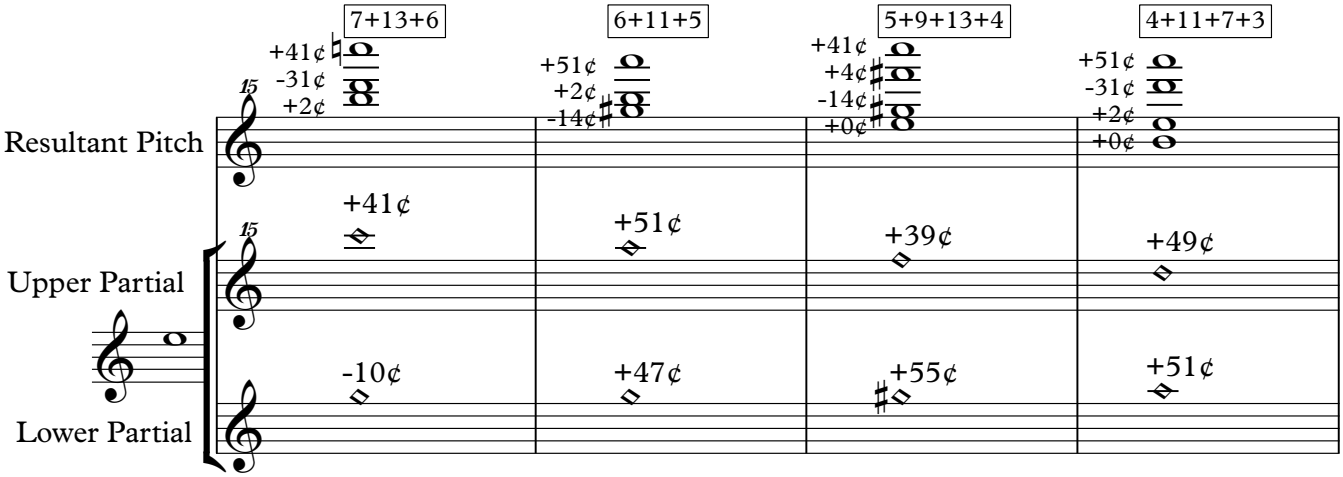

7+13+6
6+11+5
5+9+13+4
4+11+7+3
Resultant Pitch
Upper Partial
Lower Partial
+41¢
-31¢
+2¢
+51¢
+2¢
-14¢
+41¢
+4¢
-14¢
+0¢
+51¢
-31¢
+2¢
+0¢
+41¢
+51¢
+39¢
+49¢
-10¢
+47¢
+55¢
+51¢

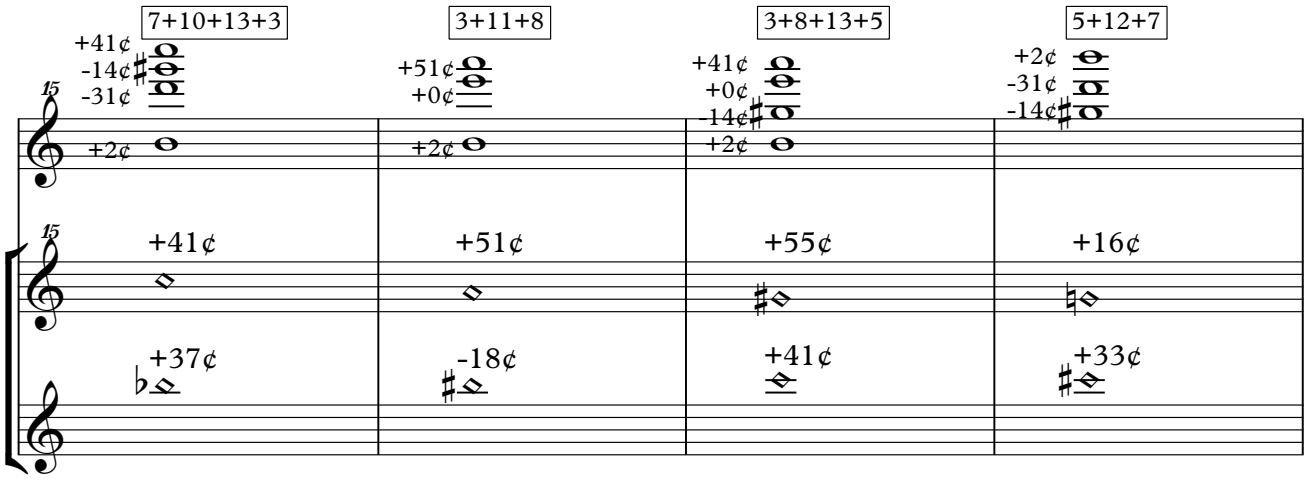

7+10+13+3
3+11+8
3+8+13+5
5+12+7
+41¢
-14¢
-31¢
+2¢
+51¢
+0¢
+2¢
+41¢
+0¢
-14¢
+2¢
+2¢
-31¢
-14¢
+41¢
+51¢
+55¢
+16¢
+37¢
-18¢
+41¢
+33¢


7+13+6
6+11+5
5+9+13+4
4+11+7+3
Resultant Pitch
Upper Partial
Lower Partial
+41¢
-31¢
+2¢
+51¢
+2¢
-14¢
+41¢
+4¢
-14¢
+0¢
+51¢
-31¢
+2¢
+0¢
+41¢
+51¢
+39¢
+49¢
-10¢
+47¢
+55¢
+51¢


7+10+13+3
3+11+8
3+8+13+5
5+12+7
+41¢
-14¢
-31¢
+2¢
+51¢
+0¢
+2¢
+41¢
+0¢
-14¢
+2¢
+2¢
-31¢
-14¢
+41¢
+51¢
+55¢
+16¢
+37¢
-18¢
+41¢
+33¢


7+13+6
6+11+5
5+9+13+4
4+11+7+3
Resultant Pitch
Upper Partial
Lower Partial
+41¢
-31¢
+2¢
+51¢
+2¢
-14¢
+41¢
+4¢
-14¢
+0¢
+51¢
-31¢
+2¢
+0¢
+41¢
+51¢
+39¢
+49¢
-10¢
+47¢
+55¢
+51¢
7+10+13+3
3+11+8
3+8+13+5
5+12+7
+41¢
-14¢
-31¢
+2¢
+51¢
+0¢
+2¢
+41¢
+0¢
-14¢
+2¢
+2¢
-31¢
-14¢
+41¢
+51¢
+55¢
+16¢
+37¢
-18¢
+41¢
+33¢


7+13+6
+41¢
-31¢
+2¢
6+11+5
+51¢
+2¢
-14¢
5+9+13+4
+41¢
+4¢
-14¢
+0¢
4+11+7+3
+51¢
-31¢
+2¢
+0¢
Resultant Pitch
Upper Partial
Lower Partial
+41¢
+51¢
+39¢
+49¢
-10¢
+47¢
+55¢
+51¢


7+10+13+3
+41¢
-14¢
-31¢
+2¢
3+11+8
+51¢
+0¢
+2¢
3+8+13+5
+41¢
+0¢
-14¢
+2¢
5+12+7
+2¢
-31¢
-14¢
+41¢
+51¢
+55¢
+16¢
+37¢
-18¢
+41¢
+33¢

Appendix B

FOR SOLO VIOLIN

---

what are you doing with the humans

October, 2019

Rhys Gray

Program Notes

what are you doing with the humans is a solo work for violin that explores half-harmonics. It is a non-programmatic work, and the title was inspired by a question that my supervisor posed to me while I sought ethics approval for my exegesis; a simple phrase laden with possible contexts, spurring the imagination to try and complete the meaning.

It is, in a way, an etude, treating the half-harmonics in a way similar to those found in Sciarrino's *6 Caprricio for violin*. Half-harmonics are produced by applying left hand finger pressure halfway between that required to create a harmonic, and a *normale* sound. The sound that is produced should be a mixture of the stopped string pitch, the harmonic pitch, and a resistant, slightly noisy quality.

