Université de Montréal

Negotiating the frontier between Computer-assisted composition and traditional writing:
The utility of each and their effective cross-integration

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Résumé

Alors que les ordinateurs ont eu une influence majeure sur la composition musicale, par le biais de la musique électroacoustique et la composition assistée par ordinateur (CAO), il peut exister une division entre ceux qui utilisent surtout des techniques d'écriture traditionnelles (composition intuitive faite à la main) et ceux qui incorporent des éléments algorithmiques dans leur musique. Ce qui suit est une exploration de quelques-unes des façons de créer des points de rencontre plus fluides entre les mondes d'écriture intuitive et la composition assistée par ordinateur, en utilisant certains logiciels et pratiques spécifiques à la composition assistée par ordinateur. Ceux-ci s'étendent des situations où l'ordinateur nous pousse légèrement dans une direction ou fournit un réservoir d'information dans laquelle on peut puiser, jusqu'à des situations où, en se servant des indices de l'usager, l'ordinateur exerce un grand degré de contrôle sur l'information musicale finale. Des œuvres de l'auteur serviront à démontrer l'usage d'un nombre de ces technologies, en conjonction avec des explications plus détaillées de leur incorporation.

Une première section ciblera la composition et les techniques de programmation pour l'intégration légère de CAO, reflétant une approche plus intuitive. Les pièces *Mutations II, « Waves »* et *« Run »* de *Short Pieces on Falling*, *Never a Moment Lost*, et *(Let Me Hear) What Maria Hears*, parmi d'autres, serviront à démontrer l'efficacité de ces techniques.

La deuxième section observera l'intégration moyenne de CAO, démontrée par le système modulaire de progressions de l'auteur. Cette structure, développée en OpenMusic, aide à la génération de progressions musicales, et est facilement adaptable et modifiable pour différentes pièces. Ce système sera examiné principalement par une analyse des œuvres *Melodious Viscosity* et *Like a Square Peg*.

La troisième et dernière section concerne un niveau élevé d'intégration de CAO par l'intermédiaire des gestes, utilisant le logiciel *ScoreScrub* de l'auteur. En se servant de ce logiciel, l'usager peut effectivement faire du *scrubbing* à travers des segments de partitions existants afin de produire de nouveaux passages musicaux. Les œuvres centrales analysées seront *Gift efter Carl Herman Erlandsson* et la pièce orchestrale, *Världen och Jag.*

Mots-clés : Composition assistée par ordinateur, CAO, OpenMusic, Max, bach automated composer's helper, composition algorithmique, composition par gestes, improvisation, comprovisation

Abstract

While computers have had a major influence on music composition, both through electroacoustic music and computer-assisted composition (CAC), there can remain a divide between those pursuing more traditional writing techniques (intuitive composition done by hand) and those incorporating algorithmic elements in their music. The following is an exploration of some of the ways to produce smoother intersections between the worlds of intuitive writing and computer-assisted composition, through the use of a number of different computer-assisted composition software and practises. These range from situations where the computer provides little more than a gentle nudge or a pool of information from which to draw, to situations where, through the user's input, the computer exerts a high degree of control on the final musical information. Works by Matthew Lane will demonstrate the use of some of these technologies, alongside detailed explanations of how they were incorporated.

A first section will look at composition and programming techniques for low integration of CAC, reflecting a more intuitive approach. The works *Mutations II*, "Waves" and "Run" from *Short Pieces on Falling*, *Never a Moment Lost*, and *(Let Me Hear) What Maria Hears,* amongst others, will serve to demonstrate the efficiency of these techniques.

A second section focuses on medium integration of CAC, as demonstrated by the author's modular progression management system. This framework, developed in OpenMusic, helps in the generation of progression passages, and is adaptable and easily modified for different works. This framework will be examined primarily through the works *Melodious Viscosity* and *Like a Square Peg.*

The third and final section looks at high CAC integration through gesture, using the author's software *ScoreScrub*. Using this software, the user can effectively "scrub" across existing score samples to produce new musical passages. The primary works analysed will be *Gift efter Carl Herman Erlandsson* and the orchestral work *Världen och jag.*

Keywords : Computer-assisted composition, CAC, OpenMusic, Max, bach automated composer's helper, algorithmic composition, gestural composition, improvisation, comprovisation

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List of Acronyms

BPF: Break-point function

CAC: Computer-Assisted Composition

DAW: Digital Audio Workstation

EQ: Equalizer

FM: Frequency modulation

IRCAM: Institut de Recherche et de Coordination Acoustique/Musique

OM: OpenMusic

List of Abbreviations

m. : Measure

mm. : Measures

etc. : Et cetera

Dedicated to my wife, Mikaela,
who held me and our family together
through this long, but rewarding project.

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A good deal of gratitude goes to Alan Belkin and Pierre Michaud, who supported not only my research and my composition through these years, but who also guided me through years that were both personally and academically challenging and rewarding.

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Introduction

> We have artists with no scientific knowledge and scientists with no artistic knowledge and both with no spiritual sense of gravity at all, and the result is not just bad, it's ghastly.[1]
>
> *Zen and the Art of Motorcycle Maintenance*

The above statement is one I would be uncomfortable making about the world in general, but one that feels very at home in my being. My journey starts from a deep belief that neither a strong musical intuition nor a learned, scientific, analytical, and rational framework is sufficient for me to produce the music that interests me. For reasons that will be seen, both of these are elements essential to my creative process.

The best musical decisions I make are based on auditory cues. The ear and the brain is at the centre of the way I try to understand, structure, and compose music, and the emotional response they engender is the ultimate goal. And yet I am constantly fascinated by the possibilities of technology to advance in areas where we as humans are unable or less-suited to act, and to augment the capacities of our minds. Computers, and the way they work, provide inspiration for the way I compose, and while the ear must remain the guide, pieces without this technological component often feel like they are missing something: that they haven't taken full advantage of the capacities of the world in which we live today, and they lack a formal foundation that I feel expresses a very important part of who I am and how I think.

And yet, as I look around me in the world of computer-assisted composition (CAC) and composition as a whole, I often don't see artistic visions resembling my own reflected back to me. While there are many exceptions, to one side I tend to notice a school of CAC that is fascinated with the complex: not only complex processes, but a complex sound, and an opaqueness in the aesthetic of the final work. And in another direction, I see those whose styles I connect with: the neo-romantics and neo-classicists, who in many cases seem wholly averse to the idea of computers helping in the creative process. For many years, the teachers I

[1] Robert M. Pirsig, Zen and the Art of Motorcycle Maintenance : an Inquiry into Values, (HarperCollins e-books, 1999). 264.

studied with were either in the world of instrumental music and generally uninterested in CAC, or in the world of electronic or mixed music and more interested in the use of computers. Many instrumental composers perceived CAC as cold, difficult, and lacking in emotional capacity.

It seems to be oil and water, these two worlds. And understandably, my early attempts combining these two was like attempting to mix oil and water. I would throw these things together in a bottle, shake them really hard, and hope the oil wouldn't float to the top. I would add more oil and try again. Then I would add more water, and try again. Eventually that separation was always clearly evident, and I struggled to find ways of unifying them.

What I needed, and what I needed to become as a composer, was an emulsifier.[2]

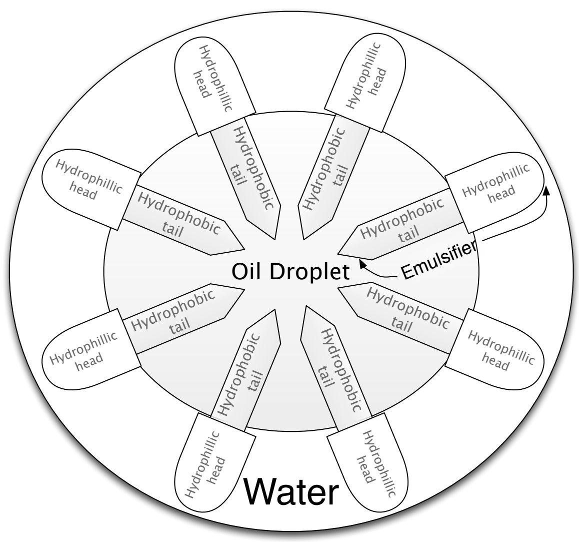

Figure 1 Emulsifiers serve as a bridge between water and oils

An emulsifier acts as a bridge molecule between oil and water (Figure 1). Its hydrophobic ends surround the oil molecules, while the outer hydrophilic ends connect to the water molecules. On top of this, emulsifiers cannot only combine water and oil into a comfortable relationship, but may confer additional properties to the mixture, like in many

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[2] Sarah Zielinski, "Oil and Water Do Mix," Smithsonian.com, http://www.smithsonianmag.com/science-nature/oil-and-water-do-mix-38726068/.

foods: foam aeration, crystal inhibition, antisticking, viscosity modification, and a host of others.[3] This was the perfect metaphor for what I was searching to do. The aim would be not only to combine CAC with my intuitive and auditory approach to composition, but to find a solution that was synergetic – to find solutions that not only allowed this marriage, but produced something in excess of both the originating members.

These emulsifiers, though, were not only combining different approaches to composing, but different ways of using the brain: intuitive and analytical. Acknowledging a partial cognitive disconnect in the way my brain functions while programming and how it functions while listening to music provided a number of central tenets to how I would approach this emulsion process.

In the following document, we will analyse the ways I incorporated CAC into otherwise intuitive composing. Some uses of CAC were exceptionally effective, while still leaving significant space for intuitive composition, while others felt like they forced out the role of intuition. Some philosophical approaches contributed a good deal to approaching these worlds in a harmonized way, and a good deal of programming was done to create systems that would allow them to coexist.

The varied musical works, each demonstrating one or more capabilities of CAC, will help deconstruct some of the ways in which these two worlds can come together. Alongside this discussion will be a more detailed explanation of the formal constructs that served as the basis for the programming, and specifically how the intersections between these sections were accomplished. In some cases, this will amount to an honest admission of the limits of CAC in my music where I would have liked it to go further, while in other cases it will provide evidence of places CAC was surprisingly well-suited to impulsive musical ideas. Throughout the analysis, the reader will progress from low-involvement of computers in the composition process to much more highly integrated situations, were CAC was used to generate fully-formed musical material. The first section will explore situations where CAC provided little

[3] Gerard L. Hasenhuettl and Richard W. Hartel, Food Emulsifiers and Their Applications, (New York: Springer, 2008). 7.

more than raw material for intuitive composition, while the second section looks a modular system in OpenMusic, and the third focuses on a gestural system in Max.

Most of all, we'll see not just how intuitive composing fits into a CAC framework with algorithmic constraints and rules, but also how CAC can fit into an intuitive framework with emotionally and auditorily valenced guides and rules.

1. Aesthetics, Influences, and Inspiration

This section is devoted to the aesthetics of my music as they are informed by my creative impulses, by other music, by art, and by philosophy. While not independent of the aesthetics sought in the CAC portion of my music, it's important to see these elements of my music as emanating from their historical, religious, and sometimes cultural origins, in part because that is what defines much of the music I write intuitively, pencil to paper or with an instrument, and because this will help demonstrate the disruptive and enhancing role that CAC is capable of playing later on.

My influences have a strong tendency towards the traditional, with the harmonies, textures and forms of my works often emanating from a neo-classical or even neo-romantic strain.

1.1. Musical Influences

1.1.1. Elements of My Aesthetics

The most representative elements of my musical style can be found in my harmonies, rhythms, ensemble textures, and counterpoint. This is a direct reflection of the fact that my music stresses a connection with the past, a connection with tradition that often used to hide in overly complex structures, but which has grown to be a fundamental and clearly portrayed element of my music.

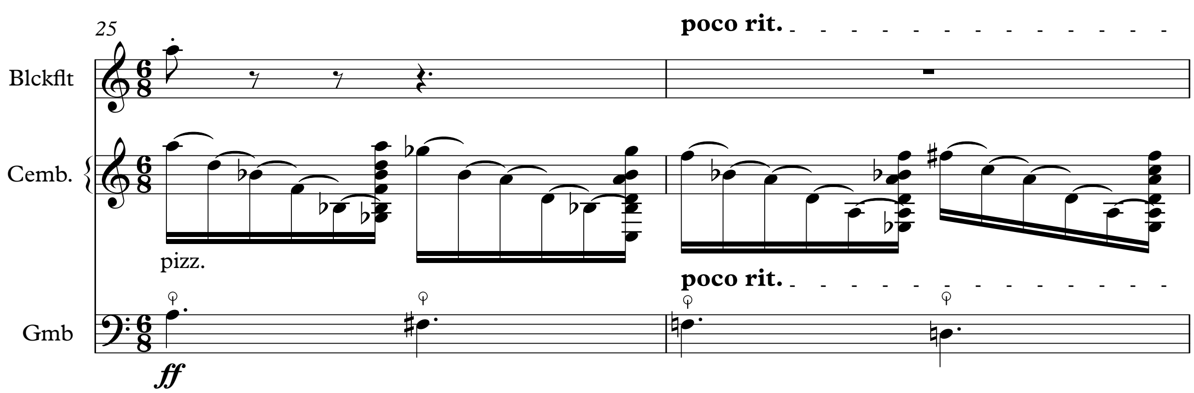

Figure 2 Chords constructed with fourths and fifths in *Läst Igen: Fredmans Epistel N:o 27*

Harmonically, I reside in a general world of tonal functions without traditional triadic tonal chord structures. Preferring chord structures of stacked fifths or fourths, often separated by a second (see Figure 2), my music nonetheless tends to retain a clear tonal direction. Since the tonal system is best suited to chords that divide the octave relatively evenly (such as a major triad), in order to balanced macroharmonic and contrapunctal needs,[4] my harmonic structures force the tonality into a state of ever-changing base macroharmony. Such chords, based on spaced fifths, are also weakly suited to counterpoint[5] unless one considers instead a counterpoint of textures, thus my harmonies often move in direct-motion clusters, giving a forceful weight to the mass of sound. Such stacked fifths essentially allow variations in timbre through added notes with shared partials without overcomplexifying the overall harmonic world, or necessarily adding further true voices.[6]

On occasions, I rely more on a macroharmony than a particular chord structure, especially in works with a single plane of tone[7], deliberately seeking ambiguity in the chord structure, the way one might observe harmonies in a Scriabin organ interlude, or a R. Vaughan Williams hymn. Yet, in other cases, harmonies are built from near-spectral structures, partially due to an awareness of the pleasing psychoacoustic nature of chords spaced in such a way[8], and in part to evoke a real spectrum, but with its elements not quite fitting, allowing the listener to hear the skeleton of the spectrum. In a similar way to how a furniture designer

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[4] Dmitri Tymoczko, A Geometry Of Music : Harmony And Counterpoint In The Extended Common Practice, (New York: Oxford University Press, 2011). location 465.

[5] A Geometry Of Music : Harmony And Counterpoint In The Extended Common Practice, (New York: Oxford University Press, 2011). location 442.

[6] By true voices, I mean voices that are contrapunctally independent. While a chord structure of 4 stacked fifths may technically require four instruments, as long as they move in parallel, they represent a single true indissociable voice.

[7] Alan Belkin, "Orchestration: Basic Notions, Part 2," http://alanbelkinmusic.com/site/en/index.php/orchestration-notions-2/.

[8] This has to do with the relationship of chord spacing to the critical bands along the basilar membrane. This relationship is not exactly spectral, but the interval size does become progressively smaller as pitch becomes higher. For much more on this, see David Huron, "Tone and Voice: A Derivation of the Rules of Voice-Leading from Perceptual Principles," *Music Perception: An Interdisciplinary Journal* 19, no. 1 (2001): 14-18.

might use varied inlays from many types of wood to draw more than the natural attention to the different grains, I find artificial spectra allows my mind to discern difference rather than blend.

Rhythmically, my music leans towards simplicity, but obsessive: basic binary or ternary rhythms that help the listener remain grounded especially in a complex texture, and which help to maintain a sense of drive in passages without a clear harmonic direction. Here I'm inspired by the work of Scriabin, whose rhythms are often unpredictable yet simple, or the larger scale works of the English composer Edward Gregson, whose basic rhythms nonetheless maintain a consistent momentum throughout his works. My works tend to explore the nature of anxiety and obsession through rhythm, using simple rhythms in unpredictable larger contexts.

Figure 3 Sharply contrasting textural structures in "Run" from *Short Pieces on Falling*. Note one plane of tone consisting of the flute, clarinet, and violin, one consisting of the sustained piano treble region, and one consisting of the bass region of the piano and the cello *pizzicati.*

Texture and form, however, tend to be less conventional, inspired more by the works of Stravinsky or the Swedish composer Kurt Atterberg. I often favour brusque juxtapositions between contrasting rhythmic and textural structures (see Figure 3), and enjoy toying with the anticipated tempo relationship suggested by a motive. Independent of these juxtapositions, but adding to their strength, is the fact that my music tends to be dense in planes of tone. Even in music for 5 instruments or fewer, I tend to favour 3 or more independent planes of tone at a time (Figure 3), often grouping instruments into subgroups with relatively independent directions. These features, especially prominent in the work of Atterburg or the Danish composer Carl Nielsen, are something I have repeatedly tried to emulate for the depth they provide, even when concerning the simplest motives.

1.1.2. Religious Music

I would be remiss not to point out the special place that religious, and specifically church music occupies in my craft. My instrumental background is as an organist, and much of my ensemble training and leading has involved church choirs. Regardless of specific religious belief, my experience with my music and that of others has taught me that music attempting to convey something about an unfathomable higher power carries with it the possibility of great mystery and emotional range.

Bach and Buxtehude were the basis of much of my training, and Buxtehude's larger works, in fact, evoke a closer relationship with today's music than Bach's in many ways. Buxtehude's music, far from lacking formal unity, still allowed many significant emotional, tempo, and textural digressions, many of which can actually be seen as a commentary on previously heard music. The intricate web of small ideas that fills a Buxtehude *Fantasia* speaks to the capacity of one part of a work to drastically alter another part simply through the relief in which it is placed, or the contrast structure. Through the work of Buxtehude and Arvo Pärt, I have slowly been imbued with the power of simplicity, especially in large religious spaces. Many of my works received their premières in churches, and quite deliberately. Pärt's music provides an excellent demonstration of how one may allow a building, it's acoustic, and even its architecture and art, to help convey the message of a piece.

Finally, R. Vaughan Williams sets perhaps the most profound example for me of what religious music can be. Again based on this principle of allowing the space, and even its accompanying faith to do much of the work, his music often exudes a rawness and insistent simplicity that leaves significant space for an interpreter to add meaning, again in conjunction with their space. He divests of tonality while maintaining a strong sense of tonal direction, and the ease and naturalness of his music to play eliminates the cognitive dissonance that so often makes difficult new pieces seem less enjoyable.[9] Furthermore, his capacity to take folk music and invest it with a much more profound spiritual meaning perhaps sets the greatest example, since folk music (though not English) has become a significant part of my work.

1.1.3. Swedish Folk Music

Swedish folk and traditional music became a part of my musical life in the past ten years. While there are emotional reasons I have grown attached to this music, including many trips to the Swedish countryside, and hearing my extended family sing some of these melodies to my children, the music has objectively influenced my composition in a number of ways.

Figure 4 *Polska efter Johan August Pettersson*. Note how different beats are accented through bowing, *appoggiaturas*, jumps, and longer note values.[10]

First and foremost, these melodies that I enjoy listening to have become an interesting base material for some of my music, often as a sort of cantus firmus. These often originate from *Spelmanslåtar*, pieces passed down orally (but with attribution) for fiddle and *nyckleharpa*, and played in large groups at town halls and churches. Texturally, the pieces' interest lies in the approximate unison of the group, with each player playing with their own

[9] Kahneman (Cognitive Dissonance - make a link to the difficulty of reading a text and how we assume it's wrong)

[10] This Polska from Tolg is in the public domain, but it and many others like it, can be found in the compendium *Svenska Låtar*: Nils Andersson, ed. *Småland, Öland och Blekinge*, Svenska Låtar (Svenskt visarkiv, 2006).

tuning, and to some degree, their own accents - ideas that have influenced me as I've explored more homophonic writing in some of my music, or areas with multiple instruments playing the same motives in randomly overlapping and accented fashion. This has inspired a little more experimentation with rhythmic "messiness" in my work. Especially prevalent is the *Polska* (see Figure 4), originally a Polish dance which has acquired a distinctly Swedish bent over the ages, and makes itself known through it's unstable accents where the beat seems to be constantly disappearing and reappearing, emphasizing different subdivisions of 2 and 3; an obsessive idea I've adopted in much of my music.[11]

The work of CJL Amlqvist and Carl Bellman, while not folk musicians in the traditional sense, but rather 18th and 19th century troubadours, has become ubiquitous in the Scandinavian folk music repertoire, serving as the basis for many folk and jazz arrangements in modern times. Likewise, I have used melodies from these composers as the basis for some of my own work.

The political climate in Sweden for the last decade, especially in relation to immigration, has also pushed me further into understanding the country's folk music. Sweden's most important cultural music, far from being able to claim much sincere connection to Sweden, tends to have travelled to Sweden from elsewhere and become repossessed and ingrained in the culture. Watching this folk music evolution over several hundred years has served as a useful contemplation on our own view of our immigrant past, and a learning experience in what it is that actually composes a culture. Using this music thus became a subtle political statement about the lack of true originality in nearly any human culture, and rather in the layers of sharing that truly embolden powerful art.

1.2. Algorithms and Models

> A process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.
>
> Oxford English Dictionary

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[11] A little more detail in English on the rhythmic structure of *Polskas* can be found here: Henrik Norbeck, "Swedish Traditional Music," http://www.norbeck.nu/swedtrad/.

I have always taken great pleasure in art where I could find an algorithmic explanation or interpretation, especially when that coincided with elements that *nearly* fit an algorithmic model, but not completely. I find a beauty in numbers, and in the sorts of symmetry and progression that exist in numbers and logic systems. The works of Dunstable, Bach, Xenakis, Vivier, or Harvey are in many ways formally predictable through algorithms, and their works provide me with several guiding ideas that shapes some of my compositional thinking. Firstly, an algorithm is a constraint: constraints, as Stravinsky noted in his own way,[12] open up freedom through what they force shut. Much like a beaver can create a new waterway by constraining an existing one, some of the ideas with which I'm happiest come through deliberately closing doors. The corollary of this is that one can find some of the most potent musical moments through where composers did not *quite* follow an explicit musical algorithm: these diversions provide a controlled insight into the intuition of how we understand music and listening.

What's most relevant in my work is the contrast and bridging between the coldness or detachedness of algorithms and the nearly romantic intuition that shapes my music otherwise. I often find what I'd term a cold richness in harmonies derived through algorithms: moving implacably forward with a clear logic, but unpredictable or unstable by traditional tonal standards. These often provide inspiration for me to build outwards and away from hackneyed tonal constructs.

Algorithms and models share a lot of common ground in my music, but are ultimately different paradigms for creation. In my case, models represent the incorporation of extramusical frameworks to provide a new framework for musical creation, and for me these represent the most potential-laden way of truly creating something that has not previously been heard or even imagined. Algorithms, for me, provide the means of transposing models onto instrumental music. Historical examples abound, including genetics sequencing for

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[12] "The more constraints one imposes, the more one frees one's self [...], and the arbitrariness of the constraint serves only to obtain precision of execution." from D. Ambrose and R.J. Sternberg, *Creative Intelligence in the 21st Century: Grappling with Enormous Problems and Huge Opportunities* (SensePublishers, 2016), 113.

formalizing composition,[13] or even the simple process of using Frequency Modulation as a generative process in instrumental music. I'm personally most interested in physics and mathematics as a source for models: again, beauty, symmetry, and progression through numbers.

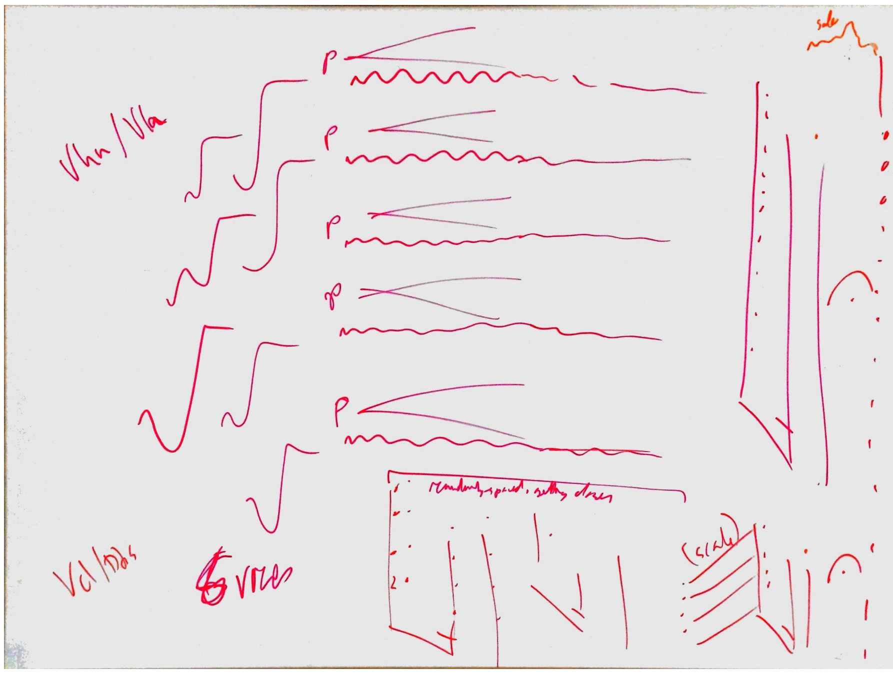

Figure 5 Whiteboard drawings for passages in *Like a Square Peg* (section 0).

Modelling, or the application of a non-musical concept to music, applies strongly to my music in one further, yet unrelated way: drawing. Many of my works originate not as purely musical ideas, as sketches signifying some combination pitches, volume, instruments, articulation, and so on (Figure 5). These primitive drawn gestures can form the basis for phrases, sections, or even entire pieces, and as will be revealed in section 4.6**,** this continued use of basic drawing provides some of the basis for much of the Computer Assisted Composition software I use and create.

[13] See Andrew Horner and David E Goldberg, "Genetic Algorithms and Computer-Assisted Music Composition," *Urbana* 51, no. 61801 (1991).

2. Computer-Assisted Composition

2.1. Definition

The field of computer-assisted composition (CAC) is in many ways a concrete extension of this idea of algorithmic thought. The definition can expand or contract to include any number of processes from the creation of orchestral simulations to nearly automatic composition. For some of the clearest definitions, we can turn to Mikhail Malt, who describes CAC as "all the processes that assist the composer in determining the positions of different objects in musical space. Musical space comprises all the parameters representing a musical or sonic reality."[14] This is a vast definition, into which nearly anything we do today could fit, but which I will contract for my work to describe only those processes where I could formally see and documents the effects of computer assistance (as to, for example, the fact that repeated listening to a basic computer simulation of ones work could inspire one to change it). Malt perhaps designates what is the most useful form of CAC when he says it is used to "stimulate" or "amplify" the imagination of the composer.[15]

Malt goes further to give three levels of CAC, being "assistance to repetitive or mechanical tasks", "assistance in simulations or maquettes", and "assistance to thought".[16] Assistance to simulation can of course be a form of assistance to thought: simulation creates feedback, a mirror through which we can see our own musical constructs in a more concrete way. This, however, remains often a static representation, as opposed to a process: a mostly unchanging, unfiltered sonic representation of what's on a page. Here we are most concerned with processes in composition, and while the feedback loop simulation creates is certainly a process, it's less a process for machines and more a process in our minds (and an intuitive one,

[14] Mikhail Malt, "Les Mathématiques et la Composition Assistée par Ordinateur (Concepts, Outils et Modèles)" (Docteur en Musique et Musicologie du XXè siècle, École des hautes études en sciences sociales, 2000), 19.

[15] "Les Mathématiques et la Composition Assistée par Ordinateur (Concepts, Outils et Modèles)" (Docteur en Musique et Musicologie du XXè siècle, École des hautes études en sciences sociales, 2000), 30.

[16] "Les Mathématiques et la Composition Assistée par Ordinateur (Concepts, Outils et Modèles)."

at that). The exception to this, however, is when a truly generative or transformative process allows us to simulate a musical process that surpasses, at least slightly, the standard capabilities of musical ear training. For example, algorithms that allow not just the playback of static scores, but the dynamic interpretation of instructions to musicians, such as controlled aleatory scores, remain of interest to a study on CAC. In other cases, it may be simply the simulation of an idea that we hope to develop more intuitively later. One example might be an orchestral microtonal interpolation between two chords over 10 seconds. Perhaps the composer wishes to eventually develop this by hand, to control for the details of the counterpoint, but wishes to test the global effect of the idea. Here, simulation takes on a much greater sense that the traditional MIDI playback of notation software.

Most relevant, however, are the assistance to mechanical/repetitive tasks and assistance to thought. There exists a significant degree of crossover between these two domains, in fact, "assistance to thought" can be thought of as a general umbrella under which much of CAC (including simulations) exists. Take, for example, the idea to develop several artificial spectra, each based partially on a frequency shifting of some partials from the previous spectrum. CAC could certainly help in the domain of mechanical, or mathematical, tasks: anything relating to patterns, numbers, repetition, and so on. But the process of programming this also provides the programmer with a formal framework for what they are doing, a framework that can be expanded on to perhaps develop a formal design for the entire work. Thus, both the auditory feedback from the computer, and the natural constraint system of the machine become learning tools for the composer.

It's important to note, however, the role of the composer in the selection of materials. While the computer can furnish materials as a response to the composer's instruction, the composer is responsible for choices. The material is consequential, but not to the same degree as how it is chosen, organised, and elaborated upon. Mozart is not known for having created new chords, but for his selection and organisation of musical materials that largely already existed. The act of composition takes place not only in the generation of materials via CAC, but in the choice of how to use it.

2.1.1. Instrumental music

CAC, for our definitions, will concern primarily instrumental or mixed instrumental and electronics works. The relationship between CAC and electronic music is more complex, since in the latter's case, computers are already responsible for many of the generative and transformative processes involved. CAC, with its status as "assistant", implies that a human composer may *intervene* in the computerized process or *interpret* the final results. In the case of intervention, the composer may seize back control of the process where it is most artistically propitious. Perhaps at a point in a sequence of generated pitches, the composer becomes inspired to complete such a line by pure intuition: this is part of the process; the computer is only providing materials that may be used in the final work. In another vein, pitch fields may be generated by a computer, but the composer is left with the task of interpreting the artistic values of these: assigning them to times, timbres, volumes. The concept of interpretation may be taken further: a whole passage may be computer-generated, but the composer reserves the right to reinterpret this passage (see Figure 6). Perhaps to adjust the rhythms or notes to better suit their artistic concept, sometimes via major cuts, and sometimes via subtle changes of nuance. In this space, the roles of performer and composer can actually become somewhat intertwined, since both may share a role in interpreting what was at one point computer-driven data. Regardless of the split between those roles, there remains human interpretation between the generated material and the listener. We could see CAC like a research assistant who provides sets of data points to a researcher, and perhaps runs experiments, but from which the head researcher will ultimately write the article and provide their interpretation of the results.

Gérard Assayag describes best the intersection in instrumental music that makes CAC possible:

> Instrumental writing seems to us a field of study which is at the same time precise and open: it constitutes a still unequalled model of adequacy between combinatorial systems of operations on sets of

> symbols on one hand and a sound universe having its own rules of perceptive and cognitive operation on the other hand.[17]

Due to this combination of worlds, between symbol and sound, instrumental music is by its nature already partially formalized, and the missing link between the symbol world and the sound world ensures that there is always human intervention.

2.1.2. Relationship to Algorithmic Composition

A final point is in order to distinguish CAC from Algorithmic Composition (or Formalized Composition). On a basic level, there is an important etymological difference between CAC and algorithmic composition: "computer" directly implicates machine computation, while algorithms are simply sets of instructions, which can be (and have been) done by hand. The term “Algorithmic Composition,” however, is favoured over formalized composition in this text for two reasons. The first is to place the term Algorithmic Composition in chronological context alongside CAC: discussions about formal processes in music long predate our modern use of computers,[18] while algorithms, though not limited to computers, are generally associated with them.[19] Furthermore, the term "formalized music" is often directly associated to the seminal work by Xenakis,[20] complicating its use.

[17] Gérard Assayag, "Computer Assisted Composition Today" (paper presented at the First Symposium on Music and Computers, Corfu, Greece, 23-25 October 1998), 7.

[18] See, for example, the following 1938 article from Rutgers University: Carroll C. Pratt, "Structural vs. Expressive Form in Music," *The Journal of Psychology* 5, no. 1 (1938).

[19] See the "Editor's Note: What Does Algorithm Mean?" from "Algorithm," *Merriam-Webster.com*, https://www.merriam-webster.com/dictionary/algorithm.

[20] Iannis Xenakis, *Formalized music : thought and mathematics in composition* (Stuyvesant, NY: Pendragon Press, 1992).

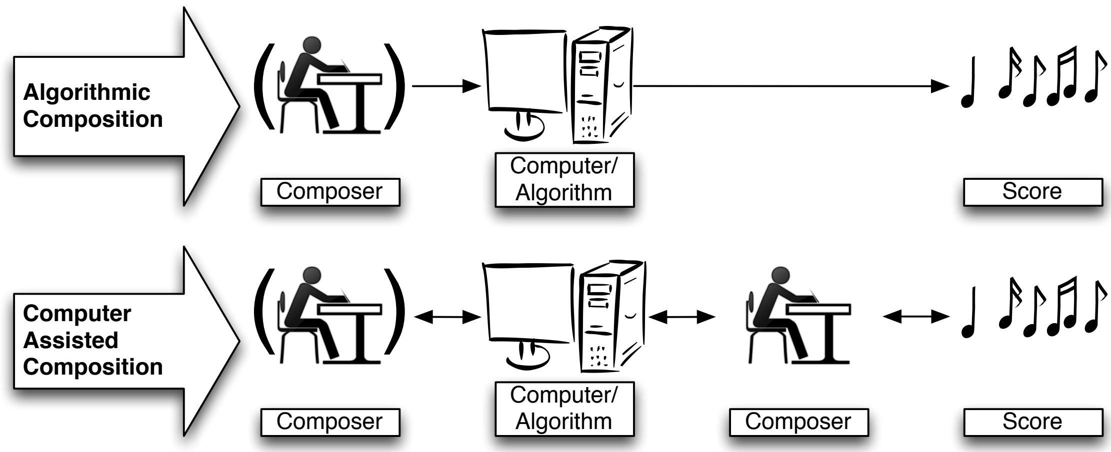

Figure 6 A simplified representation in the steps of Algorithmic Composition versus Computer Assisted Composition[21]

While these disciplines have the potential to share many processes, the key difference is the aforementioned intervention or interpretation by a composer. As Malt points out, Algorithmic Composition can be explained by a complete isomorphism between the world of calculations and the world of sound (see the direct link between the computer and the score in Figure 6).[22] Horacio Vaggione offers a somewhat analogous definition of formalized composition, suggesting that music is completely formalized when, "all non-defined symbols present in the system are properly enumerated."[23]

In short, in Algorithmic Composition, the algorithm forms the whole of the final musical result, while in CAC, it forms only a part of the process, and a delicate negotiation by the composer is required to move in and out of this process. CAC, thus, is capable of containing many of the processes inherent to Algorithmic Composition, one of the most

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[21] Note that the images are for representative purposes only: algorithms can be developed and executed without computers. Most modern work in algorithmic composition uses computers, but it is not a requirement.

[22] Malt's explanation of algorithmic composition can be found in: "Les Mathématiques et la Composition Assistée par Ordinateur (Concepts, Outils et Modèles)," 61.

[23] Horacio Vaggione, "Some Ontological Remarks about Music Composition Processes," *Computer Music Journal* 25, no. 1 (2001): 56.

prevalent of which is mapping, the transformation of a gesture into something recognizable in the sound domain.[24] This concept plays a significant role in portions of my work.

2.1.2.1. Authorship

Here, however, we've glossed over several topics, and made several assumptions, especially concerning authorship of the final musical work. The first assumption is that the composer is the programmer. Arguably, since instrumental music notation is nothing but a series of instructions for performers, then the composer's role can well extend to writing the instructions to generate the music, even one layer removed.[25] We rarely question whether the serialists truly wrote their own music, and by extension, we shouldn't question the authorship of music by a composer who designs their own algorithm. As Bruce Jacob mentions, the difficult questions comes when the person using the algorithm is different from that which created it (see the brackets in Figure 6).[26]

This question provokes no black and white answers. On a basic level, one can come back to serialism: we consider each serialist to have written their own music, even those using "instructions" passed down from Schönberg. Serialism, however, more closely mirrors the practice of CAC in many ways: many of the great serialist composers acted as drastic interveners between the process-generated material and the final musical work. Like the serialists, users of CAC remain composers, even without having produced the initial algorithm (note the dual roles of the composer for CAC in Figure 6: the composer retains a role, even while outsourcing their initial algorithm). In the case of Algorithmic Composition (see Figure 6 again), using the algorithm of another programmer/composer has removed the only role for a composer, and the question of authorship becomes more complex. Any authorship in such a case would arguably depend on whether the user influenced the algorithm's parameters. Even giving a most basic, yet original instruction to the machine could represent authorship,

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[24] Paul Doornbusch, "Composers' Views on Mapping in Algorithmic Composition," *Organised Sound* 7, no. 2 (2003): 145.

[25] Bruce L. Jacob, "Algorithmic Composition as a Model of Creativity," ibid.1, no. 3 (1996): 157.

[26] Ibid.

similarly to giving the most basic, yet original instruction to a performer (think John Cage's *4'33"*).

A final question revolves around algorithmic music based less on explicit instructions, and more on analysis of existing works; music-generation machines, for example algorithms that analyse all of Bach's inventions and recreate something stylistically similar (a pastiche of sorts). In such cases, one could argue that authorship is shared between Bach and the programmer: the programmer's choices (weights, coefficients, analysis methods) lead to tangible differences in the music, making the programmer a composer. While such algorithms strike some as unmusical, there can be a large gray area between such a machine, and one that analyses spectra of bells and then builds a musical narrative from it: both are fed external information, from which they build music. It is only the question of authorship that remains, and assuming computers don't build their own algorithms, a human retains some roll of author.[27] In either respect, however, when the composer does not interfere with the musical data between computer output and performance, the argument can be made that it's a form of Algorithmic Composition.

2.1.2.2. Live-coding

Similarly the field of live-coding cannot quite be considered computer-assisted composition, even though it's generative processes are controlled by continual interaction with performer-composers.[28] By its nature, any algorithmic process taking place live eliminates the time necessary for intervention between an computer-generated result and a score or performance. Similarly, because the computer is both generator and ultimately producer of sound, the data cannot be interpreted. It is, however, quite close to CAC, and becomes closer with every new advance, as the levels and means of interaction with the musical data in the

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[27] A further topic, of course, is algorithms actually generated by artificial intelligence. Similarly, however, we can trace our logic back further and proclaim any of the humans who influenced the composition process, such as the coders of the artificial intelligence, to have shared in the composition process. This discussion, however interesting, falls outside the scope of this thesis.

[28] Andrew R. Brown and Andrew Sorensen, "Interacting with Generative Music through Live Coding," *Contemporary Music Review* 28, no. 1 (2009): 17.

process advance. Live-coding will always lack, however, the possibility of a final, considered, intuitive intervention between what is produced by the computer and what is heard by the audience.[29]

2.2. History

CAC is generally considered to have been born in the 1950s, and one of the first machines used by Olson and Belar implemented Markov chains to generate musical data from score analyses, before the composers made selections from the results.[30] This is significant, since this already contained the basic necessities of CAC: human input (the extant scores the computer would analyse), computer processing, and human evaluation. While other works like Hilliar's Illiac Suite followed, they tended to be more algorithmic composition than CAC, giving full control of the final work to the algorithm. Xenakis' work is obviously important to mention, since he formalized early on the role of computers or "computerized construction" as a fundamental part of his work.[31] Xenakis employed stochastic processes early on in Pithoprakta,[32] embarking on a formal journey with sound masses or “clouds”[33]. These are especially relevant to the early years of CAC, since they represent certain processes that could be much more quickly and easily achieved via computers, and represented a domain in which computers specialized, and where the human mind had significant lacks.[34] Then his UPIC system, from which he composed *Mycenae Alpha*, amongst others,[35] could be seen as the precursor to much of the software we use today for CAC, even though it was a tool for audio,

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[29] This is not a values judgement of any kind, but rather an important means to differentiate two fields.

[30] Assayag, "Computer Assisted Composition Today," 1.

[31] Xenakis, *Formalized music : thought and mathematics in composition*, 22.

[32] Sergio Luque, "The Stochastic Synthesis of Iannis Xenakis," *Leonardo Music Journal* 19(2009): 77.

[33] Linda M. Arsenault, "Iannis Xenakis's Achorripsis: The Matrix Game," *Computer Music Journal* 26, no. 1 (2002): 58.

[34] Here I’m referring to the human capacity for thinking in true randomness. For more background on this phenomenon, see: Philip J. Boland and Kevin Hutchinson, "Student Selection of Random Digits," *Journal of the Royal Statistical Society. Series D (The Statistician)* 49, no. 4 (2000).

[35] James Harley, "The Electroacoustic Music of Iannis Xenakis," *Computer Music Journal* 26, no. 1 (2002): 34, 51.

and not for scores.[36] UPIC allowed the composer to define individual waveforms and envelopes for different synthesized instruments, and then draw their lines on a board, with the x-axis representing time and the y-axis representing pitch (Figure 7). It was an important step towards allowing composers to trigger computer-assisted calculations by using gesture.

Figure 7 Xenakis' UPIC at the Museum of Music in Paris (Photo by the author)

Robert Baker and Lejaren Hillier's MUSICOMP (1963) was another important step, providing a first programming basis that was truly based on music and musical symbols, and could interface to a certain degree between then notation and sound worlds.[37] The coming years, however, saw these technologies increasingly dedicated to sound production,[38] until Stephen Pope began programming in the Smalltalk language, allowing for visual interfaces like those in the "Music Toolkit".[39]

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[36] Jean-Baptiste Thiebaut, Patrick G. T. Healey, and Nick Bryan-Kinns, "Drawing Electroacoustic Music" (paper presented at the ICMC, Belfast, North Ireland, 2008), 2.

[37] Lejaren Hiller and James Beauchamp, "Research in Music with Electronics," *Science* 150, no. 3693 (1965): 168. and Alex Di Nunzio, "Musicomp," http://www.musicainformatica.org/topics/musicomp.php.

[38] Assayag, "Computer Assisted Composition Today," 3.

[39] Stephen Travis Pope, "A Smalltalk-80-based Music Toolkit" (paper presented at the International Computer Music Conference, University of Illinois at Champaign/Urbana, 1987).

As might be expected, IRCAM played a significant role in much of the advancement of CAC.[40] Software like CHANT was significant for their combined analysis/synthesis abilities,[41] but especially for their "synthesis-by-rule" structure,[42] which allowed human interference, or intervention, between the analysis and synthesis.[43] FORMES (1984) was one of IRCAM's first attempts to create a whole environment devoted to CAC,[44] and an acceptance that the common languages were insufficient for CAC.[45]

Elsewhere, composers such as Heinrich Taube began attempting to harness the power of the home computer to create CAC systems, and starting to see the value of the LISP programming language for CAC.[46] While Taube's system, Common Music, was text-based, Patchwork (created in 1986,[47] and still in use through its successor PWGL[48]) further resembled the CAC systems of today, incorporating a visual interface, and the kinds of notation boxes now available in software like OpenMusic. Following its initial development, Laurson began working on the PatchWork project with Rueda and Duthen at IRCAM,[49,50] and

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[40] For a lot more detail on this, see Gérard Assayag et al., "Computer-Assisted Composition at IRCAM: From PatchWork to OpenMusic," *Computer Music Journal* 23, no. 3 (1999).

[41] Xavier Rodet, Yves Potard, and Jean-Baptiste Barrière, "The CHANT Project: From the Synthesis of the Singing Voice to Synthesis in General," ibid.8(1984): 15.

[42] "The CHANT Project: From the Synthesis of the Singing Voice to Synthesis in General," *Computer Music Journal* 8, no. 3 (1984): 17.

[43] "The CHANT Project: From the Synthesis of the Singing Voice to Synthesis in General," 26.

[44] Gérard Assayag et al., "Computer-Assisted Composition at IRCAM: From PatchWork to OpenMusic," ibid.23(1999): 59.

[45] Xavier Rodet and Pierre Cointe, "FORMES : composition et ordonnancement de processus," in *Rapports de recherche IRCAM* (Paris: IRCAM, 1985), 32.

[46] Heinrich Taube, "Common Music: A Music Composition Language in Common Lisp and CLOS," *Computer Music Journal* 15, no. 2 (1991): 21.

[47] Mikael Laurson, "PATCHWORK: A Visual Programming Language and Some Musical Applications" (Doctoral Dissertation, Sibelius Academy, 1996), 8.

[48] Mika Kuuskankare et al., "PWGL," http://www2.siba.fi/PWGL/pwgl.html.

[49] Hiroki Nishino and Ryohei Nakatsu, "Computer Music Languages and Systems: The Synergy Between Technology and Creativity," in *Handbook of Digital Games and Entertainment Technologies*, ed. Ryohei Nakatsu, Matthias Rauterberg, and Paolo Ciancarini (Singapore: Springer Singapore, 2017), 667.

several of the later libraries created for PatchWorks were developed in collaboration with IRCAM, including Murail's *Esquisse* and Rueda's *Situation*.[51] PatchWork contained predefined modules to simplify work for composers, and was musically “neutral”.[52] What followed, and still exists, is OpenMusic, a cross-platform, object-oriented, visual system for CAC.[53] Current versions of this software allow notation input and output via XML, sound synthesis and processing, and a variety of visual objects that allow control of notation and sound, simultaneously if desired.

Perhaps the final step, one I consider extremely significant in terms of my own work and its implications for the future, is *bach automated composer's helper*. *bach* is a toolset for Max, using approximately the same programming and object structure as OpenMusic, and incorporating a set of functions to enable interfacing between the Max's real-time environment and the Lisp-like system of OpenMusic.[54] Merging real-time control with computer-assisted composition has obviously been a goal of many for a long time, and there have been steps in that direction through OMax, a system that sends data back and forth between Max and OpenMusic,[55] and reactive functions for OpenMusic, which merge the existing demand-driven architecture with a data-driven capabilities.[56]

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[50] Laurson, "PATCHWORK: A Visual Programming Language and Some Musical Applications," 8.

[51] Assayag et al., "Computer-Assisted Composition at IRCAM: From PatchWork to OpenMusic," 62.

[52] "Computer-Assisted Composition at IRCAM: From PatchWork to OpenMusic," 59.

[53] "Computer-Assisted Composition at IRCAM: From PatchWork to OpenMusic," 64.

[54] More details on *bach* are exposed in: Andrea Agostini and Daniele Ghisi, "Real-Time Computer-Aided Composition with bach," *Contemporary Music Review* 32, no. 1 (2013).

[55] Gérard Assayag, Georges Bloch, and Marc Chemillier, "OMax-Ofon" (paper presented at the Sound and Music Computing, Marseille, France, May 2006).

[56] Jean Bresson and Jean-Louis Giavitto, "A Reactive Extension of the Openmusic Visual Programming Language," *Journal of Visual Languages & Computing* 25, no. 4 (2014): 370.

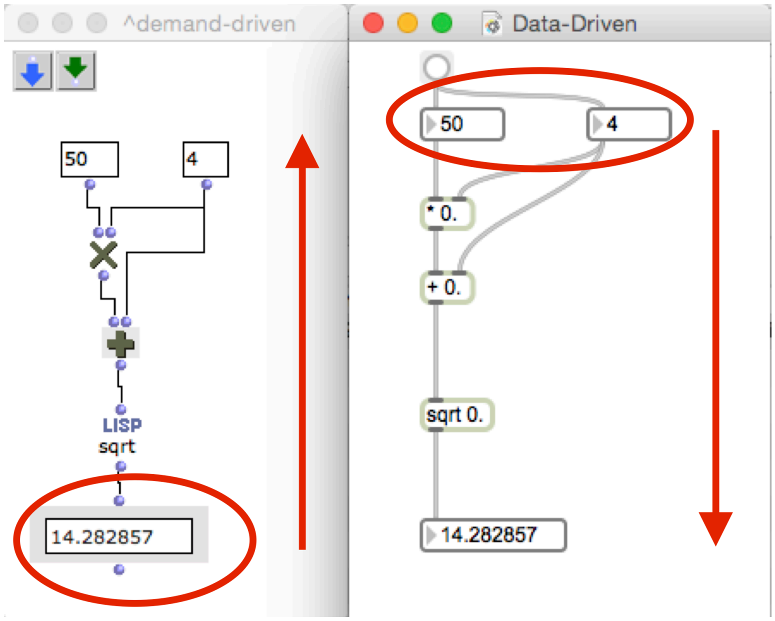

Figure 8 Demand-driven OpenMusic (left) and data-driven Max (right).

Figure 8 shows the difference between a demand-driven and data-driven architecture. In the demand-driven architecture to the left (OpenMusic), the sequence is only calculated when the circled box at the bottom requests it. It then goes up the chain, first to a square-root function (*sqrt*), which asks the boxes above it, "what am I taking the square-root of?", then to an addition function, which asks, "what am I adding?" and so on. The functions are only performed if a box underneath it demands it. By contrast, in the data-driven architecture to the right (Max), things move from the top down. When new numbers are entered, they are automatically sent to the multiplication box, then the addition box, then the square-root box. This is well-suited to live applications, because generally we send information to a computer, through MIDI keyboards or controllers for example, in live processing, rather than simply demanding it.

Max has much more widespread use than traditional CAC software, which means that *bach* for Max may provide a way of introducing CAC to a much more significant audience. This combination of real-time and CAC also allows us to envision more processes being created for CAC with instantaneous user feedback, and with further stability, may allow more dynamic scores, able to be updated and altered in real time in response to musicians or composers. We may increasingly see composers using gesture-based systems to compose music in real-time for musicians to perform, always just a few bars ahead in a live concert. Live-electronics may take on new purpose in purely instrumental compositions.

2.3. Personal Interest

2.3.1. Kahneman's Systems 1 and 2

Programming languages have held special interest for me since a young age. I am fascinated by the creation of systems, sometimes more than the results of those systems themselves. I will rework simple systems to make them as efficient, intuitive, and effective as possible. Computer science also occupies a very different part of my mental capacities. Let us turn to Daniel Kahneman's two systems of thought, systems 1 and 2.[57] System 1 is impulsive, emotional and automatic, while system 2 is analytical, weighted, and structured. These systems often conflict with each other,[58] and yet we rely on both: system 1 for quick, instinctual decisions, and system 2 for calculated disciplined ideas. As might be imagined, the act of composition encompasses tasks that fit into both. The initial idea, the creation of a first draft of a melody or harmonic progression, an improvised rhythmic device all fit into system 1. Most often, my first gesture of composing comes from system 1 – an intuition or inspiration that I can't always place; in fact, over-analysis (system 2) often creates a sort of writer's block in my process.

Programming, however, fits clearly into system 2: it's calculated, with clear functions and a completely logical framework. For me, this part of my mind is equally important to nurture, and equally gratifying to explore. CAC provides this faculty with an outlet into my compositional process. Through exploration in this analytical world of CAC, a greater formal understanding of music may open up.

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[57] Daniel Kahneman, *Thinking, Fast and Slow* (Toronto: Doubleday Canada, 2011), 20-22.

[58] *Thinking, Fast and Slow* (Toronto: Doubleday Canada, 2011), 26.

2.4. Computational Thought and Form

Tom Igoe from NYU suggests that teaching computer programming is not necessarily the correct approach for students, but that "computational thought" would be significantly more useful.[59] He explains that programming is about formalization, and from this we can posit that programming music (to a certain degree) through CAC is a manner of formalizing music. CAC can thus serve as an underlying formal structure, and thereby as a link between the formal structures of different works. Furthermore, though, the mode of thinking used in computers can serve as a means of helping to mentally formalize music even where computers are not present. This is part of the true pedagogical importance of CAC: not only how algorithms can help to suggest musical material, but how the return from programming to pure composing makes its influence felt in the formal understanding of music.

Like many forms of analytical thought, the essence of computational thinking is "abstraction",[60] similar to the way different degrees of abstraction help us to analyze a musical work.[61] Being able to see and define patterns and progressions in music involves a certain degree of abstraction: abstraction allows us to distance the patterns from their pure musical notes in order to see larger elements of a form. Abstractions are symbolic, and music deals primarily in symbols, specifically traditionally notated music. Abstractions equally exist outside of time and space - in fact it serves their function to do so - and music occupies a similar position.[62] As such, a programming mindset centered on abstraction allows us to perform very much the same type of analysis of algorithms, and gives us the tools to then apply similar concepts to the arts. But because programming, and it's teaching, is much more closely linked to the idea of abstraction, it allows a broadening of our analysis of our own processes upon a return to composition. Tod Machover summarizes this nicely:

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[59] Tom Igoe, "Stop Teaching Programming, Start Teaching Computational Thinking," http://makezine.com/2016/04/05/stop-teaching-programming-start-teaching-computational-thought/.

[60] Jeannette M Wing, "Computational thinking and thinking about computing," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 366, no. 1881 (2008): 3717.

[61] Nicholas Cook, *A Guide to Musical Analysis* (London: J.M. Dent, 1987), 175.

[62] Wing, "Computational thinking and thinking about computing," 3717.

> "[the computer] is an instrument the composer is forced to study rigorously, and which obliges her to return on oneself with even more rigour, requiring her to set limits and establish rules that she will use in a creative fashion to make music"[63]

Through repeated exposure to CAC, this thinking allows us to work backwards, through works by Xenakis, Messiaen, Boulez,[64] Vivier, Grisey, and many newer composers to understand their formal workings in a different way. The processes of all these composers can often be understood as algorithms or "programs"; a set of rules and conditions that structure the output in a certain way. Xenakis said as much in his treatise, *Formalized Music*, proposing that "the term imaginary machine means that the composer may rigorously define the entities and operating methods, just as on an electronic computer".[65] Arguably, pioneers of 20th century music like John Cage were engaging in what might today be called computational thinking, through the amount of abstraction that was present in the thought process for their works.[66]

The idea of computational thinking affecting composition falls into a historical pattern of seemingly unrelated fields often being significantly influenced by the advances in others. Computer models developed to follow nuclear fallout or measure shockwaves from nuclear explosions served as guides to the early models for measuring climate change,[67] similar to the way the technology for the ink-jet printer later became the basis for the fluorescence activated cell sorter (FACS), an important tool in immunology.[68] The Fourier transform is a classic musical example: while many composers use Fourier analysis to analyse spectra, the

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[63] Translated from Tod Machover, "Le compositeur et l'ordinateur : quelques réflexions" (paper presented at the Le Compositeur et l'ordinateur, Paris: IRCAM, February 17-21 1981).

[64] Serialism obviously represents a type of computational thought, but in many senses a simplistic type, using sequences that are relatively straightforward in the context of today's computer systems.

[65] Xenakis, *Formalized music : thought and mathematics in composition*, 39.

[66] James Pritchett, *The Music of John Cage*, Music in the twentieth century (Cambridge, England; New York: Cambridge University Press, 1993), 191.

[67] Paul N. Edwards, "Entangled Histories: Climate Science and Nuclear Weapons Research," *Bulletin of the Atomic Scientists* 68, no. 4 (2012). p 28

[68] L. A. Herzenberg et al., "The History and Future of the Fluorescence Activated Cell Sorter and Flow Cytometry: a View From Stanford," *Clinical Chemistry* 48, no. 10 (2002): 1819.

understanding of spectra from this analysis has become the basis for many works in which no computers were involved. While this in some cases resembles the modelling discussed above, in many cases it is simply a matter of abstracted concepts being applied from one field to another. The interest of the Dutch composer Willem Pijper in botany have been observed in his compositions: he employs what he calls a germ cell, and the outgrowth from such cells and their transformation appear to be significantly inspired by botanical understanding.[69]

In many ways, this represents a far more important outgrowth of my work than some of the CAC itself: its structure, and even its formalized and weighted ways of analysing situations led me down mental paths towards musical ideas. I've often noticed that as a pianist, organist, and singer, the way I compose is perhaps shaped differently from those who don't hold these roles, regardless of whether I'm actually composing for one of these instruments. It's a tool I sometimes use for composition, but even when I don't, I can still note its influence. When writing for orchestra, the idea of two independent base lines and two independent chords above comes quite naturally to me: this is because I can mentally imagine sitting at an organ playing a bass line with each foot and a chord with each hand. Similarly, a programmer's understanding of their instrument shapes the way they compose. When asked about the use of computers in composing, Grisey suggested that the time saved by a computer would be time lost in composing, something he valued.[70] This misses the point, however, that programming the algorithm for one of Grisey's works may not in fact be faster than doing it by hand, but it would force the composer to formalize in a computer-oriented way, precisely what was happening in the works. The composer may arrive at precisely the same formulation by doing the calculation by hand, but I hypothesize that in my case, writing these algorithms by computer may open up additional streams of thought that I had not considered. This is not to suggest they are better, but only that they are different and provide an enhanced creative repertoire. I know that if I were to sit down with the same base material to compose a work for

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[69] Hans Eduard Kooij, "Composition by Use of Germ Cells: A Botanical-Musical Analogy in the Willem Pijper Sonata for Piano," *Tijdschrift van de Koninklijke Vereniging voor Nederlandse Muziekgeschiedenis* 54, no. 2 (2004): 120.

[70] Malt, "Les Mathématiques et la Composition Assistée par Ordinateur (Concepts, Outils et Modèles)," 40.

the same instruments after either an hour of piano playing or choral singing, the result would be different: both prime my mind with different ways of thinking about music.

2.4.1. Insects and Tool Marks

Well, bugs, rather. When I consider Grisey's work and the possibility for formalization, there is a final element that strikes me as especially relevant from the world of computers and calculations: bugs. Most computer users find bugs to be an occasional frustration, but for someone who works more intimately with programming, they can be immensely rewarding.[71] It's been pointed out that the Linux operating system is "plagued by bugs" (compared to systems like Apple OS and Microsoft Windows),[72] and yet many programmers thrive in this environment. Similarly, composers that regularly employ CAC (and the many bugs that come with open-source, academic software), often learn to thrive on the bugs. While bugs represent errors in code, either the composer's or that of she who wrote the base language, they present two interesting opportunities.

Because computers cannot generally make errors, errors represent a formal problem to be solved. The resolution of a formal problem is a formal construct in itself, and may provide a framework for a musical form as and provides a greater understanding of the computer's formal framework. For a "classical" thinker, as expressed in *Zen and the Art of Motorcycle Maintenance*,[73] understanding the nuts and bolts of an underlying form can be aesthetically rich in itself. Any aesthetic can provide the inspiration for art.

Furthermore, bugs often produce unexpected output, some of which can provide a truly original seed for the composer. In many ways, this is the reason some composers have chosen to engage in aleatoric practices: it is a way of forcing oneself out of the clichés of their writing. It's worth remembering that often the main reason for undertaking CAC is not simply

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[71] John Dooley, *Software Development and Professional Practice* (New York, N.Y.: Apress, Distributed by Springer, 2011), 222.

[72] Bertel King Jr., "6 Reasons Your Favourite Linux OS is Plagued by Bugs," http://www.makeuseof.com/tag/reasons-why-linux-plagued-bugs/.

[73] Pirsig, *Zen and the Art of Motorcycle Maintenance : an Inquiry into Values*. location 1200.

to perform mathematical calculations for quickly, but because of its power of suggestion. I do not use CAC to generate pitch sets based on frequency modulation only because it saves me the time of doing the calculations by hand; often it's because I can truly not predict the results and am looking for inspiration. A computer bug does precisely this, but unpredictably: when you learn to embrace the error, there is often additional material that you never would have considered. Boulez prophetically said that "the machine renders an answer to the question you did not ask."[74] Other composers have based entire pieces on these errors, like *Solange Orange* by Dall'Ara Majek.[75] Of course, like in all CAC, the most crucial choice is whether this material is worth incorporating, and that falls to the composer, and not the computer.

2.4.1.1. Tool Marks

What I refer to as "tool marks" are the traces that are liable to be left by any tool on the final product. An illustration made with a certain brand of pencil is likely to contain discrete markings that an expert will locate, differentiating it from a similar illustration drawn with another brand of pencil. Similarly, a wooden sculpture will reveal traces of the coarseness, shape, and curve of the implement used to chip away the wood. The final work may also reveal whether the tool functioned better in the right hand or left hand of the artist, and the choice of aesthetic or work itself might reveal what types of tasks the tool is best suited for.

Compositions, whether consciously or not, are also influenced by the tools with which they are sculpted. A set of harmonies I construct while sitting at a piano is more likely to not have spacings exceeding the span of my hand, while those written with a guitar are more likely to incorporate open strings, possibly octaves away from the other harmonies. Unlike cruder physical tool marks, these psychological tool marks can be overcome with a little thought, but they nonetheless shift the preponderance of how I compose. This is a concept I will refer to as a "groove", like a path in the road that is pre-worn: it's possible to take another

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[74] Pierre Boulez and Patrick Greussey, "«Et La Musique», entretient avec Philippe Manoury," *Traverses* Machines Virtuelles, no. 44-45 (1988): 133.

[75] Ana Dall'Ara Majek, "La pensée mixte : une approche de la composition par l'interaction des pensées instrumentale, électroacoustique et informatique" (Doctoral Dissertation, Université de Montréal, 2016), 52.

path, but all else being equal, one will take the path of least resistance, and one will use a tool for a job to which it is well suited. Composing inside certain notation software (as opposed to composing by hand and then transcribing on a computer) can also leave tool marks: again, while it's possible to consciously avoid them, one is probably less likely to compose using microtonality or aleatoric sections if one's feedback device - the tool - is better suited to other forms of composition, and if the input device offers less resistance to other forms of writing. Even composing on paper leaves tool marks, and some that are more consistent with what will be seen in CAC. A paper composition serves many purposes, but it acts as an idea feedback device as well, providing visual feedback of a musical idea. The availability of symbols for musical representation can skew the direction of the composition: a standard staff shows a fairly isomorphic representation of a tonal melody, but not an atonal or microtonal one.[76]

The tool marks of CAC often take the form of bugs or imperfections in the tool for doing what it is meant to do, but also through a set of symbols that make some tasks better suited to some tasks than others. Like with a piano, compromises in any one system can lead to evident tool marks in the music: a quantification, that creates oddly complex rhythms when presented with a quintuplet, a jumble of "unused" notes from a pool at the end of a line, or lost articulations through format conversion.

Artistically, tool marks often represent frustrations, for they are a chipping away at the pure formal concept of a work: a compromise with the available tools that, while in a state of attempting to record an intuition, we often make. Even small tool marks can eventually become a defining feature in a work, like a painter who paints many distinct works with the same unique brush. I would contend that the frustration, however, is not necessarily due to the

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[76] This is not to suggest that chromatic or microtonal music cannot be described on a standard staff - composers regularly do this, arguably out of convention. The vertical representation of notes, however, is much more analogous to a tonal arrangement of notes, as is a keyboard. For example, in a tonal C major scale, the staff lines and spaces are perfectly proportioned to give equal space to each note in the scale. A C-major scale with equidistant spacing on a staff will produce a straight line. A chromatic scale, however, will slope slightly less in the areas around B and E. Considering our tendency to associate pitch with the vertical position of notes on a staff, microtonal melodies on a traditional staff are not nearly as isomorphic as tonal scales.

tool mark alone, however, but that the tool is not of our creation, and yet it has an indelible influence on our composition.

CAC, however, provides us an interesting solution to this problem: we create the tool. Of course, some tool marks will be present from the underlying programming environment (we are, after all, building from existing tools), but other tool marks will be from our own creation, whether as bugs or just as natural limitations of the formalization we create. The tool is an extension of ourselves, and not an external product, and thus there is a relationship of "quality" with the tool.[77] A tool mark that becomes a defining aspect of our work imbues the composition with more of ourselves.

The concept of "rut" also applies here: while an instrument or software created by someone else, but that naturally leads us to a specific type of composition, feels like an external constraint upon our creativity, the same constraints created by ourselves may guide the work closer to something that we can claim as our own creative world.

Some tool marks we will still wish to remove, however. Similar to the woodworker, we will sand down some of the rougher edges in some cases, especially of those tools that we did not create ourselves. Perhaps the most evident of these is the overt regularity that a computer system will compile based on a simple formalization; this, in many ways is a tool mark of the computer and not the program. This is not so much defined by what the program does, but by what it does not do. Querying a computer for a chord progression based on a model will not automatically produce this in an interesting rhythm: it will produce it in a calculated, even rhythm for the sake of simplicity. These rigid lines that are drawn by computers, when no other instruction is given, are often lines we will choose to blur or bend. It's important to remember that the human brain is plastic, a "wet squishy computer" that can dynamic respond to the world around it, while a computer's architecture tends to be much more rigid.[78]

[77] See *Zen and the Art of Motorcycle Maintenance* for more information on this idea

[78] Stephen Dubner, "This Is Your Brain on Podcasts," in *Freakonomics Radio* (WNYC Radio, 2016). Minutes 5-7

3. Creating Flexible Intersections Between Intuitive Composition and CAC

It seems perhaps strange to discuss hybridization of disciplines with a discipline that is inherently a combination of two elements from the outset. CAC, as explained above, is already a combination of hand-tooled composition and computer algorithms, with no specific organization of the former. The question then becomes not "can these two be combined", but how can the flow between these disciplines become as expeditious as possible? Further questions drawn from this may be: is there a desired balance between these two founding disciplines of CAC, and are there technologies or tools that could encourage CAC to become more widespread for more varied styles of composition.

3.1. The Personal Justification for New Meeting Spaces Between These Disciplines

My life is a paradox between a deep inclination towards the older traditions of music and a need to explore the digital possibilities of solving problems in these domains. Two personal examples will serve to show the kinds of meeting places in which I enjoy finding new solutions.

As a church organist, primarily in the Anglican tradition, I'm surrounded by the music of Bach, Purcell, Gibbons, Vaughan Williams, Holst and many others. This is my daily music, coupled with modern reharmonizations, interludes, descants, and chorale preludes on these works. I am indebted to the styles, playing techniques, and idiomatic elements of these works as a nurturing part of my weekly musical intake. Picking and organising this traditional music, however, is a challenge, and a large monthly project at that.

As such, I developed databases and algorithms for sorting and linking this music. Small computer programs tell me if a certain hymn shares a melody with other hymns, when the congregation last heard it, whether there are alternate harmonizations or descants available, and which instrument to use or invite (organ, trumpet, guitar, trumpet...). The database also contains subjective information: do I like the work, what mood does it set, do I perceive the congregation as liking it. The software allows me to ensure a coherence and variety of musical selections, to avoid redundancy, and even to find thematic strains. The software, however, does not pick the hymns: this is undertaken with the help of a committee, but the software quickly queries and compiles useful information to facilitate the most interesting choice. Like with CAC, I will sometimes disregard this information in favour of another practical concern or a creative impulse: the ultimate choice is human.

Similarly, I have spent the past year teaching university counterpoint, predominantly in the style of Palestrina. While the writing generally sticks to a Renaissance tradition, the marking is partially automated. Different errors (or omissions) are given different codes, belonging to different subsets of errors, which are then automatically tallied and weighted to suggest an appropriate mark for the student. While the sum of errors cannot explain the sum auditory result of a musical exercise, continually refining the program allows me to formalize and weight more appropriately each aspect on the final result. Every step closer to formalizing how these errors affect the sum musical experience is a step closer to a more nuanced understanding of counterpoint. Of course, there are other musical factors involved, and the suggested mark is precisely that: the software is an assistant serving several purposes. First, it speeds up marking, but it also accomplishes other functions. It helps me internally formalize what it is I'm teaching to better direct my focus during courses. And finally, it serves a check against the inherent biases in marking, similarly to how CAC serves to direct me away from clichéd concepts in my music.

There are other personal motivations to do this, beyond those expounded upon above in section 2.4. Old, traditional, or cliché musical devices take on new life when constrained by specific formal systems. These computational limits provide a great framework for creativity, but the opposite effect also occurs. Programming can be obsessive, and continually returning to the most intuitive forms of composition (improvisation, for example) helps keep my programming better grounded in the auditory experience of the music.

3.2. General Challenges and Approaches

There are a number of general challenges to improving this fluidity between disciplines, responding to my own needs, the needs of others, and my perception of how CAC is used most often in the musical world. These issues are tied to the ability of a composer to shift between the use of computers and intuitive composition, the fact that CAC is more deeply rooted in certain communities, and philosophical issues surrounding technology and the arts. What follows is a short exploration of some of these issues, their potential roots, and suggestions for how they can be rectified. Some of these suggestions have been explored in work for this thesis, and they will be elucidated in the analysis section with some background behind the pieces in which they were used.

3.2.1. Programming Required

One of the primary difficulties for incorporating CAC for those more familiar with intuitive composition, or composing strictly by hand with only instrumental feedback as a guide, is the *level of programming required*. Many composers are not highly trained in programming: our education systems promote the learning of traditional crafts throughout undergraduate degrees in instrumental composition (harmony, analysis, counterpoint, orchestration, performance), but not generally programming. This is not to suggest that it is discouraged, but that natural limits in time mean other potential interests like computer sciences and advanced maths are not necessarily considered. Despite some recent studies showing that music students performed better in mathematics than the control group at a young age,[79] personal experience suggests that there is more inclination amongst composers/performers of instrumental music to explore fields in other arts, literature, classics, or soft sciences before pursuing further in maths and computer sciences.

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[79] See Olive Emil Wetter, Fritz Koerner, and Adrian Schwaninger, "Does musical training improve school performance?," *Instructional Science* 37, no. 4 (2009): 368. This is not to suggest there is a natural inclination one way or another to these fields as a group, as this seems disputable (see Jennifer Haimson, Deanna Swain, and Ellen Winner, "Do Mathematicians Have Above Average Musical Skill?," *Music Perception: An Interdisciplinary Journal* 29, no. 2 (2011): 205.), but that there appears in some studies to be a correlation between the two in primary school learning. This is not the platform to launch extensively into this contentious issue, but simply to point out that musicians would seem to have equal, if not better, ability to handle mathematical learning.

Students studying electronic music, however, are often required to take more courses dealing with physics, algorithms, and logic systems as part of their training. Part of the standard training is often studying languages like Max, PureData or Python, which provide a base in languages.

The sum of these observations leads to one potential problem, and one observation, which can be perceived as a problem depending on your leaning. The first problem is that many instrumental composers face a remarkable uphill battle in an attempt to use algorithms with their work. Some courses exist to help them make this leap. Secondly, it means that a certain group of composers are more likely to engage in CAC: those coming at least partially from an electronic music background, where they already have the framework for handling algorithms. This appears to create a perception of a certain aesthetic of music being served best by CAC, simply because so many composers using CAC come from a specific technological, aesthetic, and musical background. This leads to a further disparity between the field of CAC and intuitive instrumental composition, since instrumental composers don't necessarily see their own ideas reflected back to them when looking at CAC-inspired music.

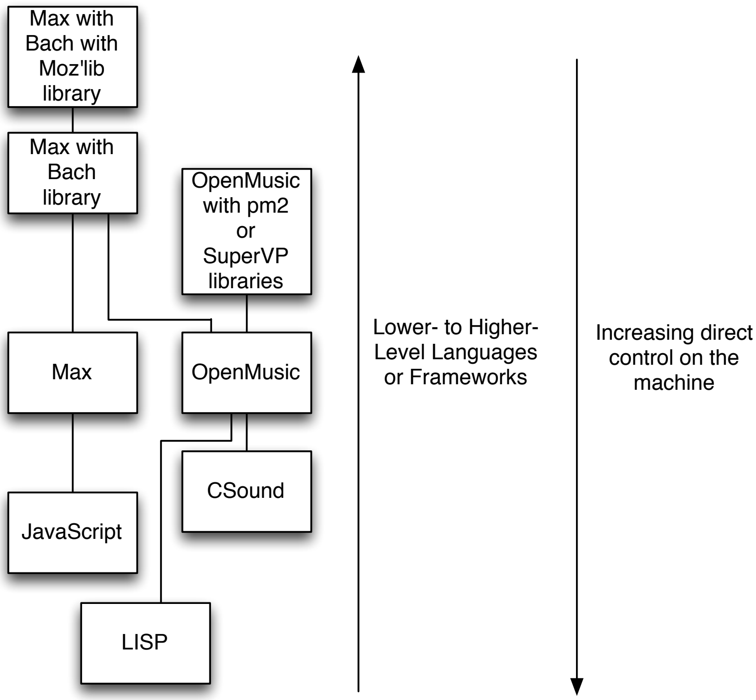

Figure 9 A rough layout of low- to high-level CAC languages, showing how some of these languages are connected to each other

There are several solutions to this problem, and many have already been established, although have not necessarily reaches the necessary audience yet. One solution is to introduce software with preprogramed musical functions that enables a quicker access to the musical necessities of programming without having to be a low-level programmer.[80] This has already been done to a large degree, through programs like PatchWork or OpenMusic, and to some degree, Max. Further modules or libraries have then been developed for this software, such as OM-pm2 and OM-SuperVP for OpenMusic, or *bach automated composer's assistant* for

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[80] Low level programming is the programming closest to the specific code that the machine uses to work (the 1s and 0s, it could be said). Higher and higher level programming tends to see programming ideas more reflective of human understanding. A programming language that allows you to type a statement like "write circle to screen at 30px and 80px" is already quite high-level: human words are used, and under the surface those are converted and complexified to be more specific for the computer. Lower-level programming allows more control, ultimately, but the programmer must be more aware of the "thought process" of the machine.

Max.[81] These modules, in some respects, allow their host software to behave more like high level languages: they enable humans to get the results they are seeking by interacting in more human terms with the machine (see Figure 9 A rough layout of low- to high-level CAC languages). This nesting process of placing higher-level modules into lower-level languages and modules can continue for quite some time, like Russian nesting dolls, representing further and further layers of abstraction from the machine code.[82] Each level of nesting, or new library as in the cases above, generally represents a step closer to higher-level programming.

For example, let's take a simple transposition. At the lowest level, this will be simply 1s and 0s. As we progress towards higher-level programming languages, perhaps the transposition can be expressed as a set of numbers (the notes) to which we add another number after breaking down the pitch, time, and timbre information of each note. A level higher might allow us to describe the notes by note names and the transpositions by musical intervals, while another level higher might actually show us a staff. The higher we go, the closer to human thinking about instrumental music.

