Swinging the Score: Compositional and empirical investigations into the performance of swing and groove rhythms by score-reading musicians

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UNIVERSITY OF CAMBRIDGE
Faculty of Music

Preface

This PhD project consists of both an empirical thesis and a portfolio of compositions with commentary. As agreed with the Faculty of Music, each element makes up 50% of the submission towards a PhD in Music.

Consequently, the thesis does not exceed 50% of the stipulated word limit for a full thesis submission (80,000 words, i.e. here resulting in a limit of 40,000 words). The portfolio of compositions and its commentary likewise do not exceed 50% of the stipulated length for a full portfolio submission (eight pieces of 60-100 minutes' total playing time and a commentary of 10,000-12,500 words, i.e. here resulting in a limit of four pieces of 30-50 minutes' length and a commentary of 5,000-6,250 words).

In the thesis, the insights and data presented in Chapter 5 of the thesis have been submitted in a collaborative article with my supervisor Dr Neta Spiro for publication in the *Journal of Interdisciplinary Music Studies* (accepted). The data and insights in Chapters 2–6 have been presented at numerous conferences and institutions between 2018 and 2020.

Disclaimer: This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text. It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. I further state that no substantial part of my thesis has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. It does not exceed the prescribed word limit for the relevant Degree Committee.

PhD Project: Swinging the Score: Compositional and empirical investigations into the performance of swing and groove rhythms by score-reading musicians

Author: Christopher Farrel Rory Corcoran

Abstract:
This PhD project consists of (1) an empirical thesis and (2) a portfolio of compositions with commentary.

1.) The thesis explores the effect of habitually playing from music notation on classical musicians' ability to play by ear and produce the jazz phrasing structure known as "swing". Swing and its relationship to groove are explored from musicological and psychological perspectives, focussing especially on its conflicting relationship with notation when performed by classical musicians. Two behavioural studies explore interactions between classical musicians' notation reading, aural discrimination skills, and their swing performance. One of these also allows for formulating a syntax definition of swing, which so far is lacking in the literature.

    The first study investigates levels of score-dependency, i.e. dependency on notational over aural learning, in classical musicians. Results of several aural reproduction tasks show that score-dependent musicians are more limited in aural reproduction of pitch than score-independent musicians, though no difference between groups is found for rhythmic reproduction. Score-dependency is found to be a likely consequence of long-term task specialisation that can be mitigated by engaging in practices involving playing by ear.

    The second study focuses on how classical musicians produce swing while playing from notation, as evaluated by jazz-enculturated listeners. In line with the first study, results suggest that performers' score-dependency has little bearing on their perceived swing rhythm. Instead it modulates the relationship between notational style and swing, with score-dependent musicians swinging more using classical and jazz notation formats. Unlike in jazz practice, listening to jazz recordings did not improve classical musicians' swing. Jazz listeners' detailed critiques of classical musicians' swing provided details for formulating a syntax definition of swing: Swing is a particular cultural expression of groove, characterised by both synchronization and de-synchronization from a near-metronomic beat sequence, an unequal beat subdivision, rhythmic displacement, offbeat articulation, and a preference for faster tempi.

    The results presented in this thesis have wider implications for research on behavioural and microrhythmic issues in swing and groove production, cognition in aural vs. notation-based music learning, and effects of musical experiences on performance practice.

2.) The portfolio of compositions demonstrates the practical application of swing and groove rhythms in notation for artistic purposes. Over the course of four pieces, it explores how such rhythms can be negotiated in a variety of contexts, including semi-improvised vs. fully scripted performances, classical vs. crossover orchestrations, and metric ambiguities vs. steady rhythmic frameworks.

Together, the portfolio and thesis contribute to both creative and empirical research on intercultural composition and associated notation practices.

Thanks

Just as it takes a village to raise a child, it takes the support of an entire community to complete a PhD. Many people generously contributed their time, skills, and advice to making this PhD happen. Even if there isn’t enough space to mention all of them, I am grateful to each one.

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THESIS

When classical musicians struggle to swing: Aural and notational enculturation mechanisms in intercultural performance practice

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Abstract

This thesis explores the effect of habitually playing from music notation on classical musicians' ability to play by ear and produce the jazz phrasing structure known as "swing". Swing and its relationship to groove are explored from musicological and psychological perspectives, focussing especially on its conflicting relationship with notation when performed by classical musicians. Two behavioural studies explore interactions between classical musicians' notation reading, aural discrimination skills, and their swing performance. One of these also allows for formulating a syntax definition of swing, which so far is lacking in the literature.

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The results presented in this thesis have wider implications for research on behavioural and microrhythmic issues in swing and groove production, cognition in aural vs. notation-based music learning, and effects of musical experiences on performance practice.

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Chapter 1: Introduction: Enculturated behaviour in intercultural contexts

How does one's musical experience with specific learning and performance traditions shape musical behaviour? That question lies at the heart of this thesis. In my own experience, I have often been surprised by how specific enculturation and associated expertise can limit musicians' behavioural responses. Be it the career orchestral musician who struggles to join in a spontaneous performance of a simple diatonic folk song by ear, the big band musician who easily sight-reads the most difficult passages but won't solo 'unless you write it down for me', or the rock guitarist who can shred with the best of them but has trouble following jazz chord symbols—it is surprising how expert musicians struggle to bring their considerable ability to bear in an unfamiliar performance scenario. It has been well established that many musical skills are trained by participation in domain-related activities—but to what extent can these skills be usefully applied in domain-*un*related activities?

1.1. The problem: Classical musicians and swing

That question is of particular relevance in the area of 'third stream' music—compositions that consciously integrate elements from jazz[1] and other ethnic or popular music traditions into compositions written for interpretation by classical musicians (Schuller, 1961). One often acknowledged problem in the third-stream and jazz literature is that many classical musicians struggle to 'groove' or 'swing' (e.g. Banks 1970b; Joyner, 2000; London, 2012, 157; Schuller,

[1] The terms 'classical', 'popular music', and 'jazz', as used in this thesis, are relative social constructs based on wide-ranging conceptualisations that can paradoxically subsume overlapping fields of musical activity. However, despite the many largely socially constructed differences that form most genre divisions (see Cook, 2014, 241-42), there are also distinctions between the wider fields of 'classical' and 'popular music' (here including 'jazz') in terms of musical goals and techniques applied to achieve these goals (see Vuust, et al., 2010, 220). In order to be able to analyse these goals and techniques, I have to work with the perceived differences between both traditions. As a result, I will continue using these terms in the context of this document, but will point out their limitations where necessary.

1961; Sussman & Abene, 2012; Turnage & Lewis, 2008), i.e. imbue the performance with a style-appropriate rhythmic impetus.[2] London discusses why this may be:

> …musicians do not readily cross musical styles—a great classical pianist may be unconvincing when performing a jazz ballad, for example. One reason for such crossover difficulties may be that the timing behaviors musicians have learned so well for the performance of one style are not appropriate for another. And because these timing behaviors are so well learned—the product of decades of practice and reinforcement—it is difficult to suppress overlearned performance habits when trying to sing or play in a new style. […] The difficulties […] suggest that skilled musical performance is highly task-specific.
> (2012, 157)

As London points out, performer expertise shapes task-specific skills in musical performance, which expresses itself in motor behaviour. Therefore, a simplistic answer to why classical musicians struggle to swing is that they were enculturated differently compared to jazz musicians.

However, in this context, it is important to explain what I mean by the term 'enculturation'. The term here is meant as the way musicians learn to engage with and perform new music. Both jazz and classical musicians typically experience one-to-one tutoring processes (Feichas, 2010; Vuust et al., 2010) designed to enable a greater realisation of their performance potential in the manner of Vygotskyan zone-of-proximal development (see Wood & Wood. 1996, for an overview on tutoring processes). In doing so, both musician types benefit from interactions with more experienced performers and tutors, as has also been shown for non-musicians (Kleinspehn-Ammerlahn et al., 2011). However, differences arise in the focus of these lessons and consequently in the ways each musician type reinforces them. Classical musicians are taught primarily to read and perform notated music and imbue it with their own sense of musical expression, reinforcing this training by spending a great deal of time training music-reading and motor skills on their own; jazz and other musicians from so-called 'popular' styles are taught to focus more on playing by ear rather than from notation, and reinforce these

[2] One might argue that many kinds of music and performance can 'swing', i.e. be played with engaging rhythmic impetus. However, I do not mean imply that classical musicians cannot play with rhythmic impetus generally. In this thesis, I am specifically discussing the jazz-phrasing style known as swing (i.e. as in 'playing *with* swing', although for simplicity's sake I will avoid this construction and simply refer to 'swing' going forward). This is also not to be confused with the historical period genre known as swing (i.e. specifically signifying big band music typical of the 1930s-1950s).

experiences by practising their performance and motor skills in social group settings or in virtual social settings by playing along to or transcribing from recordings (Feichas, 2010; Vuust et al., 2010). As a result, where jazz musicians tend to have a greater focus on learning in group settings in order to become more fluent in spontaneous social performance interactions, classical musicians spend more time on solitary score study in order to interpret scripted music with an individualistic expression and become more fluent in scripted social interactions.

Given these nuanced differences between jazz and classical musicians' training goals, simply claiming that differences in musical background can account for performance differences does not satisfactorily explain potential underlying causes in why classical musicians allegedly struggle to swing. Instead, more insight might be gained by enquiring *how* specific aspects of their music learning and performance patterns can manifest themselves in concrete cognitive and motor processes: What aspects of classical musicians' enculturation challenge the way they can bring their considerable musical skills to bear in a (to them) culturally foreign performance scenario, such as playing with swing? That is the question I wish to explore further in this thesis.

As already hinted at above, a notable difference between jazz and classical performance cultures is their diverging interest in the interpretation and usage of notation. In jazz traditions, swing is considered a skill that must be learned by ear, as it is rooted in spontaneous, improvisational motor responses. As a result, many authors find swing inherently un-notatable, or more precisely find Western staff notation incapable of capturing swing without stifling the necessary improvisational responses in performance (e.g. Banks, 1970b; Butterfield, 2016; Haywood, 1993; Keil, 1966; Kenny, 1999; Prögler, 1995). As a result, traditional jazz notation fulfils a more mnemonic role, avoiding specifying swing in notation and instead relying on musicians to create swing based on their experience. This is potentially problematic for classical musicians, who engage more deeply with notated scores and may have limited experience with jazz traditions. Consequently, it is possible that one cultural hurdle is the way jazz and classical musicians approach the role of notation in learning new music.

Taking this possibility as a point of departure, in this thesis I seek to engage with the wider field of aural and notation-based music learning mechanisms and their interaction—doing so through the specific problem of classical performers' perceived struggle in executing swing rhythms. Consequently, the wider problem of the way enculturation manifests differently in aural and notation-based music learning traditions is investigated in two experimental studies. These explore what cognitive and perceptual effects a notation-focussed performance culture might have on classical musicians, and how these differences may affect swing production.

1.2. Thesis overview

Any discussion of how swing is generated first requires a clear delineation of what swing is and how it relates to groove, which will be explored in Chapter 2. The term 'groove' is defined in the literature (Monson 1996; Pressing 2002; Stupacher, Hove, Janata 2016) as the force that induces in listeners an urge to move in synchronization with music. However, the term 'swing' is less well defined in the literature. Therefore, in Chapter 2 I examine the component techniques of swing, as identified by empirical literature. This will serve to show both what techniques swing consists of and why swing is traditionally considered a process that can only be learned in practice.

The insights gained from this survey will be used to delineate an operational definition of swing as related to groove. I will propose the term 'groove archetypes' to describe conceptual idiomatic phrasing structures aimed at inducing groove in performance—of which the 'swing groove' archetype is one. The concept of groove as inducing movement can apply to any number of performance styles, however this thesis will focus only on the swing groove archetype and why many classical performers reportedly struggle to realise it effectively. Due to the conceptual nature of groove archetypes, they only ever manifest in performance. This is also true of swing, which relies heavily on the situation-specific use of improvisational techniques.

Chapter 3 expands on why swing and other groove types are considered nearly impossible to represent adequately in notation (e.g. Benadon, 2006; Butterfield, 2011 & 2016; Keil, 1966; Kenny, 1999; Lilliestam, 1996; Prögler, 1995). Especially swing's famously uneven 'swing quavers'—changeable beat-upbeat-ratios (BURs) that are modulated across a performance—represent a challenge to notation. Traditional jazz notation represents them using even quavers and relies on performers' tacit knowledge of relevant conventions to make appropriate choices in their interpretation. Scores adapted for classical musicians commonly represent them as a steady 2:1 BUR, displayed as a crotchet and quaver in a 12/8-time signature (or the equivalent in triplets), ignoring their changeable nature. This makes it extremely difficult to convey swing to unenculturated performers via traditional forms of notation alone, and explains why jazz is rooted primarily in playing by ear (or 'ear-playing'), with notation fulfilling a primarily mnemonic rather than descriptive purpose.

These limitations have major implications for performers who engage with scores in detail. Therefore Chapter 4 surveys literature on music literacy and concludes that an overspecialisation in music-reading without matching aural skills training makes it less likely for otherwise highly skilled score-reading classical performers to develop ear-playing skills (Feichas, 2010; Kendall, 1988; Vuust et al, 2012; Woody & Lehmann, 2010). This can lead to musicians struggling to perform without notated music, rendering them '*de facto* score-dependent' (Harris and de Jong, 2015, 254). Based on the empirical literature on music literacy and ear-playing, I suggest several possible explanations for how score-dependency may interfere with aural reproduction and propose a model for its onset. The model posits score-dependency as a feedback loop of sight-reading-related activity induced by a near-exclusive focus on music literacy without participation in ear-playing scenarios, which causes aural reproduction skills to decrease over time.

Consequently, since score-dependent musicians may struggle to swing due to training- and practice-induced limitations in ear-playing, Chapter 5 presents a behavioural experiment designed to evaluate score-dependency on an empirical basis. In the experiment, professional classical performers were tested on how much they rely on music notation over aural information when learning new music. Results show that score-dependency has a measurable impact on musicians' abilities to identify or reproduce pitch, though not rhythm, by ear.

Score-dependent musicians' visual focus and the limitations inherent in traditional swing notations styles raise the question as to whether a more explicit swing notation may help these musicians swing better. To investigate this question, Chapter 6 presents a second behavioural study. The same sample of classical musicians recorded jazz tunes, playing from three different styles of notation with differing information content, both with and without aural priming. Then enculturated jazz listeners were asked to rate the recordings for swing and other factors. The outcome of this experiment shows that score-dependency, with its impact on only pitch but not rhythm perception/production, does not significantly affect perceived levels of swing. However, score-dependent musicians produce most swing when performing from forms of notation that neither specify too much nor too little detail in notation (i.e. the classical and possibly the jazz notation styles), while score-independent performers are equally successful with all notation styles.

In Chapter 6's experiment, the jazz listeners' were asked to define swing and critique each performance. The listener critiques outlined the minimum requirements required for successful swing and so are used to form a definition of swing. This definition agrees with the one presented in Chapter 2 and extends it by an additional swing feature (a preference for faster tempi), filling in the literature's lack of an empirically based definition of swing's syntax.

In the final chapter, Chapter 7, the results are discussed with a view to suggesting avenues for future research. Score-dependency is posited as a symptom of overlearning using a particular technology (i.e. notation). This suggests that future research might investigate resulting practice-induced neurological changes and their effect on aural perception of music syntax violations. Long-term, such research might be geared towards investigating wider effects of aural vs. script-based learning, for example in language learning.

Chapter 2: What is swing?

This chapter will set out definitions for the terms 'swing' and 'groove' in preparation for the experiment presented in Chapter 6. It does so on the basis of insights gained from the swing literature. While there is extensive literature on individual component techniques of swing, the literature offers few coherent definitions of swing. Existing definitions (e.g. Spring, 2014; Berliner, 1994, 245; Butterfield, 2011 & 2016) remain relatively open and tend to focus on the notional effect swing exerts on listeners.[3] Given the improvisational, situation-specific nature of swing—as further explored below—this is understandable. However, as Butterfield points out, swing is likely 'a feeling that emerges from quantifiable processes, both rhythmic and microrhythmic, syntactic and sub-syntactic' (2011, 24). Therefore, while swing as a manifestation in performance remains highly individualistic and difficult to trace, as a concept it is also driven by a set of governing syntactic principles. That is why, in the absence of a useful overall definition in the literature that could be operationalized for an experiment, this chapter draws on the extensive empirical swing literature in order to identify its syntactic component techniques and apply them towards a larger definition of swing.