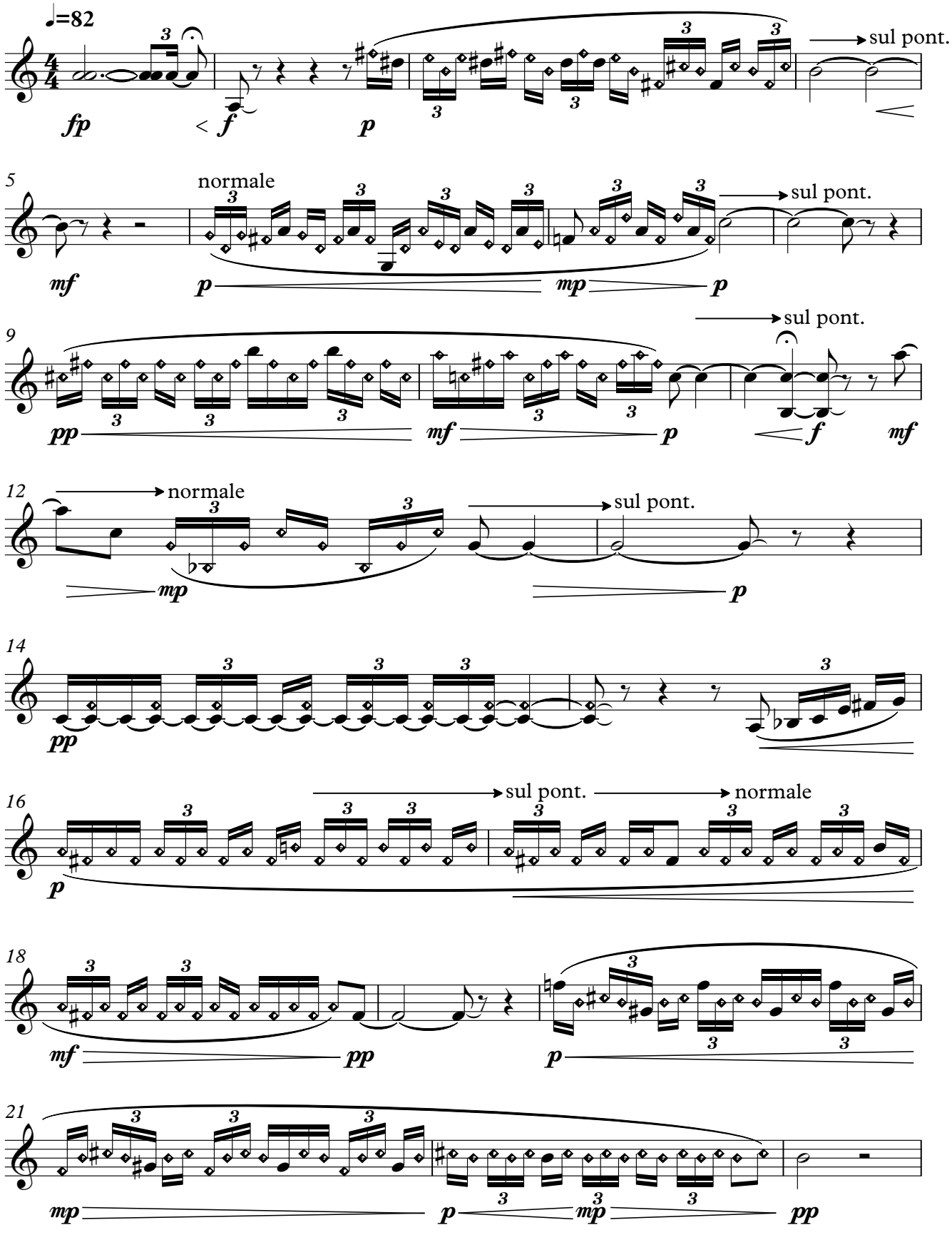
Notation

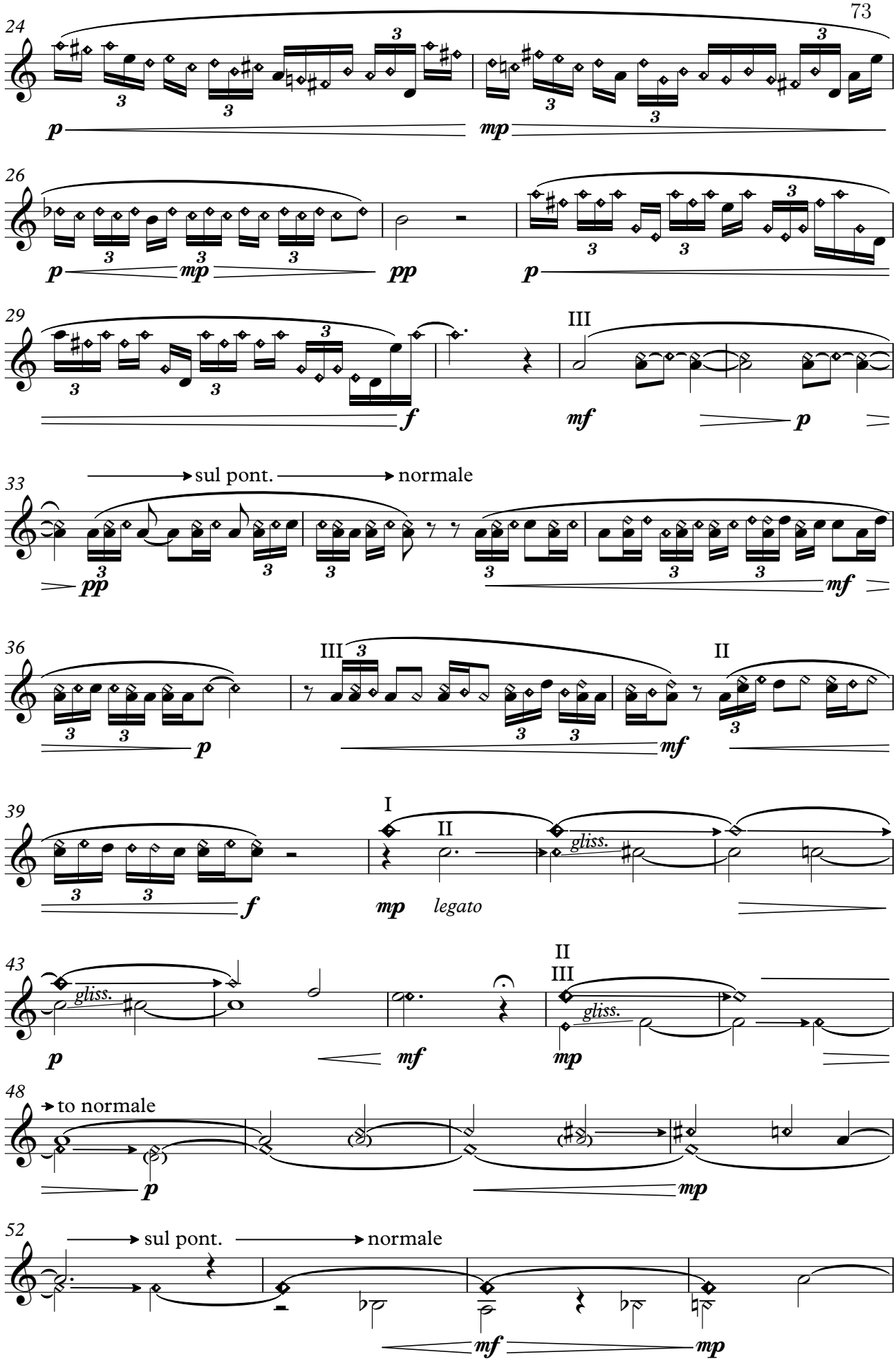
- Half-harmonics are notated in the score as a half-filled diamond notehead.
- Arrows denote gradual transitions to the technique that the arrow is pointing to.
    - Arrows between notes denote transitions between the types of notes (i.e. *normale* to harmonic finger pressure.)

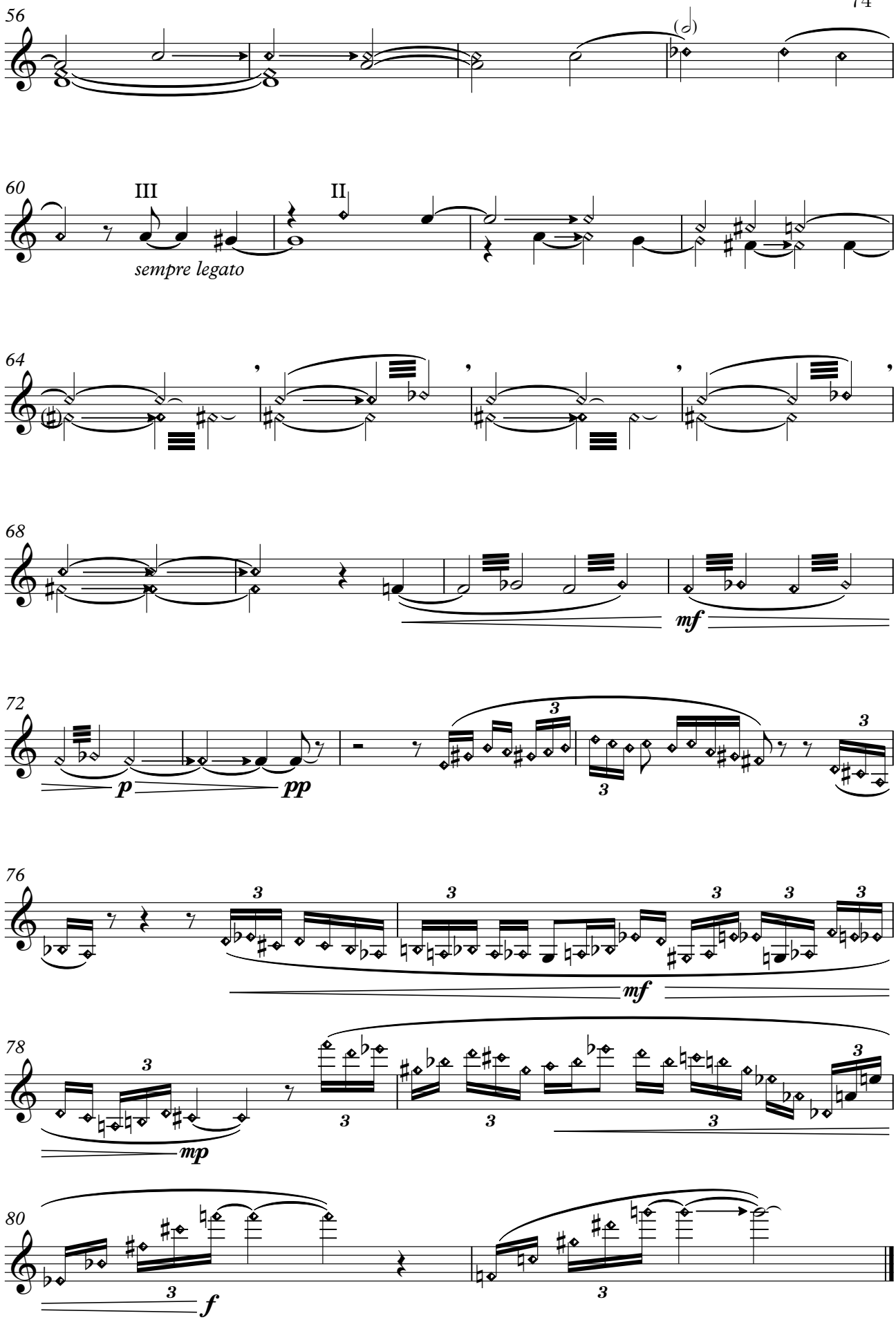
what are you doing with the humans?