This means moving closer the composer's final musical intentions and towards usability, but it also generally represents some sacrifice of very detailed control because layers of language interpreters have to exist to understand the code. Part of my work has involved developing further patches, algorithms, and interfaces on top of these existing ones, bringing the tools of the software immediately closer to a musical vision. This is also done with the hope that this approach and these tools can be shared to allow other composers interested in working with the same kinds of musical materials to bypass much of the more difficult programming. This does, however, require a shared musical vision, since the more the tools are intuitively interactive with the user, the more specific their function tends to be.

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[81] *bach* will be discussed later in some detail, but more detailed information can be found in A. Agostini, D. Ghisi, "A Max Library for Musical Notation and Computer-Aided Composition", Computer Music Journal, Volume 39, No. 2, p. 11–27, 2015

[82] Daniel Spiewak, "Defining High, Mid and Low-Level Languages," http://www.codecommit.com/blog/java/defining-high-mid-and-low-level-languages.

This process can be anything from creating a simplified musical function for transposition from an existing addition function (since transposition is either positive or negative addition) all the way up to elaborate software with user interfaces and gestural inputs. The level of the function (whether it's a machine level calculation or a user interface) will dictate the amount of programming background the user requires, and how accessible CAC becomes for composers.

3.2.1.1. Plugins

It's fair to point out that the "plugins" in Sibelius and Finale are also forms of CAC, these essentially being algorithms designed to alter elements of a score. These tools are mostly basic mechanical processes, designed to speed up the process of composing, but not necessarily designed to provoke new trains of thought. They are things like transposition, retrograde, inversion, straighten written-out swing. There are, however, a small number of tools that more closely represent the suggestive power of CAC, such as "rotate" or "randomize" pitches, augment intervals, pitch mapping, interpolation, and so forth.[83] The language for writing plugins in Sibelius, *ManuScript*, is actual quite simple as programming languages go, but is still not easily learned by someone who has not previously programmed (see Figure 10).[84]

```
    if (item.Type = "NoteRest") {
         if (item.ParentTupletIfAny != null) {
              ratio =
((item.ParentTupletIfAny.Right*1.)/(item.ParentTupletIfAny.Left*1.));
              return (Round(ratio*item.Duration));
         } else {
              return (item.Duration);
         }
    }
```

Figure 10 A small part of a controlled aleatory plugin written in *ManuScript*

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[83] These particular examples are found in Sibelius 7.5. Finale has similar functions, and offered the possibility to import from or export to OpenMusic until Finale 2009.

[84] Details about the structure of the language can be found in: Jonathan Finn et al., "Sibelius 7: Using the ManuScript language," (Avid, 2011), 5.

The other problem with using *ManuScript* as a starting point for CAC is that it is a score-based language more than a music-based language. Objects contain an excess of information concerning their positioning and their visual appearance, while things like time-based calculations are very difficult because notes always "belong" to a specific bar, a constraint that is often arbitrary for modern (or early) music. Being ultimately an engraving program more than a composition program, the language is structured as such. Of course, other solutions are approaching for this problem as well: programming is being incorporated increasingly into school curricula, and more portable, higher-level languages are being increasingly exploited for musical purposes, such as Python.

3.2.2. Speed, Time, and Competing Thinking Processes

Another hindrance to the effective use of CAC can be *speed*, and while related to the previous issue, it can affect a different group of composers. The issue with speed is perhaps better expressed as *time*, for it is not the capacity of a composer to program, and not necessarily the speed at which they do such, but the time it takes to move between algorithms and intuition. Essentially, an interesting idea, sometimes one that is not easily conveyed through words or sketches, can be lost in the intervening time between when it comes to mind and when an algorithm is complete allowing its realizing. Or worse, the inherent inspiration the idea carried with it may have disappeared.

This doesn't necessarily affect composers whose inspiration always lies directly in the algorithm itself, but for those who voyage between the two worlds often. Xavier Rodet and Pierre Cointe, who referred to a “complexity barrier” in CAC, acknowledged this exact problem thirty years ago:

> In MCS [Musical composition and synthesis], perhaps even more than in artificial intelligence, programs have to be tested, modified, and rewritten very often. This modification must be effected quickly and easily; otherwise, the continuity between musical ideas and results gets lost.[85]

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[85] Rodet Rodet, Potard, and Barrière, "The CHANT Project: From the Synthesis of the Singing Voice to Synthesis in General," 32.

Perhaps the closest compositional analogue comes from composing using a piano to simulate harmonies (another "assistant"). Many times while improvising in order to develop an idea, I have come across an interesting harmony requiring both hands that I was determined to write down. By reordering my fingers and attempting to memorize some of the notes I could no longer hold, I would keep one hand on the keyboard while quickly scribbling down the chord with the other hand. While this device proved successful, in the meantime I will have lost my musical train of thought and the flow of where my fingers wanted to go to find the *next* chord. This approximates the problem often faced with CAC.

Granted, our software has come a long ways since then: we now have dedicated software for music, with visual interfaces and computer-based objects. But the problem still persists, because even the most basic processes still require some programming, using that "analytical system 2" Kahneman talked about. The problem with this analytical and severe way of functioning is that many creative impulses never make it past the analytical stages. In my own experience, when I am feeling overly analytical, I become blocked: the analytical mind rejects ideas before they have germinated. Regardless of whether these ideas would have been good, other ideas don't come forward. Imagine suggesting several ideas in the same day to your employer, all of which are swiftly rejected: you probably would not suggest another idea that day, regardless of how convinced you were of its quality.

What is essentially at stake here is the barrier between formalization (Kahneman's system 2) and raw creativity (Kahneman's system 1), regardless of whether computers are involved. These systems can functions collaboratively, but system 2 tends to filter system 1.[86] As a composer, that means that system 2 can often get in the way of the very necessary intuitive thinking of system 1, and the time and effort involved in moving from system 2 back to the unfiltered system 1 can be discouraging and slow.

Again, there are a number of general proposals to deal with this, many of which involve better software in various forms. Improvements here may improve input/output mechanisms (just getting music into CAC software can be time-consuming), objects more

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[86] Kahneman, *Thinking, Fast and Slow*, 44.

closely associated with the musical sound, simulation practices to allow musical feedback from algorithms, and software that even allows gestures rather than programming to elicit a notated result. Some of these solutions that have been specific to my work will be discussed in the next section on combinations, while more algorithmic solutions will be discussed in the analysis section.

3.2.3. Computers and the Creative Instrumental Composition Process

Another far more subjective statement I might make about composing instrumental music, with the intent that it only be applied to me, is that excessive time in front of computers can easily take me out of my creative element. It's perhaps best to point out first that time in front of a computer is time away from other elements that are useful for my creativity. It's time away from a tactile and acoustic approach to an instrument, and thus places me in a different frame of mind. It's also time not spent using pen and paper, which I ultimately find less constraining than a computer. Computers have theoretically no constraints, but most software limits you to specific symbols, layouts, and patterns. Software that doesn't (basic drawing programs, for example) serve no significant advantages over pencil and paper, as far as my compositional process is concerned. Furthermore, while computers can simulate instruments in many regards, they often don't properly account for idiomatic constraints or preferences of an instrument (for example, a computer can "play" a fast flute line 30 seconds long without ever breathing)

Furthermore, I have often felt that excessive time in front of screens dulls my other senses, and consequently my inspiration for new musical ideas. While this is not scientific, but rather a personal empirical observation, there is some research showing that children who spend excessive time in front of screens have reduced creative imagination.[87] I am far from suggesting that computers, as a whole, stunt creativity: this document hopefully serves as testimony to the contrary, but rather that certain forms of computer use remove me from certain forms of impulse and instrumental creativity.

[87] Karen Martin, "Electronic Overload: The Impact of Excessive Screen Use on Child and Adolescent Health and Wellbeing," (Perth, Western Australia: Department of Sport and Recreation, 2011), 3.

Finally, in my own experience, collaborative projects work better in rooms without computers. A piano, organ or pencil and paper have served me as better collaborative tools than a computer when working with performers. While there is no specific research on composers and performers collaborating with computers in the room, there is some interesting surrogate research involving doctors and patients, suggesting that a computer represents less eye-to-eye time and less of a personal relationship.[88] This, I would postulate, could be a major drain on the creative process.

Some solutions will be explored more in the section on how I personally combine these disciplines, but a couple of possible directions are worth mentioning outright. The first is that computers can serve in cognitive priming in order to brainstorm.[89] It deserves exploring whether they can serve in priming instrumental creativity in similar ways that an instrument might. The second possibility is creating CAC tools that allow more freedoms, specifically through gesture, to overcome what feels like the symbolic limitations of computers. This has already been done extensively for live music, so the question became could it be done for CAC and to what degree.

3.3. Combinations

Before delving into the specifics of how individual works were created with different modes of CAC, it's worth looking at some of the overriding approaches at which I've arrived for effectively integrating CAC into intuitive composition, starting with the larger trains of thoughts, and working down towards more specific preparations I make in my process. These might be seen as three building blocks to prepare a space for this creativity: the philosophical underpinnings, the necessary compositional material for a process, and the physical and

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[88] Emran Rouf et al., "Computers in the Exam Room: Differences in Physician–Patient Interaction May Be Due to Physician Experience," *Journal of General Internal Medicine* 22, no. 1 (2007).

[89] Alan R. Dennis, Randall K. Minas, and Akshay P. Bhagwatwar, "Sparking Creativity: Improving Electronic Brainstorming with Individual Cognitive Priming," *Journal of Management Information Systems* 29, no. 4 (2013).

worldly elements that help to reunite these. From these, we build the more specific systems from which actual music is created.

3.3.1. Philosophy

3.3.1.1. CAC is an Extension of the Mind, with Technical, but not Artistic Advantages

This is the primary philosophy behind my use of CAC, from which many others can be extrapolated, but inside of which all my art can be conceived.

Underlying this is the fact that a computer, in its present state, cannot formalize anything on its own. It carries out the instructions of its user, and even with the concept of "machine learning" considered, the user sets the parameters. The computer has a greater memory, greater speed, and perhaps most importantly, the capacity to *not remember*: to let go of bias. Seeing CAC as an extension of the mind, we can derive a few more important concepts.

3.3.1.1.1. CAC is a descriptor, not a definition

If CAC is an extension of the mind, than it is truly the mind that composes, and not the computer. The piece can no longer be defined as being composed by CAC, and thus, CAC becomes something within the piece. This sounds trivial, but if a bookcase were defined by the use of a hammer, the workman would feel the need to incorporate a hammer wherever possible. "To a man with a hammer, every problem is a nail" thus becomes an appropriate descriptor, and we search for problems to solve with our tool, even when it is not necessary. This presents a similar problem to the common human heuristic of mentally answering not the question we are asked, but that for which we have the best response.[90] If our only available response is CAC, every problem is reframed in this optic, and the composer loses their ability to *choose:* one of the foundations of CAC. This would be unfortunate, because:

[90] Kahneman, *Thinking, Fast and Slow*, 97.

3.3.1.1.2. CAC is one of many tools

Defining a work by CAC places the composer in the uncomfortable space of feeling a need to use CAC to the disadvantage of many other tools. As previously mentioned, CAC is a manner of working that implies the interplay of the composer's intuition in every step of the process, and if other tools are also extensions of our mind, like CAC is, then they as well have place in the process. Some works may not need several tools: it's a question of availability.

3.3.1.1.3. CAC is a kaleidoscope through which we may see musical material differently

CAC allows us to see musical material in new ways. This is similar to the old basic formalizations of retrograde or inversion, but with the possibility of much more elaborate transformations. Much like a kaleidoscope, however, the function only exists with an object in front of it, and an eye behind it to see and interpret the changes in light. The computer has done nothing artistic, which would involve choices. Like a kaleidoscope, it has not even decided what to transform or look at. It has simply transformed the perspective of some material based on a straightforward formalization. The composer remains the eye on the other side, without which there is no effect, no choice, and no mental interpretation or reaction. As such, it's an extension of the mind.

3.3.2. CAC Process Ingredients

While the overall influences of my work are discussed at length above, a short explanation is necessary to depict how these influences translate into a musical work. While there is no formula for a work, I present below some broad generalities about the starting points and developments for pieces, and how the elaboration of these two categories connect, taking into consideration the use of CAC.

3.3.2.1. Musical Seed

The initial seed of a project generally takes one or more of six forms. It may take the shape of an artistic model, a theoretical model, a gesture, an audio sample, an algorithm, or an instrumental score sample. Invariably, however, one of the former four is transformed into one (or several) of the latter two as an early step in the process.

Poems, paintings, emotional situations, or other works of art provide the foundation for an artistic model, while scientific, political, or statistical phenomena provide the basis for a theoretical model. In a theoretical model, there is a higher degree of visible isomorphism between the inspiration and the musical starting point than in an artistic model, where the starting point passes through a series of mental filters and inspirations of which I am not always fully cognisant. Artistic models have a tendency to become musical passages outright, while theoretical models have a tendency to become algorithms first.

The use of raw audio could be seen as an extension of a theoretical model or an artistic model, depending on the specifics of how it is used, and consequently passes through an algorithm or directly to the intuitive composition of an instrumental idea. Gestures may pass through either of these: in some cases, they provide the basis for more intuitive composition, while sometimes they are the direct material used in CAC to generate further musical material.

Regardless of the seed material, however, I prefer not to remain in the theoretical domain too long at the outset of a work. As such, when a piece begins with an algorithm, I quickly find means of rendering it conventional notation, so that I have the means to assess its musicality and intervene where necessary. While I am perfectly comfortable beginning a work intuitively, and launching directly into a further intuitive composition process, I avoid remaining too long in the theoretical or modeled world. In my work, CAC requires emotional and intuitive intervention at each step along the way.

Thus gestures or audio become theoretical or artistic models, and these models become either algorithms or musical passages. Furthermore, algorithms subsequently become musical passages before any true writing takes place. This, for me, is a necessity in keeping a work grounded in the oral reality.

As an aside, the musical source material of others that I tend to use separates almost evenly between the categories of theoretical and artistic models, much like audio samples. In either case, however, they are rarely the primary material: they are not the underlying concept from which a piece is born, but a secondary material processed by the underlying concept.

3.3.2.2. Development

Regardless of whether a work starts from a theoretical model or another model further down the chain, most works undergo some development through CAC. There is a slight inverse relationship between whether the seed material of a work was CAC and whether it undergoes development using CAC. Works whose seed material is in CAC have often provided sufficient constraints to point me towards interesting developments by my own intuitive means: they rarely risk sounding jaded or cliché, because the less intuitive material on which the piece is based has not grown out of the same subconscious that has been developed many times in other pieces. However, if intuitive material, without significant constraints, provided the basis for the piece, CAC is more often used, as an aid in helping me formally vary the approach between works, constraining me to develop intuitive ideas differently in different works. In short, this is both a creative approach and a pedagogical one: it is a means of constraining myself to break free from the "groove" of my intuitive thinking at some point in the process.

The tools for development have some specific criteria, and because in developing a piece, there is already an advanced musical train of thought, these tools are most helpful if they do not take too long to prepare, lest they break the creative flow of the piece. The first criterion is that they be advanced as possible from the outset while retaining the flexibility needed. This is actually achieved through a slow, methodical, progressive build-up and cataloguing of tools. For example, if in one work, I need to develop a tool for spectral transposition (you may imagine it as whatever you like), I create the tool to be as flexible as possible, allowing it to potentially be implicated in other works further on. I don't want the process to necessitate complexity, so the concept of *default* is very important, but a tool should be sufficiently flexible to be portable between pieces. For reasons that will be seen, I must always maintain away to adjust the source code of these tools.

As such, when I arrive a year later to work on another piece that requires a similar sort of "spectral transposition", the tool is ready, easily found, and hopefully containing the flexibility to function in this context. If it isn't, the source code and compiler are nearby, and it can be adjusted as needed. The tools, algorithms, and programs must remain dynamic, but backwards compatible. Due to this extensive process, year over year, many tools are quickly available.

For my purposes, tools should also be as modular as possible, and designed to communicate in a common language. Developments of ideas are rarely in one dimension only, and thus several often need to be combined. They are most effectively when one can work dynamically with several different processes at a time, without having to retrace steps between them. The common language, be it *MIDIcents*,[91] *MIDI*, *musicXML*, or *LISP* objects, allows tools to effectively pass their product directly to the next tool, streamlining the work process.

The tools must have a feedback mechanism that comes as close to a musical reality as possible. In the development of a work, it's not only necessary that models are internally consistent, but they must maintain consistency with the music surrounding them. For this, either an auditory simulation or readable music is necessary, allowing the composer to verify the effect of the development against the existing passages.

The tools function best for me when their actual control places me back in that intuitive domain of *system 1*. If the idea is to connect with the intuitively designed music that preceded it,[92] then a development must be intuitively verified, and thus the mind of the composer needs to remain in that intuitive *system 1*. As such, tools allowing for visual control of something, especially those that equate easily to manual control, help maintain that intuitive state-of-mind, while instructions more rooted in code tend to produce a *system 2* reaction.

Finally, the tools must generally be able to import and export in notated musical formats. Because a development is predicated on existing music, it's often necessary to import this music as a starting point for a development (whereas in the beginning of a piece, an idea may be modeled from a completely abstract algorithm). Similarly, because my developments are meant to be expansive: to grow something out of a smaller idea, the significant musical

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[91] *MIDIcents* are based on MIDI note numbers, but multiplied by 100, allowing for the expression of microtonal deviations. For example, the MIDI note number for middle C is 60. In *MIDIcents*, this is 6000. A quarter tone above middle C would be 6050, and an eighth of a tone below would be 5975.

[92] Obviously, there are cases where juxtapositions are desired here, and this is another matter.

output must have a means of being returned to the score, and again without breaking the creative flow.

3.3.3. Raw Materials

Finally, some of the specific raw materials and how they're used can have major implications for the final results of the music.

3.3.3.1.1. Computers

The details of language and program are mostly irrelevant for the general philosophy, but there are basic elements that have remained the same in progressions from tools like *CSound* to *Max*. First and foremost, some sort of programming language is required, and it must allow the user to access both high and low level programming: processes that are closer to the user and those that are closer to the system. Lower level programs allow a detailed control that is inherently necessary for certain truly original ideas, yet high level objects allow us to remain closer to the sonic/visual reality of the music. Obviously, the closer the objects come to representing my musical reality, the better they will provide feedback.

A device allowing gestures as a means of control is also essential for maintaining that link, however all of today's computers have at least a basic mouse or trackpad, fulfilling this need. The closer the gesture can remain to intuition, however, the more useful it may become: a writing pad or Kinect[93] may allow the user express something beyond what a mouse would, and will also pull more dimensions of information.

Finally, sound libraries are helpful in some cases, especially in cases where the feedback loop between the idea and CAC is intended to be short, and where multi-instrumental ideas are being auditioned. In cases where only raw pitch material is used, a harmonic instrument suffices as a feedback mechanism, and in some cases is preferable, allowing more nuanced testing of the ideas, and allowing some freedom to improvise from such ideas. However, with ideas relating to specific orchestrations, melodies, or rhythms, a

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[93] Kinect is a set of motion sensing devices developed by Microsoft, and used with XBox. There are numerous tools allowing them to integrate with Max, and thus for their gestures to control musical material.

sound library provides the best approximation and shortens the latency between idea and simulation.

3.3.4. Generalized Ideas about Approaching this Meeting Space

3.3.4.1. Singing or Playing

The means to approach the relationship with CAC are varied and subjective, but two key guidelines have developed in how I use CAC in my music, the first of which is to sing or play generated material. A computer's simulation of acoustic instruments, especially one that is raw output from an algorithm, often does little to convey musicality of an idea, whether it be a harmonic sequence, a rhythmic pattern, a melody, or any combination of these. Even an elementary reading of the material using a real instrument or voice (by a musician) often gives a better idea of its musical capacity than a computer does, and furthermore, may be a better guide in how the musical material can be used. In many cases in my process, raw, relatively objective or seemingly astylistic material from an algorithm proves more interesting through improvisation, and simply playing through it by hand can be especially suggestive of a particular musical gesture. One could say that instrumental music does not come alive until it is played, and while this may be true of any music written by hand, the parts of my music generated by programmed abstractions does not necessarily have an intuitive strain to it from the outset, and therefore needs to be imbued with meaning through performance.

3.3.4.2. Time and Space

> You don't have to go fishing, of course, to fix your motorcycle. A cup of coffee, a walk around the block, sometimes just putting off the job for five minutes of silence is enough.
>
> Zen and the Art of Motorcycle Maintenance[94]

Much like fixing a motorcycle, time and space away from programming CAC have proved immensely important to me. Computer logic is by nature rigid and objective, while

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[94] Pirsig, *Zen and the Art of Motorcycle Maintenance : an Inquiry into Values*. location 265.

creativity is generally considered to be flexible and subjective.[95] Computers and creativity certainly coexist well in many contexts, but the aforementioned computational thinking alongside problem solving can also inspire some sense of rigidity of thought over time - constricting ideas to the logical possibilities of the machine, which is not necessarily conducive to the creative process. Time and space away help here, and on a number of other levels.

First, computers programs are like logic puzzles in many respects, especially once the idea is clear. It's easy to become obsessed with the puzzle, while forgetting that composing music, and not solving the puzzle is not the final goal. Time helps to refocus on priorities.

Secondly, time allows us to forget. While simulation plays an important role in much composition today, it has a heightened role in CAC due to the testing of musically unverified models under a large variety of circumstances. The act of listening to several simulations of similar concepts may render it familiar enough to sound attractive, even in cases where it wouldn't upon a first listening,[96] and thus time is needed to help reset this relationship.

Finally, by taking regular time away from computers, I allow myself to be primed by different environments, reframing of a computational situation in many cases. This often helps to see solutions to bugs that were not immediately evident sitting at a computer.

All of this resembles the *Creative Pause Technique,*[97] and it's especially relevant when hoping to move seamlessly back and forth between intuitive and logical environment. While this is a tool engaged by many composers in some form, it takes on additional importance given the potential for a highly addictive nature in the coding-testing-debugging cycles.[98] As

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[95] Geraldine A. Shaw and Stephen T. DeMers, "The Relationship of Imagery to Originality, Flexibility and Fluency in Creative Thinking," *Journal of Mental Imagery* 10, no. 1 (1986): 65.

[96] This relationship between familiarity and liking has been well documented, especially for popular music. See Adrian C. North and David J. Hargreaves, "Subjective Complexity, Familiarity, and Liking for Popular Music," (US: The Florida State University, 1995).

[97] Edward De Bono, *Serious Creativity* (London: Vermilion, 2015), 86.

[98] John P. Charlton, "A Factor-Analytic Investigation of Computer 'Addiction' and Engagement," *British Journal of Psychology* 93(2002): 342.

such, not only do I require time and space away from CAC, but I must consciously plan and take it.

4. Analysis

4.1. Introduction

The musical output relevant to my research project includes over a dozen different works, ranging from works for solo organ to works for orchestra, and represents over 1.5 hours of music. What these works share is some amount of interplay between intuitive composition and CAC, ranging from situations where information systems were present only in the conception of the piece to places where fully-playable sections were generated using algorithmic processes.

For the sake of being able to truly delve into the internal mechanics of some of these pieces, only about half of the works will be subject to a detailed analysis. As we enter each section of the analysis, a brief introduction will serve to justify why certain works were chosen for fuller analysis. The following section, however, serves to introduce all of the works that were written, and provides some background on their inspiration, their use of CAC, their instrumentation, and their performance context where applicable. The pieces are organised by size of instrumentation, from works for solo performers up to those for large ensembles.

It's important to mention outright that concepts around depression and anxiety serve as inspiration for both small musical ideas and larger forms in several works. The fragmented, jagged repetitions in works like *Mutations II* or *Short Pieces on Falling* ("Choke") are motivic representations of common anxiety symptoms, such as loss of breath, inability to rest, or trembling.[99] Other works, like "Follow" from *Short Pieces on Falling*, try to capture the loss of energy and trouble concentrating many experience with depression,[100] through haphazardly attacked chords and the absence of harmonic functions. This particular inspiration is presented here instead of piece-by-piece, to not detract from the primary focus of the thesis.

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[99] Melinda Smith, Lawrence Robinson, and Jeanne Segal, "Anxiety Disorders and Anxiety Attacks," HelpGuide.org, https://helpguide.org/articles/anxiety/anxiety-disorders-and-anxiety-attacks.htm.

[100] "Depression Symptoms and Warning Signs," HelpGuide.org, https://helpguide.org/articles/depression/depression-symptoms-and-warning-signs.htm.

4.2. Works Submitted

Ruminations on the Season - 15 minutes, 4 pieces for organ from a larger set

These interludes for organ were written simply as a reflection on the season between late Winter and early Spring, a fairly impulsive answer to the emotions and torment that this particular season tends to inspire in me. A selection of 5 has been included as being representative for this document. They are less directional and dramatic than other works, and are meant to be more contemplative or evocative than narrative. The interludes included have used a variety of types of CAC, including *ScoreScrub.* Three of them were premiered by Alexandra Fol in Montreal in Spring 2017.

Mutations I and II - 12 minutes, Organ

These organ works, built on the play on words representing both a type of organ stop and the transformative processes of CAC in the music, are both designed for 3 manual French organs (though they may work on any 2-3 manual organ). Mutations I is an experiment in the synthesis between free sections with artificial resonance and strict counterpoint sections, reminiscent of Baroque organ works. Mutations II exploits the inherently unpredictable nature of anxiety, exploring both its immediate surface effects and its slower underlying agitations. Mutations I, based loosely on a Swedish folk melody, makes extensive use of CAC to develop progressions in OpenMusic. Mutations II features extensive use of CAC-generated pitch-fields in its middle section.

Never a Moment Lost - 6 min, Piano and Violin

This controlled aleatory work was inspired by the inevitable passage of time, and the corresponding sentiment that such time is never truly lost, but is rolled into who we become. As the improvisation becomes the piece, this idea is played out through the music not being lost, but being performed, or learned as part of a future performance, with each section dedicated to the forward motion of the music. While the underlying musical material of the piece is derived from the double-stop open strings of a violin, much of the more complex harmonic material was generated using OpenMusic, and the middle of the piece is defined by this. This piece grew out of a creative context where I felt the need to allow performers more suggestive space in my music. It was premiered by Katarzyna Fraj (violin) and the author in November 2016 in Montreal.

Gift I and II - 15 minutes, piccolo trumpet and piano

These pieces occupy a special place for me because they are written for my wife, who happens to be a piccolo trumpet player. The word gift implies “present” but also the Swedish word for “married,” and the second movement was played in part at our marriage. This work is again partially based on a Swedish *spelmanssång,* or folk song, and represents an attempt at simplicity while still incorporating elements of CAC. In the first and second movements, *ScoreScrub* was used to develop more rhythmic sections of the piece, while more basic pitch modulation techniques were used in the second movement as part of the development. These are largely a nod to many of the romantic Swedish composers who have influenced my music. These were premiered (in their current incarnation) by Nils Ek (trumpet) and Marcus Tom-Pack (piano) in 2016.

Lullabies for Little Boys Who Will Not Sleep Anyways - 15 min, Piano, Toy piano, Fixed Electronics

This suite of 3 pieces is not actually intended as lullabies, but as music to keep the listener engaged in a half dream-like state until one may actually sleep. It's inspired by the way both my son and I seemingly fall asleep, and by the toys and sounds he likes to play with. CAC played a crucial role in the creation of the actual score: *ScoreScrub* was used extensively in these works to produce large segments of the piece, in both the electronics and instrumental parts. This was done through a quasi-improvisation that allowed control over motives, speeds, orchestration, and some other effects. Both my children received toy pianos for their first birthdays, and played with them extensively, and this piece was partially a response to that. Movements 1 and 3 were premiered in Montreal in October 2016 by Daphnée Chabalier (piano) and Julien Gagnon (toy piano).

What Maria Hears - 6 min, Guitar, Flute and Cello (include poem in final description)

A reflection on art nested in art, this work is based on a piece by the Swedish Composer CJL Almqvist (*Den Lyssnande Maria*), which is itself based on paintings of the virgin Mary by Spanish artist Murillo,[101] based on the biblical story of the annunciation. The work attempts to capture some of the emotions from the poem, and also to imagine Maria's emotions at the annunciation. Not being Catholic myself, and seeing Mary entirely as human, there is an attempt to humanize these emotions - to render them less serious than they are often considered. CAC played important roles, both for low-level pitch generation in the opening sections, and then for progression management in a couple of the later sections, allowing for a quasi-linear, but complex, development of the material.

Läst Igen: Fredmans Epistel N:o 27 - 11 minutes, Baritone voice, alto recorder, harpsichord, and viol de gamba. Text by C.M. Bellman

Translating roughly to *Fredman's Epistle No. 27 Reread,* this piece is based on an existing song by the 18th century Swedish songwriter Carl Michael Bellman, from a set of songs about drinking, love, and as in this particular piece, death.[102] Inspired strongly by the lilt and melodic flow of the original, the piece is harmonized by superposed major-minor chords, representing the bittersweet lamentations of Fredman, and harmonies derived from the spectral analysis of recorder overtones. The choice of instruments was inspired by the original era from which this song is taken.

Short Pieces on Falling - 20 minutes, Flute, Clarinet, Piano, Violin, Cello

These short works all grow out of the singular idea of falling as the emotional underlying factor in conjunction with other descriptors, which are the movement titles. They were used as exploratory pieces for various CAC techniques, from simple pitch field generation to more elaborate control of the entire ensemble, either through progression

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[101] Various, "Den svenska sångboken," ed. Anders Palm and Johan Stenström (Stockholm: Albert Bonniers Förlag, 2003), 587.

[102] A transcription of this Bellman work and many others can be found in "Den svenska sångboken," ed. Anders Palm and Johan Stenström (Stockholm: Albert Bonniers Förlag, 2003), 94. An English translation can be found in Paul Britten Austin, ed. *Carl Michael Bellman: Fredman's Epistles & Songs. A Selection in English with A Short Introduction* (Stockholm: Proprius förlag AB / Unesco Publishing, 1999), 42-43.

management or through *ScoreScrub*. They provided a creative workspace to test techniques without devoting entire full-length pieces to them, in a versatile instrumental environment. "Run", "Waves", "Lush", and "Choke" were premiered in October 2016 by Marie-Hélène Rondeau (flute), Chester Howard (clarinet), Eva Lachhar (piano), Katarzyna Fraj (violin), and Thieres Brandini (cello), under the direction of Tiphaine Legrand. The movements are:

Run .... Suggestive of a chase, the character here is nonetheless stumbling as they attempt to evade something. The gritty harmonies were developed in CAC through a kind of artificial spectrum.

Waves..... Inspired by the rise and fall of waves on a lake throughout the day, the name also refers to the use of Frequency Modulation to develop the harmonies.

Lush........ The name describes the thick, romantic textures in most of this work, with the instruments falling over one another in a continuously evolving, yet imitative counterpoint. This was developed through recursive algorithms to continuously generate new melodies.

Choke ..... This is the anxiety-ridden stage of falling short of oxygen, and the moments of clarity that follow as air returns to one's lungs. Through CAC, increasingly large frequency modulated clusters create a momentum of density.

Rings ...... While the ensemble remains somewhat connected throughout, this seeks to sound like it's perpetually fraying at the edges - as if the instruments are within the realm of rhythmically falling apart. Rings draws its name from the modulation used to generate the harmonies.

Love........ Falling in love, for me, has always been an emotion that seems to come from a strong underlying current deep inside of me, radiating slowly out, but only showing the mildest of reflections on the surface. The cello in this work captures that role, while the piano harmonies are generated through ring modulation, significant for the way it encloses the original frequency in a sort of musical embrace.

Follow .... This work is built on the concept of following, as the instruments seem to follow each other throughout the work (and actually do follow each other at one point). There is a sense that they follow so closely that they are tripping, and falling, over one another. Much of this was developed using delays in *ScoreScrub*, software for CAC.

Float........ Based on quick cycles of floating up and falling gently back down, the piece nonetheless retains a rhythmic intensity throughout. The modular progression management system (a series of CAC algorithms) was used for the development.

Sliding Apart - 11 minutes, flute, clarinet, piano, violin, cello

This work was one of the first in which I explored various uses of CAC in the same work, especially including progressions for several instruments with some degree of randomisation. As someone who has long worked with amateur ensembles, the work is inspired by the disquieting states of works that feel like they are about to fall apart in performance, and allowed me to explore the bounds of my comfort with randomized attacks between instruments in a piece. An earlier version of this piece was read by the Meitar Ensemble in 2014, before being considerably overhauled.

Melodious Viscosity (Still Flows) - 15 minutes, wind quintet

Melodious Viscosity is a musical interpretation of the dynamic state of viscosity, where the music represents a liquid undergoing changing states of thickness and speed, and asking the questions: when does a liquid become solid and how does its flow change over different surfaces. This piece was an early look into the possibilities of managing motive-based progressions with modular patches in OpenMusic, and at the shifting gray zone which can be either occupied by CAC or composition by hand. It was premièred by the Brèva wind quintet in 2014.

A Little Snow - 7 min, Women's Choir, poetry by Emily Dickinson

This piece, written for the Aella women's choir of Ottawa, was inspired directly by the poetry upon which is was based, whose choice was in turn inspired by the pervasive sexism during the 2016 American election campaign. This particular work used, in its final creation, no elements generated by a computer, and yet it probably presents some of the strongest formal and analytical traces of CAC. The work, based on Scriabin's mystic chord and its derived scale alternates between freely composed sections, and slow stochastic builds of various motives by different members of the choir. The work was premiered in Ottawa in February, 2017

Vinst och Förlust - 5 min, Mixed Choir and Flute, poetry by Viktor Rydberg

This work for SATB choir and flute is about the constant efforts we make to tame nature, to finish by seeking out only that which is truly natural. The middle contrapuntal section of this piece uses a series of recursively-generated pitch fields as its harmonic material. OpenMusic was used for the generation of material in this work, but played a relatively small roll in the shape of the final work. The piece's textures were inspired by the harsh openness of much of the Swedish landscape, and the pervasiveness of light throughout the day. It was premièred at the Montreal Botanical Gardens by Ensemble Kô in the summer of 2015, directed by Tiphaine Legrand, and with Marie-Hélène Rondeau on flute.

Like a Square Peg - 15 min, String orchestra with solo violin

This piece is inspired by struggles with feelings of inclusion in a mental health context. The solo violin in this work exemplifies the feeling of one who, despite their inherent strengths and capacities, feels isolated and incapable of sharing fully with the world around them. This work uses CAC to generate complex pitch fields that help shape the harmonic progressions in several parts of the piece. Occasionally, the melody is even prescribed by CAC, and the closing section of the work is a long progression, generated with the help of my modular progression management system in OpenMusic. Katarzyna Fraj consulted extensively on the violin part.

Världen och Jag - 13 min, Orchestra

This work, inspired by struggles with a sense of community, plays out in the sense of opposition between the composer and the perceived obstacles in society. The work used specialized patches in OpenMusic to generate specific passages in the music, and to create gradients between pitch fields. It also used *ScoreScrub* to generate much of the orchestral material for a large middle section. A first version of this work was read by the Université de

Montréal orchestra under the direction of Christos Kolovos in 2015, but has been drastically altered since then.

4.3. Analysis Organization

The analysis portion will examine six of the pieces in detail, looking especially at how a flexible workflow allowed the interplay between intuitively composed sections and sections developed using CAC, and revealing areas where the residual computational thought nonetheless remained present. It will explore different attempts at incorporating CAC at different places in the creative process, beginning with situations in which CAC and intuitive composition were loosely related, and working towards examples in where they worked with nearly simultaneous integration. Split into three sections, the areas can be seen as follows:

1. Low integration of CAC, where materials developed algorithmically were ultimately used as guidelines for intuitive composing, reflecting more closely the influences of Chapter 1.
2. Medium integration of CAC, where composer-designed algorithms generated musical passages with only limited intuitive guidelines, reflecting more explicitly the role of CAC alone. The principle system explored here is the modular progression management system.
3. High integration of CAC, where intuitive gestures work closely within original software, reflecting a fuller synthesis of these two worlds. The principle system explored here is the *ScoreScrub*.

This grouping does not always represent the order of composition, and in many cases does not showcase the only way that CAC was used in a piece. My works most often use algorithms for the elaboration of micro-structures: "small musical materials that require musical deployment in larger structures".[103] As such, any piece may incorporate any number of CAC processes throughout, but those chosen for each section contain sections that are clearly representative of that approach. Each section will conclude with a summary, showing where other pieces used similar techniques, but with a more limited analytical background.

[103] Christopher Ariza, "Navigating the Landscape of Computer Aided Algorithmic Composition Systems: a Definition, seven Descriptors, and a Lexicon of Systems and Research" (paper presented at the ICMC, Barcelona, Spain, 2005), 3.p. 3

4.4. "Nudging": CAC Provides Constraints and Directions

Computer algorithms, in many cases, don't directly dictate any of the notes that are ultimately chosen in the music, but rather serve to shape aspects of the music through banks of raw material, from which the composer can pluck and build something up. Here, that which serves as the emulsifier is not a specific tool, but rather the void left by the tool. The absence (and deliberate exclusion) of rhythms, orchestrations, articulations, and myriad other considerations leave space for the intuitive composer to connect with the material.

In the cases explored here, the CAC-generated materials are generally pitch fields, which are then orchestrated or rendered melodic in a number of ways. This work was done in OpenMusic, a relatively high-level programming environment containing many objects for interacting with musical pitches and rhythms. This section will first examine the organ work *Mutations II* in detail. Following this will be an exposition of other relatively flexible uses of CAC in other works, explained in somewhat less detail.

4.4.1. Mutations II

Mutations II was meant to evoke, in two moods, the outwards expression of a high-functioning individual with anxiety, and the underlying inner turmoil. Written in a state of general calm, in a reprieve from the actual emotions it seeks to represent, it's infused with a sort of quirkiness, a humour that has become a recurring theme in much of my work. This seemingly out-of-place whimsicality, seen in the odd rhythms and almost scherzo-like haste, is my way of filtering ideas into music that feel too emotionally heavy from the outset.

It is written for an organ containing three manuals, a full pedalboard and a typical romantic French assortment of stops.[104] The piece is divided in three major sections, tracing a general ternary form, with the A and B sections representative of the two different moods evoked. The piece's registration follows it's formal organisation, as seen in Table 1.

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[104] More information on the concept of a typical French Romantic organ can be found in Douglas Earl Bush and Richard Kassel, *The Organ: an Encyclopedia*, Encyclopedia of Keyboard Instruments (New York: Routledge, 2006), 206.

Section		Measures	Registration
A.	.1	1-42	Great: Flutes (8',4',2') / Swell: Strings + mutation / Pedal: Principal + flutes
	.2	43-74	Same, with added Swell mutation
	.3	75-91	Same
B	.1	92-116	Swell: Strings / Great: Flutes (fundamental only) / Pedal: Flutes Increased at organist's choice at m. 106, 110
	.2	117-135	Voix Celeste added to Swell, increased to Full organ at m. 129
A'.	.1	136-170	Same as A.1, increasing registration at 167
	.Coda	171-110	Full organ, added chimes at 176 if available

Table 1: Breakdown of sections by measure and registration in *Mutations II*

4.4.1.1. A Section: Intuitive Composing by Hand

Section A, mirroring the outwards manifestation of anxiety, is metrically unstable, unsure in articulation, and contains a slowly building, yet uneven melody in the underlying pedal line as an imagination of this internal expansion of restlessness. The chord structures of stacked fourths over major and minor triads are meant to symbolize something seemingly stable, but irregular enough to never seem fully at peace (Figure 11). The registration of this A section is also significant: the orchestration is insecure and restrained, using a full three octave complement of stops on the great, but with no principals, and using a slightly destabilizing 11/3 on the swell, a fairly prominent fifth two octaves up. Significantly, these fractional stops on an organ are known as "mutations", and while they enrich the overtone series in a forceful set of stops, their exposed presence can make them rather destabilizing, especially in chords.

Figure 11 Mutations II, mm. 10-14

4.4.1.2. B Section: CAC-Generated Harmonies

OpenMusic was used in the B section of the work to develop the harmonies in a deliberately different direction, created before the completion of the A section to allow a more logical harmonic progression (see Appendix A.1).[105] The harmonies are modified frequency modulations of components of the upper harmonic spectrum of a low G.[106] Formally, every second partial between harmonics 5-16 was produced (Figure 12.a), calculated in *MIDIcents*[107] to retain the maximum physical pitch accuracy. Then a frequency modulation (FM) was applied to each of these partials (with E_2 as a modulator)[108], with notes removed falling outside the range E_2-D6 (Figure 12.c). This is the approximate range for the various human voices, and as such the approximate keyboard range of organs, which can to vary greatly. While a practical condition for organ music, this has the additional effect of gradually increasing the complexity of chords, since the frequency modulation of the lower partials produced numerous notes outside the range.

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[105] Throughout the document, there will be references to certain patches that can be seen in Appendix A. These are not necessary for a general understanding of the processes, but may be of interest to those with a background in CAC.

[106] Incidentally, G is the tonic resolution of the modified D dominant chord that ends the first section.

[107] *MIDIcents* are based on MIDI note numbers, but with two additional significant digits to preserve pitch information up to a 100th of a semitone (like "cents")

[108] Note names throughout will be given using International Pitch Notation (see reference), where C_4 refers to middle C on a piano

Figure 12 CAC-generated material for *Mutations II*

The pool of melodic notes for each harmony was derived from the same source, but also including the notes from the adjacent harmonies, to allow the melody to soften the hard edges between some of the harmonies (Figure 12.b). These were then transposed up an octave allowing them to take auditory precedence over the harmonies. Only at this point were the notes rounded to the nearest semitone. The harmonic-melodic progressions are clear-cut in the B section, with m. 1 from Figure 12 reflected in mm. 92-97 of the score, m. 2 in mm. 98-101 (Figure 13), m. 3 in mm. 102-105, etc. In the B.2 section (see Table 1), the melodies are sustained, both thickening the texture, and creating a growing sense of the inability to let things go. While the CAC-generated harmonies and melodic note pool obviously nudged the thinking about time, melody, and texture in a certain direction, the music was still written out entirely by hand, based on colours I intuitively sought for the music .

Figure 13 Mutations II, mm. 98-101

The B section was registered more warmly, and without mutations, to better represent what I consider the interior warmth of humans (contrary to an exterior coldness). The lack of mutations also kept the harmonies from sounding more complex than necessary, and allowed dynamic space for growth near the end of the section (B.2) when we approach a point where the interior emotions attempt to burst forth onto the surface of the individual, before being cut short and restrained to a more presentable exterior. This is a deliberate attempt at a commentary on society's approach to mental health. The melody, inspired by a sense of being frozen or incapacitated by panic, relies on repeated, and obsessive-sounding gestures, over an irregular metre, but with an underlying attempt at self-restraint through the left hand and pedals. While there's an audible attempt to calm down, to catch one's breath, at mm. 115-116, the panic subsequently returns and grows more quickly. Increasing numbers of high rolled chords in the right hand evoke moments of internal shock and incapacitation, become ever more frequent near the end.

4.4.1.3. Linking Ideas

The use of CAC to generate harmonies allowed considerable manoeuvrability to create coherent links between the two sections, and careful decision ensured that the B section provided suitable contrast to the A section, partially through the use of CAC, and partially through non-computerized planning.

The way in which the B section melodic pool was elaborated ensured several key contrasts from the A section. Foremost was the fact that the FM harmonies naturally produced relative widely spaced harmonies. Unlike in the A section, where the pedals carried what most closely resembled a melody, these best suited to the lower register left hand and pedals due to the size of auditory critical bands in the bass.[109] This allowed relatively complex chords to avoid sensory dissonance in the beginning, and slowly increase this sensory dissonance throughout the section.[110] With increasingly complex chords, placing the harmonies in the bass also made the most efficient use of the organist's assets: in all, and organist can play 5 notes per hand and one per foot.[111] Bass intervals such as a minor seventh with nothing in between

[109] Huron, "Tone and Voice: A Derivation of the Rules of Voice-Leading from Perceptual Principles," 16.

[110] For an explanation of sensory versus cultural dissonance, see "Tone and Voice: A Derivation of the Rules of Voice-Leading from Perceptual Principles," 15.

[111] While proper organ shoes allow the playing of seconds and thirds if they are a combination of a black and a white note, this is somewhat unreliable between organs, and does not allow for legato playing.

(m. 106 in the score) provide the most efficient use of the feet, but a waste of three fingers in the hands. Furthermore the contrastingly quick melody of the B section (compared to the slow lumbering melody of the A section) was more easily playable in the right hand than the pedal, and the upper register of the organ is better suited to fast melodies due the delayed attack of the larger pipes in the low register.[112]

The generated harmonies, however, do provide some links with the surrounding sections, done with some deliberation through testing various combinations of spectra and modulators in OpenMusic. The opening harmony of the B section, for example, contains both the upper and lower note of the final harmony in the A section, and the G♯ was also present in the previous chord.

Some of the important contrasts and links between the sections were also possible due to the incorporation of only harmonies from CAC, with no temporal or even melodic constraints. It was possible to maintain the combinations of irregular compound rhythms throughout, while contrasting the highly articulated A section with an ever more sustained B section. This sustained character, combined with the pedal as a strong sustained tonal force, is prepared near the end of the A section. In contrast to the metronomic A section, however, the B section's dotted and triplet rhythms feel even more uncertain.

4.4.2. Further CAC Interventions in Other Works

The following sections will look some other flexible uses of CAC, albeit in less detail. These flexible uses of CAC will include the application of various types of modulation ("Waves" and "Run" from *Short Pieces on Falling*, *Never a Moment Lost)*, recursion (*What Maria Hears*, *Vinst och Förlust,* "Lush" and "Choke" from *Short Pieces on Falling*, third movement of *Little Boys Who Will Not Sleep Anyways)*, mechanical assistance (first movement of *Little Boys Who Will Not Sleep Anyways, Läst Igen: Fredmans Epistle N:o 27, Världen och Jag*), and generalized assistance to thought in the composition process ("Tempt" from *Short Pieces on Falling*, *A Little Snow Was Here and There*).

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[112] Jack Hardman, "How Organ Pipes Work," http://hardmanwurlitzer.com/pipes/.

4.4.2.1. Uses of Modulation

Many other works included similar interventions by CAC to establish harmonic patterns, often based in part on existing material in the piece. Many of these used other forms of modulations, borrowed in many cases from the world the physical or electroacoustic world.

"Waves" from *Short Pieces on Falling* relied on a frequency modulation to produce the note pool from which the harmonies were developed (see Appendix A.2), forming part of the meaning of the title "Waves". Once this initial frequency modulation was produced, higher octave doublings were removed, and the program ran through each note of the remaining collection of notes. Each note (doublings included) was treated as a bass note, and for each a series of partials was produced.[113] The other notes in the field were tested against it: if they belonged to the spectrum, they were moved to the lowest position of that pitch-class in the spectrum; otherwise they were transposed up an octave. This reinforced the absent fundamental with notes in the spectrum, and moved others out of the way, while still allowing them to provide colour, but less harmonic relevance. As such, a series of harmonies developed (Figure 14), which were then distributed amongst the instruments. Figure 14 shows first the original result of the frequency modulation, then with octaves removed, and then reorganized according to various spectra. Regular noteheads indicate notes that were moved or left in place because they were part of the spectrum. Diamond noteheads indicate non-spectrum notes, which were transposed up an octave from their original location. While the texture was elaborated intuitively from this CAC-generated harmonic system, I allowed the latter to prod me towards a sparser orchestration and a slow harmonic rhythm. The resultant melodic note pool inspired in me the playful clarinet character at the beginning.

[113] The fundamental was not included to retain closer spacing of the chord.

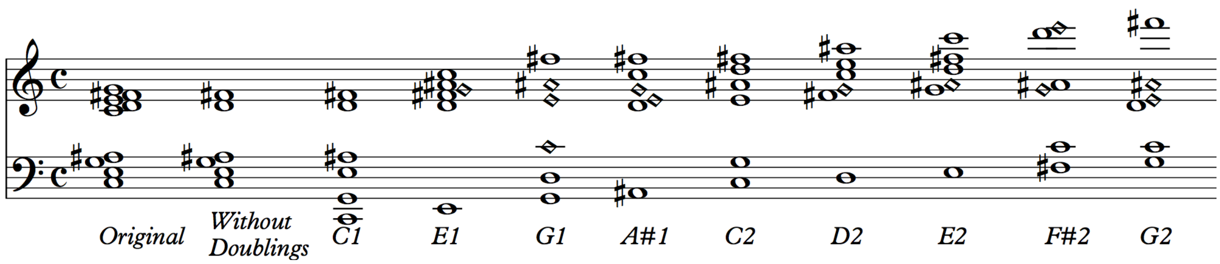

Figure 14 Generated harmonies from "Waves"

Short Pieces on Falling 3 ("Run") used a very similar process for elaborating the harmonies in the opening section, again reorganising a pitch field by an artificial spectrum that ascends slowly through to m. 17 (see Appendix A.3). Movement 8 from the same series, "Love", uses ring modulation instead to generate its harmonies, though the piano notes are transposed higher to operate on a different plane of tone.[114]

Finally, the second movement of *Gift efter Carl Herman Erlandson*, also uses ring modulations, but more subtly and in an extreme micro-context, as a means of seeking a change of colour in the middle of the piece (see Appendix A.4). This new colour, orchestrated with fifths, is clearly heard between mm. 33-40.

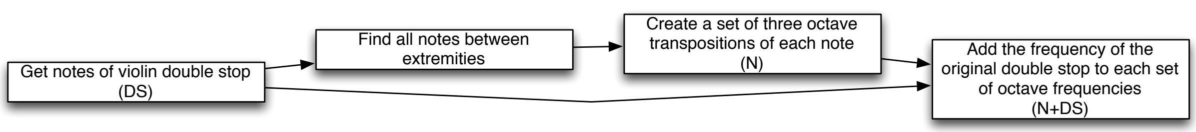

Figure 15 The approximate process for the B section of *Never a Moment Lost*

Never a Moment Lost, a semi-improvised work allowing the performers to choose both the order of sections and the melodic movement themselves based on provided structures, was also based on a form of frequency shifting in its B section (see Appendix A.5). In this case, the carrier notes were the double stops of the violin, incidentally the notes that would serve as the accompaniment in the violin. One pitch set was produced for every semitone including between the two notes of each double-stop: the frequencies of different octave transpositions of a given semitone were added to the frequencies of the original double stops (see Figure 15), producing a set of notes with some relationship to the original notes. Each subsequent set for

[114] See Belkin, "Orchestration: Basic Notions, Part 2". for more on the concept of "planes of tone"

each double stop tended higher in pitch, and in the semitones between the outer notes of the double stop, became harmonically detached from the accompanying violin part.

Short Pieces on Falling 7 ("Choke") also used frequency modulation functions to establish a slowly changing harmonic note pool. These pitch-sets, however, resemble clusters that continues to increase in size and span (see the notes used at mm. 1, 5, 9, 12, etc.).

4.4.2.2. Uses of Recursion

While many used types of modulations, several used various recursive patterns, something programming languages excel at. Recursion, called lambda calculus in its early days by Alonzo Church in the 1930s[115], allows functions to be applied to themselves. In musical terms, this could imply a function that generates one chord based on the previous chord, applied to itself over and over. Imagine we begin with a simple major triad. Our function takes the interval between the lowest two notes (4 semitones in Figure 16), adds one semitone, and appends this interval to the top of the triad, and removes the lowest note. If this function is applied to each successive triad, a complex harmonic structure is built, and furthermore, once that can be dramatically altered by a small change in the initial triad.

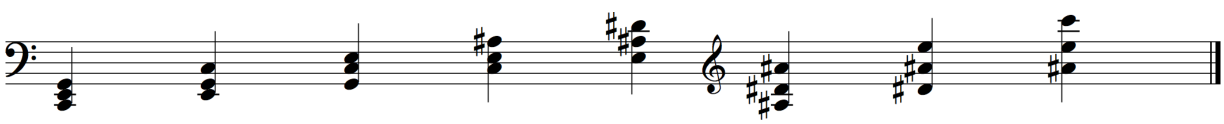

Figure 16 Simple recursion pattern

Such a function was used in *(Let Me Hear) What Maria Hears*, although operating in the frequency domain instead of the note domain, to generate the harmonies for the entire A section. The recursive pattern was inspired by the idea of obsessing over a memory, as I imagined Mary might have done during the annunciation:[116] after hearing something amazing and processing it, I often feel I am no longer considering the original memory, but rather

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[115] Paul Hudak, "Conception, Evolution, and Application of Functional Programming Languages," *ACM Computing Surveys* 21, no. 3 (1989): 363.

[116] The annunciation is the biblical story in which Mary is told by the angel Gabriel that she will give birth to Jesus. (Luke 1:26–38) I choose to read the Bible as a humanist document, and ascribe emotions to the characters as I would imagine them, but not necessarily as they would be perceived in a literal reading.

considering it through the filters of each time I have remembered it and thought about it. I consider recursion as a digital equivalent to this, and these CAC-generated harmonies guided the subsequent harmonic rhythm, and the amount of space or obsession around a set of notes.

Figure 17 The opening from *(Let Me Hear) What Maria Hears*

A similar recursion formula was used to generate the harmonic progression for the contrapuntal section in *Vinst och Förlust* (mm. 51-79, harmonies seen in Figure 18), although with an interesting feature found in some recursive formulas: after ten steps, the recursion produces its original generative harmony (see Appendix A.6). For a simple example of how this works, one might consider the pitch-class set of a diminished chord. After three transpositions by three semitones each time, one will return to the original pitch-class set. The circularity in the pattern from *Vinst och Förlust* is especially interesting, since while it returns to its starting point, it does so after ten steps in a 12-tone chromatic macroharmony,[117] meaning there is an inherent imbalance between the steps in the function. As such, the first five steps were used for the piece, going like in a circle of fifths in a modal context, to the farthest point from the beginning (before the return). In this particular piece, cyclical recursion, and the concept of returning to a starting point, perfectly captured what the poem and I were attempting to express about nature.

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[117] See Tymoczko, *A Geometry Of Music : Harmony And Counterpoint In The Extended Common Practice*. location 506., for a definition of macroharmony.

Figure 18 Note pools generated for *Vinst och Förlust*

“Lush”, from *Short Pieces on Falling,* again used a similar recursive procedure for it’s harmonic and melodic material (see Appendix A.7), this time, however, to develop ordered pitches (as opposed to octave-generalized pitch-class sets). These CAC-generated passages, passed back and forth in an antiphonal-style counterpoint between the flute and clarinet, serve as the basis around which the rest of the opening section is constructed. However, the passages are in no way prescriptive, either melodically or harmonically: the order of notes is changed where it no longer serves the counterpoint, and the piano adds additional notes in the left hand to create a richer harmony that corresponds with the generated passages. The cello line is an elaboration of the bass note for these harmonies, while the violin line is a harmonic echo of the first note of each passage, and the piano right hand as octave resonance of one of the wind instruments.

In the third movement of *Lullabies for Little Boys Who Will Not Sleep Anyways,* “Scherzo Insomniac”*,* another simpler recursive process takes place, transposing the Bartok-like motives through a latticework of scales and transpositions (see Appendix A.8). In *A Geometry of Music*, Tymoczko proposes a three-dimensional latticework of raising notes to produce the macroharmonies in tonal pieces,[118] in which a step on the axes y, x, and z (in that order) produces a progression through the circle of fifths. However, other directions through the lattice (effectively raising notes out of their habitual order, such as a C♯ before and F♯) produces the acoustic, harmonic minor, and harmonic major scales as well. Thus a recursive algorithm was created to not only move through this latticework in alternate directions, but also to map the existing series of motives into this new scale, and to move the tonal centre of the motive progressively higher. For example, we start with the diatonic mode of C major,

[118] *A Geometry Of Music : Harmony And Counterpoint In The Extended Common Practice*. location 2237.

with a D root (dorian mode). In the first instance we add C♯ and nudge the root up one step to E, meaning we are now in a G acoustic scale with its tonal centre on the sixth degree (see Table 2) The G♯ added next moves us to a harmonic major, and finally the F♯ moves us back to a diatonic scale, but no longer with the same root: because both the root and the changing accidentals shift independently, the realignment between these does not occur for many instances, giving each transformation a unique flavour. The final work passes audibly through many of these transformations, which can be seen in Table 2, though many of these were also cut to ensure that the pattern did not always remain linear and predictable. The kind of gestures undertaken in each transformation, the orchestration used, and the character developed therein were all influenced by the colours of these CAC-developed modes.

Mode	**♯s**	**Base Note**	**Position of Root in Scale**	**Entry in piece**
C Major[119]	None	D	2	m. 34
G Acoustic	C♯	E	6	m. 52
A Harmonic Major	C♯ G♯	F	6	m. 58
A Major	C♯ G♯ F♯	G♯	7	m. 65
E Acoustic	C♯ G♯ F♯ A♯	A♯	4	m. 82
F♯ Harmonic Major	C♯ G♯ F♯ A♯ E♯	B	4	cut
F♯ Major	C♯ G♯ F♯ A♯ E♯ D♯	C♯	5	m. 86

Table 2: Modes in *Lullabies for Boys Who Will Not Sleep Anyways III*

4.4.2.3. Uses of Mechanical Assistance

"The Spectrum of Stars" from *Lullabies for Little Boys Who Will Not Sleep Anyways* used a variety of CAC processes, including some that will be seen in later sections, but that which was at the foundation of the piece's character was spectral analysis (see Appendix A.9).

[119] The designation major is used here, as opposed to diatonic, not because the scale has the tonal centre of a major scale, but because it's categorically similar to the other modes, where the standard root was given for a reference point from which to compare the actual root.

While basic spectral analysis has existed for some time, and arguably can be done without advanced musical software, OpenMusic provides additional features such as adjustable transient detection, which can be linked to the tools for spectral analysis (which is easily viewable as pitch-weighted notation).[120] The source material for this movement was a low piano string, plucked on an old piano to elicit as many artefacts and inharmonic harmonics as possible. Then the audio was analysed to find at which points the sound's harmonic structure changed considerably using transient detection with a very low threshold. From each of these transients, representing usually the sudden emergence of new harmonics or the fading of old ones, analyses were done, producing score samples with each note weighed. Two analyses were done: one for the computer instrument in the piece (which had no limits on range or numbers of notes), and one for the piano part (more limited in range, and taking only the six strongest partials due to their spacing).

Following this, a string of fast notes was produced to be played by the electronics by a transposed version of the original piano string. (Figure 19, system 3) This was inspired by the concept of fractals, in which a shape is self-similar at different levels of magnification.[121] The new line of notes was selected with weighted randomness based on the harmonics of the original piano string, and each note in the line's length and velocity was adjusted based on the relative strength of that original harmonic. All of this was then combined with the original sound of the low piano string. Spectral blurring was applied to the fast notes, and the toy piano was given an elaborated version of the upper note of the piano harmonies.

[120] For more detailed information on Super-VP and PM2, the OpenMusic libraries used for this piece, see Bresson's article "Sound Processing in OpenMusic", pages 3 and onwards.

[121] Geoff Boeing, "Visual Analysis of Nonlinear Dynamical Systems: Chaos, Fractals, Self-Similarity and the Limits of Prediction," *Systems* 4, no. 4 (2016): 7.

Figure 19 Pitch material from *Lullabies for Little Boys Who Will Not Sleep Anyway*

The results of the CAC material can be seen in Figure 19. The top system contains the material generated for the piano part, the second system contains the base harmonies for the electronics part, and the third system contains the randomly chosen notes for the electronics part, with both velocities and lengths of notes weighted by the harmonic from which they were derived.

Läst Igen: Fredmans Epistel N:o 27 also used spectral analysis, but in a much less rigorously constrained way. Here a series of recorder multiphonics were analysed to produce a pitch set, and at different punctuating[122] points in the piece, CAC was used to compare the various pitch sets against the prevailing harmony (see Appendix A.10). In general, the multiphonic pitch set most resembling the harmony at that point in the piece is used, and in the original score the actual multiphonic was incorporated. However, even with the support of the other instruments in the spectrum of the multiphonics, the sound of recorder multiphonics

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[122] I prefer the term "punctuation" over "cadence" for the more global applicability, which is unrestricted by tonal context and considers things such as rhythm, orchestration, and articulation. See Alan Belkin, A Practical Guide to Musical Composition, (Self-published., 2008), http://alanbelkinmusic.com/bk/F.pdf. 11.

proved too aggressive for the aesthetic of the piece, and they were eventually replaced with only the fundamental. As such, the "tool marks" of having worked with the spectral analyses of multiphonics remain in the piece, without the multiphonics themselves, providing a novel variation to the harmony in places. CAC provided the nudge to momentarily change the harmonic context. Examples of this can be seen in the transition between mm. 24-25, or 37-38, or 85-86 (here the multiphonic harmony prepares the upcoming harmony).

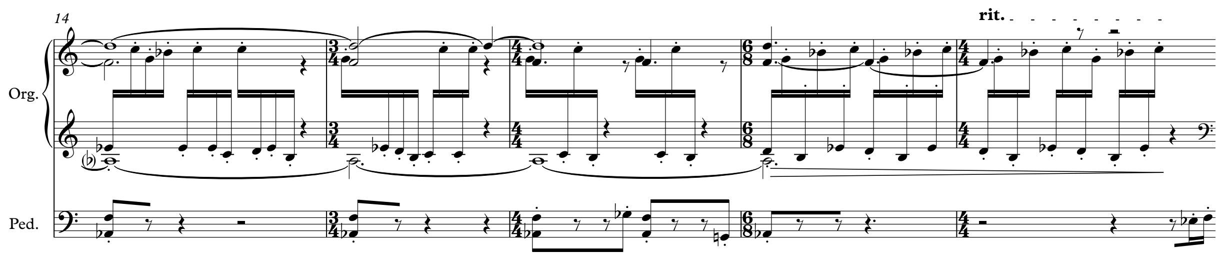

Figure 20 A portion of interlude 6 from *Ruminations on the Season*

Interlude 6 from *Ruminations on the Season* equally used mechanical assistance to help build an entire texture from a frequency modulation (see Appendix A.11). The piece attempts to capture the constricting feeling of February, with its oppressive dusk and omnipresent clouds. Formally, this is done through ever smaller stacked intervals (see the held notes in the manuals, m. 14 in Figure 20), upon which frequency modulations are built. What happens next is much like in the first movement of *Little Boys Who Will Not Sleep Anyways* in the beginning of this section: the relative weights of the harmonics are factored in (as is the organist's hand-span) to create a pointillistic texture representative of the original frequency modulation (the staccato notes in the manuals in Figure 20).

4.4.2.4. Assistance of Thought

The term "controlled aleatory", generally associated with Lutoslawski, involves the use of relatively simple individual parts that come together somewhat randomly to create a good deal of rhythmic sophistication.[123] With enough voices, this produces something akin to

[123] Charles Bodman Rae, The Music of Lutoslawski, (London: Omnibus Press, 2012). Electronic Book. 124.

Ligeti's micropolyphony; clustered chords in moving rather than static lines.[124] While these techniques on their own do not require computers (it is the musicians who make the ultimate decisions regarding times of entries, lengths, etc.), computers can aid in a number of ways.

Several years ago, a colleague, interested in creating a simulation of an orchestral work, proposed that perhaps computers could help in this process. Before venturing further, the idea of simulation as Computer-Assisted Composition deserves some discussion: while simulation doesn't provide any new raw musical material, it should provoke the composer to think, and may encourage them to make subtle changes (hence the inclusion in the section "Nudging"). Under Malt's classification, simulation is a form of "assistance of thought",[125] which he in turn categorizes as a form of CAC (alongside other forms of feedback).[126] I ultimately included this plugin in the "Nudging" chapter because its results prompted me to reconsider the organisation of parts of my own piece: I wrote the music differently with the feedback of the plugin.[127]

While my colleague's goal was to produce an eventual simulation with such a plugin, I saw further possibilities that would aid in the composition process itself, through feedback of how well a musical idea actually worked. The software would be programmed as a plugin to run inside *Sibelius*: while such programming would obviously be simpler in OpenMusic, inside *Sibelius* would mean that the user remain in their workflow, and simply edit portions of the score to check the efficacy of their idea.

In the final plugin (see Figure 21), the user indicates where the passage is by the use of a line, and the motive at the beginning of the passage is repeated throughout with some degree of variance each time. Functions exist for quantification, to determine the time between repetition, to decide where the notes are written (new staff or same staff), whether they are hidden, and whether they follow the same approximate tempo as the original motive. The

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[124] David Cope, *Techniques of the Contemporary Composer* (New York: Schirmer Books, 1997), 101.

[125] Malt, "Les Mathématiques et la Composition Assistée par Ordinateur (Concepts, Outils et Modèles)," 109.

[126] "Les Mathématiques et la Composition Assistée par Ordinateur (Concepts, Outils et Modèles)," 58.

[127] The general classification for "nudging" was: "materials [in this case, the hidden notes added to the score for simulation] developed algorithmically were ultimately used as guidelines for intuitive composing" (Section 4.3)

plugin can be applied several times to the same staff to simulate several independent instrumentalists.

While controlled aleatoric music is not ultimately going to be performed by a computer, the feedback from the simulation provides useful feedback on two levels. First, it enables the composer to return and modify certain elements in a passage. Perhaps chance meetings between certain notes are particular undesirable and aren't noticed until the simulation, or perhaps the performers need to be instructed to play the motives slower, or to leave more time between motives. This serves very much the same function as simulation normally does in notation software, except there is one level of abstraction further between what's written on the page and the final sound, rendering this form of simulation more helpful for me. It's a final "nudge" for the composer to adjust certain aspects of a score.

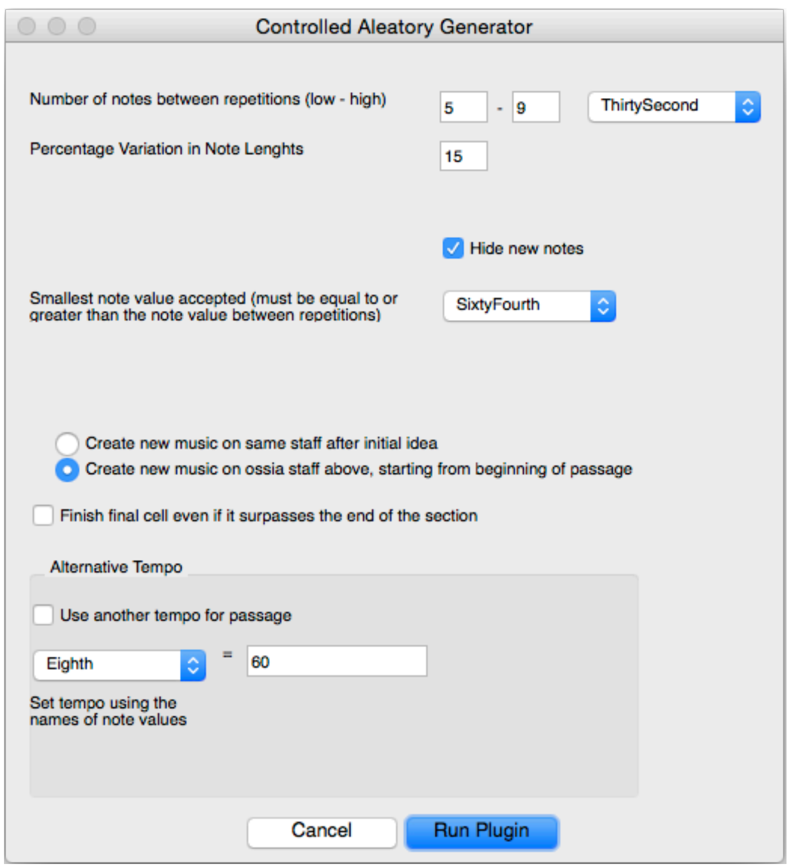

Figure 21 The control window in the *Sibelius* plugin for controlled aleatoric passages

The other aspect is that computer programs are relatively good randomizers, even if their processes are only truly pseudo-random.[128] Controlled aleatoric music involves letting go of some compositional control to the performers, and sometimes the actual layering of voices in a performance isn't what one imagines when composing, possibly due to human limitations concerning randomness. Like other humans, one would suspect that when composers attempt a random distribution of sorts, it will be a much more balanced distribution than true randomness proposes, especially for small sequences.[129] For example, in a truly random string of numbers, a human will be unlikely to repeat an item, include zeros, or a number of other phenomena that should happen in a completely random number.[130] Aleatoric sequences of events thus find a useful aid in CAC, because they excel in this situation where the mind so often fails.

This software was use in the movement "Tempt" in *Short Pieces on Falling* from mm. 50-58 to test musical hypotheses for the use of controlled aleatoric fashion. The plugin was used several times, to ensure the results were satisfactory even when they fell outside of my expectations, as they would be wont to do in a live context. *A Little Snow Was Here and There* employs similar controlled aleatoric passages in mm. 17-21 and 42-46. This work allows for a greater proliferation of independent lines because of the number of independent voices in a choir (13 at the première). Furthermore, development of the plugin gave greater insight into the variable factors in a controlled aleatoric passage, inspiring a form of computational thought that better prepares the formal planning stages of my before a computer is ever used.

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[128] Jason M. Rubin, "Can a Computer Generate a Truly Random Number?," MIT School of Engineering, http://engineering.mit.edu/engage/ask-an-engineer/can-a-computer-generate-a-truly-random-number/.

[129] See the law of of small numbers, as explained in Deborah S. Blinder and Daniel M. Oppenheimer, "Beliefs about What Types of Mechanisms Produce Random Sequences," *Journal of Behavioral Decision Making* 21, no. 4 (2008): 415.

[130] There are copious academic resources on this, but a particularly clear, concise, and comprehensive explanation can be found at: Keith Hillman, "Why We Can't Choose Random Numbers," Psychology24, http://www.psychology24.org/why-we-cant-choose-random-numbers/.

4.5. "Moulding": CAC Produces Score Material, the Composer Sets the Constraints and Conditions

> The material and the craftsman's thoughts change together in a progression of smooth, even changes until his mind is at rest at the exact instant the material is right.
>
> Zen and the Art of Motorcycle Maintenance[131]

In many ways, this represents my relationship with CAC, with the algorithm its result being the material, and the material and my mind forming a slow fusion of ideas. The back and forth between algorithms and my thoughts on a piece is constant in the compositional process, and as was seen in the previous section, often involved sculpting otherwise static CAC-generated material into music at each step.

4.5.1. Progression Management System[132]

For many pieces, however, I was interested in the possibility of the CAC material being more directly integrated into the pieces. CAC could provide suggestions not just for harmonies or melodies, but could provide entire sequences complete with melodies, harmonies, rhythms, and even orchestration.

Particularly interesting was the idea of developing existing motives through formal progressions. Evidently, progressions, especially sequences, have played a part in music since the Baroque era, and have been formalized in ways more adapted to computational thought in the 20th century by composers like Messiaen.[133] I wanted to create a system that would allow me to input a musical "seed" and then apply any number of processes to it over given number of repetitions. This would allow me to incorporate CAC mid-piece as a means of developing

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[131] Pirsig, *Zen and the Art of Motorcycle Maintenance : an Inquiry into Values*. 266.

[132] More detailed explanations from a programming standpoint may be found in Matthew Lane, "Programming Modular Progressions In Openmusic," in *The OM Composer's Book 3*, ed. Jean Bresson, Carlos Agon, and Gérard Assayag (France: Delatour/IRCAM - Centre Pompidou, 2016).

[133] See Olivier Messiaen, *The Technique of My Musical Language*, trans. John Satterfield, 2 vols., vol. 1, Bibliotheque-Leduc (Paris: A. Leduc, 1956), 16-30.

material. It could serve as an emulsifier between existing intuitively-composed music, and CAC-based developments.

I decided to use a modular system inside OpenMusic. OpenMusic is well-suited to the kinds of pitch- and time-related processes that interested me, and a modular system would allow me to create reusable patches to apply different processes, which could then be reused and reordered as necessary. The system has a number of base patches (containers with algorithms in them) that allow the system to function, and other patches that apply "treatments". A treatment, a term common in the electroacoustic word, implies any formalized change to existing musical material in this context; for example, the gradual transposition or lengthening of a passage.

After looking at the base functionality of this system and its benefits, the reader will follow a detailed analysis of two works using this system: *Melodious Viscosity* for wind quintet and *A Square Peg* for string orchestra. Shorter notes on other pieces where the system was used will follow, and will include the works *Sliding Apart*, "Float" and "Lush" from *Short Pieces on Falling*, *Mutations I*, and *(Let Me Hear) What Maria Hears*.

4.5.2. Functionality

The overall structure is simple, and begins with one or more seed musical objects (see Figure 22), which is then repeated any number of times to create a string of motives or cells which can subsequently be sculpted by treatments, or "functions" in programming vocabulary. This string of repetitive material is then passed to an "applicator" patch. The applicator has two inputs: one is which function or treatment to apply, and the other is the arguments that will dictate the specifics of the function. For example, the function might be a progressive transposition that slowly raises the pitch throughout the line of repeated motives. The most basic argument would likely then be the interval over which to transpose the passage. A function might also be one that removes notes at each repetition, and the argument might dictate what percentage of notes is removed. In short, it allows the composer to mould a more complex progression starting from fairly crude processes.

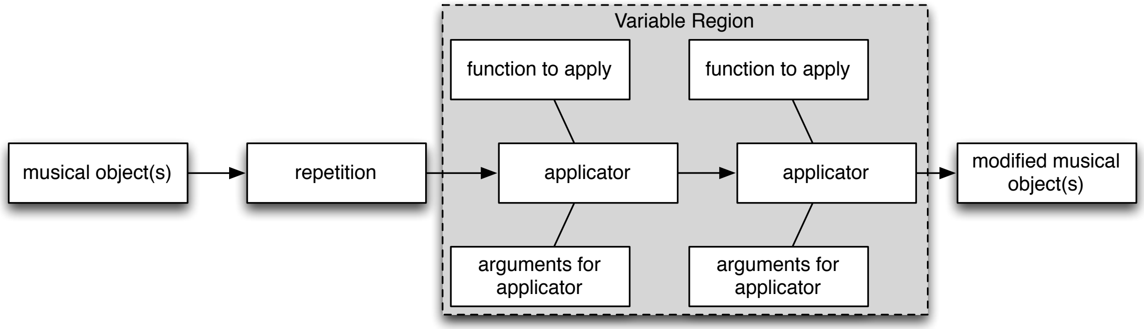

Figure 22 Generalized structure of the modular progression management system

In the "variable region" in Figure 22, any number of applicator-function-argument sets may be applied, and in any order, since in some cases the order may change the final result. The arguments may be numbers or lists, but also BPFs (or lists thereof): break-point functions. BPFs are essentially linear graphs on an x-y axis, with x representing time and y representing a value of anything else (Figure 24). These are useful for using changing, more intuitive values over the course of a function. A simple example of the entire system can be seen in Figure 23, with labels corresponding to the functions in Figure 22.