This is done in two steps. In the first part of this chapter (2.1), I draw on literature to identify swing's practice-based component techniques. Since many of the relevant techniques rely on a spontaneous, improvisational deployment, they also form the basis for Chapter 3 on why swing, as an aural tradition, is difficult to capture in notation. In the second part of the current chapter (2.2), I use swing's identified component techniques to establish an empirically based theoretical delineation of swing. Here I will define swing in relation to the wider concept of 'groove', positing it as a member of what I term 'groove archetypes'. By taking into account perception- and practice-based aspects of swing, including tempo, note timing, note duration, and note dynamics, I will establish the syntactic principles of swing to define the 'swing groove

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[3] For example, Spring's encyclopaedia entry for Grove Music Online (2014) calls it 'a way of playing music that results in a feeling of forward motion or momentum, often accompanied by a propensity to embody the music in some form of rhythmic movement'. Berliner (1994) refers to it as an outcome of multiple phrasing and articulation strategies that produce 'qualities of syncopation and forward motion' (245). Butterfield (2016) calls it 'something distinctive that sets rhythm in jazz apart from rhythm in other forms of music—indeed, it is the very essence of good jazz' (257) and elsewhere (2011) describes it as 'an active rhythmic process involving the skillful management of "motional energy"' (3).

archetype'. This definition will form a basis for the hypotheses tested experimentally in Chapter 6.

2.1. Component techniques of swing

To provide an empirical basis for establishing a definition of swing, the following sections identify the component techniques of swing.

Near-metronomic beat spacing

At its most basic level, swing is characterised by a near-metronomic[4] tactus beat sequence (Berliner, 1994; Sussman & Abene, 2012, 58; Wesolowski, 2012, 39-40). As a result, swing fulfils the basic requirement for entrainment, i.e. the ability in listeners to physically and psychologically match rhythmic expectations to regular oscillations and thereby in music anticipate rhythmically salient points in cyclical meter (Clayton, Sager & Will, 2005). This basic feature may already provide one of the reasons why swing and many other musics are associated with a physical sense of forward motion:

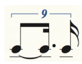
> metric entrainment allows listeners to synchronize their perception and cognition with musical rhythms as they occur in time. When we are entrained our attention literally "moves with the music," and this engenders and encourages our bodily movements as well—from tapping toes and swinging arms to dancing and marching.
> (London, 2012, 5)

[4] The beat is primarily metronomic but can be subliminally moved from its metronomic position (Collier & Collier, 1994; Lindsay & Nordquist, 2006). This is likely done for expressive effect, pushing it ahead for a sense of urgency or behind for relaxation (Butterfield, 2010). Berliner (1994) notes that this effectively makes jazz a 'group interaction that requires the negotiation of a shared sense of the beat' (349).

There is a strong emphasis on the so-called ‘backbeats’ 2 and 4 in a quadruple-meter context (Butterfield, 2006; Berliner, 1994; Monson, 1996, 28; Zbikowski, 2004), which may additionally engender the urge to move in audiences.[5]

Unequal tactus divisions

Perhaps the most recognisable element of swing is the unequal subdivision of tactus beats. Traditionally, when simply asked to play a series of beat subdivisions, jazz musicians will ‘swing’ them, i.e. play them unevenly, unless explicitly instructed not to do so (Monson, 1996; Sussmann & Abene, 2012, 58; Witmer & Robbins, 1988). These long-short tactus subdivisions, usually understood as downbeat-upbeat quavers in a crotchet context, provide a strong sense of syncopation and are commonly conceptualised as a constant 2:1 or 2.0 beat-upbeat ratio (BUR).

In notation, a 2:1 swing BUR is often depicted as  = , giving the impression of a constant crotchet-quaver triplet configuration. However, empirical data indicates that this conceptualisation is a gross oversimplification and that swing BURs vary much more widely. How far they vary depends on multiple factors, including tempo, role of the instrument, and the desired rhythmic effect. Drummers play with high and stable BUS, [6] but BURs among soloists tend to be consistently lower than 2:1 and vary strongly across different performers, ranging from close to 1:1 ( = ) to nearly 3.5:1 (approximately  = ) across assorted case studies (e.g. Benadon, 2006; Busses, 2002; Butterfield, 2011). Soloists’ BURs can also vary considerably within a solo: Butterfield (2011) demonstrates that a mere four-bar phrase by Coleman Hawkins covers a range of BURs of 1.31:1 – 2.44:1, while a phrase of similar length by Charlie Parker covers a range of 0.97:1 – 1.89:1. In a recent article with Klaus Frieler (Corcoran

[5] Iyer (2002) finds that metaphors used to describe jazz techniques, such as a ‘walking bass’ or a ‘four-on-the-floor’ beat, indicate swing’s fundamental rooting in human locomotor perception.

[6] For example, drummers tend to play much higher BUR values than soloists (see Butterfield 2011, 5-7, for an overview), demonstrating minimal variation within a performance in order to highlight the downbeat crotchet tactus and so provide a strong and reliable reference grid for other musicians (Butterfield 2011; Monson 1996). However, across performances, they tend to decrease their ride-cymbal BURs with increasing tempo. Drummers possibly do this in an approximately linear fashion, starting with BURs at around 3 to 3.5 for tempi of 100-150 BPM and levelling out at c. 1.0 at tempo 300 BPM (Friberg and Sundström, 2002; Prögler, 1995; Wesolowski, 2012). Unlike the other authors, Collier & Collier (1996) found that BURs only decrease to a point, after which they returned to a stable 2:1 BUR. Honing and de Haas (2008) found no linear increase, but instead found that BURs stabilise at 2.2:1 at a beat duration of 350 ms and slower. This reduction in BURs with rising tempo does not seem to hold for other band members, with neither Busse (2002), Benadon (2006), nor Ellis (1991) being able to show this finding for melody performers and soloists.

& Frieler, 2020), I conducted a corpus analysis of swing BURs among 454 jazz solos and found a mean BUR of 1.3:1, with soloists primarily keeping their BURs around that level and only some soloists in certain jazz sub-styles additionally employing BURs approaching 2:1, presumably for special effect. We also found that BURs even out with increasing tempi.

It is likely that performers vary their BURs in this manner to heighten or attenuate swing's noted sense of forward momentum across a solo (Butterfield, 2011). In addition to e.g. note choice or articulation, BURs provide another parameter by which performers can control the expressive properties of their solo (Butterfield, 2011; Sussman & Abene, 2012, 58; Williams, 1993). The shortened upbeat division likely serves to perceptually highlight the following beat (Benadon, 2006; Butterfield, 2011), causing a sense of anticipation and therefore also forward momentum.[7]

However—if soloists vary BURs with phrasing—why is swing so persistently depicted as a 2:1 BUR. Some authors (e.g. Sussman & Abene, 2012, 58; Benadon, 2006) have suggested that this could be due to particular BURs being associated with particular periods or subgenres in jazz history, with 2:1 typically representing swing traditions of the big band era up to the 1940s. However, results obtained by Corcoran and Frieler (2020) indicate that BURs approaching or exceeding 2:1 are only systematically used in the later Postbob and Hardbop styles, suggesting instead that listeners conflate solo rhythms with the high BURs in the underlying swing drumming due to perceptual reasons. Another reason may be that a clear triplet articulation is easier to synchronise among a large body of musicians.

Nonetheless, the most likely explanation is that human perception is reductionist in nature: Butterfield applies findings by Povel, which suggests that 'listeners tend to assimilate durationally uneven ratios ranging from 1:4 to 4:5 to a simpler 1:2. Thus subjective interpretation of swing ratios tends toward the triplet model simply because any succession of unequal

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[7] Butterfield (2011) applies research by Povel and Okkerman on perceptual grouping of uneven beats to point out that the short upbeat in swing is tied not to the previous but to the *ensuing* long downbeat beat. The forward motion inherent in the anacrustic upbeat makes it a powerful syntactic effect, so that any additional sub-syntactic changes in timing (i.e. changing BURs, attacking notes later/early) can merely heighten or attenuate this 'power of anacrusis' (167), but will remain secondary to the syntactic effect of an unequal tactus divisions. This agrees with how Iyer (2002) describes microrhythmic deviation from a recurring norm in swing as a mechanism for momentarily highlighting perceptual awareness of specific musical occurrences. However, it should be noted that BURs have different effects on listeners at different tempi, given human perceptual limits. This means that BUR variations are unlikely to be perceived by listeners at high tempi, either as a distinctive timing discrepancy or as an unspecified 'engendered feeling' in the music, as the short upbeats will fall below perceptual limits (Benadon, 2007).

durations tends to sound to us like triplets' (2011, 3-4). This matches with London's (2012, 35-36) suggestion that, when two evenly spaced notes are moved further apart, a sense of triplet will emerge and listeners will naturally divide the two notes into two simple categories: long and short. Thus, the assumed 2:1 BUR may be a reductionist effect of entrainment that guides pattern recognition and corresponding expectations towards salient beat occurrences,[8] similar to the way listeners extract metric subdivisions from multi-level polymeters (Handel & Lawson, 1983).

Rhythmic elasticity

In light of the important role played by the tactus upbeat in jazz, it is interesting that not all players in a jazz band delay the upbeat by the same amount of time. As mentioned, soloists tend to demonstrate a preference for BURs beneath 2:1, but drummers prefer higher BUR values, meaning that soloists tend to divide the beat much more evenly than drummers. Soloists nonetheless achieve good synchronization by delaying their downbeats after the metronomically correct position (Busse, 2002; Friberg and Sundström, 2002; Wesolowski, 2012) and then synchronising with the drummers' upbeats (Friberg and Sundström, 2002; Iyer, 2002). This achieves the sense of laid-back soloing commonly ascribed to jazz, in which downbeats are deliberately played late (Ashley, 2002; Brothers, 1994). Data collected by Ellis (1991) also suggests that downbeat delays may increase with rising tempo.

Late downbeat attacks in solos contribute to a sense of rhythmic elasticity in jazz. Ashley (2002) observes that jazz musicians consciously delay the downbeat of a phrase by an extreme amount of time, then accelerate to catch up or even overtake the rhythm section. This ability to deviate from the underlying beat, yet track it while playing "out of time", and synchronise with it again when desired is considered an important factor in swing production and soloistic innovation (Stewart, 1982; Monson, 1996). Upon resynchronization at phrase endings, soloists tend to extend their BURs to match with the rhythm section, thereby 'locking in' to the

[8] Butterfield (2010) also argues that sensitivity to salient rhythmic locations may cause us to believe that events occur right on top of them, even if they only occur in the rough vicinity. Butterfield (2011) expands on this phenomenon and summarises Paul Fraisse's findings, according to which test subjects, when asked to reproduce a pattern of unequal long and short sound durations, frequently approached a ratio of 2:1, even when the longer stimulus wasn't twice as long as the short stimulus's duration. Therefore Butterfield applies Narmour's theory of the '50% rule', which states that if a note is 50% longer than its immediate predecessor it will cause melodic closure and provide the pitch with new structural significance (2011, 11).

underlying groove to produce a sense of closure (Benadon, 2006; Berliner, 1994, 198; Butterfield, 2001). This heightens perceptual awareness of these structurally significant moments (Ashley, 2002) and therefore likely contributes to good swing (Monson, 1996, 82-83).[9]

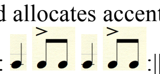
As a result, from an entrainment point of view, the syncopation caused by short swing upbeats and its associated anacrustic nature may induce 'the perception of a virtual articulation' of an ensuing beat (Butterfield, 2006, para 25). Quoting David Temperley, Butterfield points out how this effect can realise the fulfilment of a projected rhythmic duration even if the rhythmic event itself remains absent (para 25). Therefore, the swing upbeat may be considered as forming a phase relationship with the ensuing tactus beat, periodically phasing closer and further from the ensuing beat (see also Clayton, Sager & Will, 2005, Chapter 7 on phase relationships between instruments in other musics). In this way, the beat becomes something negotiated between musicians (Berliner, 1994, 352), with subliminal push- and pull-sensations being fostered by member of a band phasing in and out of the commonly defined beat that defines the overall tempo.

Backbeat emphasis

As previously mentioned, one of swings significant traits is the heavy emphasis on the so-called 'backbeats', which are tactus beats 2 and 4 in a 4/4 or 12/8 metrical context (Berliner 1994; Butterfield 2006; Monson 1996: 28; Sussman & Abene, 2012, 60; Wesolowski, 2012; Zbikowski, 2004). Backbeat emphasis—although present in multiple band instruments[10]—especially finds expression in the jazz drummer's iconic 'ding-ding-a-ding'[11] ride rhythm played on the cymbals, as this creates a simple phenomenal emphasis at tactus level (Butterfield, 2006) and subdivides the backbeats at sub-tactus level (Butterfield, 2011). Bassists often similarly play

[9] Brothers (1994) traces this jazz solo tradition of only occasionally synchronising with the underlying beat to West African Ewe music, where cross-rhythms are employed to only coincide with an underlying ostinato at specific moments, thereby offering ever-changing articulations of the ostinato's cycle. Brothers finds that jazz phrasing analogously offers multiple rhythmical interpretations of a fixed harmonic and rhythmic cycle and regards it as a fundamental aspect of jazz syntax: 'The syntactic "meaning" of a jazz solo is determined by its relationship to the cycle; at least, this is the primary syntactic identifier of jazz.' (500)

[10] Backbeats serve as targets for chordal dissonances in bass lines (Butterfield 2006, para 23) and provide rhythmic targets for improvisers (Berliner, 1994, 148-49). Intriguingly, this draws a parallel between metrical structures and sub-tactus structures, given Friberg and Sundström's (2002) data showing that soloists tend to synchronise with drummers' quaver upbeats.

[11] The common ride rhythm divides the bar and allocates accents as follows, usually with high BUR-values (i.e. very long quaver downbeats, very short upbeats). ||:  :||

full tactus durations on beats 1 and 3 but subdivide beats 2 and 4, thereby anacrustically leading onwards to beats 1 and 3 (Berliner, 1994, 316; Butterfield, 2006, para 23). The backbeats can be slightly longer than the downbeats (Waadeland, 2016). Particularly beat 4 seems to receive additional emphasis (Prögler, 1995; Liebmann (2003) in Wesolowski, 2012), possibly due to its anacrustic role towards the ensuing bar's beat 1.

Articulation

Presumably in response to the near-metronomic regularity of the tactus, jazz soloists have found several ways to strategically subvert and reinforce salient beat occurrences. Performers, and especially wind players, slur at below-tactus-level from offbeat jazz quavers into downbeats quavers, varying the levels of intensity between the two notes and thereby likely contributing to the anacrustic effect of the upbeat (Butterfield, 2011, 13). This is further increased by soloists' tendency to increase note duration with rising tempo and so create a legato effect (Busse, 2002; Wesolowski, 2012). Techniques like phrasing across bar lines and tying anacrustic upbeat quavers to downbeats may additionally enhance perception of the ensuing beat (Butterfield, 2006, para 25; London, 2012, 88).

Summary

In summary, the data summarised and presented here suggests that swing's basic quantifiable elements consist of occasional synchronization with a near-metronomical beat sequence, occasional de-synchronization from the beat by using displacement and articulation to syncopate, and an unequal subdivision of the beat. In the next section, these insights will be used to create a definition of swing, tying these elements into the concept of groove.

2.2. Swing as a groove archetype

In the absence of an empirically based comprehensive definition of swing, the following section establishes a theoretical delineation. This delineation draws on the presented insights gained from existing literature and empirical analyses of recordings to define swing in relation to the wider concept of 'groove', positing it as a member of 'groove archetypes'. By accounting for perception- and practice-based aspects of swing, including tempo, note timing, note duration, and note dynamics, this approach establishes the syntactic principles of swing to define the 'swing groove archetype'.

Swing's relationship with dance and groove

Many of the processes described above—including variable BURs, downbeat delays, and backbeat emphasis—rely heavily on cyclical, near-metronomic oscillations in the tactus and the resulting anticipation of forthcoming beats. As a result, entrainment in terms of a physical awareness of the ongoing tactus is a central aspect of swing performance. An underlying principle in jazz and other 'popular' music styles when learning to keep a steady beat is to nod along or tap a foot while playing, tracking salient beats physically while learning to phrase around them. Consequently, swing techniques—such as phrasing across barlines, adapting BURs, or tying anacrustic upbeat quavers to the ensuing downbeat—are directly related to the perception and prediction of individual beats in the underlying metric framework. These techniques allow listeners and musicians to anticipate the placement and musical significance of upcoming events or beats and accompany them with an adequate gesture. Therefore, swing phrasing depends on tracking beats instinctively through physical motion, while simultaneously reinforcing or weakening their affect by making expressive phrasing choices. This autogenerative link between musical material and beat placement can likely be generalised to many different forms of dance music, which jazz was considered as originally,[12] and relates to the link between physical movement and musical gestures.