for solo violin

Rhys Gray




24
p
mp
26
p
mp
pp
p
29
f
III
mf
p
33
sul pont.
normale
pp
mf
36
p
III
mf
II
39
f
I
II
mp
legato
gliss.
43
gliss.
p
mf
II
III
gliss.
mp
48
to normale
p
mp
52
sul pont.
normale
mf
mp


56
60
III
II
sempre legato
64
68
mf
72
p
pp
3
76
mf
78
mp
80
f

Appendix C

FOR SOLO VIOLA

---

doppelganger

October, 2019

Rhys Gray

Program Notes

doppelganger is a piece for solo viola, written to explore the lower register of the viola using subharmonics juxtaposed with upper harmonics.

To play subharmonics, one should place the bow at the 6th partial of the harmonic series of the fingered pitch, and bow with excessive pressure and an absolutely consistent speed. The increased pressure will distort the vibration of the string, producing a phase loop which, in turn, produces the subharmonic.

Subharmonics are achieved through precise control of torsional oscillation, which usually produces the sound of an amateur string player's heavy handed, slow bowing.

The production of subharmonics can be aided by using older strings (which work better due to fats building up on the strings). Making a counter-clockwise half-twist in the string can also make it easier to produce octave and major second subharmonics (additional twists can help achieve lower subharmonics, at the expense of higher ones).

Notation

- Subharmonics are notated in the score using a square notehead for the fingering, with a small notehead at the desired resultant pitch. Where additional clarification is needed, 'sh' is placed above.
- Arrows denote gradual transitions to the technique that the arrow is pointing to.
  - Arrows between notes denote transitions between the types of notes (i.e. *normale* to harmonic finger pressure.)
- sp denotes *sul ponticello.*
- msp denotes *molto sul ponticello.*
- n denotes *normale.*

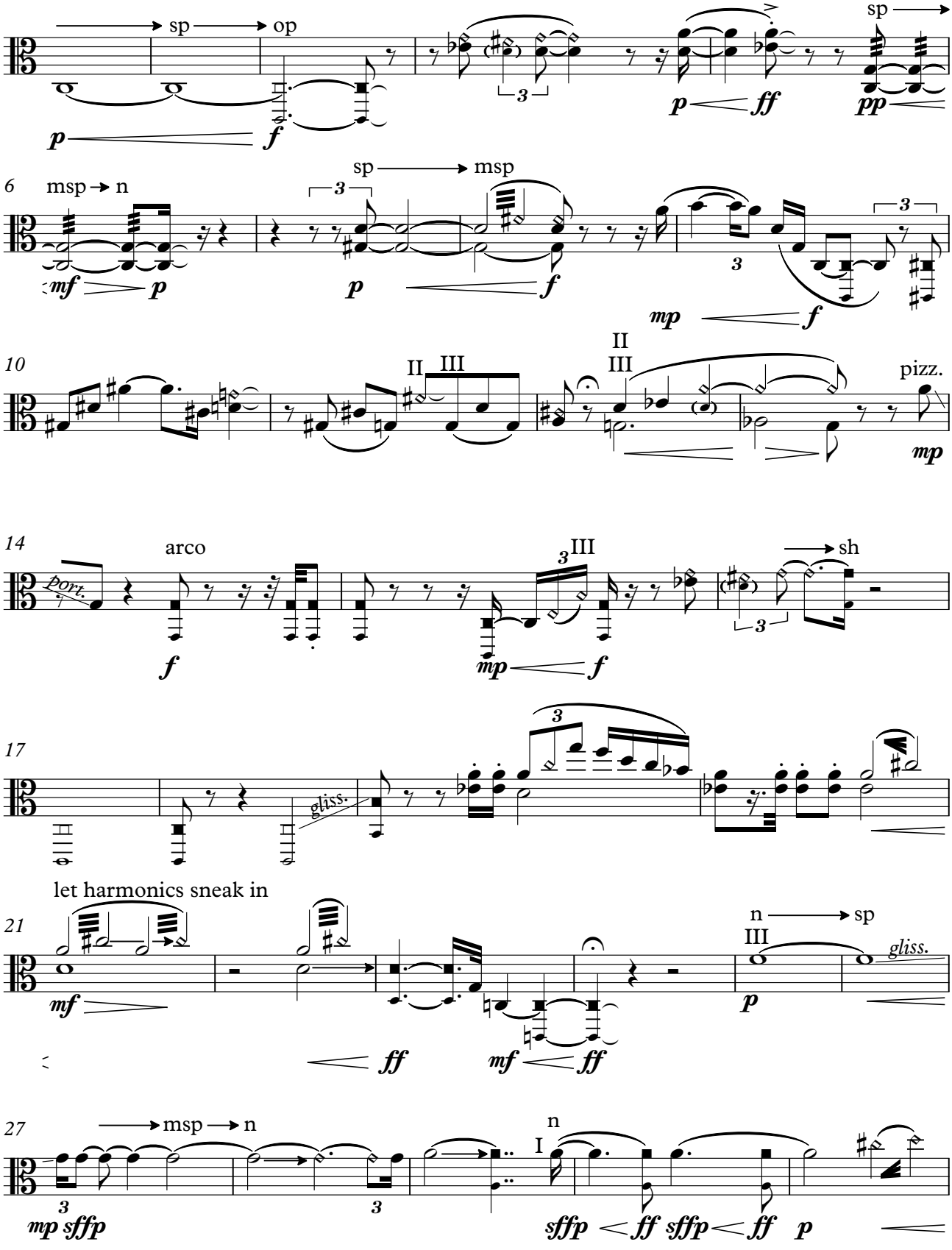
- Feathered beams denote a gradual acceleration to a tremolo.