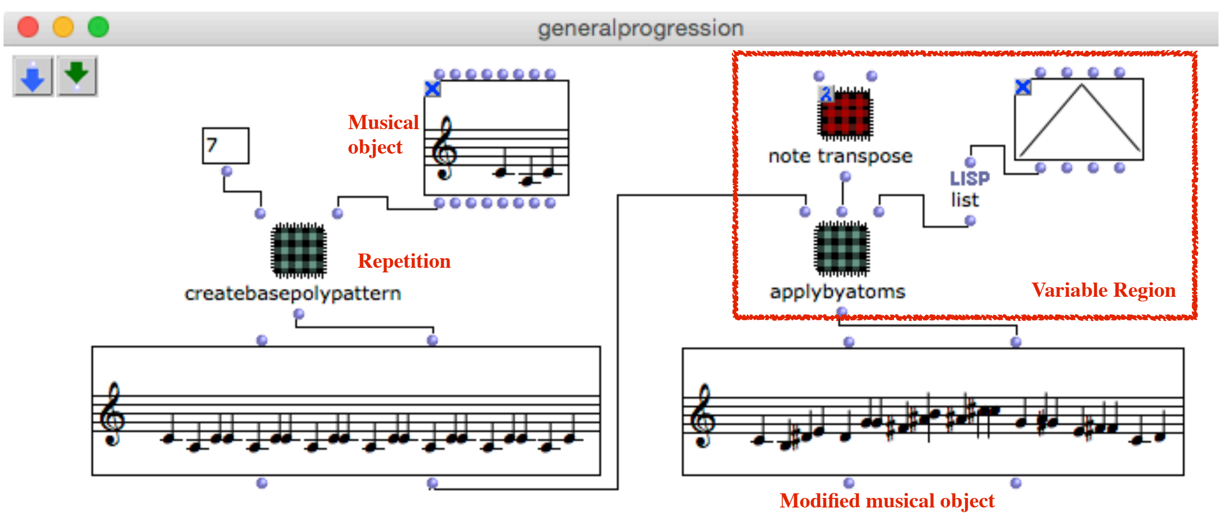

Figure 23 Modular progression management structure in OpenMusic

Finally, it's worth returning to the idea of musical objects for a moment. Each score segment for each instrument is considered a musical object. As such, a motive written for string quartet would be four musical objects, each of which can be controlled independently by the arguments provided to the applicator.

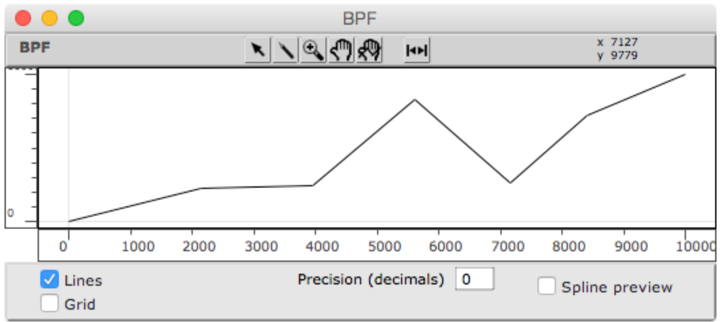

Figure 24 A BPF in OpenMusic

4.5.2.1. Discrete vs. Continuous Progressions; *chord-seqs* vs. *atoms*

The system was also designed to allow both temporally continuous and discrete progressions.[134] A continuous progression across time is like a glissando, while a discrete progression is more like a staircase. A continuous progression will apply the function one note at a time (Figure 25.a), while a discrete progression will apply functions to an entire cell or motive at once (Figure 25.b). They allow similar functions to be applied, but moulding the progression at different degrees of detail.[135]

Figure 25 Examples of continuous (a) and discrete (b) progressions

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[134] From here on, the terms “discrete” and “continuous” progressions refer to the treatment of temporal blocks, and should be considered in terms of the time domain.

[135] For a further analogy, one might consider an exercise plan. If your plan is based on increases at each discrete temporal block, perhaps you will add 20 push-ups at the beginning of each week, until you can do 80 push-ups after four weeks. If your plan is based on continuous increases over time, you’ll make sure to do the exact number of push-ups that corresponds to how far through your training you are: at day 12 of 28, you’ll do 32.3 push-ups. You’ll probably round that to 32 push-ups. Now imagine the push-ups are semitones of transposition: in my case, I’ll round those to the nearest semitone (as is done in all of the examples of my music).

Discrete progression is especially useful for retaining characteristic elements of a motive. For example, by transposing a cell as a whole instead of note-wise, one retains the internal interval structure of the motive. Similarly, to gradually truncate the end of a cell, rendering each successive cell shorter, it is necessary to retain information about where a motive begins and ends. As such, at the repetition stage (see Figure 22), the repeated cells may be either joined together as one long musical idea for continuous progressions, or kept separated for discrete ideas. If they are joined together, what is sent to the applicators is a list of musical lines: one line for each instrument (Figure 26.a). However, if they are kept separate for a discrete progression, then a matrix is sent to the applicators: one line on the vertical axis for each instrument, and one column on the horizontal axis for each cell (Figure 26.b).

Figure 26 Lists of instruments vs. matrix of cells

From a programming perspective, these treatments can be handled in *chord-seqs* or *atoms*, depending on the kinds of treatments desired. *Chord-seqs*, or "chord sequences", are a akin to the musical material for one instrument (Figure 27). They contain information for each note or chord, including the pitch, velocity (volume), onset (starting point in time), duration, and channel (for MIDI information, but also to allow independent voices). Atoms, a concept I've developed, and not to be confused with atoms in the LISP language on which OpenMusic is based, contain only the information for one note at a time. An atom might look like this:

```
MIDIC   ONSET   LENGTH   VEL.   OFFSET  CHANNEL
(6000    250     1000     100      0        1)
```

In order, the numbers represent pitch in *MIDICents* (middle C in this case), onset in milliseconds (250 ms from the beginning here), duration in milliseconds (one second here), velocity (between 1 and 127), offset in milliseconds (for chords that are arpeggiated, how long after the beginning of the chord it should sound), and channel (MIDI channel number).

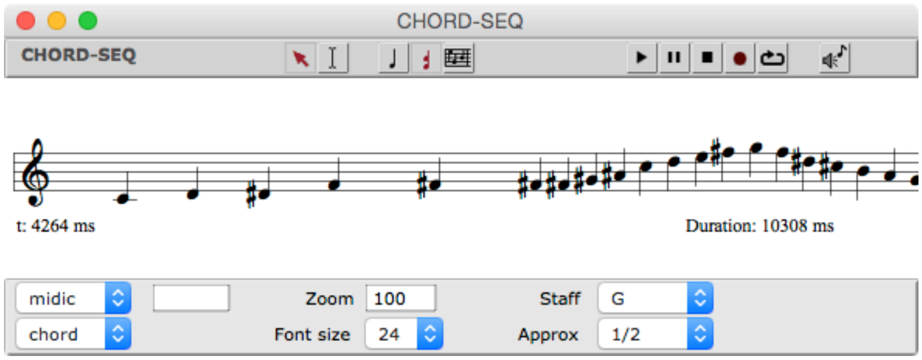

Figure 27 *Chord-seq* object in OpenMusic

For simple treatments, perhaps a frequency shifting of pitches or slight randomization of the starting time of notes, atoms work very well: the programmer-composer has only to worry about whichever elements in the atom that concern them. Functions for atoms, however, are blind: they cannot see outside of the atom, meaning they are less suited to treatments that involve a note's relationship to the notes around it.

4.5.2.2. The System in OpenMusic

Between discrete and continuous progressions, and *chord-seq* and *atom* functionality, there are four ways the system can work. These four are shown in parallel in Figure 28, starting with continuous progressions using *chord-seqs* and *atoms,* and then discrete progressions using *chord-seqs* and *atoms*. (A) and (B) are our two base materials: the score motive we will develop, and the series of BPFs defining the modulations for the different lines. (C) is the creation of the pattern of the repeated motive: *createbasepolypattern* for continuous progression, and *fillmatrix from multiseq* for discrete progressions. In the (D) row is the series of "applicators" (see Figure 22 for reference, Appendix A.12/13 for patches), slightly different depending on the type of progression and the choice of *atoms* or *chord-seqs.* Attached to these from above are the actual treatments: a simple transposition, but each slightly different. Line (E), for those that are in a matrix for discrete progressions, takes the cells from the matrix and connects them all into one musical instrument again (compare the right and left sides of Figure 26). Row (F) simply merges the two upper lines into one instrument (for example a keyboard or string instrument capable of playing two notes at once), and row (G) assigns MIDI channels to them for simulation.

While using *chord-seqs* or *atoms* is mainly a programming preference (some treatments lend themselves better to one than the other), there is a clear distinction between the result for continuous and discrete progressions. For the results of the discrete progressions to the right, each three note cell retains its melodic interval structure, transposing only between cells. For the continuous progressions to the left, however, the slow transposition begins immediately on the second note.

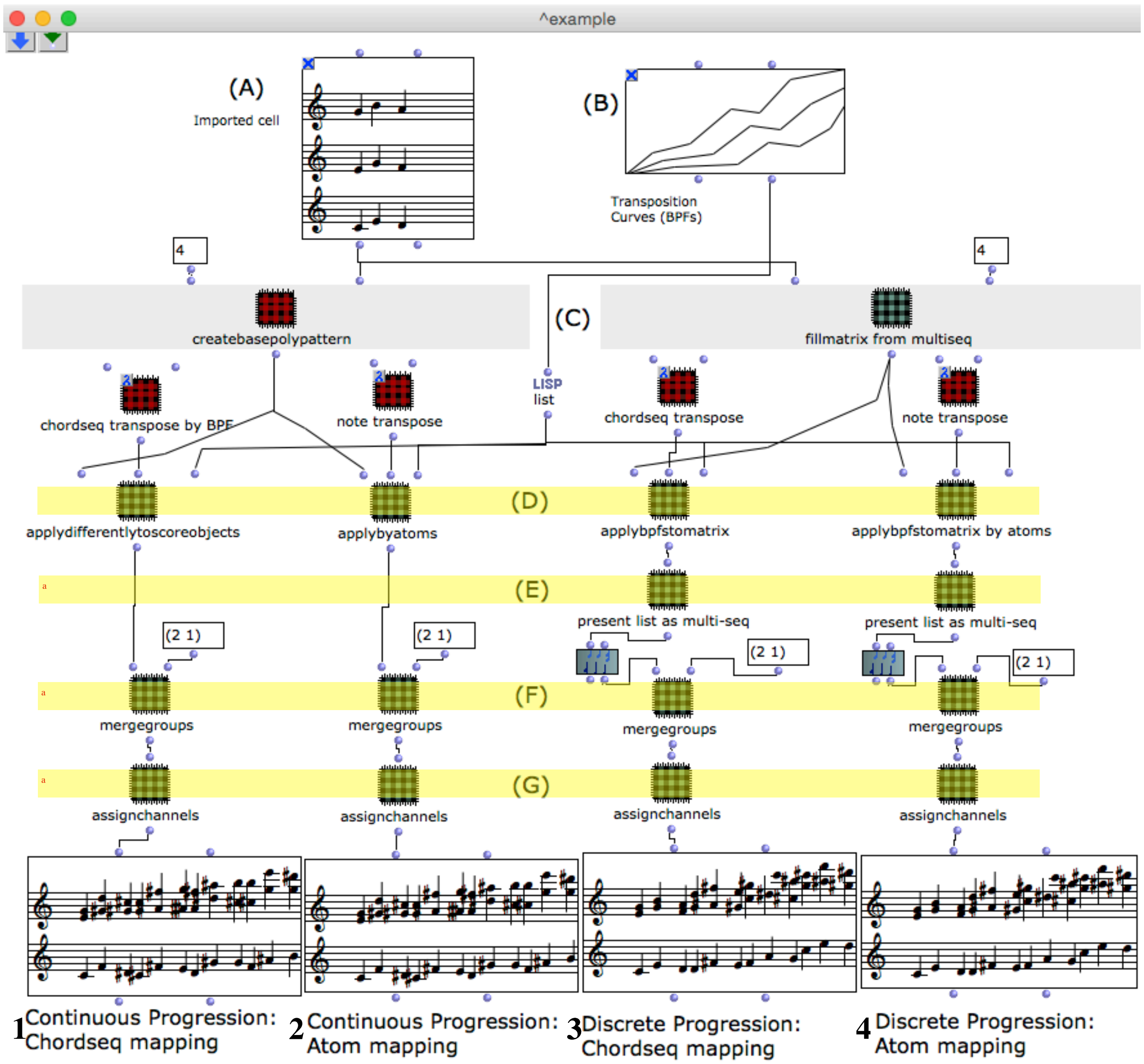

Figure 28 Four ways of using the modular progression management system

4.5.3. Benefits of the System

While anything this system does could be arguably done by hand, once it was established it provided relatively quick solutions to numerous concepts. First and foremost, the transition between notation software and OpenMusic is relatively smooth and simple, taking only a matter of minutes to isolate an idea from an existing passage and to import it into OpenMusic via MIDI or Music XML. The reverse is equally easy, though sometimes requiring more clean-up in the final score depending on the quantification used (especially where significant rhythmic treatments were used).

In terms of the processes themselves, which generally start out as concrete musical seeds with more abstract ideas to create progression, this system allows fast and flexible programming. It provides a lot of ease in tweaking arguments, whether intuitively or mathematically, while not requiring significant work. Treatment modules can be easily reorganized, which can change the output: transposing before a ring modulation has a completely different effect than doing it after. The length of the sequence can be changed with a few keystrokes, providing the possibility of testing the temporal efficacy of a sequence over different lengths of time. And when BPFs are used to provide arguments for a sequence over time, they can be quickly redrawn, or changed in scale. They also provide a more intuitive, visual link with the process, helping to move from an analytical world into a more intuitive one. The same BPF can also be applied to a number of functions. Imagine the BPF in Figure 24 is used as an argument, with its overall rise over time and a peak in the middle. This could be applied in sequence to a transposition, a change in speed, and an increasing tendency to trill, so that by the end of the sequence, the passage would be one octave up, twice the speed, and trilling on every note. Simply drawing a different line could dramatically change the musical gesture for the whole segment.

4.5.3.1. Identity with the Work

> And it is this identity that modern, dualistically conceived technology lacks. The creator of it feels no particular sense of identity with it. The owner of it feels no particular sense of identity with it. The user of it

> feels no particular sense of identity with it. Hence, by Phaedrus' definition, it has no Quality.[136]

Formally and regarding the identity of the composition, this system also has value. Formally, several evaluations of this same sequence of treatments, with a slightly different BPF line or number, will create different musical gestures, but will share the tool marks of the common tools they share, creating a link between them. And because the tool marks are from tools designed by me, there is a sense of continuity between the programmer, the program user and the music, and also an unconscious formal unity, since the composer is intimately aware of the formal structure of the software. These elements become a unified extension of the work, and thus Quality, as defined by Robert Pirgis.

[136] Pirsig, *Zen and the Art of Motorcycle Maintenance : an Inquiry into Values*. 261.

4.5.4. *Melodious Viscosity*: a Musical Relationship with Liquids

Melodious Viscosity represents an aesthetic I was exploring near the beginning of my doctorate, and while many of the harmonic and melodic elements of this aesthetic followed into later works, the formal layout was drastically different.[137] The title of this work is inspired by the image of water running unevenly down the windows of a moving car, and grew to represent larger analogies on rivers and watersheds. The piece projects images of confluent streams of liquid and how they move together and apart. It can be best understood using imagery from the field of rheology and fluid dynamics. The piece will be examined in its entirety, with some additional attention provided to the sections where the progression management system was used.

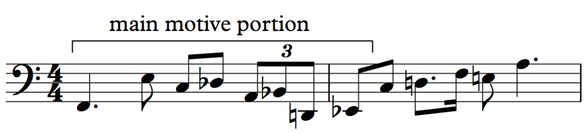

Figure 29 Main motive from *Melodious Viscosity*

It's based primarily on one rhythmic motive and one melodic theme (Figure 29), which represent the components of an anonymous liquid, which remain ultimately unchanged in different situations, yet respond differently depending on their surroundings, such as temperature and pressure.[138] Table 3 presents the overall layout of the piece, while the following section details the logic behind some of the musical equivalencies to the liquid flow imagery. The sections, however, do not always represent the continuous motion of one stream, but rather tableaus of different water movements.

Section	Location		Liquid Flow Analogy	Musical Equivalency
Section 1 (High viscosity, low flow)	A	1-13	High viscosity liquid slowly beginning motion. Low slope, uneven surface, small volume, therefore emergence of independent streamlets. Streamlets in sand.	Starts and stops, flute streamlet separates and rejoins from ensemble.

[137] While *Melodious Viscosity,* in many ways, represents a different formal approach to composing for me, this piece is very relevant because the things I was attempting to do in CAC eventually pushed me to develop tools that I used in many further pieces.

[138] Anton Paar, "Factors Affecting Viscosity," http://www.viscopedia.com/basics/factors-affecting-viscometry/.

Section	Location		Liquid Flow Analogy	Musical Equivalency
	B	14-29	Streams being added to the main flow (m. 20) before slowing and evaporation/absorption.	Canonic entries (m. 20), dispersion of instruments and disappearance with *rallentando*. (m. 26)
	C	30-48	Several nearly-static streams amalgamating, beginning to ebb.	Layering of instruments, still relatively static. Ebbing trough swell accents and *flz.*
	D	49-58	Slow moving streams growing in breadth, volume and speed. In beginning, most water is thus near the boundary layers, and easily obstructed	Gradual entry of instruments, randomized flow speeds (obstructions), increasing speed, volume, and coincidence.
	E	59-73	One streamlet breaking off and rejoining, flowing through irregular terrain, as the primary streams thins and evaporates.	Flute represents breakaway streamlet (prepared in mm. 59-61). Intervallic compression of harmonies represent thinning stream, while dynamics and rests represent evaporation.
Section 2 (Low viscosity, high flow)	F. 1	74-91	Steeper downward slope, faster flow, greater volume (less boundary layer obstruction). Some turbulence due to high Reynolds number.	Simultaneity of 8th notes, faster tempo, downward motion, *flz.* for turbulence.
	F. 2	92-125	Stream widening, slope levelling and flow slowing	*Rallentando* and separation of instruments as slope levels.
	G. 1	126-133	Rapids: high turbulence.	Rhythmic and articulated noise and unpredictability. Loss of melodic direction in ensemble overall. See discussion.
	G. 2	134-153	Reprise of F.1	
	H	154-163	Turbulent slowing of stream	
	I.1	164-173	Stream moves slowly down irregular surface. Streams separate, and some evaporate.	
	I.2	174-181	Final blind rapids. Quick acceleration, leading to turbulence.	Trills, builds in pitch and speed.
Reprise/Coda (High viscosity, low flow)	J.1	182-186	Reprise of concept from D.	
	J.2	187-196	Stream coming to rest in a stable body of water, without current.	Slowing down as current disappears, unifying of streams (instruments) into one idea, degradation of river motive.

Table 3: Formal table for *Melodious Viscosity*

4.5.4.1. General Formal Overview

Written in two major sections with a recapitulation, the work can be primarily divided into two categories of images for the movement of liquid: slow and fast. While a more typical ternary form was originally planned, the extremely shortened recapitulation (m. 182 to the end) was partly necessary because the extreme loss of energy after the central section (mm. 74-181) meant it would be difficult to maintain momentum or interest for a length similar to that from the beginning. In addition to this, unlike in a traditional sonata form where the development takes place in the middle section, significant development took place in the slow opening A section; a classical formal analogy of this work would more closely resemble a minuet and trio. The primary sections of the work are explored in more detail below.

4.5.4.1.1. Slow opening and final sections

The first slow section relates to imagery of high viscosity liquids, like oil, in thin layers on imperfect surfaces like sand. In small amounts of liquid (shallow streamlets, for example) more liquid is close to the boundary layer of the flow,[139] meaning that even with a laminar flow of liquids (layers of liquids moving in relatively stable, predictable movement)[140], there will be some friction and small disturbance in the layers of liquid closer to the uneven surface. (see the near simultaneous movement of instruments in section D or E, for example)

The overall understanding of the flow of this section can perhaps be summarized by its low Reynolds number, calculated as $Re = \frac{uL}{V}$. u is the velocity (slow), L is the linear dimension (small, for small thin streamlets), and V is the viscosity (high, for thick fluids).[141] This formula has no isomorphic mathematical link to the piece, but rather serves as inspiration for its general movement. Understanding, for example, that high viscosity with a low linear

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[139] Epifanov V. M., "Boundary Layer," *Thermopedia*(2011), http://www.thermopedia.com/content/595/.

[140] Mechanical & Mechatronic Engineering Department of Aerospace, "Laminar and Turbulent Boundary Layers," University of Sydney, http://www-mdp.eng.cam.ac.uk/web/library/enginfo/aerothermal_dvd_only/aero/fprops/introvisc/node8.html.

[141] Unknown, "9. Transition and Turbulence," *efluids: Bicycle Aerodynamics*(2007), http://www.efluids.com/efluids/bicycle/bicycle_pages/transition.jsp.

dimension leads to less surface disturbance, helps me to imagine the movement of a passage based metaphorically on liquids. With a low Reynolds number, even with these disturbances from the uneven surface, the flow remains generally predictable and stratified. It moves in logical, generally streamlined, layers.[142] (see the slow, predictable, canonic passage in Figure 30, or the barren stratification of instruments at rehearsal B)

Figure 30 The B section of *Melodious Viscosity*, representing slow flow[143]

This slow section is also imagined, however, as liquid running down low slope (contributing to the low velocity previously mentioned), meaning not only a slower flow, but an increased ability for streamlets to diverge from one another across uneven surfaces (the flute in section E, for example). The relatively low volumes of liquid, often lost through evaporation or absorption, can be seen in the areas where instruments fade to their quietest registers and dynamics, often cutting out completely (see the end of the B or E sections). In some of these areas, CAC was used for it's capacity to develop slow interpolations towards

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[142] G. L. Shires, "Reynolds Number," *Thermopedia*(2011), http://www.thermopedia.com/content/1093/.

[143] The H, first seen in the first bar on the top staff, indicates *Haupstimme*, a German word indicating the "primary voice" or line for a section. The bracket in the second bar of the top staff indicates the end of *Haupstimme*.

thinner harmonies, with slight variances over time, much of which imposed the need for the more elaborate progression system to manage such directional patterns.

The bassoon was chosen as the instrument most representative to carry the motivic material in this section (see sections B, D, J). I associate the thick viscosity of the fluid to the large physical form of the bassoon and its relatively slower attack.[144] I equally connected the dispersion of streamlets on low slopes with the greater dispersion of sound at low frequencies.

4.5.4.1.2. Primary D section

The D section provided the primary gesture around which the rest of the piece was constructed. This section represents the confluence of smaller streams, which pick up in speed and volume, exhibiting progressively less boundary layer effect in the form of melodic perturbations. One can note the slow, seemingly random entries of instruments, at first lacking some of their notes, whose divergent rhythms at the beginning gradually flow together into a general homophony. This D section and its sister section J.1 were both elaborated using the progression management system in OpenMusic, in examples of "micro" uses of CAC: uses not at the heart of the formal structure of the overall work, but that influence smaller sections.

[144] William Strong and Melville Clark, "Synthesis of Wind-Instrument Tones," *The Journal of the Acoustical Society of America* 41, no. 1 (1967): 49.

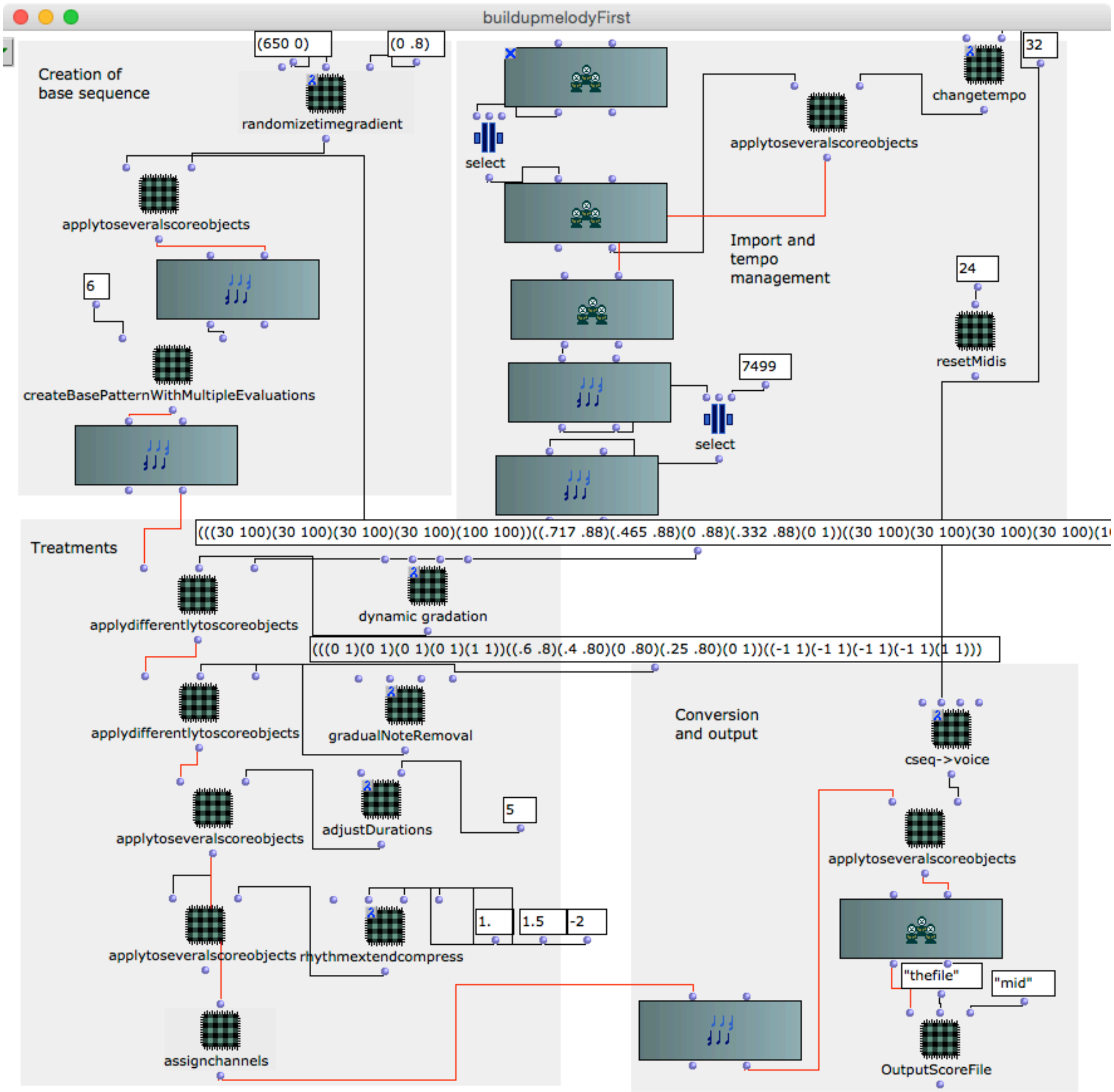

Figure 31 Screenshot of progression management system in *Melodious Viscosity*

The source material for this patch (Figure 31) is comparable to m. 55, but moving in precise homophony. These were developed by hand, and then quickly imported into OpenMusic for development. The functions to the above right include procedures to import this material, cut trim it and change its tempo so it can be more easily manipulated by the software.[145] The first function above left, *randomizetimegradient*, randomized the time slightly of each instrument. While *createBasePatternWithMultipleEvaluations* created a string of identical motives, running the patch several times produced slight variances of in rhythm in different evaluations. This chain, consisting of 6 copies of the original motive, was then passed through a number of functions, some serving to alter the musical content for the final score, and some serving only to simulate the effect in the interim. This interim simulation enabled me to go back and change things like the degree of randomization, or even how many repetitions I wished to explore (obviously, the different development processes dictated how much a motive could be repeated until it became fatiguing). This process of continually returning to the musical block of clay to mould and remould it took several sittings.

As seen in Figure 22, the system involves an applicator (*applydifferentlytoscoreobjects* or *applytoseveralscoreobjects* in this case), applied functions (*dynamic gradation, gradualNoteRemoval, adjustDurations, rhythmexstendcompress*), and arguments (the numbers and lists of numbers).

Two of the functions applied ultimately served no purpose in the final score, but aided in the decision making (simulation level) before leaving OpenMusic. The first of these is *dynamic gradation*, which gradually increased MIDI velocities - irrelevant since a *crescendo* instruction is clearer and more idiomatic for actual instruments in this case. Similarly, *rhythmextendcompress* gradually compressed the rhythm, simulating an *accelerando*. While some composers have chosen to actually quantify this sort of function and hold the tempo constant, it seemed it would only make the instrumentalist's work more difficult in this case.

Thus, the functions that actually contributed to the notated development in the final score were *gradualNoteRemoval* and *adjustDurations*. *gradualNoteRemoval* gradually removes notes from a passage, as a function of time. It can, however, work backwards, which it did in this context, gradually removing notes closer to the beginning. Different coefficients

[145] Some of these functions were simplified or enhanced in later versions of this system. For example, both import and export functions require less patches (and therefore less work in each new piece), and the arguments now work better with BPFs, providing a better intuitive visual layout. The patch, however, has been presented as it was used at the time.

were tested and used for different instruments. *adjustDurations* then adjusted the length of the remaining notes so that now-isolated notes would hold on for a little longer, making their attempted entry into the main flow more evident.

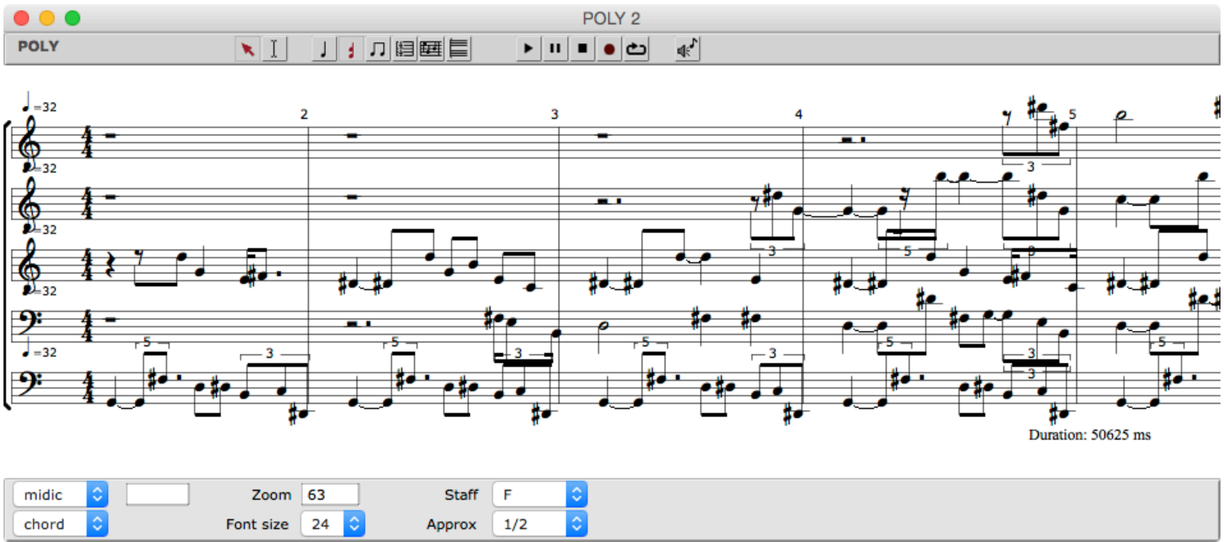

Figure 32 The results of one evaluation for *Melodious Viscosity* in OpenMusic

The final functions, in the bottom right-hand corner of Figure 31, quantified the millisecond times into more readable notated values (*cseq->voice*) and created a MIDI file for exporting to a notation software. Due to the random factors in *randomizetimegradient*, several versions were created, from which were picked the measures with the most interesting instrumental interactions. The section was then reworked by hand and keyboard, using the ear as the guide for overall flow, and inserting elements like the aeolian flute at m. 51 to complexify the colour. A portion of one of the many evaluations of this patch can be seen in Figure 32.

Being able to evaluate this sequence of processes for two different sections in the piece allowed me to create some formal unity, while quickly testing changes many of the factors involved in the progression, such as its length, the order of instrument entry, the relative variance of the different instruments, and even the approximate point of entry for different instruments.

4.5.4.1.3. Middle fast section

In this middle section, with all else being equal, there is a higher volume of liquid on a steeper, smoother slope (so moving at greater velocity), with a lower viscosity fluid such as water. The speed of the fluid on the smooth slope ensures a greater directionality and confluence of our layers of liquid (instruments) This confluence can be seen in the way the instruments are no longer independently playing their own motives, but contributing together to build the motive at F. This same section also displays a more deliberate downward motion due to the steeper slope on which the fluid is running. With increases volume (*L*) and velocity (*u*), and lower viscosity (*V*), our Reynolds number becomes significantly higher, approaching the point at which moving liquids become turbulent (generally at 2300).[146] The piece is moving towards some degree of turbulence, introduced momentarily in the F section by the *flz*. at m. 79.

The G section is an outright switch from the laminal flow of slower liquids to a short period of turbulence as seen in faster fluids with higher Reynolds numbers. Polyrhythms evoke the unpredictable nature of turbulent flow, with the repeated quick articulated notes producing the kind of static "noise" caused by turbulence, as from a tap turned on high pressure. Like in any form of physical turbulence, there are seemingly random velocity fluctuations and non-repeating patterns. This false climax deliberately lacks direction in the ensemble as a whole, and the true climax returns in the I section at around m. 176.

The I section hovers around that Reynolds number of 2300, demonstrating some degree of turbulence through the shifting trills in the high winds (m. 175), and yet some consistency between the stratified layers of the horn and bassoon (especially mm. 174-176).

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[146] Unknown, "9. Transition and Turbulence".

4.5.5. *Like A Square Peg*: Fitting CAC into a Neo-Romantic Work

This 15-minute work for string orchestra and solo violin is a somewhat personal reflection of the feelings of not fitting into a community as a result of mental health disorders. While *Like a Square Peg* doesn't follow a traditional concerto form, it does retain many of its confrontational characteristics, and some of its formal elements. The concerto form has long been interpreted as a confrontation between the individual and the group[147], which plays out as a central human theme in this work, and a formal trace of a concerto-sonata form remains, albeit dramatically warped. We see this through the exposition of two distinct themes, their combined development, and a short reprise of the opening at the end (though more reminiscent of a coda than of a recapitulation).

The works looks not only of themes of feeling isolated on the outskirts of society, but at how those concepts are not always an objective reality, but a perverted reflection of the world that comes with mental illness. The title is a tongue-in-cheek play on the expression "like a square peg in a round hole", but with the latter part of the expression removed as a degree of acceptance that perhaps a square peg does not need to fit into a round hole. While the music is not programmatic to the sense of being completely defined by these feelings, important sections nonetheless retain this inspiration for their structure and orchestration.

Like A Square Peg used CAC for a variety of capacities seen up to this point. It was used for the generation of harmonic structures, as seen in *Mutations II,* for generation of interpolations and other relatively straightforward processes, and also for the development of progressions from existing material using the modular progression management system.

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[147] Simon P. Keefe, ed. *The Cambridge Companion to the Concerto*, Cambridge companions to music (New York: Cambridge University Press, 2005), 10.

4.5.5.1. Narrative Structure

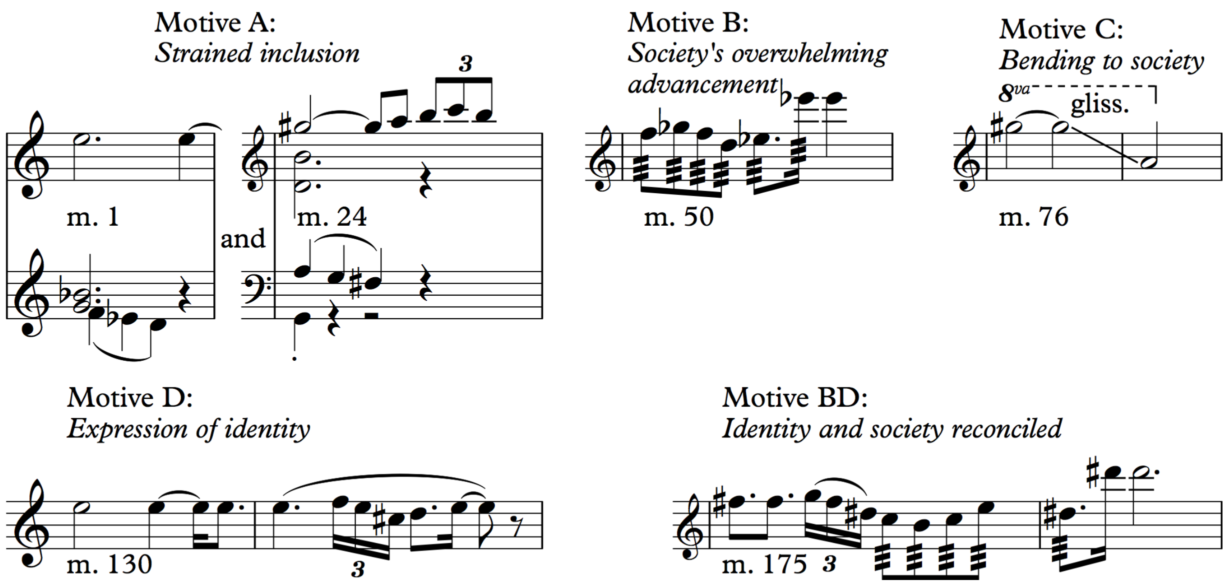

Figure 33 Central motives from *Like a Square Peg,* and the measures in which they first fully appear

Much of the piece can be understood through the recurrent motives that form the major sections of the piece, what they are intended to represent and how they do so. The slow section that opens the piece, based on Motive A in Figure 33, represents the strained inclusion of an individual into a larger society. While the solo violin and the orchestra work in some degree of synchronicity, there is a clear sense of not quite fitting in. The violin remains an obstinate holdout from the fairly consonant triadic harmony, and pushes melodically in the opposite direction from the other instruments. Despite these divergences, however, there is a sense of tolerance.

Figure 34 The opening of *Polska efter Lapp-Nils*

By measure 46, we see the gradual introduction of Motive B, representing the advancement of society. This is not the objective advancement of society, but the perception of society advancing in an overwhelming wash from someone feeling on the outside of it. There's a perception of freneticism, and also that the individual (the solo violin) is no longer able to contribute in a meaningful way. This, in terms of mental health, is not reality, but the skewed version of reality as seen by someone within the confines of mental illness. This motive is adapted from the first part of *Polska efter Lapp-Nils* (Figure 34), as these quick Swedish Polskas represented for me the musical freneticism and social activity that I was trying to capture. The *Polska* itself is also older, and there was a desire to capture the slow-changing nature of society.

When the solo violin returns at m. 65 with Motive A, it no longer truly exists in the context of society as a whole, but is withdrawn and retreating into itself. There is no longer a true link between the actions of the individual and society, but rather the individual has isolated where it is safe, but disconnected. While it makes some desperate attempts to participate in society's Motive B, it seems unable to rise above the crowd.

Figure 35 Reduction of the stacked fourths at m. 77

Measure 77 (Figure 35) shows this initial idea of strained tolerance (Motive a) returning, but with a sense that society continually encroaches on the space of the individual, before continuing their build in a way that doesn't truly include the violin (m. 84). This section, like others that will follow, is almost a dream sequence: the individual no longer truly belongs and feels as though the world around it is a blur.[148] Stacked fourths in the orchestra help create this blurry sensation (m. 77): nearly all twelve tones are used in equal force, depriving the music of a harmonic centre. These evenly spaced inert-sounding[149] intervals across the whole string orchestra spectrum create a kind of tonal grayness.

Measure 94 again sees the violin return with it's own personality, attempting to assert itself and sometimes trying to break free, but each time is now shorter, as if the violin is losing its strength and succumbing to Motive B. We also begin to see the *glissandi* being used in the orchestra in m. 96, an evocation of a societal melting pot where the individual of one in times of weakness falls to the general flow of the mass.

Following several more of these alternations between orchestra is a sense of defeat beginning at m. 117. This transitional section shows the individual being left on the outside as the group gradually converges. Accomplished using interpolation algorithms in CAC, this is intended to give the distinct impression that the violin does not feel welcome, and also to illustrate that while society is rarely a cohesive whole, it often appears as such to those who feel at the margins of it. The violin is differentiated by its timbre and register, but also by its rhythmic values and pacing.

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[148] While I hesitate to get into diagnosing the music with specific mental illnesses, much like I would be hesitant to do the same on a human, this sensation is perhaps best described by the derealization portion of depersonalization-derealization syndrome.

[149] Hella Oelmann and Bruno Laeng, "The Emotional Meaning of Harmonic Intervals," *Cognitive Processing* 10, no. 2 (2009): 116.

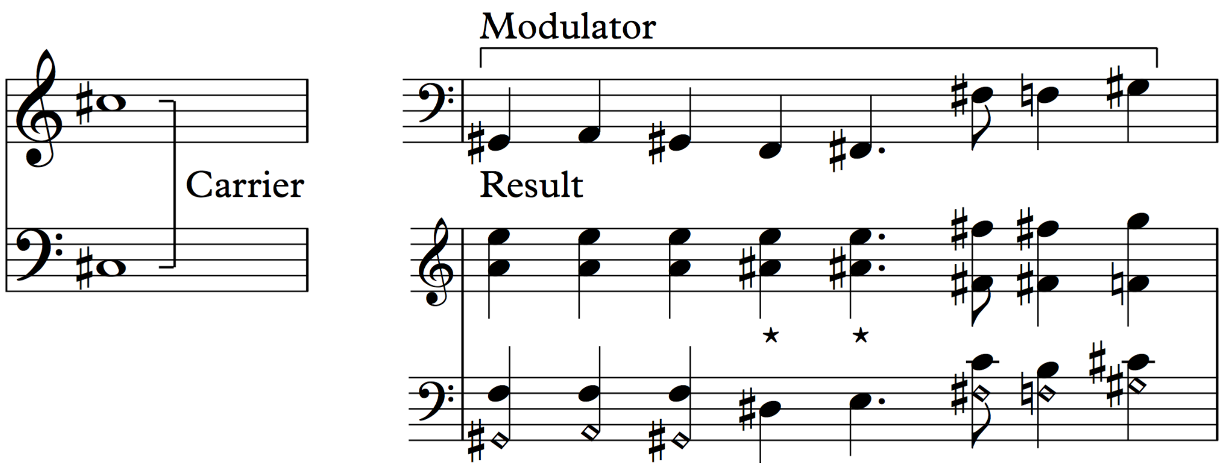

Figure 36 Pseudo-ring modulation in *Like a Square Peg*

The next major section of the work, the first truly fast section, begins at m. 128, and it's here that we begin to see a shift in the approach of the individual to their place in society. For the first time, there is truly the sense of a stream of movement, into which the individual enters into. The individual, in Motive D, expresses an individual identity confidently, as opposed to the hesitating initial Motive A. With this confidence comes a following by the orchestra, and the possibility of the individual to lead. The melody is derived from a harmonic pattern (m. 134-137), which is in fact derived from the same *Polska* from the opening section (Figure 34). This choice was very symbolic, representing the ability of the individual taking something created by society and transforming to an expression of its own identity. This was done by modulating the tonic of the section in two different octaves (C♯^{5} and C♯^{3}), as played in the second violin and viola, by a transposed and slightly altered version of the original melody. The carriers, modulators, and results can be seen in Figure 36, although the result does not represent a true ring modulation, due to an inherent bug in the *ring-mod* object in OpenMusic (diamond note-heads represent erroneous results compared to a true ring modulation, and stars represent results that were returned as *nil*, or empty).[150] The generated harmonies were, however, considered aesthetically desirable and retained in the final composition.

[150] For each carrier/modulator pair of frequencies, ring modulation should produce two new frequencies: $f^1 = f^{carrier} - f^{modulator}, f^2 = f^{carrier} + f^{modulator}$. In cases where the frequency of the modulator is

By m. 157, the individual (violin) enters into a true natural flow, sometimes making compromises to fit within the ensemble, but sometimes accepting to move independently at its own rhythm. There is, however, a degree of peace here that hasn't been seen before, represented in the simple chordal harmonies, of which the violin is part. This pace, however, becomes exhausting, and we see the result at mm. 166-167. We are left with the sense that the individual has found a way of expressing their pure identity, but that this requires an unsustainable degree of energy.

It's only in m. 170 that we begin to see a synthesis of the individual with society. There is no longer the same perceived conflict between the individual's ideas and those of society, but an acknowledgment of ways of reconciling the creativity of the individual with the collective interests of society, as seen in Motive BD. mm. 181-187 demonstrate the use of the progression management system, which will be seen below in detail.

The end, however, contains a caveat that I wished to attach in the nature of the theme of mental illness. While in many ways the piece could have ended at m. 189, the section that follows from m. 190-197 serves as a reminder that those feelings of isolation and conflict with society are not entirely gone. There is another bending to fit into society (Motive C in m. 190-191), and a brief return to the slow strained discomfort of Motive A in m. 193 followed by that old sense of the outside world taking over (Motive B in m. 196).

Finally, from m. 197-201 comes the final climax, a representation of a true emersion from isolation by the individual into a great social build. Before closing, however, there is a final reminder of this isolation in m. 202-204: a retreat by the individual into themself, before a gesture that I hoped would represent the support of society at the end of m. 204, through the rising passages of the violin and viola. This final gesture was essential, because that support is one of the final and most difficult things to accept in this journey.

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greater than the frequency of the carrier, negative frequencies can result. In these cases, the *ring-mod* function in OpenMusic produces erroneous results. It's a bug, but one which suited my musical tastes in this piece.

4.5.5.2. Use of the Progression Modulation System

The role of the progression management system in this work was significant, not for the size of the role it took in the final music, but for its signification in an increasingly integrated composition process. While early works using this system used it for much greater proportions of this work, this one is important because it represents a place where I easily transitioned between CAC and intuitive composition.

I specifically elected to use it here, between mm. 181-187, because this was intended as a climactic moment in the piece, and also represented the fusion of the individual with society. For me, this was very representative of the fusion I was trying to accomplish between CAC and intuitive composition, and this tool had already proven itself to be most adept for climaxes. Its power also lay in its ability to handle different motives in different instruments simultaneously. As such, several layers of sound could be controlled simultaneously.

Figure 37 OM input material for *A Square Peg*

The OpenMusic patch for this section (see Appendix A.14) created an 8 column matrix of cells (see Figure 26) using existing material from the piece (Figure 37) which included elements of Motive B in the violin with a subsequent echo in the cello, a syncopated motive resembling Motive D in the double bass, and the harmonic filler material resembling that used in the beginning of the fast section at m. 128. Here, however, these 16th notes alternate with neighbour tones, creating an increasingly restless mood and foreshadowing the greater movement to come.

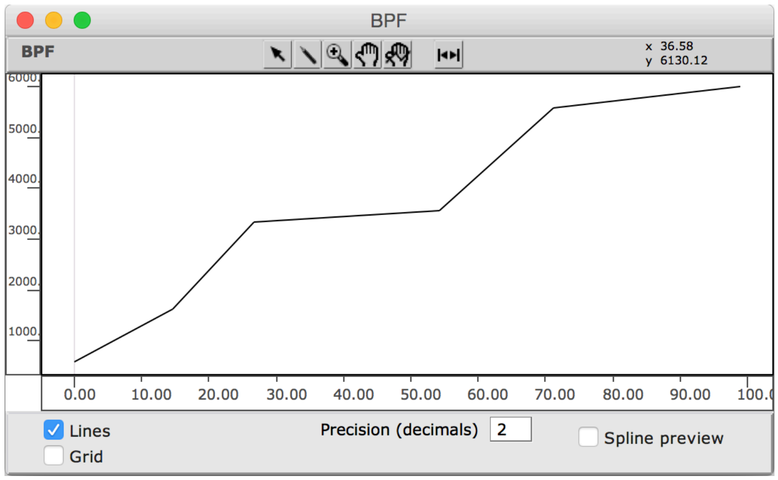

Figure 38 BPF used to control the change rate of the progression

The score material matrix was then passed through a number of processes, controlled by a BPF (Figure 38), which allowed the auditioning of many different curves, while also testing with different matrix sizes and different scales of the BPF. In short, it meant continuously and quickly moulding, or sculpting, the source material with new parameters until it captured my vision for the music. Different scales were necessary because the Y-axis of a BPF might need to change depending on the function: for transposition, it might be counted in semitones, for time, in milliseconds, and for probabilities, in percentages, all on very different scales. The first process used to treat the matrix of material was one that progressively shortened the motive: as the BPF curve moved higher, the start point of the motive was later and later, meaning that near the end, only the end of the motive would be heard in a repetitive, obsessive gesture. The next function perturbed the pitch randomly, but based on probability. Here, the BPF represented the probability of perturbing the pitch anywhere up to a minor third, making it more and more frenetic.

The function that followed applied only to eighth notes, and split a percentage of them (based on probability controlled by the BPF) into sixteenth notes before transposing the second one down a minor third. This increases the movement in the parts, increasing the intensity, but also transforming the rhythmic profile of the violin melody to move more closely with the rhythmic profile of the accompaniment. See the end of m. 183 in the solo violin for an example of this. The final function in this transformation was a transposition that would move the melody progressively upwards. In this case, a value from the Y-axis of the BPF (Figure 38) was added to the square root of the original pitch (in Hz), before it was squared again (Equation 1). The net effect of this was that lower pitches transposed much more significantly, an effect that was amplified by the fact that frequency is a logarithmic scale where the Hertz difference between notes is much greater for higher notes.

$$fnewpitch(Hz) \quad = \left(\sqrt{oldpitch(Hz)} + Y\right)^2$$

Equation 1 The pitch-shifting mechanism in *Like a Square Peg*

Auditioning various possibilities through OpenMusic was aided by listening to simulations playing the actual effects they would play in the piece (*col legno, tremolo*) and with some dynamic playback. And as is the case in much of my music, this collection of techniques allowed me to produce something with an ever-increasing degree of intensity and obsession.

4.5.6. Other Works

A number of other works used the progression management system, although often in very different ways. The following is a brief overview of *some* of these cases.

4.5.6.1. *Sliding Apart*

This earlier work that sought to explore the concept of falling apart, used the progression management system in some small, but significant ways that inspired some of my further work, specifically with regards to aleatoric processes. This was the initial test piece for this system, which was used in several distinct sections, but with a key difference to how it was often used later: it was used with falling sequences. Instead of using this systems for builds and climaxes, it was used to denature the sound. This falling pattern may be seen in mm. 101-108 or several times in mm. 162-175. A similar, but earlier, program helped to develop the introduction and conclusion (from the beginning to m. 17, and m. 177 to the end).

Note that this system did not start from existing material, but generated the lines from algorithms. While it offered considerably less control in some respects, it did allow the different instruments to move further out of sync with one another, creating more contrapuntal writing.

4.5.6.2. *Short Pieces on Falling*: "Float", "Lush", "Rings"

Mm. 24-35 of "Float" shows a similar build to that seen in *Like a Square Peg* (see Appendix A.15). Again with three somewhat independent ideas in the winds, strings, and piano, there is a progressive build. The first process, again using a matrix of score material resembling m. 24 and a curvy BPF, was transposition. Following this was a progressive shortening of the base motive, this time truncating the end, and leaving only the opening. The final, and most complex process, served to make the motives more obsessive, by taking the final remaining part of the motive (remembering they've been truncated), and repeating it. The number of repeats was also controlled by the Y-axis of the BPF. The net result was a motive that became progressively higher, with a shorter and shorter part of the original motive contained, and with more repetition at the tail of the motive of its final segment.

Passages using the progression management system can also be seen in mm. 23-31 of "Lush", as part of its more spartan central section. It was equally used in "Rings", a BPF controlling not only the shapes of lines, but their speeds, the probability of removing a note, and the amount of ring modulation. The results were then chopped up and used as the rising gestures in the woodwinds and strings (Figure 39).

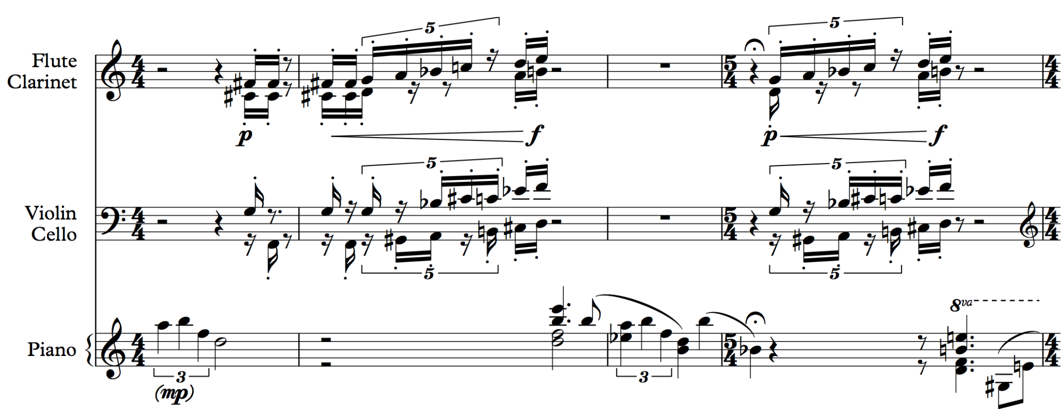

Figure 39 Reduction from "Rings" showing mm. 4-8

4.5.6.3. Mutations I

While only small portions of this piece used CAC (see Appendix A.16), one of the most significant was the end of the work: the final build, again combining textures and motives from throughout the work. The large build beginning at m. 63 was developed using progression application management tools. The source motive incorporated both the opposing octave jumps between pedal and right hand that were originally found in at the beginning of the piece, as well as the slower textured pattern that began at m. 43. As this was essentially a two-part work, this final section represents the synthesis between these two sections. Based on a BPF curve, two fairly basic treatments are applied: a frequency shifting of the notes, followed by a progressive shortening of the motive to create an increasingly obsessed and dissonant texture.

Figure 40 OpenMusic source material for Mutations I

4.5.6.4. (Let Me Hear) What Maria Hears

Creating obsessive-sounding gestures became one of the key uses for this progression management system, including one that begins at m. 102 in *(Let Me Hear) What Maria Hears*. While it was possible to go in either direction to and from intensity, I find the build-up more pleasing than the loss of energy in most cases, and prefer to handle the loss of energy through other musical devices. Here, again, this kind of CAC intervention is near the end of the piece, where I'm attempting to create different kinds of builds, and relatively intense and quick ones (see Appendix A.17). These fast builds are much better suited to these tools because they take fewer detours on their way to maximum intensity, and can be formalized in a fairly straightforward manner.

What's most relevant about this piece is that the same set of processes is used two times, once at m. 102 and once at m. 108. In each case, the same group of treatments are used. The first is a progressive expansion of the melody from the bottom: taking the melody in each cell and stretching the intervals out, upwards in this case, while leaving the lowest note in place. Next, there is a progressive transposition upwards, and after that a tool to constrain the melody to a specific mode, avoiding the piece falling into complete pitch-class randomness as it's stretched and transposed. This tool that constrains the pitch classes is one that's been used in a many pieces, and it simply adjusts the pitches to the nearest pitch class that's part of a given mode, much like a type of "autotune", but working on entire harmonies. This particular instance of the tool has an additional layer of interest, because it also is affected by the BPF source material. As the BPF rises the mode becomes increasingly complex, leading to a gradual harmonic saturation of the materials being used. Finally, like in the other examples, the motive is progressively shortened.

There is one other significant difference in this case, and that is that the flute part is separated from the group and subjected to its own separate treatments. First, again following the curve of the BPF, an increasing number of pitches are added to a pool of notes to which the flute can jump. As the BPF y-value rises, so does the probability that the flute will jump to such a note.

4.5.7. Discussion

There are a number of potential pitfalls in working in CAC, one of which becomes attempting to program things that are quite obvious to do by hand. Simple compositional practices that are intuitively evident to most composers can be surprisingly frustrating to formalize for a computer, and yet while this can seem like a waste of time in the short term, the formalization process provided me with many new insights into how I think about music. Many of the progressions created in this section were types of builds, and after an initial evaluation, it would be easy to recognize that something was missing from how one might compose a similar progression by hand. While, in some cases, I decided to simply make those changes by hand, in other cases, whether out of stubbornness or curiosity, I proceeded in to formalize CAC. Some eventually proved far too complex for me to program, and begin to enter the realm of computer-assisted analysis and artificial intelligence, such as using the complexity of harmony and timbre to determine suitable changes in speed, but at least one is worth mentioning.

One of the most obvious ones, realized early on, was that progressions must occasionally be interrupted. In general, I follow the principal that the moment it becomes predictable, something must change. But accounting for this in CAC is complex. The types of interruptions available are limitless and entirely dependent on the surrounding material, but two that may work in many situations are a “freeze” or a “pause” of the music. The failed attempts I made to create a system to generate freezes in the music were predicated on two pieces of information: where in the music, and for how long. In one case, I decided freezes should take place at the peak of the melody.

So I wrote a patch to do this, but quickly realized that more information was needed to formalize a better program. It depended on the length of the build-up before a peak: a longer build-up usually meant a longer freeze. This could be programmed, but once it was, I realized that a build-up that bowed towards the bottom (like an exponential graph) required a longer freeze, while one bowed towards the top (like a square-root graph) needed a shorter one. These would require an analysis and a coefficient to multiply by the freeze length. It also depended on what followed: passages that worked their way down gradually from the peak required little time, while those starting a new build from a lower register required more significant freezes. Freezes also seemed to be more effective after a certain speed threshold.

While this particular program eventually became more complex than was worth pursuing, it left me with a wealth of small formulas that help to guide some of my compositional choices and become internalized. More importantly than providing me with the tools for creating new freezes in music, it forced me to account for all of the factors influencing the length of a freeze and their relative strengths, allowing me to more quickly analyse and correct perceptible errors in existing scores. This kind of computational thought provided me with the tools necessary to *correct* compositions.

4.6. “Drawing”: CAC and Intuitive Gestures Produce Score Material

This chapter will look at the software *ScoreScrub* and the music developed using it. *ScoreScrub* is software that allows the user to “draw" across an existing score segment using a digital pen and tablet, while simultaneously simulating and transcribing the portions over which the pen passes. First, the author exposes the problematic behind this software*,* followed by an explanation of its architecture and functionality. The subsequent analysis will focus specifically on the works *Gift efter Carl Herman Erlandsson* and *Världen och Jag*, and to a lesser degree, *Lullabies for Boys Who Will Not Sleep Anyways*. Shorter exposés follow on *ScoreScrub* in other works, including “Waves” from *Short Pieces on Falling*, the first movement of *Little Boys…* and the 11th interlude from *Ruminations on the Season.* We end the chapter looking forward at future possibilities for the software.

4.6.1. The Inspiration for *ScoreScrub*[151]

While I was generally happy with the results from the progression application management system, certain drawbacks remained, the most evident of which was time. Testing different coefficients and curves gave me quick means to evaluate a musical hypothesis, and a fast system to generate material, but the repeated tests meant that memory could take an undue effect on the music. The sense of surprise was lessened by repeated listenings to simulations, meaning ideas that were originally too complex to follow became predictable enough to sound logical, and ideas that were good to begin with became boring.

The logical next step was to take many of these concepts, and attempt to integrate them with real-time feedback for the composer. As opposed to using BPFs to control parameters in progressions, one could use a gestural and more interactive equivalent: a digital stylus. The

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[151] The *ScoreScrub* software is discussed in more detail in an article from the proceedings of the 2017 Journées d'informatique musicale: Matthew C. Lane, "Real-Time Scrubbing and Transcription of Score Materials Using ScoreScrub," in *Journées d'informatique musicale*, ed. Pierre Couprie, et al. (Paris, France: Collegium Musicæ, 2017).

goal was something that would allow me to unite two sides of my composition, Kahneman's systems 2 and 1, or in musical terms, CAC and improvisational elements.

> "Improvisation is traditionally regarded as a process in which performers, with their voice or instrument, in 'real time,' use luck or skill to respond to or incorporate mistakes; the improvisation grows out of innovation, exploits freedom, and relies on talent in an instantaneous process that involves emotional invention and intuitive impulse to create simple, direct expressions."[152]

I set out to create a system that would allow some degree of improvised composition, sometimes referred to as "comprovising". This system was not intended for live performance, but rather for CAC, with the goal of not having to pause and transcribe ideas as they come to mind, and not having to do too much touch-up work after the fact. It was also important to be able to interact directly with score material, and so the idea of "scrubbing" seemed appropriate. It could act as an "emulsifier" – one means of joining gestural and intuitive composition with CAC and programming. Furthermore, I was hoping to achieve one thing that always evaded me: to control time intuitively through CAC.

4.6.1.1. Scrubbing

Scrubbing is a relatively well-known effect in the analog and digital audio worlds. The term comes from "scrubbing" tape across a magnetic head.[153] Through scrubbing, one can hear the audio in either forwards or reverse, and with variable speeds depending on how fast the tape is moved. This concept was adopted by DJs, waveform editors, and even cellphones, recently. The notation software *Finale* even offers a scrubbing feature, although it's purpose is to audition music rather than to act as a tool for CAC.[154] Most systems, however, are intended for electronic music, and many are intended more for live performance.[155] Figure 41 shows

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[152] Steve Larson, "Composition Versus Improvisation?," *Journal of Music Theory* 49, no. 2 (2005): 241.

[153] Doug Van Nort, "Multidimensional Scratching, Sound Shaping and Triple Point," *Leonardo Music Journal* - (2010): 17.

[154] Tom Johnson, "Scrubbing Your Music?," *finale Blog*(2010), http://www.finalemusic.com/blog/scrubbing-your-music/.

[155] For more on this, see Lane, "Real-Time Scrubbing and Transcription of Score Materials Using ScoreScrub," 2.

how scrubbing might look in a notational system (and approximately how it works in *ScoreScrub*), where scrubbing forward (1) plays and transcribes the music moving forward at the speed of the gesture, scrubbing backwards similarly plays the music backwards (2), and holding the "magnetic head" (4) in one place holds a pitch.

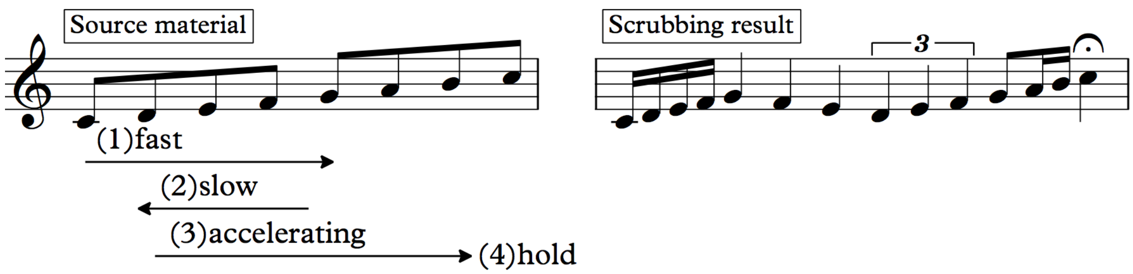

Figure 41 The arrows show the scrubbing movement through the base material on the left, and on the right is the result.

Scrubbing, by its nature, requires existing material: originally this was a tape, but now it can be a sound or video, or in some cases, a score. Using existing material provides a number of advantages compared to other systems. One could compose virtuosic passages without the instrumental technique that's usually required for improvising, allowing what Wessel and Wright termed "low entry fee with no ceiling on virtuosity."[156] It also meant one could improvise many layered and independent voices, such as might be the case in a piece for large ensemble, which surpasses the "one gesture to one acoustic event" standard for traditional instruments.[157] It wouldn't be an instrument in the traditional sense, but could still respond with much of the immediacy and intuition that a good instrumentalist can use to respond to an idea. Since the process would not be "generative" so much as "transformative", certain idiomatic instrumental kinks could also be sorted out in advance. And finally, using the same source material, even with a varied number of treatments, would ensure some degree of motivic resemblance in a section, and thus some degree of formal unity.

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[156] David Wessel and Matthew Wright, "Problems and Prospects for Intimate Musical Control of Computers," *Computer Music Journal* 26, no. 3 (2002): 12.

[157] "Problems and Prospects for Intimate Musical Control of Computers," *Computer Music Journal* 26, no. 3 (2002): 11.

Specific to my own composition, there were a number of important benefits this could bring. It could move beyond the technical limitations I would have composing intuitively at an instrument such as piano or organ: large ranges with contrasting motives could be used, and different timbres could be superposed. It would also serve my desire to build passages using CAC from existing material. Simple ideas that I regularly employ in my music, such as a sense of obsession or sudden very directional lines, could easily be imagined. And the idea of cross-cutting, as one might imagine in Stravinsky, Finnissy, or Carter, would be easily possible, along with many of the jolty changes in pattern or direction that inspire some of my music. Most importantly, perhaps, it uses existing material that can have been written by hand, allowing CAC interventions midway through works. Much of the literature regarding CAC[158] treats it as the starting point for the large-scale form of a work. While there can be good formal reasons for this, it may also be because incorporating computer generated ideas midway through intuitively-composed ideas can often sound jarring and unnatural, as if one added an electronics section to a piece midway through. In this case, however, the departure point from existing material allows for the creation of a bridge between the worlds, and a smoothing of any jarring divides between the two. It also allows the composer to begin a work with an intuitive or even improvised idea, and still retain the possibility of reworking this material through CAC.

4.6.1.2. Existing Software

While similar programs or processes already existed, none served the specific functions that I was hoping for. First was the ability to scrub: to move forwards and backwards in an existing piece of music. Second was the ability to audition (hear) what was being played at any given point in the scrubbing process, in a way that was nearly immediate. And third was the capacity to transcribe.

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[158] For a good summary of this, look at the contributions in: Jean Bresson, Carlos Agon, and Gérard Assayag, *The OM Composer's Book*, 3 vols. (France: Delatour/IRCAM - Centre Pompidou, 2006-2016). Nearly all of them look at CAC as part of the underlying form of a work.

Some of the systems created and used by Philippe Leroux, for example in his works *Apocalypsis*[159] or *Quid sit musicus,*[160] explore ideas that resemble scrubbing, but are ultimately generative instead of using existing material. The reactive programming features in OpenMusic used for the latter, however, provided some of the inspiration for this system, but the underlying functionality of OpenMusic is still not really designed to generate results in real-time due to the demand-driven architecture (see section 20).[161] Other libraries, especially Moz'Lib for bach and Max, also allow the drawing of lines to produce musical material, but not in a way that truly allows the use of complex existing score material.[162] Devices like *ReacTable*[163] or Small Fish Tale[164] also use scrub-like features to produce electronic music, but they have MIDI-outputs, meaning these ideas could be adapted to write scores for actual instruments. They are still, however, generative (as opposed to transformative with the use of existing material).

4.6.1.3. Wacom Tablet

There are a number of ways to register a composer's gestures for scrubbing, but inspired by Leroux's work, the use of a Wacom digital stylus and tablet was chosen. Input devices for musical expression tend to fall into two categories: either those that rely on

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[159] Yiorgos Vassilandonakis, "An Interview with Philippe Leroux," *Computer Music Journal* 32, no. 3 (2008): 15.

[160] Jérémie Garcia, Philippe Leroux, and Jean Bresson, "pOM: Linking Pen Gestures to Computer-Aided Composition Processes" (paper presented at the 40th International Computer Music Conference (ICMC) joint with the 11th Sound & Music Computing conference (SMC), Athenes, Greece, September 15 2014).

[161] Bresson, J. *Reactive Visual Programs in OpenMusic*. [Research Report] IRCAM, https://hal.archives-ouvertes.fr/hal-01142078/document, 2014.

[162] Ghisi, D. et al. “Extending bach: A Family of Libraries for Real-time Computer-assisted Composition in Max”, *Journal of New Music Research*, 46:1, p. 34-53, 2017

[163] Sergi Jordà et al., "The reacTable Exploring the Synergy between Live Music Performance and Tabletop Tangible Interfaces" (paper presented at the Conference on tangible and embeded interaction, Baton Rouge, Louisiana, February 15-17 2007).

[164] Hugo Solís García, "Improvisatory Music and Painting Interface" (Master of Science in Media Arts and Science, Massachusetts Institute of Technology, 2004), 42.

existing motor functions, or those that force the user to develop a new paradigm for expressing themselves.[165] Trying to avoid the necessary virtuosity of learning a new "instrument", it seemed wise to use a motor skill and compositional tool most composers already relate to: a pen and paper. Because the pen point could be linked directly to the score on the screen, one could have the impression of drawing on the score, giving the user visual feedback of what they were scrubbing.

Furthermore, modern Wacom tablets capture at least three dimensions, including the obvious x- and y-axis, as well as a z-axis capturing pressure. The more independent dimensions of a composer's gesture that could be captured, the more that gesture could be sourced to produce a complex and unique musical idea. One final benefit of the tablet was its ability to capture the pen’s position while it was still hovering, allowing the user to prepare their hand without having to guess.

While it's true that devices like the Kinect software for XBox 360 could also be used to capture gestures in several dimensions, it would represent a more complex setup and possibly a less natural transition for composers used to traditional pen and paper composition. In addition to this, partway through this project, pressure-gradient trackpads began to appear for many computers, meaning the software could be easily adapted in the future to work on a simple laptop without an external input device.[166]

4.6.2. *ScoreScrub* Architecture and Functionality

4.6.2.1. Software Architecture

ScoreScrub was developed in MaxMSP because it provided the tools to handle real-time musical information, and other tools were already available for the Max environment that enabled it to deal with the external input of a Wacom tablet, MIDI devices for simulated playback, and score objects for music reading and transcription.

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[165] Marcelo Mortensen Wanderley and Nicola Orio, "Evaluation of Input Devices for Musical Expression: Borrowing Tools from HCI," *Comput. Music J.* 26, no. 3 (2002): 62.

[166] See, for example, the Force Touch Trackpad available on new Macs since 2016.

The set of objects that most strongly inspired the creation of this software was the *bach automated composer's helper* library for Max. This library, by Andrea Agostini and Daniele Ghisi,[167] allows Max to interact with musical scores, including staves, notes, and nearly any kind of markup that is necessary for a conventional musical score. The language that *bach* objects use to send information is referred to as lisp-like-linked-lists, or *llll*s. This list structure is extremely close to that which is used in OpenMusic, which made the transition especially easy, and made it possible to easily incorporate ideas that I had previously tried in OpenMusic. Of the two notation objects in *bach,* "roll" and "score", "roll" served the needs of my software best because it displayed music as proportional across time. This meant that as the pen would move across the score, it's movements would have a directly proportional relationship to time, unlike in a true score, where notes, barlines, and other elements are not always spaced with even proportionality. This "roll" object would serve as the interface object that a user could "write on", although the actual pen or cursor movement was handled by an invisible layer on top of the "roll" object.

Existing objects for Max also reinforced the decision to use the Wacom tablet, such as the *s2m.wacom* object by Charles Gondre from CRNS-LMA, which allows Max to communicate with a Wacom tablet, retrieving all three axes of information as well as any buttons pressed. Rather than attempting to handle simulations "in-house", the MIDI information for any music scrubbed was simply sent to any MIDI device chosen by the user, or an IAC bus in order to handle this via external libraries. In its most basic mode, all the notes in the *bach* object were stored in two MIDI buffers, one for moving forward in time, and one for moving backward in time, due to the complexity of handling note-on and note-off messages, and the program chose which buffer to use depending on the direction the pen was being moved. The placement of the pen over the score was used in conjunction with information from the "roll" object about which portion of the score was displayed to sample

[167] For more information on the library, see Andrea Agostini and Daniele Ghisi, "A Max Library for Musical Notation and Computer-Aided Composition," *Computer Music Journal* 39, no. 2 (2015).

different parts of the appropriate MIDI buffer. In general, the “roll” object only serves as a visual reference point for the scrubbing.[168]

As the scrubbing occurs, detailed note information is immediately sent through a whole stream of potential processes and treatments, which will be discussed further below. These can cause a perceptually miniscule time-lag, but which is large enough to confuse the quantification at the end in fast music. For this reason, all of these are time-stamped at the beginning of this chain, and realigned according to their original time-stamp at the end.