Entrainment in dance music is naturally not only based on musical material, but also on physical movement. Keil (1966) quotes a text by Hornborstel from 1928, in which Hornborstel claims that Western art music conceives the inaudible preliminary hand movement preceding a rhythmic figure on a downbeat as an extra-musical event that doesn't add to the perception of the rhythmic figure—the rhythmic figure only begins with the ensuing audible beat. However, Hornborstel notes, some African audiences would see the movement itself as the first musical act in the rhythmic phrase: 'we proceed from hearing, they from motion; we separate the two phases

[12] To do this day, jazz and many other popular music styles are referred to as 'rhythmic' instead of 'popular' music in Scandinavia, referencing their original primary social function as dance music.

[sic] by a barline, and commence the metrical unity, the bar with the acoustically stressed time-unit; to them, the beginning of the movement, the arsis, is at the same time the beginning of the rhythmical figure' (Keil, 1966, 348, footnote 17). In certain kinds of African music, is the implication, the physical movement is an essential part of entraining audiences and therefore carries anacrustic signification: it implies to African audiences that a sound is about to happen on the downbeat. Although Hornborstel's argument is noticeably a child of its time—assuming absolute cultural divisions and referring to 'Africans' and 'African music' without differentiation—later ethnomusicological scholarship confirms that musical events, gesture, and dance are inextricably linked with great affective power in West African cultures (Agawu, 2006). In these music cultures, phase relationships between fixed time series and spontaneously deviating soloistic articulation in the rhythmic domain (Nketia, 1982) are organized in patterns very similar to the way soloists in jazz deviate from underlying fixed drum patterns, being possibly related or historically foundational to jazz rhythm (Brothers, 1994).

As mentioned earlier, Butterfield (2006) notes that flexibly phrased swing quavers can be used to imply projected beats without actually articulating them. Consequently, the central force in creating swing's affective power may be the combination of entrained audiences' expectation of upcoming tactus beats and the musicians' ability to subvert or reinforce such expectations by flexibly placing their syncopated sub-tactus.[13] London (2012) points out how skilled disruption of expectations by application of local rhythmical contracictions (hemiolas, 'loud' rests, etc.) can reinforce expectations of salient event placements by making listeners more aware of the ongoing meter.[14]

This connection between swing, metric framework, and physical movement or dance places it in close proximity to "groove". Defined in the literature as a pleasurable urge to move in synchronization with music (Monson 1996; Pressing 2002; Stupacher, Hove, Janata 2016),

[13] Already in 1924, music critic and composer Virgil Thomson noted how in the jazz of his day 'the way to make a strong on pulse on 3 is by tying it to 2 […]. A silent accent is the strongest of all accents. It forces the body to replace it with a motion. But a syncopated tune is not jazz unless it is supported by a monotonous, accentless rhythm underneath. Alone it may only confuse the listener. But with the rhythm definitely expressed, syncopation intensifies the anticipated beat into an imperative bodily motion. The shorter the anticipation the stronger the effect. The systematic striking of melodic notes an instant before the beat is the most powerful device of motor music yet discovered.' (1924, 137)

[14] 'Many contradictions are merely local, as in hemiola, loud rests, and the like. These local perturbations depend on the presence of an established metric framework for their musical effect. Indeed, they often make the listener more aware of their role in creating meter [...]' (London 2012, 88)

groove is heavily bound up with dance and possibly represents a human universal (Madison, 2006). Music in many cultures has the potential to engage humans in movement, even if the movement is not conceived as dancing in synchrony with rhythmic detail (e.g. swaying along to an orchestral recording with strong tempo variations). If groove is a human universal, this is likely due to entrainment being a possible human universal (London, 2012). Zbikowski points out that even listeners uninitiated to certain popular groove rhythms seem to be able to identify implicit rhythmic events within explicitly articulated events and map their body movements onto the relevant rhythmical events accordingly (2004).[15]

When specifically considering groove as moving in synchrony with the rhythmic detail found in popular music of the twentieth century as influenced by African-American musics, groove can be enhanced by dynamic variability and pulse clarity (Stupacher, Hove & Janata, 2016), increased tempi (Janata, Tomic, & Haberman, 2012), and medium levels of syncopation (Witek et al., 2014; Sioros et al., 2014). All these factors are directly or indirectly modulated by the swing features listed above, and therefore swing closely corresponds with Pressing's definition of groove:

> [Groove] forms a kinetic framework for reliable prediction of events and time pattern communication, and its power is cemented by repetition and engendered movement. Various characteristic rhythmic devices […] manipulat[e] expectancy with techniques producing perceptual rivalry and multiplicity, using direct temporal manipulations of musical materials.
> (2002, 308)

In view of the importance that temporal devices have in producing groove, tempo plays an essential role. Monson notes how in swing 'certain tunes or time feels just don't groove if they are played too quickly or too slowly' (1996, 68-69). London (2012) points out that various types of metric subdivisions take on different sensory qualities at different tempi, since some of the

[15] Zbikowski (2004) argues that we should distinguish between two rhythmic layers in groove-based music: An implicit layer, which the musicians use as a frame of reference to identify the tactus and articulate their notes at the right time, but which itself isn't necessarily articulated (i.e. a metric framework, an implicit metre); and an explicit layer, which is made up of the notes the musicians actually perform and therefore represents the materials that constitute the groove. Zbikoski points out that even listeners uninitiated to a certain type of groove seem to be able to identify the implicit layer within the explicit one and map their body movements onto the relevant rhythmical events accordingly (286-87 & 296-97).

subdivisions will fall below or above perceptual limits.[16] Correspondingly, it has been shown that groove's power to engage is modulated by microtiming deviations from metronomic positions (Davies et al. 2013; Kilchenmann & Senn, 2015; Senn et al., 2016) For swing, this seems particularly relevant in light of performers' tendency to alter BURs with changing tempi,[17] implying that a syntactically correct swing articulation at one tempo might feel inappropriate at other tempi if not adapted.

All this raises the question as to whether groove and swing are synonymous or separate concepts. Madison (2006) mentions that the term 'swing' in Swedish expresses both the concepts of swing and groove, and showed that Swedish speakers nonetheless see these concepts as related but ultimately separate. Therefore, as discussed in the next section, swing may be not a synonymous concept, but rather a culturally specific expression of groove.

Groove archetypes

The term 'groove' takes on multiple meanings in colloquial language, beyond the effect of inducing an urge to move with music. The common usage of the term 'groove' often describes recognisable musical devices that induce this effect —both in terms of particular performances (e.g. the groove on Michael Jackson's recording of *Beat It*) as well as stylistic concepts (e.g. the song with a Latin groove). Therefore groove as a stylistic concept is an abstraction that may be considered analogous to a musical work: Cook (2014) describes a musical work (i.e. a composition) as a socially-agreed upon conceptual construction that can actually only be perceived in its manifestation during a musical performance. Shared socially agreed-upon attributes allow us to identify it in many different guises during performance manifestations, but the exact nature of these attributes depends on subjective interpretation: One person may ascribe a certain set of attributes to it, another person may ascribe a similar but not fully overlapping set

[16] London's (2012) calls this the theory of tempo-metric types: Based on his concept of metric types—different configurations of subdivisions in metrical cycles that showcase the different 'flavours' of a meter (2012, 7 & 60)—tempo-metric types are metric types at different tempi (7 & 76-77). Due to perceptual limits, 'our perceived sense of a given meter will change with tempo, even if its formal architecture remains constant' (7), effectively meaning that a tempo-metric type takes on a different rhythmic feeling when the tempo is shifted, as some of its subdivisions then fall outside perceptual limits. Correspondingly, Sussman and Abene (2012) recommend that contemporary jazz arrangers should familiarise themselves with many groove rhythm configurations in various tempi and metres.

[17] London (2012) finds that listeners can identify individual musicians and subgenres by their rhythmic mannerisms, recognising connections between expressive variations in timing/dynamics and certain metric subdivisions/tempi. Monson believes that the sub-tactus upbeat defines how audiences perceive jazz musicians' phrasing style (1996, 70).

of attributes, and so its identity and meaning is socially negotiated. Cook notes that the same principles apply to genre (2014, 241).

By extension, a stylistic concept such as the 'swing groove' is similarly an abstract concept, since it can only be defined through its manifestations in performance. A term like 'swing' is associated with different things by different people (see Madison, 2006) and therefore its meaning depends on socially-negotiated stylistic attributes that become only perceivable in performance. As a result, I define culturally specific expressions of groove (e.g., funk, Latin, swing) here as 'groove archetypes'—conceptual idiomatic phrasing structures that aim to engender groove when manifested in performance.

Groove archetypes can be identified in various ways: In line with groove's roots in physical movement and dance, Zbikowski (2004) finds that performing or experiencing a groove is not an intellectual challenge, but rather one that involves more instinctive processes, such as 'a complexity of perceptual and proprioceptual information, bodily motions (both potential and actualized), introspective states of awareness, thoughts and feelings that contribute to the texture of our conscious lives.' (2012, 277) Therefore, musical factors are not the only aspect in identifying groove archetypes, since likely a number of extra-musical visual or cultural cues (e.g. audience ethnicity, social status, clothing, dance moves, the music's song lyrics, etc.) are similarly involved. These factors directly interact with our responses to music, such as in the example of Ghanaian Akan court music, where royal drum rituals are associated with behavioural etiquette (Nketia, 1982). Such social associations with music directly impact the perception of musical events and associated levels of groove among audiences (Senn et. al, 2018).

However, which musical features do listeners use to identify particular groove archetypes? Busse (2002) uses the example of computer-produced MIDI grooves to point out that we can recognise stylistic traits by a groove's particular syntactic configurations of note placement (timing), note duration (articulation), and velocity (note dynamics). As mentioned in the last section, London (2012) highlights the significance of tempo in identifying phrasing structures. This suggests that certain manifestations of a groove archetype may be more effective at some tempi than others. Consequently, combining Busse's and London's points, we can assume that listeners identify and distinguish specific groove archetypes (e.g. Latin, techno, blues) in performance by their event placement, event on- and offsets, i.e. event durations, and event dynamics, as appropriate to the ongoing tempo (in addition to extra-musical features). Since knowledge of musical styles is possibly accumulated by probabilistic learning (Hansen, Vuust, & Pearce, 2016), these deductions are likely based on repeated exposure to each style during earlier personal musical experience, meaning that such deductions remain individualistic and therefore their accuracy is socially negotiated between listeners.

However, no groove archetype is ever stable in performance, just as no two performances are alike. Any sounding manifestation of an archetype naturally includes performer-specific sub-syntactic deviations ('participatory discrepancies' in Keil 1966, 1987, 1995) from the abstract syntactic norm. This does not seem to alter the fundamental nature of the underlying archetype: Research indicates that although sub-syntactic responses may enhance or dampen the effectiveness of a swing groove to induce movement (Butterfield 2006; 2011), listeners consider excessive sub-syntactic deviations from syntactic regularity as performance errors (Busse, 2002; Butterfield, 2010; Datseris et al., 2019; Davies et al., 2013; Kilchenmann & Senn, 2015). This suggests that sub-syntactic responses cannot alter the fundamental nature of the underlying syntax without distorting it beyond recognition.[18] Consequently, individual performances can be assessed on whether they violate the perceived syntax of the underlying groove archetype. Since the identification of groove archetypes is based heavily on listeners' experiences and so inherently involves a degree of subjectivity, such archetypes should ideally be assessed by multiple enculturated experts to account for their socially negotiated nature. This point will become especially relevant in the experimental process described in Chapter 6.

[18] The assessment of how much of swing's power to engage audiences is rooted in syntax or sub-syntax is complicated by the fact that swing is traditionally played by ear, and therefore this is a long-debated topic in swing literature. Charles Keil (1966, 1987) in particular argued that performer-specific 'participatory discrepancies' from a syntactic norm could be the very elements that produce swing (1987). This was experimentally refuted by Butterfield (2010), who found that such deviations can heighten or attenuate the power of swing, but do not constitute that power as excessive deviations distort perception of the underlying syntax structure. Studies showing that listeners prefer more stable rather than overly varying microtiming deviations from metronomical rhythmic positions in jazz and other groove-based styles (Busse, 2002; Datseris et al., 2019; Davies et al., 2013; Kilchenmann & Senn, 2015; Senn & Kilchemann, 2016) further support the notion of swing as a syntactic framework that is strengthened or weakened by sub-syntactic processes. This is particularly true of Busse's (2002) research on MIDI-generated swing, which demonstrated that listeners do not prefer computer-generated swing rhythms any less than performed swing rhythms, as long as the computer-generated ones are not overly simplistic. These results confirm that listeners understand swing as a systematic configuration of events whose power is further enhanced or reduced by additional sub-syntactic processes. This also agrees with Vuust and Kringelbach's (2010) assumption that the positive affect associated with swing production may reinforce successful pattern prediction.

The swing groove archetype

Since a groove archetype's attributes are socially negotiated, several archetypes may appear very similar. That is why it is important for a definition of any archetype to be open enough to create a widely recognisable representation, but closed enough not to be confused with another archetype. Table 2.1 draws on the swing techniques established earlier in this chapter to create such a definition of the swing groove archetype ('swing'). Although swing's features cannot be identified unequivocally, the features listed in Table 2.1 create a syntactic configuration that should make it possible to differentiate swing from other groove types. They also satisfy the earlier definition of a groove archetype as a syntactic configuration of event placement, event durations, and event dynamics, as appropriate to tempo.

Swing features	Satisfies groove archetype definition
Synchronization with beat An evenly spaced, near-metronomical beat articulated explicitly by bass and percussion instruments, which soloists link with at structurally important moments, such as phrase endings. (Ashley, 2002; Butterfield, 2001; Berliner, 1994, 198; Benadon, 2006, Berliner, 1994; Susman & Abene, 2012, 58; Wesolowski, 2012, 39-40).	- Event placement - Event dynamics
Unequal quavers An unequal subdivision of the beat, with a tempo- and phrasing-dependent varying beat-upbeat ration (BUR) typically above 1:1 and typically imagined as 2:1, with short and accented upbeats highlighting the ensuing downbeat through syncopation. (Benadon, 2006; Butterfield 2006, 2011; Friberg and Sundström 2002)	- Event duration - Event placement - Appropriate to tempo - Event dynamics
De-synchronization from the beat A melodic line that forms a complex and only occasionally synchronised rhythmic and dynamic relationship with the underlying beat sequence. Synchronization with beats is often merely implied through syncopation and accenting, since notes are displaced ahead and behind the metronomic subdivision of beats to create expressive effects at particular moments in the phrase (in the form of downbeat delays at the beginning of phrases, sped up phrase speed, anticipated downbeats, and higher BURs at the beginning and end of a phrase with lower BURs in the middle; BURs are lower at low and high tempi than at mid-range tempi). (Ashley 2002; Benadon 2006; Brothers, 1994; Butterfield 2006, 2011; Friberg and Sundström, 2002; Pressing, 2002; Susman & Abene, 2012, 60; Wesolowski, 2012; Zbikowski, 2004)	- Event placement - Event duration - Event dynamics - Appropriate to tempo
Articulation A strong emphasis on upbeats and backbeats. Both staccato and legato articulation is employed to tie syncopated (i.e. anticipated) notes perceptually to the ensuing downbeat position. (Butterfield 2006; Berliner 1994; Monson 1996, 28; Sussman & Abene, 2012, 60; Wesolowski, 2012; Zbikowski, 2004).	- Event duration - Event placement - Appropriate to tempo - Event dynamics

Table 2.1: Features used to identify a performance as a member of the swing groove archetype

As a result of the information summarised in Table 2.1, swing is here operationally defined as a groove archetype with a performance syntax characterised by a near-metronomical beat with emphasis on the backbeats, a tempo- or phrasing-dependent unequal subdivision of the beat, and an only partially synchronised melodic phrase structure that relies on displacing notes from their metronomic positions, using articulation to effectively syncopate and circumscribe the underlying beat sequence. Given that these syntactic characteristics of swing remain somewhat broad, their power of engagement is strongly influenced by the particular sub-syntactic responses of the performers who execute them.

Summary: Swing's theoretical syntax

In summary, this chapter provides a theoretical operational definition of swing based on its component techniques as suggested by empirical literature. Swing is theoretically defined as a conceptual phrasing structure or groove archetype. Performance manifestations of groove archetypes such as swing can be assessed qualitatively for their ability to induce groove and on whether they violate the underlying syntax. A number of syntactic processes for swing are included in the definition. Their ability to induce groove are heightened or dampened by their performer-specific application.