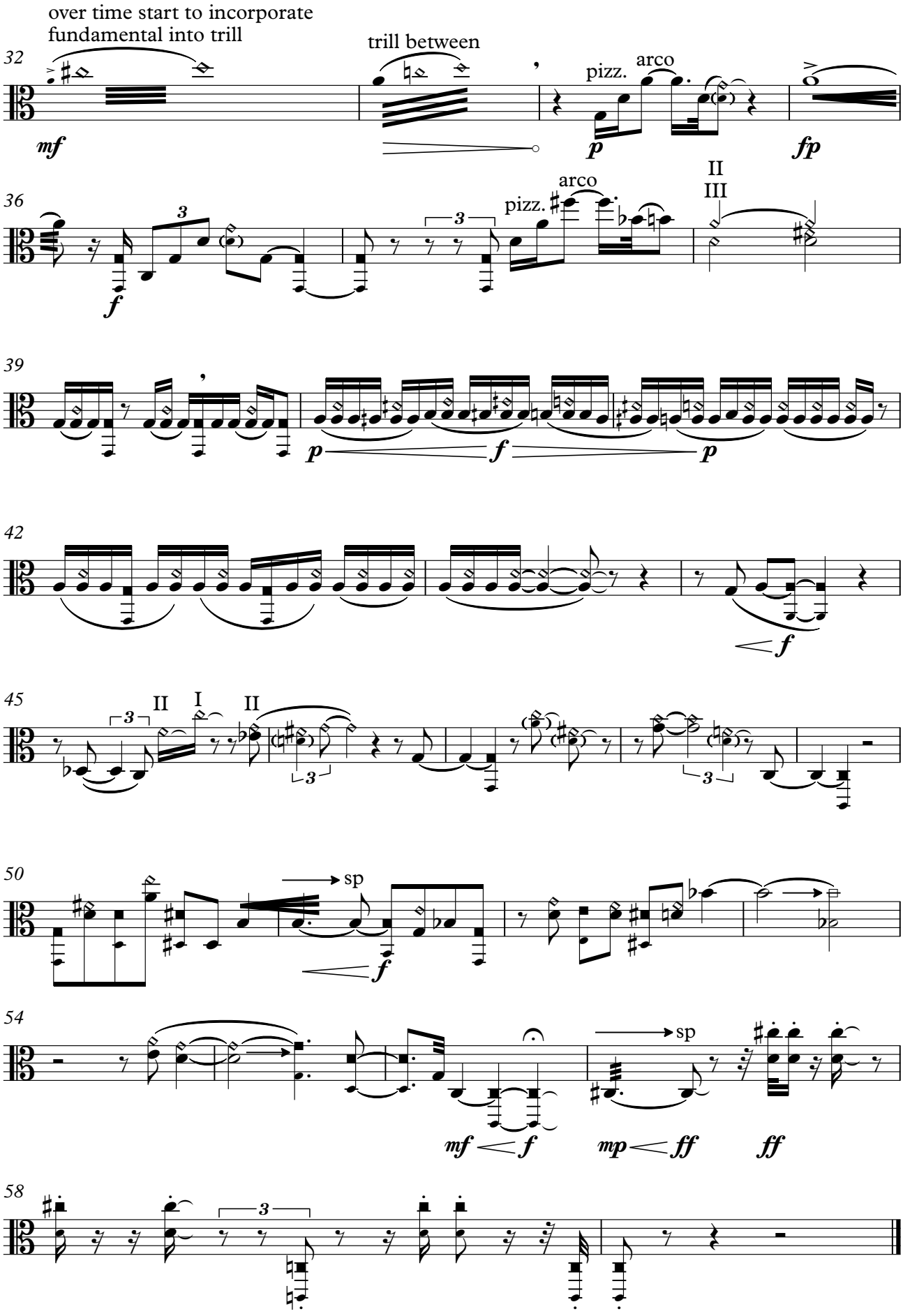
Doppelganger

for solo viola

Rhys Gray

♩=52 **Rubato**




over time start to incorporate
fundamental into trill
trill between
32
mf
p
pizz.
arco
fp
36
f
pizz.
arco
II
III
39
p
f
p
42
f
45
II
I
II
50
sp
f
54
mf
f
sp
mp
ff
ff
58

Appendix D

FOR SOLO VIOLONCELLO

---

liminal

October, 2019

Rhys Gray

Program Notes

liminal is a piece for solo violoncello, written to explore multiphonics.

Multiphonics are achieved through clusters of close harmonic nodes, and by playing a harmonic close to the highest partial. Note that not all of these pitches will actually sound in practice.

Multiphonics are notated as a harmonic position using a diamond notehead, with an 'M' above the note to be fingered. Where the string used is ambiguous, it is notated below the sounding pitch as a small, bracketed notehead. Precise tuning is given in cents, and unless otherwise notated, is intended for the first note that the multiphonic is attached to.[44] The theoretical sounding pitches are given in a bracketed staff above the main stave.

The bow should exert slightly more pressure than usual and should be drawn with a consistent speed which should be slower than for harmonics. The location of the bow can encourage or discourage upper or lower partials, and experimentation should be done during the practice of this work to achieve the pitches desired.

Notation

- Multiphonics are denoted with a diamond notehead, marked with an M (see Figure 3.5 for an example).
  - Precise tuning in cents (i.e. +41c) is provided to help the performer pitch the fingering required for the multiphonic to be produced.
  - The multiphonic resultant pitches are notated at pitch in the *suono reale* stave, with the cents tuning of the resultant pitches to the left or right of the notes.

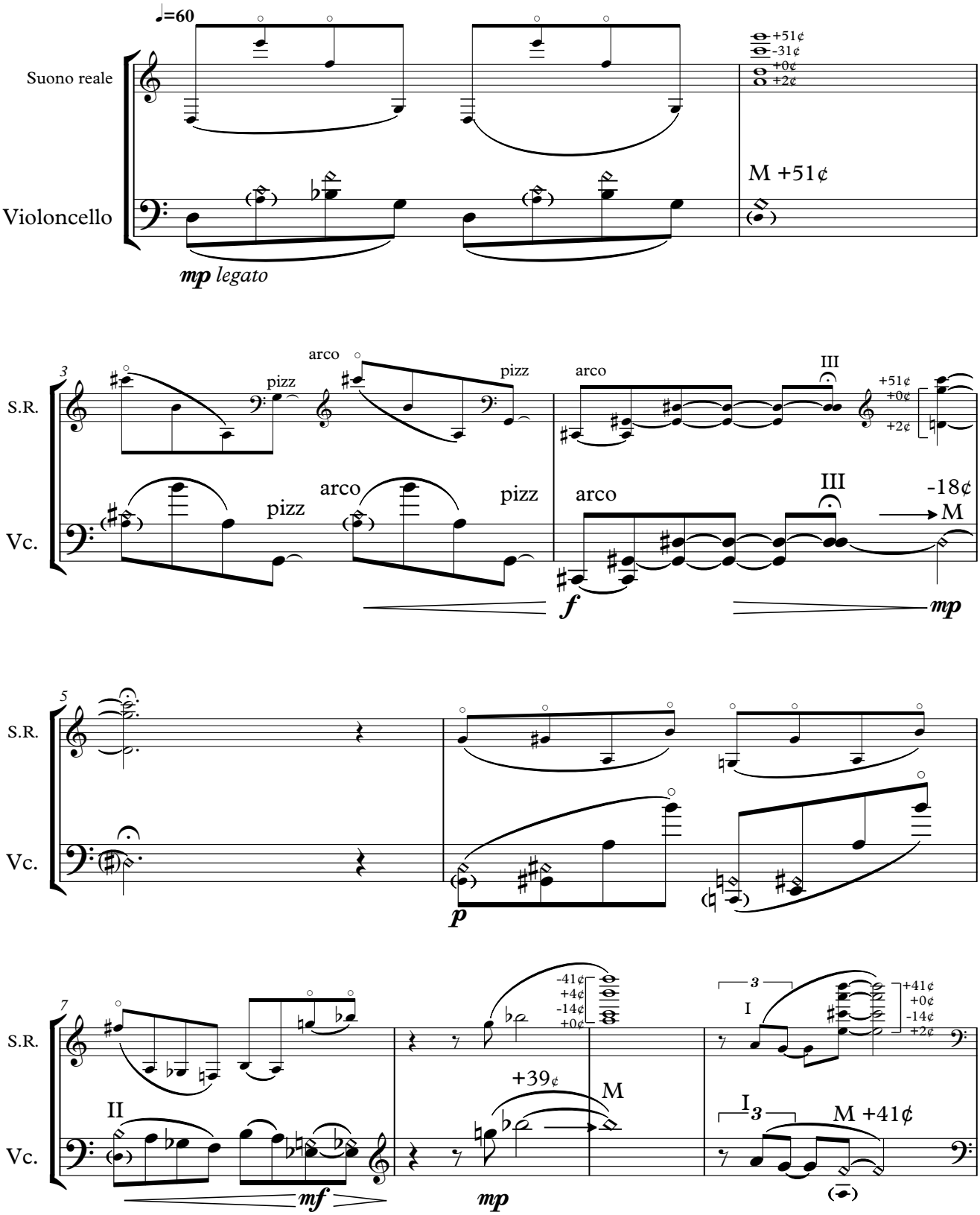
---

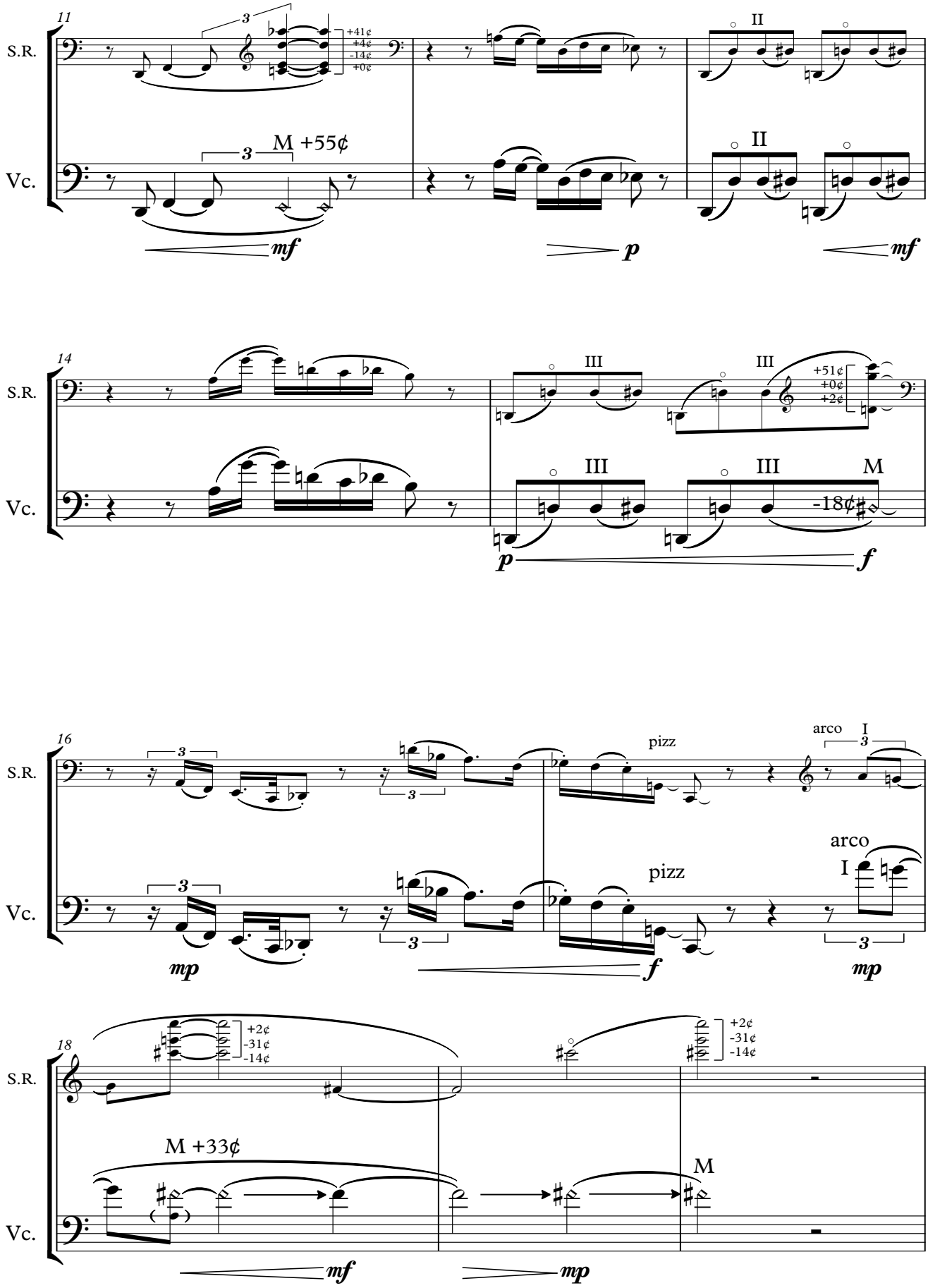
44. 100 cents is equal to a semitone. Therefore, +51c is roughly equal to half a semitone sharp. Cents have been used due to their precision compared to more granular accidentals such as the quartertone sharp.