4.6.2.2. Functionality

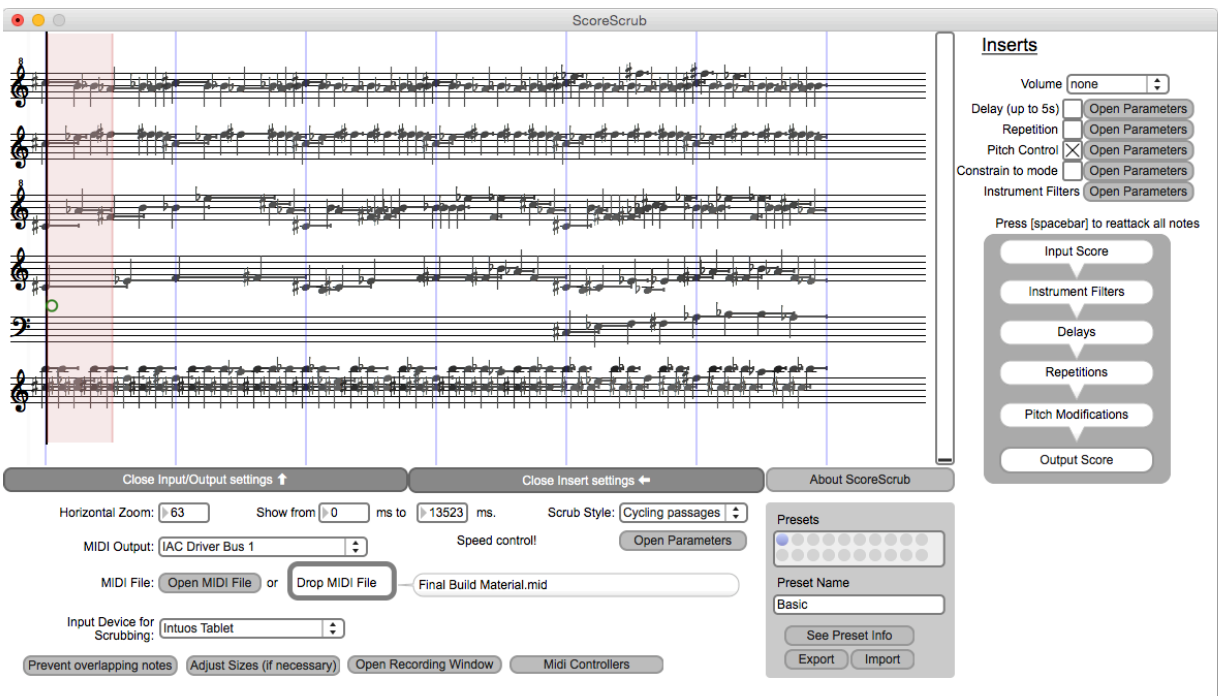

Figure 42 Screenshot of *ScoreScrub*’s main window

The vast majority of the main window of *ScoreScrub* is occupied by score material the across which the user can scrub (top left in Figure 42, larger in Appendix A18). Using the Wacom tablet, the user controls the cursor (represented as a small green circle, below the 4th staff in the score). Pressing the pen down will play the notes at the time-point where the cursor

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[168] This is, however, complicated slightly when *cycling* mode is used, which will be seen in section 4.6.2.2.

is, and lifting the pen will silence them. Moving a depressed pen will play the notes that the cursor passes over in time, regardless of its y or vertical position. For example, if the user moves a depressed pen halfway across the score to the right, the program will play along in all the voices as the pen cursor moves past the time points for the different notes: the vertical position is irrelevant for this, only the horizontal “time” position matters. This will work left-to-right or right-to-left, similarly to dragging the play head across a sound file in many audio editors. For a clarification on this principle, see Figure 41.

Instead of a traditional scrubbing method, there is also a cycling mode (see Appendix A.18). Under this mode, the segment of the score enclosed in the red box plays forward and cycles when it has completed. Moving the pen controls the start point of the red box, and another control, such as the y- or z-axis controls the length. This would resemble the way a DAW can cycle a particular segment of a piece, but in this case, the section being cycled is dynamic. It is in many ways a immediate-feedback parallel to the discrete progression management system discussed in section 4.5.2.1. A vertical black line shows where the current cycle ends, and a vertical green line shows its progress. While this is happening, the user may be moving the pen to prepare for the next are that will cycle. This is especially useful in highly motivic or obsessive music, and a grid and snapping feature helps the user to work within the original metre of the source material.[169]

[169] While in cycling mode, the score creation and audio feedback is no longer truly in real-time, since in allowing cycles to finish, the program is no longer following the pen as immediately as in the regular mode.

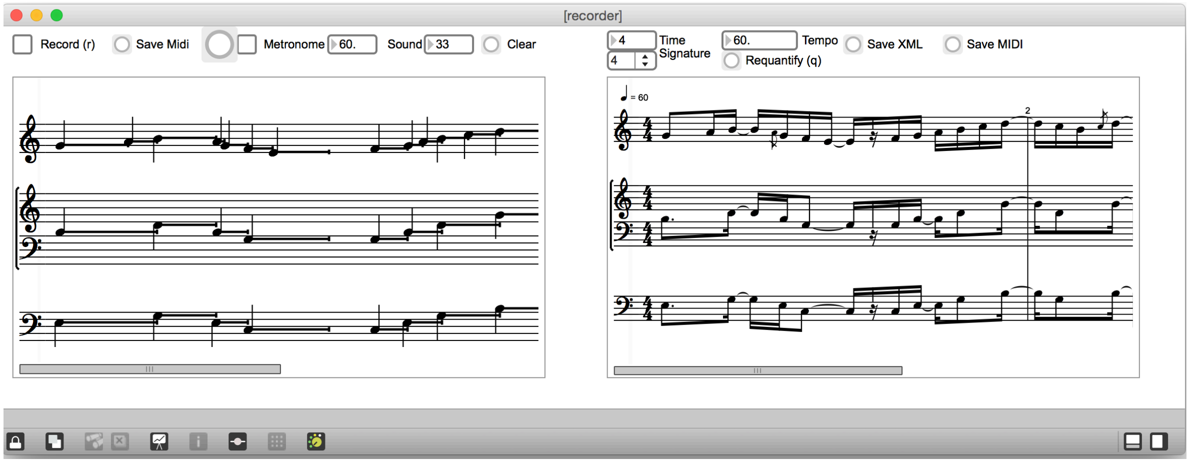

Figure 43 The recording window in *ScoreScrub*

Thus far, we have touched on the audio feedback of what's being played and the visual feedback of the cursor on the screen. But as a CAC device, the most important element is an ability to transcribe what's being scrubbed, and in a way that is relatively simple and legible for a musician. Some work will always be required to touch things up, either because there are musical elements that couldn't be fully expressed with the pen, or because the quantification system was not sufficient, but the goal was to require as little of this as possible. As such, there is a "recording window" for recording a scrubbing session, with two objects notation objects (Figure 43). On the left is a container that captures everything that was scrubbed in raw timed data, while on the right are quantification settings that allow the user to test parameters to produce a more playable score. The time-deferred score generally represents almost precisely what the user heard while scrubbing, but allows the computer to devote all resources to actual scrubbing and plugins while ongoing (see section 4.6.2.2.1), only doing the heavier visual transcription when the session is finished.

Other basic tools like a metronome or shortcuts facilitate the recording process. This covers the basics of how the system works, but there are a host of other features that render it a much more elaborate tool for complex scrubbing processes.

4.6.2.2.1. Plugins

One idea that came from the world of digital sound processing was the idea of plugins, or treatments. Because I was working with instrumental music with immediate feedback, I questioned how one might apply treatments to the music: either by pitch, dynamic, or timing. Furthermore, like one might see in a DAW, I hoped to make these plugins dynamic, and capable of responding to the pen movement or another input. These plugins are located down the right-hand side of the main window, under the label “inserts” (Figure 42).

In terms of timing plugins, there are features for note delay and note repetition (see Appendix A.19). The delay functions much like a multi-band EQ delay in a DAW, but instead of different frequency regions, it works with different voices or instruments. The user can set different delay amounts for different instruments, delaying their attacks. Furthermore, these delay times can be amplified by y- or z-axis value or a MIDI-controller (see Appendix A.20), meaning they can be largely controlled dynamically.

The repetition plugin will repeat a held note after an interval, and the note length can also be influenced by either axis or MIDI-controller. This can be useful, especially in conjunction with the delay, to give some life to the ensemble through repeated attacks instead of held notes, and can also give the instrumentalists space to breathe.

The various pitch processes can be found in the parameters for “Pitch Control”, and they allow the user to influence the pitch of the scrubbed notes while scrubbing, and as for all the plugins, the simulation and transcription reflect these changes (see Appendix A.19). The simplest of these is a basic transposition, where the y-, z-axis, or MIDI-controller controls the amount of transposition. The next simplest is transposition by interval, controlled the same way, but snapping the transposition to certain intervals. Perhaps the music should only move in fourths, and thus, all transpositions should be by fourths. Next, there is pitch-shifting or frequency-shifting. In this case, the y-axis, z-axis, or MIDI-controller determines the modulating frequency by which to shift the notes.

Finally, and perhaps most importantly for those working in a modal or tonal environment, there is a “constrain to mode” plugin: this takes any of the pitches that have been altered through any of the other plugins and constrains them to a chosen mode.

4.6.2.2.2. Orchestration

The feature that allowed the most variety while actively scrubbing was the orchestration feature. This plugin takes the form of an instrumental router, and while it does not perform any complex changes to the music, it allows some simple rearranging of instruments. This permits fairly dramatic textural changes, dynamically applied while scrubbing.

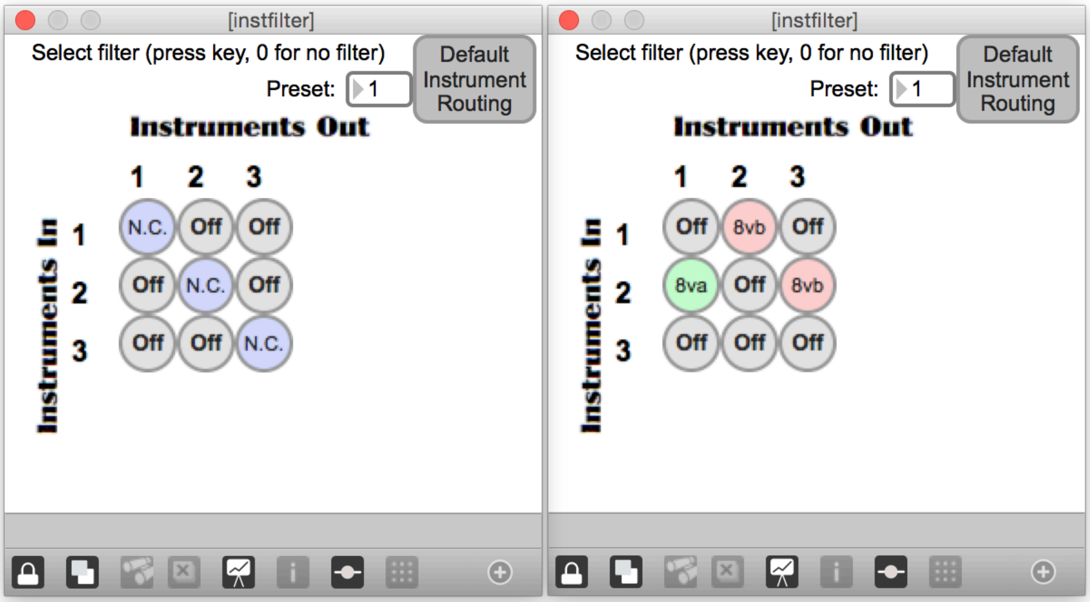

Figure 44 Two examples of orchestration presets in *ScoreScrub*

The orchestration feature is simply a matrix router (Figure 44), with incoming instruments (from the scrubbing) represented on the y-axis, and outgoing instruments (to simulation and transcription) represented on the z-axis, inspired in part by the matrix systems used in studios. Here, we will assume that the instruments were originally flute, clarinet, and cello. Any input instrument can be sent to any output instrument and transposed either up or down two octaves. In the left example, there is no change: instrument 1 is sent out to instrument 1 (flute), instrument 2 to instrument 2 (clarinet), etc. Furthermore N.C. indicates "no change", meaning in they are sent out without transposition. In the right example, the scrubbed flute passage is instead sent to instrument 2 (clarinet) an octave down. The scrubbed clarinet passage is sent to the flute an octave up and to the cello an octave down. No one plays the cello part.

Up to 5 presets can be prepared, and they are then controlled by the number keys. Thus, in an orchestral piece, a passage intended for the brass might be transposed up an octave and given to the woodwinds, but with the possibility to switch orchestrations while scrubbing. With this tool, I was able to immediate feedback for changes in instrumentation and test and transcribe them in real musical time.

4.6.2.2.3. Miscellaneous

A variety of other features serve to simplify or amplify the capabilities of *ScoreScrub*. MIDI controllers may be not only used, but mapped with a BPF function, giving them control over any function that can then be applied to an insert. A general preset system is present to ensure the easy retrieval of more complex setups, allowing the user to quickly move between sections of the input score and different uses of inserts.

4.6.3. Gift efter Carl Herman Erlandsson

4.6.3.1. Context and Overall Form

These two works for piccolo trumpet and piano are a celebration of marriage, the second movement of which was partially written for mine. Inspired by the small 17th century wooden church we had chosen in rural Sweden, and the ideals of harmony and eternity that the architecture captured, I felt compelled to write something resembling a *romance* for the wedding; this spirit is found in the openings of both works.

In the title, "Gift" carries a dual meaning: that of a present in English, and the word "married" in Swedish. As is common with the nomenclature for transcribed folk tunes, the word "efter" designates the source from which the author or musician drew materials (in this case, a Swedish folk tune). Both movements are written in a type of rounded-binary form, with a slower A section, a faster B section, and a disintegrating transition back to a slow but shortened B section to finish.

The second movement was written first; the first movement was only written after as it seemed like a moderating counterbalance to the extant second movement. François-Hugues Leclair, as Masters advisor, stressed the value of writing new music based on the elements we love in our existing music, and I sought to capitalize on this concept. The first movement is inspired by the second in form, texture, and in the choices in harmony. Both use some form of modal minor harmony in the A section, and both made use of the *ScoreScrub* software for the B section. *ScoreScrub* was used in its cycling mode, allowing motivic rhythms, melodies, and textures to be partially preserved while still drawing freely.

4.6.3.2. Second Movement

4.6.3.2.1. A section: counterpoint and contrasts in speed

As a forward to this section, it's important to understand that this section of the work was initially written for a recorder instead of a piccolo trumpet. While the full piece was ultimately written for piccolo trumpet, the range, line lengths, breathing spaces, and balance between instruments retain characteristics from their original orchestration.

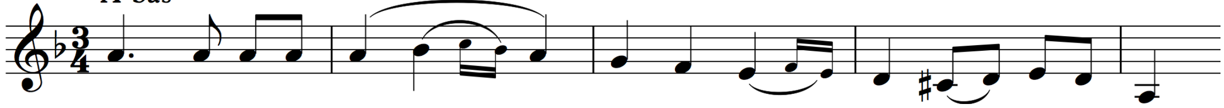

Figure 45 The first phrase from Vals efter Erlandsson[170]

There are three planes of tone in this first section – three independent ideas – taking place, each with some degree of personal significance. First is the trumpet melody, based on a Swedish folk melody (Figure 45), and organised in triplets. This melody is progressively lengthened and developed throughout the section, but nearly always retaining its characteristics repeated notes followed by an upward neighbour tone and then a conjunct downward motion. The repeated notes help not only to provide a motivic reference point, but also to create a sense of stability, familiarity, and comfort: this was a large part of the emotional image sought in the A section of this work.

The piano right hand attempts to provide a stabilizing counter-rhythm to the trumpet, creating a persistent hemiola pattern: these cross-rhythms are here to capture different speeds at which we tend to live and in our marriage, but also the common meeting points where we are completely in sync. These fifths in the piano right hand represent stability, continually sounding the tonic and dominant tones of the mode at even intervals, creating a modal minor framework that allows some degree of tonal flexibility between the tonic and dominant. Again, the idea of common meeting points prevails. These fifths are also adorned with chromatic neighbour tones, which serve to slightly complexify the harmonic world as well as the rhythmic world, since they return someone capriciously, but also to prepare new arriving harmonies. Perhaps most importantly, however, they act as a form of leading tone, always guiding back to the stabilizing fifth.

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[170] A full transcription of this work by Erlandsson can be found, amongst other places, at: Nils L., "Vals efter Erlandsson (SvL Uppland nr. 93)," FolkWiki, http://www.folkwiki.se/Musik/2464.

The notation is reproduced as is from Swedish folk music notation. The smaller notes are similar to grace notes, but considered to be an extension of the notes to which they are slurred, and not a preface to the notes that they precede.

Finally, the piano left hand serves two purposes: harmonic grounding and a second melody in counterpoint to the trumpet melody. The harmonic grounding occurs primarily when the pedaled left hand reaches lower for a bass note to support a section. The melodic portion, deliberately divided by register to allow it a greater melodic range, attempts to contrast the upper melody both directionally and rhythmically, beginning its phrases in relay with the trumpet, ensuring the piece, while slow, never completely loses momentum.

The section is organised as two major builds, linked through a ring modulation progression. The first build culminates at m. 24 before returning to the tonic where the ring modulation progression takes over until measure 42, before the second build, which culminates at m. 55 with the arrival of the B section. This is simply intended as a play on expectations: after the first build, the expectation has been created that we will return to the tonic, so it was important to go elsewhere to provide some degree of novelty. The first build is achieved through complexification and length increase of both the trumpet and bass melodies, as well as increased returns to the stabilizing bass notes, the progressive upwards movement of the right-hand fifths, the saturation of the pitch space and register range[171], and obviously, the increase in dynamics.

The ring modulation section begins in earnest at m. 34 after a short transition. I gravitated towards ring modulation, like many other types of modulation, because it is a way of enhancing, thickening, and complexifying existing material, allowing that crucial link between music composed intuitively and CAC processes. It's a process that's generative but equally transformative, and transformative processes allow a link to be made with what has already been done. To arrive at these pitch sets the treble C at the root of everything is modulated by octave transpositions of the three first notes of the left hand melody, excluding the C: B, A♭, and F, but in reverse order. This produced a total of two pitches per modulator (carrier + modulator, carrier - modulator), and the pitch of the modulator itself was also retained for a total of three pitches. To each of these was added a fifth, and the carrier (C) and its fifth (G) were placed back in the right hand from where they were derived. The remaining

[171] Pitch-space refers to the use of the 12 semitone pitch-classes (regardless of octave), while register range refers to the total pitch spread over several octaves.

sets of fifths are then played by the left hand, as seen in m. 34. With the three modulators, there are then three sets of harmonies, the first of which (from modulator F) is found in m. 34 and m. 37, the second of which is found in m. 35 and 38, and the last of which is found in mm. 39-40. The trumpet line was composed freely over these harmonies, allowing me to create motivic links to the preceding and succeeding material, and to create a compositional link back to intuitive composing.

The final build, one of full saturation, is first foreshadowed by the rising fifths in the left hand at m. 41, which with the pedal, creates a full saturation of the modal pitch space. Nearing the B section, this saturation becomes even more extensive, and the sense of heaviness from the increased pitch baggage becomes obvious in the gradual arpeggiating of the chords and the *ritardando*, making it feel like the section is dragging to a complete halt and creating an even greater contrast with the upcoming B section.

4.6.3.2.2. B section

This section was developed in *ScoreScrub* using the cycling feature, allowing the preservation of much of the rhythmic material. The grid functions enabled metrical continuity throughout the section, while the y-axis control of pitch and the orchestration presets enabled significant variance in the section.

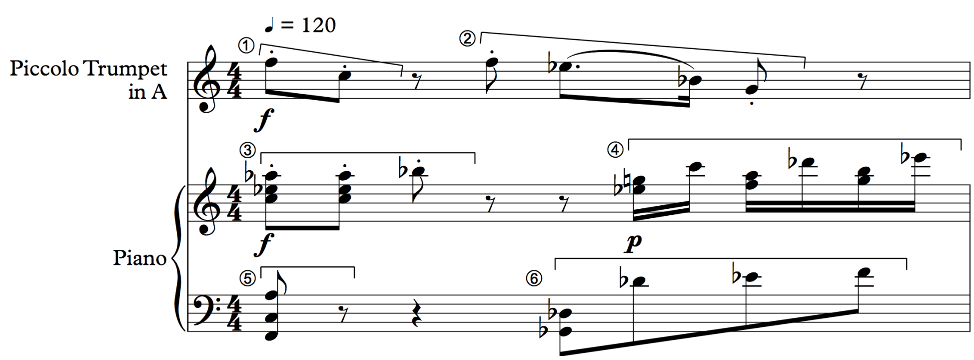

Figure 46 Motive used as *ScoreScrub* base material for B section

The complex motive (Figure 46) also helped, because the different orchestrations and different temporal placement of ideas in this motive meant that there were no fewer than 6 relatively independent musical items that could be targeted using the pen in *ScoreScrub* (Figure 46). Different orchestrations allowed these be to transposed or eliminated entirely (such as cell item 4 at the beginning of m. 61, where only the piano is playing), and different cell-sizes (controlled by the y-axis) allowed me to zoom in on temporal elements of particular interest (such as the obsessive use of portions of cells 2, 4, and 6 in m. 69). In this piece, the cyclical function of ScoreScrub was especially useful in capturing the idea of obsession and anxiety, in stark contrast with the peaceful meditation of the A section.

Like any CAC material, part of the act of composition is in the choices. In many forms of CAC (especially in LISP-based architectures like OpenMusic), many of the choices are made before the algorithm is run. In *ScoreScrub*, many choices are also made through improvisation, while the algorithm is already running. But in both, some important choices happen after. Two different composers may take the same material and build something entirely different out of it. Thus, for me, much of the work is going over the result, determining which sections should perhaps be cut, which should be repeated, which should be thinned out, transposed, etc. It's sculpting. But it's rare that I add anything. In some cases, a simple-repetitive moment was simply captured, and something else was layered overtop (see m. 58).

One of the most basic processes is "subtraction", very much inspired by Patrick Saint-Denis' idea of the "black page" from which one subtracts contents to produce a clearer musical idea.[172] My use of ScoreScrub tends to produce dense layers of instrumental sound. Often, I'm very familiar with the materials, so the constant novelty and complexity of the sound is appealing on the initial scrubbing. Often what is most effective is simplification and thinning: respecting the beauty of silence or simplicity in the music (such as the thinning of sound and the pause at m. 79), or the removal of an instrument from the texture (m. 84). This simplification, conversely to removing, may also involve repeating a particularly jarring moment: in some cases, the revisiting of scrubbed material reveals something that sticks out far too much from the prevailing texture. I may choose to incorporate it by adding some sort of transition (see the eighth notes preceding m. 72) or repeating it by hand (m. 87). Finally, subtle

[172] Patrick Saint-Denis, "De la musique au-delà des frontières du son" (D.Mus. Thesis, Université de Montréal, 2013), 89.

changes in dynamics and articulations in the final score can help lead the listener to these more jagged changes, rendering them slightly less shocking.

4.6.3.3. *ScoreScrub* in Movement I

While movement I of the work is very similar in structure, both the *ScoreScrub* software and my use of it were significantly more advanced when the piece was completed. In movement I, the B section begins at m. 43, and many of the same processes were used, both in the program and in making choices in the material after the fact.

Figure 47 The original scrubbing material for the B section of movement I

Though similar, the pitch changing was done through frequency shifting as opposed to simple transposition (meaning that lower pitches tend to transpose more), and the orchestration presets were much more elaborate (note, for example, the very high piano section at m. 63, where the pianist is responsible for both the trumpet part and the right hand of the piano from the original motive.

During the process of reincorporating the raw material into music, many more liberties were taken, but often along the same subtractive or simplifying lines. Breathing space was added, both for the performers, and for the listener to accustom to new motives (such as at m. 46) or to prepare a significant change in texture (m. 63). Harmonies were thinned out to create more gradual progressions instead of pure juxtaposition (see the thinning piano chords in m. 55 or m. 65). Ideas were repeated to aid in familiarization, and while this is an additive process, it's actually decreasing the amount of new information over a given time that the listener has to absorb (see the octave repetition in the piano at m. 58). Finally, transitions were added to smooth out some areas (m. 79), and dynamics, articulations and octave doublings were added to give a clearer direction and reinforce the metric structure (m. 85).

4.6.4. ***ScoreScrub*** **in *Världen och jag***

4.6.4.1. Inspiration and Context

In early 2012, many post-secondary students in Québec began to boycott classes as a protest against lowered government subsidies of their tuition. Like many born outside of the province, I had not grown up in a culture with the same kinds of civil disobedience. I felt increasingly on the outside of the student society, not sharing the beliefs or tactics of my peers, and was becoming increasingly dismayed by the $10 000 per semester my Swedish then-fiancée was paying for classes that weren't being held.

This piece provided an outlet for many of these feelings, which I dwelled on for far too long. *Världen och jag,* or "The World and I" is more personal than political. It's not intended as a commentary on the students nor on the government, but rather on my own feelings in this experience. Much like the *Like a Square Peg*, this piece is a reflection on the sense of belonging in a community. Unlike the work for string orchestra, however, it's less about developing a personal sense of identity in that community, and more about reacting to that community as they militarize. Contrary to *Like a Square Peg*, however, there is no synthesis: the individual does not eventually conform or find common ground with the group; there is simply a dialogue and an opposition.

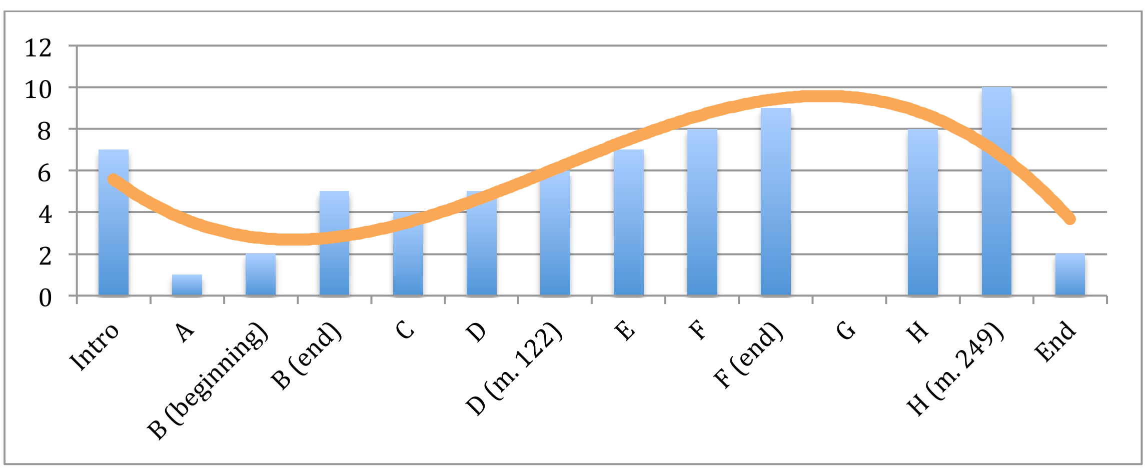

Figure 48 The composer's perceived intensity levels for sections of *Världen och jag*

Similarly to *Melodious Viscosity,* my compositional process involved composing one of the inner sections that contained essentially all of the materials for the piece, and then creating sections to preface that section and to develop that section. Disregarding the intense introductory section, the general structure is an interrupted dynamic and intensity arc, building towards a climax right before rehearsal G, and then continuing that climax at rehearsal H and slowly coming down from it towards the end (see Figure 48). This intensity scoring is very subjective, but includes factors such as the density of orchestration, the register and spread of voices, the dynamics, and the dissonance of harmonies. The section at rehearsal G, the interruption, is a deliberately large deviation precisely at the time of the climax, which will be treated separately below.

Figure 49 Primary materials for *Världen och jag,* (b) being the individual motive, and (c) being the group motive

4.6.4.2. Structure

The section around which all the others were built begins at rehearsal B, and includes the primary motives that drive the piece. Much as in *Like a Square Peg*, there are contrasting ideas representing the thoughts and emotions of the individual and the intentions of the group. The motive representing the individual is derived from a *Polska* by the 19th century Småland (Sweden) musician Lars August Bengtsson, the beginning of which can be seen in Figure 49 (a). This is a region in Sweden in Sweden that represents family and soul-searching for me, and the motive felt inward-looking through its turning around the tonic, and somewhat melancholy through its minor mode. It was adapted for the piece (Figure 49 b) slowing and simplifying the rhythm to capture a more ponderous emotion, and by fitting it with leading tones to either side of the tonic.

Figure 50 Interpolations between the same note sets with different arcs

The other primary gesture was an accelerating collapse inward from a chord, creating a sense of falling. The top line of one of these collapses can be seen in Figure 49 (c), but the idea was actually developed from sketches, like the one seen on the front page of the score. Contrary the folk music motive, this one was harmonically complex, fast, unstable, and violent. This gesture technically collapses inward, but is perceived more as falling due to a number of factors. First, the fall interval (for example at m. 66) is greater in the flute than the rising interval in the bassoon, drawing our attention to the more dramatic of the two outer passages (the inner passages being somewhat dissonantly compressed between the two outer ones, especially as the gesture proceeds, and difficult to hear independently). This gesture, representative here of a mass social movement, deliberately obscures the identities of the individual, and its often-downward sensation is deliberately oppressive. Developing this simple passage in CAC using interpolation functions allowed me to create and test many different versions, and to slightly alter the arc of the interpolation to produce the desired effect in each case (see the results with different arcs in Figure 50). The CAC process also automatically constrained the notes of the interpolations to a given mode, depending on whether the given line was upwards or downwards, thus varying the up and down passages.

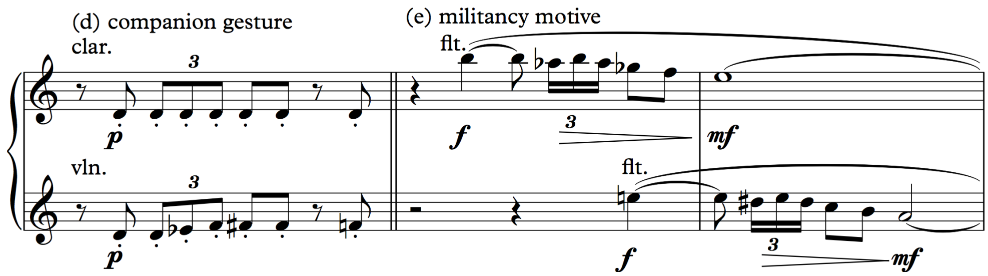

Figure 51 Secondary motives/gestures in *Världen och jag*

The B section contains the main narrative that gave rise to the motives upon which the other sections were constructed. While the piece can be understood in purely musical terms of tension and release, composers and listeners both grant some degree of narrative agency to musical ideas.[173] Furthering this sense of agency in my own practice allows me develop an emotional connection to the interplay between the gestures, creating a cycle that feeds the musical input. The Swedish folk motive ((b) in Figure 49) represents the individual's attempt to rise to some form of self-expression and out of the inward-looking base of the motive (m. 65). The collapsing gesture in the winds (m. 67) then takes the role of the group effectively suppressing that self-expression. What follows for the clarinet in m. 68 is an important parallel to my own experience with defeat, where I tend to find myself feeling isolated and paralysed, if only momentarily, with the violin II playing the role of companion attempting to guide the clarinet towards the group (referred to henceforth as the companion gesture, Figure 51). In this short passage, it's important to note that the clarinet line remains fixed between the two horn notes, the sustained final notes of the collapse gesture, in a very literal attempt to give life to the social situation of being caught between two somewhat unpleasant and conflicting positions. This small rhythmic rise in the violin after the fall (m. 68) was also crucial to avoid excessive loss of momentum for too long in the music. This whole cycle repeats itself several times, in an attempt to give hope to the sense of increased renewal after defeat, and eventually builds to a stronger and more powerful gesture approaching rehearsal C.

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[173] Narrative in music, and music's capacity for agency, are extensive topics that fall outside the scope of this thesis. Anthony Newcomb, however, provides some of the framework for musical agency in "Action and Agency in Mahler's Ninth Symphony, Second Movement," in *Music & Meaning*, ed. Jenefer Robinson (Cornell University Press, 1997), 133-35.

4.6.4.3. Section Details

The opening section of the work is primarily an exposition, allowing both motives to be presented independently and sequentially in full orchestra, in order to leave no doubt about their importance in the work. Both are presented in the brass, whose gravitas and combined spectral density provided the most forceful introduction. The collapsing motive is built one small piece at a time, acclimating the listener to the slightly jarring harmonies and awkward rhythms. Once introduced, it must leave space for the introduction of the Swedish folk music, but without the piece losing overall momentum so early. Thus a kind of *stretto* helps to intensify the rhythm while lightening the texture.

The Swedish folk motive is built similarly starting at m. 13, first by introducing larger and larger portions of the motive, and then by presenting it in canon. Here, however, the imitation is overlapping instead of dialoguing, creating a heavier feeling than previously.

The section beginning at rehearsal A represents the true beginning of the large arc, allowing just an unthreatened expression of the individual motive: lonely, and introspective, before the conflict of the B section. To the other side of the fulcrum B section, the section beginning at rehearsal C is a development of only the societal or "group" motive (c from Figure 49) and the companion gesture (d from Figure 51). The companion gesture in this case, however, actually builds to be a variant of the Swedish folk music before morphing into the militancy motive at m. 94 (see Figure 51), bringing in rhythmic elements and the melodic direction from the group motive. Here, instead of climbing to reinforce its own identity, as in the B section, the clarinet rises in a kind of mob mentality to join the militancy motive at m. 94. An important part of the personal narrative is found here, albeit subtly: the militancy motive fizzles out, as the individual who has attempted to join with it does not truly ascend to its values.

The following sections, beginning at rehearsals D, E and F form the primary build in the piece, and narratively, they show the build of the individual motive and the societal motive in spite of one another, both trying to speak over one another in some respects. There is no synthesis here (or ever).

The section beginning at G falls completely outside the realm of this dialogue, partially as a musical means to contrast with the two main recurrent motives, and partially as a retreat of the individual into itself: this is a journey into the mind rather than into society. It's modeled after the concept of the "dream sequence", a technique dating back to 472 BCE[174] that allows the audience to enter into an individual's internal psyche or memory.[175] A more detailed look at this section, inward-looking and almost self-pitying, will be seen further on, but the important element to note for the moment is its placement: as an interruption directly at the climax of the work.

Figure 52 Raw material for *ScoreScrub* in *Världen och jag*

The final section, beginning at rehearsal H builds into something resembling a full-blown battle through the militancy motive, representing the peak of this movement, "les casseroles", and much of the anger that was being spread from all sides. Much like the whole

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[174] Olga Taxidou, *Tragedy, Modernity and Mourning* (Edinburgh University Press, 2004), 99.

[175] Mark Montgomery, "Dreaming Up Dream Sequences," *Videomaker*, December 2010, 57-59.

event, however, this section simply fades around m. 231, without any major event to truly mark it, finally leaving space for the individual to return with a sense of completion and peace.

4.6.4.4. Primary Integration of *ScoreScrub*

This piece represents the most elaborate use of *ScoreScrub* I had made use of to date, totalling 15 staves in the software, which would actually be expanded to 20 instruments through the virtual instrument and the conversion back into a score. It also represents one of the more elaborate integrations between intuitive writing and CAC. One of the reasons for this was the plethora of available layers in an orchestra, but another was that both the section preceding and succeeding this section were written first, meaning there was a clear harmonic reference point for the beginning of the scrubbing, and a clear formal reference point for the end.

Much of the structure of this section was integrated in the raw material that was imported into *ScoreScrub*, which is seen in reduced form in Figure 52. First a set of four harmonies was written intuitively, with the first forming a kind of resolution to the preceding section and the final creating a preparation for the section at H. The four-note chords were approximately spaced by fifths to give the slightly airier feel sought after for a dream sequence, compared to the tight clusters in preceding sections.

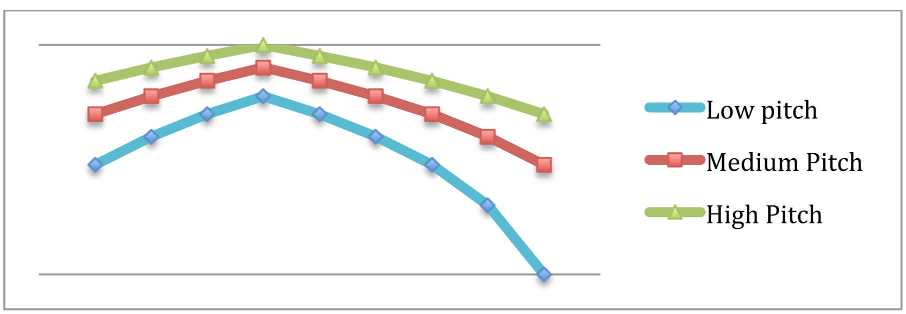

Figure 53 Approximate relationship between pitches affected by frequency shifting

At the beginning of each chord were elements specific to the attack: instruments and notes that would appear momentarily when the chord changed, giving the new harmony a sense of deliberation. These include the brass and metalophone percussion attacks. The middle section of each harmony (or measure in Figure 52) contained only the harmony, but this would drastically thickened and given direction through *ScoreScrub*. While the strings would stay in place to provide a degree of stability and a sense of general lack of motion, as if asleep, the various processes in *ScoreScrub* would apply to the first chair of each woodwind instrument. These would first be delayed, reminiscent of the wind attacks in the A section (see m. 36), each instrument by a different non-metric amount (and influenced by the pen movement) in order to create a kind of dreamy haze. Then they would be reattacked at intervals controlled by the y-axis position of the pen: as the pen moved higher, the reattacks became more frequent, but due to the delay between the instruments, they were not reattacked in unison. Finally, the notes were frequency shifted based on the y-axis of the pen, which unlike a traditional transposition, tends to compress the music upwards because the addition of frequencies to higher notes does not have as pronounced of intervallic effect (Figure 53). This dense pitch and rhythm cloud, especially in relatively airy harmonies, allowed the creation of a very foggy pitch space that captured the essence of a dream sequence for me.

Finally, at the end of each harmony, in the two beats before the next harmony, other instruments were increasingly added at varied rhythms, allowing a build as I moved the pen from one harmony towards the next. Because this would be scrubbed at the speed of intuition, the rhythms were not important, but it was important that they be irregular to avoid coincident attacks and to blend with the texture of the winds being frequency shifted.

The scrubbing, or "writing" process, was only a small part of the work, but allowed me to take these intuitively constructed harmonic materials and improvise freely with them. I traced large arcs, moving slowly, with no dramatic gestures, but with a bit of scribbling, to create more attacks in the lead-ups to each section.

The next significant stage of work was elaborating based on the output material from *ScoreScrub*. I had intended for the scrubbed material to be a layer in a larger structure, and thusly, I analysed what I had scrubbed, keeping in mind the general intensity, formal lengths, and serendipitously created harmonies, and used this as a guide for the brass melodies I composed over top. The rhythms were very simple, reminiscent of the "individual" motive to which this "dream" was attached, and the melodies were embellished with simple canons and spectral orchestration to allow the melody to shine through more forcefully. The melody was deliberately untethered to time or harmony, as I imagine the layers of a dream, and they were relatively non-motivic, allowing them to float freely and independently of their surroundings, and not requiring a larger formal structure to justify their motives (the formal structure had, of course, already been provided by the scrubbing).

Finally, I reminded myself that I was in many ways working with a "black page", as Saint-Denis calls his source material: an already harmonically and rhythmically saturated space in which removing notes (m. 173, for example) can often provide the greatest contrast, and creates the opportunity for emphasis when such notes return. While formally loose, the whole section is a generalized build, due at first to the upwards motion of the harmonies (and therefore all the voices), and subsequently due to the melodic and orchestration choices that were made to prepare the return of the summit that we left before rehearsal G.

4.6.5. *ScoreScrub* in Other Works

4.6.5.1. *ScoreScrub* in *Lullabies for Boys Who Will Not Sleep Anyways*

The third movement of *Lullabies for Little Boys Who Will Not Sleep Anyways* contains one of the more elaborate uses of *ScoreScrub*, especially with regards to the orchestration tool and the cycling capability. The piece, whose harmony was discussed in section 4.4.2.3, attempts to capture the agitated movements in and out of sleep and the contrasting yet connected stream of ideas and emotions that come at night. I wanted to capture the wandering of thoughts, but the clarity of ideas, comprised in an obsessive framework.

Figure 54 The *ScoreScrub* source material in *Lullabies...* (3rd movement).

The source material for *ScoreScrub* contained 6 motives developed by hand on different staves that could theoretically be overlapped in 63 different combinations (Figure 54). The orchestration presets then allowed these different lines to be sent to up to 7 different instruments: 2 real (piano and toy piano) and 5 synthetic (toy handbells, toy xylophone, pitched blocks, and two types of low bells). On top of this, the different routings could be transposed up to two octaves above or below (as seen in the orchestration feature in section 4.6.2.2), and instruments could be sent more than one motive simultaneously, limited only by what the human performers could play. Given all this, the orchestration possibilities were in the thousands, but 5 were selected as presets. Frequency shifting, as seen in section 4.6.4.4, was applied only to the higher-register electronic instruments based on the pen's y-axis. This simplified the work for the physical players, since they didn't have to cope with erratic transpositions, and by keeping the frequency shifting in the high register, ensured that the changes acted as colouring rather than strong harmonic changes. These upper instruments were also passed through spectral-blurring plugins, creating more sustained cloudy layers of frequency-shifted harmonies.[176]

[176] The plugins used belong to Michael Norris' *Soundmagic Spectral* and can be found at "Soundmagic Spectral," http://www.michaelnorris.info/software/soundmagicspectral.

Figure 55 The final result in both the real instruments and electronic instruments at m. 199

Further more, each motive existed in three states of increasing complexity (Figure 54), so that as I progressively moved right with the pen, the combinations became more harmonically rich and rhythmically dense. Cycling mode was used with an 8th-note grid, and the length of the cycled sections controlled by the y-axis, allowing long lines in some sections and obsessive gestures in others. Similarly to previous examples, some thinning out was often done after the fact to create more of a gradient between orchestrations. Finally, the lines were sculpted with dynamics and short introductions or tails to lines to create smoother transitions between the often-jagged orchestrations (see Figure 55).

4.6.5.2. Other Works

Numerous other works used *ScoreScrub* for portions of the piece, allowing a fairly easy transition between intuitive writing and intuitive use of CAC. One of the earliest ones was from *Short Pieces on Falling*: "Waves". "Waves", whose initial harmonies were seen in section 4.4.2.1, used *ScoreScrub* with its cycling mode (and variable length cycles) between mm. 37-63 to develop the original motives and to move through a sequence of harmonies in which each instrument had a solo.

The first movement of *Lullabies for Little Boys Who Will Not Sleep Anyways* used the material in Figure 19 as the scrubbing source material. This material contained both MIDI notes played by a sampler for the tape part and notes used by the real musicians. This material, which is first presented at the beginning of the piece, is scrubbed to create the last section of the ternary form, beginning at m. 83. Since this theme had already been established at the beginning, I could scrub freely at the end, forwards and backwards, obsessing over some notes and providing new degrees of instability before the ultimate fade-out.

Finally, from *Ruminations on the Season*, no. 11 used *ScoreScrub*. Instead of seeking a readable quantification, however, the score was simply presented in proportional notation. It is organised in a kind of ternary form, with the two A sections beginning at the start and at m. 50, and the B section beginning at m. 30. The scrubbing material is simply a series of chords, spread across different staves to be inserted in to *ScoreScrub*. Each staff was given its own amount of delay, but which was entirely controlled (multiplied) by the y-position of the pen. The first 9 measures, for example, show the chords going from nearly coincident attacks to differentiated attacks by m. 6 and then back to coincident attacks. The B section, transposed down a major third, is slightly more active due to the use of the repetition treatment in *ScoreScrub*, creating attacks not only when the harmony changes, but within the same harmony at changing time intervals. The staccato notes were composed intuitively.

4.6.6. Discussion

The issues with scrubbing are comparable to the issues with other forms of CAC: too much time with the same material breeds familiarity, which in turn gives the composer a warped conception of the musical value of what was scrubbed. However, there is an additional factor I noticed over time: there is the very real creation of a kinetic connection with the music being created through the use of the pen. That physical action seems at time to augment my perception of the gesture's strength, which can create a truly joyful experience in composing this way. However, once the scrubbing is over, so is that tactical connection with the music, and in the same way that film music removed from its image context can lose some of its power, I've occasionally found that scrubbed music removed from its physical roots can lose some of its interest.

The program also lacks a number of features that will be important going forward. The incorporation of microtonality will be important, as will the creation of counterpoint through multi-touch trackpads. In order to make the transition between intuitive composition and the use of *ScoreScrub* truly fluid, a module inside notation software should be developed. This would allow the user to select a portion of the score to scrub, and subsequently that would be transitioned directly into *ScoreScrub*, while the result would be retransitioned directly back to the notation software.

5. Conclusion

It's important to remember that intuition and traditional compositional judgement have always played a role in CAC, though often in the later stages; in the decision-making stages. As was discussed at the very beginning, one of the major differences between algorithmic music and CAC is the human filter through which we pass the results through. Dmitri Tymoczko describes it in his compositional process with CAC:

> "Here my compositional role is that of a gatekeeper or judge, selecting the computer-generated passages that strike me as intuitively compelling, and arranging them, in a collage-like fashion, so as to produce the best musical effect."[177]

For me, though, finding this link between the intuitive and the formalized and coded involved trying to find other moments in the process where they could intersect: not only would the intuition take place after there was computer-generated material, but passages could be composed before to provide input to a CAC passage. Other gestural connections could be made between CAC and intuitive composition, to the point of even allowing them to exist concurrently, such as in *ScoreScrub*. Harkening back to the very beginning of this discussion, what is needed are emulsifiers that allow this oil and water to mix: new emulsifiers that continually find new ways for these two to interact.

The less concrete part of this is not just where and how the connections are made, but how these two approaches can influence one another: how to move between them with fluidity, and in my case, how to avoid the feeling that you cannot transition back from one world to the other. Both intuitive composition and CAC have capabilities the other lacks, and a summation of these helps guide when to let go of one process and embark in another. In my work, CAC has been useful for highly formalized processes; logical progressions towards a goal and providing new raw materials that can be shaped as I wish. Creating foundations and expectations have been valuable uses of CAC. Where CAC has not succeeded, and not through lack of trying, is through subverting expectations in major ways, debatably one of the

[177] Tymoczko, *A Geometry Of Music : Harmony And Counterpoint In The Extended Common Practice*. location 667.

primary goals of music.[178] The act of building something, and then building something completely different that on some level responds to the initial gesture - moving laterally through musical ideas. The play of opposites, contrasts, and sudden deviations. CAC works effectively within constraints of similarity, but there is no one axis on which one can find contrasts in music: there are millions of them, and short of programming recipes for a specific few, intuition seems to be the most effective tool here. The capacity of the human brain to be inspired and creative through the thousands of connections that light up based on an existing piece of music does not have an easy parallel in the CAC world, and even if it did, those neural connections are based on the life of personal and musical experiences of the composer. Any computer would have a hard time replacing that.

This experience has reminded me throughout that there is something precious and emotional in the physical writing of music. In the rare cases where I've written music entirely at the computer, there always feels like there is something missing: a sense of touch to connect me to the score. For this reason I'm increasingly convinced that the future of CAC will allow composers to make more physical connections to their music. I suspect this is especially true if we are to widen the tent of CAC. Some physical gestures, like drawing, allow us to surpass the capabilities of the speed of the mind, without the limitations of instruments. The relationship between memory and musical ideas is remarkably complex, and yet whenever we compose music, we drastically warp this relationship through the time it takes us to write things out.

For this reason, the flexibility and availability of tools is crucial. Tools allowing the use of a physical gesture, such as *ScoreScrub*, or even the BPFs in the progression management system, keep the intuitive system 1 of the composer engaged. Completely programmed tools, regardless of how useful, tend to fall into the system 2 category: slow and methodical. One of the greatest lessons I've taken away from this is about the flexibility and adaptability of tools: I keep a tool chest of CAC tools nearby whenever I compose intuitively. They are flexible,

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[178] For comprehensive looks at the central role of expectation/anticipation in music, see the seminal work by Leonard Meyer, *Emotion and Meaning in Music*, vol. 16 (University of Chicago Press, 1956)., or more recently, David Huron's *Sweet Anticipation : Music and the Psychology of Expectation* (Cambridge, Mass.: MIT Press, 2006).

adaptable to different types of music, and always within metaphorical reach. They remain as simple as possible to accomplish their goal while allowing me to still remain in my intuitive state of mind from whence I came, and yet they have enough functions to allow me to solve a variety of different musical functions. Furthermore, if possible, they are visual: visual CAC tools help me to maintain a link between the aesthetic and the practical, those two worldviews from *Zen and the Art of Motorcycle Maintenance*.[179]

Through this incorporation of gesture and flexible tools, part of what I hope to demonstrate is the possibility of greater links between the conventional world of composition and the algorithmic. Despite the prevalence of CAC in the academic world in which I reside, a great deal of composing goes on outside of this world, and in many ways my music often resembles that world more. I hope to share this with that world: that CAC may be limited in its capacities, but not by style. It does not always need to produce something more complex than our mind can comprehend: sometimes it's just a question of producing it differently, and being inspired by a different result. We are influenced by the paths along which we travel, and then same may be said for our music. The same idea that travels along the world of intuition and of CAC may come out differently. Perhaps the intuitive path will be best, but perhaps we will nonetheless learn something from the CAC path.

One thing of which I am sure is that the future is in computers, and largely in coding. I suspect this is largely the same way that the future of composition at the turn of the 19th century was in pianos. To engage the rest of the compositional world in CAC, we need to create new bridges towards this new world without requiring composers to check their compositional style at the door. We need emulsifiers to link these two worlds, because the journey from the piano to the computer is much more complex than the journey from the harpsichord to the piano.

[179] Pirsig, *Zen and the Art of Motorcycle Maintenance : an Inquiry into Values*. 60.

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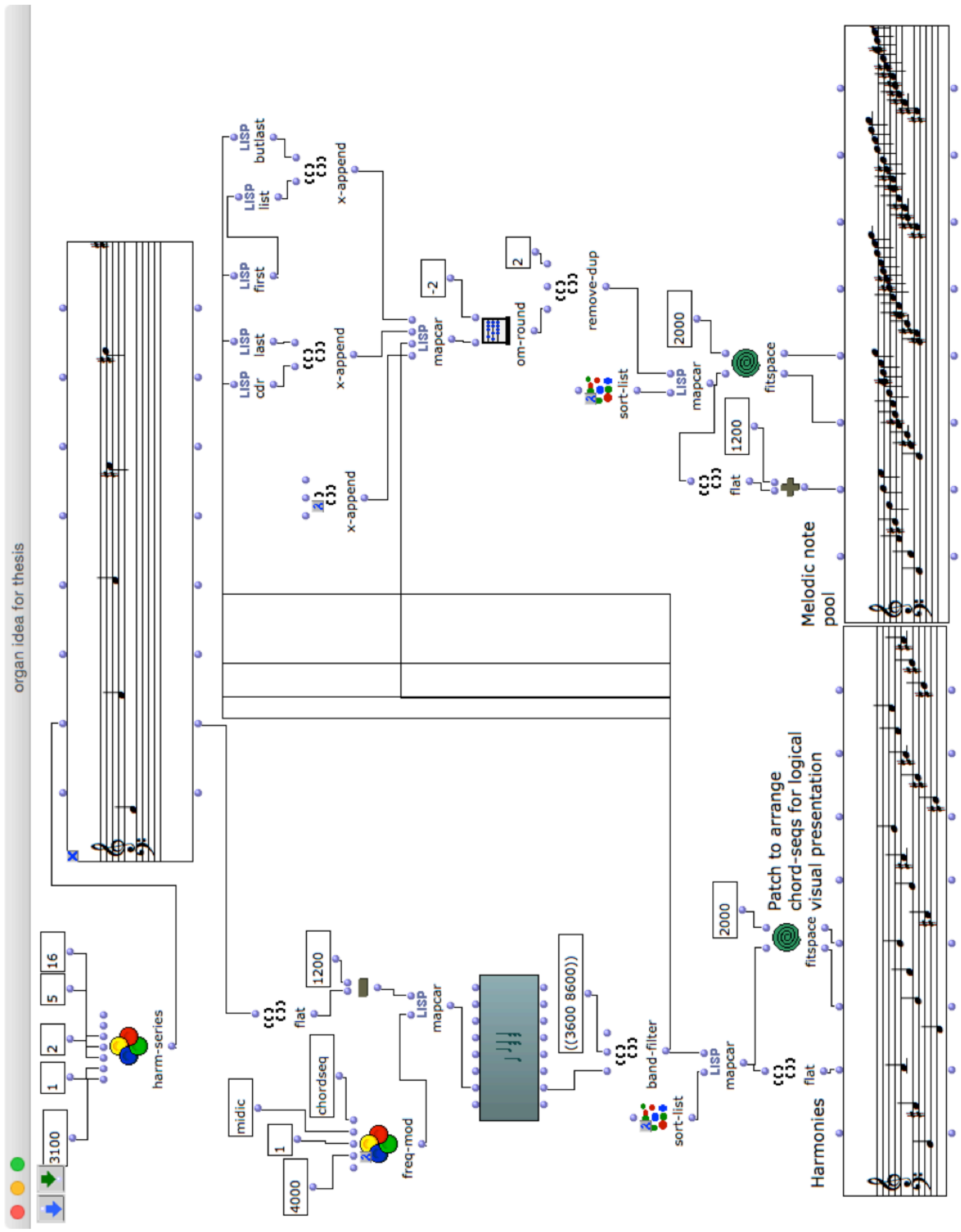
Appendix A: Patches and Screenshots

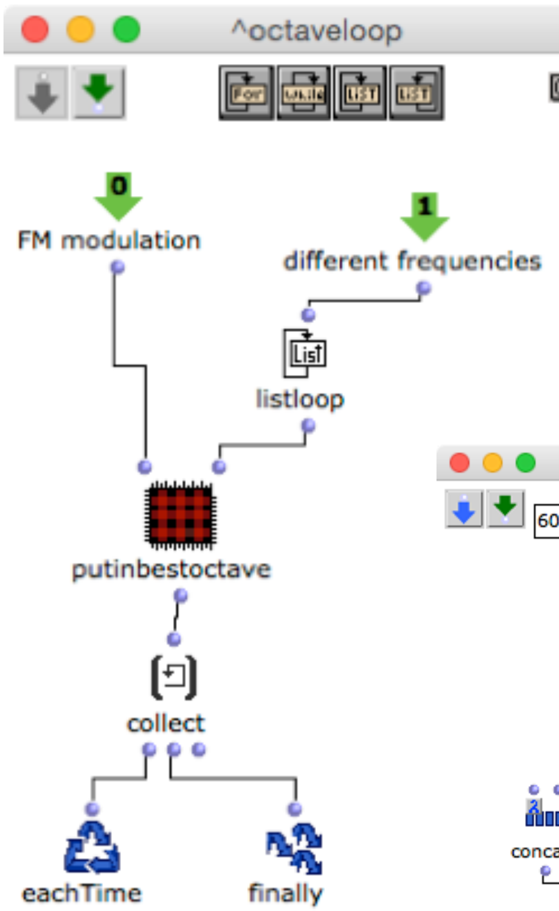
The programming portion of this appendix is intended for those with a good understanding of the software used. As many as possible of the elements and sub-patches have been laid bare, except in cases that involved a number of calculations so elevated as to appear confusing on paper. In such cases, short descriptors are left to indicate the purpose of a sub-patch. Patches with excessive "spaghetti" have generally not been included due to their near-impossibility to understand on paper.

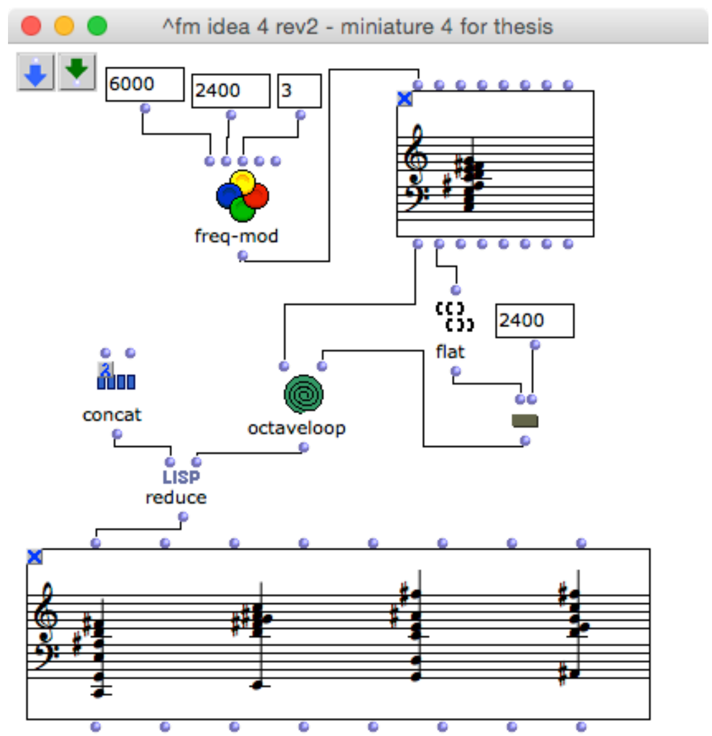
All of these patches are either in OpenMusic or *ScoreScrub*, a Max-based software, but without its functionality exposed. Large patches have been rotated in order to allow more of a single patch to be shown on a page.

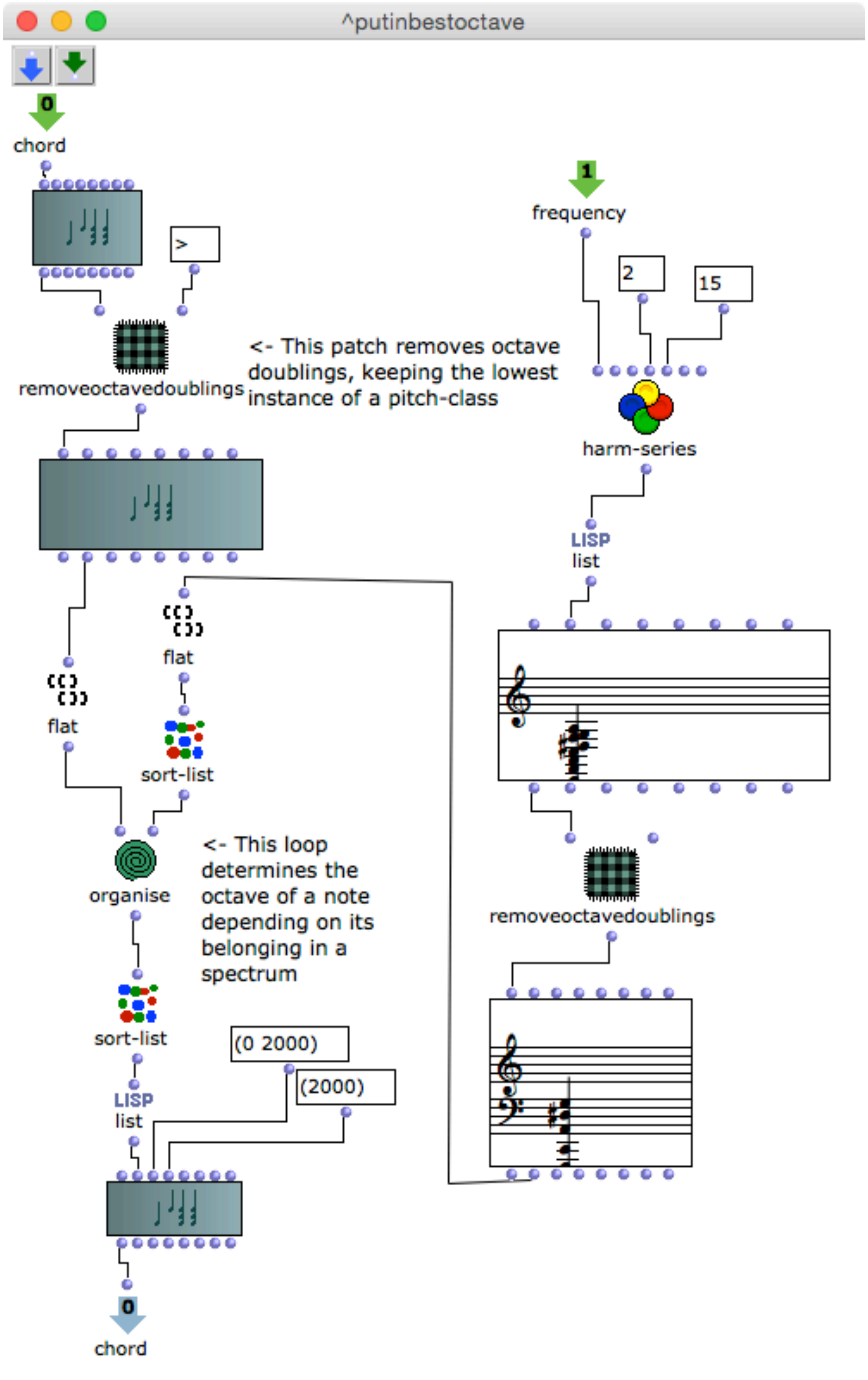
1. *Mutations II*: Patch for B Section



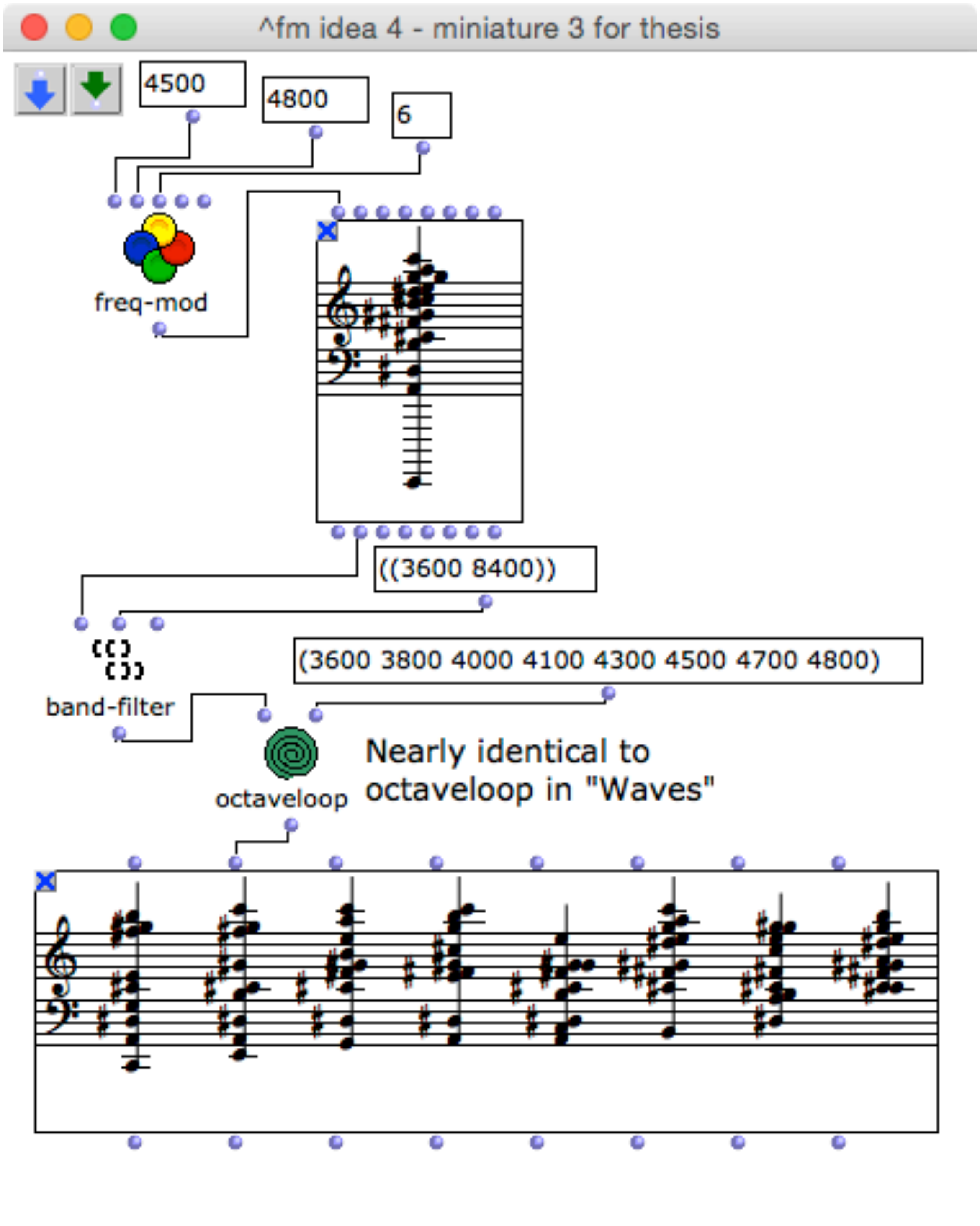
2. "Waves" from *Short Pieces on Falling*: Pitch pools



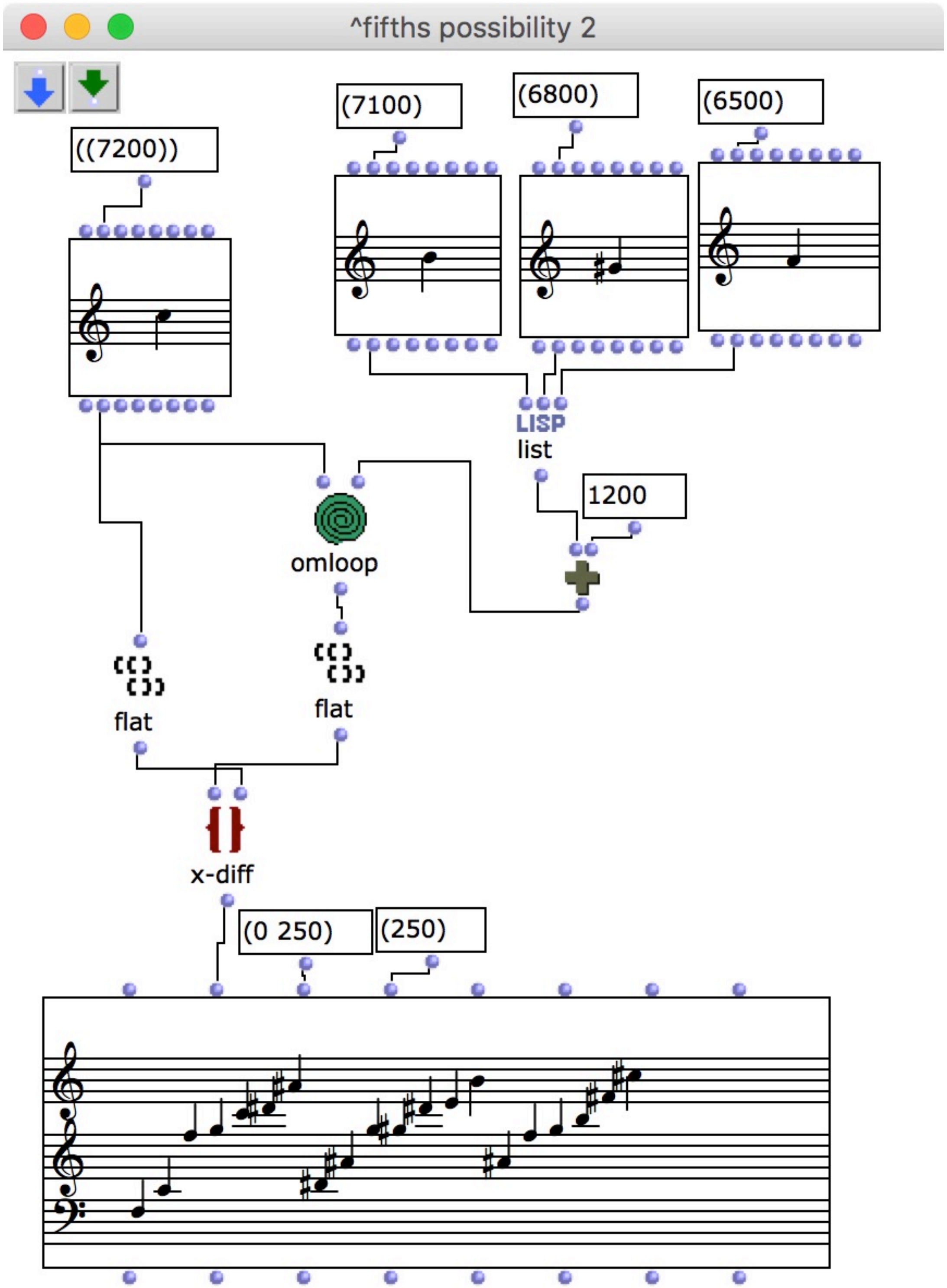



^putinbestoctave
0
chord
>
1
frequency
2
15
removeoctavedoublings
<- This patch removes octave doublings, keeping the lowest instance of a pitch-class
harm-series
LISP
list
flat
flat
sort-list
organise
<- This loop determines the octave of a note depending on its belonging in a spectrum
removeoctavedoublings
sort-list
(0 2000)
(2000)
LISP
list
0
chord

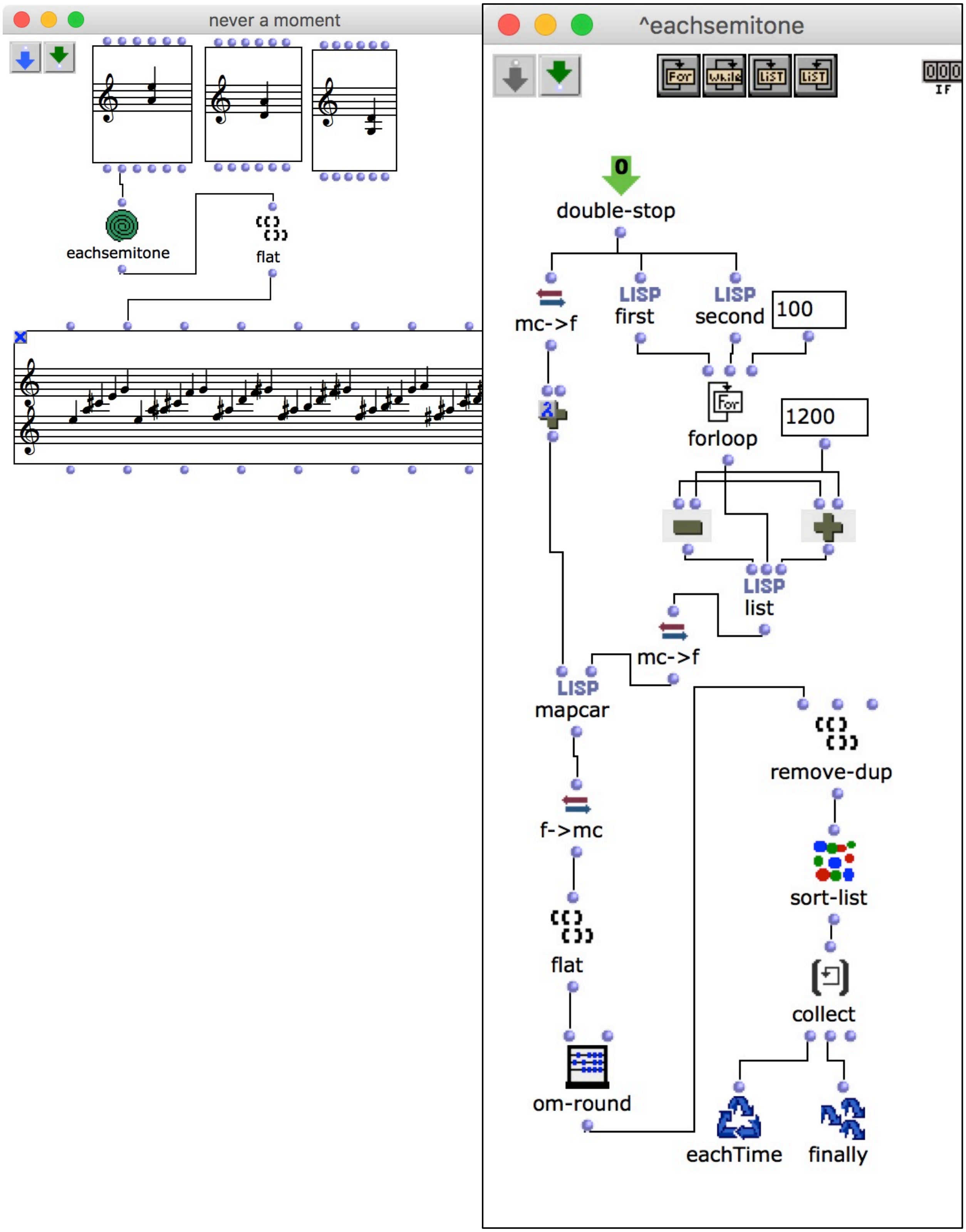
3. "Run" from *Short Pieces on Falling*: Pitch Pools



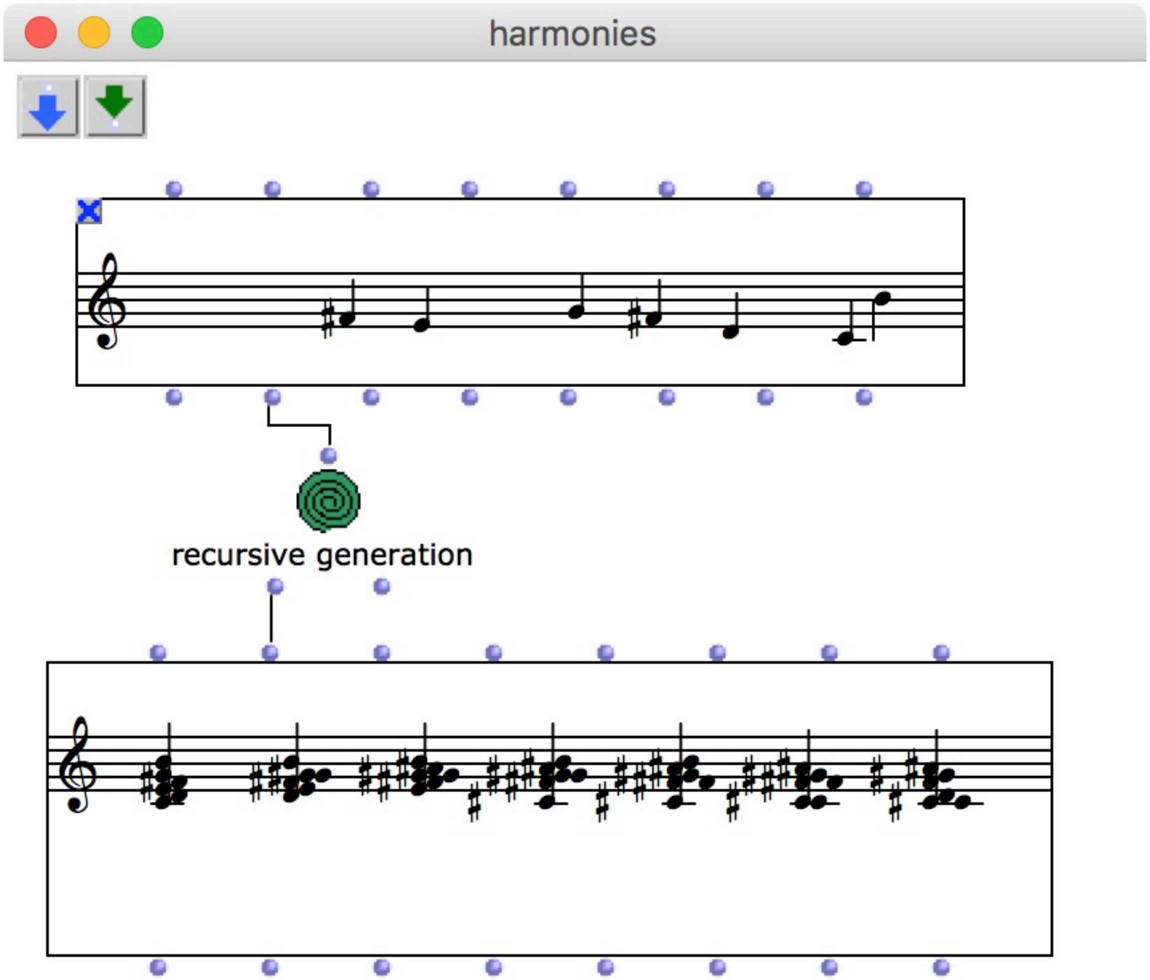
4. *Gift efter...* (2nd movement): Ring Modulation