Now that swing has been operationally defined and its component techniques have been identified, the next chapter (Chapter 3) will examine how they are conveyed in traditional forms of swing notation. That will demonstrate the difficulties of learning swing from conventional notation without the benefit of relevant ear-playing skills. The chapter after (Chapter 4) will investigate why many classical musicians might struggle in acquiring such ear-playing skills based on their enculturation and training.

Chapter 3: Notation of swing for intercultural performance

Music notation is a powerful tool: It allows for displaying a wealth of musical detail to mediate the social interactions of performers (Schuilling, 2019). In a Western classical context, it can allow for planning out complex musical performances of compositions that are too long and too intricate to be performed by ear or from memory alone and coordinate potentially large numbers of musicians. However, as a mediating agent, notation also has limitations in its communicative ability, especially regarding communicating nuanced gestures across cultural boundaries and in groove-based contexts, as this chapter will show.

As laid out in the previous chapter, groove archetypes are abstract conceptions and (like any form of musical intent) can only be realised in performance. This is particularly true of swing, which, as was shown, relies heavily on the situation-specific deployment of improvisational techniques, and therefore may resist detailed codification in notation. The current chapter will analyse several notational styles to explore particularly which features of swing are difficult to represent and induce via notation. This will provide the context for Chapter 6's assessment of why classical performers may experience difficulties when attempting to swing from notation.

3.1. Scripted action in music scores

From a perspective of describing musical outcome, Western staff notation can never create a definitive representation of a musical performance—for as Bennett puts it: 'To make the notation dense enough in informational detail to take in all the features of music, the notation would become the music itself.' (1983, 219) Cook therefore describes the score as less of an artwork in itself and more of 'a highly worked out, and often hermeneutically suggestive, framework' (2014, 225), which performers fill with musical content.[19] Since, as Cook implies, a score is not a static set of instructions with a predictable outcome, notation cannot be relied on to reliably produce performance details beyond a certain general limit. Consequently, Schuilling (2019)

[19] Cook also adds: 'regarded as specifications of sound, Mozart's string quartet scores are woefully incomplete […]. But that is not the right way to see them. Like lead sheets, Mozart's notations define frameworks within which musicians collectively negotiate the fine details of their performance.' (2014, 235)

suggests that notation should not be considered as a representation of an underlying musical text or a desired performance, but rather as a form of mediation between text and performance, thereby empowering musicians' creative efforts.

This perspective accounts for transcriber bias inherent in musical transcriptions, which, highlight some musical elements at the expense of others (Bennett, 1983; Grupe, 2006).[20] Any music transcription must be done in the conscious knowledge that highlighting certain structural features in notation for educational or analytical purposes will involve limitations: At worst, transcription leads to culturally charged misrepresentations—at best, to a purposeful act of highlighting the most essential aspects of a desired performance. Consequently the meditational role of notation also assumes tacit conventions understood by performers and composers/transcribers, which is further addressed in the next section.

3.2. Scores and tacit knowledge

Any aim of using notation as an educational tool in an intercultural context is easily frustrated by diverging cultural attitudes towards notation. In the vast majority of music cultures—and especially popular music styles—notation may fulfil a host of social coordinative and mediating functions, playing an empowering (Schuilling, 2019) or at least mnemonic rather than prescriptive role (Bennett, 1983). While this does not mean that notation is unimportant in such music cultures, it highlights that different ontologies of music and notation allow musicians to 'position themselves differently as agents in relation to the various processes of social interaction that characterize performance' (Schuilling, 2019, 444). This also means that there are inherent limitations in communicating musical intent via notation, since different tacit cultural expectations may come to bear on how notation is engaged with. Consequently, performers' experience and training play a major role in how they approach a score for performance, since a shared tacit understanding among genre performers of what 'normal' behaviour is affects how

[20] Bennett aptly describes notational systems as 'sound-noticing systems, cultural creations that emphasise attention to some aspects of sound while suppressing others.' (1983, 217)

they imbue notated music with the right degree of latitude in terms of tempo, rhythm, dynamics, and articulation (Cole, 1974, 33; Lehmann & Kopiez, 2016).[21]

As a result, the score as a dynamic entity exists in an ongoing state of cultural negotiation with its writer and interpreter in a way similar to language text: The act of language writing involves a dynamic exchange with the written medium in forming and editing the written message, so that the medium can be said to restructure a writer's cognitive process (Menary, 2007). A similar dynamic exchange can be said to take place between reader and written medium during the act of reading (Harris, 1989). With regard to music notation, this is what Schulling refers to as 'the way in which notation can construct its user […]' (2019, 454).[22]

Given the human agency in interpreting notation, musically deterministic communication attempts via notation are unlikely to be successful and Cox (2002) finds that even the hyper-prescriptive wealth of notational detail in modernist complexity scores can only express technique, but not intent.[23]

Part of the problem of communicating musical intent is that the score requires performers to identify the tacit conventions 'implicit in the material', as Cox puts it, and apply their interpretive knowledge appropriately. Through in-depth study and interaction with the score, performers may attempt to approach such conventions and begin to flesh out the performance, often filling in missing information with diacritical markings that make explicit any implicit assumptions; these processes help them to memorise and practice their own unique performance based on the musical text (Payne & Schuilling, 2017). When score and performers share a set of cultural norms, this is less of a problem, since the score's interpretative framework forms the very basis for novel musical interpretation within a socially accepted deviational norm.

However, if this is not the case, as for example when performers engage with scores from other cultural backgrounds than their own, the negotiation process between score and differently enculturated musicians breaks down and there is a risk that performers will project their own

[21] 'The jazz player will bend and modify time and pitch in note sequences in ways that would be wholly unallowable for the straight player' (Cole, 1974, 20).

[22] 'we can see this function of notation in terms of a more general way in which musical performance challenges and reshapes standard accounts of human agency, and ask how musicians are being called upon and constructed as creative agents, and on what basis their subjectivity is perceived as (more or less than) human.' (Schuilling, 2019, 454-5)

[23] 'notation is both too unclear and too precise: it […] indicates a vast amount of previous technical, theoretical and stylistic knowledge [to performers] for their realization, and can only barely indicate the […] "spiritual" domain intended by composers and implicit in the material.' (Cox, 2002, 88)

cultural tacit conventions on the notation, thereby creating a personal, but socially inappropriately styled ethnocentric performance. The following section will explore further how these problems specifically apply to the interpretation of swing notation styles by classical performers.

3.3. Swing in notation

As described in Chapter 2, the syntax features ascribed to the swing groove archetype remain abstract conceptions until they are articulated in performance, where their effect can be heightened or attenuated by performers' individual responses. Given scores' potential for empowering musicians' creativity in a dynamic interaction process, it may be possible to communicate basic swing syntax features with roots in universal musical principles, or at least in shared musical ground between text and performer, via notation. However, due to this interaction process and scores' limitation in representing dynamic musical process, the precise performance of these syntax features is unlikely to be deterministically 'fixable' in conventional Western staff notation. As a result, though syntax features can likely be indicated in notation, the sub-syntactic performers deviations cannot.[24]

In response to this dilemma, as found often in hyper-descriptive contemporary classical compositions, Kanno (2007) recommends turning away from 'descriptive' scores and towards 'prescriptive' scores, which outline process and gesture rather than musical outcome; their aim is to alter performers' psychological state when reading the score and focus on empowering them to engage more deeply with the expressive potential of the music. This is challenging in intercultural notation, where processes should be described as closely as possible to avoid misinterpretations based on differing enculturation, but remain open enough to avoid curbing performer responses and so creating a stilted performance.

[24] This is borne out by comments in the literature on how difficult swing is to capture in notation: Don Banks writes that 'The subtleties of jazz phrasing [...] are such as to defy precise notation at times' (Banks 1970b, 61), and Keil comments: 'Every drummer has what is known in the jazz argot as a distinctive tap, that is, a manner of applying stick to cymbal. The basic tap may be notated approximately' (Keil 1966, 341). Schuller—in a preliminary note to his *Woodwind Quintet*, which utilises jazz rhythms in a piece for classical performers—points out the limitations of notation, since he finds that precise transcription of a possible swing inflection with all the relevant nuances would be 'in the long run self-defeating in its complexity' (*Woodwind Quintet*, 1968).

In attempting to communicate across stylistic boundaries, it therefore may be more productive to think about how notation can enable the text's musical intent and process in the act of mediation, instead of aiming to outline a specific sound result in notation. In the specific context of swing notation, the aim should therefore not be to *describe* musical outcomes, but to *enable* performer actions that are the basic requirements for the musical gestures and actions necessary to produce swing. In the intercultural context explored here, where the aim is to elicit appropriate sub-syntactical responses from classical musicians in a swing context, it makes sense to take into account performers' existing skillsets when notating.[25] Following this line of thought, the aim of intercultural notation should be to play to the strengths of musicians' culturally overlearned responses while outlining tacit knowledge. Therefore, this section considers how different swing notational styles can tap into pre-existing task-specific skillsets in performers while filling in any enculturation-based knowledge gaps.

Butterfield's suggestion that swing 'is less a specifiable rhythmic essence than an active rhythmic process involving the skillful management of "motional energy" in the midst of performance' (2011, 4) is a useful guide. This view of swing as a dynamic practice rather than static outcome accounts for how swing techniques are employed context-specifically. Therefore, following Kanno's 'prescriptive' scoring approach, it may be more useful to conceptualise any notational techniques used to communicate swing as means to an end instead of goals in themselves. Instead of prescribing an invariable outcome aimed at producing predictable results, the aim of notation should be to engender a stylistically defined but variable process. This also addresses that many swing techniques—BURs changing from moment to moment, shifting articulatory emphasis, variable phrasing used to create an appropriate momentary response to the musical context—are entirely situation-specific. Therefore they cannot be pre-figured in any form of notation, since fixing them defies their very nature. At best, notation can offer approximations of swing processes by describing the gestures that underlie them.

This reflects a common problem in notation, which Cook (2014) aptly describes in a few words: 'Writing sucks time out of music' (248). Cook points out that, due to its static nature, notation can only spatially indicate what are actually temporal processes in music. Time flow is

[25] Cook likens the way scores script social action to the way managers enable their employees to work together—avoiding excessively specifying details in order to empower people to use their own creativity and the tacit knowledge that already governs their interactions (2014, 265).

something that a score can only represent figuratively, as it represents a static and quasi permanent snapshot of a musical piece as a whole. A score therefore cannot adequately represent the ebb and flow of phrasing. As will be shown in the following section, this inherent limitation of notation is addressed differently in various styles of swing notation.

Jazz notation

In jazz traditions, notation traditionally fulfils a primarily mnemonic purpose, enabling musicians by providing a comparatively basic melodic and harmonic structure, asking that musicians flesh it out based on their expertise in variation and improvisation. Pieces are traditionally represented by so-called 'lead sheets'—bare-bone depictions of melodies that primarily show pitch and only the vaguest rhythmic and phrasing detail. As mentioned in Chapter 2, despite the generally assumed sense of a 2:1 BUR in swing (e.g.  in crotchet-based contexts), jazz notation usually represents swing quavers as equal () and relies on verbal instructions or often mere inference for a swing effect (see Figure 3.1).

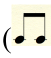
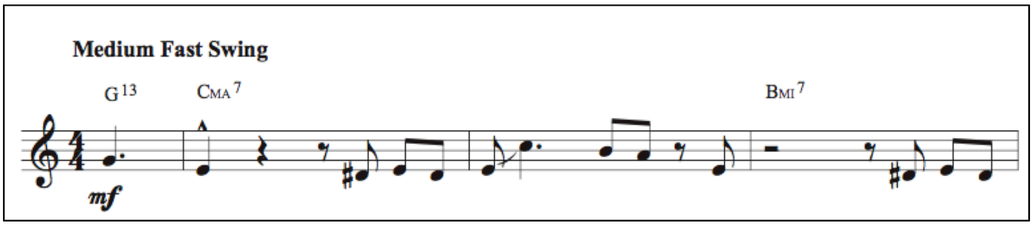



Figure 3.1: Example of four bars from jazz standard *I've Heard That Song Before* (Cahn & Styne, 1942)

The reason for the apparent misrepresentation of BURs in jazz notation seems to be that jazz performers are expected to work out or 'feel' the adequate ratio between the longer first and the shorter second quaver according to context. Contemporary jazz performers playing from scores are expected to swing notes of equal notational value unless explicitly instructed not to, letting context dictate the exact note placement (Monson, 1996, 53; Davies, 2018, section 'Jazz Notation – The Default'; Sussman & Abene, 2012, 62). Sometimes (as in Figure 3.1), this context is provided by a simple tempo or groove indication, which performers understand in tacit agreement on the appropriate rhythmic inflection (Sussmann & Abene, 2012).[26] [27]

This demonstrates how musicians assume a default mode of performance unless explicitly told not to do so, and therefore exemplifies the wider point of how performers cannot be simply notationally literate, but must be notationally literate in a culturally informed and appropriate manner (Stenberg, 2019, 39-40).

Classical notation adaptations

The obvious problem with tacit expectations is that they do not translate easily across cultures. In music, this is even more exacerbated by diverging cultural attitudes towards the exactitude with which musical options embedded in notation are to be interpreted:

> 'Any jazz musician, from a student to a seasoned professional, will instinctively interpret a series of eighth or sixteenth notes toward a triplet feel, with varying degrees of emphasis […] classically trained musicians will generally interpret the same passage literally, playing the rhythmically correct eighth and sixteenth notes.'

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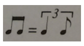
[26] The occasional marking of  may clarify this further for jazz-unenculturated musicians, but generally indications such as 'Medium bounce', 'Slow blues', 'Medium blues', 'Jazz waltz', 'Slow', 'Moderately slow', 'Bright', 'Moderato', or 'Marcato' are expected to elicit different degrees of swing; similarly 'Rock style' is assumed to be played straight, while 'Boss nova style' or 'Ragtime style' are subject to their own particular groove inflections (all these markings are practical examples found in the sheet music publication *Saxophone sight-reading* by Paul Harvey, 1997).

[27] This approach of relying on tacit convention for the rhythmic interpretation of notation is reflected throughout multiple periods across music history. A good example is the French Baroque tradition of playing equal note values as 'notes inègales' (literally 'unequal notes'). Much like in swing, inégales performers would commonly extend the first note of an equally notated pair, taking many different stylistic factors into account in order to decide on the exact durations of the individual notes (Rastall, 1983, 211). As in swing, this manner of interpretation was so common that it rarely was made explicit in the notation, and so a composer wishing to avoid it would have to explicitly state his wish in the score by written instruction or placing particular articulation marks over the un-swung notes (Rastall, 1983, 211-12). Also as in swing, even in examples where the 'inégales' style was explicitly notated, its exact rhythmic execution remained subject to interpretation, with the length of a dot in dotted rhythms becoming subject to a variety of interpretations according to context and period (212-13).

Another good example is medieval music's use of rhythmic modes: These were commonly known rhythmic patterns of long and short syllables, as based on poetic metres, which were used to interpret ligature notation. The organisation of the ligatures would suggest the appropriate mode for the piece and so enable singers to draw on their knowledge of the correct rhythmic inflection for synchronisation in polyphony (Rastall, 1983, 37-38). Since the rhythmic relationship between long and short syllables could differ across different modes, performance practice and context defined the exact value to be sung, which is why Bennett points out the modes as an example of how pre-existing musical knowledge is required for interpreting notation (1983, 221). Interestingly, Mode I, the oldest of the modes, reflects a short-long pattern similar to the modern 2:1 BUR notation of swing. It's context-specific interpretation and the fact that exact note-placement would have to be agreed upon by performers is further reminiscent of swing's context-specific nature.