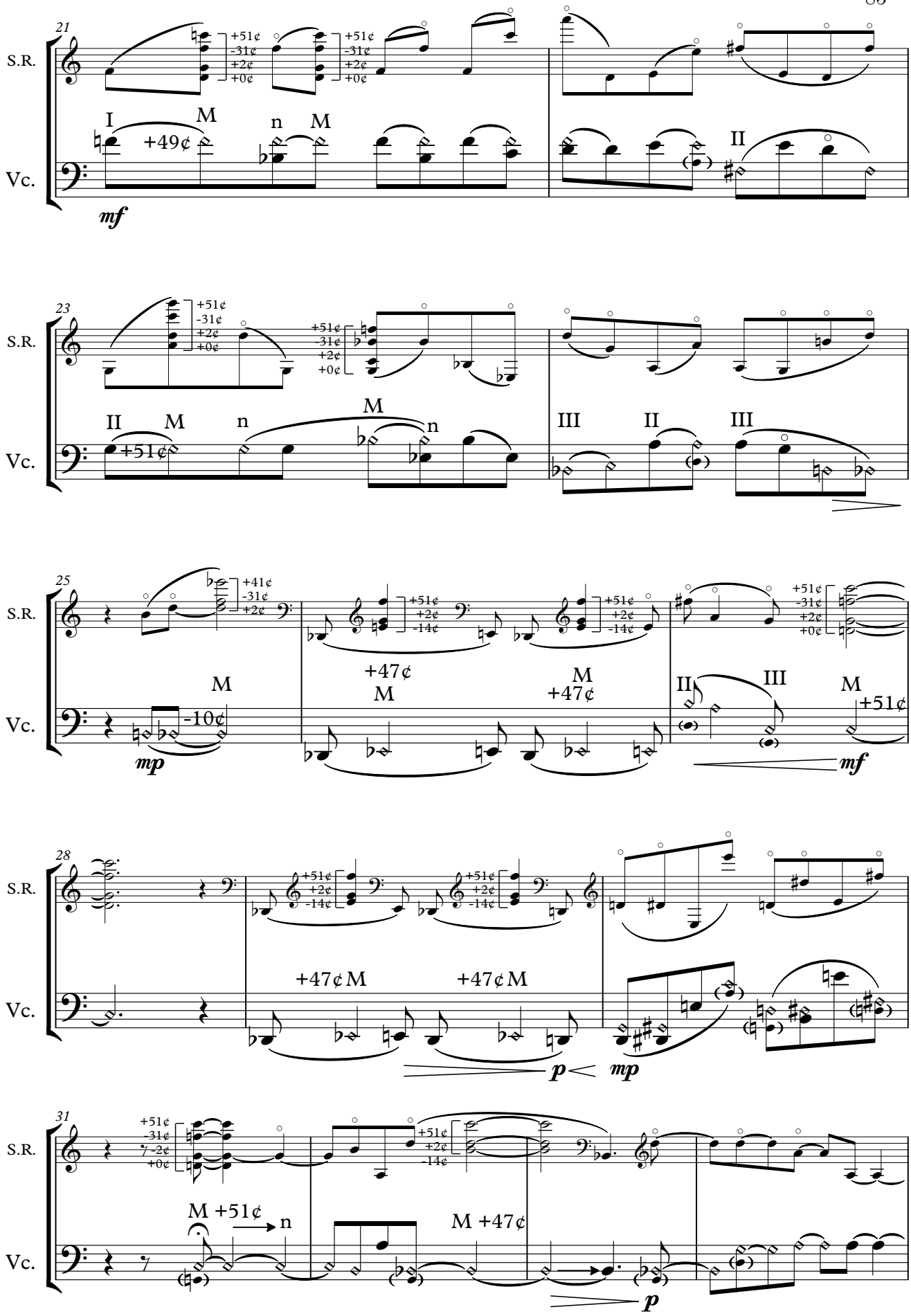
- Arrows denote gradual transitions to the technique that the arrow is pointing to.
    - Arrows between notes denote transitions between the types of notes (i.e. *normale* to harmonic finger pressure.)
- n denotes *normale*.
- sp denotes *sul ponticello*.
- msp denotes *molto sul ponticello*.
- similarly, st denotes *sul tasto*, and mst denotes *molto sul tasto*

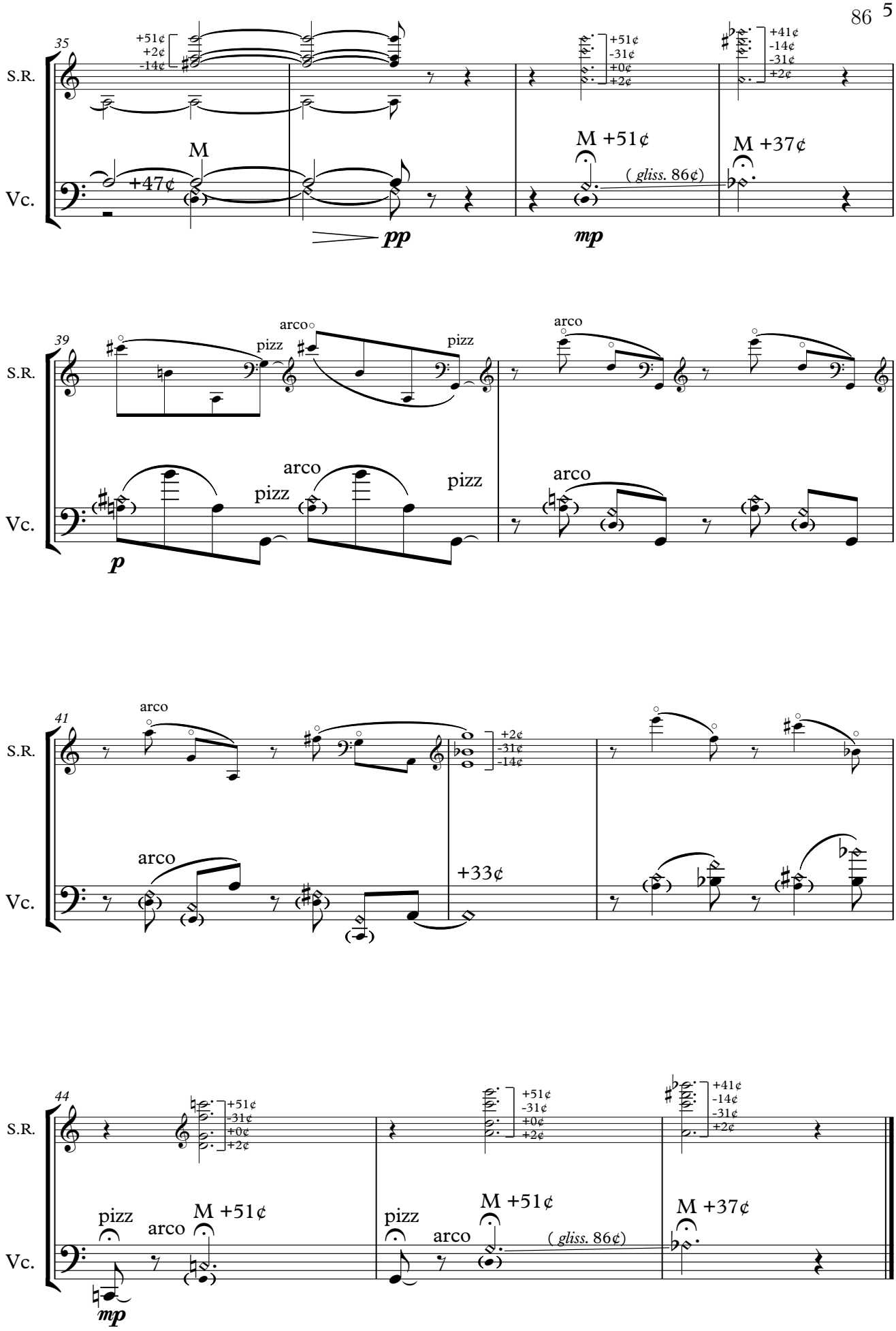
liminal

Rhys Gray




11
S.R.
Vc.
3
+41¢
+4¢
-14¢
+0¢
M +55¢
II
mf
p
mf
14
III
+51¢
+0¢
+2¢
M
-18¢
p
f
16
arco
I
pizz
mp
f
mp
18
+2¢
-31¢
-14¢
M +33¢
M
mf
mp