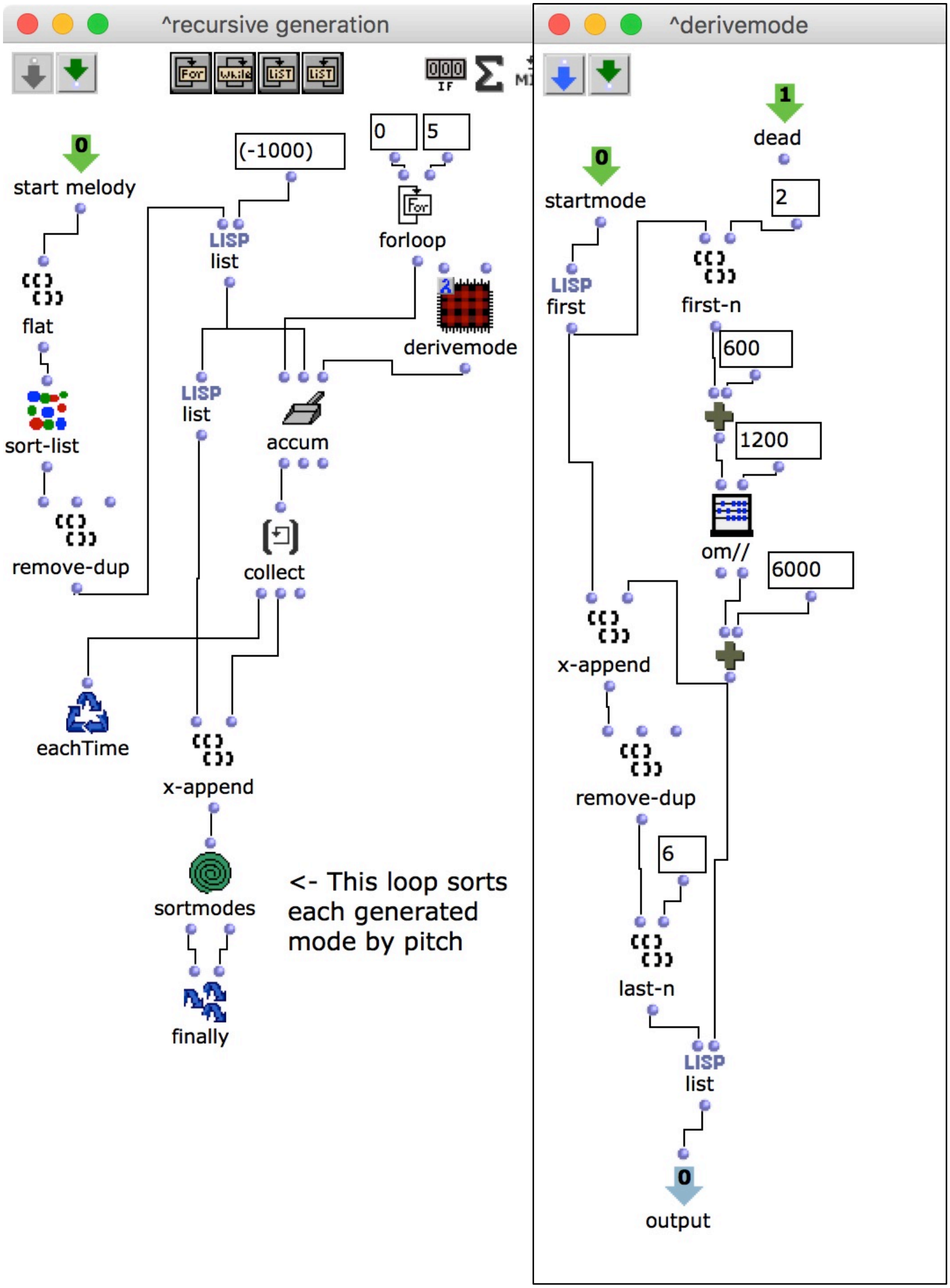


5. *Never a Moment Lost*: Frequency Shifting

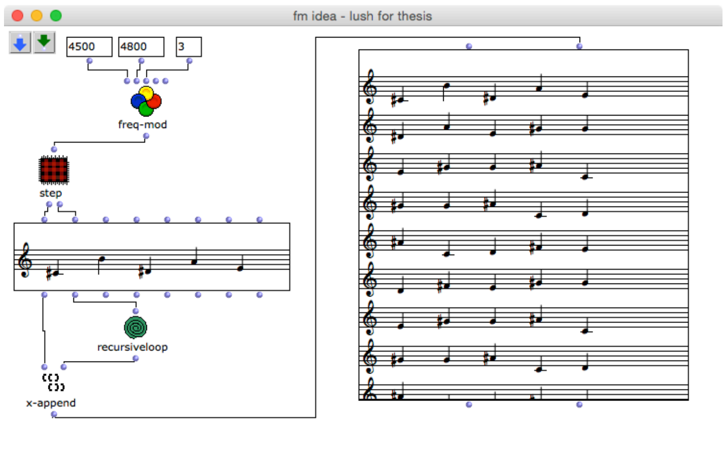


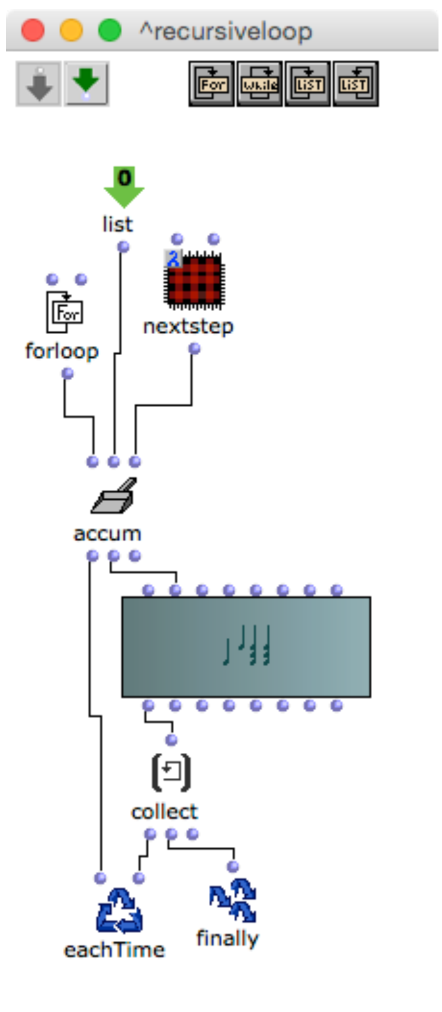
6. *Vinst och Förlust*: Recursive Pitch Generation

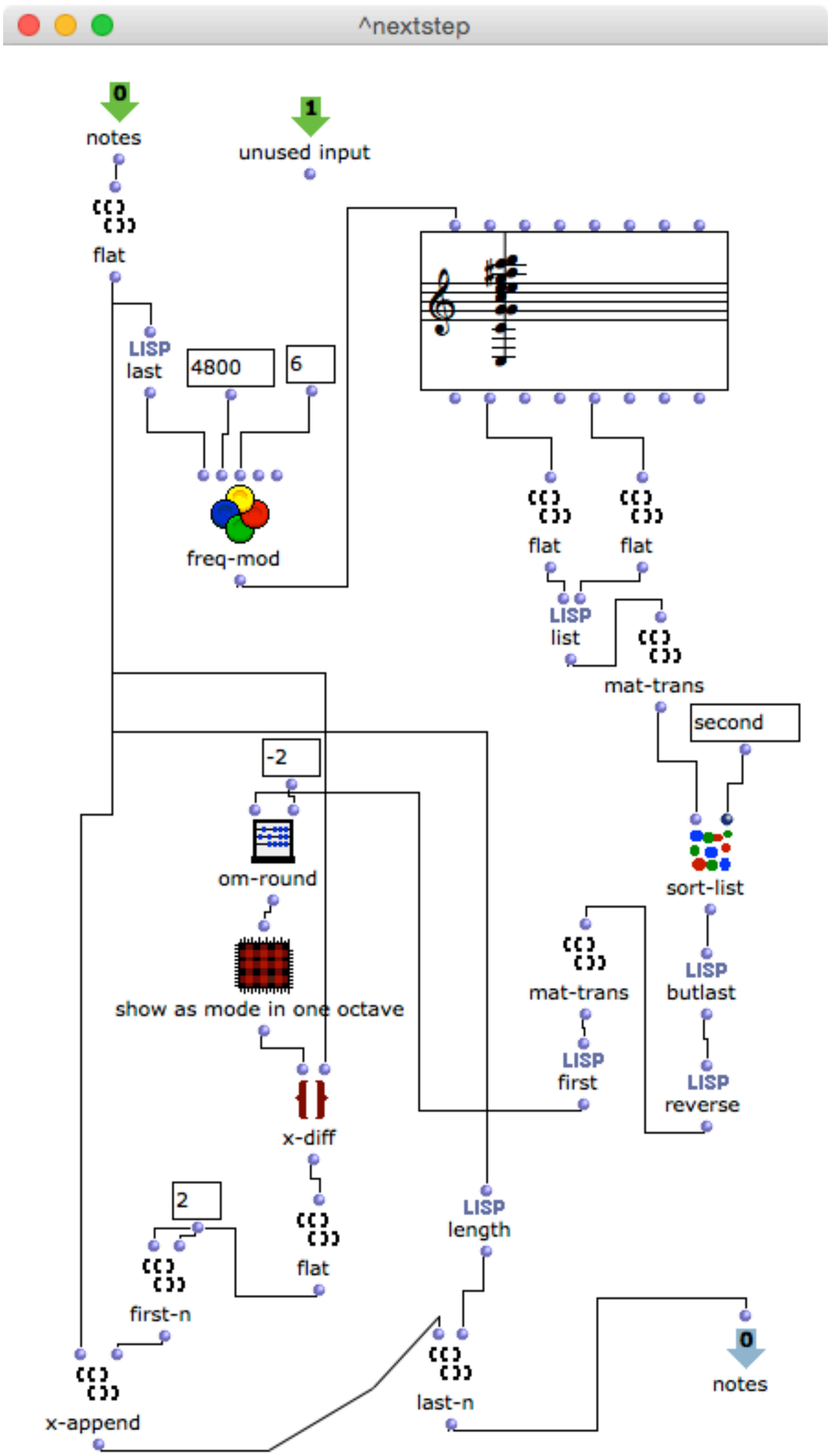



^recursive generation
^derivemode
start melody
(-1000)
0
5
LISP
list
forloop
flat
derivemode
sort-list
LISP
list
accum
remove-dup
collect
eachTime
x-append
sortmodes
finally
<- This loop sorts
each generated
mode by pitch
dead
2
startmode
LISP
first
first-n
600
1200
om//
6000
x-append
remove-dup
6
last-n
LISP
list
output

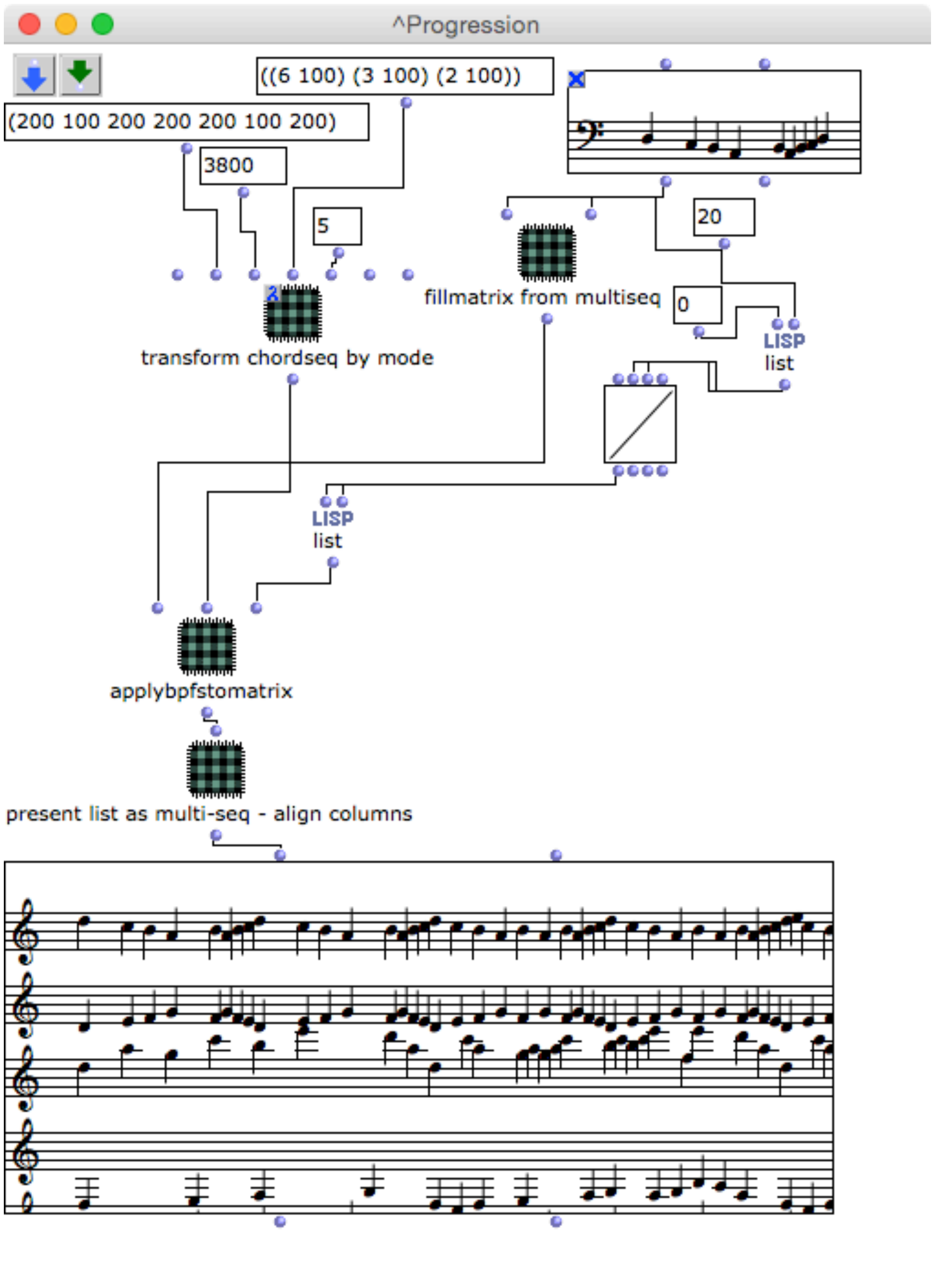
7. "Lush" from *Short Pieces on Falling*: Recursion and Frequency Modulation



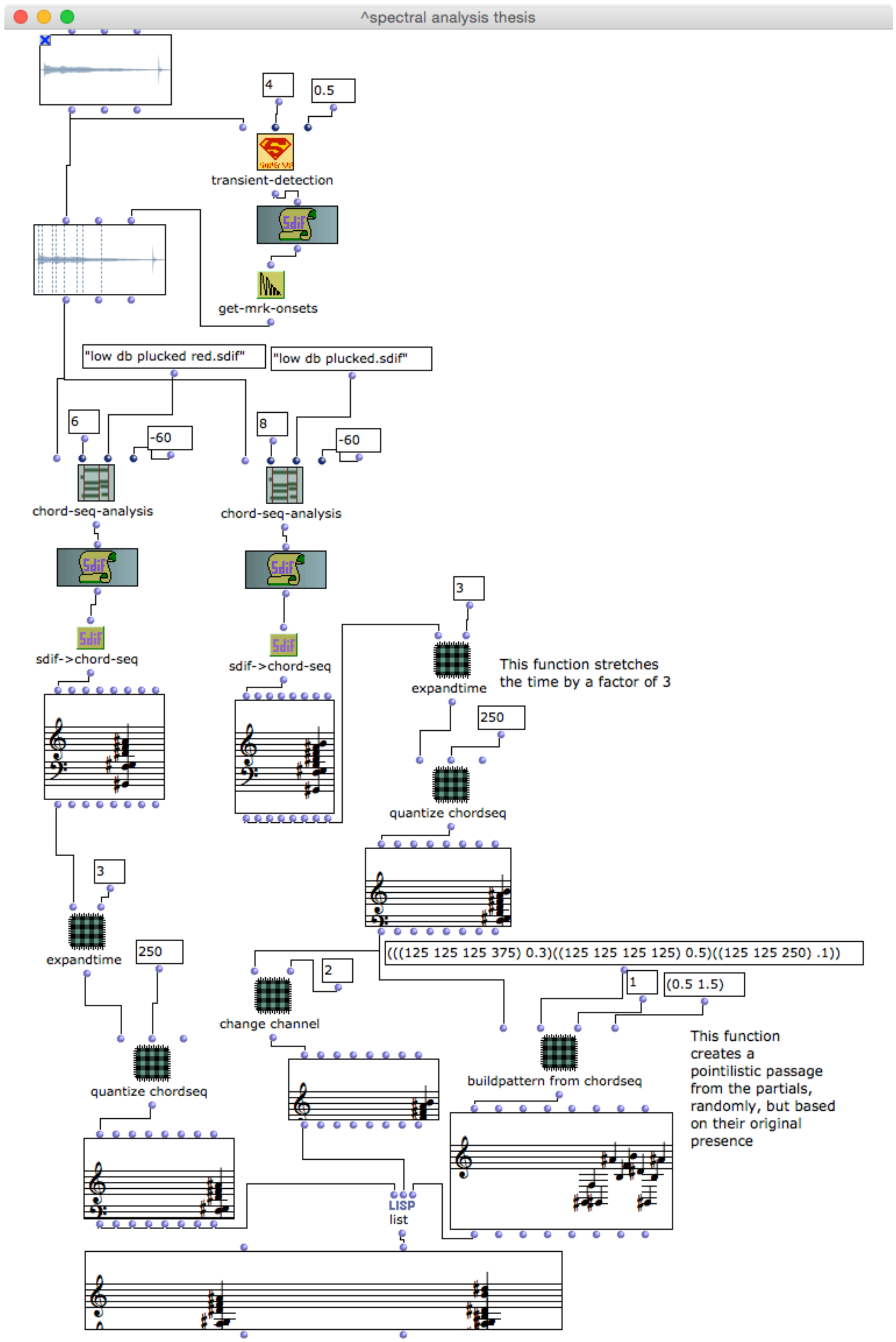



^nextstep
0
notes
1
unused input
flat
LISP
last
4800
6
freq-mod
flat
flat
LISP
list
mat-trans
second
-2
om-round
sort-list
show as mode in one octave
mat-trans
LISP
butlast
LISP
first
LISP
reverse
x-diff
2
flat
LISP
length
first-n
0
notes
x-append
last-n

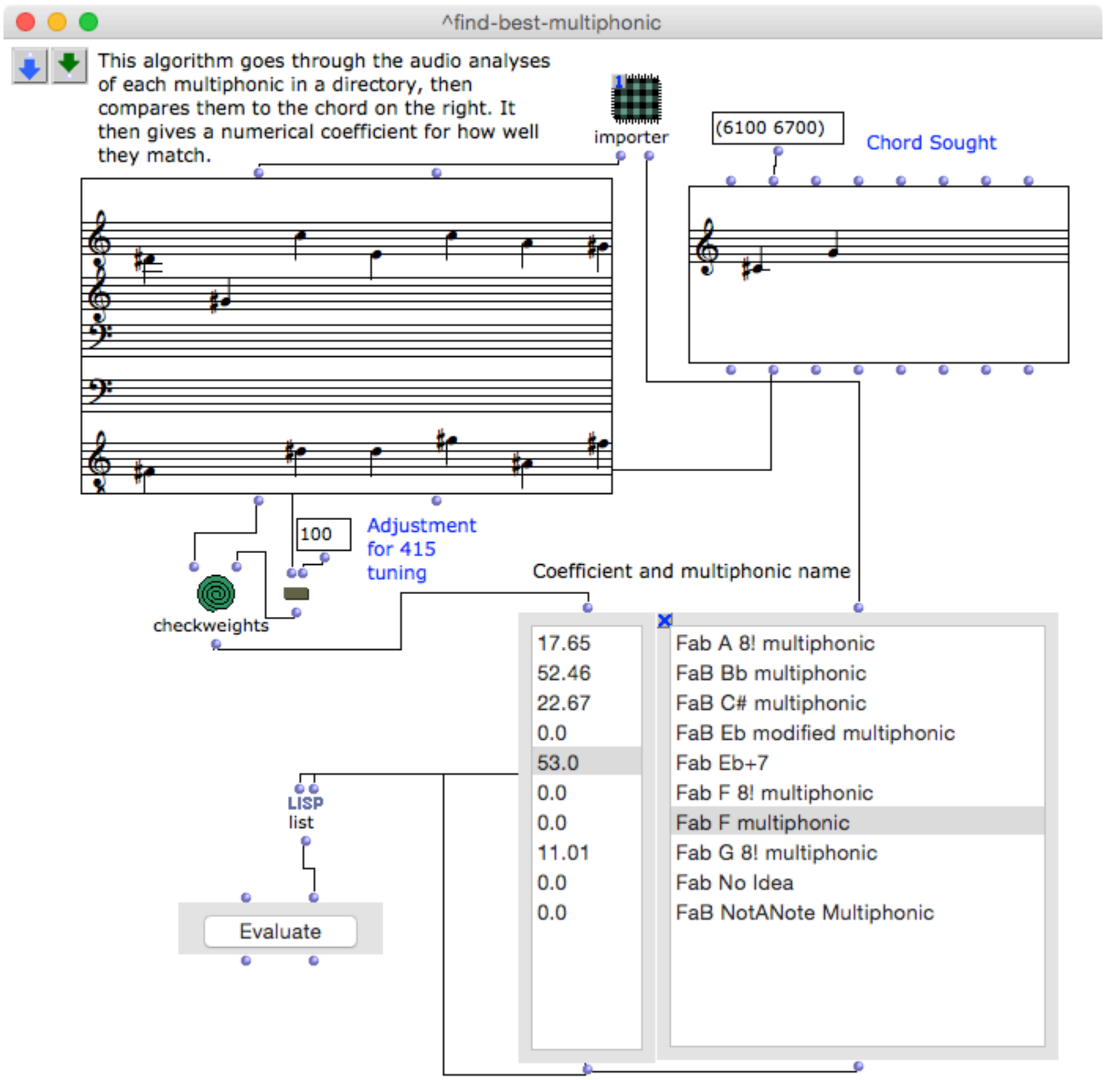
8. "Scherzo Insomniac" from *Lullabies for Little Boys...*: Pitch-space Lattice Construction and Application

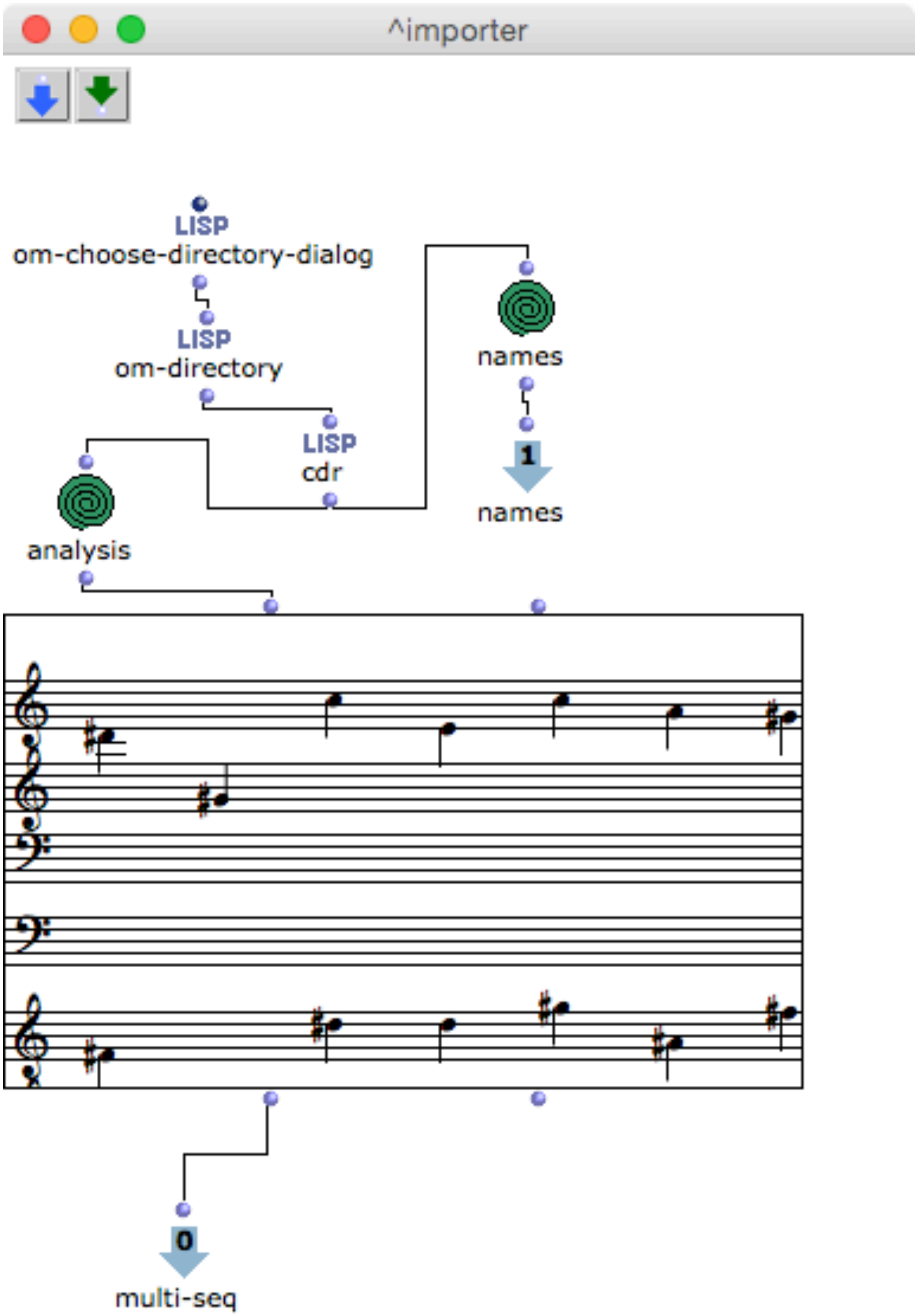


9. "The Spectrum of Stars" from *Little Boys Who Will Not Sleep Anyways*: Spectral Analysis and Generative Functions



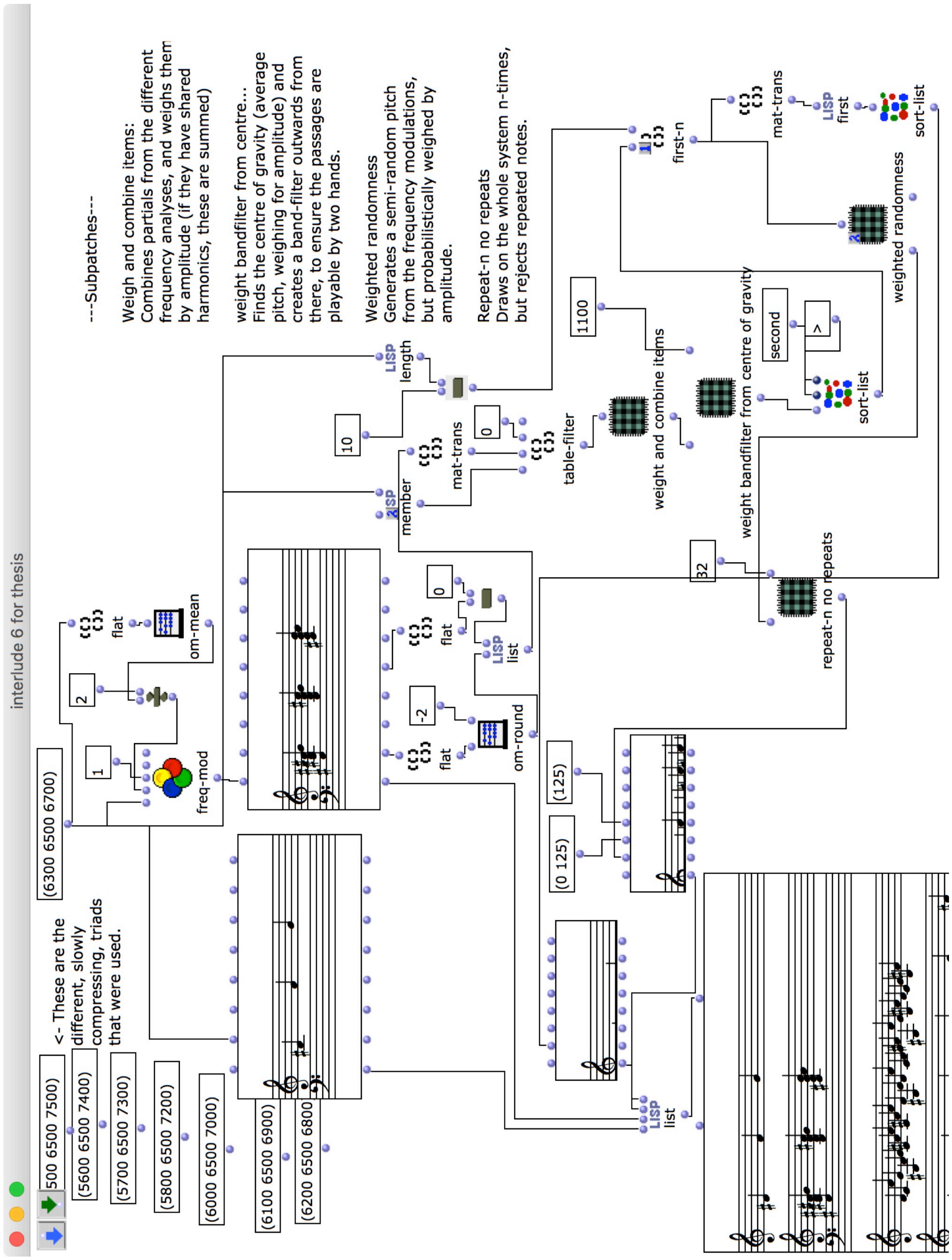
10. *Läst Igen: Fredmans Epistel N:o 27*: Spectral Analyses of Recorder Multiphonics



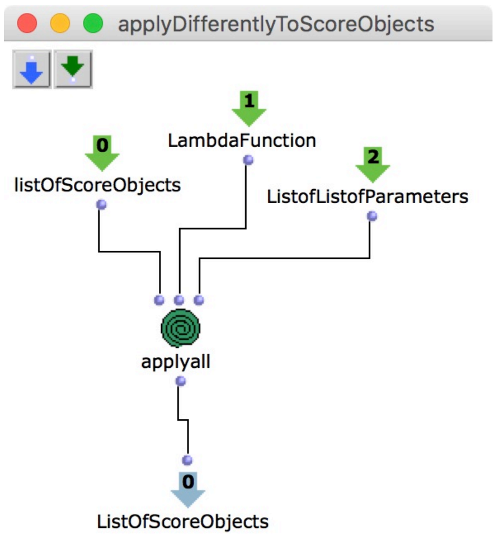


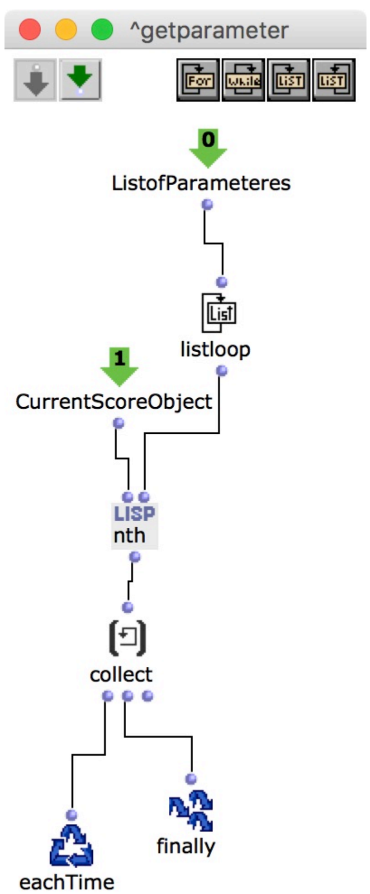
^importer
LISP
om-choose-directory-dialog
LISP
om-directory
LISP
cdr
names
1
names
analysis
0
multi-seq

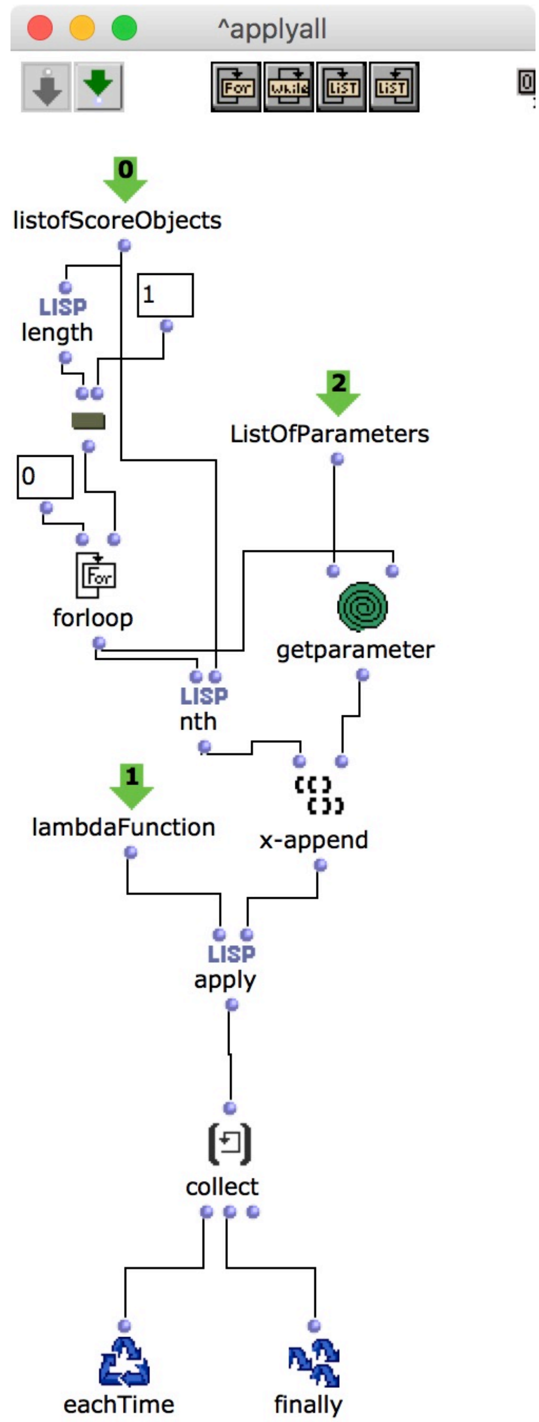
11. *Ruminations on the Season* (6): Frequency Modulation and Probabilistic Generation



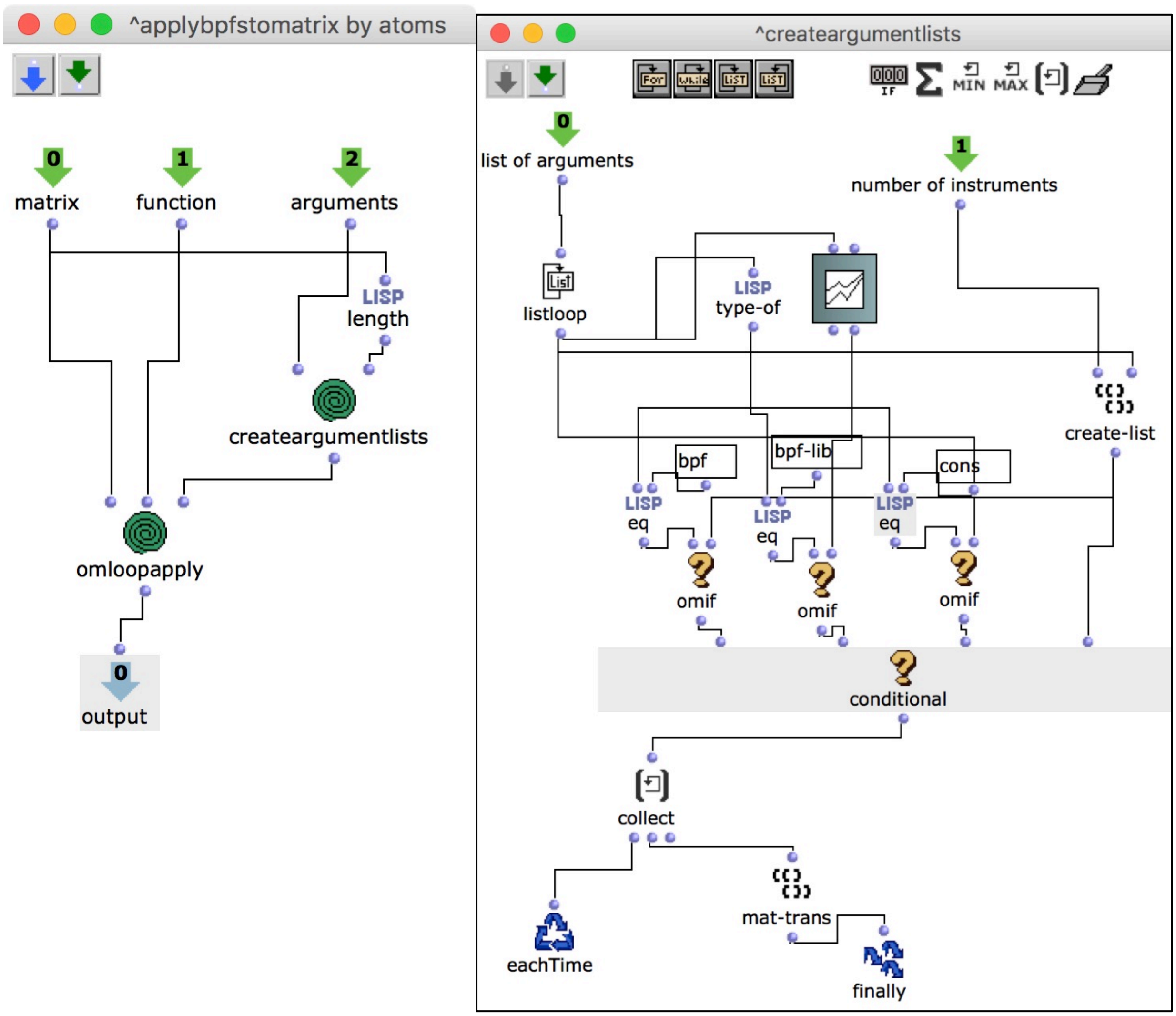
12. Modular Progression Management System: *applyDifferentlyToScoreObjects*

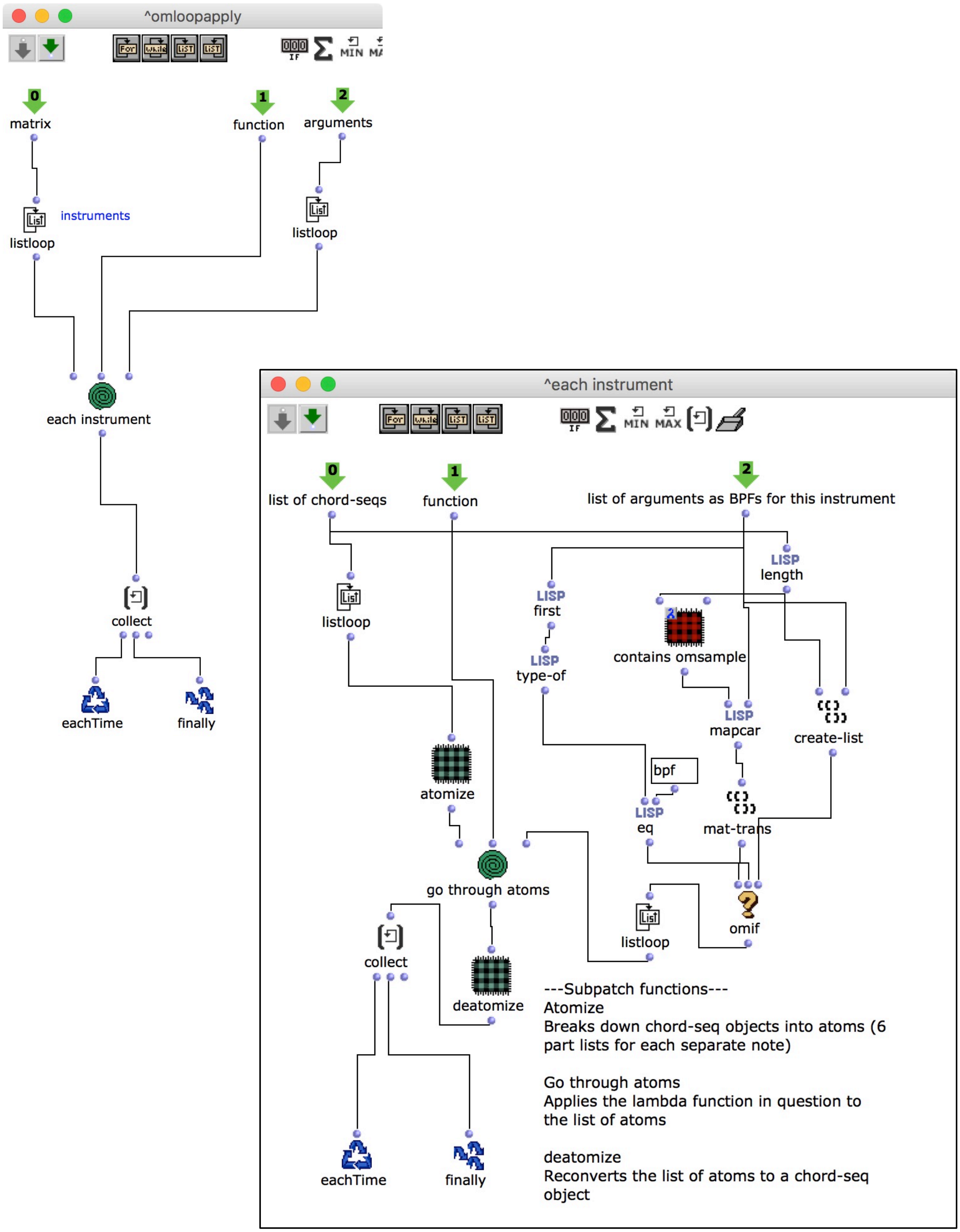




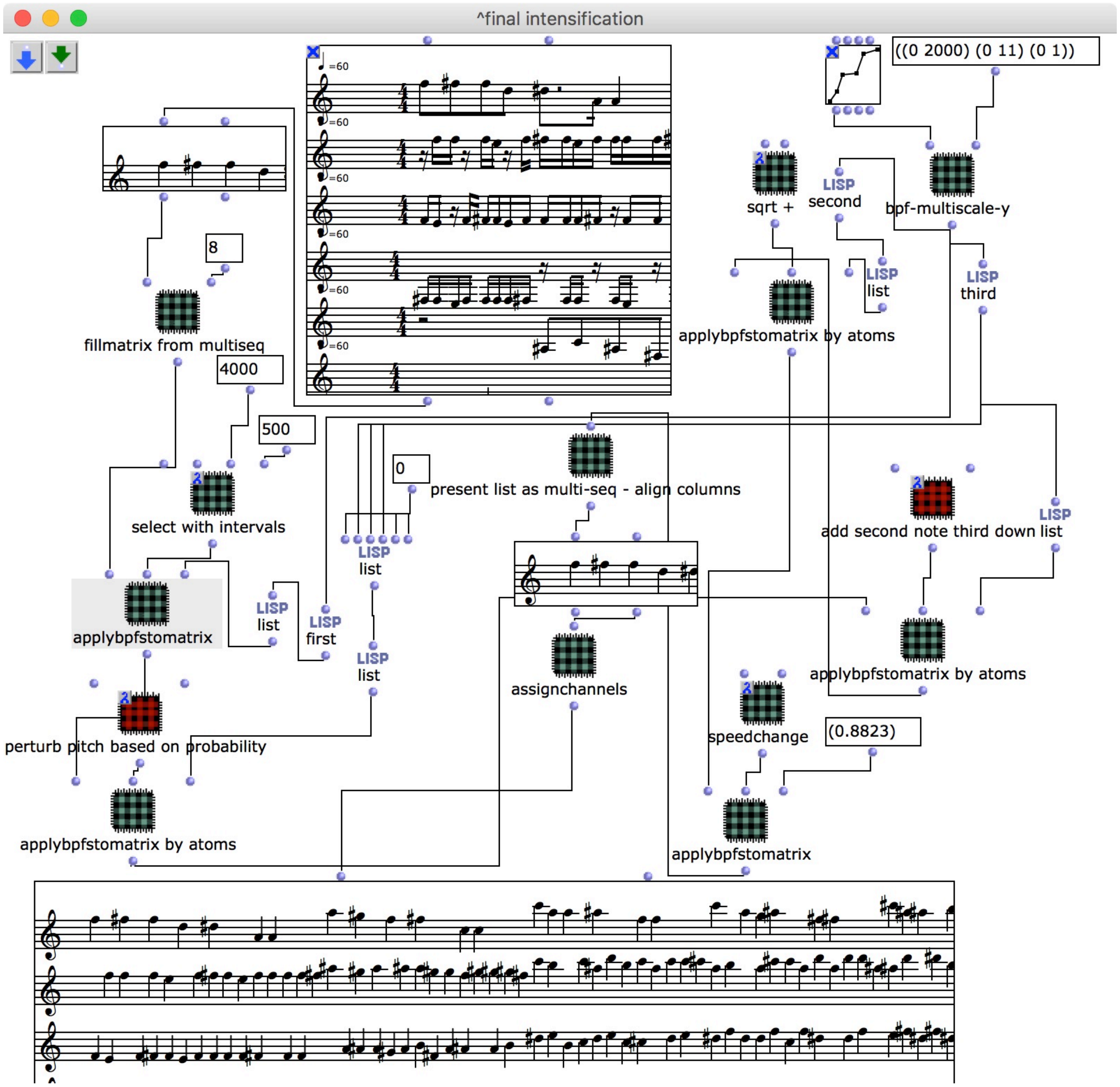


13. Modular Progression Management System: *applybpstomatrix by atoms*

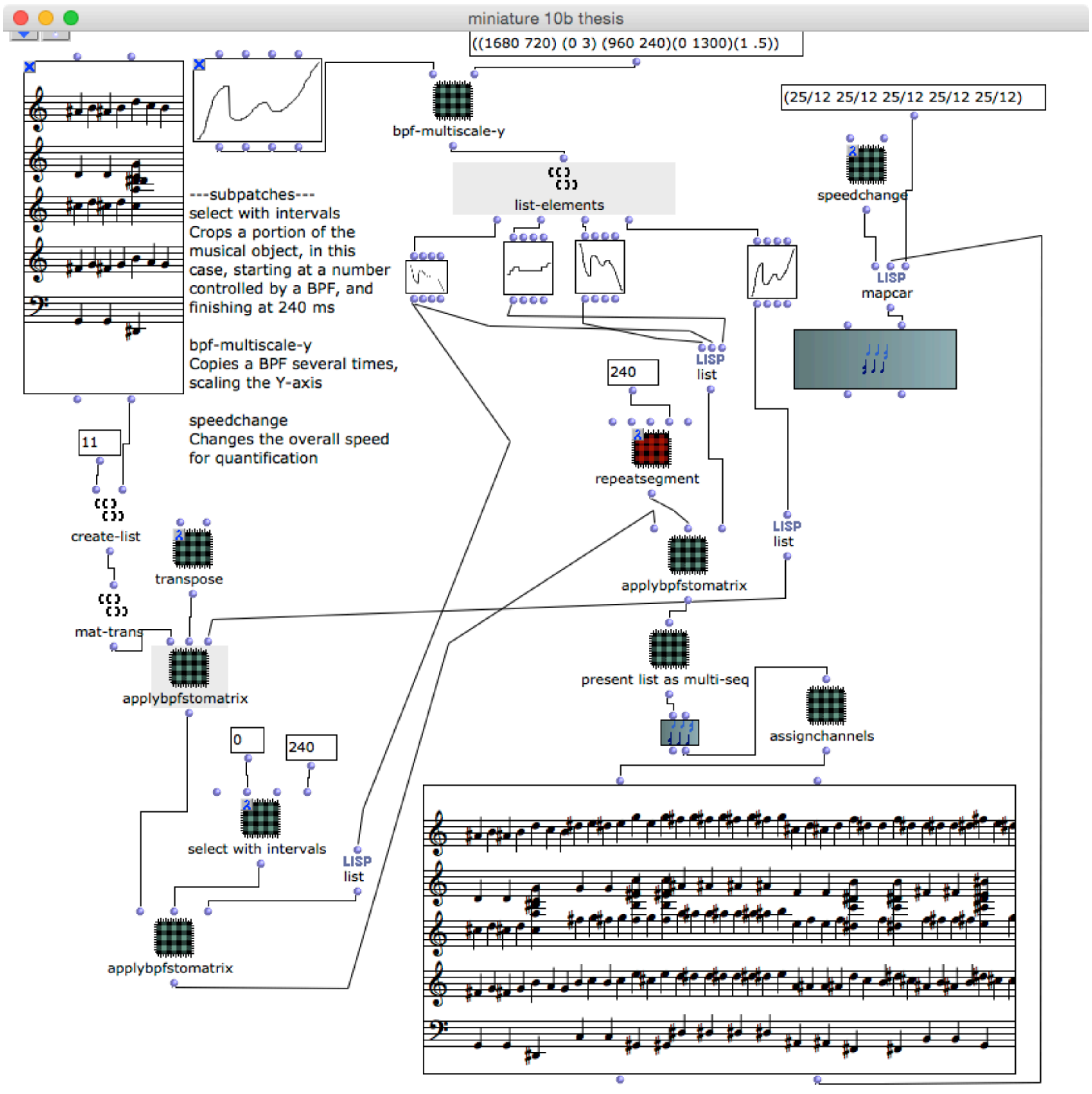



^omloopapply
matrix
function
arguments
instruments
listloop
listloop
each instrument
collect
eachTime
finally
^each instrument
list of chord-seqs
function
list of arguments as BPFs for this instrument
LISP
length
listloop
LISP
first
contains omsample
LISP
type-of
LISP
mapcar
create-list
atomize
bpf
LISP
eq
mat-trans
go through atoms
omif
collect
listloop
deatomize
---Subpatch functions---
Atomize
Breaks down chord-seq objects into atoms (6 part lists for each separate note)
Go through atoms
Applies the lambda function in question to the list of atoms
deatomize
Reconverts the list of atoms to a chord-seq object
eachTime
finally

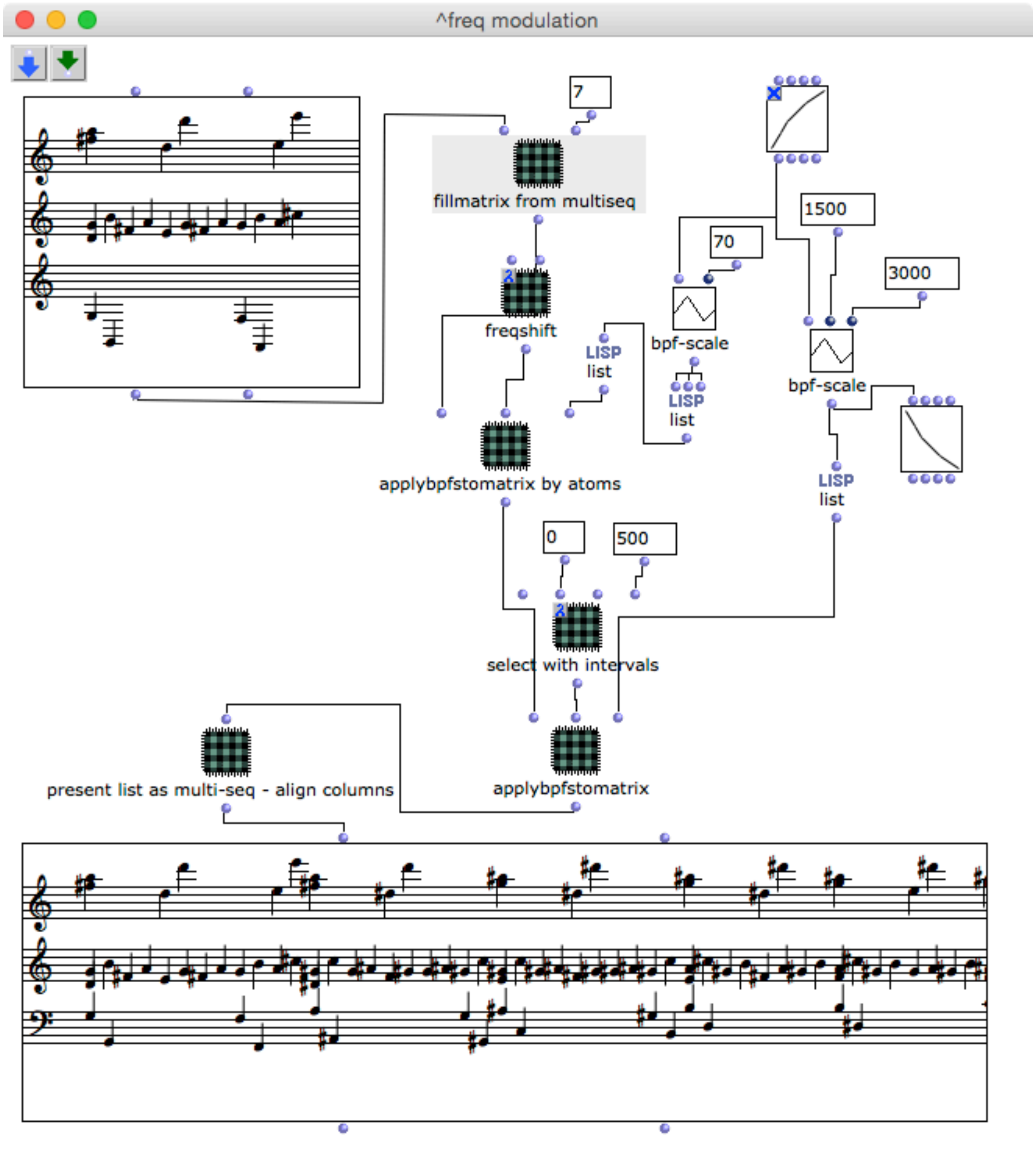
14. *Like a Square Peg*: Modular Progression Management



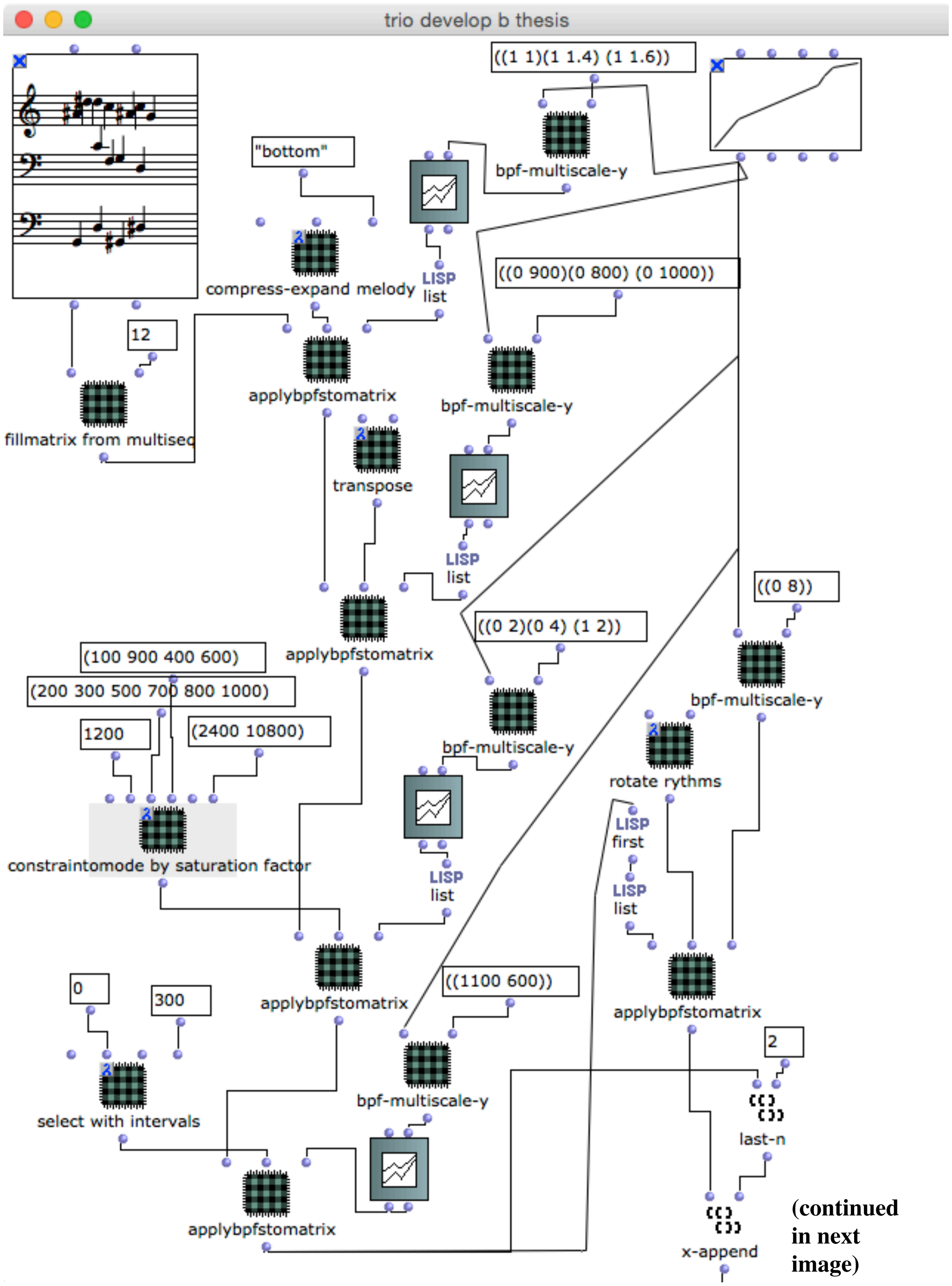
15. "Float" from *Short Pieces on Falling*: Modular Progression Management



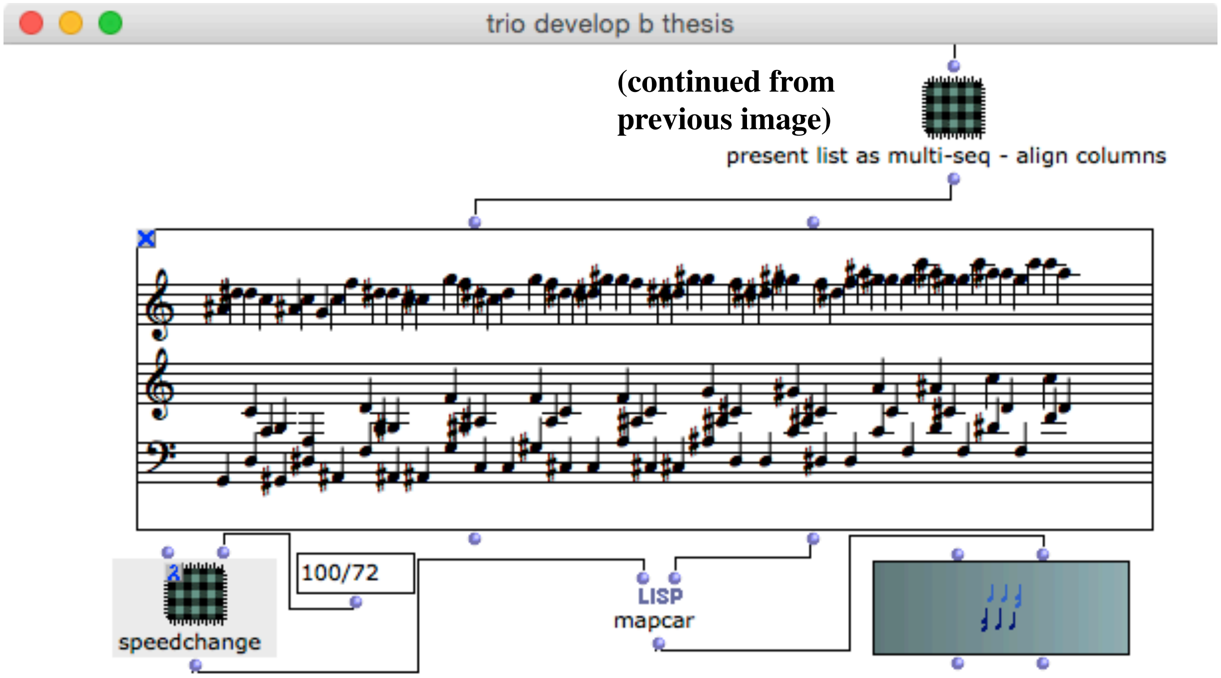
16. *Mutations I*: Modular Progression Management



17. *(Let Me Hear) What Maria Hears*: Modular Progression Management

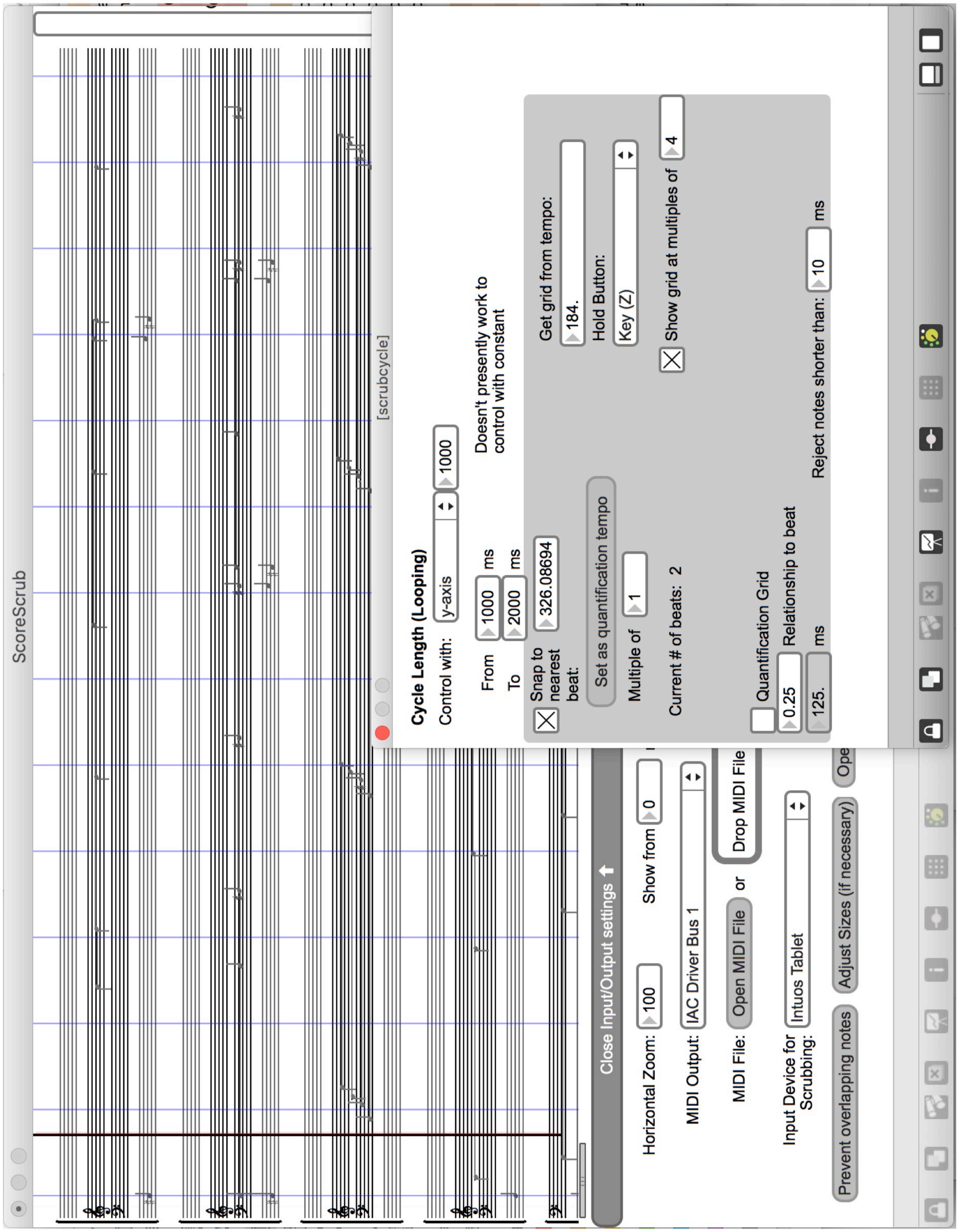


(continued in next image)

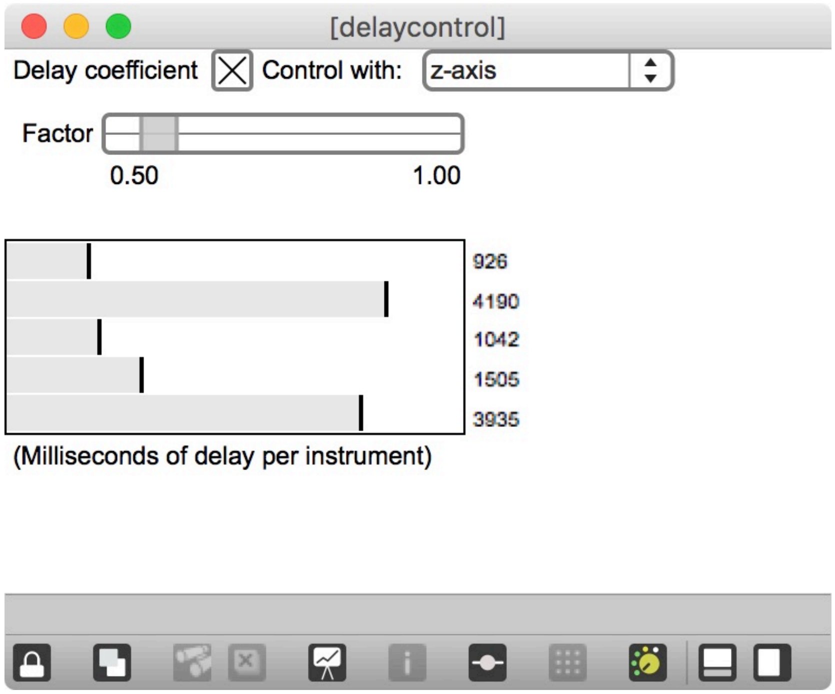


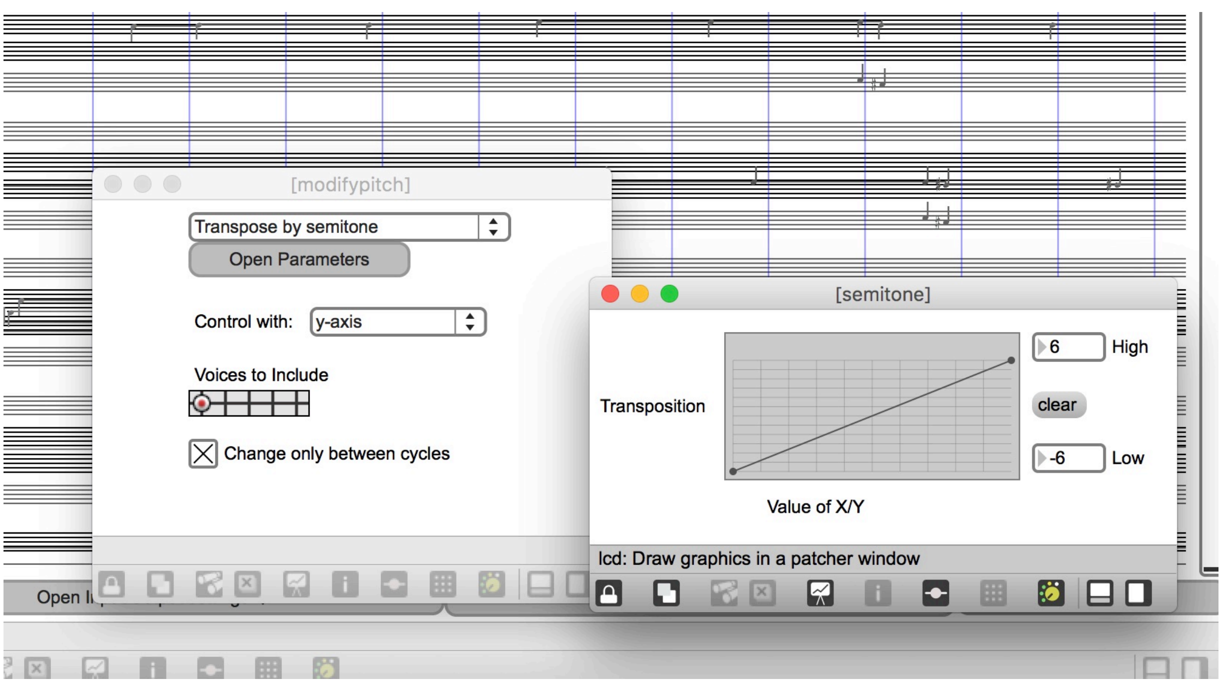
trio develop b thesis
(continued from previous image)
present list as multi-seq - align columns
100/72
speedchange
LISP
mapcar

18. *ScoreScrub* Cycle Control

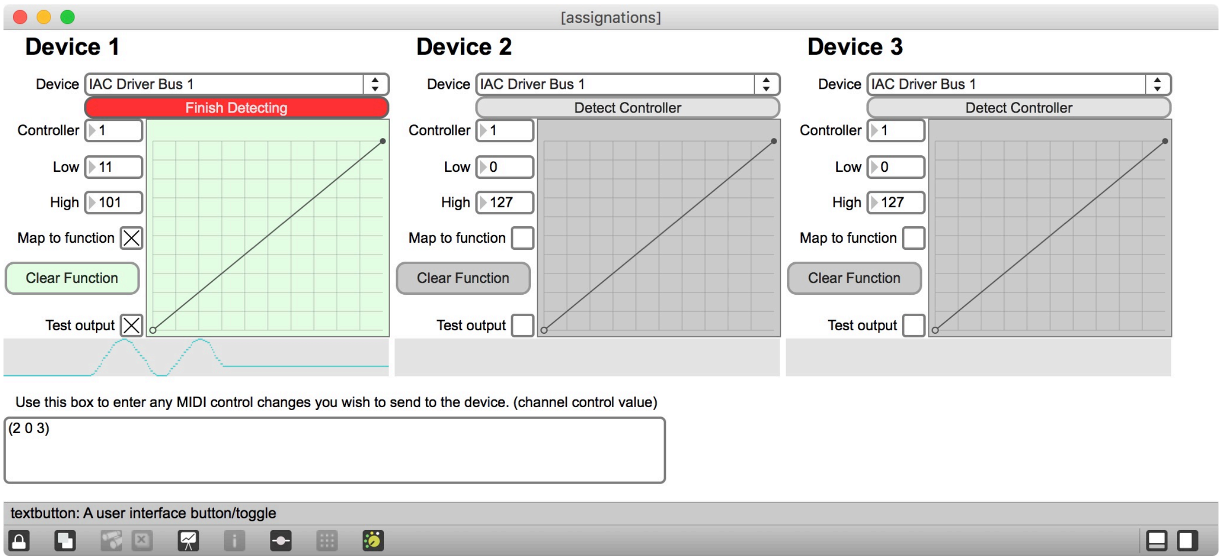


19. *ScoreScrub* Delay Control and Pitch Control





20. *ScoreScrub* Auxiliary MIDI Device Input



Appendix B: Compositions

Scores are bound in three different packages, by paper size.

Part 1. 8.5” x 11” (letter)

A Little Snow

Gift efter Carl Herman Erlandsson

(Let Me Hear) What Maria Hears

Lullabies for Boys Who Will Not Sleep Anyways

Läst Igen: Fredmans Epistel N:o 27

Melodious Viscosity (Still Flows)

Mutations I and II

Short Pieces on Falling

Sliding Apart

Vinst och Förlust

Part 2. 8.5” x 14” (legal)

Like a Square Peg

Part 3. 11” x 17” (tabloid)

Never a Moment Lost

Ruminations on the Season (selections)

Världen och Jag

Appendix C: Multimedia

File name	Description
Recordings and simulations of compositions (in directory "Recordings")	
A Little Snow Was Here and There.aif	Aella Women's Choir of Ottawa, February 2017 singing "A Little Snow Was Here and There"
Gift efter Carl Herman Erlandsson - I.wav Gift efter Carl Herman Erlandsson - II.wav	Nils Ek (piccolo trumpet) and Marcus Tom-Pack (piano) studio recording of *Gift efter Carl Herman Erlandsson*
Läst Igen Fredmans Epistel.wav	Maquette of *Läst Igen: Fredmans Epistel N:o 27* with vocals by Lukus Uhlman, baritone
Like a Square Peg.wav	Maquette of *Like a Square Peg*, with Katarzyna Fraj (violin).
Lullabies ➤ Lullabies I.wav ➤ Lullabies II.aif ➤ Lullabies III.wav	Sound files for the three movements of *Lullabies for Little Boys who Will Not Sleep Anyways*. Movements I and III were recorded by Julien Gagnon (toy piano) and Daphnée Chabalier (piano) in October 2016. Movement II is a simulation.
Mutations ➤ Mutations 1.wav ➤ Mutations 2.wav	*Mutations I,* recorded by Shawn Potter, October 2016, at St. Ansgars Lutheran Church, Montreal, and *Mutations II,* recorded by Matthew Lane, with the help of Gabriel McCann at Mount Royal United Church, 2016.
Never a Moment Lost.wav	*Never a Moment Lost*, recorded by Katarzyna Fraj (violin) and Matthew Lane (piano), Salle Serge-Garant, Montreal, November 2016.