(Sussmann & Abene, 2012, 62)

In response to this specific problem, classical notation practice often offers an approximation of swing. Following classical notation practices, phrasing is often approximated in greater detail than in the minimalist jazz notation style, as appropriate to the composition's or ensemble's requirements. More importantly, swing is indicated in the rhythmic spelling out of the material, usually either as crotchet-quaver triplets () in a 4/4-time signature or as alternating crotchets and quavers in 12/8 (see Figure 3.2).[28]

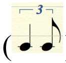
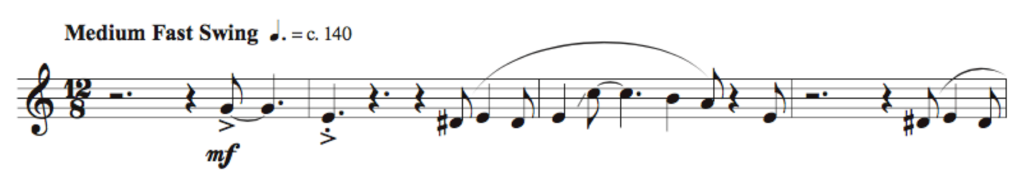



Figure 3.2: Example of four bars from jazz standard *I've Heard That Song Before* (Cahn & Styne, 1942) transcribed into the traditional classical depiction of swing

The result is a fixed 2:1 (or occasionally 3:1) BUR employed throughout the piece, which is problematic since the fixed BUR oversimplifies the diverse role of BURs (as laid out in Chapter 2). Considering classical musicians' greater adherence to notational instruction compared to jazz musicians, this can therefore lead to a stylistically inappropriate, stilted interpretation by performers uninitiated in jazz phrasing.[29]

The classical adaptation of swing in notation is problematic in several other ways. Not only does it heighten the risk of classical performers interpreting the fixed BUR in notation too

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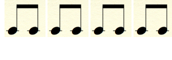
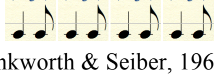
[28] The piece *Improvisations for Jazz Band and Symphony Orchestra* by bigband leader John Dankworth and classical composer Mátyás Seiber shows the rhthms for jazz musicians in 4/4 with straight quavers and for classical musicians in 12/8, with a footnote stating: 'According to Jazz convention the rhythm  is played approximately  Therefore, these bars are in unison with the Jazzband [sic] in spite of different notation.' (Dankworth & Seiber, 1961, footnote attached to bars 44-46; underline in original).

[29] This reductionist approach to notating swing rhythm reflects a long-critiqued Western Art music tradition of prioritising pitch and harmony over rhythm or timbre in the transcription of African-American music styles (Kenny, 1999).

literally, but it also highlights different cultural expectations surrounding phrasing structure and articulation. One of the greatest obstacles to classical musicians attaining jazz phrasing is navigation of the beat, with swing's near-metronomicity (Larsen, 2006) and its corresponding syncopations (Sussmann & Abene, 2012, 59) presenting particular challenges. This is likely due to the differing role of rubato across the two performance cultures: Since the nature of syncopation (as used in swing) requires the tactus beat to be predictable, so that the syncopation can anticipate perception of the beat, syncopation works most effectively when the tactus beat is steady and played without rubato. As noted in Chapter 2, rhythm instruments in a jazz band articulate the underlying beat with near-metronomic precision, while soloists can play with extensive rubato in their phrasing, essentially dividing the roles of the band members. Ashley points out that this division of the jazz group into rubato and non-rubato roles is a significant departure from the wider classical tradition of allowing rubato to affect all performers simultaneously (2002, 32).[30] Part of classical musicians' challenge in performing swing is therefore learning to desynchronise more from their ensemble as a whole at key moments to ensure both a steady tactus beat and swing-appropriate deviation from it. However, by showing a steady BUR, classical notation of jazz implies that musicians remain synchronised throughout the performance, culminating in a stilted performance that is both too flexible (in tempo) and too rigid (in its fixed BUR).

As with tempo, different cultural expectations also exist around articulation markings. Just as many markings are interpreted differently in classical music practice depending on performance context (Gould, 2011, 114), the same markings often represent slightly different actions in jazz traditions (Sussmann & Abene, 2012, 151-52).[31] This also affects how different tactus beats of a bar attain different weights across various performing cultures: Notably the backbeat emphasis in many African-American, popular, and folk music cultures contradicts the

[30] Ashley assumes a somewhat limited role of classical music practice here and ignores the liberty individual musicians may take, particularly in opera, solo, or chamber music performance. However, the specific approach and circumstances that lead to spontaneous individualistic expression in jazz melody phrasing are nonetheless very different from those in the wider classical practice. Therefore they may pose significant obstacles to emulation by classical musicians, and so this difference is highlighted here.

[31] This affects both accent and timing, with ensembles developing their own idiomatic phrasing based on their performance habits and the motor feedback gained from their instruments—for example, classical string sections will often treat staccato markings in a rhythmically contracted manner, causing certain beats to take up less metronomic time than others, as pointed out by Hollywood conductor and orchestrator Tim Davies (2018, 'Conducting Part 3'). He mentions that this is partially also a problem inherent in notation, which 'is great at telling people how to start a phrase but it is not great at conveying how to end one' ('Conducting Part 2').

emphasis traditionally placed on beats 1 and 3 of a 4/4 bar in classical traditions (Temperley, 1999). A similar problem also applies to sub-tactus beat divisions, with classical performers likely to emphasise the downbeat rather than the upbeat of a swing quaver pair or to shorten the third note of a triplet (Schuller, 1958, foreword).

As a result of these cultural differences, classical notation of swing suffers from several problems. The fixed BUR implies both overly rigid synchronization and overly coordinated tempo variation, while articulation markings can activate stylistically inappropriate accenting and phrasing behaviours. In this way, classical notation of swing can exacerbate rather than alleviate differences in performer attitudes between many jazz and classical musicians, playing inappropriately into latent classical conceptions of phrasing and articulation. Therefore it is possible that this classical notation contributes to why many jazz aficionados in the literature find that only jazz performers are capable of delivering a convincingly phrased musical result (e.g. Banks, 1970a, 59; 1970b, 597; Dommett, 1964, 19).[32] This questions will be explored further in Chapter 6.

Specialist notation systems

Perhaps in response to these challenges, several jazz-enculturated composer-performers have applied specialist notation systems in swing transcription or notation. These are specifically designed to bridge the cultural gap between Western staff notation practices and swing performance. This section will examine a selection of these systems, each of which features advantages and drawbacks for use by classical musicians. I will also propose an alternative with a view to assessing classical musicians' swing experimentally in Chapter 6.

One option of depicting swing processes in notation is the detailed transcription of a representative performance using Western staff notation in the manner of a complex modernist

[32] In response to these issues, many crossover composers using jazz in classical concert works therefore choose a set-up reminiscent of the Baroque *concerto grosso*—dividing performers into a larger classical ensemble and a smaller jazz band (Ehle & Ehle, 197; Hair, 2007; Sussman and Abene, 2012, 62). Often this is done with the aim of scoring swing passages for the jazz band only, with the orchestra providing sustained backing notes or phrasing around the band's intricate rhythms (examples abound; see for example Turnage & Scofield's *Scorched* (2001), Dankworth and Seiber's *Improvisations for Jazz Band and Symphony Orchestra* (1961), or Schuller's *Conversations* (1959)). This way composers avoid causing any phrasing clashes between the groups. As composer Don Banks writes: 'I am convinced that one should not expect orchestral musicians to deal with jazz phrasing, and equally sure that one should not inhibit jazz musicians from their natural inclinations in dealing with a phrase. Let each party do what he can best achieve.' (1970a, 61) However, this approach merely avoids but does not address question of how to deal with classical musician's performance of swing.

score. A good example of this is guitarist Roland Dyens' transcription of Thelonious Monk's piano recording of *Around Midnight* for classical guitar (Williams, Monk & Hanighen, 2001). This is a transcription of an iconic solo instrument performance arranged for another solo instrument. Therefore it avoids many of the synchronisation issues in larger ensembles in favour of addressing questions of transcribing a specific fixed performance, while offering notational solutions to displaying swing processes.

Dyens uses a hyper-detailed notational image, filled with: changing or unspecific time signatures (but including 12/8 for extended swing passages); fanned beams to indicate ritardandi and rallentandi on specific note groupings, as well as 'rit.' and 'rall.' markings in different fonts to indicate local and sectional tempo changes; detailed articulations on individual notes; groups of grace notes with changing note values; and detailed rhythmic subdivisions throughout the score (though he avoids complex tuplets, only using sextuplets, triplets, and quadruplets). As a result, the phrasing and articulation structures from Monk's performance, including changing BURs and complex rhythmic gestures, are closely approximated on the page. The wealth of detail makes this score suitable for the carefully preparing solo performer who wishes to reproduce this specific performance, as is intended by the arranger. However, due to its exacting nature, this approach also encourages greater performer adherence to displayed details rather than enabling spontaneous phrasing. This, together with its notational density, makes it less feasible for time-pressed musicians and ensemble performances.

A visually simpler approach is suggested by Haywood (1993), who provides solutions for depicting the anticipation/delay of notes from their metronomic position without specifying these in the note text. In the manner of Kanno's 'prescriptive scoring' of actions rather than outcomes, Haywood recommends using arrows of varying thickness underneath individual notes in order to indicate how far they can be moved off the metronomic position, with an initial symbol key explaining which thickness corresponds to which note-value. As a result, Haywood's system combines jazz-style notation with visual aids, which addresses the beat-independent nature of swing phrasing, with its downbeat delays and rhythmic anticipations, but still allows for relatively free individual interpretations. However, this very freedom is also its disadvantage, as the system expects a degree of jazz experience among performers for stylistically accurate interpretation of the relatively imprecise arrows. An added complication is that performers must first learn the symbol key by heart, so that they can internalise which arrow thickness indicates which level of displacement, posing a challenge to many performers with overlearned notation reading habits and little rehearsal time.

Stewart (1982) proposes a similar system to Haywood that offers a solution to this last criticism. By superimposing Western staff notation over a grid of lines showing where the metronomic beat is, he presents notes in easy-to-read Western note heads, but accurately shows their displacement in spatial terms by moving them away from the lines. In doing so, his system also indicates swing's quasi-metronomic tactus beat structure very clearly. While this requires performers to translate spatial displacement into temporal displacement, and so may metaphorically challenge some performers, it offers a relatively intuitive solution to the problem of displaying varying rhythmic ratios. However, this also makes it visually challenging, with groups of notes bunched up closely together while others are spaced far apart. Regarding articulations, Stewart proposes letters with superscripted numbers above individual notes, with each letter describing an articulation effect (e.g. attack, slurring, etc.) and the number indicating the degree of severity. This approach offers finely grained differences in articulation, but it also requires performers to read both in and above the staff for each note, making it difficult to interpret quickly.

In summary, the three approaches presented here all offer some advantages, but suffer from being visually complex and either overly detailed or overly reductionist, and therefore are unhelpful in light of short preparation time or for synchronised ensemble performance.

The explicit swing notation

In preparation for the experiment outlined in Chapter 6—in which classical performer's are assessed by how much swing they produce when sight-reading from different notational styles—I have drawn on the approaches outlined above and synthesised them into yet another notational approach to approximating swing. Based on the criticism outlined above, this system makes the various processes required for Chapter 2's swing syntax explicit and offers a readable, easy-to-interpret solution aimed specifically at classical musicians.

I followed the previous examples in adapting Western staff notation instead of proposing a new system, allowing me to build on skills that classical musicians already have.[33] This has the practical benefit of saving on rehearsal time, since musicians do not need to familiarise themselves with an entirely new way of decoding symbolic instructions. In addition, it quantifies time in a way that classical performers are accustomed to, and can be used to indicate dense rhythmic events (as in Dyens' approach outlined above) as has become common in contemporary classical scores. Drawing on musicians' existing skills in this manner may allow me to enable desired performance mannerisms without over-specifying the desired effect.

As a result of all these considerations—performer strengths, the normalisation of complex notation in some contemporary Western art music styles, the need to specify tempo behaviour—the explicit swing notation takes the basic shape of complex conventional Western art music notation. It uses verbal instructions and arrow markings (though differently from Hayward above) to highlight timing. As its basis, it takes the syntax features of swing outlined in Chapter 2 and aims to show them explicitly in an attempt to enable relevant sub-syntactic responses. Figure 3.3 shows an example of this notation style, featuring the same music excerpt as in Figures 3.1 and 3.2.[34]

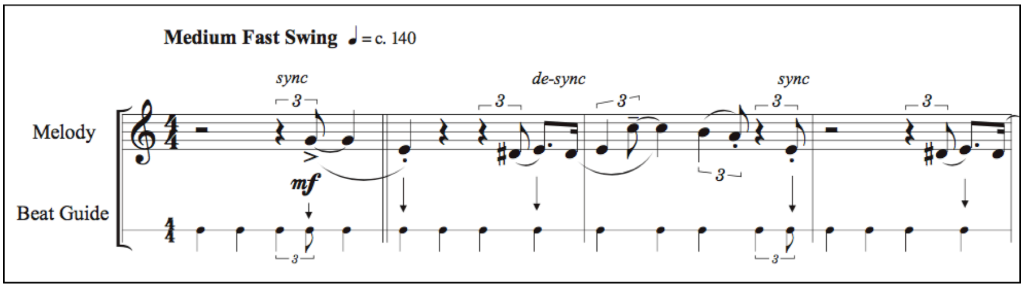


Figure 3.3: Example of four bars from jazz standard *I've Heard That Song Before* (Cahn & Styne, 1942), transcribed into the explicit swing notation system.

[33] Even though an entirely new notational system may act like a blank canvas—having the benefit of not carrying with it a range of historical associations and therefore perhaps evoking less ingrained classical associations accumulated during hours of training and experience (although performers might immediately fall back on exactly those instincts when faced with an unknown notation system)—a conventional notation system does not require learning new music reading skills from the ground up.

[34] The music text shown is a close transcription from a sample performance found on a jazz learner book's accompanying CD (Cahn & Styne, 1942). The audio was integrated into the notation programme (MakeMusic Finale 25) and the notation was adjusted until its MIDI playback was no longer noticeably different from the simultaneously playing original performance.

A tempo inscription above the score shows the exact tempo and explicitly references swing, avoiding more detailed genre-internal descriptions such as ‘Bounce’ or ‘Jazz Ballad’, which are unhelpful to unenculturated performers. The notational text uses simple subdivisions and avoids fanned beaming (unlike in Dyens’ approach) as well as intricate tuplets,[35] in order to allow for quick readability under time pressure. Articulations are employed in the manner common in classical music scoring, carrying associations understandable by most classically enculturated musicians. Early or late attacks are indicated by a combination of fast rhythmic subdivisions and grace notes or grace rests (not visible in Figure 3.3).

The system also features an additional staff titled ‘Beat Guide’, with arrows indicating when certain notes should link with the metronomic grid. Since Western staff notation is limited in displaying temporal flow, it was necessary to find a way to make explicit how pulse underpins swing’s time flow and its rhythmic inflection. The Beat Guide serves to ensure that differing approaches to time flow between classical and jazz musicians don’t undermine the regular beat oscillations needed for a swing effect. It also shows the relationship between a beat and its surrounding elements (anacruses, accent, phrasing across the beat, anticipation or delay). This serves to clearly delineate how important a steady tactus is, which quality of timing both the tactus and melody phrasing require, and how varying instrumental roles (e.g. background rhythm, foreground solo) are linked and interact while still retaining degrees of autonomy.

This last point is additionally reinforced by instructions above the main staff titled ‘sync’ and ’de-sync’, which are meant to empower musicians in choosing when to depart from or lock with the underlying grid. The system avoids overly specifying anticipations and delays (unlike Dyens’ dense scoring approach), but does not assume an advanced degree of enculturated knowledge (unlike Haywood’s arrow approach), and so does not distort the notational image (unlike Stewart’s grid-based system). Although research by Stenberg and Cross (2019) indicates that musicians may benefit from additional spacing in sight-reading scenarios, this feature was

[35] Benadon (2009) discourages the use of fanned beaming for accelerandi or rallentandi. Although he finds it a helpful guide for placing event onsets, he claims it will lead to performance inaccuracies when performed in a larger ensemble or when articulation markings are added. Additionally, instead of complex rhythmic subdivisions, he recommends tempo substitutions, so that rhythms that appear notationally complex at one tempo are simpler in another. However, several fast tempo changes in succession are also likely to lead to performance errors.

not applied here in order not to overload the score with novel features any more than already present.

Overall, the explicit notation was designed to be both specific (detailed notation, arrows) and open ('sync'/'desync' markings), offering information on motional actions required for swing syntax in the manner of Kanno's (2007) prescriptive score, while depicting rhythms and articulation markings in a manner already familiar to classical musicians. It was created under the hypothesis that performers who rely strongly on notational instructions may engage more strongly with a detailed yet readable depiction of swing. This hypothesis was formed based on the assumption that classical performers, due to their more notation-focussed practice, are less likely to learn swing by ear alone, as is the common jazz practice.

Summary: Notation is limited in encouraging swing

In summary, notation plays a mediating role between composer/transcriber and the musician, relying heavily on shared tacit norms for style-appropriate performance, which is exacerbated in jazz notation due to its minimalist styling. The traditional classical notation of swing attempts to overcome this obstacle by showing swing as a steady BUR, which in itself is problematic as it suggests an inappropriately rigid phrasing structure and does not take the different degrees of rhythmic deviation among backing band/soloists into account. This has been partially addressed in several experimental notation styles, including the explicit swing notation I designed for the experiment presented in Chapter 6.