21
S.R.
Vc.
+51¢ -31¢ +2¢ +0¢
I M n M
+49¢
II
mf
23
II M n M n
+51¢
III II III
25
+41¢ -31¢ +2¢
+51¢ +2¢ -14¢
M
-10¢
+47¢
M
M +47¢
II III M
+51¢
mp
mf
28
+47¢ M
+47¢ M
p
mp
31
+51¢ -31¢ -2¢ +0¢
M +51¢ n
M +47¢
p


35
S.R.
Vc.
+51¢
+2¢
-14¢
M
+47¢
pp
+51¢
-31¢
+0¢
+2¢
M +51¢
(gliss. 86¢)
mp
+41¢
-14¢
-31¢
+2¢
M +37¢
39
pizz
arco
p
41
+2¢
-31¢
-14¢
+33¢
44
M +51¢
M +37¢

Appendix E

FOR SOLO CONTRABASS

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the veldt

October, 2019

Rhys Gray

Program Notes

Inspired by the eponymous short story by Ray Bradbury, *the veldt* is a composition for solo contrabass, and uses subharmonics and multiphonics. Similarly like the namesake, this world is filled with danger but also beauty. It is non-programmatic, and my intent with Veldt was to create a soundworld and space that the performer was able to 'roam around' in, and features several sections of improvisation on pitch-sets.

Subharmonics

To play subharmonics, one should place the bow at the 6th partial of the harmonic series of the fingered pitch, and bow with excessive pressure and an absolutely consistent speed. The increased pressure will distort the vibration of the string, producing a phase loop which, in turn, produces the subharmonic. Subharmonics are achieved through precise control of torsional oscillation, which usually produces the sound of an amateur string player's heavy handed, slow bowing. The production of subharmonics can be aided by using older strings (which work better due to fats building up on the strings). Making a counter-clockwise half-twist in the string can also make it easier to produce octave and major second subharmonics (additional twists can help achieve lower subharmonics, at the expense of higher ones).

Multiphonics

Multiphonics are achieved through clusters of close harmonic nodes, and by playing a harmonic close to the highest partial. Note that not all of these pitches will actually sound in practice.

Multiphonics are notated as a harmonic position using a diamond notehead, with an 'M' above the note to be fingered. Where the string used is ambiguous, it is

notated below the sounding pitch as a small, bracketed notehead. Precise tuning is given in cents, and unless otherwise notated, is intended for the first note that the multiphonic is attached to.[45] The theoretical sounding pitches are given in a bracketed staff above the main stave.

The bow should exert slightly more pressure than usual and should be drawn with a consistent speed which should be slower than for harmonics. The location of the bow can encourage or discourage upper or lower partials, and experimentation should be done during the practice of this work to achieve the pitches desired.

Notation

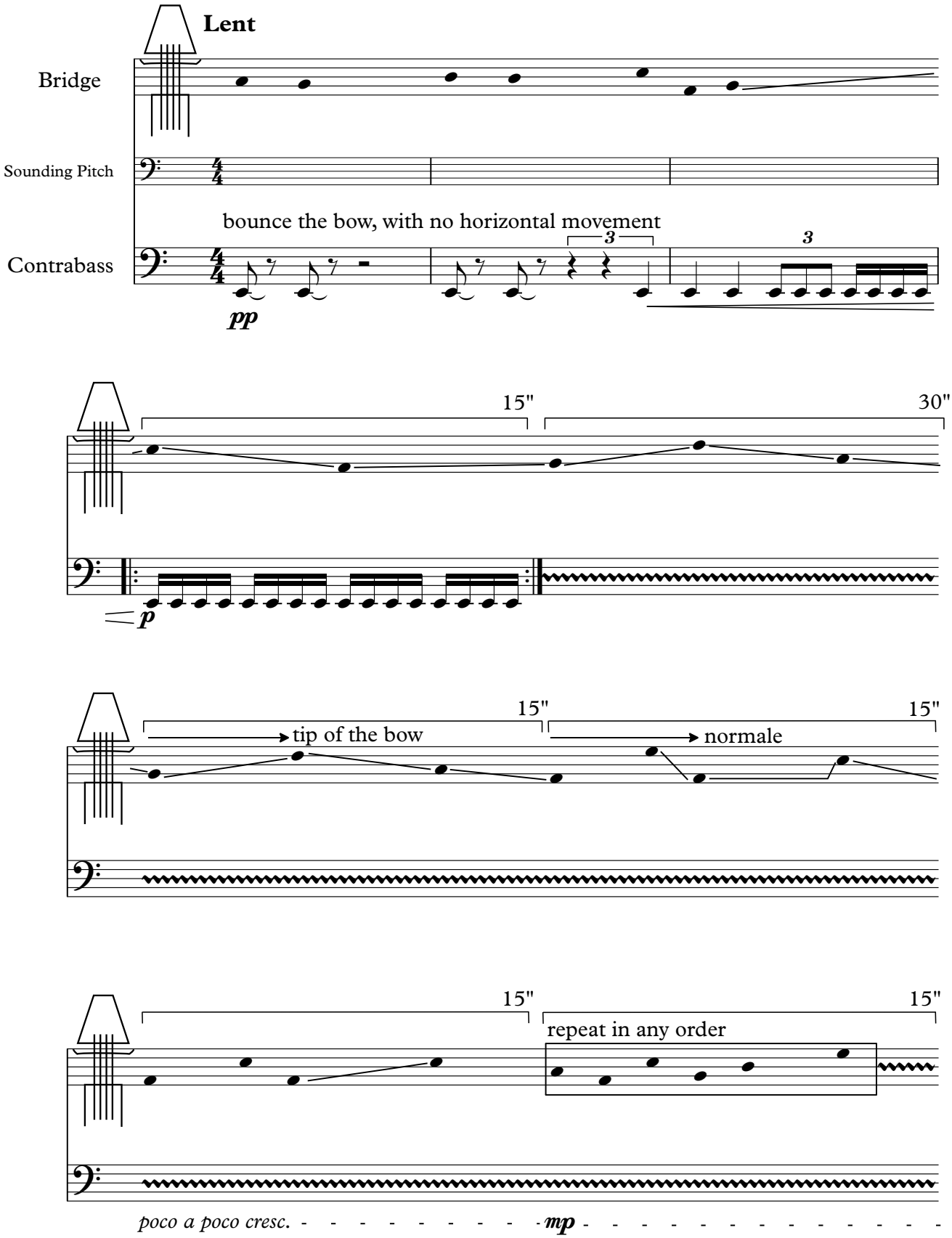
- Subharmonics are notated in the score using a square notehead for the fingering, with a small notehead at the desired resultant pitch. Where additional clarification is needed, 'sh' is placed above.
  - They are notated at pitch in the cue sized stave above, with a harmonic circle above them.
- Multiphonics are denoted with a diamond notehead, marked with an M (see Figure 3.5 for an example).
  - Precise tuning in cents (i.e. +41c) is provided to help the performer pitch the fingering required for the multiphonic to be produced.
  - The multiphonic resultant pitches are notated at pitch in the cue sized stave above, with the cents tuning of the resultant pitches to the left or right of the notes.
- Arrows denote gradual transitions to the technique that the arrow is pointing to.

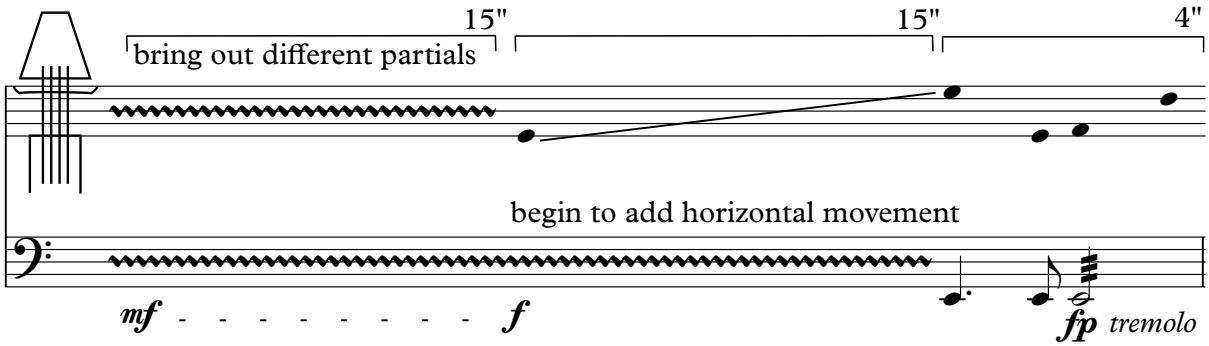
45. 100 cents is equal to a semitone. Therefore, +51c is roughly equal to half a semitone sharp. Cents have been used due to their precision compared to more granular accidentals such as the quartertone sharp.