File name	**Description**
Ruminations ➤ Interlude 1 sim.aiff Interlude 4 live.wav Interlude 4 sim.wav Interlude 6 live.wav Interlude 6 sim.wav Interlude 11 live.wav Interlude 11 sim.wav Interlude 12 sim.wav	Selected interludes from *Ruminations on the Season*. Those files marked with "live" were recorded at Paroisse Saint-Paul-de-la-Croix in May 2017 by Alexandra Fol. All others are simulations, including some duplicates provided due to the noisy room during the original recording.
Short Pieces on Falling ➤ Choke.wav Float.aiff Follow.wav Love.aiff Lush.wav Run.wav Tempt.aiff Waves.wav	Recordings and simulations from the suite *Short Pieces on Falling*. "Choke", "Lush", "Run", and "Waves" were recorded by October 2016 by Marie-Hélène Rondeau (flute), Chester Howard (clarinet), Eva Lachhar (piano), Katarzyna Fraj (violin), and Thieres Brandini (cello), under the direction of Tiphaine Legrand. "Float", "Follow", "Love", and "Tempt" are simulations
Sliding Apart.wav	Simulation of *Sliding Apart*.
Världen och Jag.wav	Simulation of *Världen och Jag*.

File name	**Description**
Vinst och Förlust.wav	Recording of *Vinst och Förlust* by Ensemble Kô under the direction of Tiphaine Legrand, with Marie-Hélène Rondeau on flute. 2016
What Maria Hears.wav	Studio maquette of *(Let Me Hear) What Maria Hears* by Gabriel Penido (flute), Danilo Petroni (guitar), and Joanna Wiebe (cello). 2017

Other multimedia (in directory "Programming")

ControlledAleatory.plg	The Sibelius controlled aleatory plugin, created in the *ManuScript* language. Can be imported into Sibelius 7 or higher, or viewed with any text editor.
ScoreScrub ➤	The complete source material for *ScoreScrub*, written in Max 6. The primary patch is *Scrub Patch.maxpat.* The directory "Necessary Packages" include packages that may need to be installed on your system to run *ScoreScrub.*
ScoreScrub video.mov	Quicktime video of *ScoreScrub* in use, from my presentation at *Journées d'informatique musicale* 2017 in Paris.
openmusic ➤ atoms bpf tools continuous progression management discrete progression management general chord-seq line alterations General Purpose Tools	Many of the OpenMusic patches forming parts of the modular progression management system, and patches upon which they depend. These function properly in OpenMusic 6.10 for Apple OSX, and are provided for reference, especially to see the inner workings of many of the screenshots in Appendix A. In some cases, supplementary (paid) extensions may be required from IRCAM. The primary tools for the system can be found in the sub-directories "continuous progression management" and "discrete progression management".

Appendix B: Compositions (Part 1)

A Little Snow

Gift efter Carl Herman Erlandsson

(Let Me Hear) What Maria Hears

Lullabies for Boys Who Will Not Sleep Anyways

Läst Igen: Fredmans Epistel N:o 27

Melodious Viscosity (Still Flows)

Mutations I and II

Short Pieces on Falling

Sliding Apart

Vinst och Förlust

A Little Snow was Here and There

Emily Dickinson

Matthew C. Lane


a tempo
14
S.
A.
p
mp
gliss.
Since she and I had met and played
played.
Since she and I had met and played, played
played.
Since she and I last played played.
Since she last played.
17
cresc.
Each singer enters individually, one at a time and freely. Singers then repeat their fragment ad libitum for the remainder of the section, as the ensemble builds in voices.
De-cade had ga-thered
De-cade had ga-thered
De-cade had ga-thered
De-cade had ga-thered.
22
mp
f
p
mp
3
ga-thered to de cade de - cade de - cade But
ga-thered to de cade de - cade de - cade de - cade
ga-thered to de - cade. de cade de - cade
ga-thered to de - cade. de - cade de - cade


poco accel.
Time had ad-ded not ob-tained, had ad-ded not ob - tained
But Time but Time had ad-ded
But Time but Time had ad-ded not ob-tained
But Time had ad-ded not ob tained, had ad - ded not ob tained but
a tempo
but Time had ad - ded not ob tained. Im-preg - na-ble the Rose Im
not ob tained had ad - ded not ob- tained Im-preg - na-ble the Rose Im
but time had ad-ded not ob-tained Im-preg - na-ble the Rose
Time had ad - ded not ob-tained Im-preg - na-ble the Rose
preg - na-ble the Rose For sum - mer For
preg - na-ble the Rose For sum - mer
Im-preg na-ble the Rose For sum - mer For
Im-preg na-ble the Rose For sum - mer
S.
A.


38
S.
sum-mer For sum-mer in-del-li-ble in-de-li-ble
For sum-mer in - de-li-ble
A.
sum-mer For sum-mer too in-de-li-ble in-de-li-ble
For sum-mer too in-de-li-ble in-de-li-ble
42
Too ob-du-rate
Same as mm. 17-21, but longer.
Too ob-du-rate
Too ob-du rate
Too ob-du-rate
47
for Snows Too ob-du-rate for Snows
for Snows Too ob-du-rate for Snows
for Snows Too ob - du-rate for Snows
for Snows Too ob - du-rate for Snows


52
poco rall.
mp
p
S.
a lit-tle snow was here and there
a lit-tle snow, snow was here and there
A.
a lit - tle snow here and there
lit - tle snow here and there

Gift efter Carl Herman Erlandson

I

(concert pitch)

Matthew Lane

9
p
p
11
tr
p
subito p
14
tr
16
p
mf
3


18
subito p
20
pp
f
p
3
22
24
legato
p
p


legato


36
39
tr
Ped.
43
♪ = 144
p
mf
p
f
ff
subito p
3
Ped.


46
pp
p
p
Ped.
49
f
f
Ped.
Ped.
51
mf
p
mf
p
mf
Ped.
Ped.
Ped.
54
mp
p
mp
Ped.


56
pp
mp
58
ppp
p
ppp
pp
Ped.
60
mp
Ped.
Ped.
Ped.
62
1 sec.
f
p
15ma
f
mp
8va
Ped.
Ped.


64
(15)
(8)
pp
67
pp
mp
mf
p
mf
Ped.
70
f
f
72
pp
15ma
p
15ma
8va


75
(8)
(15)
3
Ped.
77
8va
pp
Ped.
poco rit.
Ped.
79
2 sec.
A tempo
pp
82
p
mf
p
pp
3
15ma
p
mf
f
pp


85
mf
87
f
f
Ped.
90
mp
mp
3
3
pp
pp
93
♩ = 72
Left Hand
p


95
p
p
98
subito p
tr
102
rit.
♩ = 68
p
pp
3
105
f
f
p
p


109
p
fp
p
mf
114
f
p
pp
118
ff
122
molto rall.
8va

Gift efter Carl Herman Erlandsson
II
(concert pitch)

Matthew Lane


13
mp
mp
16
mp
mf
mf
18
p
fp
21


subito pp
subito pp


49
mp
mf
50
ff
p
52
rit.
Rolls slowly slowing down until they are nearly even arpeggios


♩ = 120


67
ff
p
f
Ped.
69
70
72


74
77
rit.
pp
start slow and speed up
81
A tempo
♩ = 120
85
Ped.

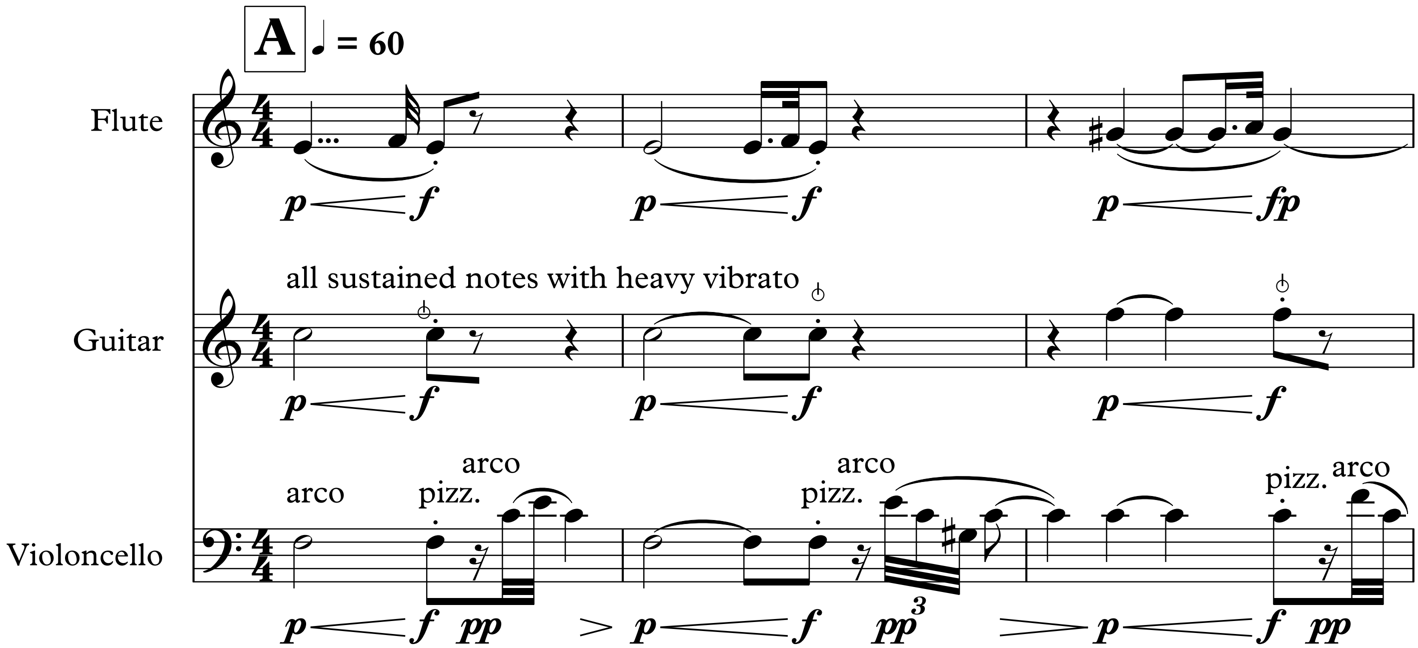

88
ff
p
ff
p
3
92
♩ = 60
(half speed)
rit.
3
3
3
96
♩ = 40
f
p
3
3
3
fp
98
3
3
3
3


101
Straight mute
pp
106
110
ppp
p

(Let Me Hear) What Maria Hears

efter Den Lyssande Maria (Almqvist)

Matthew C. Lane




8
Fl.
Gtr.
Vc.
1 s.
(flz.)
arco
pizz.
11
14


17
Fl.
Gtr.
Vc.
arco
pizz.
arco
19
Fl.
Gtr.
pizz.
arco
Vc.
21
Fl.
Gtr.
Vc.
pizz. arco

⋆ Chord diagrams are provided as suggestions only


33
Fl.
Gtr.
Vc.
7fr
hold and let ring where possible
gliss.
36
5fr
hold and let ring where possible
39
hold and let ring where possible


42
Fl.
Gtr.
Vc.
pp
hold and let ring where possible
pp
gl.
gl.
gl.
pp
46
Fl.
Gtr.
Vc.
p
mf
hold and let ring where possible
gl.
gl.
gl.
gl.
p
50
Fl.
Gtr.
Vc.
pp
f
f
5fr
5fr
mf
f
f
gliss.
gliss.


53
Fl.
Gtr.
Vc.
gl.
gliss.
57
hold and let ring where possible
60
hold and let ring where possible
7fr
gliss.


64
Fl.
Gtr.
Vc.
f
p
5fr
hold and let ring where possible
gliss.
68
pp
switch to
open string
72
sul tasto


molto rall.
♩ = 72
C
78
Fl.
pp
8fr
6fr
Hold and let ring where possible
Gtr.
hold and let ring where possible
p
pizz.
Vc.
pp
p
82
Fl.
3
p
Gtr.
Vc.
84
Fl.
Gtr.
5fr
3fr
Vc.


87
Fl.
Gtr.
Vc.
6fr
3
p
90
5fr
93
mp
mf


96
Fl.
Gtr.
Vc.
non-L.V.
arco
98
Hold and let ring
100
D
Repeat measure ad libitum,
crescendo and decrescendo ad lib.
Flutist signals others
when to continue
L.V.
Repeat motive,
feeling free to
dephase from others
Repeat motive,
feeling free to
dephase from others


102
Fl.
pp
Cresc..
3fr
3fr
Gtr.
Cresc..
Vc.
Cresc..
104
Fl.
fp
Gtr.
fp
Vc.
fp
106
Fl.
f
p
Gtr.
f
p
Vc.
gliss.
gliss.
f
p


108
Fl.
Gtr.
Vc.
Cresc..
mp
Cresc..
p
Cresc..
110
f
fp
f
Don't let ring
f
fp
f
mf
fp
f
p
112
E
fp
p
fp
mf
fp
p
114
mf
f
p
pp


116
Fl.
Gtr.
Vc.
f
mp
F
118
7fr
Hold and let ring where possible until end
mp
mf
gliss.
gliss.
f
120
4fr


124
molto rit.
Fl.
Gtr.
Vc.
p
p
4fr
128
ppp
p
mf
p
3
131
pp
mp
pp

To Nils-Erik

Lullabies for Little Boys
Who Will Not Sleep Anyways

Matthew C. Lane

25-key Toy Piano
(Grand) Piano
Fixed stereo audio

I. The Spectrum of Stars
II. Restless Soundboards
III. Scherzo Insomniac

Performance instructions

The musicians should be seated so that they can easily make eye contact, with the toy piano placed on a wooden table for resonance.
Each pianist should be given a single earbud with the click track, allowing them to remain sychronized with the fixed audio throughout.

The toy piano should be amplified by a very close condenser microphone pointing at the rear of the piano. It should be given a small amount of reverb (1 second). It should also be equalized to cut out most pitches under 260 Hz to avoid unnecessarily amplifying the piano or causing feedback.

The regular piano should also be amplified, but very lightly, only to create some sense of blend with the electronics part. The microphones should be placed relatively close to where the pianist will knock on the instrument in movement II.

The musician controlling the fixed stereo audio should control the diffusion in real-time in no fewer than 2 speakers (ideally 4-8).

Lullabies For Boys Who Will Not Sleep Anyways

I. The Spectrum of Stars

Matthew Charles Lane


15
pizz.
T. Pno.
Pno.
p
20
mf
f
3
23
p
mp
mf


27
T. Pno.
pizz.
p
Pno.
p
32
ord.
T. Pno.
mf
f
Pno.
mf
f
35
T. Pno.
f
p
Pno.
mp
f
ff
mp


38
T. Pno.
Pno.
p
mf
43
Ped.
47
pizz.
f


51
T. Pno.
Pno.
55
T. Pno.
Pno.
60
T. Pno.
Pno.


65
T. Pno.
Pno.
69
ord.
pizz.
ord.
73
(pizz)


76
T. Pno.
Pno.
ff
78
pizz.
p
ord.
83
f


86
T. Pno.
Pno.
ff
89
T. Pno.
Pno.
p
93
T. Pno.
8va
Pno.


96
T. Pno.
(8)
Pno.
100
T. Pno.
mf
Pno.
104
pizz.
T. Pno.
p
Pno.

Lullabies For Boys Who Will Not Sleep Anyways

II. Restless Soundboards

Matthew Charles Lane


14
T. Pno.
Pno.
17
T. Pno.
Pno.
20
Roll all chords slightly to
avoid overly aggressive attacks
T. Pno.
Pno.
(l.h.)


23
T. Pno.
Pno.
knock on cover of piano
26
T. Pno.
Pno.
31
T. Pno.
Pno.


35
T. Pno.
Pno.
mp
pp
37
T. Pno.
Pno.
mf
pp
38
T. Pno.
Pno.
mf
pp

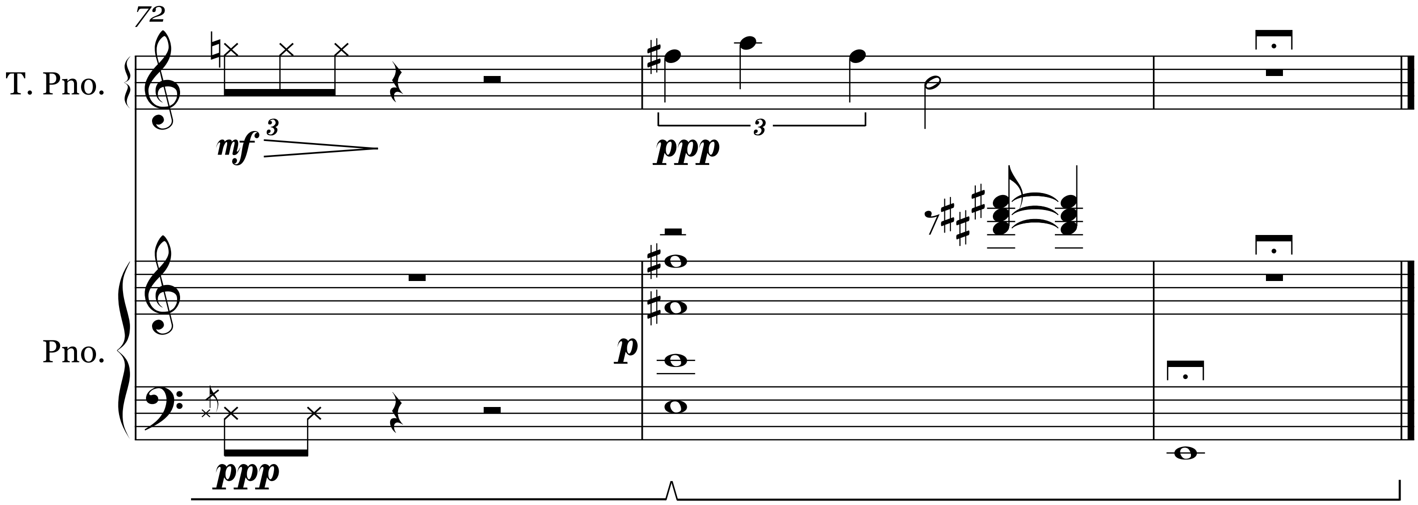

39
T. Pno.
Pno.
mf
pp
40
T. Pno.
Pno.
mf
pp
41
T. Pno.
f legato
Pno.
mf
pp


42
T. Pno.
Pno.
43
T. Pno.
Pno.
44
T. Pno.
f
pp
Pno.
f


46
T. Pno.
Pno.
f
pp
subito f
pp
subito f
48
T. Pno.
Pno.
f
mp
p
p
51
T. Pno.
Pno.
f


T. Pno.
Pno.


61
T. Pno.
Pno.
p
f
pp
15ma
p
ppp
65
T. Pno.
Pno.
pp
mf
p
mf
ppp
Ped.
69
T. Pno.
Pno.
pp
mp
8va
ppp
p


72
T. Pno.
mf
3
ppp
3
Pno.
p
ppp

Lullabies For Boys Who Will Not Sleep Anyways

III: Scherzo Insomniac

Matthew Charles Lane

V.S.


50
Ped.
53
p
56
60


63
mf
Ped.
67
p
72
pp
f
pp
75
f


79
pp
f
pp
5
5
82
5
5
5
5
84
mf
5
5
5
5
86
p
3
3
3
3
f

V.S.


101
105
111
p
115
f

V.S.


137
(8)
f
Ped.
142
f
145
148
(pizz.)
pp
pp
ppp

V.S.


170
173
pp
mf
176
178
pp
mf


181
184
186
188
pp

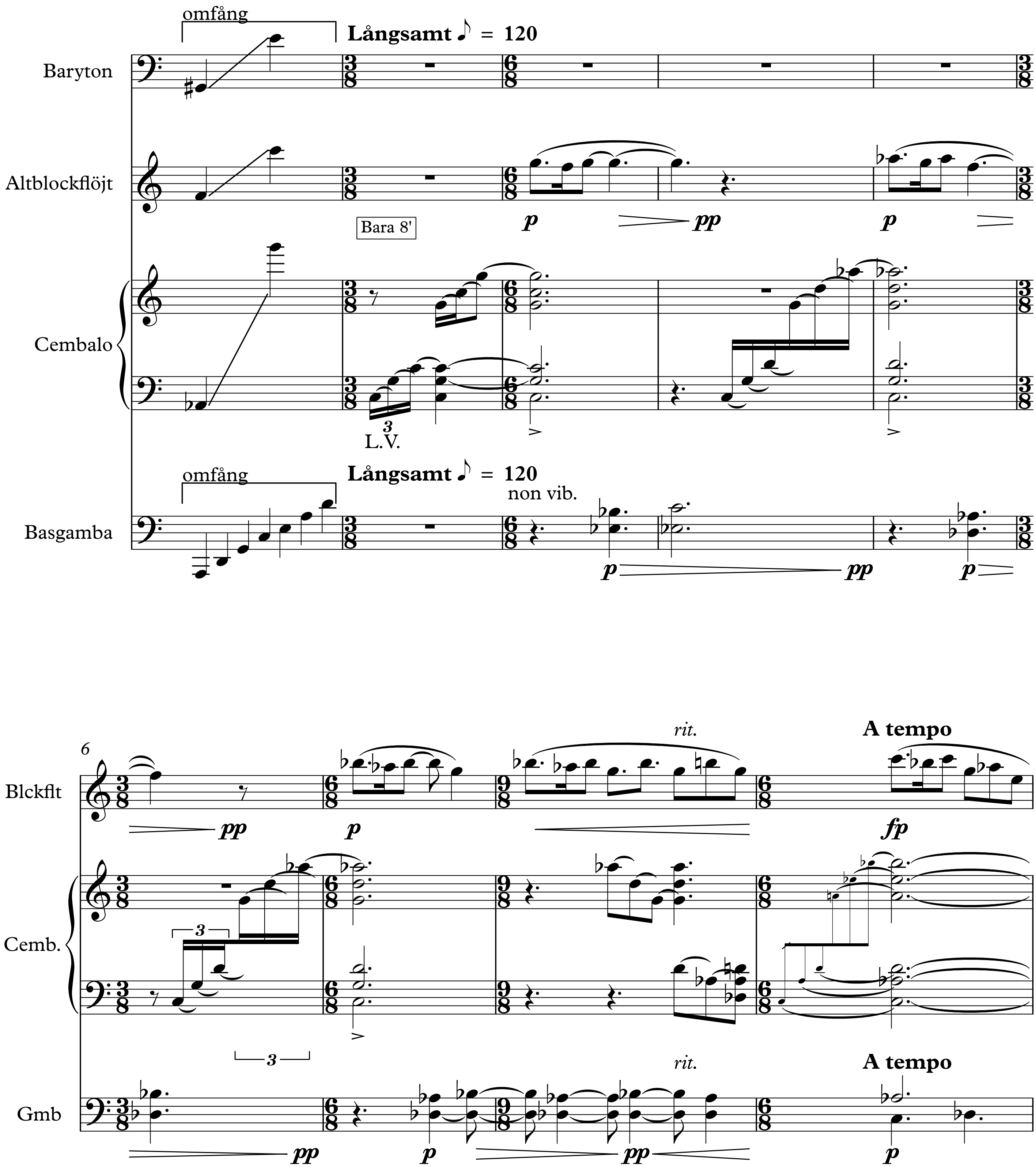

191
mf
194
197
200
f


203
206
209
2
2
2
214
3
3
ff
Ped.

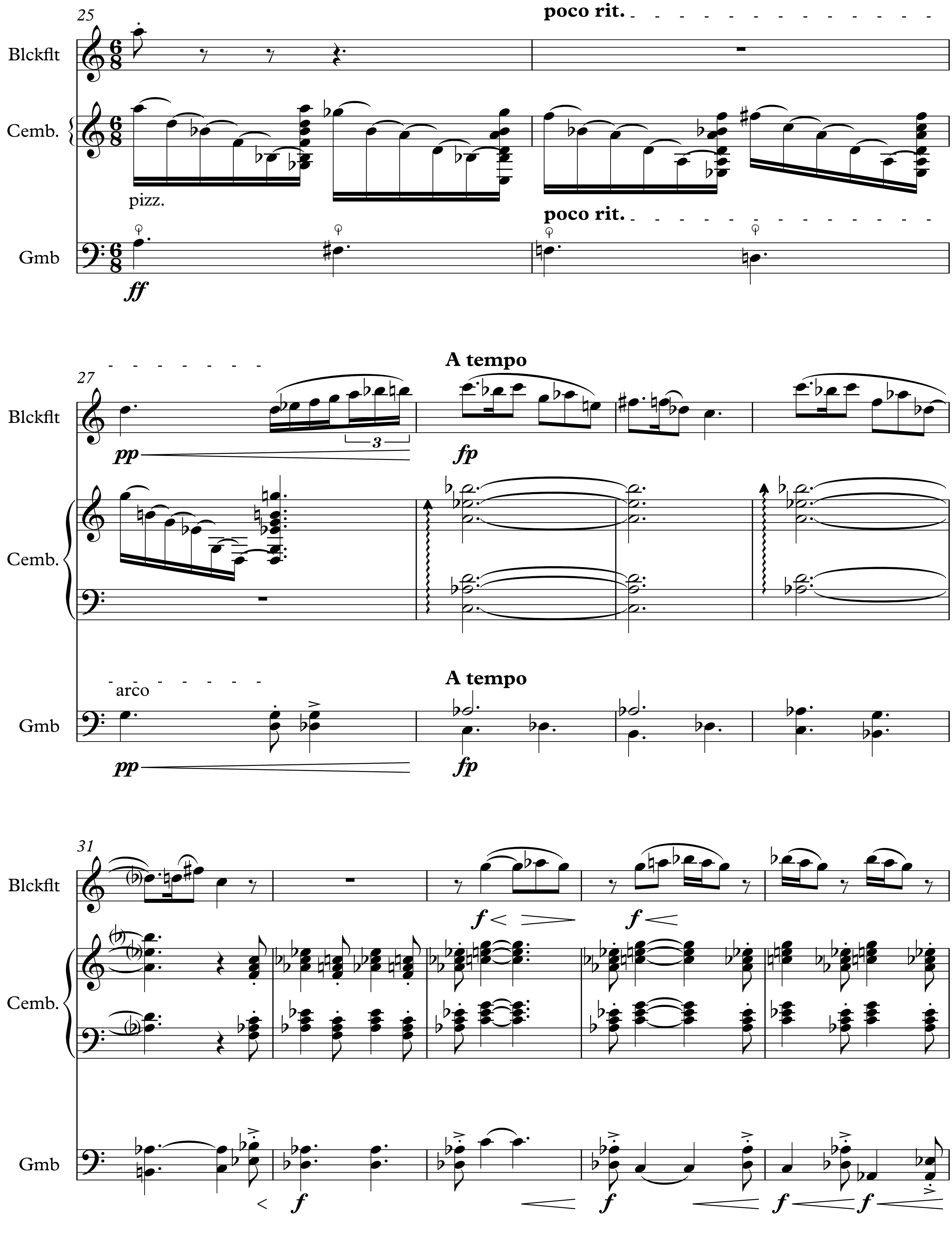
Läst Igen: Fredmans Epistel N:o 27

Carl Michael Bellman

Matthew C. Lane




10
Blckflt
Cemb.
Gmb
pp
16
Blckflt
f
f
f
Cemb.
Gmb
f
f
21
Blckflt
f
f
Cemb.
Gmb


25
poco rit.
Blckflt
Cemb.
pizz.
poco rit.
Gmb
ff
27
A tempo
Blckflt
3
pp
fp
Cemb.
arco
A tempo
Gmb
pp
fp
31
Blckflt
f
f
Cemb.
Gmb
f
f
f
f

* Multiphonic: siffrorna är hålen att måste vara täckte


44
a tempo
p
Bar.
Gub-ben är gam- mal,
ur ver-ket dras
Blckflt
subito p
p
Cemb.
a tempo
Gmb
ppp
p


49
Bar.
Vi sa-ren vi-sar, tim-man il - ar, tim - man il-ar il-ar
Blckflt
Cemb.
3
Gmb
(molto)
ff


54
Bar.
Dö-den sitt tim-glas
har stält vid mit glas
Kring bu-tel-jen
Blckflt
p
Cemb.
Gmb
subito p


59
Bar.
pp
strött si-na pil - ar, strött si - na pil - ar
pi - lar mmm
Blckflt
pp
Cemb.
3
Gmb
pp


64
Bar.
Tim -
Blckflt
flz.
Cemb.
Gmb
subito pp
68
man Tim - man
flz.
håll ner alla tangenterna


72
Bar.
Blckflt
Cemb.
Gmb
Törs-tig jag skå-dar min Stjer-na och Sol.
Van-drings-man hör nu min Bas - fi - ol
håll ner alla tangenterna
76
port.
Mo - vitz
port.
Mo - vitz
Mo -
gliss.
gliss.
81
vitz
din tje - na - re hvi - lar
L. H. pizz.
(bara pizz.)

84
Blckflt
Cemb.
Gmb
arco
86
Bar.
Kla-ra-ste skö-te, ljuf - li-ga, ljuf-li-ga barm!
Blckflt
Cemb.
Gmb
subito p
90
Bar.
Sorg - ligt de blom-mors lif fö-röd-des, lif fö - röd-des, fö-
Blckflt
Cemb.
Gmb

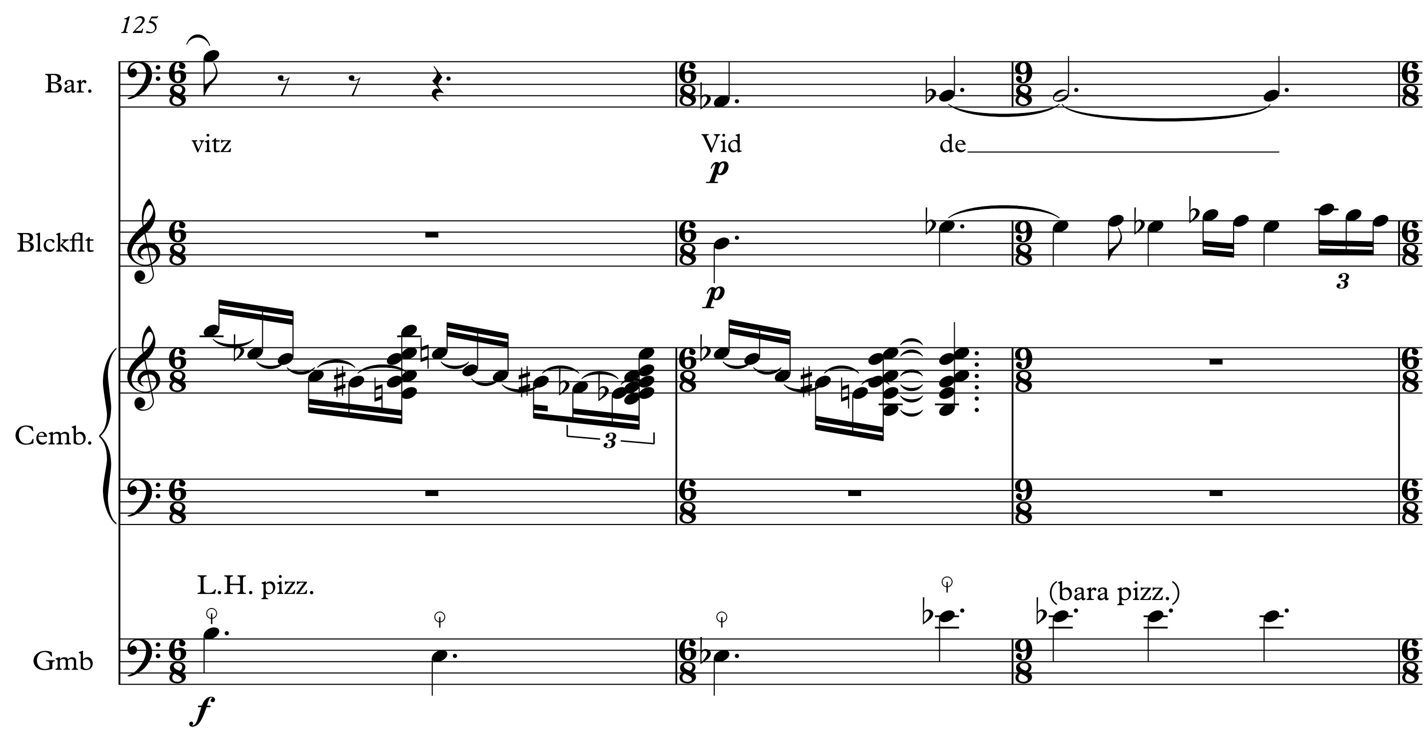

94
ppp
p
Bar.
röd-des. fö-röd-des. fö-röd-des. fö-röd - des.
Som gaf min far,
Blckflt
p
Cemb.
3
Gmb
(molto)
ff
subito p
97
Bar.
til min sve-da och harm,
Väl- lust i den sang
Blckflt
Cemb.
Gmb


102
Bar.
Blckflt
Cemb.
Gmb
där jag fö... föd - des föd-des
p
pp
pp
pp
3


107
Bar.
Blckflt
Cemb.
Gmb
mmm
Tim -
flz.
f
f
f p
3
f
subito pp
f p


112
Bar.
man Tim - man
Men bå-da sof-va. Gu
Blckflt
flz.
håll ner alla tangenterna
Cemb.
Gmb
117
tår i för-tret!
Sjung Mo-vitz,
sjung om hur ö- gat gret
Mo - vitz
håll ner alla tangenterna
gliss.


121
Bar.
Blckflt
Cemb.
Gmb
mf
f
Mo - vitz
Mo -
M: 02456
p
f
gliss.


125
Bar.
Blckflt
Cemb.
Gmb
vitz
Vid
de
p
3
L.H. pizz.
(bara pizz.)
f


128
Bar.
cy - pres-ser som ströd- des.
Blckflt
Cemb.
arco
Gmb
132
Blckflt
Cemb.
138
Blckflt
Cemb.
Gmb


143
Bar.
Blckflt
Cemb.
Gmb
subito p
Mo- vitz, Mo- vitz din tje-na-re hvi- lar.
tr
148
flz.
subito pp
mp
153
M: 01345
L.H.
pizz.
subito pp


156
Blckflt
Cemb.
Gmb
ord. vib.
159
161
Bar.
Rag - lan-de skug - ga,
b, b, b,
bru - si - ger min,


164
Bar.
Ska-pad at Bac-chus gå til han - da; gå - til han-den til
Blckflt
Cemb.
Gmb


169
Bar.
f
p
han-den
Blädd-ri ger tun - -
Blckflt
f
p
Cemb.
Gmb
(molto)
ff
subito p


171
Bar.
ga af brän-vin och vin Känn där far
Blckflt
Cemb.
Gmb


175
Bar.
mf p pp
min, känn där hans an - da an - da
Blckflt
mf p pp
Cemb.
Gmb
mf pp p pp


179
Bar.
mmm
Blckflt
Cemb.
Gmb
subito p
subito pp
184
An - da An - da
flz.
håll ner alla tangenterna


189
p
3
Bar.
Frö - ja och Bac-chus gaf kring den et sken.
Mo-vitz lät bland mi-na
Blckflt
3
håll ner alla tangenterna
Cemb.
3
Gmb


192
mf
port.
port.
Bar.
fä - ders ben.
Mo - vitz
Mo - vitz
Blckflt
3
f
p
Cemb.
3
Gmb
f
p
f
p


197
Bar.
Mo - vitz
Det ta mit
M: 02456
Blckflt
Cemb.
L.H.
pizz.
Gmb
202
stoft få sig blan - da.
Det-ta mitstoft få sig blan - da.
(bara pizz.)
208
mit stoft få sig blan - - da


213
molto rit.
Blckflt
Cemb.
3
molto rit.
Gmb
p

Melodious Viscosity (still flows)

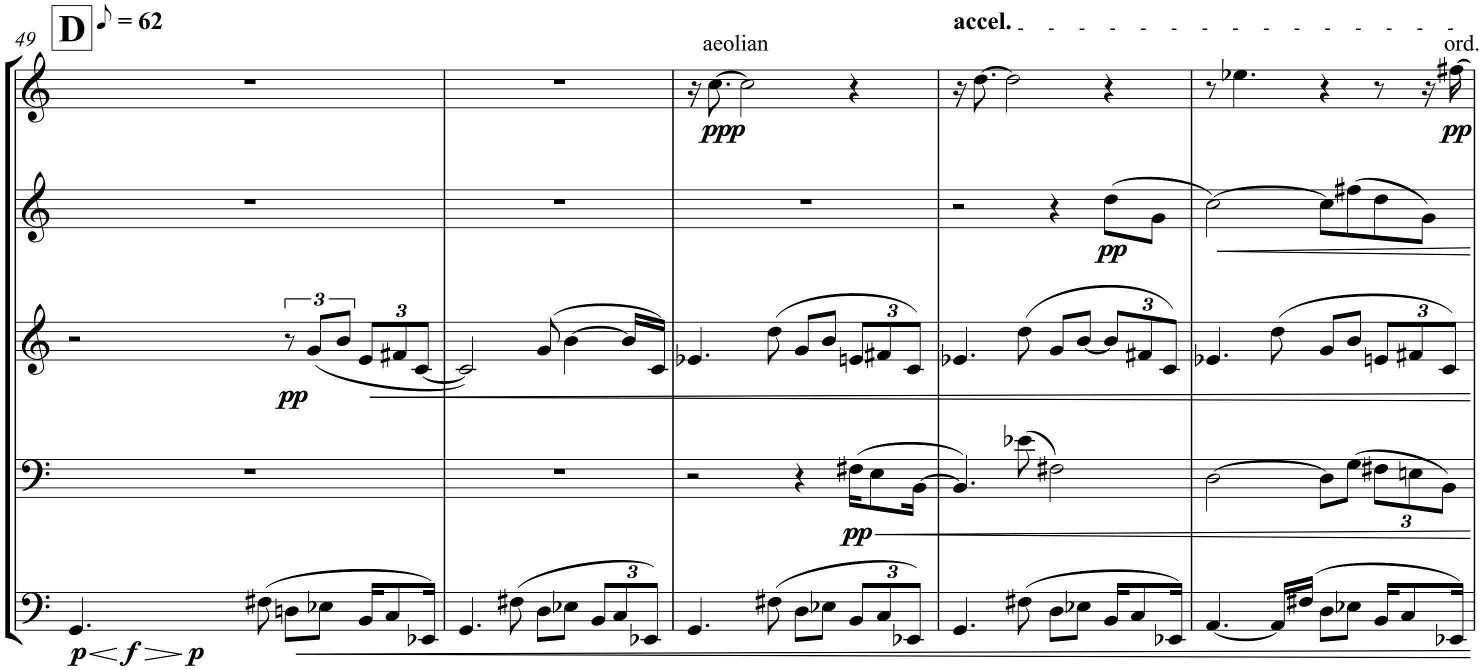
Concert Pitch

Matthew C. Lane


B
♩ = 60 (♪ = 120 subito)
aeolian
ord. no vib.
rit.
ord.
no vib.
(slow)
no vib.
no vib.
♪ = 120
rall.
♪ = 112
ord.
ord.
ord.
niente
rall.

C
= 64 Molto expressivo
Tied accents (>) denote a sudden and quickly fading swell on the note, without retonguing
p possible


39
44
Bend down
p possible


49
D
= 62
aeolian
accel.
ord.

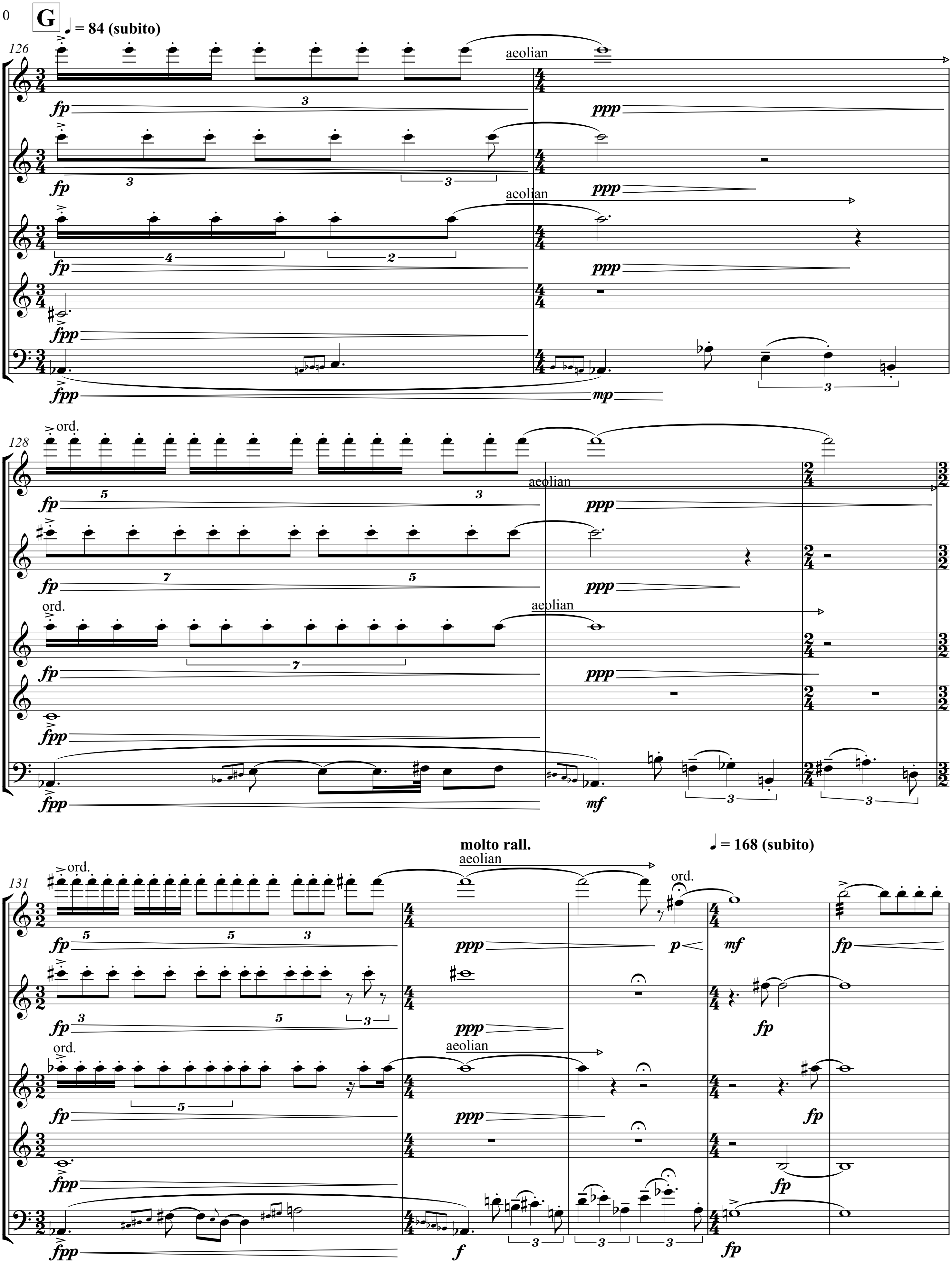

54
accel.
= 88


= 66 (subito)
E
59
solo
poco accel.
subito p
niente
Create air noises in the easiest way producing the most sound, by inhaling or exhaling through or around the mouthpiece.
air noise
air noise
with mute
Create air noises in the easiest way producing the most sound, by inhaling or exhaling through or around the reed.
air noise
air noise
65
poco accel.

70
♪ = 84
molto rit.
pp
ppp
p
subito p
74
F
Con fuoco
♩ = 168 (subito)
(2+3)
no mute
f
fp
81


87
rall.
94
rall.
♩ = 152
rall.
niente
103
rall.
♩ = 120


110
niente
117
121


G
♩ = 84 (subito)
126
aeolian
fp
ppp
fpp
mp
128
ord.
mf
131
molto rall.
♩ = 168 (subito)
f
p


136
mf
fp
p subito
f
subito p
f
144
subito f
ff
(2+3)
149
p subito
f
ff
3
p


154
H
162
molto rall.
I
♪ = 66
167


173
subito pp
subito pp
subito pp
subito p
176


178
molto rall.
p
ppp
sfzp
mp
182
J
♪ = 84 (subito)
(3+2)
pp
mp
cresc.
subtle lip gliss.
p possible
mf


186
Freely
lip gliss.
lip gliss.
molto rall.

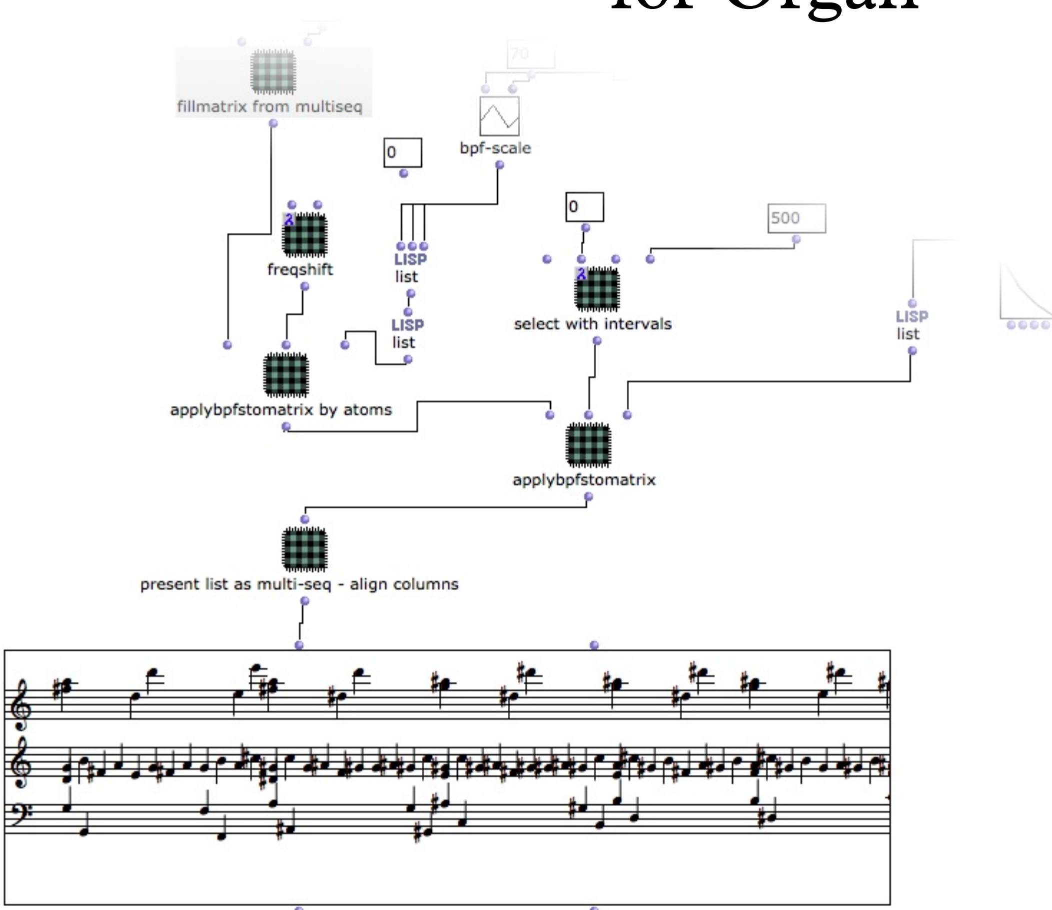

191
aeolian
lip gliss.
Molto largo
♪ = 48
niente
aeolian
niente
ppp subito
p possible subito
ppp subito
ppp subito
subito p possible
p possible
gl.

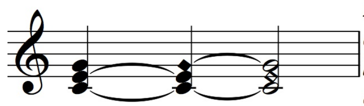
Dedicated to Shawn Potter

Matthew C. Lane

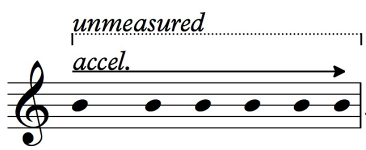
Mutations I

for Organ



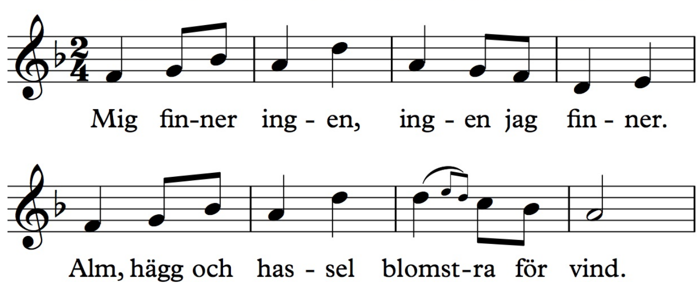


Diamond noteheads show re-attacked notes, when they are located within a chord that is already sounded.



Stemless notes with unmeasured *and* accel. *lines above them are free of rhythmic constraints, but should nevertheless be played with increasing speed.*

Tintomaras sång (Carl Jonas Love Almqvist)



Mutations I

Matthew C. Lane


A tempo
unmeasured
12
freely
Choir: quieter strings
start slowly
accel.
15
unmeasured
freely
Choir: strings
unmeasured
freely
start slowly
accel.
start very slowly
accel.
19
rit.
A tempo
Great
22
accel.
rit.

* Use 4'/2' if necessary
(to produce higher notes on shorter manuals)

** Optional: turn organ off while holding chord, and turn back on when sound is nearly gone. Release both keyboards when restarting blowers, but hold pedal.


A tempo
rit.
A tempo
50
54
(quieter pedal, just 8' flute)
57
8'4' Flute
8' Principal


poco rit.
A tempo
Great
8'4' Principle
8'4'2' Flutes
Mixtures
Full Ped.
Allarg.
molto rall.
A tempo
Full Great
Full Swell
f


66
67
68
rit.
70
Shut off blowers.
The piece ends when
nothing remains.

Mutation II

Matthew Lane


26
Flip manuals
Org.
Ped.
32
Org.
Ped.
37
Org.
Ped.
43
Add mutation if present (2 2/3)
Org.


49
Org.
54
Org.
Ped.
61
Org.
Ped.
68
Org.
Ped.


73
Org.
Ped.
80
Switch manuals
Org.
Ped.
85
Org.
Ped.


♩ = 100
92
Strings
Flutes
Org.
Ped.
98
Org.
Ped.
102
Org.
Ped.
106
Increase Registration
Org.
Ped.


110
Org.
Increase Registration
Ped.
113
freely, slower
A tempo (♩ = 100)
Strings with Voix Celeste
117
121


125
Org.
Ped.
Full organ
129
rit.
133
molto rit.
Full organ
Full pedal


♩ = 160
Great
Flutes 8',4',2'
136
Org.
Swell
Strings
1 1/3'
8' Principal
8',16' Flutes
Ped.
143
Org.
Ped.
149
Org.
Ped.
Flip manuals
154
Org.
Ped.


160
Org.
Ped.
166
Increase
registration (all)
171
Full organ
Full organ
175
rit.
Add chimes if poss.
Roll (chimes)

Short Pieces on Falling

Matthew C. Lane

Flute
Clarinet
Piano
Violin
Cello

The order of movements is at the liberty of the performers.

Choke
Float
Follow
Love
Lush
Rings
Run
Waves

Performance note:
Don't take any of this too seriously

Short Pieces on Falling

Choke

Matthew C. Lane


10
Fl.
Cl.
Pno.
Vln.
Vc.
(8)
Cresc.
gliss.
pp
p
14
mf
mp
gliss.


18
Fl.
Cl.
Pno.
Vln.
Vc.
Cresc.
f
pp
mp
no pedal
gliss.
gliss.
sul pont.
subito p
22
8va
pp
mf


26
(8)
Fl.
Cl.
Pno.
mp
mf
f
Vln.
gliss.
Vc.
30
(8)
8va
p
ord.


34
Fl.
Cl.
Pno.
Vln.
Vc.
subito p
(8)
(using both hands)
p
f
gl.
subito p
gl.
f
38
Fl.
Cl.
Pno.
Vln.
Vc.
f
subito pp
8va
(l.h.)
mf
gl.
gliss.
f
subito pp
gliss.


42
Fl.
Cl.
Pno.
Vln.
Vc.
(8)
8va
gliss.
gliss.
mp
pp
f
sfz
46
pp
f
mf
p


50
Fl.
Cl.
Pno.
Vln.
Vc.
f
fp
mf
mp
p
sfz
54
molto rall.
ff
pp
molto rall.


57
Fl.
Cl.
Pno.
Vln.
Vc.
pp
f
ff
Ped.

Short Pieces on Falling

Float

Matthew C. Lane


10
Fl.
Cl.
Pno.
molto vib.
ord.
Vln.
molto vib.
ord.
Vc.
15
(flz.)
Fl.
(flz.)
Cl.
Pno.
8vb
8vb
Vln.
Vc.


21
Fl.
Cl.
(split hands)
Pno.
(8)
Vln.
Vc.
f
mp
p
mf
pp
26
fp


29
Fl.
Cl.
Pno.
Vln.
Vc.
32
Fl.
Cl.
Pno.
Vln.
Vc.
fp


35
Fl.
Cl.
Pno.
Vln.
Vc.
f
p
Ped.
38
mp
pp


42
Fl.
Cl.
Pno.
Vln.
Vc.
f
mp
p
vib.
47
pp
8vb
Ped.


52
Fl.
Cl.
Pno.
Vln.
Vc.
p
f
subito p
56
Fl.
Cl.
Pno.
Vln.
Vc.


60
Fl.
Cl.
Pno.
Vln.
Vc.
pp
pp
pp
pp
pp
64
Fl.
Cl.
Pno.
Vln.
Vc.
f
f
mp
mf
f
mp
ff
p
ff
p
ff
mp
fp
fp
fp
fp
mp
mp
fp
mp


67
Fl.
Cl.
Pno.
Vln.
Vc.
pizz.

Short Pieces on Falling

Follow

Matthew C. Lane


8
Fl.
Cl.
Pno.
Vln.
Vc.
(8)
mf
11
p
pp
ppp
3


15
Fl.
Cl.
Pno.
Vln.
Vc.
(8)
Ped.
p
19
ppp
pp
mf
3


23
Fl.
Cl.
Pno.
Vln.
Vc.
3
p
mf
f
pp
26

28
Fl.
Cl.
Pno.
Vln.
Vc.
3
p
ppp
pp
31
No conductor
Wait until all instruments arrive before proceeding
p molto rubato
follow the violin within 1 second
improvise freely from these notes in varied 8th note configurations, with rests
8va
follow the flute within 1 second


Wait until all instruments arrive before proceeding
35
Fl.
Cl.
Pno.
Vln.
Vc.
p
mf
8va
Ped.
follow the clarinet within 1 second
39
mp
f
slowly increase the following time to 2-3 seconds
slowly increase the following time to 2-3 seconds
slowly increase the following time to 2-3 seconds


46
Conductor begins again
Fl.
Cl.
Pno.
Vln.
Vc.
50
Fl.
Cl.
Pno.
Vln.
Vc.


54
rit.
Fl.
Cl.
Pno.
Vln.
Vc.
mp
pp
p
3
(15)
15ma

Short Pieces on Falling

Love

Matthew C. Lane


7
rit.
Fl.
Cl.
Pno.
Vln.
Vc.
pp
mp
mf
10
accel.
(mf)
pizz.


12
A tempo
Fl.
Cl.
Pno.
Vln.
Vc.
ppp
pp
mp
p
arco
14


17
Fl.
Cl.
Pno.
Vln.
Vc.
pp
f
mf
21


23
Fl.
Cl.
Pno.
Vln.
Vc.
pp ff p pp
pp ff p mp
ff p pp
pp ff p pp
ff mp p pp
3
26
Fl.
Cl.
Pno.
Vln.
Vc.


28
Fl.
Cl.
Pno.
Vln.
Vc.
31
poco rit.
Fl.
f
p
pp
ppp
Cl.
f
p
pp
ppp
Pno.
f
8va
mp
poco rit.
Vln.
f
p
pp
ppp
Vc.
f
mp
p
pp

Short Pieces on Falling

Lush

Matthew C. Lane


7
Fl.
Cl.
(8)
Pno.
Vln.
Vc.
10
Fl.
p
Cl.
3
p
(8)
Pno.
mf
mp
Vln.
Vc.


13
Fl.
Cl.
Pno.
Vln.
Vc.
f
p
mp
(8)
3
17


20
Fl.
Cl.
Pno.
Vln.
Vc.
ff
p
f
(8)
23
pp
sempre legato, con pedale
mf
pizz. l.v.


25
aeolian
Fl.
Cl.
Pno.
Vln.
Vc.
ppp
ppp
28
Fl.
Cl.
Pno.
Vln.
Vc.

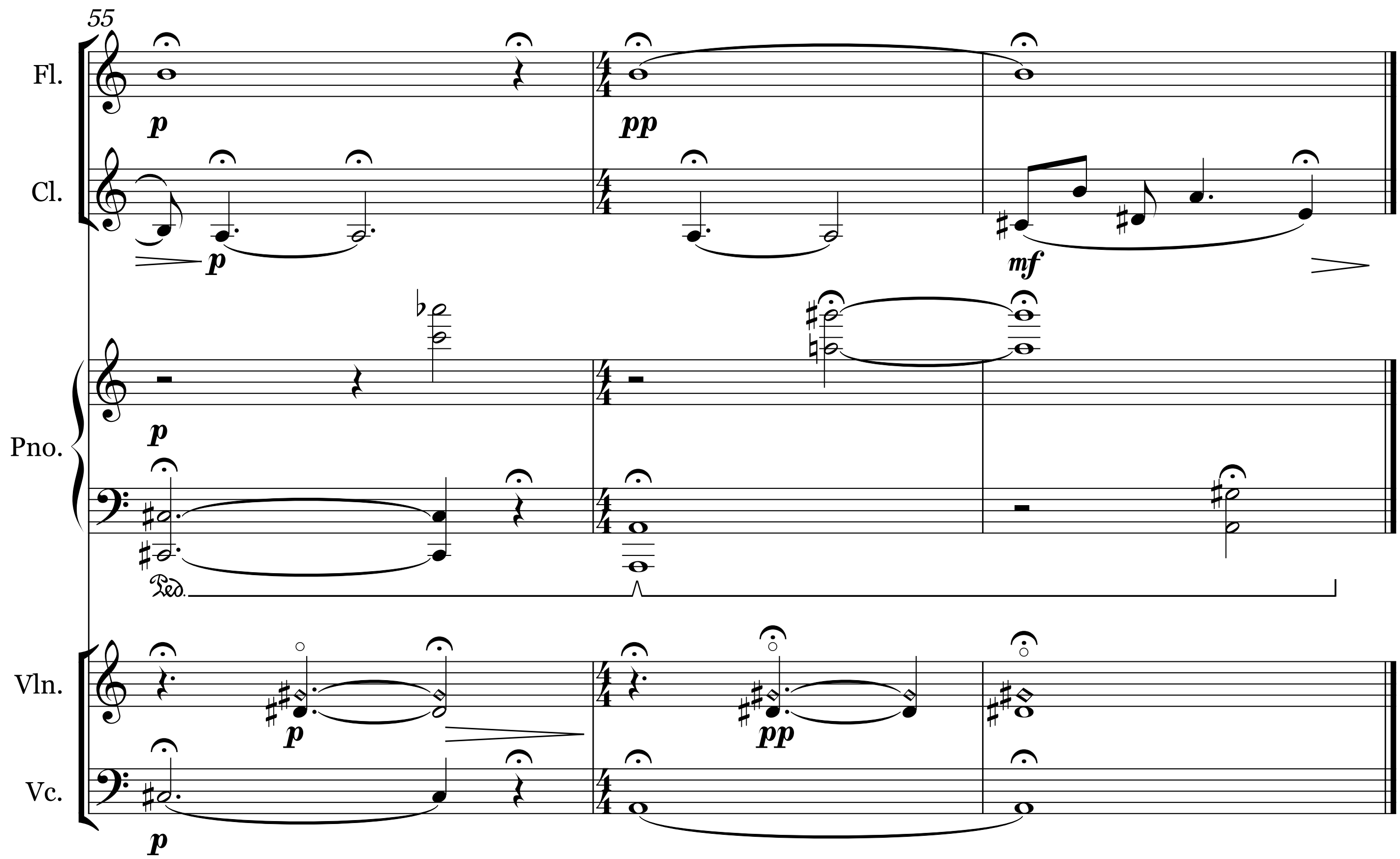

30
Fl.
Cl.
Pno.
Vln.
arco.
Vc.
p
32
accel.
non vib.
ppp
pp
accel.
l.v.
pizz,
mf


34
Fl.
Cl.
Pno.
Vln.
Vc.
36
Fl.
Cl.
Pno.
non-vib.
Vln.
pp
Vc.


38
♩ = 72
rit.
Fl.
Cl.
p
p
Pno.
3
3
3
p
♩ = 72
rit.
Vln.
mf
pp
arco.
Vc.
gliss.
pp
40
♩ = 52
Fl.
Cl.
p
p
Pno.
mp
♩ = 52
Vln.
pp
arco
Vc.
mp


43
Fl.
Cl.
Pno.
Vln.
Vc.
mf
mf
mf
mp
p
p
f
p
pp
Ped.
3
46
p
p
mp
mp
mp
p
mp
Ped.


49
8va
Fl.
Cl.
Pno.
Vln.
Vc.
f
3
53
Fl.
Cl.
Pno.
Vln.
Vc.


55
Fl.
Cl.
Pno.
Vln.
Vc.
p
pp
mf
Ped.

Short Pieces on Falling

Rings

Matthew C. Lane


8
Fl.
Cl.
(8)
Pno.
Vln.
Vc.
12
Fl.
Cl.
Pno.
Vln.
Vc.


15
Fl.
Cl.
Pno.
Vln.
Vc.
f
p
mf
mp
pp
Ped.
18
mf
Ped.


20
Fl.
Cl.
Pno.
Vln.
Vc.
22
Fl.
Cl.
Pno.
Vln.
Vc.


25
Fl.
Cl.
Pno.
Vln.
Vc.
p
f
p
27
f
pp
mp
3


31
Fl.
Cl.
Pno.
Vln.
Vc.
3
p
pp
mp
35
pizz.
mf
f


38
Fl.
Cl.
Pno.
Vln.
Vc.
p
f
8va
mp
arco
arco
41
pp
ppp
mp
pizz.


45
Fl.
Cl.
Pno.
Vln.
Vc.
ppp
p
f
arco
48
Repeat ad lib., with increasing intensity and less regard for tone
Cresc.
Repeat ad lib., with increasing intensity and less regard for tone


52
Fl.
Cl.
Repeat ad lib., with increasing intensity and less regard for tone
Pno.
(cresc.)
Vln.
Vc.
56
Fl.
Cl.
Pno.
(cresc.)
Vln.
Repeat ad lib., with increasing intensity and less regard for tone
Vc.

60
Fl.
Cl.
Pno.
Vln.
Vc.
pp
ppp
p
(p)
Cresc.
Ped.
mp
A.H.
65
f


67
Fl.
Cl.
Pno.
Vln.
Vc.
p
f
(cresc.)
69
Fl.
Cl.
Pno.
Vln.
Vc.
p
f
(cresc.)


71
Fl.
Cl.
Pno.
Vln.
Vc.
(cresc.)
73
mf
subito p
Cresc.
pp


76
Fl.
Cl.
Pno.
Vln.
Vc.
3
p
f
(cresc.)
78
3
p
f
(cresc.)
3
p
f


80
Fl.
Cl.
mp
f
Pno.
(cresc.)
3
3
Vln.
mp
f
Vc.
82
Fl.
f
Cl.
Pno.
(cresc.)
3
3
Vln.
Vc.
f


84
Fl.
Cl.
Pno.
Vln.
Vc.
ff
subito p
3
86
f
pp
sfz


89
Fl.
Cl.
Pno.
Vln.
Vc.
sfz
pp
mp
p
mp
p
94
Fl.
Cl.
Pno.
Vln.
Vc.
p
f
pp
mp
Ped.


97
Fl.
Cl.
Pno.
Vln.
Vc.
5
5
p
5
5
5
100
molto rit.
Fl.
ppp
Cl.
ppp
Pno.
molto rit.
pizz.
Vln.
ppp
mf
pizz.
Vc.
ppp
mf

Short Pieces on Falling

Run

Matthew C. Lane


5
Fl.
Cl.
Pno.
Vln.
Vc.
subito p
9
Fl.
Cl.
Pno.
Vln.
Vc.


12
Fl.
Cl.
Pno.
Vln.
Vc.
15
Fl.
Cl.
Pno.
Vln.
Vc.


18
Fl.
Cl.
Pno.
Vln.
Vc.
ff fp ppp
f fp
mf
8vb
Ped.
3
23
mp
pp
ppp


28
Fl.
Cl.
Pno.
Vln.
Vc.
ppp
p
Pedal (keeping chords connected)
mf
pizz.
mf
34
pp
p
mf
arco
p


39
Fl.
Cl.
Pno.
Vln.
Vc.
p
f violent
mp
43
15ma
f
pp
f
p


48
Fl.
Cl.
Pno.
Vln.
Vc.
pp
pp
p
mf
Ped.
pizz. non-vib.
mf
52
mf
mf
f
mf


55
Fl.
Cl.
Pno.
arco
Vln.
Vc.
58
Fl.
Cl.
Pno.
Vln.
Vc.


61
Fl.
Cl.
Pno.
Vln.
Vc.
ff
p
64
3 sec
molto rall.
pizz.
arco
f
pp


3 sec A tempo
68
Fl.
Cl.
Pno.
Vln.
Vc.
harm.
pizz.
72
flz.
flz.
jeté
jeté
simile
arco
Ped.


76
Fl.
Cl.
p
Pno.
mf
Vln.
Vc.
mf
78
Fl.
ff
Cl.
ff
Pno.
f
Vln.
f
pizz.
arco
Vc.
f

Short Pieces on Falling

Waves

Matthew C. Lane


7
Fl.
Cl.
Pno.
Vln.
Vc.
10
Fl.
Cl.
mp
Pno.
Vln.
Vc.


14
Fl.
Cl.
Pno.
Vln.
Vc.
mp
3
17
pp
mf
p
8va
arco


21
Fl.
Cl.
Pno.
Vln.
Vc.
pizz.
arco
p
mf
24
8va


28
Fl.
Cl.
Pno.
Vln.
Vc.
mf
subito p
f
p
31
pp
ppp
Ped.


35
Fl.
Cl.
p
p
Pno.
Use pedal as necessary
3
p
pp
non-vib.
Vln.
ppp
mf
Vc.
pp
pp
p
39
Fl.
Cl.
mf
Pno.
Vln.
Vc.


42
Fl.
Cl.
mp
mf
Pno.
Vln.
p
Vc.
45
Fl.
p
mf
p
Cl.
p
Pno.
Vln.
p
mf
p
Vc.
mf


48
Fl.
Cl.
Pno.
Vln.
Vc.
f
mp
p
51
mf
8va


54
Fl.
Cl.
Pno.
Vln.
Vc.
p
mf
(8)
57
Fl.
Cl.
Pno.
Vln.
Vc.
f
p
(8)
f
f
mf


60
Fl.
Cl.
Pno.
(8)
Vln.
Vc.
63
ff
8va


68
Fl.
Cl.
Pno.
Vln.
Vc.
2 sec.
fermata
ppp
pp
p
mp
3
2 sec.
fermata
71
molto rit.
mp
p
pp
ppp
arco.
pizz.
mf
3
pp

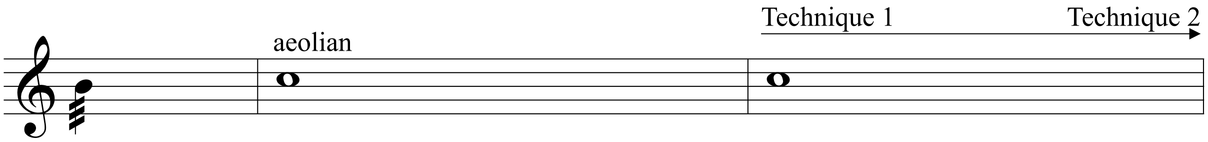
Score

Sliding Apart

for flute, clarinet, piano, violin, and cello

Matthew C. Lane

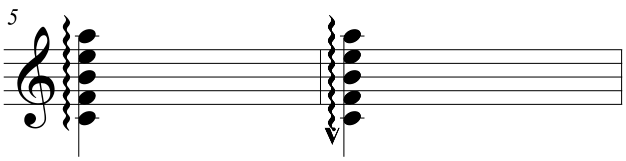
Notes for musicians



Flutter-tongue

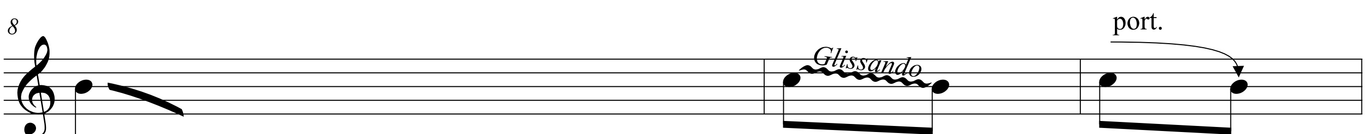
Allow more air than usual in the sound. Create a somewhat airy sound.

Technique 1 transitions as smoothly as possible to Technique 2



Roll upwards

Roll downwards

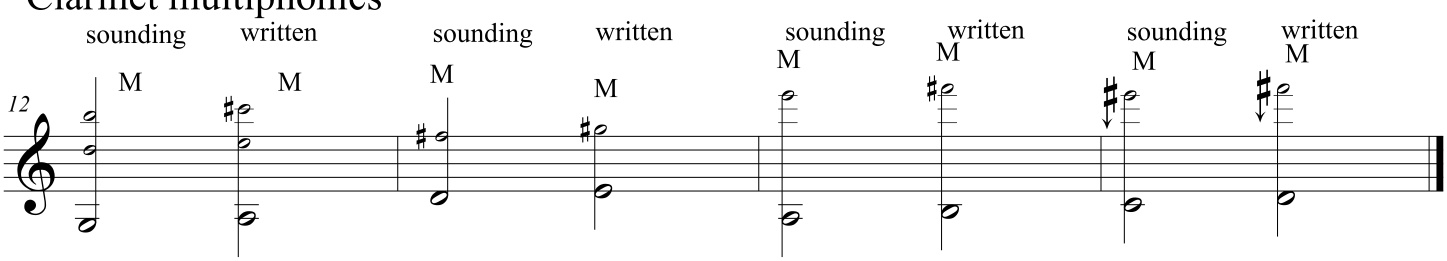


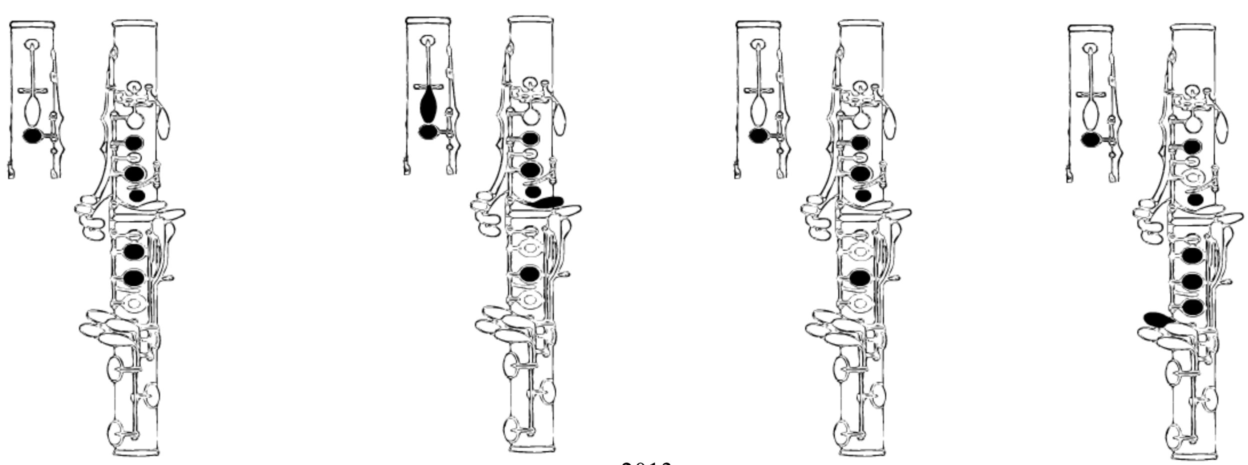
Once the initial pitch of the note is established, slide down up to a semitone over the remaining duration. Break before the next note.

Continuous glissando

Portamento

Clarinet multiphonics





2013

Multiphonic fingerings from

http://clarinet-multiphonics.org/clarinet-multiphonics.html

Concert Pitch Score

Sliding Apart

Matthew C. Lane


Fl.
B♭ Cl.
Pno.
Vln.
Vc.


10
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
13
Fl.
B♭ Cl.
Pno.
Vln.
Vc.


16
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
3
sfz
pp
ord.
p
Ped.
18
mp
mf
5
*


A
♩ = 112
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
20
pizz. pinched L.V.
pizz. pinched L.V.
f
pp
22
subito p
sfz


24
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
f
p
27
pp
3


29
Fl.
B♭ Cl.
f
Pno.
Vln.
Vc.
32
mp
3
5


34
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
mf
mf
mf
36
8va
aeolian
p
p
mf
pp
mf
f
pp
arco
p
arco
p


39
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
pp
f
mp
p
42
aeolian
ppp


44
♩ = 48
aeolian
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
p
8va
pizz. L.V. light gliss downwards after each pizz.
(both notes)
pizz. L.V.
mf
light gliss downwards after each pizz.
(both notes)
46
(8va)


Fl.
B♭ Cl.
Pno.
Vln.
Vc.
p
pp
(8va)


Fl.
B♭ Cl.
Pno.
Vln.
Vc.
p
mp


8va
58
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
60
mp
pp
mf
arco
p
pp
arco
p

* Each trill should form a speed arc for its duration,
fastests in the middle and slowest at the beginning and end


69
rit.
a tempo
Fl.
f
pp
flz.
B♭ Cl.
f
pp
3
Pno.
f
Plucked
3
3
3
L.V.
8va
8va
Sul ponticello
Vln.
f
pp
Sul ponticello
Vc.
p
f
pp
72
Fl.
B♭ Cl.
3
Pno
(8va)
Vln.
Vc.


Fl.
B♭ Cl.
Pno
Vln.
Vc.
75
pp
f
M
ff
(8va)
B
♩ = 112
ord.
niente
p
77
Use both hands for octaves
pizz.
pizz.
Pno.