It should be stressed again that swing is traditionally learned by ear. Therefore, it is ideally attained by long-term enculturation, which likely no form of notation can replace. Unfortunately, classical musicians' real-world performance scenarios do not always allow for extensive aural preparation before performing a piece that features swing—particularly if the target performers are musicians used to interpreting music from a score. That is why notational instruction, though not ideal, is sometimes necessary.[36] The question of notation's efficacy in

[36] Watson (2010) and Laughlin (2001) both showed that notational instruction (using straight-quaver jazz notation) yielded a learning effect in unenculturated jazz beginners—albeit one much weaker than the one generated through aural instruction. Together these studies suggest that notational instruction for jazz techniques can have some learning effect and therefore may be an acceptable short-term measure for slightly improving musician's expertise.

enabling swing is particularly relevant in light of how enculturation shapes music learning mechanisms—as pointed out in Chapter 1, while jazz musicians tend to learn music by ear, classical musicians tend to learn new music pieces from notation. Therefore, classical musicians are less likely to learn by ear, which may present an additional obstacle in how swing can be communicated to them. This topic is explored in the next chapter.

Chapter 4: Score-dependency as a potential consequence of classical musicians' performance practice

As shown in the last chapter, traditional forms of swing notation are limited in enabling swing processes, meaning that performers must infer the minutia of stylistically appropriate rhythmic responses by ear. That is likely why swing is traditionally learned by ear, as defined by Lilliestam: 'to create, perform, remember and teach music without the use of written notation' (1996, 195). Consequently, the accusation that many classical musicians struggle to swing implies a negative judgement not only on their limited enculturation in jazz, but also on their ear-playing abilities.

However, given many classical performers' extensive music education and expertise, why should playing by ear present a problem to them? It is noticeable that notation shows more musical detail in classical music traditions than jazz. Since playing by ear, like many music skills, is acquired by participation in domain-related activities (Hakim & Bullerjahn, 2018; Musco, 2010; Woody, 2019), musicians who are more used to inferring musical detail from notation rather than by ear perform worse at ear-playing tasks (Harris, van Kranenburg & de Jong, 2016; Woody & Lehmann, 2010). This raises the question whether classical musicians' participation in a more notation-focussed performance culture might manifest in specific modes of music perception and action—and consequently affect their swing production.

That question will be explored experimentally for aural reproduction generally in Chapter 5 and for swing specifically in Chapter 6. In this chapter, I will lay the groundwork for these two experiments. By summarising empirical literature on how classical musicians' enculturation might manifest in specific behavioural patterns, I will examine how notational learning without corresponding ear-playing training can lead to **score-dependency (SD)**. I will examine possible neural and cognitive effects of SD, and will propose a model for how SD develops in musicians.

4.1. SD as an effect of notation-focussed practice

One of the most notable differences between many music styles (including jazz) and Western classical music is greater reliance on ear-playing in the former and on notated musical detail in the latter. Due to the central role of playing from notation in classical music, it is especially important for classical performers to develop notational literacy and sight-reading skills (Bogunović & Vujović, 2012), which allow for the ability to perform music from notation without prior rehearsal. Yet, as Lilliestam (1996) points out, historically the majority of music has been played by ear. Therefore, he suggests, the introduction of music notation may also have implications for the perception and cognition of music for those whose practice centres on it:

> 'Unfortunately there are few discussions and analyses of how music and musical practice change when notation is introduced. Does the form of music and the way music is made change? Do note-reading musicians think about and conceptualise music differently than those who do [not] read and write music? Changes in these respects undoubtedly *do* appear, but the question is which changes and how do they come about?'
> (1996, 198; italics in original)

Consequently, this section explores how notational literacy shapes the perception, cognition, and execution of music.

Socially speaking, learning music from notation requires very different practice habits than learning by ear. Classical musicians spend more time practicing in solitude compared to popular musicians, concentrating on learning to engage with music notation and perfecting their associated motoric skills; popular musicians spend more time in social situations, focussing more on developing strong aural skills by improvising with and imitating other performers, as well as transcribing and composing by ear (Vuust et al., 2010; Feichas, 2010).[37] Therefore, formal classical music education encourages a form of specialisation, which—while necessary and important for performance practice in classical music—contributes to practice habits that are at odds with the development of imitative aural skills, particularly in group-based scenarios (Woody, 2012; McPherson & Gabrielsson, 2002).

It is only logical that literacy-centred music practice engenders the development of associated cognitive skills. General notational music literacy combines motor skills with skills for separately decoding pitch and rhythm information (Gudmundsdottir, 2010). A particularly

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[37]Feichas (2010) points out that classical musicians' practice methods—with their focus on individual study and literacy—are more closely linked to traditional notions of formal education; she finds that this link contributes to a social stratification of notation-based skills as 'high status' and ear-playing skills as 'low status', ultimately causing an entrenchment of literacy-based teaching patterns at conservatory level.

fluent form of music literacy is the skill of sight-reading (SR), in which music is performed from notation without rehearsal in real time. SR may therefore be considered a more intense music reading process due to the associated temporal constraints. With advancing complexity of notation, SR increasingly draws on performers' speed of information processing, psychomotor speed, and existing SR experience (Kopiez & Lee, 2006). The most important skill involved in SR is pattern recognition of musical elements (e.g. chords, patterns, harmony, contrapuntal motion), and more experienced sight-readers are able to look further ahead in scores, processing and executing musical features more quickly and in larger chunks than weaker sight-readers (Waters, Townsend & Underwood, 1998; Gudmundsdottir, 2010).

Statistically, SR frequently correlates positively with improvisation (Kopiez & Lee, 2006; Lehmann & Ericsson, 1993 & 1996; Lehmann & Kopiez, 2016; McPherson, Bailey & Sinclair, 1997; Mishra, 2014). This may be partially related to sight-readers' predictive ability to infer correct responses from a score's musical surface cues based on stylistic expertise (Lehmann & Kopiez, 2016; Mishra, 2014). Nonetheless, improvising and memorising music are independent skills from each other and neither one can statistically explain SR on its own (Lehmann & Ericsson, 1996). Notably, playing by ear has been shown to be a significant predictor of SR, but SR does not predict playing by ear (McPherson, Bailey & Sinclair, 1997). Instead, SR can enhance links between aural experience and notational representation if combined with aural skills training (Kendall, 1988).

This supports the view of SR as a result of long-term domain-related activities, which on its own does not reflect innate musical talent or necessarily a particular talent for SR (Gudmundsdottir 2010; Lehmann & Ericsson, 1996; Mishra, 2014; Waters, Townsend & Underwood, 1998; Wristen, 2005). As a result, an exclusive focus on music literacy in training and practice may limit top-down benefits in ear-playing scenarios (Harris & de Jong, 2015), at worst atrophying creativity and the ability to memorise music (Mills & McPherson, 2006). Classical conservatory students reported that they regretted lacking aural and improvisational skills, attributing this directly to their education's near-exclusive focus on developing notational literacy skills (Feichas, 2010).[38] This is a relatively recent development in classical music history: Improvisation used to be a skill expected from expert performers until the middle of the

[38] This is anecdotally further supported by Banks, who mentions that it is uncommon for classical performers to confidently improvise and that specifically orchestral players may react unwilling if asked to do so (1970b).

19th century, after which it declined due to a series of social and technological changes—including professional conservatoire education culture, the dissemination and availability of printed scores, and the rise of performers raised on such scores without enculturation in improvising ensembles (Moore, 1992).

While there certainly still are improvisation-capable classical musicians, improvisation has largely disappeared in many classical performance cultures. Western classical music education has shifted towards emphasising notational literacy over playing by ear, which several education experts have criticised (see McPherson & Gabrielsson, 2002, for an overview). That educational focus is problematic in several ways: Exposing young musicians too early to staff notation before developing their aural skills may hold back their musical development and leave them blind to musical detail not captured in the score (e.g. note offset, timbre, articulation, dynamics, tempo changes) (Mills & McPherson, 2006). Reading notation does not seem to aid working memory, as it could not improve melodic recall based on aural memory (Buonviri, 2015). Similarly, SR negatively affects students' ability to internalise new musical content compared to listening, and so is not recommended as a strategy for the study of new pieces (de Stwolinski, Faulconer & Schwarzkopf, 1988). While these effects may be attributed to the likely higher cognitive load in SR compared to listening, these examples support positing SR as a psychomotoric decoding skill that offers limited top-down benefits.

As a result, much of the literature agrees that the strong focus on literacy in formal music education comes at the cost of detrimentally affecting classical musicians' aural and ear-playing skills (Feichas, 2010; Harris & de Jong, 2015; Kendall, 1988; McPherson & Gabrielsson, 2002; Mills & McPherson, 2006; Vuust et al, 2012; Woody, 2019; Woody & Lehmann, 2010).[39] While a mixed teaching approach may enrich classical performers' understanding of expression, cadence, and phrasing (Watson, 2010; Gamso, 2011), classical music education's focus on learning music from notation rather than also by ear means that many classical musicians experience difficulties in learning or performing music without the aid of notation (Harris, van Kranenburg & de Jong, 2016; Woody & Lehmann, 2010). This renders them—in the words of Harris and de Jong—'*de facto* score-dependent' (2015, 254).

[39] Therefore several authors call for a more holistic education that combines both notational literacy and ear-playing (Davidson, Scripp & Welsh, 1988; Feichas, 2010; Gamso, 2011; Kendall, 1988; McPherson & Gabrielsson, 2002; McPherson, Bailey, & Sinclair, 1997; Wristen 2005; Woody, 2019; Woody & Lehmann; Watson, 2010).

However, classical musicians are unlikely to be equally score-dependent. An absolute division of musicians into dependent and independent does not take into account the range of experiences performers have—many will have received some degree of aural training, or may have participated in musical practices that engender ear-playing skills. Each individual musician's background is different and typically involves a variety of musical and educational experiences. Consequently, SD should therefore be considered a tendency rather than absolute factor in how much a musician relies on visual over aural cues when learning new music. This means that many musicians are likely somewhere on a spectrum between score-dependent and independent, as influenced by their practice and training. However, as a behavioural trait reinforced by enculturation-based practices, SD offers a first indication of why many classical performers may struggle in ear-playing scenarios. Thererfore, in order to explore effects of SD, in this chapter the absolutist division of musicians into **score-dependent musicians (SDMs)** and **score-independent musicians (SIMs)** will be maintained until experimental results presented in Chapter 5 allow a more nuanced interpretation.

In summary, SR—although a cognitively demanding skill itself—on its own may be primarily a psychomotoric decoding skill that offers few top-down benefits in non-literacy based performance scenarios. Therefore, formal Western music education's entrenched focus on acquiring fluent music literacy can be problematic without additional aural skills training. An exclusive focus on developing literacy can be detrimental to performers' other musical skills, in particular their ability to learn music without the aid of notation, leaving them dependent on learning music from scores alone. This dependency should be conceived as a tendency rather than an absolute effect and is likely influenced by how much a musician has participated in performance scenarios that require aural learning.

4.2. SD's effect on cognition when playing by ear

In order to explore the issue of how SD, ear-playing, and top-down effects interact, it is worth considering how SD manifests in behaviour and how this affect musicians in ear-playing scenarios. This may offer a sense of why otherwise very skilled and experienced score-focussed musicians can struggle to bring their skills to bear in ear-playing scenarios.

Woody and Lehmann (2010) investigated ear-playing skills in performers, dividing them into those with only classical music and those with additional 'vernacular' music performance experience. They found that the classical musicians required nearly three times as many attempts to correctly repeat back a melody on their instruments than the vernacular musicians. The classical musicians reported in post-task interviews that they had received little ear training as part of their education and therefore had to make a conscious effort to find appropriate fingerings. However, the vernacular musicians, merely commented on the ease with which they produced appropriate fingerings. As a result Woody and Lehmann speculate that a 'cognitive bottleneck' occurs in the production of motor representations when the classical musicians tried to play by ear (112).[40]

The concept of a 'cognitive bottleneck' is supported by a neuroimaging study (Harris & de Jong, 2015) exploring neural activations in score-dependent and improvisation-capable keyboard players. Participants' cerebral activations were monitored using functional magnetic resonance imaging (fMRI), while they appraised musical recordings and imagined playing along to both familiar and unfamiliar music. Both types of musicians were notationally literate, and both groups demonstrated cerebral activations which the authors linked to manual dexterity, as well as left-lateralised activations possibly associated with symbolic representation, language encoding, and motor imagery. However, only the performers with improvising abilities showed additional strong right-hemisphere activations related to spatially-driven motor control.

To Harris and de Jong, these differences in activations therefore suggest that only musicians with improvisation training make use of a particular neural system for spatial attention and mental rotation. SDMs possibly only channel their aural perception through left-hemisphere areas linked with symbolic representation and language encoding, as activated in both participant groups due to their shared notational literacy. The authors therefore suggest that SDMs are less likely 'to realize the pitch-to-space transformations necessary for an appropriate motor response to the aural perception of music' (259). It is worth restating that both performer types were notationally literate, since results gained by Hayward and Gromko (2009) show that aural-spatial skills and notational proficiency separately are essential in sight-reading. Therefore, Harris & de

[40] Similarly, Lilliestam's (1996) notes anecdotes from Charters and Bayton, who relate that classical musicians may have to re-learn much of their technique to play rock or folk music in order to gain automaticity in producing appropriate motor responses.

Jong's results imply that the spatial reasoning skills used in aural and notational interpretation tasks may be different from each other. This is supported by Goldman, Jackson, and Sajda (2018), who found that musicians with experience in improvisation could discriminate functionally related chords better than musicians with less improvisation experience; this difference was predicted by the number of hours spent improvising. As a result, the authors speculated that improvising musicians' knowledge of chords is organized differently from musicians who do not improvise, allowing them to perceive musical structures in a way that will facilitate improvisation.[41]

Harris and de Jong's observations on pitch-to-space transformations agree with Woody and Lehmann's (2010) concept of a 'cognitive bottleneck' at the motor representation stage. Together, the studies suggest that improvisational training could engender neurological changes over time, which induce a particular mode of perceiving music not shared by musicians who primarily engage with scores. This supports the assumption that SDMs' long domain-related activity in score-reading causes them to rely heavily on producing fingerings based on shapes and patterns in notation, but that this skill does not transfer to producing fingerings based on aural information. That would support the notion of music notation as a psychomotor decoding skill that does not contribute to top-down benefits in non-notational performance scenarios.

The possible relationship between pitch-to-space transformations and producing appropriate motor responses also links to how engagement in different musical activities affects aural discrimination skills. In testing mismatch negativity (MMN) components of event-related brain potentials (ERP), Tervaniemi, et al., (2001) found that classical musicians were less sensitive to deviations in aural contour than musicians from aural learning backgrounds. Noticeably, all of those not perceiving the deviations were classical musicians—indicating that specific expertise in aural learning may increase readiness to process complex musical information by ear (298). Seppännen, et al. (2007) differentiated further between musicians who did and did not practice aural learning strategies, finding shorter post-training latency towards interval deviants in the former, but shorter latency towards melodic contour deviants in the latter.

[41] Anecdotally, this fundamental difference between improvisers and non-improviser is supported by Larsen (2006), who, based on his own experiences, finds that overcoming 'notation dependency' (29) is the most difficult task for classical pianists who wish to learn jazz, noting that 'improvisation appears to involve the use of a different part of the brain than note reading' (29).

The authors speculated that contour and interval information may be processed by separate cognitive mechanisms, and that different learning strategies therefore cause neural and behavioural differences (246).[42] Taken together, these studies support the notion that differences between aural and notation-based learning strategies affect musicians' aural perception skills.

Beyond the issue of differences in training-related perception, Harris and de Jong (2015) also found indications for differences in cognition between SDMs and SIMs in their neuroimaging study: SIMs demonstrated significantly greater activations of areas associated with music processing than both SDMs and unskilled control participants. When comparing SDMs and unskilled controls, they found that SDMs exhibited greater motor imagery-related activations in motor- and rhythm-related areas (in the right dorsal and right ventral pre-motor cortex and the supplementary motor area). However, strikingly *without exception*, they found no significant differences in the right auditory cortex between SDMs and the musically unskilled controls. This surprising result could be due to a limited sample size (n=12 for each group). However, combined with the notion of SR as a psychomotoric decoding skill without wider relevance to musical top-down benefits, these findings imply a disquieting thought: that the exclusively score-based training and practice these professional performers experienced caused them to overspecialise in notational literacy to the point that some of their aural perception skills were no longer any better than a layperson's. Given the right auditory cortex' role in decoding pitch (Peretz & Kolinsky, 1993; Thaut, Trimarchi & Parson, 2014), this may especially affect pitch perception. Such an effect could also plausibly be explained by performance practice: Since pitches are normally fixed in music notation, SDMs are discouraged from deviating or from improvising pitches and therefore experience greater constraints on their musical expression than SIMs—requiring them instead to express themselves by microrhythmic and articulation-based deviation from the score (Goldman, 2016, para. 1.7).