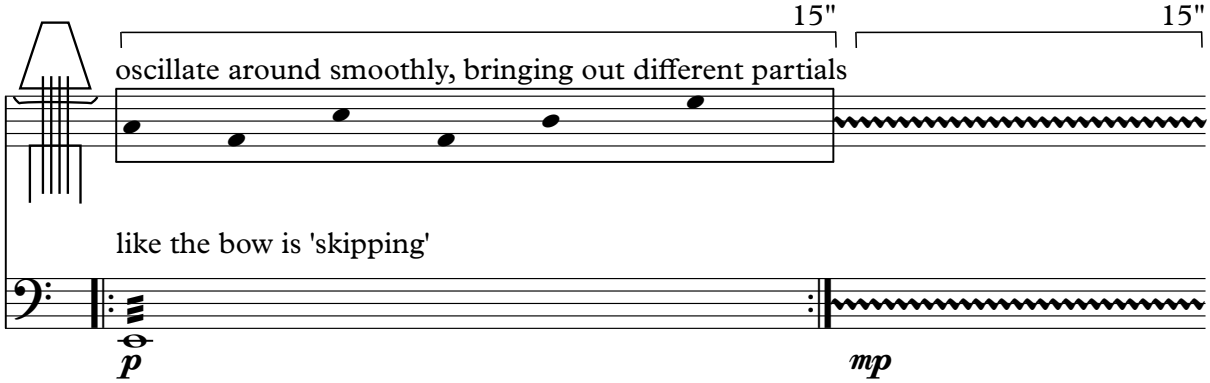
  - Arrows between notes denote transitions between the types of notes (i.e. *normale* to harmonic finger pressure.)

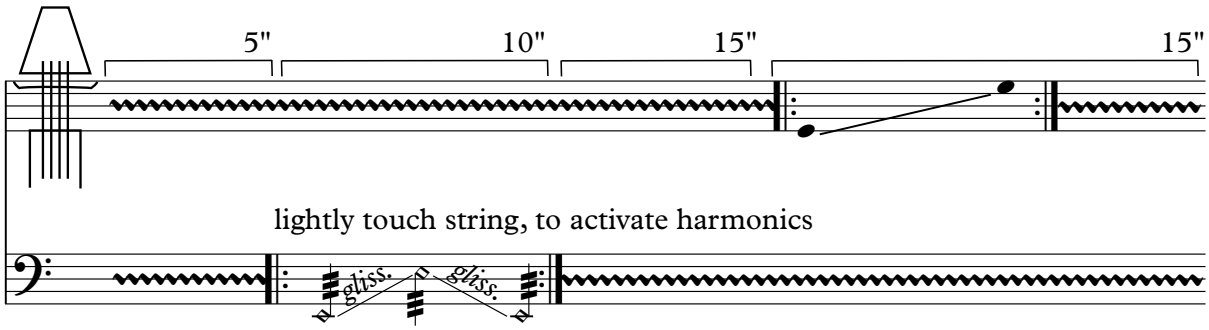
- Sounding pitch is provided in the ossia stave above.
- Bridge position is provided in the stave above, and denotes the vertical location of the bow. The bottom line is *molto sul tasto* and the top line is *molto sul ponticello*.
- For un-metered bars, approximate times are given above in seconds, and is linearly proportional (i.e. note spacing denotes approximate time.)
- Repeats are to be repeated for as long as instructed.
- op denotes overpressure.
- sp denotes *sul ponticello*.
- n denotes *normale*.