80
Fl.
B♭ Cl.
mf
80
Pno.
mf
80
Vln.
Vc.
83
Fl.
f
molto rit.
ord.
B♭ Cl.
pp
83
Pno.
f
83
Vln.
Vc.


♩= 48
8va
86
Fl.
subito pp
B♭ Cl.
p
Pno.
mp
arco
Sul ponticello
Vln.
pp
Vc.
♩= 112
flz.
88
subito mf
sfz
pizz.
f


Fl.
B♭ Cl.
Pno.
Vln.
Vc.
Approximate rhythms and pitches
Approximate rhythms and pitches
port.


ord.
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
pp
f
pp
f


101
Fl.
pp
B♭ Cl.
pp
Pno.
pp
Vln.
Vc.
104
Decrescendo


106
Fl.
Decrescendo
B♭ Cl.
Decrescendo
Pno.
(decresc.)
Vln.
Vc.
108
ord.
♩= 60
pp
(decresc.)
L.V.
mf
p


rit.
a tempo
rit.
111
Fl.
B♭ Cl.
Pno.
8va
p With pedal
arco
Vln.
arco
Vc.
pp
113
a tempo
rit.
a tempo
rit.
M
pp
mp
pp


a tempo
rit.
Fl.
B♭ Cl.
M
Pno.
Vln.
Vc.
port.
espress.


122
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
a tempo
rit.
ppp
mp
pp
M
mf
8va
124
molto cresc.


126
aeolian
a tempo
rit.
Fl.
subito pp
aeolian
B♭ Cl.
subito pp
15ma
Pno.
p
Plucked
L.V.
Plucked
L.V.
mf
mf
Sul ponticello
pizz.
Vln.
subito pp
f
L.V.
L.V.
pizz.
arco
Vc.
f
f
mf
pp
129
Fl.
Crescendo
B♭ Cl.
Crescendo
(15ma)
Pno.
Crescendo
L.V.
Vln.
Vc.
Crescendo


131
Fl.
(cresc.)
mf
B♭ Cl.
(cresc.)
mf
(15ma)
Pno.
(cresc.)
mp
Vln.
mf
f
Vc.
(cresc.)
mf
f


♩ = 120
accel.
ord.
rit.
134
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
sfz
arco
p
f
port.
137
accel.
rit.


= 136
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
fp
sfz
15ma
8va
f Plucked
pizz. L.V.
mf


149
Fl.
B♭ Cl.
149
ord.
Pno.
p
p
149
pizz. L.V.
Vln.
3
mf
mp
p
Vc.
mp
C
♩ = 112
Fl.
f
B♭ Cl.
pp
f
151
Pno.
f
151
pinched pizz. L.V.
Vln.
f
pinched pizz. L.V.
Vc.
f


154
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
sfz
f
p
157
pp


159
Fl.
B♭ Cl.
f
pp
f
Pno.
Vln.
Vc.
162
3
3/4


164
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
pp
Ped.
166
f
mp


168
Fl.
3
pp
B♭ Cl.
3
3
pp
168
Pno.
3
pp
168
Vln.
3
3
pp
Vc.
3
pp
170
Fl.
f > mp
3
B♭ Cl.
f > mp
3
170
Pno.
f > mp
3
3
170
Vln.
f > mp
3
Vc.
f > mp
3


173
Fl.
B♭ Cl.
Pno.
Vln.
Vc.
175
mf
fp
mp
p
arco

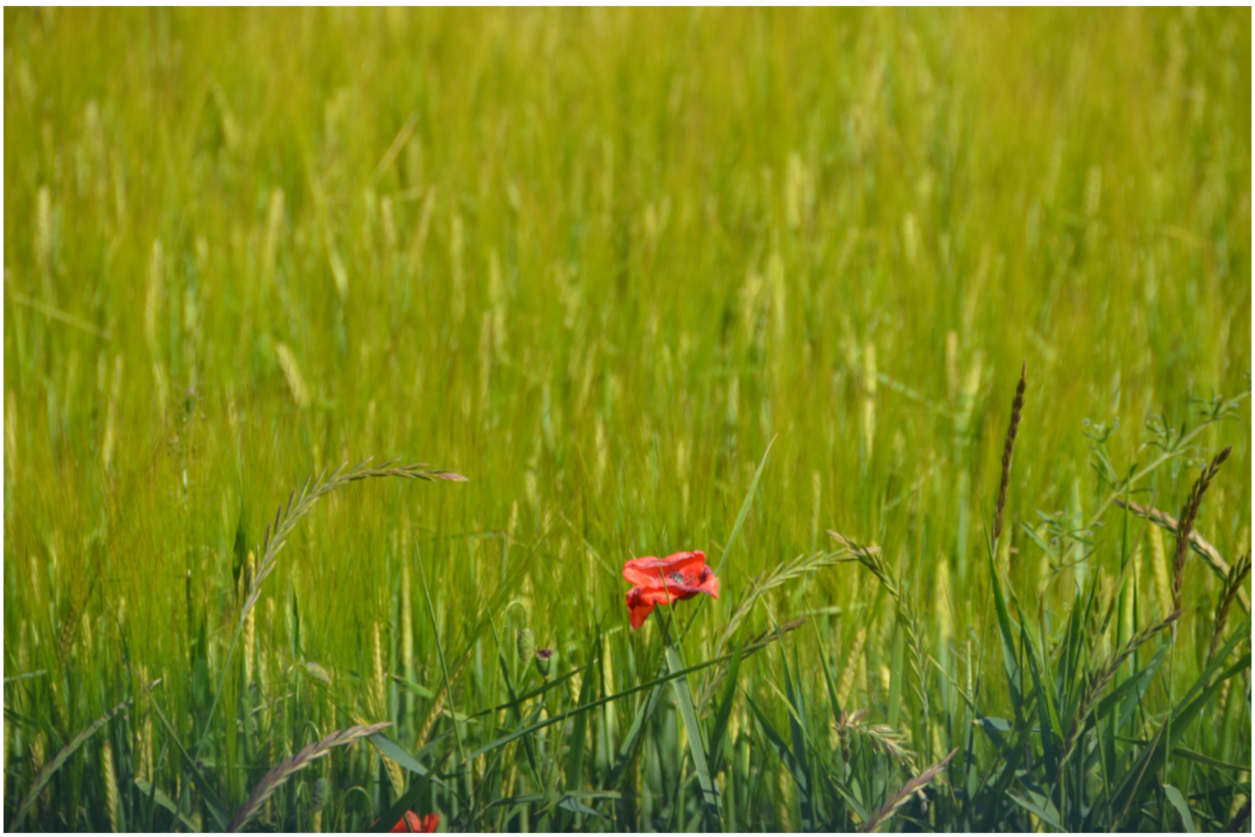

♩ = 60
177
Fl.
B♭ Cl.
Pno.
Plucked
L.V.
Vln.
Vc.
fp
f
180


183
Fl.
B♭ Cl.
fp
183
Pno.
183
Vln.
fp
Vc.
fp
186
Fl.
pp
fp
B♭ Cl.
186
Pno.
186
Vln.
Vc.
ppp
fp


189
Fl.
B♭ Cl.
fp
189
Pno.
189
Vln.
fp
Vc.
192
Fl.
B♭ Cl.
192
Pno.
8va
192
Vln.
Vc.

Vinst och Förlust

for SATB choir and flute



Music: Matthew C. Lane
Poetry: Viktor Rydberg

Dedicated to Tiphaine Legrand
and the Ensemble Kô

January, 2015
Dorval, Québec

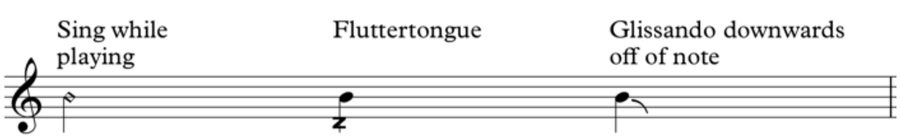
Vinst och Förlust	**What’s Won and What’s Lost**
Guld, ära, visdom och omsider båren: se där vad långa år av möder bringer, vad lyckan mäkter ge, och dock hur ringa mot det som plundras oförmärkt av åren!	Gold, glory, wisdom, and at last the coffin: see what the long years of toil bring, what happiness can give, and yet how little it is against the unnoticed theft of years!
Framåt, framåt oss våra öden tvinga, vi skynda äldre släkten tätt i spåren vi hinna ej att sörja ungdomsåren dess sista fjärlar, som till flykt sig vinga	Forward, forward our destinies force us, we hasten after the older generation close in their footsteps we have not time to mourn our youth its last butterflies escape by flight
Ett fält framför oss, vitt som havets yta! *Vi ila hän, dit våra öden kalla,* *att plöja gamla land och nya bryta.*	*A field before us, white as the ocean's surface!* *We hasten foreward, to where fate calls us,* *to plow the old land and break the new.*
Men när vi bärgat gyllne skördar alla, *vi ville dem mot liten blomma byta -* *mot kindens ros, vars blad så hastigt falla!*	*But when we have reaped this golden harvest,* *we would have traded it for a small flower -* *against a rosy cheek, whose leaves so quickly fall!*

Pronunciation (IPA)

ɛ̠t: fɛl:t ˈfràm:ˌfœ:r ɔs: vɪt: sɔm: ˈhɒ:vəts ˈỳ:ta
vi: ˈì:la hɛ:n di:t ˈvò:ra ˈø̀:dən kàl:a
at: ˈplœ̀j:a ˈgàm:la lan:d ɔk: nỳ:a ˈbrỳ:ta

mɛn: næ:r vi: ˈbæ̀r:jat ˈjʏl:nə ˈɦœ̀:ɖar ˈàl:a
vi: ˈvìl:ə dɛm: mu:t ˈlì:tən blʊ̀m:a ˈbỳ:ta
mu:t ˈɕɪn:dəns ru:s vɒ:rs blɒ:d so: ˈhàs:tɪgt ˈfàl:a

Flute techniques:



Vinst och Förlust

Viktor Rydberg

Matthew Lane


24
Fl.
S.
Ah dm Ah dm Ah dm Ah dm Ah dm Ah dm
A.
Ah dm Ah dm Ah dm Ah dm Ah dm Ah dm
T.
Ah dm Ah dm Ah dm Ah dm Ah dm Ah dm
B.
mf
Ah dm Ett fält framför oss,
30
Fl.
S.
Ah dm Ah dm Ah dm Ah dm Ah dm
A.
Ah dm Ah dm Ah dm Ah dm Ah dm
T.
Ah dm Ah dm Ah dm Ah dm Ah dm
B.
mf
vitt som ha-vets y-ta!


35
Fl.
S.
Ah dm Ah dm Vi i - la hän, dit vå - ra
A.
Ah dm Ah dm Ah dm
T.
Ah dm Ah dm Ah dm
B.
Ah dm


38
Fl.
S.
A.
T.
B.
f
p
ö - den kal - la, Vi i - la hän, dit vå - ra ö - den kal - la, att plö - ja gam - la land och
Ah dm Vi i - la hän, dit vå - ra ö - den kal - la, att plö - ja gam - la land och
Ah dm Ah dm Ah dm att plö - ja gam - la land och
Ah dm Ah dm Ah dm att plö - ja gam - la land och
42
f
p
ny - a bry - ta att plö - ja gam - la land och ny - a
ny - a bry - ta att plö - ja gam - la land och ny - a
ny - a bry - ta att plö - ja gam - la land och ny - a
ny - a bry - ta att plö - ja gam - la land och ny - a


46
Fl.
S.
bry - ta bry - ta bry - ta bry - ta
A.
bry - ta bry - ta bry - ta bry - ta
T.
bry - ta bry - ta
B.
bry - ta
50
Fl.
S.
Men när vi bär - gat gyll - ne
A.
bry-ta bry-ta Men när vi bär - gat gyll-ne skör-dar
T.
Men när vi bär - gat gyll-ne skör - dar al - la,
B.
Men när vi


58
Fl.
S.
A.
T.
B.
pp
3.
skör - dar al - la, Men när vi
al - la al - la, Men när vi bär - gat gyll-ne
Men när vi bär - gat gyll-ne skör-dar
bär - gat gyll-ne skör- dar, skör-dar al - la,
65
bär - gat gyll-ne skör - dar al - la
skör-dar al - la, Men när vi bär - gat
Men när vi bär - gat gyll-ne skör-dar al -
4
Men när vi bär - gat gyll - ne


71
Fl.
S.
6
Men när vi bär - gat gyll-ne skör-dar
A.
gyll - ne skör - dar al - la Men
T.
la al - - la
B.
skör - dar al - - la Men när vi bär - gat
77
Fl.
S.
mf
al - la a - la Vi
A.
mf
när vi bär - gat gyll - ne skör - dar al - la Vi
T.
mf
Men när vi bär - gat Vi ville dem mot li - ten
B.
mf
gyll - ne skör-dar al - la Vi ville dem mot li - ten


83
Fl.
mf
S.
A.
T.
B.
p
vil-le dem mot li-ten blom - ma by-ta Vi vil-le dem mot li-ten
vil-le dem mot li-ten blom - ma by-ta Vi vil-le dem mot li-ten
blom - ma by - ta
blom - ma by - ta
86
pp
f
ff
blom - ma by-ta
Vi vil-le dem mot li-ten blom-ma by-ta
blom - ma by-ta
Vi vil-le dem mot li-ten blom-ma by-ta
Vi vil-le dem mot li-ten blom-ma by-ta
Vi vil-le dem mot li-ten blom-ma by-ta


89
Fl.
S.
A.
T.
B.
mf
Vi vil-le dem mot li - ten blom - ma by - ta Vi vi - le dem mot li - ten
Vi vil-le dem mot li - ten blom - ma by - ta Vi vi - le dem mot
Vi vil-le dem mot li - ten blom - ma by - ta Vi vi - le
Vi vil-le dem mot li - ten blom - ma by - ta
92
blom - ma Vi vil-le dem mot li - ten blo - - ma
li - ten blom - ma Vi vil-le dem mot li - ten blom - ma
dem mot li - ten blom - ma Vi vil-le dem mot li - ten blom - ma
Vi vil-le dem mot blom - ma vi vil-le dem mot blom - ma


96
S.
A.
T.
B.
pp
p
mot kin - dens ros, ros, ros, ros, ros,
mot kin - dens ros,
104
Fl.
A dm A dm A dm A dm


110
Fl.
S.
A dm A dm A dm
A.
A dm A dm A dm
T.
A dm A dm A dm
B.
A dm A dm A dm
114
rall.
Fl.
rall.
S.
A dm mmm
A.
A dm mmm
T.
A dm mmm
B.
A dm mmm

Appendix B: Compositions (Part 2)

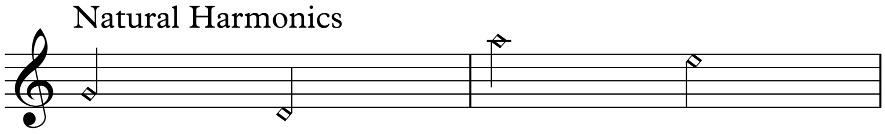
Like a Square Peg

Like a Square Peg

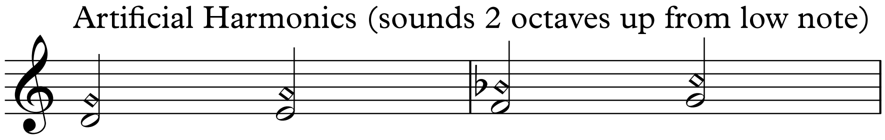
Matthew C. Lane

For Solo Violin and String Orchestra (33321)

Natural Harmonics



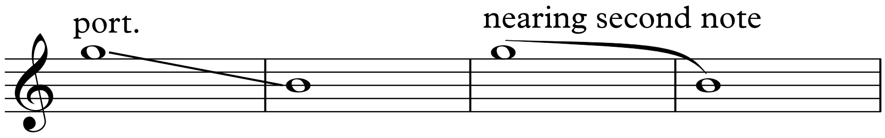
Artificial Harmonics (sounds 2 octaves up from low note)



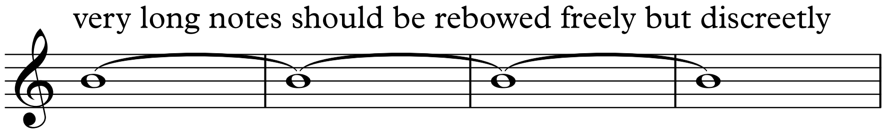
A.H.

port.

pitch glide becomes faster nearing second note

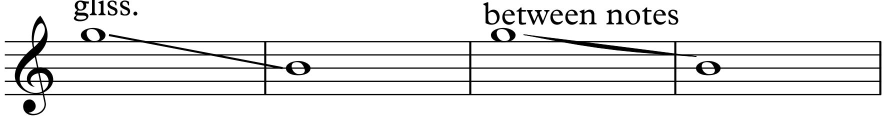


very long notes should be rebowed freely but discreetly



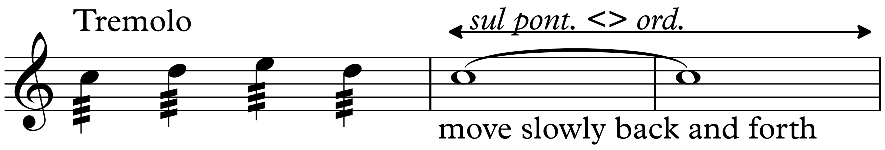
gliss.

continuous pitch glide between notes



Tremolo

sul pont. <> *ord.*



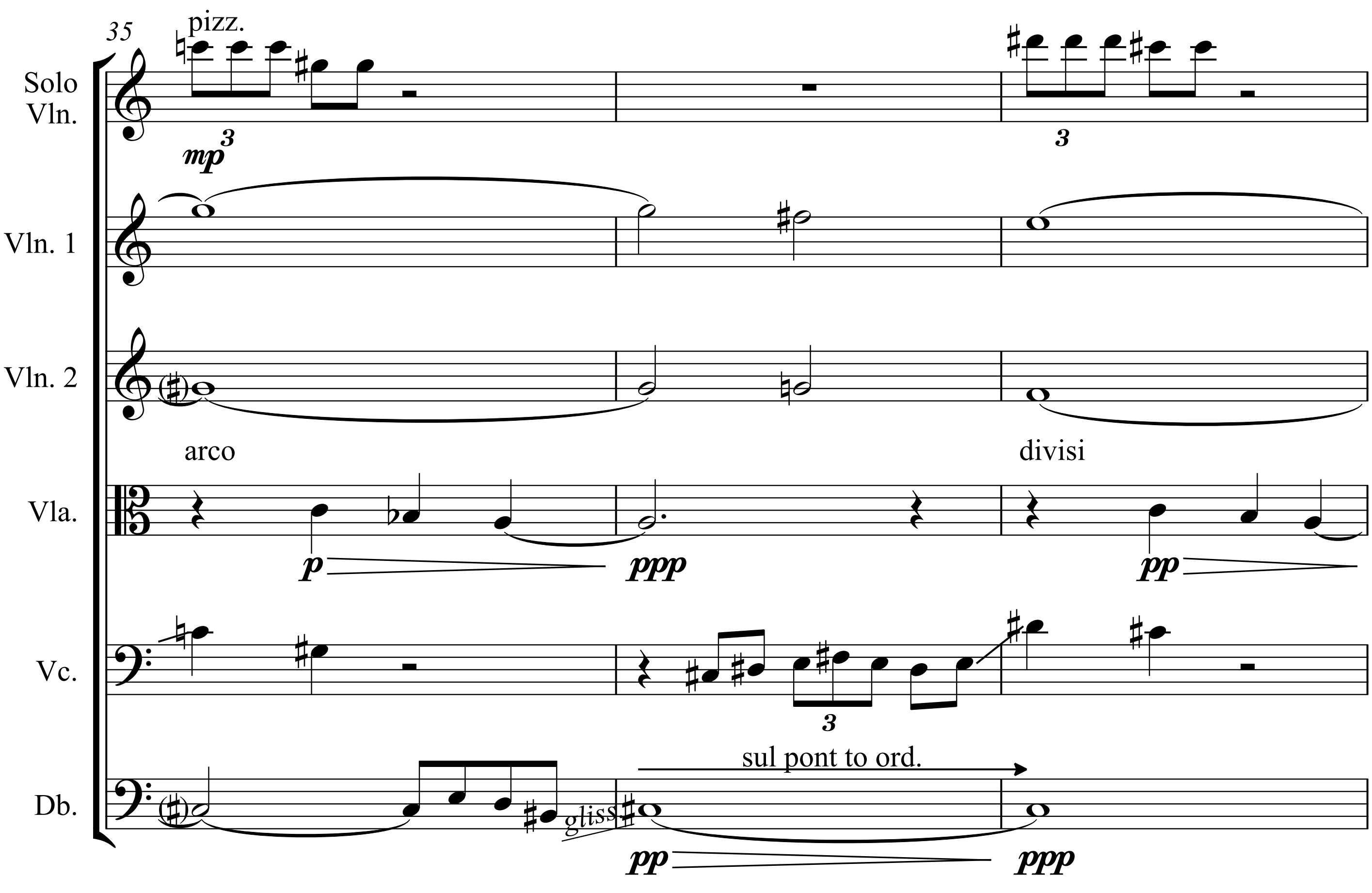
move slowly back and forth between *sul pont.* and *ordinario*

Like a Square Peg

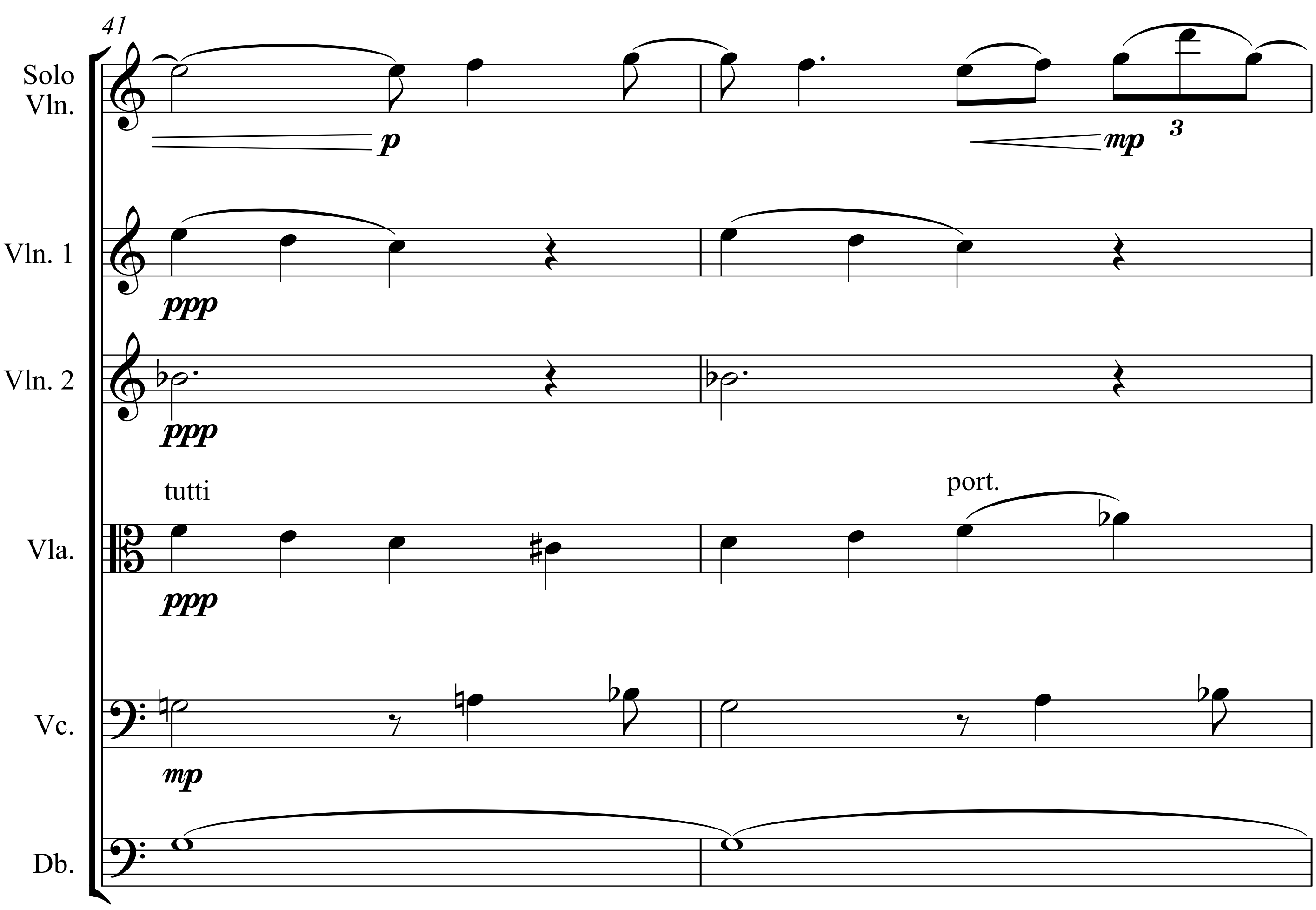
Matthew C. Lane


18
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
ppp
pp
23
sotto voce
subito p
pizz.
f
27
p
mp


31
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
A.H.
sonoro
fp
pp
ppp
p
arco
pizz.
f
sul pont to ord.
gliss.


35
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
pizz.
mp
arco
divisi
p
ppp
pp
sul pont to ord.
gliss.


38
Solo Vln.
gl.
arco
mp
3
ff
mp
pp
Vln. 1
Vln. 2
pp
ppp
pp
ppp
Vla.
ppp
pp
ppp
pp
ppp
Vc.
gl.
3
3
ff
Db.
3


41
Solo Vln.
p
mp
3
Vln. 1
ppp
Vln. 2
ppp
tutti
port.
Vla.
ppp
Vc.
mp
Db.


43
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
port.
pizz.
divisi
sul pont.
46
sul pont.
port.
port.
port.
port.

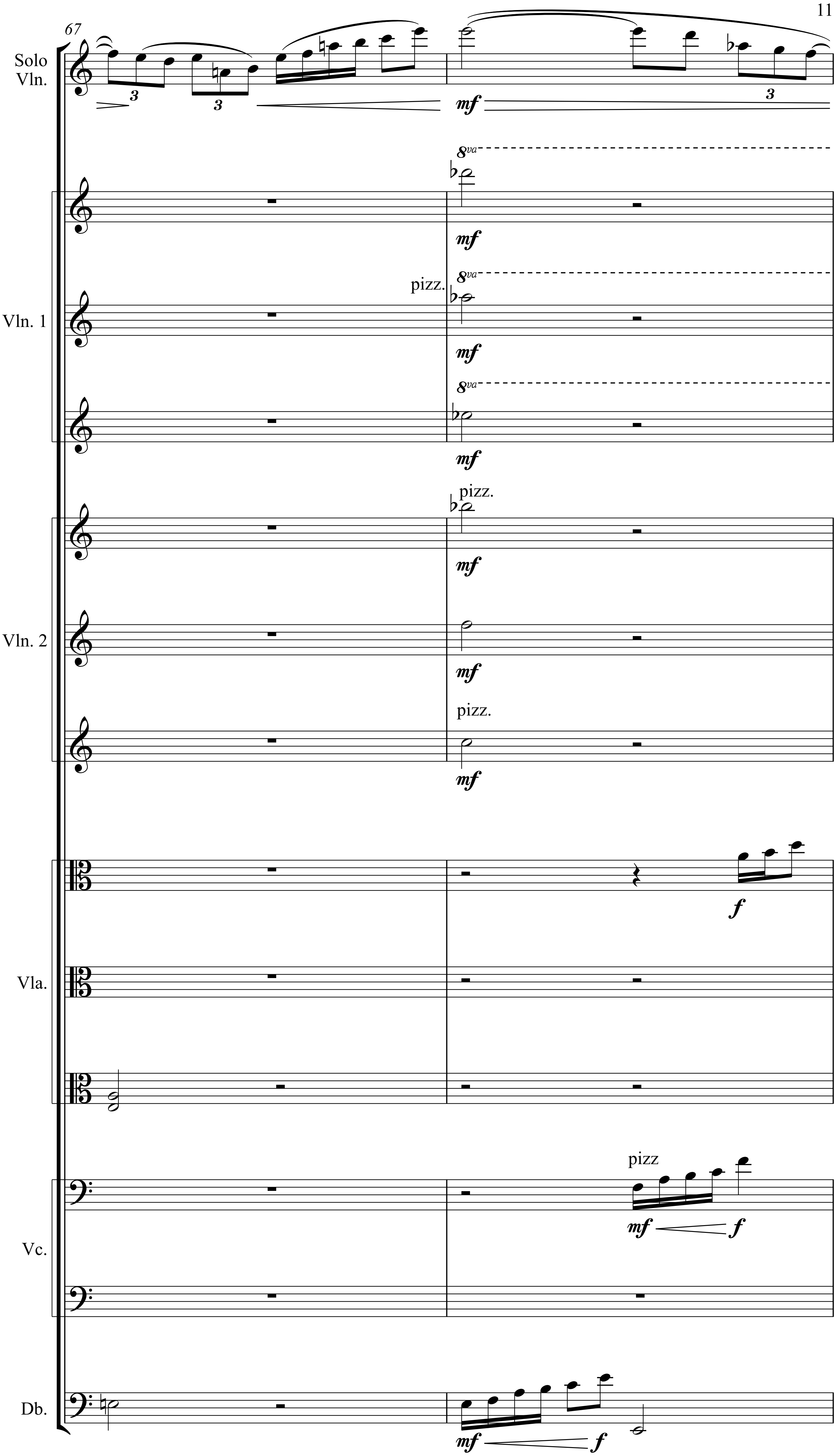

49
Solo Vln.
divisi 3
Vln. 1
8va
sul pont. <> ord.
ppp
pp
ppp
divisi 3
Vln. 2
mp
pizz.
Vla.
ppp
mf
ppp
f
Vc.
tutti
f
pp
f
Db.
accel.
52
Solo Vln.
sul D, sul tasto
ppp
Vln. 1
(8)
sul pont. <> ord.
sul pont. <> ord.
p
ppp
ppp
mp
Vln. 2
divisi
Vla.
f
divisi
Vc.
f
divisi
pizz.
Db.
f


55
Solo Vln.
pizz.
f
sfz
mp
sonoro
Vln. 1
(8)
sul pont. <> ord.
sul pont. <> ord.
ppp
Vln. 2
arco
mp
sul pont. <> ord.
mp
ppp
sul pont. <> ord.
mp
ppp
Vla.
divisi 3
arco
sul pont. <> ord.
mp
ppp
mp
Vc.
divisi
arco
mf
Db.
sfz
mp
sonoro

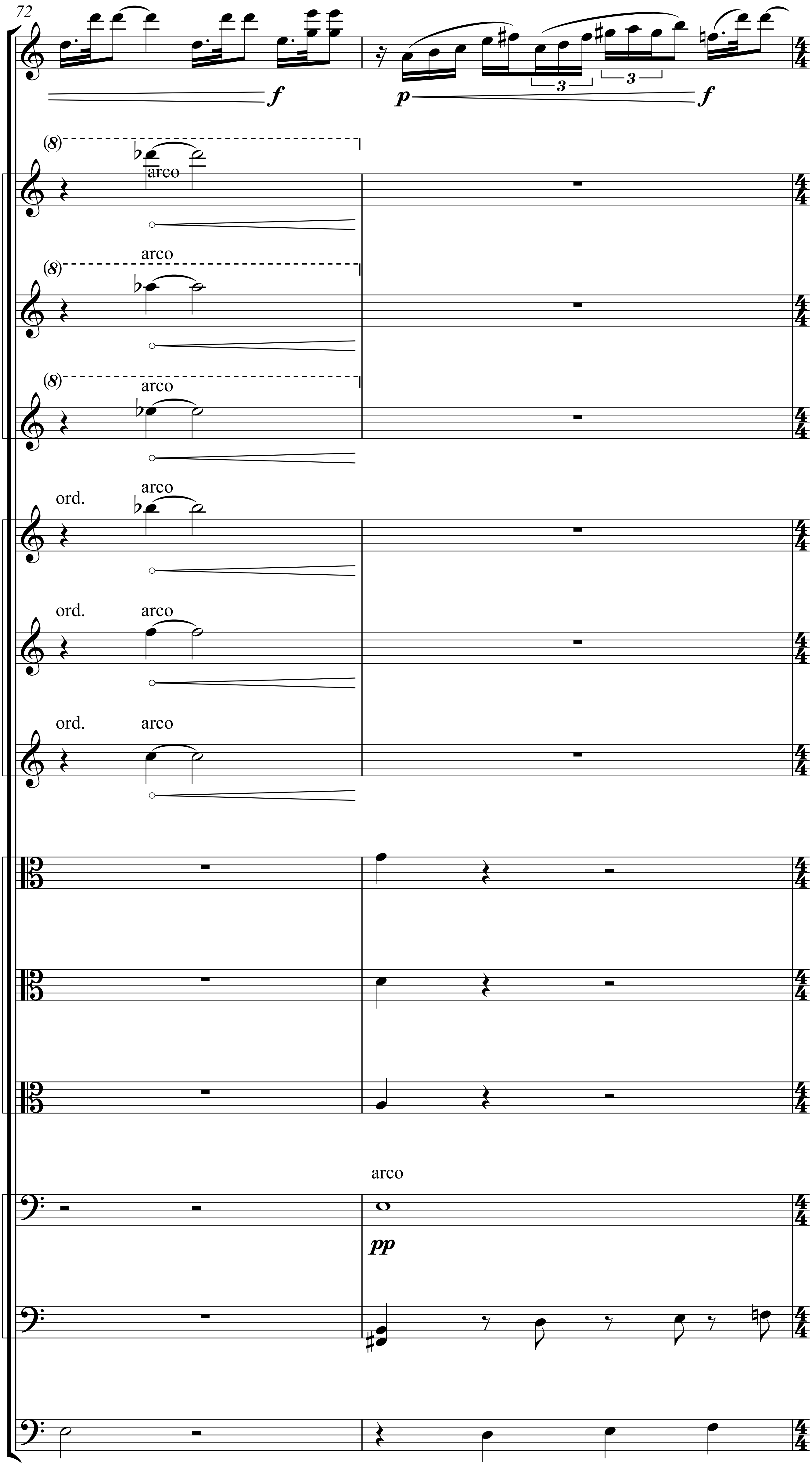

59
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
sul pont. <> ord.
(ord.)
arco
port.
8va
mp
f
mf
ppp

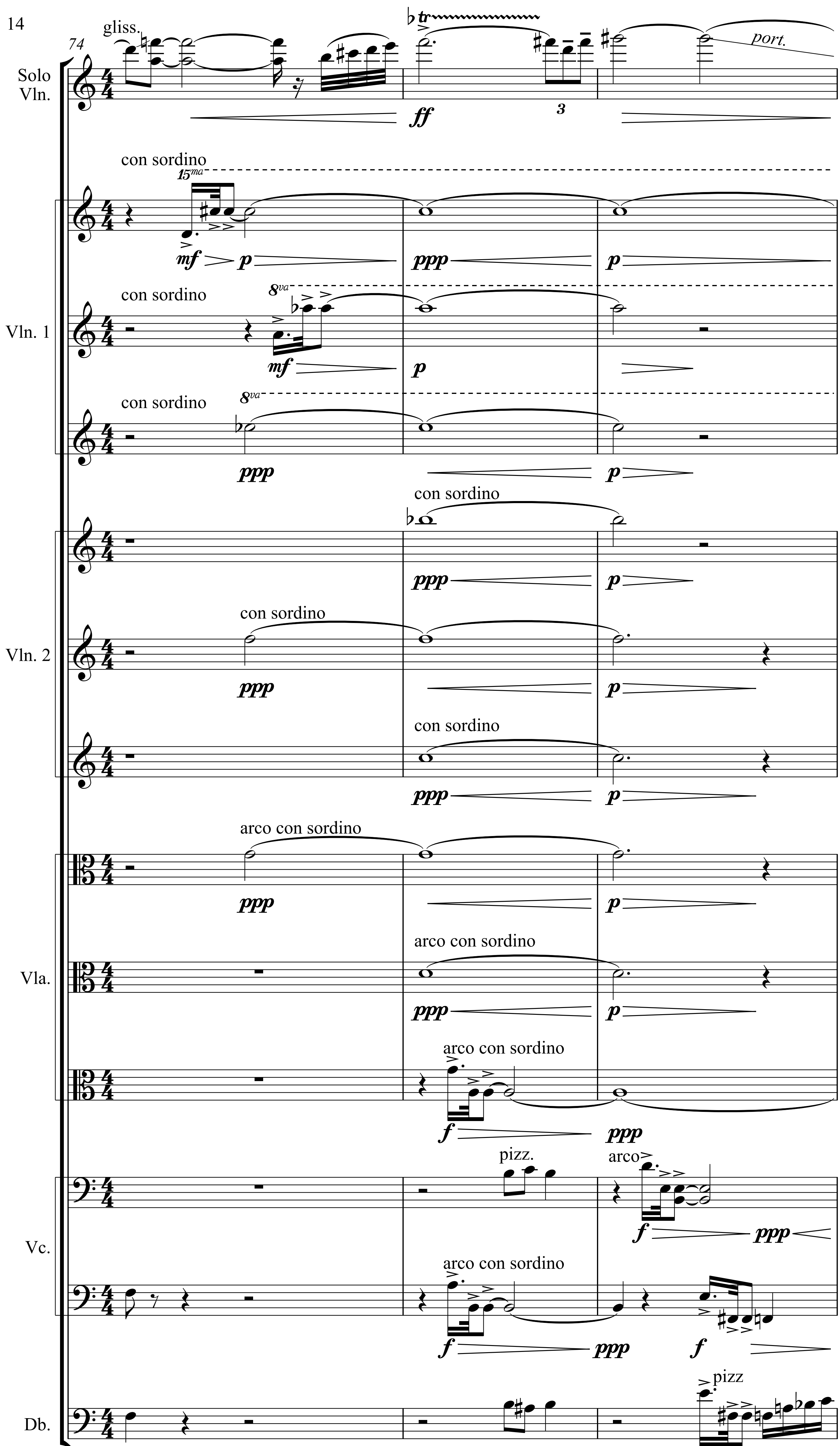

62
♩ = 54
Solo Vln.
ff
(8)
f
Vln. 1
sul pont. <> ord.
(ord.)
Vln. 2
Vla.
Vc.
ppp
Db.
arco sul pont.

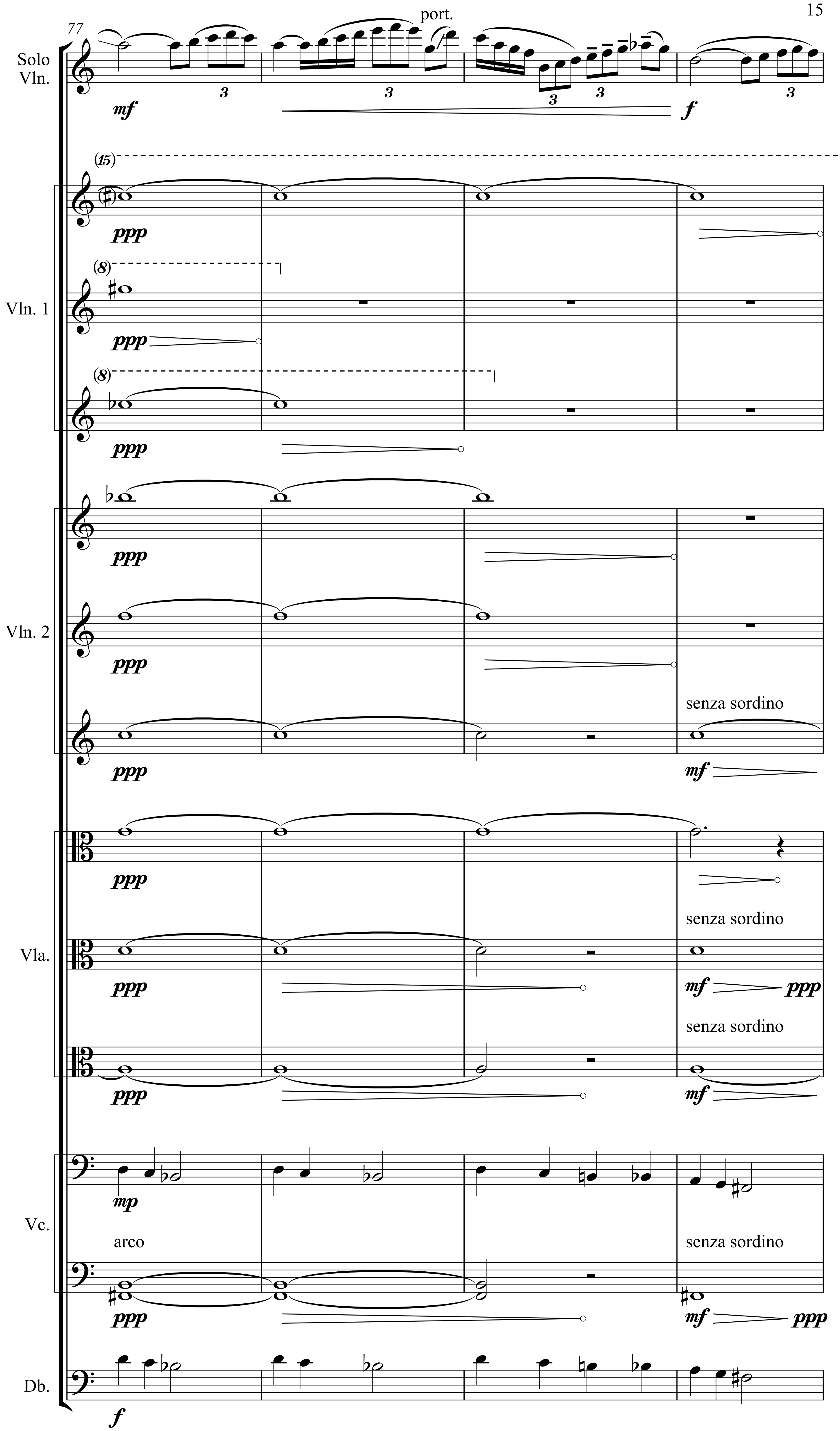

64
♩ = 60
arco
Solo Vln.
pizz.
Vln. 1
subito p
Vln. 2
Vla.
Vc.
Db.
ff
f
p
mf
pp


67
Solo Vln.
3
3
mf
3
8va
mf
Vln. 1
pizz.
8va
mf
8va
mf
pizz.
mf
Vln. 2
mf
pizz.
mf
f
Vla.
pizz
mf
f
Vc.
Db.
mf
f


69
Solo Vln.
gl.
3
p
3
3
mf
gliss.
(8)
8va
arco
Vln. 1
Vln. 2
Vla.
f
pizz.
Vc.
Db.

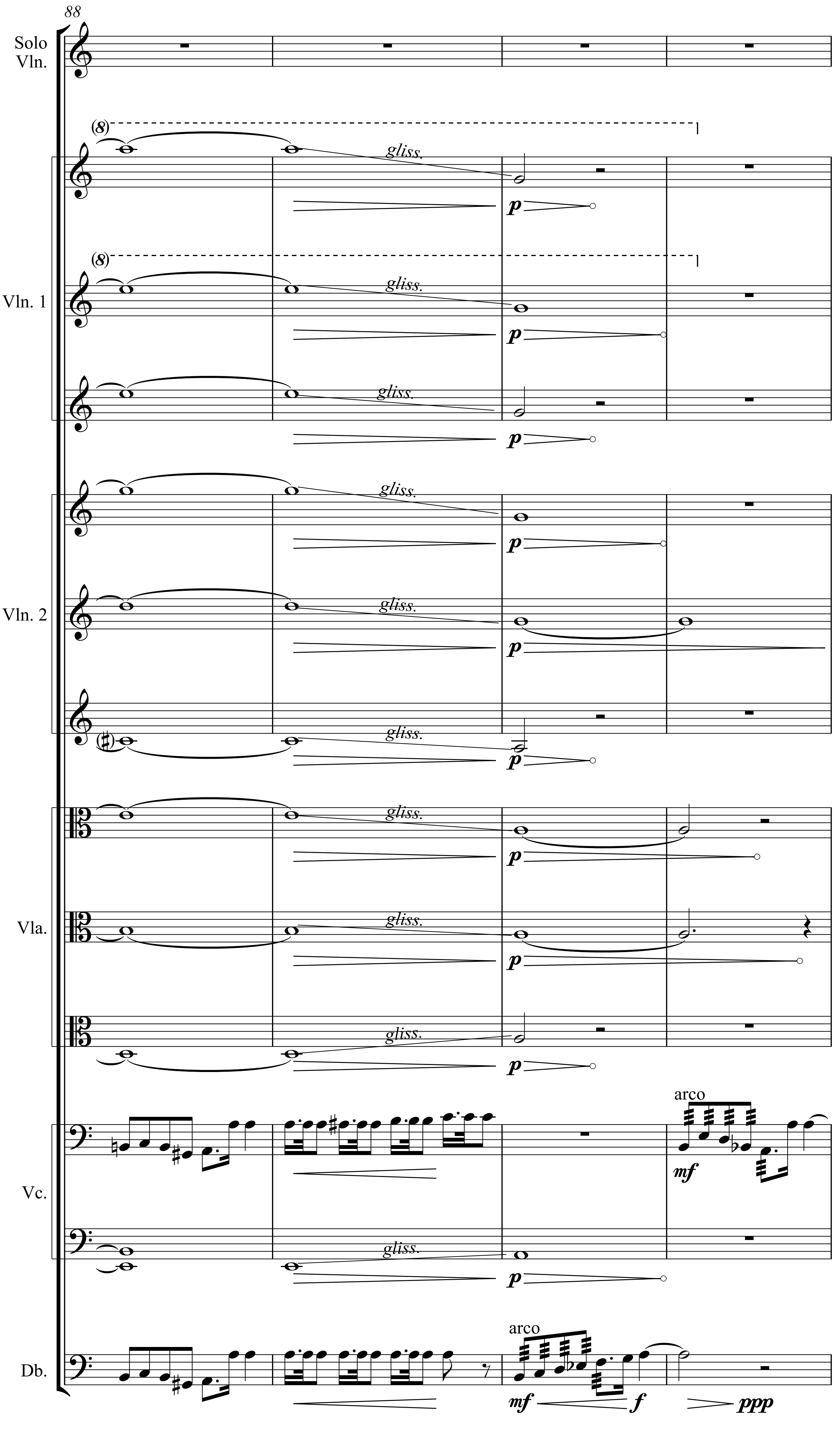

72
Solo Vln.
f
p
f
(8)
arco
Vln. 1
ord.
Vln. 2
Vla.
Vc.
pp
Db.

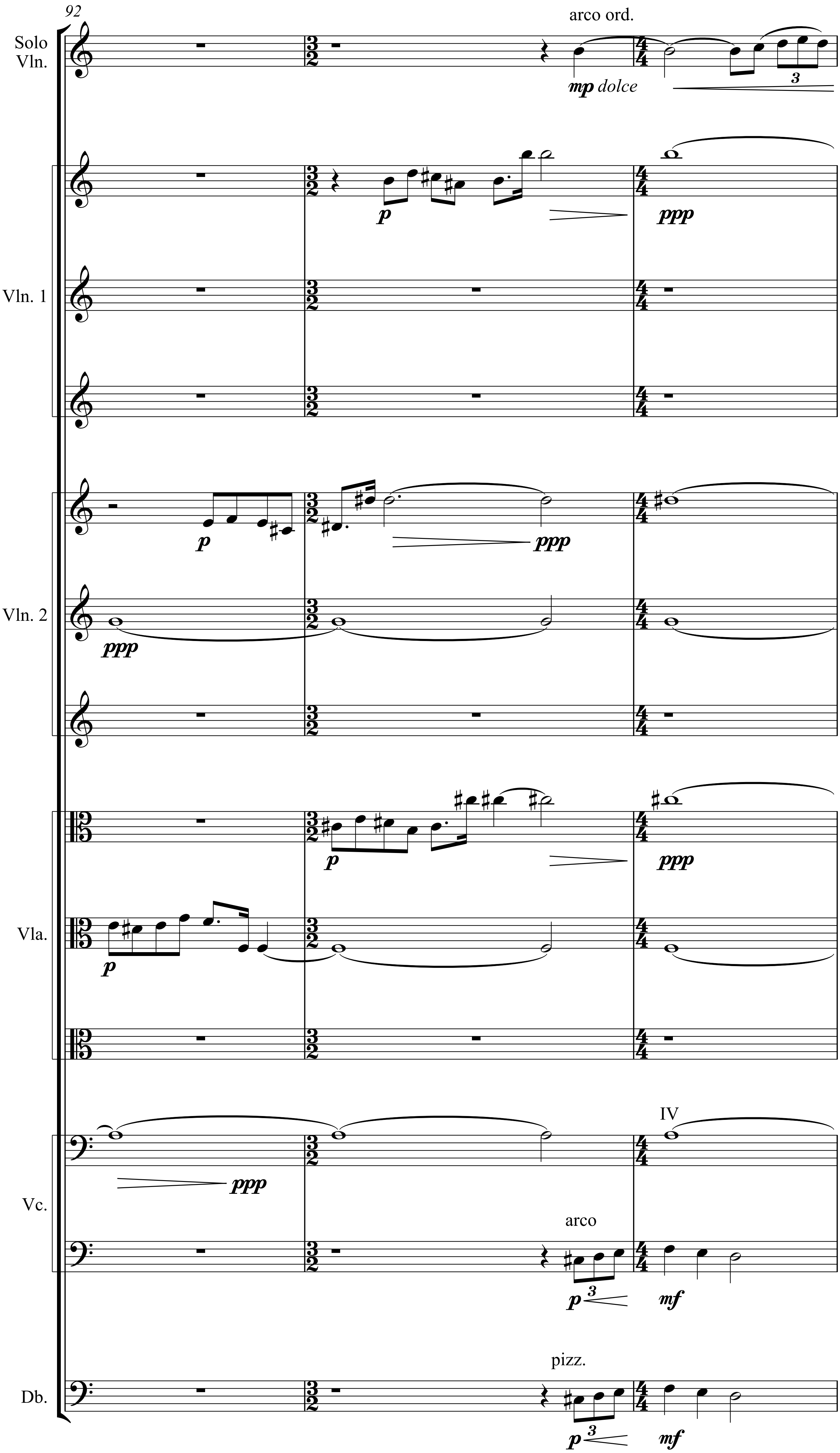

74
gliss.
tr
port.
Solo Vln.
ff
3
con sordino
15ma
mf
p
ppp
8va
Vln. 1
Vln. 2
arco con sordino
Vla.
f
pizz.
arco
Vc.
pizz
Db.

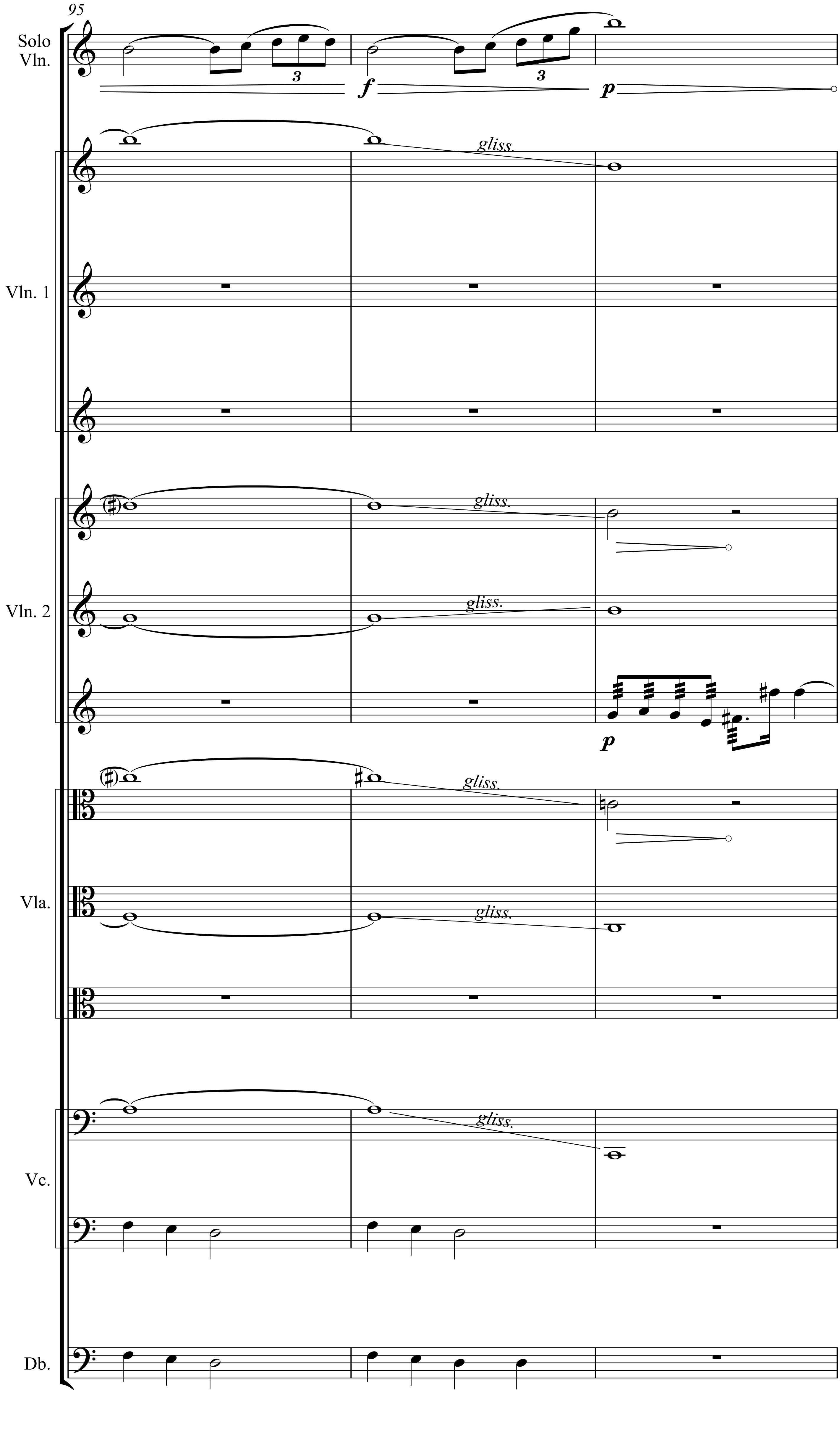

77
Solo Vln.
port.
mf
f
(15)
(8)
Vln. 1
ppp
Vln. 2
senza sordino
mf
Vla.
senza sordino
senza sordino
Vc.
mp
arco
senza sordino
Db.
f


81
port.
Solo Vln.
senza sordino
Vln. 1
Vln. 2
Vla.
Vc.
Db.
ppp
mf

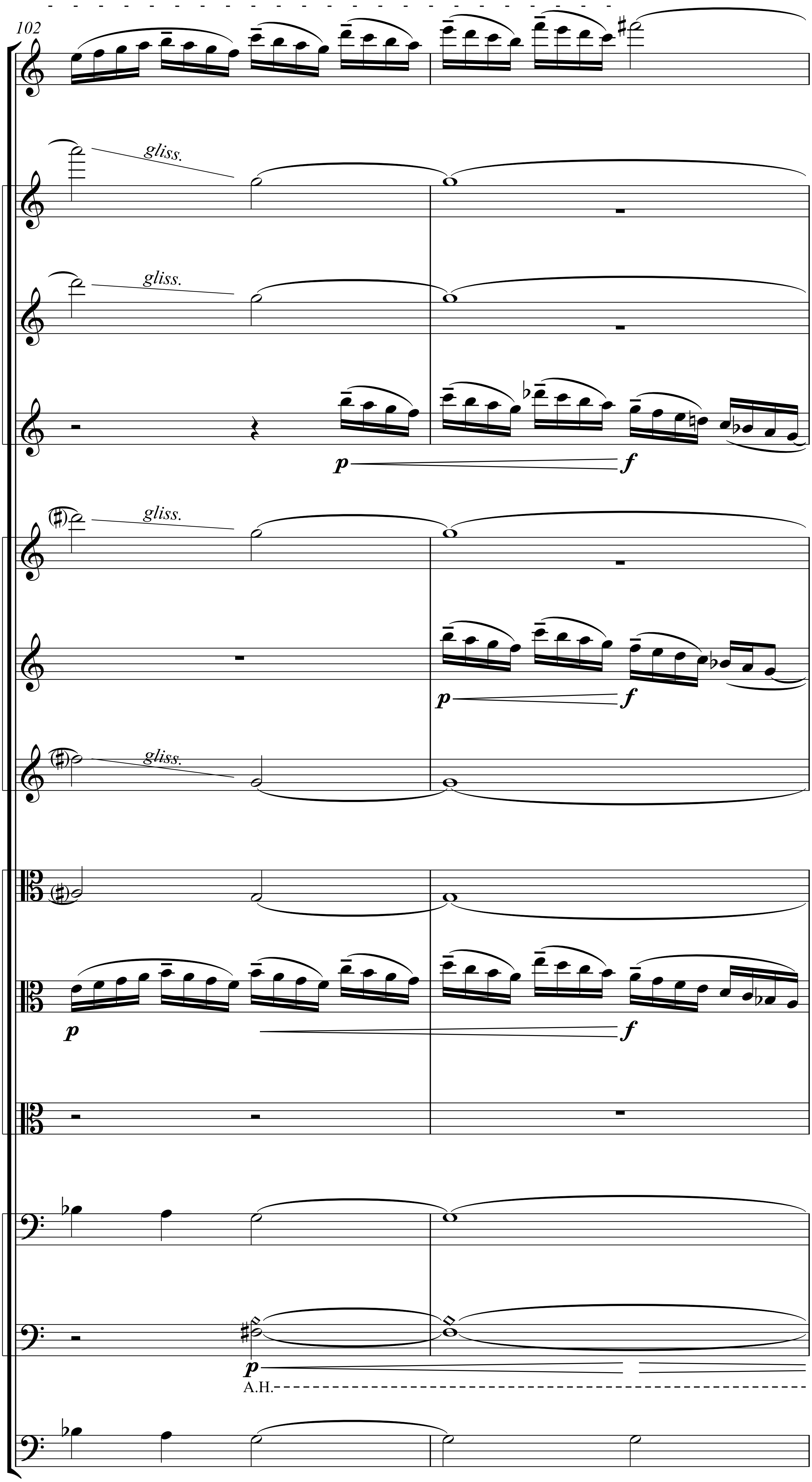

84
Solo Vln.
pizz. sonore
Vln. 1
Vln. 2
Vla.
pizz.
Vc.
arco
pizz.
Db.


88
Solo Vln.
(8)
gliss.
p
Vln. 1
Vln. 2
Vla.
Vc.
arco
mf
Db.
f
ppp


92
Solo Vln.
arco ord.
mp dolce
3
p
ppp
Vln. 1
p
ppp
ppp
Vln. 2
p
ppp
p
Vla.
ppp
IV
Vc.
arco
p 3
mf
pizz.
Db.
p 3
mf

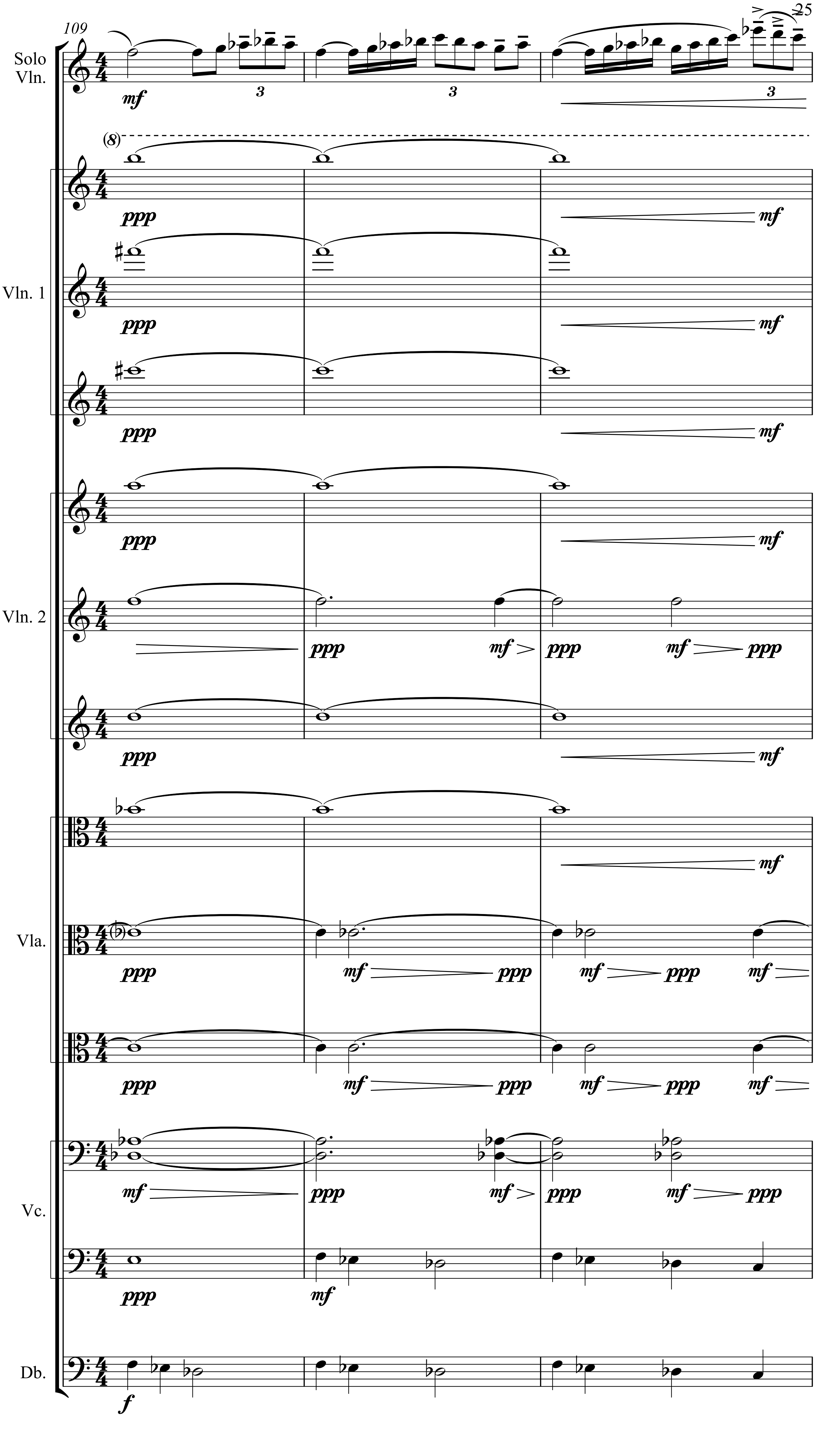

95
Solo Vln.
f
p
gliss.
Vln. 1
gliss.
gliss.
Vln. 2
p
gliss.
Vla.
gliss.
gliss.
Vc.
Db.


98
poco accel.
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.


102
Solo Vln.
gliss.
gliss.
Vln. 1
p
f
gliss.
Vln. 2
p
f
gliss.
Vla.
p
f
Vc.
p
A.H.
Db.


rit.
104
♩ = 60
Solo Vln.
Vln. 1
Vln. 2
Vla.
pizz.
arco
Vc.
A.H.
Db.


107
Solo Vln.
port.
f
8va
p
Vln. 1
p
p
ppp
Vln. 2
ppp
mf
3
ppp
mf
ppp
Vla.
ppp
sfz
ff
ppp
sfz
ff
p
mf
ppp
Vc.
p
mf
ppp
Db.
mp


109
Solo Vln.
mf
3
3
3
(8)
ppp
mf
Vln. 1
ppp
mf
ppp
mf
ppp
mf
Vln. 2
ppp
mf
ppp
mf
ppp
ppp
mf
mf
Vla.
ppp
mf
ppp
mf
ppp
mf
ppp
mf
ppp
mf
ppp
mf
Vc.
mf
ppp
mf
ppp
mf
ppp
ppp
mf
Db.
f


accel.
112
port.
Solo Vln.
(8)
sul pont.
Vln. 1
sul pont.
Vln. 2
sul pont.
Vla.
Vc.
Db.


114
♩ = 68
Solo Vln.
ff
(8)
Vln. 1
sul pont.
ppp
Vln. 2
sul pont.
ppp
mf
ppp
sul pont.
ppp
Vla.
ppp
mf
ppp
mf
Vc.
mf
ppp
Db.


117
Solo Vln.
sfz
sul A
p
(8)
Vln. 1
f
sfz
subito mp
p
mf
Vln. 2
Vla.
pizz
Vc.
Db.


122
Solo Vln.
pp
mp
ord.
Vln. 1
p
ppp
Vln. 2
arco ord.
Vla.
Vc.
Db.
pp
3


126
Solo Vln.
gliss.
tutti
Vln. 1
tutti
Vln. 2
tutti
Vla.
tutti
Vc.
sul pont.
Db.


129
Scherzo feeling
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
p sotto voce espressivo
p
131
3
133
espressivo
mp
arco
divisi.
pp
ord.
mf


135
Vln. 1
Vln. 2
Vla.
Vc.
Db.
137
Solo Vln.
mp
ppp
139
divisi.
pp
f
ord.

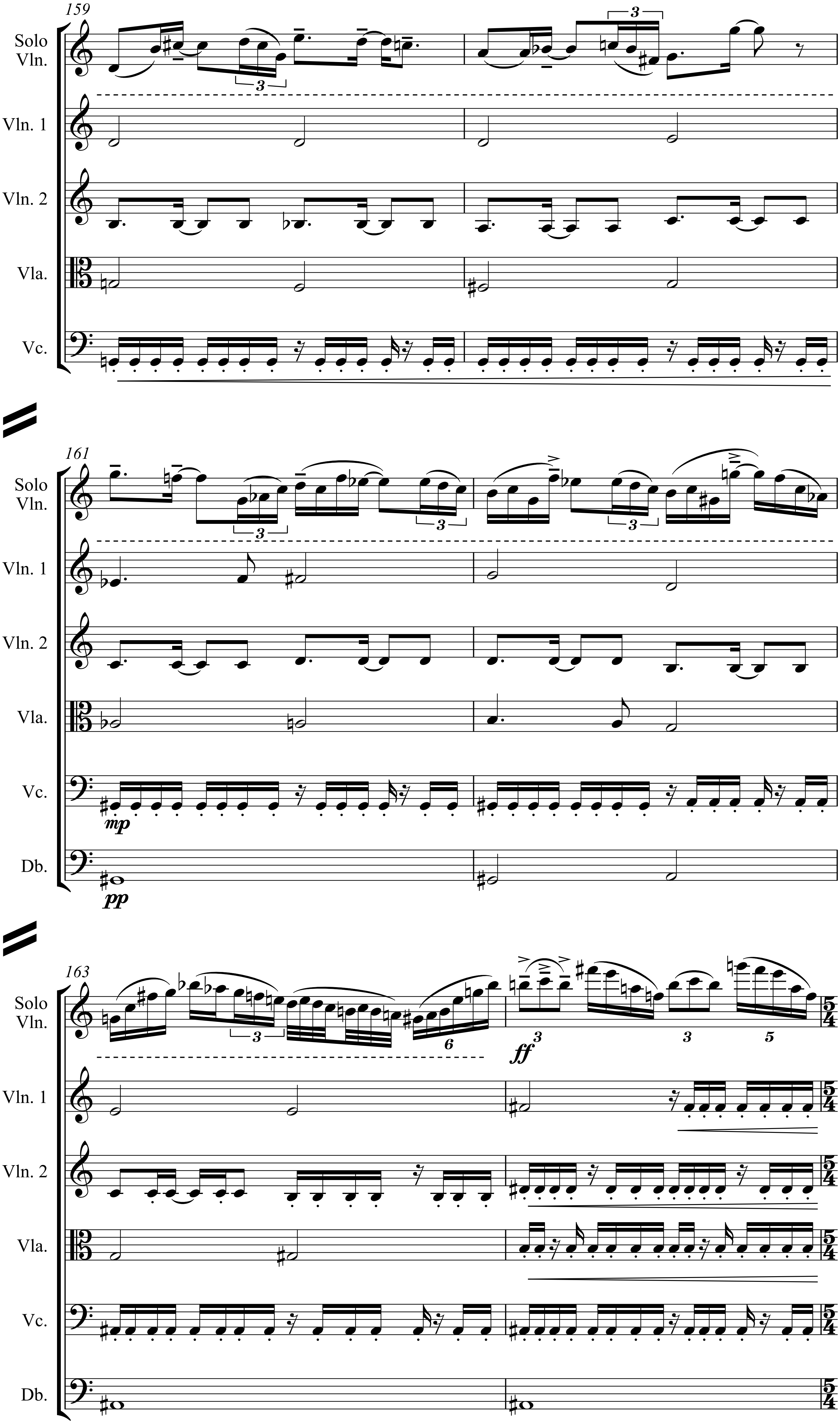

141
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
ord.
Db.
143
Vln. 1
Vln. 2
Vla.
Vc.
Db.


145
Solo Vln.
port.
f
pp
3
Vln. 1
f
pp
p
Vln. 2
f
pp
p
Vla.
tutti
sul pont.
Vc.
f
ppp
Db.


147
port.
Solo Vln.
Vln. 1
Vln. 2
divisi
Vla.
divisi
Vc.
Db.
f
pp
149
Solo Vln.
Vln. 1
Vln. 2
Vla.
pizz.
Vc.
Db.
pp
sfz
3
3
p
f


151
Solo Vln.
Vln. 1
pp
A.H.
Vln. 2
pp
pizz.
Vla.
f
ff
Vc.
ff
Db.
p
f
153
Solo Vln.
port.
p
no vib.
Vln. 1
ppp
f
A.H.
no vib.
Vln. 2
ppp
f
Vla.
mp
f
arco
Vc.
ppp
p
f
3
Db.
p


A
155
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
mf
ppp
port.
ppp
f
ppp
f
f
p
f
3
157
Solo Vln.
3
mp
Cresc
3
ord.
Vln. 1
pp
ord.
Vln. 2
pp
arco
Vla.
pp
Vc.
p
Db.


159
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
161
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
mp
Db.
pp
163
Solo Vln.
ff
Vln. 1
Vln. 2
Vla.
Vc.
Db.