Harris and de Jong took the comparatively lesser activation in SIMs in areas associated with music processing and auditory activations to imply that 'score-dependent musicians were not experiencing any benefit from top-down effects on aural processing, deriving from expertise' (259). This matches with neuroimaging findings on improvisation and top-down control mechanisms for generating novel motor sequences (see Beaty, 2015 for an overview), which

[42] Vuust et al. (2012) also found that genre musicians display greater sensitivity towards musical stimuli that play a central role in their specific genre.

share neural topographies in the pre-supplementary motor area—an area in which Harris and de Jong noted significant differences between SIMs and SDMs. As a result, SDMs may particularly struggle in applying their previous knowledge to forming goal images for motor production (Woody & Lehmann, 2010; Hakim & Bullerjahn, 2018). This is supported by an EEG study by Bianco et al. (2018), in which classical musicians were found slower at imitating unexpected harmonies than jazz musicians, though they were faster at implementing specific fingering instructions. The authors suggest that 'the specific demands and focus of previous experience may result in dramatic and enduring changes in performers' motor control system, providing neurobiological accounts for the great divide between musicians of the "swing" and the "legit" style' (392). As a result, Bianco et al. suggest that motor production is likely structure-generative in jazz musicians but structure-interpretative in classical musicians. They find that the latter tend to break actions down into smaller units of movement, likely due to their focus on interpreting notated musical gestures expressively, and so build smaller action plans.

These findings mirror Woody and Lehmann's (2010) research on aural reproduction: Their classical participants reported difficulties in reproducing the test melodies from memory, finding them 'unpredictable or difficult to memorise' (109), while half of those with vernacular music experience, described them as predictable or typical. The classical musicians also seemed to focus more on identifying melodic intervals when reproducing sample melodies, while more vernacular musicians seemed to use more harmony-based approaches, suggesting to the authors that the latter used their musical experience to mentally construct a representation of the music.[43] This may be a question of long-term working memory, since Nichols, Wöllner, & Halpern (2018) found that jazz musicians could recall aural stimuli better than classical musicians, with there being no differences between groups for visually presented stimuli.

It has been suggested that musicians probabilistically develop an understanding of genre rules, but that 'cognitive firewalls' prevent a cross-genre application of genre-specific knowledge for evolutionary reasons (Huron, 2006). However, Hansen, Vuust and Pearce (2016) showed that good general knowledge of music allowed classical musicians to make better predictions about possible endings of jazz music phrases than musically unskilled controls, relying on general

[43] Bogunovic and Vujovic (2012) observed a similar effect in music students during sight-singing tests, with performance majors using bottom-up strategies by focussing on intervals, while music theory majors used top-down strategies by focussing on larger musical structures.

expertise in music. This demonstrates a discrepancy between how classical musicians could apply their expertise in a listening and predicting scenario but not in a time-dependent ear-playing scenario, which again supports Woody and Lehmann's assumption of a 'cognitive bottleneck' that applies specifically during motor representation and production.

Together, these studies imply that SD may have a limiting effect on gaining top-down benefits from past musical experience in ear-playing learning scenarios, with SDMs experiencing linked difficulties in conceptualising music and producing spontaneous motor responses. While all of these points must remain purely speculative until a greater body of work can support them, together these studies suggest a first, tentative possible causal chain with empirical footing on why swing is believed difficult for many classical musicians:

- Due to their training and practice that is highly specialised in musical literacy, classical SDMs gain limited ear-playing experience, which over time manifests in neurological changes.
- These changes have consequences for SDMs' music perception and cognition, which remain strongly linked to notation's symbolic representation of music.
- The resulting mode of cognition in return limits them in bringing their previous musical experience to bear on melodic recognition and associated fingering patterns in an ear-playing scenario.
- This consequently limits them in applying their musical skill to a situational, changeable spontaneous group effort such as swing.[44]

In summary, the literature referenced in this section indicates that notational literacy on its own does not seem to help with deriving top-down benefits from wider musical experience. As a result, it seems that engagement with aural skills, such as ear-playing, marks the difference between SR as a useful supporting skill and SR as a musical crutch that can eventually lead to musical limitations in the form of SD. However, SD may be more appropriately seen as a

[44] Following these speculations, it is important to restate at this point that this is unlikely to hold for all music readers, but only those who specialise in music reading without engaging in ear-playing: Music literacy skills, such as SR, have never been shown to be in and of themselves detrimental to aural skills. Rather, as mentioned, they can enhance effects of aural learning (Kendall, 1988), with positive correlations between SR and improvisation common in the literature (Kopiez & Lee, 2006; Lehmann & Ericsson, 1993 & 1996; Lehmann & Kopiez, 2016; McPherson, Bailey & Sinclair, 1997; Mishra, 2014). However, as also mentioned, this could be explained by SR's role as a useful and learnable psychomotor skill that can be taken up and applied by a variety of musicians from different musical traditions.

tendency rather than an absolute condition, given that performers participate in a wide variety of musical experiences throughout their development. This leads to the question: When does expertise in SR become so central to a performer's skillset that ear-playing skills deteriorate and SD develops? This question will be addressed in the next section.

4.3. Long-term engagement with notation as a factor in developing SD

There are indications that SD, once developed, solidifies over time. As Lehmann & Ericsson (1996) point out, fluency in SR is the result of deliberate long-term involvement in relevant domain-related activities. Mills and McPherson (2006) find that musicians who ignore aural feedback generated by their own instrument, while performing from notation, may end up fingering pitches without internalising them, strengthening an eye-hand connection that ignores aural involvement. Such limited integration of aural feedback could indicate that SD is a self-sustaining process—the more performers rely on notation to perform music, the more their notational literacy skills increase and their ear-playing skills decrease.

Therefore, SD is likely to develop in parallel with fluency in notational literacy, if literacy training is not supplemented by aural skills training. Mishra's (2014) meta-analysis of SR literature indicates a saturation point for certain skillsets after which they no longer increase and contribute less to SR abilities. Mishra suggests that once a high level of SR expertise is reached, individual differences between performers in other music aptitude factors are rendered moot. McPherson, Bailey, and Sinclair (1997) found that, when comparing young clarinet and trumpet players in groups of 12-15 years old and 15-18 years old, the factor 'length of study' had an increasing effect—suggesting that SD may depend on the level of SR skills as acquired through repeated practice, independent of age. This supports the earlier theorised concept of SD as developing from increasing reliance on notational literacy over time.[45]

This implies that there may be a point in many classical performers' development when SR abilities solidify at expert level and the corresponding atrophying of ear-playing skills sets in.

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[45] Comparing effects of aural and notational instruction methods for jazz harmony on jazz-unenculturated classical music students, Laughlin (2001) found that 12th-graders improved much more from exposure to the notational materials than 9th-graders. While he linked this to increased experience in reading music, it could also point to a decreased readiness to rely on aural learning.

Since the literature offers limited and conflicting data on when notation-reading fluency is gained (see Mishra, 2014 for an overview), the onset of SR expertise cannot be pinpointed, though it is likely in late-teenage years to early adulthood. Likely, notation-reading fluency develops on an individual basis, dependent on a variety of factors in performance and practice.

However, based on the available data, one might create a speculative causal series of events for the onset of SD:

- Notation-based instruction for formally educated classical musicians can lead to SR expertise (perhaps in performers' late-teenage years or early adulthood).
- SR expertise, coupled with enculturation-based performance practices in classical music, causes a diminished reliance on aural skills.
- This diminished reliance on aural skills in turn creates a feedback loop of ever-increasing reliance on notation for performance, again engendered by classical music performance practice.
- This leads to a correspondingly decreasing facility in the application of aural skills, in turn further supporting a simultaneous increase in practice-based SR facility.
- Reliance on SR facility continues to the point that SD is developed.

Therefore, summarising the literature referenced so far in this chapter, the following speculative model of SD can be posited: SD represents a solidification of SR expertise due to hyper-specialisation in notation-based practice over time, caused by enculturation effects of classical music's training and performance culture, which render learning new music through ear-playing skills unnecessary.

4.4. Possible effects of SD on perception and encoding

In the previous section, SD was posited as a self-perpetuating effect that causes an increasing reliance on notation and a decreasing reliance on aural skills. However, it was also noted earlier that SD is likely a tendency rather than absolute effect, and so musicians may find themselves on a spectrum from very score-dependent to very score-independent, as influenced by their training and practice. Assuming that aural skills decrease as SD increases, how then is cognition and perception of aural signals affected in relatively SDMs? In order to gauge to what extent SDMs engage their aural faculties when performing from notation, this section will investigate how they audiate (form internal representations of pitch and rhythm) and in how far they integrate musical feedback into such representations. Audiation is highly relevant to all manner of musical performance—but especially to improvisation-based musical activities (Pressing, 1988). This includes swing, given its requirement for producing spontaneous responses, even when performing from notation.

It seems that while notational literacy as a whole is linked to forming inner representations of music, relying overly on notation may cause a heightened focus on executing musical instructions over encoding them. It is considered an important part of musical literacy and SR to form inner auditory representations of music by visually matching notation with aural patterns (Waters, Townsend & Underwood, 1998), and self-assessments of SR abilities correlate highly with those of inner hearing abilities in string and wind players (Brodsky, Henik, Rubinstein & Zorman, 1999). However, Kopiez and Lee (2006) show that pianists make little use of audiation at low levels of notational complexity, then increasingly audiate until a certain point of complexity is reached, and then increasingly execute notated musical material without audiation. Current theories on visual attentional load and prioritisation of information posit that task-relevant information is likely processed before task-irrelevant information (Giesbrecht, Sy, Bundesen, & Kyllingsbaek, 2014). This suggests that the attentional draw of complex notation causes musicians to prioritise correctly executing notational instructions over internalising musical meaning when sight-reading. In turn, this attentional draw of complex notation may affect how musicians integrate aural feedback into their playing in a group performance.

Therefore one must ask to what extent SDMs simply execute dense notation without reference to musical experience or outside interference. On the one hand, expert musicians do not simply execute notational instructions the way a computer reads a MIDI file, since the point of musical performance from notation is to continuously add musical responses based on years of training and experience (Cook, 2014, 235). On the other hand, Mills and McPherson (2006) find that students exposed too early to notation before developing aural skills can become blind to musical detail not captured in the score. The authors stress that such musicians do not learn to crosscheck the notation they see against internalised experience values of sound, instead learning to execute notational instructions based on a direct eye-hand connection.[46] This is illustrated by the difficulties many instrumentalists have in notating a simple song like *Happy Birthday* by ear when not sitting at their instrument (Davidson, Scripp, & Welsh, 1988) or how they continue to use certain fingerings in aural reproduction tasks over and over even when they know they are wrong (Delzell, Rohwer & Ballard, 1999).[47]

Therefore, SD may be considered a form of prioritisation based on the cognitive demands of a task, in which sound is ignored in favour of notation, and direct motor execution of notational instructions is prioritised over internalising musical meaning. As a result, SD may potentially limit the encoding of aural musical information and the subsequent forming of internal representations of music. This assumption is supported by findings of stronger domain-specific working memory in vernacular over classical musicians (Nichols, Wöllner, & Halpern, 2018; Woody and Lehmann, 2010).

This also speaks to how different musicians can form divergent representations of music, given the previously mentioned studies on differing aural sensibilities in genre musicians based on their particular enculturation (Tervaniemi, et al., 2001; Sepännen, et al. (2007; Vuust, et al., 2012). Considering how internal representations might be encoded differently, it is worth going

[46] This may be particularly true of instruments with straightforward pitch-space mapping. Three studies found that music-reading pianists hardly change their performances when the sound on their keyboard is switched off and so leaves them without auditory feedback (Banton, 1995; Finney, 1997; Repp 1999). Finney notes that notation-based piano performance is based on a visual code (i.e. notation) and so 'audition is not logically necessary at all, because the subject must simply produce the correct movements in response to a visual code.' (170) Specific results lead Banton to conclude that only experienced pianists seem to use aural feedback and then only when the sound surprisingly deviates from the one they intended to produce (1995). Repp (1999) similarly finds that pianists therefore likely make many of their expressive choices based on their internal musical representation only—logically meaning they do not conduct aural matching. That point is further endorsed by Allport, Antonis & Reynolds (1972), whose experiment showed that pianists can listen to and repeat back speech while sight-reading. Finney also found that mapping keys to a near-random scale did not affect correct motor execution during SR (1997), which further highlights the importance of the keyboard's visuospatial layout for piano performance (see also Stewart, et al., 2003). That circumstance presumably leaves able pianists to navigate by touch or vision alone (Wristen, 2005). A similar principle seems to apply to mallet instruments, with Woody & Lehmann discovering in ear-playing tests that only pianists and mallet percussionists found it easier to correctly play back than sing back heard melodies—surprisingly, since singing is usually considered a motorically less challenging task than playing an instrument (2010).

[47] Mills and McPherson (2006) liken this process to teaching a child to read a language before it learns to speak it, which is a view held by several music psychologists and educators (see McPherson & Gabrielsson, 2002 for an overview). As a result, Mills and McPherson recommend that children learn music pieces aurally before learning them from notation. However, unlike language reading, playing from notation involves the additional attentional draw of manipulating an instrument external to the body, which is further complicated by vision's relative dominance among sensory modalities (again, see McPherson & Gabrielsson, 2002 for an overview). This is demonstrated by findings that complex notation reduces audiation in musicians (Kopiez and Lee, 2006). Following the language analogy, SD could be posited as a process by which affected musicians learn to read out loud fluently and lyrically from text without being able to freely form sentences or hold an unscripted conversation.

back to Harris and de Jong's (2015) neuroimaging study: These authors found shared left-lateralised neural activations in SDMs and notation-literate SIMs during listening and imagining exercises, which suggested an engagement of areas possibly linked with symbolic representation and language encoding. However, only in SIMs did they find a significant engagement of *right-lateralised* posterior-superior parietal activations, which may be possibly related to spatial attention and mental rotation in music. Although these results were gained during listening and imagining tasks, the authors speculated that this 'does not exclude the possibility that [SDMs] might exhibit similar *right-hemisphere* parietal activations to the visual perception of the music score' (259, my italics).[48] The different neural activations between SIMs and SDMs therefore imply that their notational or aural focus caused long-term neural changes, which likely inform their perception and related internal representations of music. Therefore, one must ask whether enculturation and practice can fundamentally affect how musicians not only practice but also perceive music.

Given the neurological results found by Harris and de Jong (2015) and the differences in knowledge organization found by Goldman, Jackson, and Sajda (2018), it is worth considering whether SDMs fundamentally perceive music differently than SIMs. This may especially affect pitch perception: Mills and McPherson find that while musicians can finger pitches without intentionally audiating them, creating a straight eye-hand connection without involving internal mechanisms of musical expectation, rhythm requires a greater level of audiation, as it cannot be produced by simply pushing valves or keys without knowing how the pattern sounds (2006). This is supported by data gathered by McPherson (1994), who found that rhythm errors were by far the most common errors in young clarinet and trumpet players during SR tasks, with pitch errors being more than three times less likely, regardless of instrument. Similarly, sight-singers attend more to pitch than rhythm production (Henry, 2011). Since pitch and rhythm are decoded separately in music reading (Gudmundsdottir, 2010) and processed separately in the brain (Peretz & Kolinsky, 1993; Peretz & Zatorre, 2005; Thaut, Trimarchi & Parsons, 2014), together these studies suggest that SDMs may rely heavily on notation for pitch instructions in particular.

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[48] Brodsky, Henik, Rubinstein, and Zorman (2003) summarise research based on EEG studies, PET studies, and ERP studies to show that imaginal and perceptual processes share neural topographies—at least regarding melodies. Janata (2001) describes different forms of musical imagery, including 'expectant musical imagery', which depends on a mixture of sensory input and previous experience of what related input to expect next.

In summary, empirical studies suggest that it is possible that SD induces fundamental differences in the perception and processing of music between SIMs and SDMs. This implies the possibility that SDMs' perception of music is driven by perceiving a score, due to practice-induced neural changes based on limited engagement of ear-playing and aural perception skills. Since complex notation's attentional draw may cause musicians to prioritise correctly implementing notational instructions over engaging with inner representations of music, this may limit the extent to which SDMs integrate auditory feedback, especially pitch information.