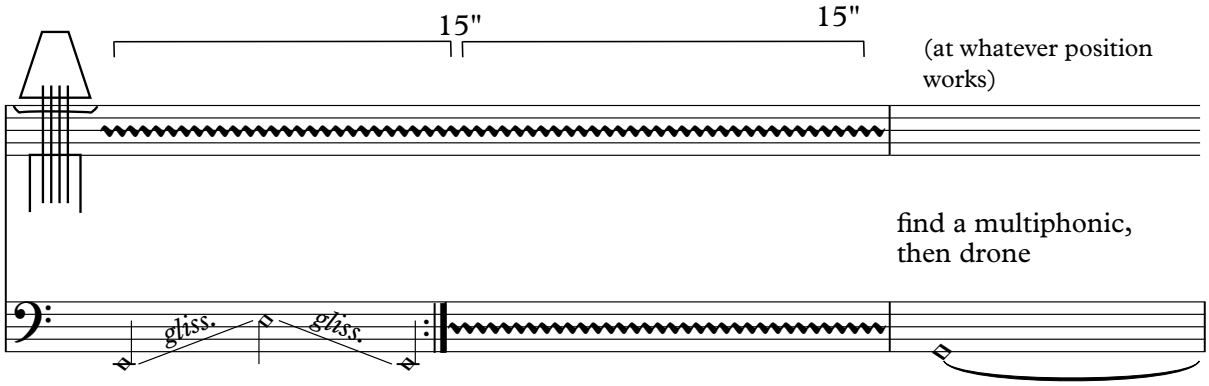
the veldt

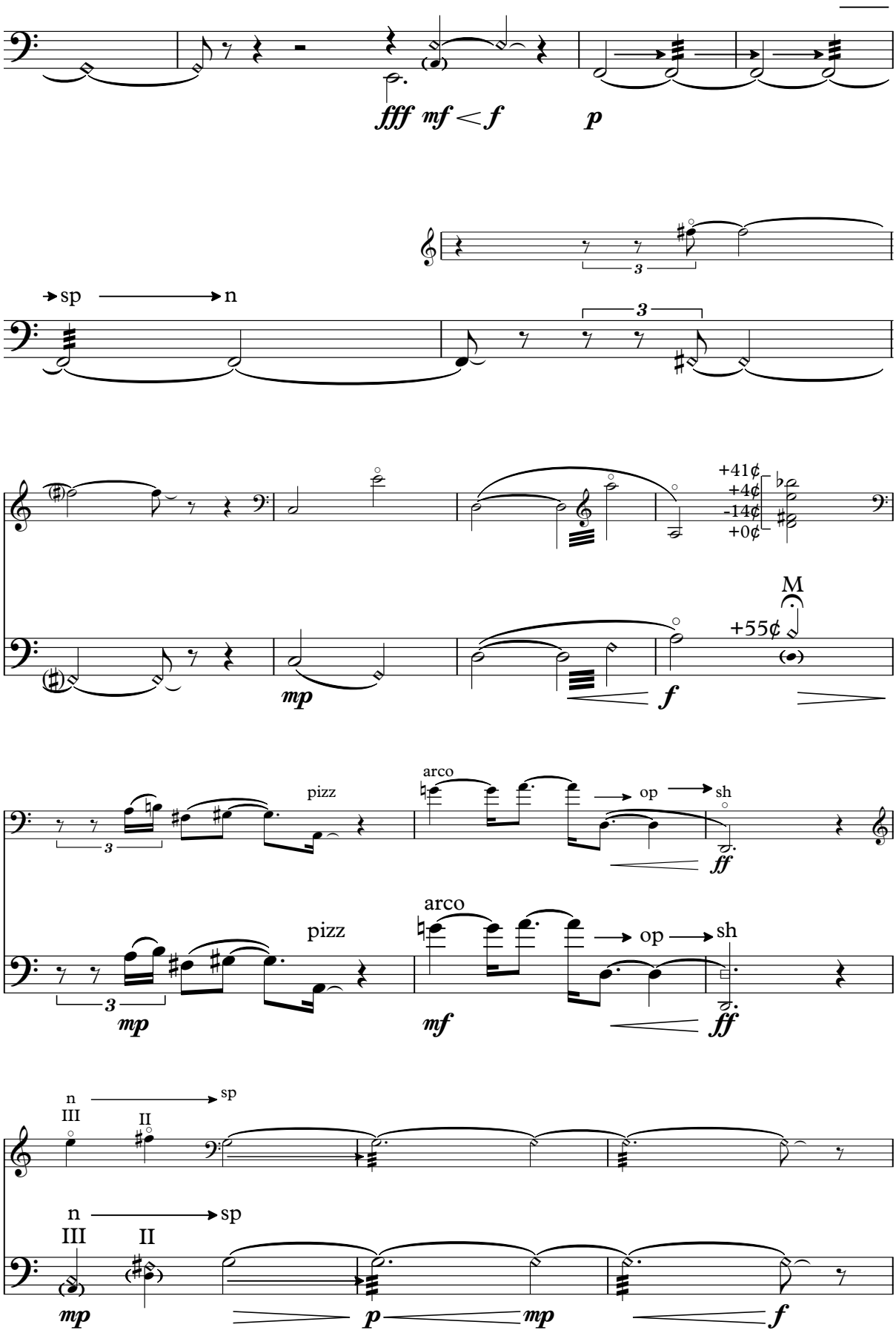


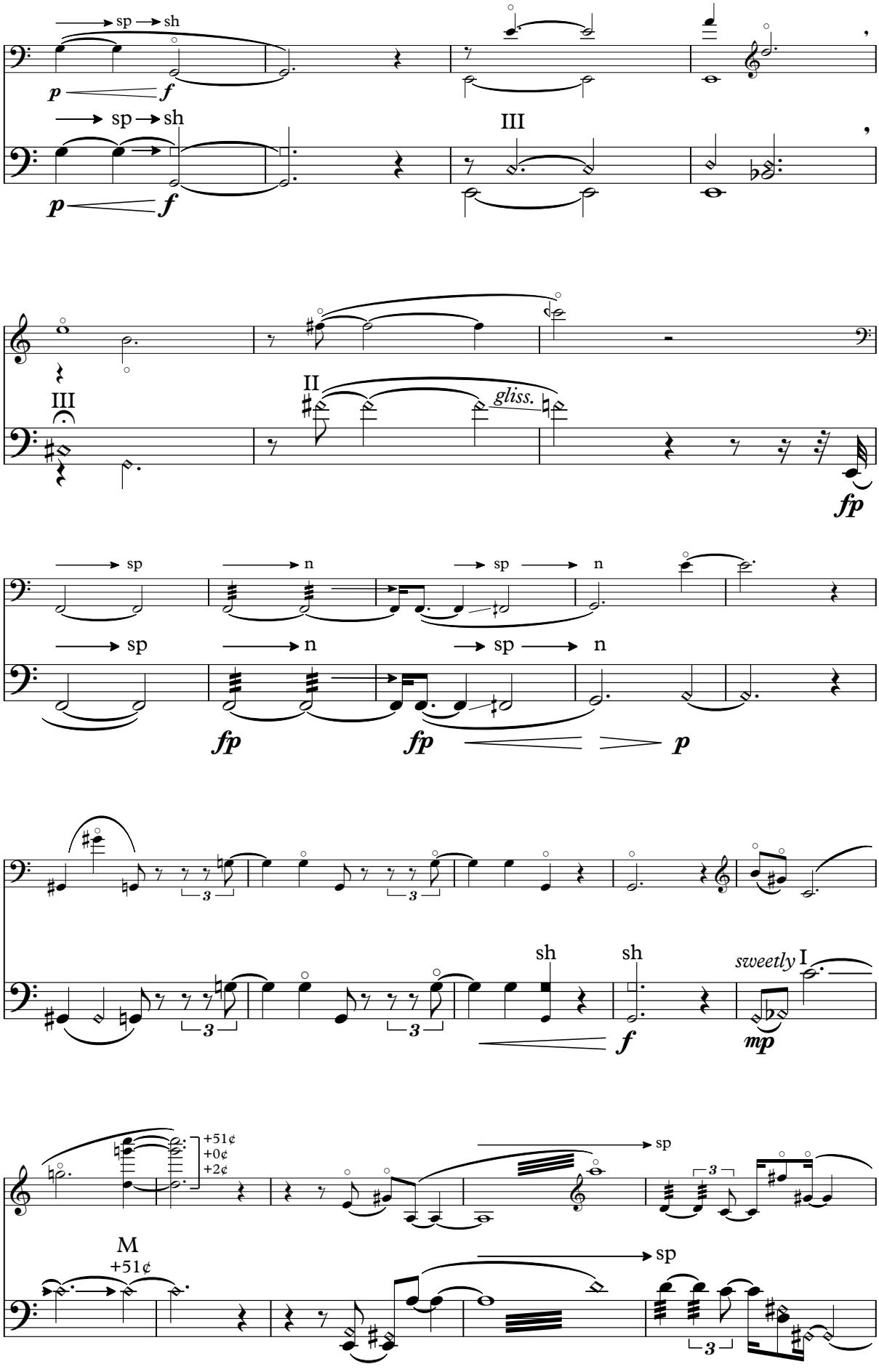

15"
15"
4"
bring out different partials
begin to add horizontal movement
mf
f
fp
tremolo

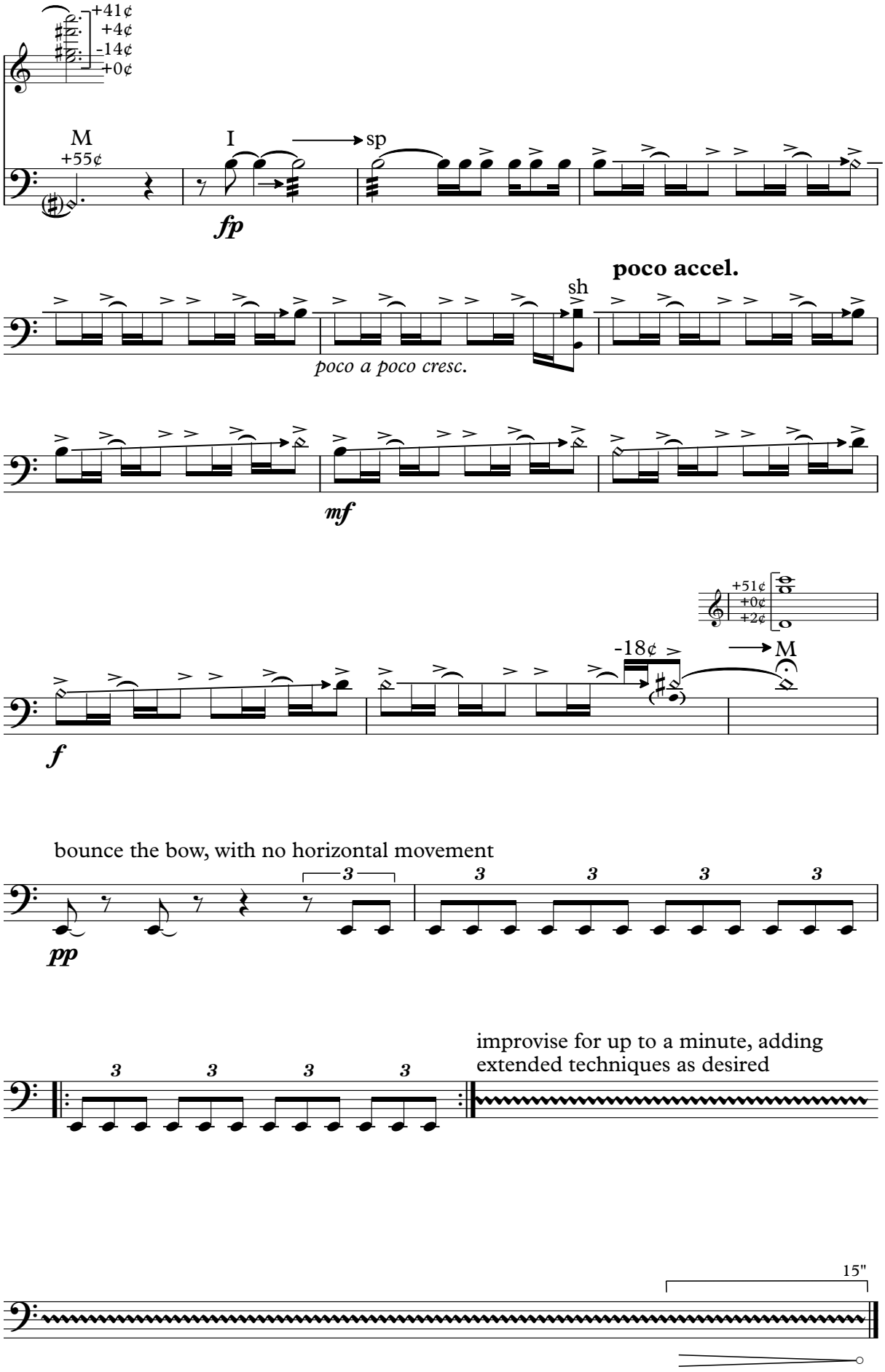

15"
15"
oscillate around smoothly, bringing out different partials
like the bow is 'skipping'
p
mp


5"
10"
15"
15"
lightly touch string, to activate harmonics
gliss.
gliss.


15"
15"
(at whatever position works)
find a multiphonic, then drone
gliss.
gliss.


fff mf < f
p
sp
n
3
+41¢
+4¢
-14¢
+0¢
M
+55¢
mp
f
pizz
arco
op
sh
ff
mf
III
II
p


sp → sh
p f
III
gliss.
II
fp
sp
n
sh
sweetly I
mp
+51¢
+0¢
+2¢
M


+41¢
+4¢
-14¢
+0¢
M
+55¢
I
sp
fp
poco accel.
sh
poco a poco cresc.
mf
+51¢
+0¢
+2¢
-18¢
M
f
bounce the bow, with no horizontal movement
3
pp
improvise for up to a minute, adding
extended techniques as desired
15"

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