165
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
repeat, speeding up
fff
f
free, portamento where slurred
167
p
col legno battuto
pp
ppp
169
mp
col legno battuto
pp
p
col legno battuto
mp
f


171
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
port.
subito mf
3


173
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
3

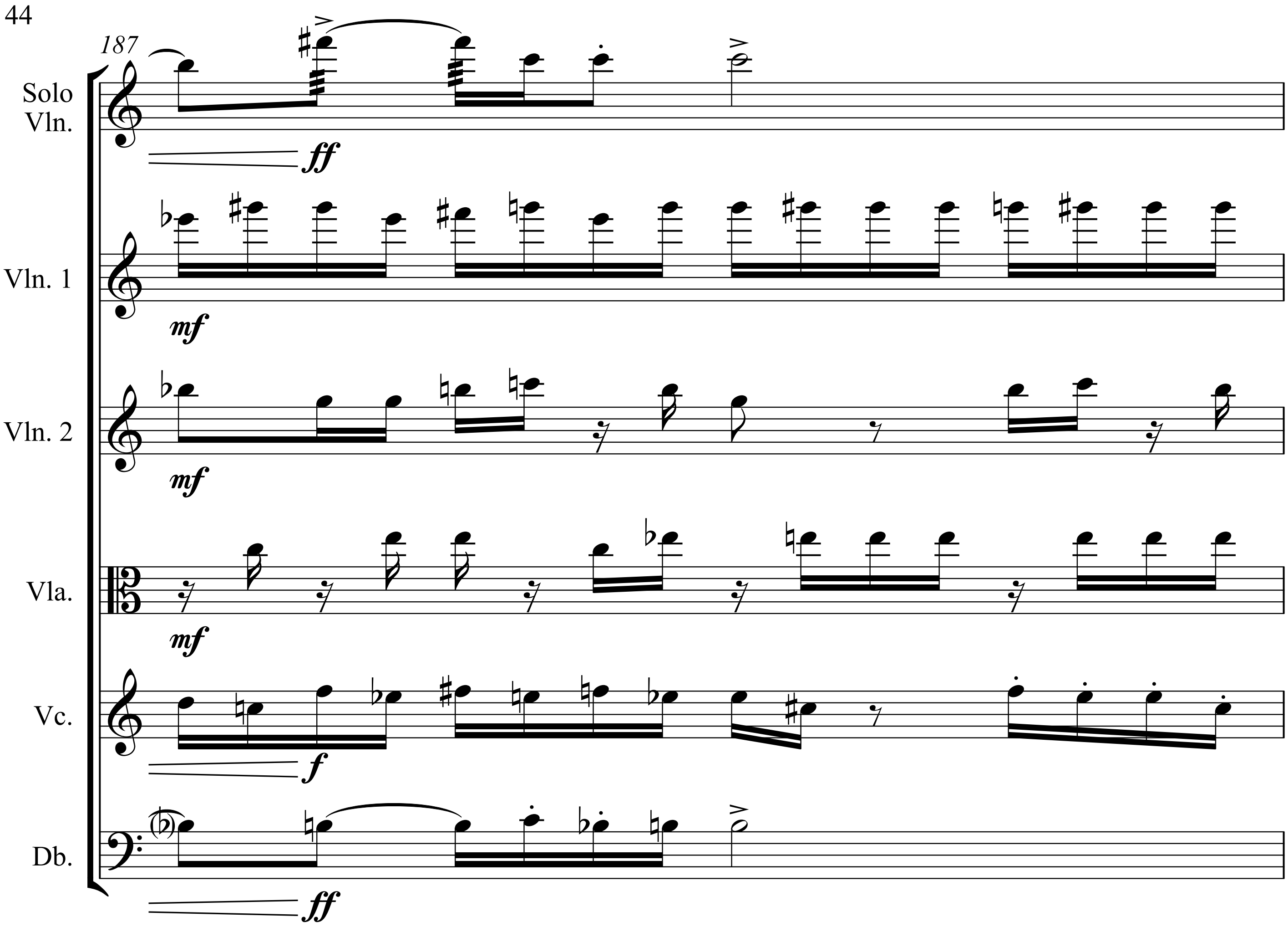

175
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
mp
f
p
f
p
f
p
f
p
f
f
3

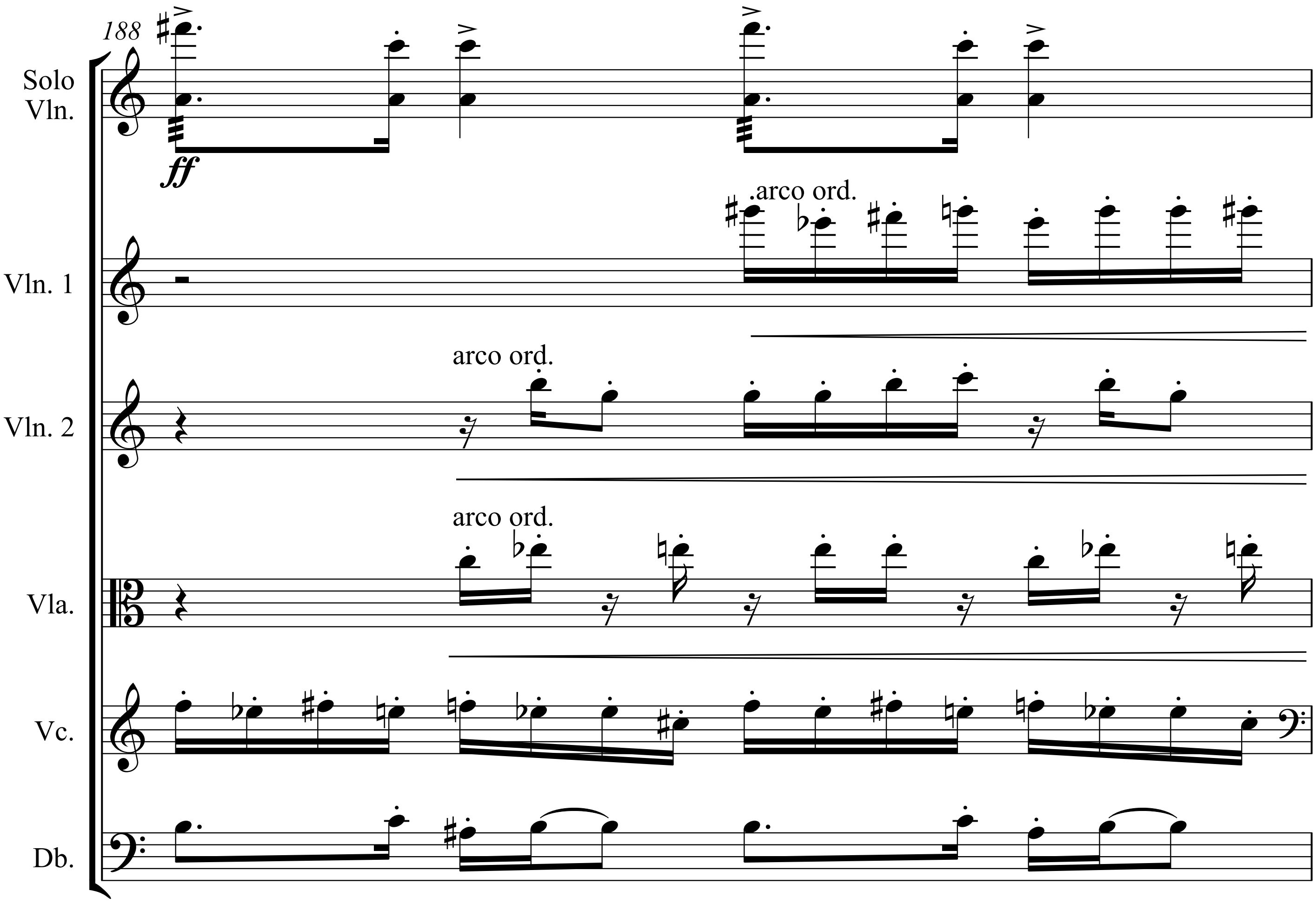

177
port.
port.
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
3
mp
p
p
p
p
p
p
p
p
p


179
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
port.
mf
mp
ord.
mp
181
ord.
mf
mf
183

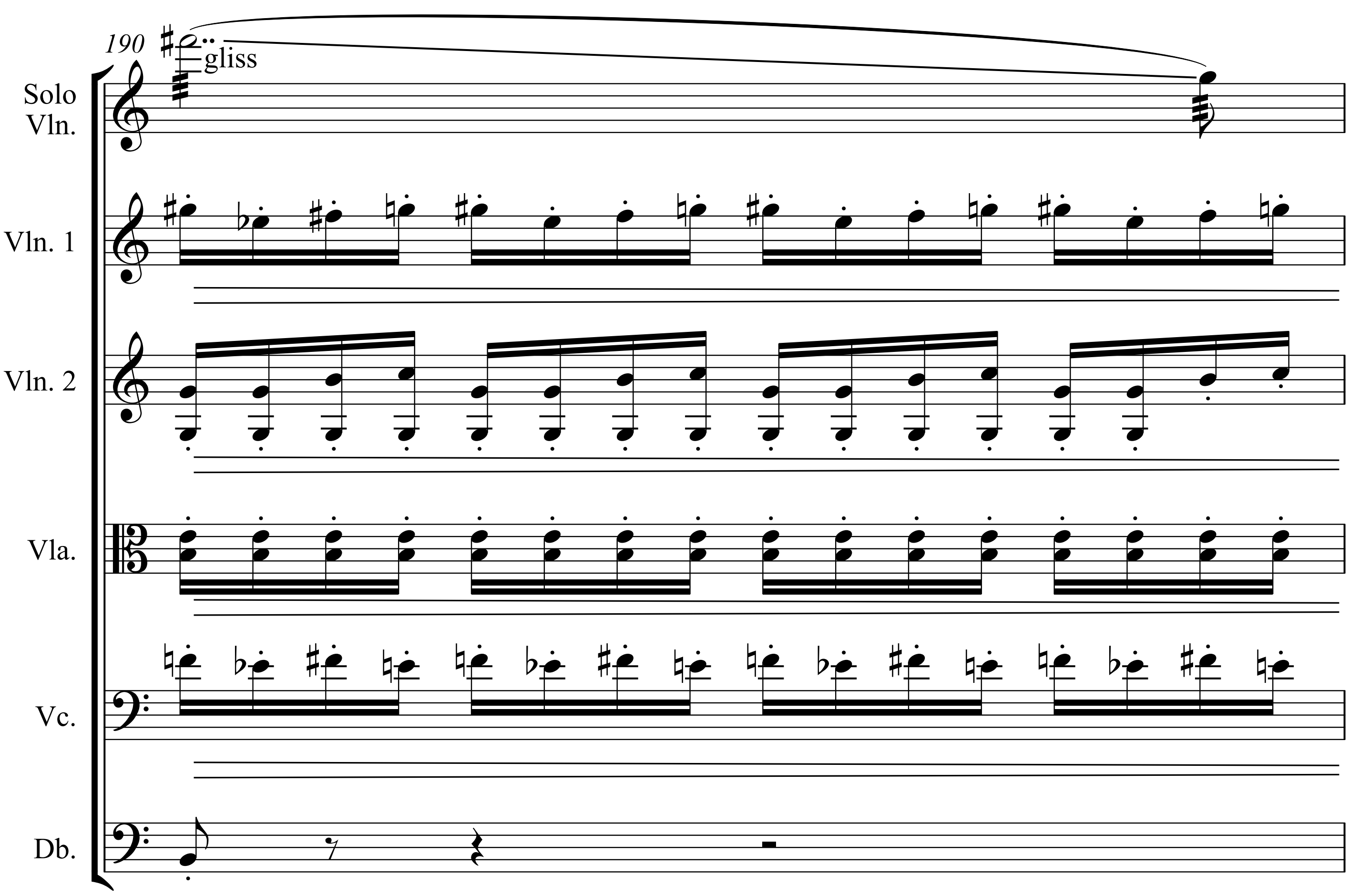

185
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.


186
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.


187
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
ff
mf
mf
mf
f
ff


188
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
ff
arco ord.
arco ord.
arco ord.


189
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.

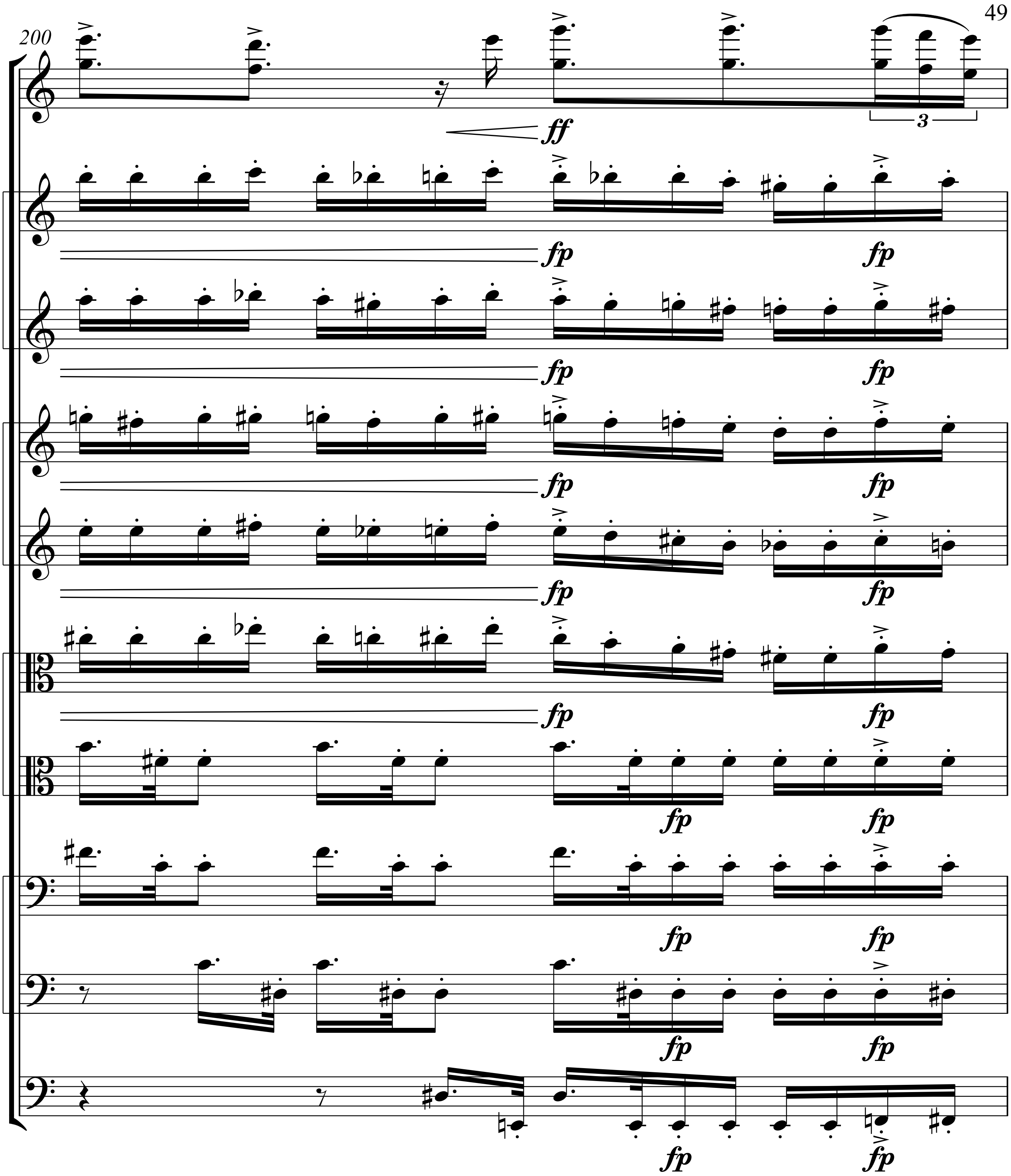

190
gliss
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.


rall.
191
gliss.
gliss.
Solo Vln.
Vln. 1
pp
Vln. 2
pp
ppp
col legno battuto
Vla.
pp
ppp
Vc.
pp
Db.
pppp
pp


193
♩ = 48
Solo Vln.
pp dolce
3
f possible
Vln. 1
pp
f possible
Vln. 2
pp
f possible
ord.
non-vib.
Vla.
pp
ppp
f possible
Vc.
pp
f possible
Db.
f possible


196
♩ = 68
Solo Vln.
f
ff
Vln. 1
mf
fp
p
fp
Vln. 2
p
fp
p
fp
Vla.
mp
fp
p
f
ff
Vc.
p
f
ff
mp
f
ff
Db.
p
f
ff


198
Solo Vln.
mp
f
Vln. 1
Vln. 2
Vla.
Vc.
Db.


200
Solo Vln.
ff
3
Vln. 1
fp
fp
fp
fp
Vln. 2
fp
fp
fp
fp
Vla.
fp
fp
fp
fp
Vc.
fp
fp
fp
fp
Db.
fp
fp


201
Solo Vln.
p sotto voce
3
Vln. 1
pizz.
ff
p
pizz.
ff
p
Vln. 2
pizz.
ff
p
ff
Vla.
ff
ff
Vc.
ff
ff
Db.
pizz.
ff
p


204
Solo Vln.
Vln. 1
Vln. 2
Vla.
Vc.
Db.
arco
col legno battuto
pizz.
arco ord.
arco.
206
pizz.
sonoro

Appendix B: Compositions (Part 3)

Never a Moment Lost

Ruminations on the Season (selections)

Interlude I

Interlude 4

Interlude 6

Interlude 11

Interlude 12

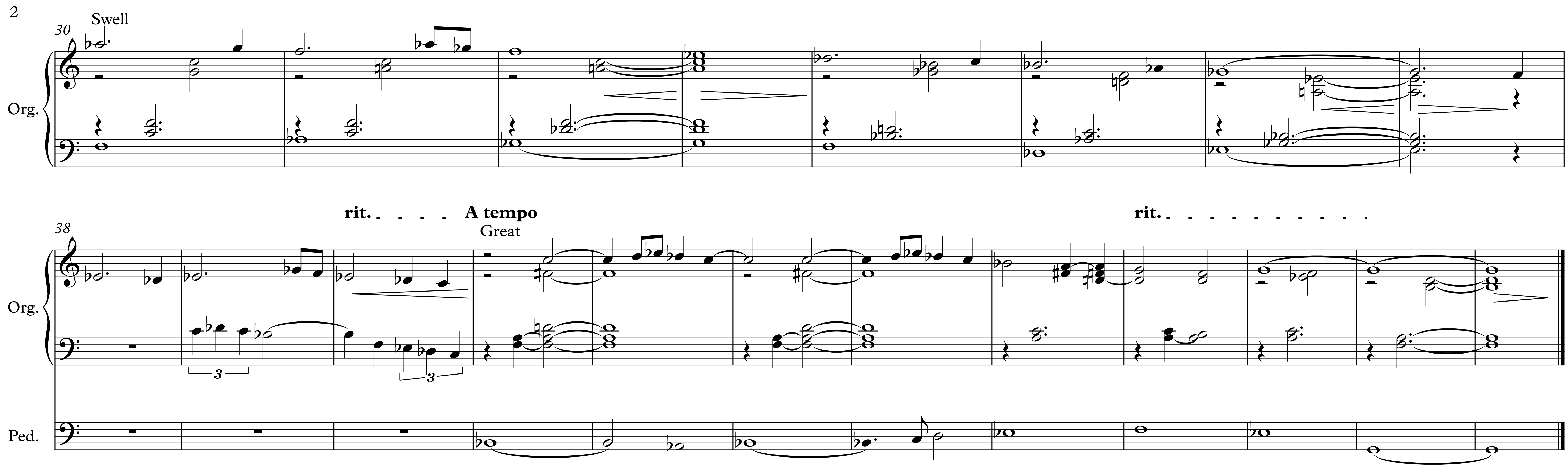
Världen och Jag

Interlude 1

Matthew Lane

Interlude 4

Matthew Lane


Swell
30
Org.
38
rit.
A tempo
Great
rit.
Org.
Ped.
3
3

Interlude 6

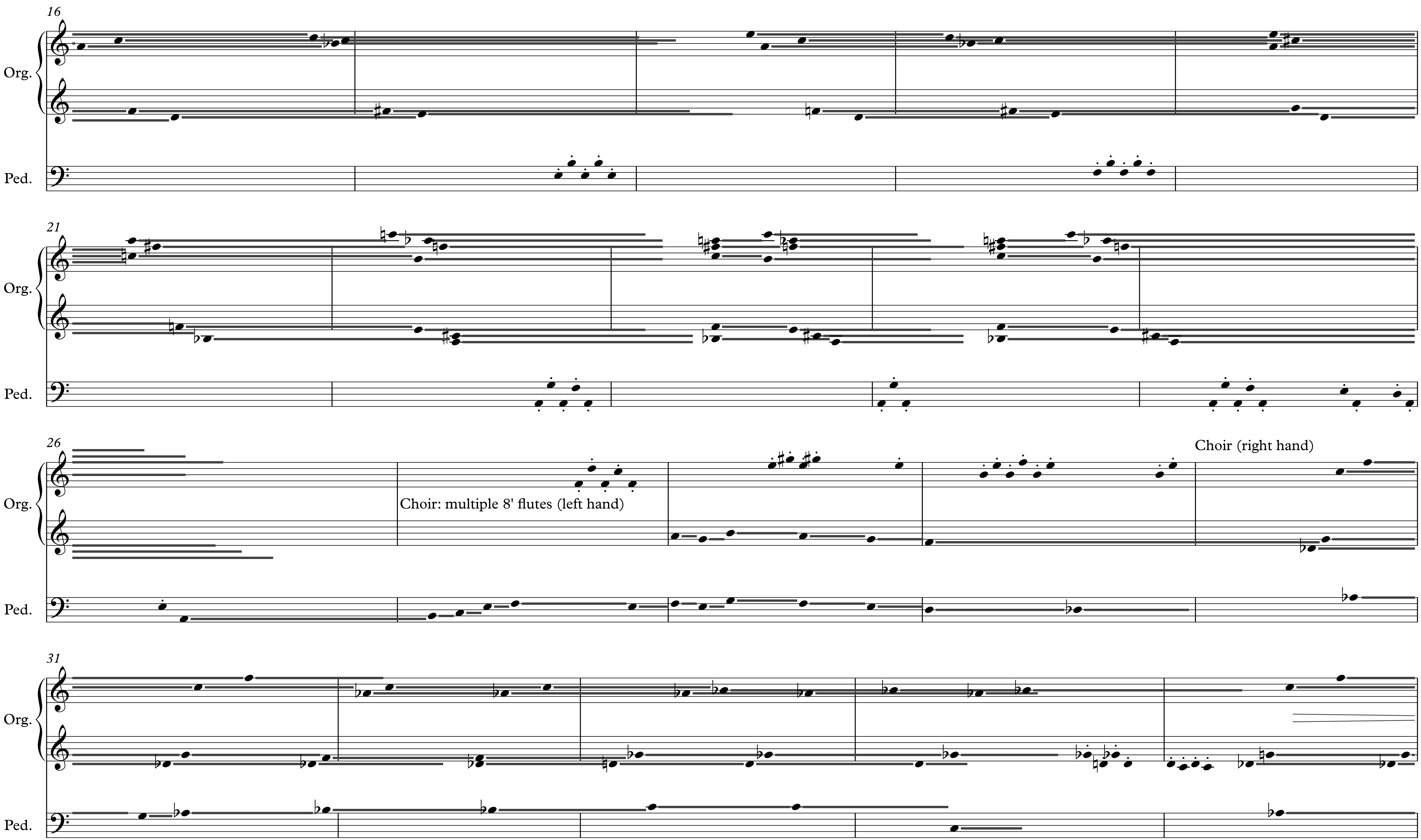
Matthew Lane


rit.
A tempo
Org.
Ped.
Org.
Ped.
Org.
Ped.
Org.
Ped.


47
Org.
Ped.
53
Org.
Ped.
62
Org.
Ped.
66
Org.
Ped.

Interlude 11

Matthew Lane

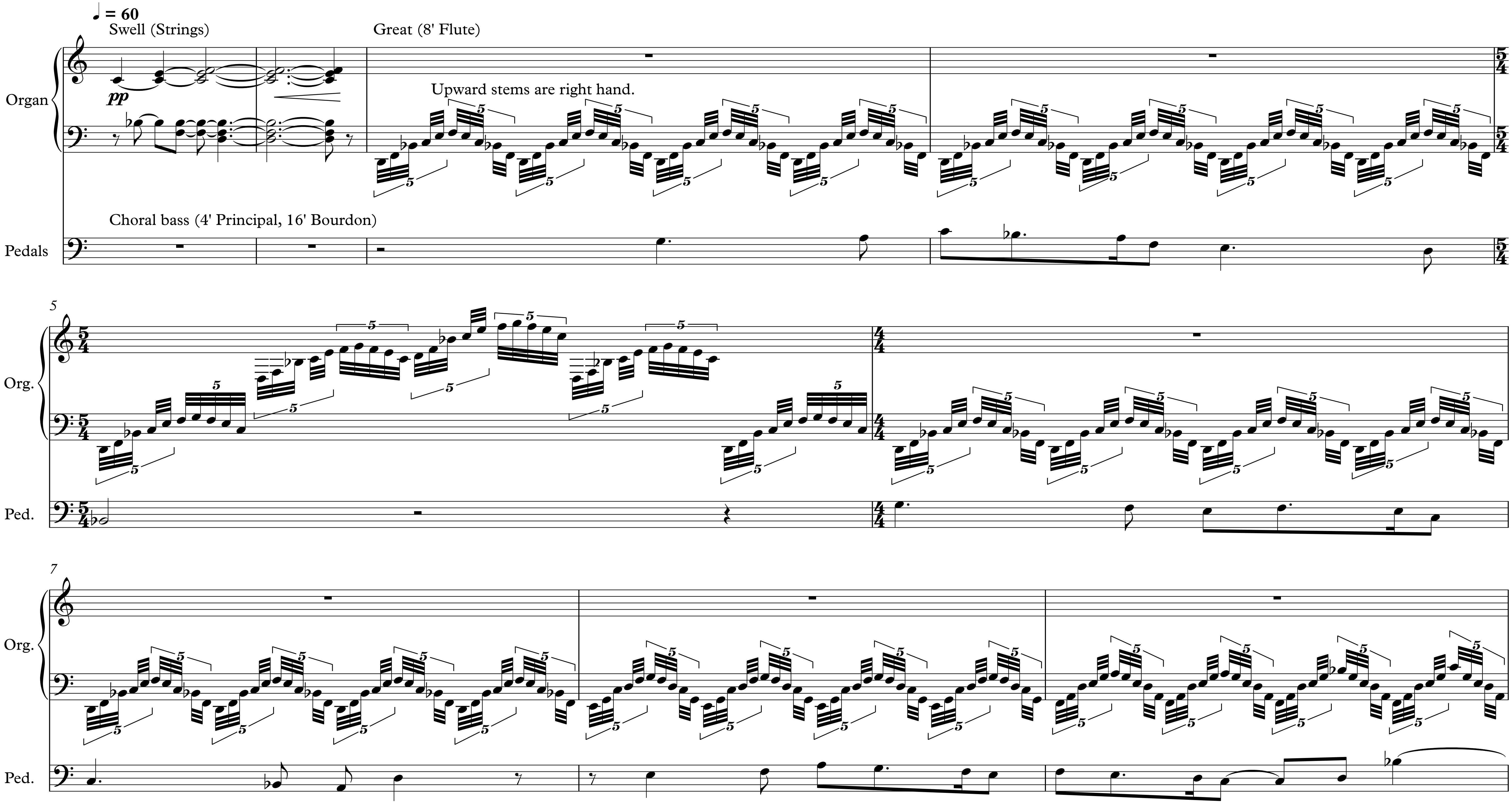

16
Org.
Ped.
21
Org.
Ped.
26
Org.
Choir: multiple 8' flutes (left hand)
Choir (right hand)
Ped.
31
Org.
Ped.

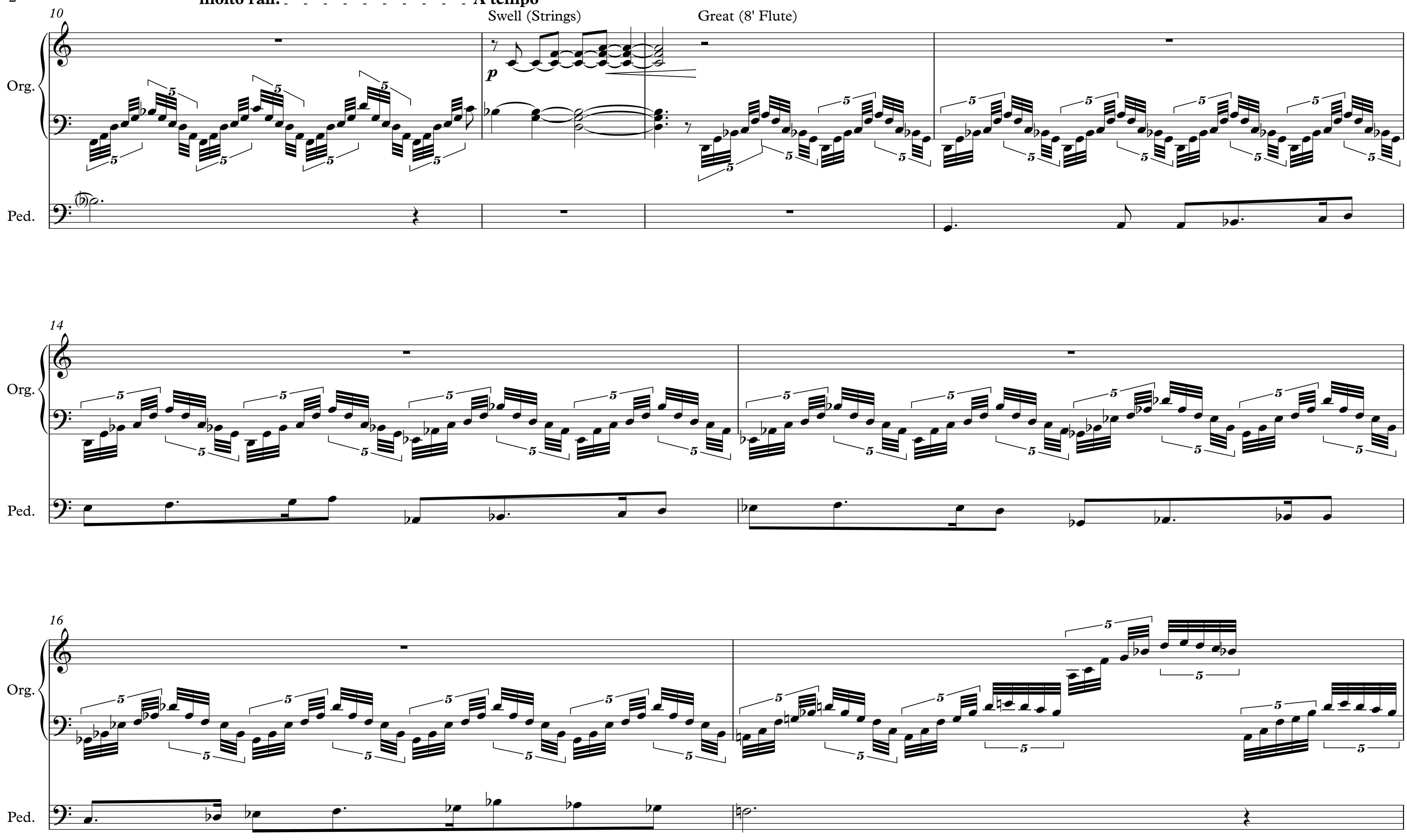

36
Org.
Ped.
41
Org.
Ped.
46
Swell (both hands)
Box closed
Org.
Ped.
52
Org.
Ped.

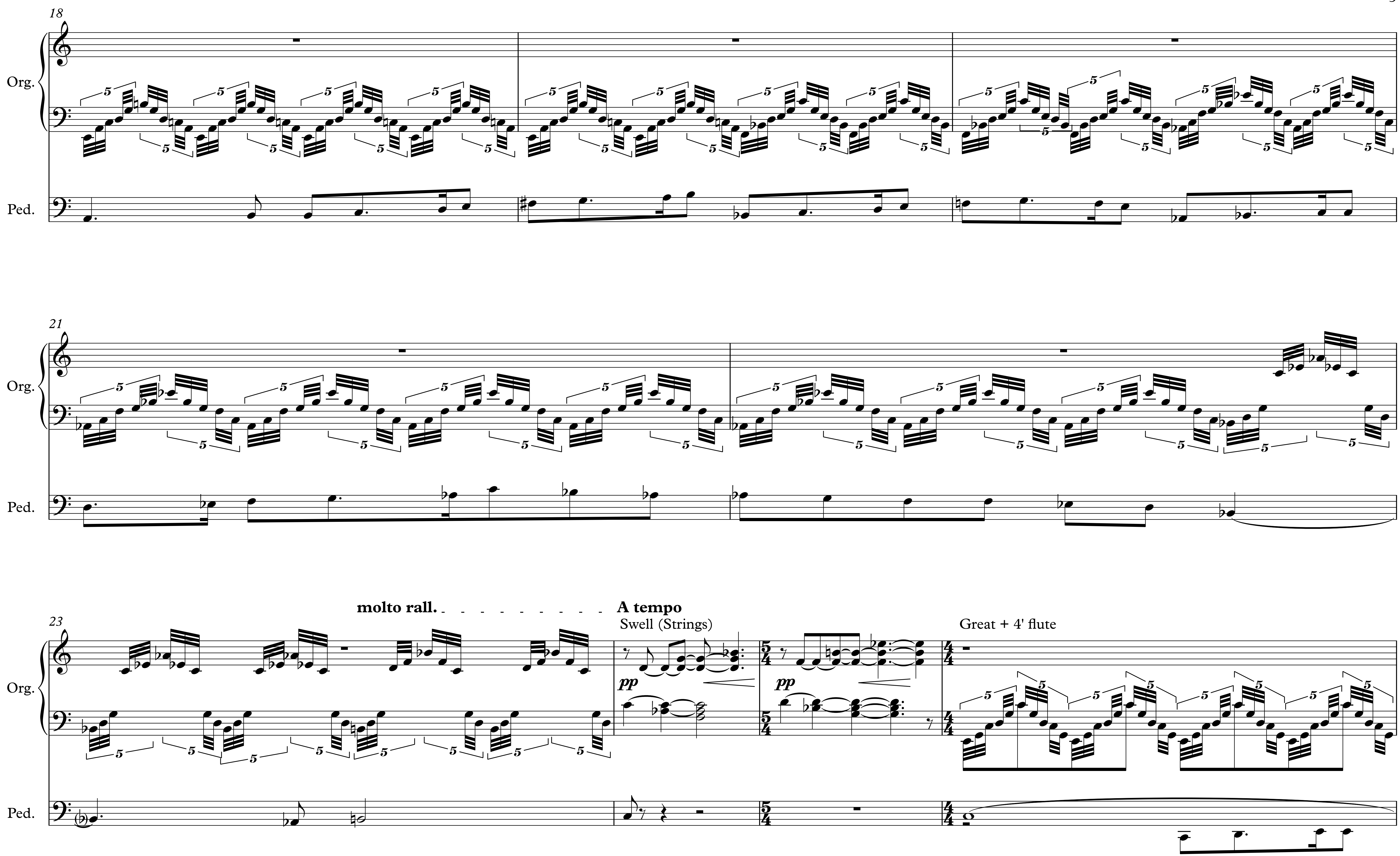

57
Org.
Ped.
62
Org.
Ped.

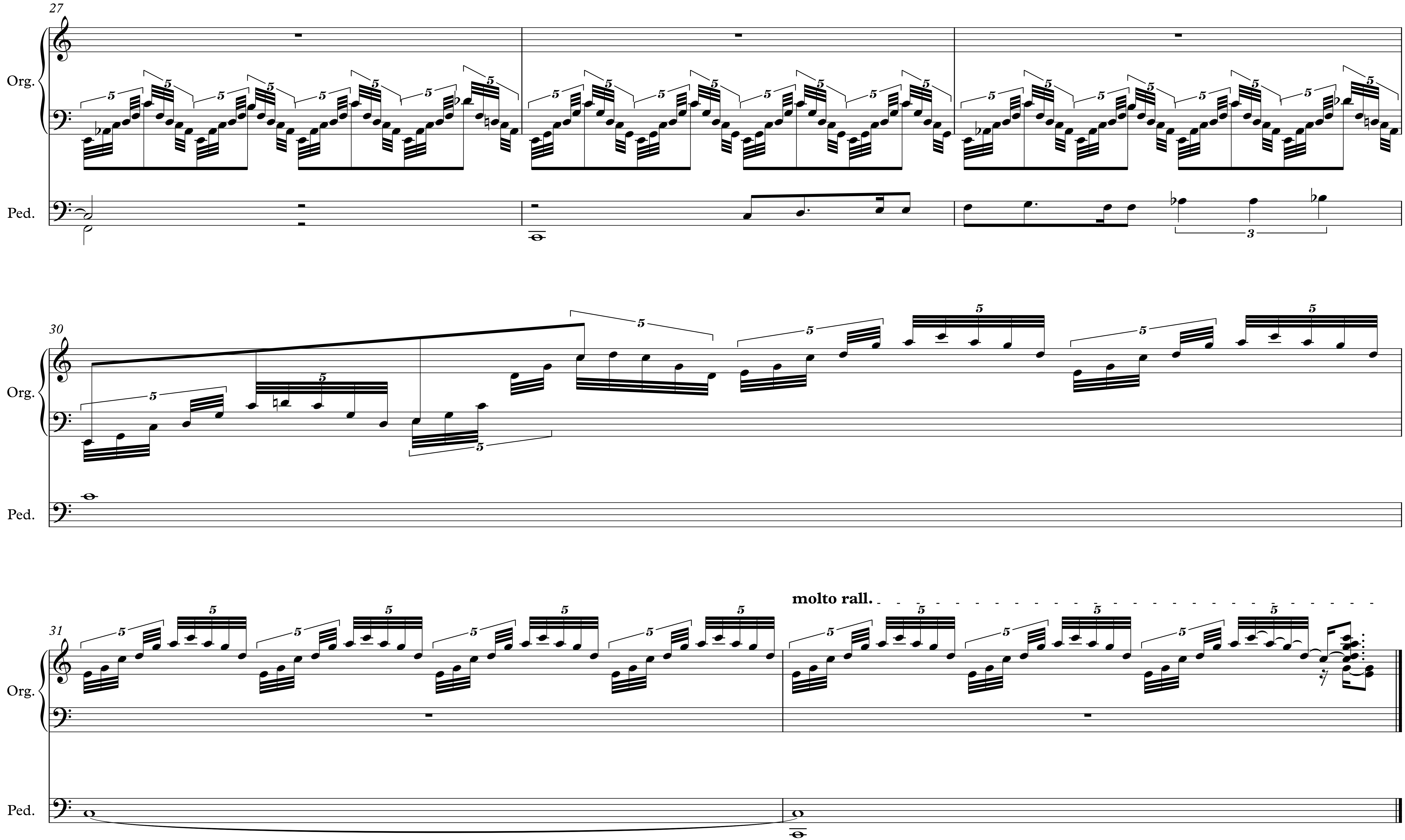
Interlude 12

Matthew Lane




molto rall.
A tempo
Swell (Strings)
Great (8' Flute)
10
Org.
Ped.
p
14
Org.
Ped.
16
Org.
Ped.


18
Org.
Ped.
21
Org.
Ped.
23
molto rall.
A tempo
Swell (Strings)
pp
pp
Great + 4' flute
Org.
Ped.


27
Org.
Ped.
3
30
Org.
Ped.
31
molto rall.
Org.
Ped.

Matthew C. Lane

Världen och Jag

Full Score

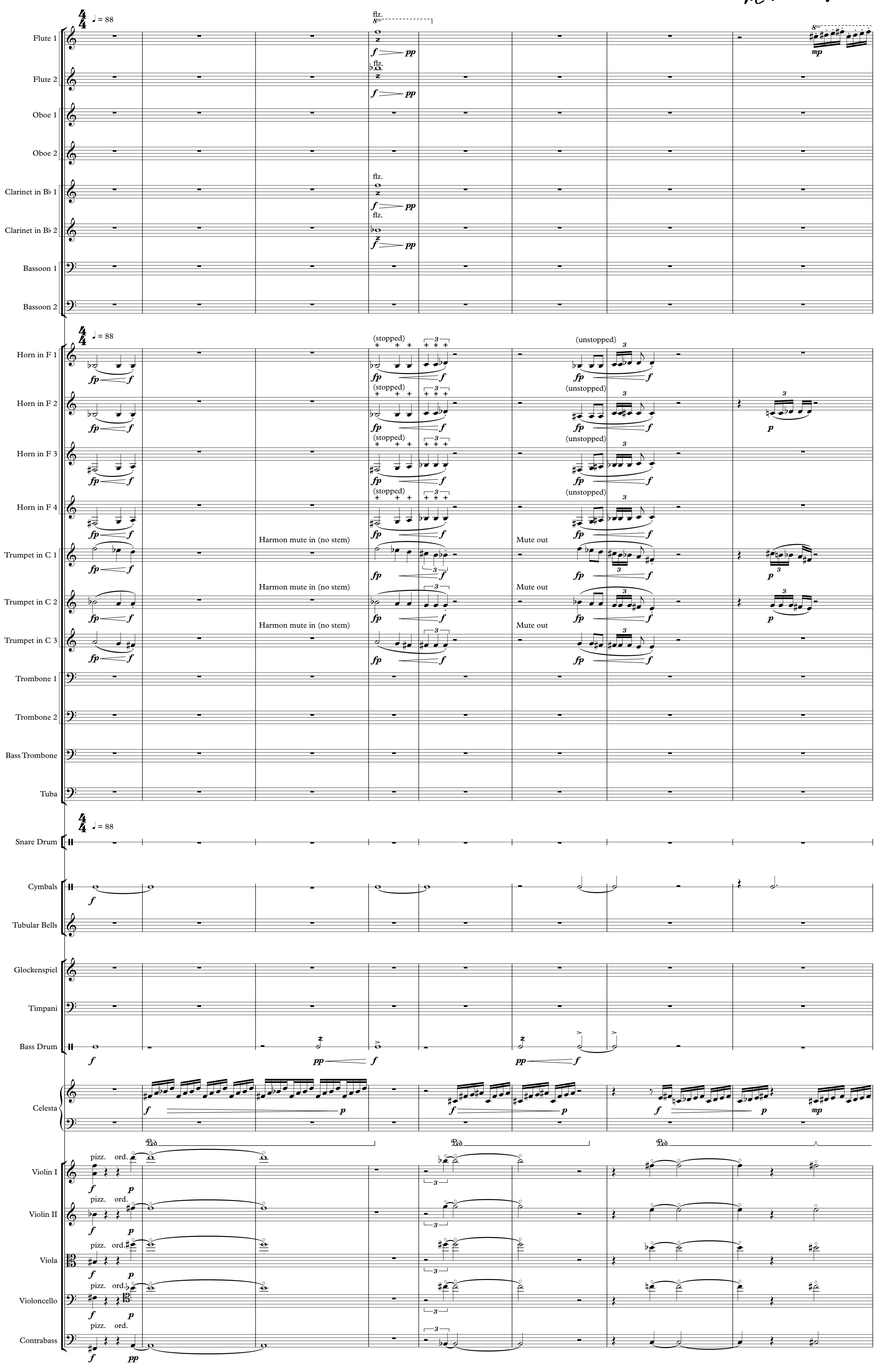
Världen och Jag

Matthew C Lane

Score in Concert Pitch

Notes for musicians:
Accidentals apply for the entire measure, for the octave they are specified.
All string harmonics are artificial harmonics.
On long notes, strings may rebow discretely as necessary.

Världen och Jag

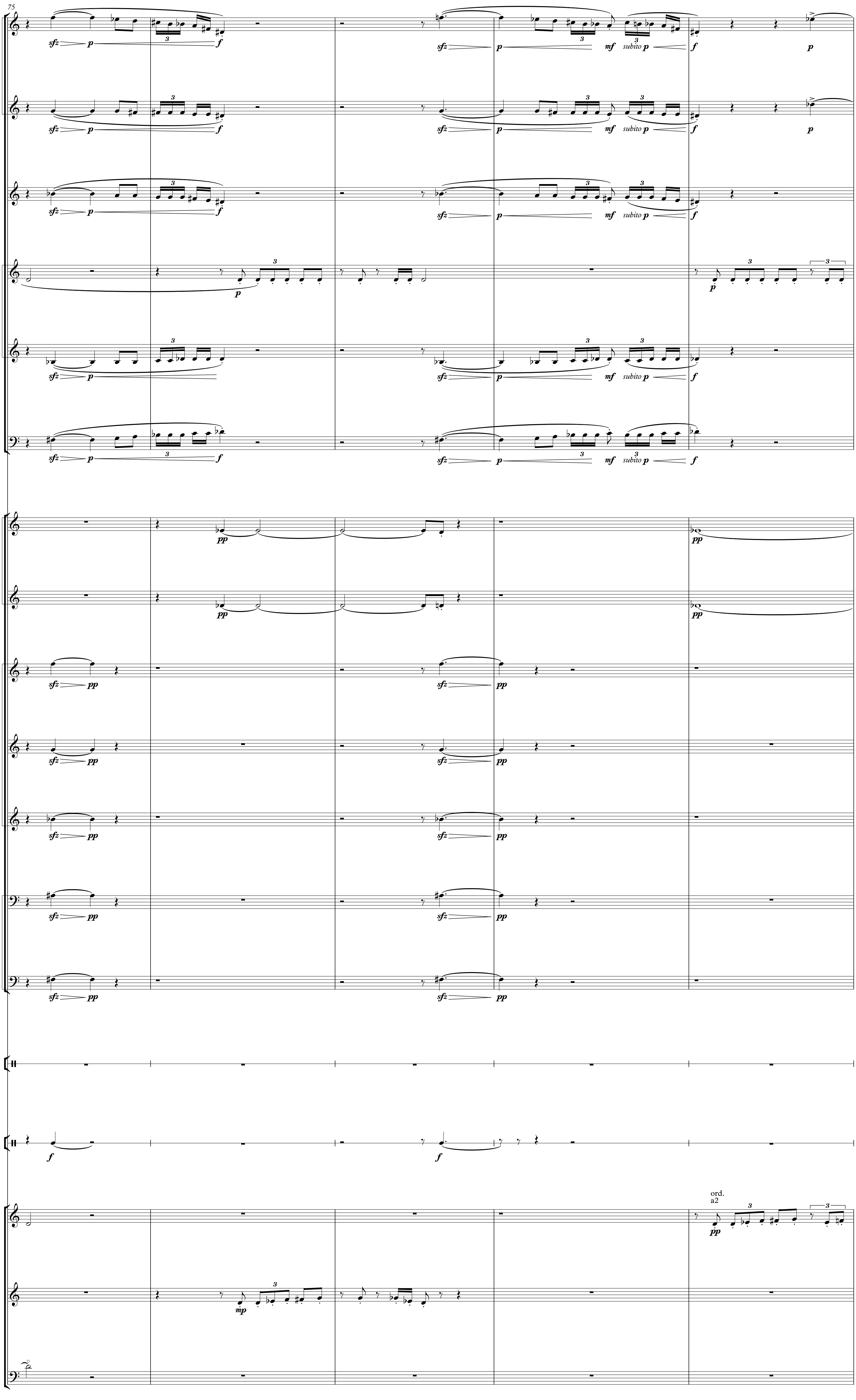



9
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
mute (straight)
mute (straight)
Tbn. 1
Tbn. 2
B. Tbn.
cresc.
Tba.
S. D.
subito p
Cym.
B. D.
Cel.
Vln. I
Vln. II
divisi.
divisi.
Vla.
Vc.
Cb.


17
Fl. 1
Fl. 2
Ob. 1
Cl. 1
Cl. 2
C Tpt. 1
C Tpt. 2
Tbn. 1
Tbn. 2
B. Tbn.
Tba.
S. D.
B. D.
Vln. I
Vln. II
Vla.
Vc.
Cb.
no mute
no mute
divisi.
divisi.
24
Cym.
Cel.
non vib.
non vib.
tutti
non vib.
Gradually increase vibrato
ord.
non vib.
tutti
Gradually increase vibrato
ord.
non vib.
Gradually increase vibrato
ord.
non vib.
Gradually increase vibrato
ord.


A
32
Fl. 1
Fl. 2
Ob. 1
Cl. 1
Cl. 2
Tba.
Glock.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
ord.
pizz.
arco
47
divisi.
55
Bsn. 1
Timp.


64
B
Fl. 1
Fl. 2
Ob. 1
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tbn. 2
S. D.
Cym.
Tub. B.
Glock.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
ord.
flz.
arco
(pizz.)
2
4


75
Fl. 1
Fl. 2
Ob. 1
Cl. 1
Cl. 2
Bsn. 1
Hn. 1
Hn. 2
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tbn. 2
S. D.
Cym.
Vln. I
Vln. II
Vc.
sfz
p
f
mf
subito p
pp
mp
ord.
a2

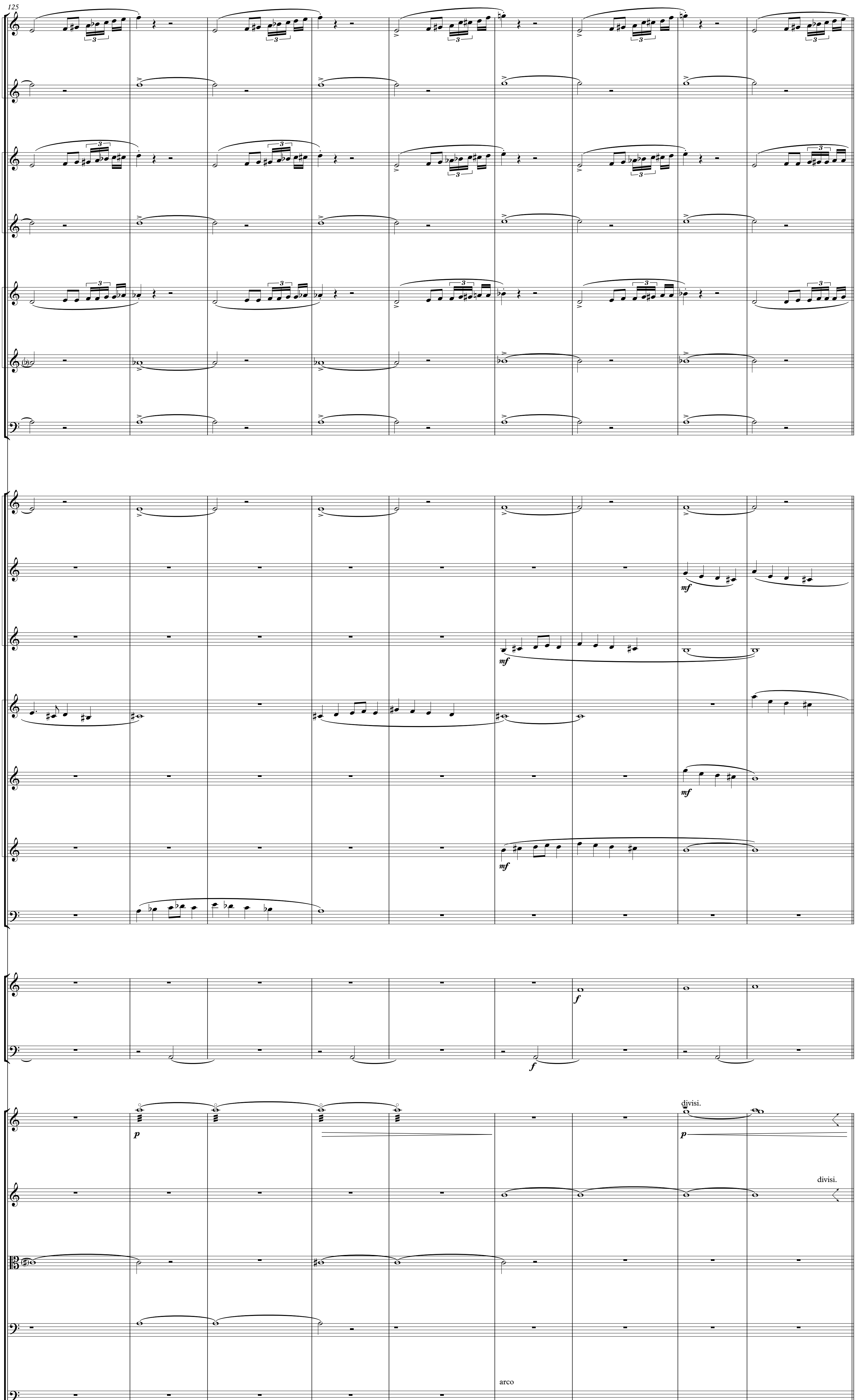

80
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Hn. 1
Hn. 2
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tbn. 2
Cym.
Tub. B.
Glock.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
ord.
ord.
84
C
C
divisi


90
Fl. 1
Cl. 1
Cl. 2
Bsn. 1
Cym.
Glock.
Vln. I
Vln. II
Vla.
Vc.
tutti


95
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
C Tpt. 1
C Tpt. 2
C Tpt. 3
Cym.
Glock.
Vln. I
Vln. II
Vla.
Vc.


D
103
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
ord.
Tbn. 1
Glock.
Cel.
sul tasto
Vln. I
Vln. II
Vc.
pizz.
Cb.

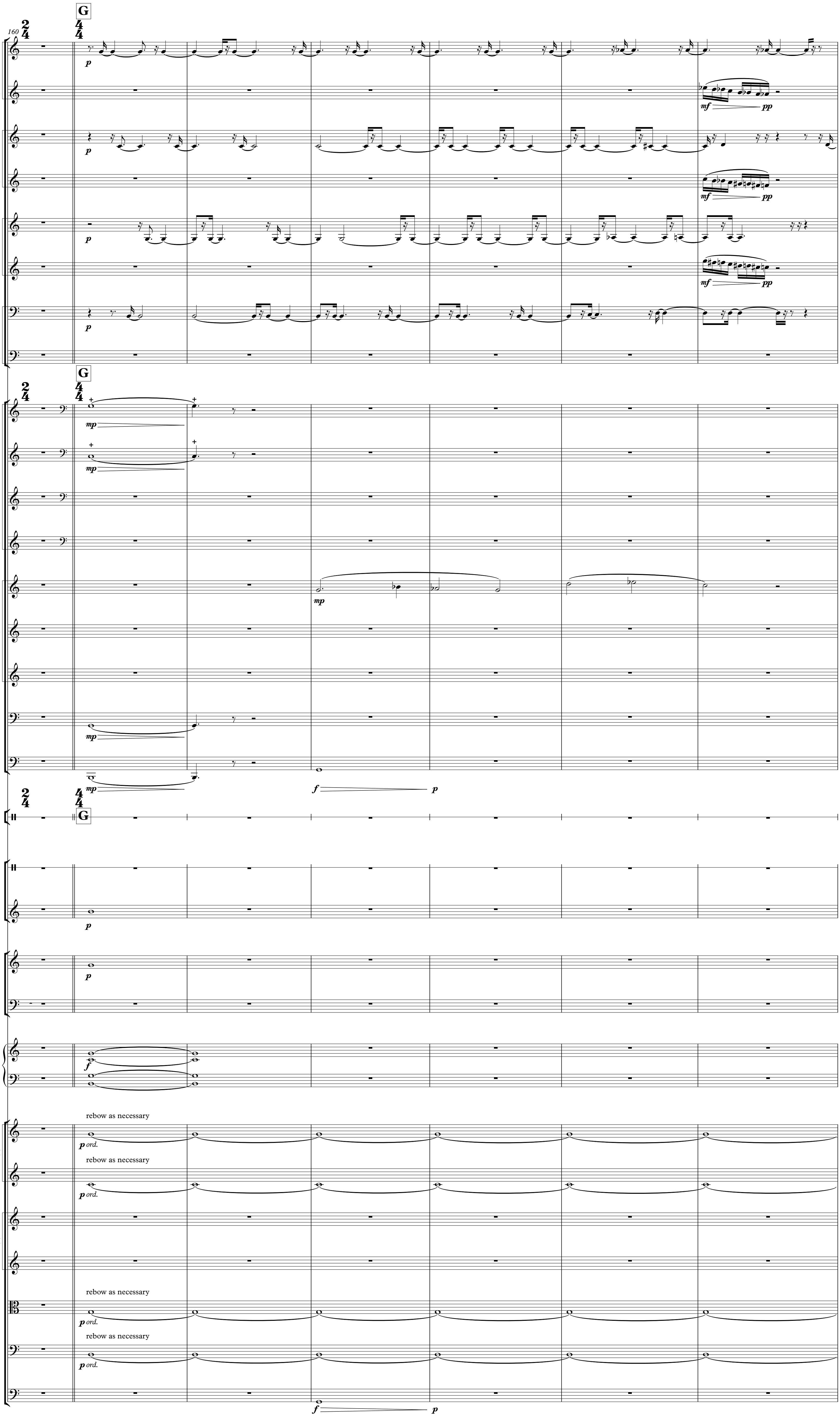

114
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
C Tpt. 1
Tbn. 1
Tbn. 2
B. Tbn.
Tba.
Glock.
Timp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
ppp
p
mf
f

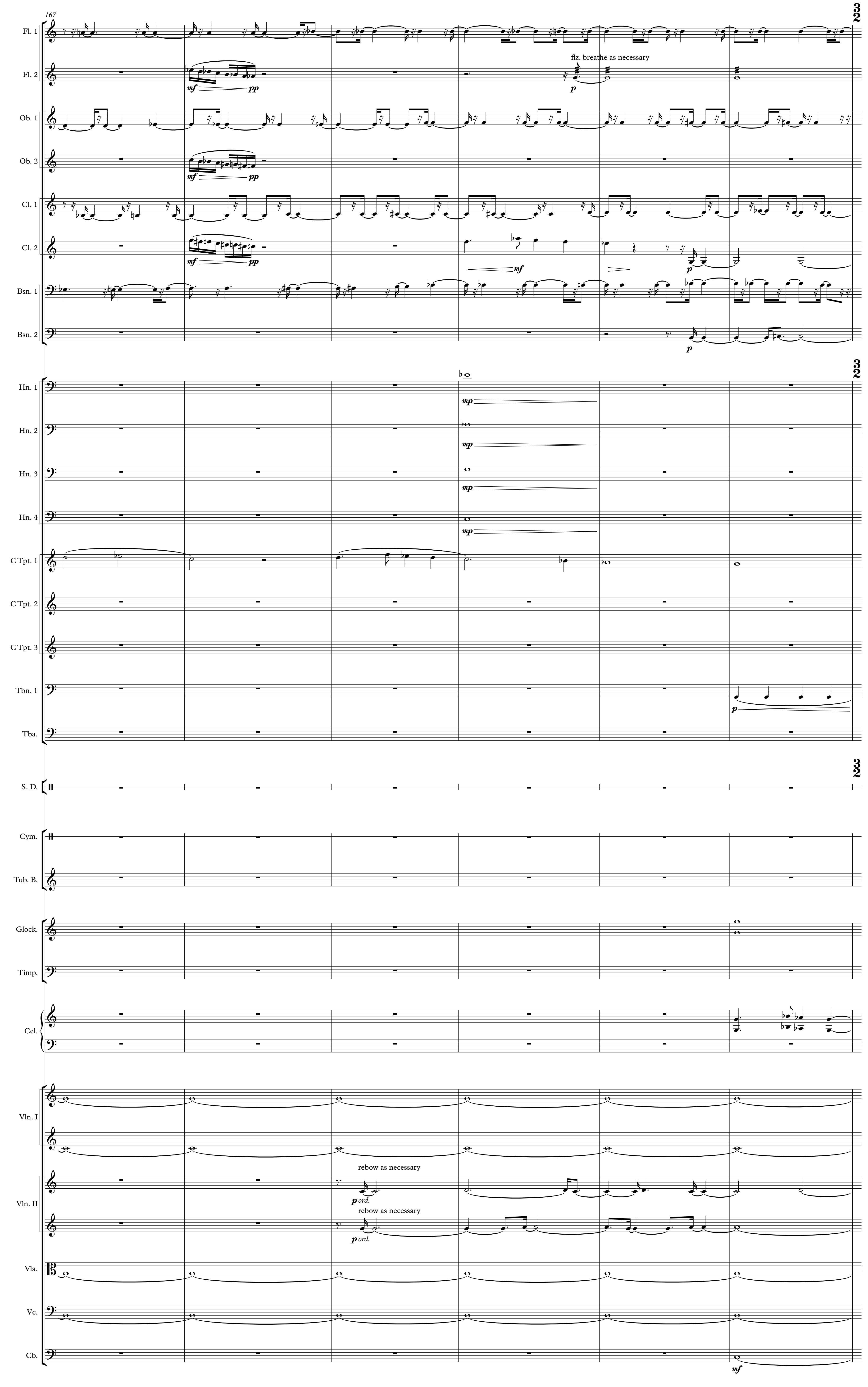

125
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 2
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Glock.
Timp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
mf
f
p
divisi.
arco


E
134
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tbn. 2
Timp.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.


F
142
Fl. 1
Fl. 2
Cl. 1
Cl. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tba.
S. D.
Cym.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
cresc.
divisi.
a2

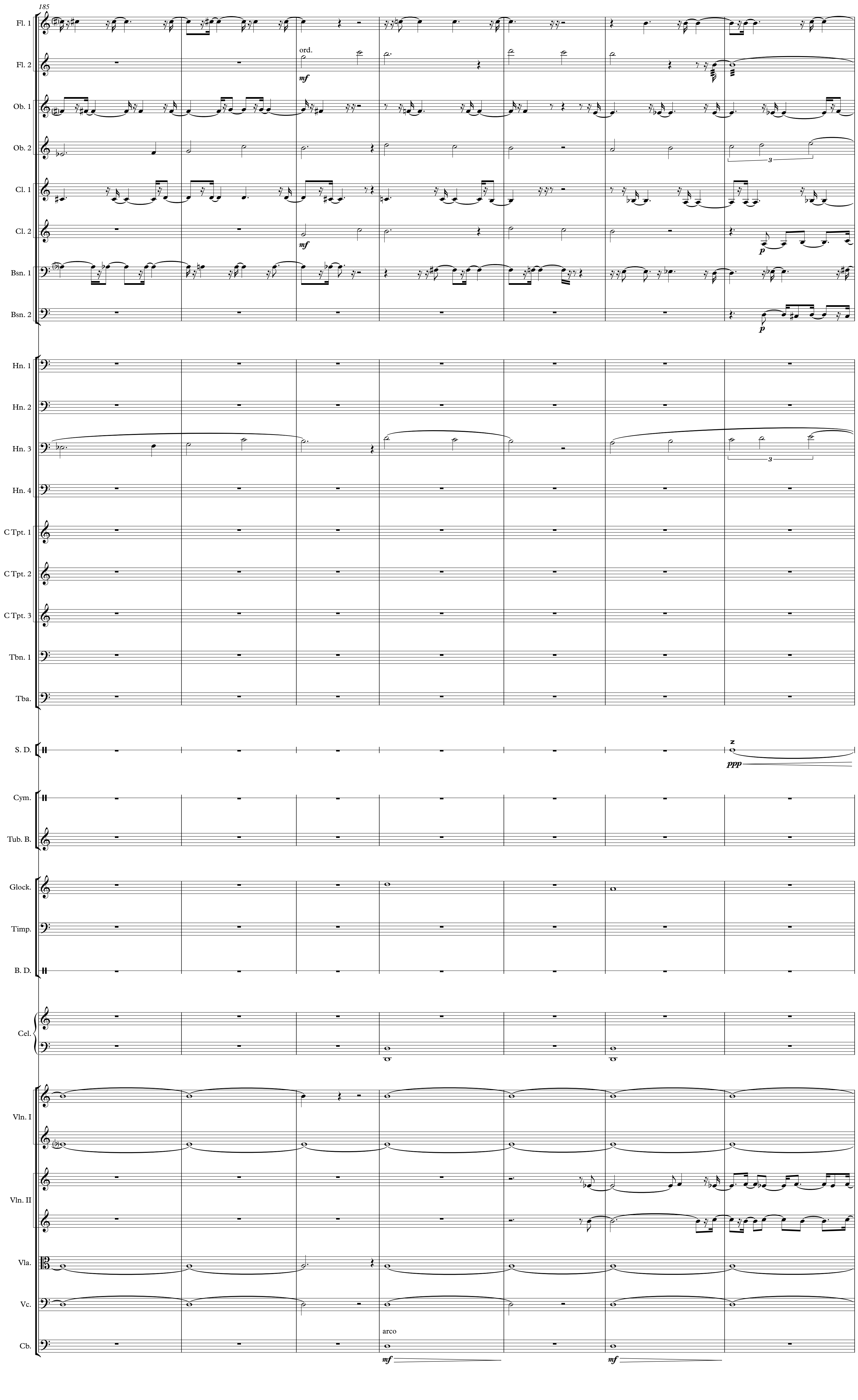

151
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tba.
S. D.
Cym.
Prepare with one timpani mallet and one glockenspiel mallet
Timp.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.


G
160
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tba.
S. D.
Cym.
Tub. B.
Glock.
Timp.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
rebow as necessary
ord.

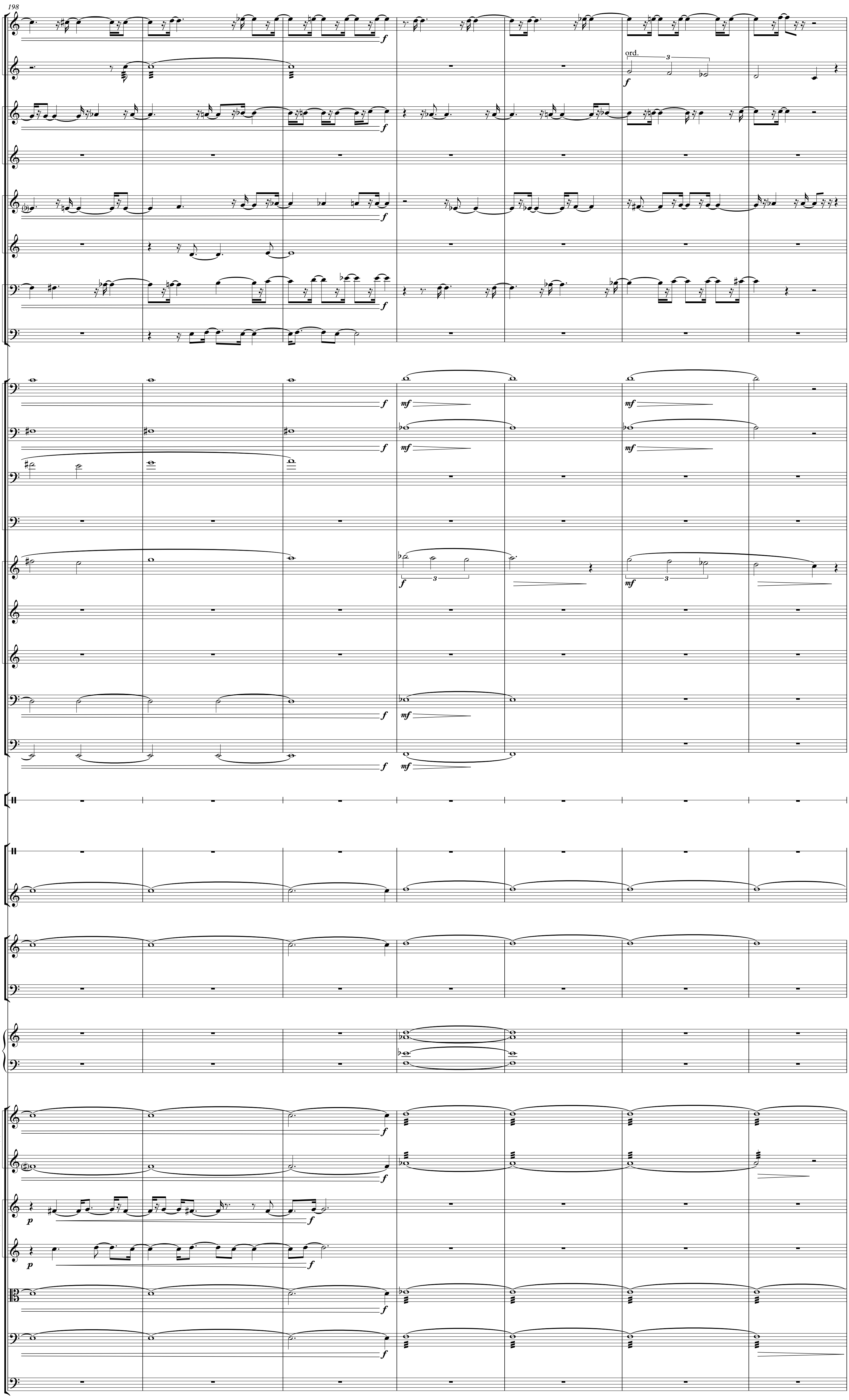

167
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
flz. breathe as necessary
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tba.
S. D.
Cym.
Tub. B.
Glock.
Timp.
Cel.
Vln. I
Vln. II
rebow as necessary
ord.
Vla.
Vc.
Cb.


173
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tbn. 2
Tba.
S. D.
Cym.
Tub. B.
Glock.
Timp.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.


179
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tbn. 2
B. Tbn.
Tba.
S. D.
Cym.
Tub. B.
Glock.
Timp.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
subito p


185
Fl. 1
Fl. 2
ord.
mf
Ob. 1
Ob. 2
Cl. 1
Cl. 2
mf
p
Bsn. 1
Bsn. 2
p
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tba.
S. D.
z
ppp
Cym.
Tub. B.
Glock.
Timp.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco
mf
mf


192
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tbn. 2
B. Tbn.
Tba.
S. D.
Cym.
Tub. B.
Glock.
Timp.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.


198
Fl. 1
Fl. 2
ord.
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tba.
S. D.
Cym.
Tub. B.
Glock.
Timp.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.


205
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tba.
S. D.
Cym.
Tub. B.
Glock.
Timp.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
arco
Cb.


212
H
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
C Tpt. 3
Tbn. 1
Tba.
S. D.
Cym.
Glock.
Timp.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
molto cresc.


217
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
Tbn. 1
Tbn. 2
Tba.
S. D.
Cym.
Glock.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.
molto cresc.
molto cresc.
divisi.
divisi.


223
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
Tbn. 1
Tbn. 2
B. Tbn.
Tba.
S. D.
Cym.
Tub. B.
B. D.
Cel.
Vln. I
Vln. II
Vla.
Vc.
Cb.


230
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Cl. 1
Cl. 2
Bsn. 1
Bsn. 2
Hn. 1
Hn. 2
Hn. 3
Hn. 4
C Tpt. 1
C Tpt. 2
Tbn. 1
Tbn. 2
B. Tbn.
Tba.
S. D.
Cym.
Tub. B.
B. D.
Vln. I
Vln. II
Vla.
Vc.
Cb.
rall.
238
airy
Glock.
Cel.
l.v.
2.
rall.
pizz.

Never a Moment Lost

for violin and piano

In either the A or B sections, begin with segment 1, passing then to segments 2 or 3, but always returning to segment 1 in between.
Use the transition sections to move between the A and B sections of the piece.
Accidentals apply only to the note indicated.
Below is the overall form of the piece in relative lengths, with one possible progression of segments shown below.
Performers may choose a segment order in advance or choose to signal each other.
The piece ends by playing through the A section transition before playing the first bar of A1.

♩ = 60 (always)

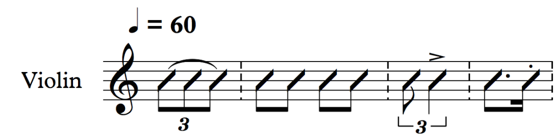
A	B	A	B	A
1-2-1-3-1-Trans.	1-3-1-2-Trans.	1-3-1-Trans.	1-2-Trans	1-Trans.-1'

The piece may also be played A-B-A.
The overall intensity should pick up throughout each section, by way of increased volume, less rests, faster repetitions (where possible), octave doublings (where indicated), and changes in timbre, technique, or articulation.

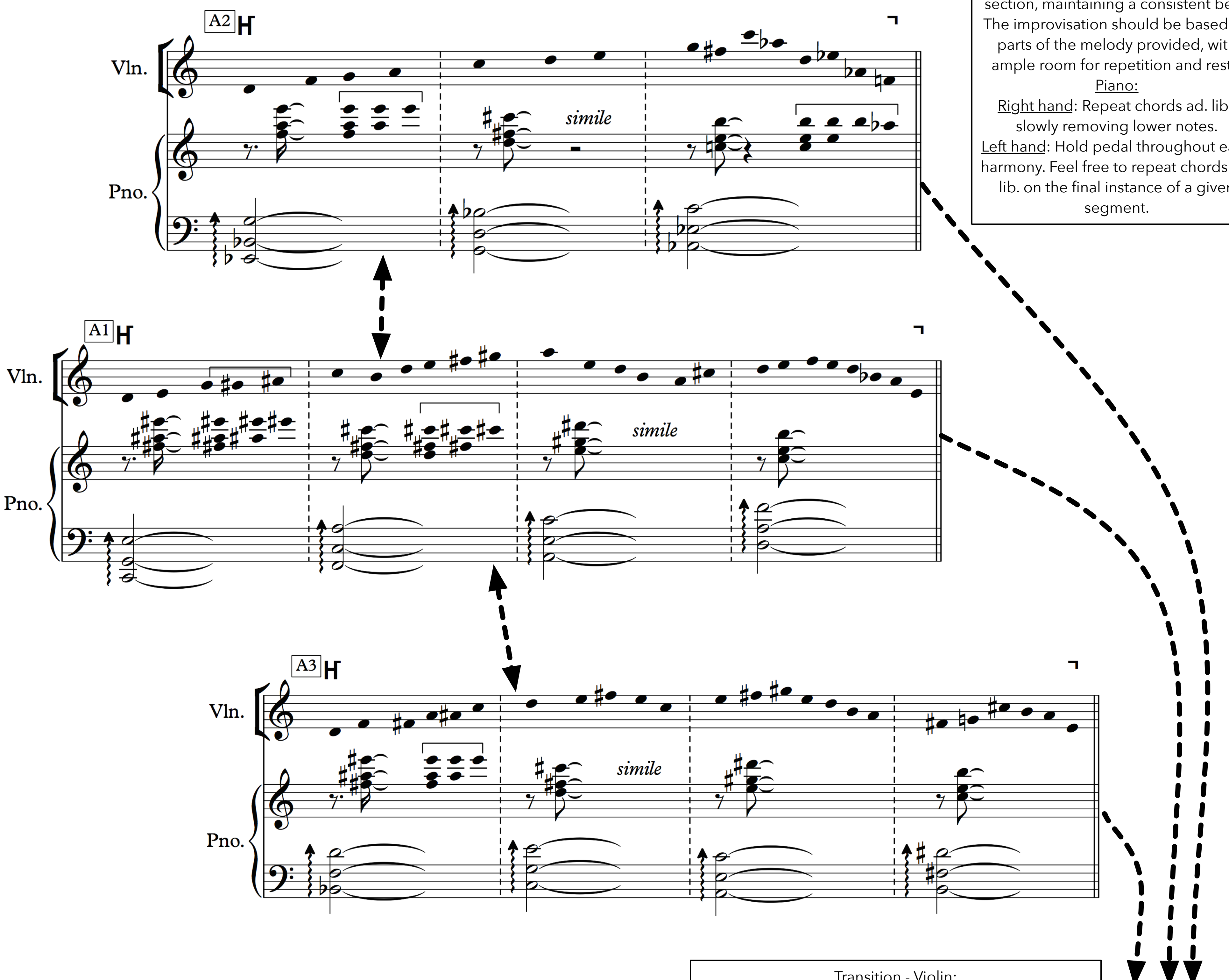
Matthew Lane

2016

A

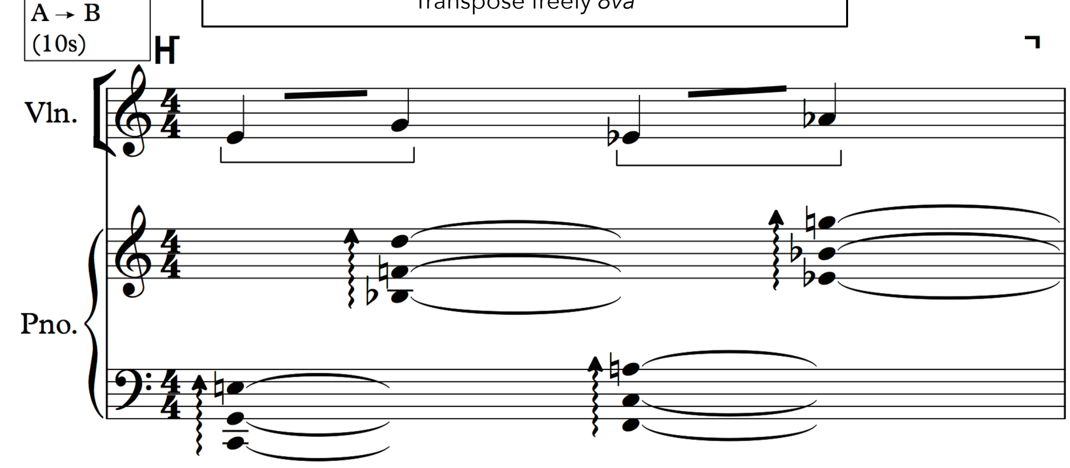


<u>Violin:</u>
Use *mostly* eighth notes and the rhythms above to improvise the A section, maintaining a consistent beat. The improvisation should be based on parts of the melody provided, with ample room for repetition and rests.
<u>Piano:</u>
<u>Right hand</u>: Repeat chords ad. lib., slowly removing lower notes.
<u>Left hand</u>: Hold pedal throughout each harmony. Feel free to repeat chords ad. lib. on the final instance of a given segment.



<u>Transition - Violin:</u>

Tremolo between the notes, gradually slowing from ♩ to ♪
Transpose freely *8va*



B

Violin
Repeat double stops in rhythm as long as necessary, occasionally holding half notes where desired.
Piano
Repeat each beamed R.H. cell as desired, repeating portions of the end of each cell ad lib., but maintaining the approximate original rhythm.
Feel free to double parts of passages one octave up or down. Those marked with the sign may be omitted on returns to B1.
Strike any of the L.H. fifths as desired once they've been introduced, transposing freely at the octave.

Piano should imitate the violin's double stops in any octave, as well as the fifths one semitone above or below, and reenter with section A1 as the violin holds the high E.