4.5. A model of aural feedback integration by instrument

As a result of the potentially different cognitive and neurological activities between SIMs and SDMs, one must ask how sensitive SDMs are not just to aural feedback from external sources, but also to aural and sensorimotor feedback from their instrument while playing. Integrating sensory feedback into ongoing motor action sequences as part of perception-action coupling is essential to producing appropriate semi-automated responses necessary for stylised music (e.g. Pfordresher, 2019; Drost, Rieger & Prinz, 2007). Therefore it is likely vital to the production of swing, given the demonstrated importance of microrhythmic structures in swing (as laid out in Chapter 2). The extent to which performers integrate aural feedback from their instrument may shape their formation of inner musical representations and so may affect the formation of ear-playing skills. As a result, this section engages with literature on how classically trained instrumentalists match aural feedback from their own motor execution with their inner aural representations of music in order to integrate auditory feedback into ongoing motor action sequences (compare e.g. Banton, 1995; Finney, 1997; Lehmann & Kopiez, 2006; Keller, Dalla Bella & Koch, 2010; McPherson 1994; Repp, 1999; Wristen, 2005).

Fine, Berry and Rosner point out that inner representations of music do not seem to play the same role across all instruments (2006): The different motor production techniques required for manipulating various instrument types likely also impact the creation of inner representations of music. Consequently, these may differ among instrument types. Taking this idea and combining it with insights from a wider body of literature, I propose a speculative model, charting different instrument types on a continuum. In this model, inner representations of music and corresponding aural feedback integration depend not only on sensorimotor feedback, as suggested by the authors, but also on an instrument's visuospatial layout, pitch-to-space mapping, and visuomotor feedback (as summarised by Pfordresher, 2019). By taking these factors into account, a more comprehensive overview is possible, which provides greater insight into how instrumental design may change the involvement of aural skills in performance for different instrumentalists. To demonstrate this model, the following empirical readings are presented by instrument-type (keeping to instruments within mainstream classical use). The order follows the suggested continuum, ranging from those instrument-types likely involving the least to those likely involving the most aural feedback integration:

- **Pianos and mallet instruments** (and presumably **harps,** though not mentioned in the surveyed literature) make up one end of the continuum, since these instruments can theoretically be operated by vision alone without aural feedback. Studies found that music-reading pianists' performances hardly change without auditory feedback (Banton, 1995; Finney, 1997; Repp 1999). Consequently, Finney notes that notation-based piano performance is based on a visual code (i.e. notation) and so 'audition is not logically necessary at all, because the subject must simply produce the correct movements in response to a visual code.' (170) Specific results lead Banton to conclude that only experienced pianists seem to use aural feedback and then only when the sound surprisingly deviates from the one they intended to produce (1995). This also corresponds with Kopiez and Lee's findings on how inner hearing does not seem to play a role for pianists when notation becomes complex enough.

  Repp (1999) similarly finds that pianists likely make many of their expressive choices based on their internal musical representation only—meaning they do not match expectations to feedback. That point is further endorsed by Allport, Antonis & Reynolds (1972), whose experiment showed that pianists can listen to and repeat back speech while sight-reading. Finney also found that mapping keys to a near-random scale did not affect correct pianists' motor execution during SR (1997), which further highlights the importance of the keyboard's visuospatial layout for piano performance (Stewart, et al., 2003)—allowing for one-to-one pitch-space mapping, with each pitch assigned to only one visible physical location (Woody & Lehmann, 2010). That circumstance presumably leaves pianists able to navigate by touch or vision alone (Wristen, 2005). A similar principle seems to apply to **mallet instruments**, with Woody & Lehmann discovering in ear-playing tests that only pianists and mallet percussionists found it easier to correctly play back than sing back heard melodies—surprisingly, since singing is usually considered a motorically less challenging task than playing an instrument (2010).

- A similar circumstance may apply to **guitars** (which are not mentioned in the surveyed literature), but with the slight addendum that pitches can be produced in several places—involving a degree of choice and therefore suggesting at least a slight degree of matching feedback and expectations. Pitches must also be produced with two hands instead of one, invoking more performance variables and greater complexity in motor control. However—bendings and rare enharmonic tuning adjustments aside—adjusting for intonation is rarely required during performance due to the fingerboard's fret structure, meaning guitarists can execute pitches purely motorically based on overlearned movements if not paying attention to the timbre of different strings.
- **String** players can also execute pitches motorically based on overlearned movements, if not paying attention to the timbre of different strings, and must also make choices between several pitch locations and use two hands. However, they require some auditory feedback to make adjustments for intonation (Fine, Berry & Rosner, 2006), implying a greater degree of matching expectations and feedback. This is supported by findings that self-assessments of SR abilities correlated highly with those of inner hearing abilities for string performers (Brodsky, Henik, Rubinstein & Zorman, 1999).
- Similar correlations were found for **woodwind** performers (Brodsky, Henik, Rubinstein & Zorman, 1999). Woodwind performers have also been shown separately to create strong internal auditory representations (Fine, Berry & Rosner, 2006). Both woodwind and **brass** performers demonstrated shorter response times than string players for matching melodies between notational and aural sources, which indicates that their inner representations formed by notation are stronger; these wind players also had significantly less years of instrument lessons and ear-learning than the string players, indicating that their stronger ability to form representations likely stemmed from instrument-specific reduced motor demands or learning patterns (Brodsky, Henik, Rubinstein & Zorman,

1999, 387-88).[49] However, brass players have less opportunity for pitch-space mapping on their instruments than woodwind performers, having to identify correct fundamentals and partials before successful motor execution, and so likely rely even more on aurally matching expectations and outcomes for correct intonation.

- Finally, **singers** constantly match expectations with sounds by continuously adjusting their pitch based on aural feedback (Bogunovic & Vujovic 2012; Fine, Berry & Rosner, 2006). Given the absence of any externalised motor functions involved in singing, as there are no buttons to press or strings to finger, singers must always imagine auditory representations of music before executing it (Bogunović and Vujović, 2012; Gudmundsdottir, 2010). However, precisely the absence of externalised motor demands also means that singing is considered less demanding in the process of transforming aural input to motor production during melodic imitation tasks (Woody & Lehmann, 2010), meaning that fluency in sight-singing and fluency in sight-reading cannot be compared (Gudmundsdottir, 2010).

On the continuum suggested here, there is an increasing demand for aural feedback integration into inner representations of music. In the posited model, instruments with direct pitch-space mappings (such as pianos, mallet instruments, and harps) do not necessarily require feedback integration for performance, while those with slightly more ambiguous pitch-space mapping (guitars) require some. And so integration requirements increase along the continuum, first for those with greater intonation requirements (strings), then for those with strong sensorimotor feedback and even less pitch-to-space mappings due to embouchure formation (woodwinds) and overtone-based pitch planning (brass). Singers with their extreme motorsensori 'instrument' without any visibly exogenous sound-producing mechanisms that could indicate pitch position require the highest degree of matching expectations with sound.

[49] Further, McPherson, Bailey, and Sinclair (1997) found that playing by ear strongly influences both sight-reading and improvising in young trumpet and clarinet performers, suggesting that aural matching could be linked to ear-playing abilities, or vice versa. Since playing by ear helps create connections between inner visualisation of sound and its motor production, strong representations probably support improvisational skills, since musicians can reliable produce the sound or sound sequence they wish to play from experience (or at least play pitches from style-appropriate scales). The authors also found that playing by ear increasingly influences SR abilities with age—which makes sense for wind player, as they must create appropriate embouchures before executing a note, strengthening their inner hearing link with motor execution as their instrumental expertise increases. This is supported by Hayward and Gromko (2009), who found that aural-spatial patterning in wind performers predicted a major share of the variance in SR abilities.

This speculative model therefore suggests possible qualitative differences in the formation of aural skills among instrumentalists as shaped by their instrument type. With regards to swing production, this may imply that certain instrumentalists are more likely to be affected by SD, due to possible interference effects incurred by the differing aural demands of specific instrumental techniques. In turn, this may have implications for performers' ear-playing abilities and so for their ability to apply these abilities to a swing groove. However, these conclusions remain speculative and can only be supported by more targeted future research.

Summary: SD may affect aural perception skills

In summary, the reviewed literature suggests that Western classical music's formal educational focus on musical literacy may cause performers to become experts at decoding music notation to the point that their aural skills diminish. This may result in SD, a condition that signifies performers' inability to learn music without the aid of notation. That condition probably does not affect all performers equally or absolutely, but rather as a tendency, depending on the individual's ear-playing capabilities. SD's effect may be mitigated by instrument-specific factors in aural, visuomotor, and sensorimotor feedback, which can affect the formation of ear-playing skills. Long-term involvement in notation-based musical practice also possibly results in neural changes that affect relatively SDMs' perception of music, encouraging a mode of cognition that limits them in deriving top-down benefits from their musical experience in ear-playing scenarios. These limitations, in turn, may have consequences for their ability to perceive certain audio features or to encode musical information and form inner representations of music, particularly of pitch. The result may be a 'cognitive bottleneck' (Woody & Lehmann, 2010) at the stage of motor production when attempting to produce music without the aid of notation.

All these possible effects represent enculturation-based obstacles that classical musicians may experience in performing swing, given swing's dependence on strong skills in ear-playing and producing appropriate spontaneous motor responses. In combination with SDMs' possibly limited aural skills, this suggests that attempts to engender swing among these performers aurally may not be particularly successful and a more music-literacy based solution might engage with their mode of cognition more efficiently. However, given the noted limitations in describing swing via traditional forms of swing notation, ear-playing skills continue to be an important factor even when performing swing with the aid of notation (as laid out in Chapter 2).

In order to understand better how SD concretely affects ear-playing, the next chapter presents an experiment on aural reproduction skills in professional classical musicians. Since SD likely affects musicians as a tendency, based on their experiences, the division of musicians into SDMs and SIMs is perhaps unnecessarily absolutist. Therefore the experiment in Chapter 5 will also serve to create a more nuanced division of musicians based on their individual preference of notation over aural perception in a music-learning scenario.

Chapter 5: Score-dependency in classical musicians (Experiment 1)

As mentioned in the beginning of Chapter 3, classical music practice today is largely based on performing compositions too complex, lengthy, and difficult to coordinate for playing by ear alone. Therefore classical musicians engage with notation to negotiate such performances. As laid out in Chapter 4, this distinct focus in music practice likely leads to them develop weaker ear-playing skills than popular musicians (including jazz performers), as was demonstrated in several behavioural studies. That is possibly due to sight-reading (as a specialised form of music literacy) being a learnable psychomotor decoding skill that does not enhance access to top-down control in an ear-playing scenario. It was considered how this may contribute to heightened score-dependency (SD) among classical musicians, discussing potential differences between score-independent musicians (SIMs) and score-dependent musicians (SDMs). I argued that it is possible that SD further decreases participation in ear-playing scenarios, which in turn strengthens reliance on notation. This may create a feedback loop in which SD increases as ear-playing skills decrease.

SD may in particular affect pitch perception. This was explored in light of score-independent musicians (SIMs) exhibiting greater activations than score-dependent musicians (SDMs) in music listening and imagination tasks during a neuroimaging study (Harris and de Jong, 2015). Notably, this included the bilateral auditory cortex, with SDMs alarmingly exhibiting no greater activations than laypeople in the right auditory cortex. Specifically the right auditory cortex is important in perceiving and encoding pitch, whereas rhythm is processed more bilaterally and across a more widely distributed network (see Peretz & Zatorre, 2005 for an overview). This distinction by pitch and rhythm is also important for behavioural considerations of SD: Since pitches are normally fixed in music notation, SDMs experience greater constraints on their musical expression than SIMs, instead tending to express themselves in their choice of microrhythmic and articulation-based deviations from the score (Goldman, 2016, para. 1.7). In addition, pitch may requires less audiation than rhythm when played from notation (Mills and McPherson, 2006), which suggests that score-reading musicians would have less practice identifying pitch aurally.

However, given many musicians' diverse musical experiences, it is likely that many of them use both aural discrimination skills and notational instructions to learn and perform music. Consequently I proposed that SD is perhaps best described as a tendential rather than absolute reliance on notation over aural discrimination skills in music performance. In order to explore SD in actual behaviour, in this chapter I test several of these assumptions in a behavioural study. In particular, this experiment explores classical musicians' tendency to engage with notated materials over aural discrimination skills during a music reproduction task. Pitch and rhythm reproduction were controlled for separately in order to explore SD's suspected effect on pitch over rhythm reproduction. Participant's musical and biographical background information were linked to SD-based behaviour, in order to identify indications for whether SD does indeed stem from a feedback loop of increasing engagement with notation. This also served as a preparatory study for the second experiment described in Chapter 6, in which classical musician's ability to create swing was tested in relation to musicians' individual SD tendencies.

5.1. Background: Operationalizing SD as a mode of music learning

The first problem to address is how to operationalize a tendency to rely on visual over aural input in music performance. Since, as Goldman (2016, para 1.5) points out, SDMs and SIMs could theoretically produce the same musical output by different methods, the question is not *what* result they produce but *how* they produce it. With regard to SD, this question was addressed by Harris, van Kranenburg, and de Jong (2016), who ran a battery of tests on non-improvising and improvising keyboard performers, which they in advance respectively classified as SDMs and SIMs. The authors assessed performers on their abilities to accompany, replicate with and without aural feedback, transpose, and harmonize music by ear alone. In line with Goldman's suggestion, they therefore tested performers' mode of music *production* rather than a specific music *outcome* (i.e. performance) and thereby were able to show that SIMs have superior ear-playing skills compared to SDMs.

However, there is a conceptual problem in dividing performers into SDMs and SIMs *a prioiri*. Harris, van Kranenburg, and de Jong based their research on the premise that 'Classical musicians are *de facto* "score-dependent", a term which refers not only to the fact that the music performed is an artistic representation of the music score, but also that it is learned from the printed score and not by aural imitation' (2016, 2). This distinction between *learning* and *performing* music with the aid of a score is an important one, as it highlights a problem in the assessment of SD: If performing music from memory after learning it from a score is counted as a feature of SD, then SD is not really dependent on the mode of music *production* (playing from memory or not) as suggested by Goldman—rather it depends on the mode of music *learning* (learning by engaging with a score or not). Replicating a heard piece by ear or replicating a piece learned with notation from memory can potentially lead to the same outcome at the music production stage, but differs in the way the music is first encountered—in sound or notation. Similarly, improvising a piece of music differs from learning a piece of music using notation in terms of from where the musical material is derived—from improvisation (i.e. experience in domain-related activities such as pattern learning, see Pressing, 1988) or from a score—and not from how it is produced at the moment of performance.

Therefore, for the following experiment, SD is defined not as a mode of music *production*, but as a mode of music *learning,* indicating that performers learn music with the aid of notation instead of by aural replication. Based on this definition, performers can be divided into two binary absolutes: If musicians learn music purely from scores without being influenced by the sound of music around them, they can be considered fully score-dependent. If they learn music purely by ear without being influenced by a visual score, they can be considered fully score-*in*dependent. The ability to replicate music by ear is here seen as a prerequisite for more advanced ear-playing skills such as harmonization or improvisation.

However, as mentioned, SD is unlikely to be an absolute but rather a tendency. At least in Western music, even many improvising musicians use visual representations to form inner representation of a piece's structure (e.g. jazz lead sheets, drummers' charts, guitarists' chord charts or tablatures, structural charts of pop songs, fully notated parts and scores). Consequently, as laid out in the last chapter, it is unlikely that even musicians who consistently use notation do not engage their aural faculties at all when performing with other musicians. Therefore, while some performers may find it easiest to learn pieces purely by ear, and others purely from notation, it is likely that a large number of Western musicians (improvising and otherwise) learn new music by employing a mixture of notational literacy and aural discrimination skills. This implies that score-dependency should not be considered a binary absolute (dependent or independent). Instead, it might best be considered a spectrum between these two binary extremes—indicating the extent to which musicians engage with visual representations of music rather than on their ears during the learning process.

As a result, below I describe an experiment in which 20 classical musicians were tested on their aural reproduction skills. This experiment differs in important ways from the one conducted by Harris, van Kranenburg, and de Jong (2016). Rather than assessing ear-playing skills at the level of music production based on an absolute division of musicians into SDMs and SIMs, this experiment assesses to what *relative* degree musicians require visual representations of music for learning new music. I based the structural setup on Woody and Lehman's (2010) experiment, where classical and vernacular musicians were compared in ear-playing scenarios: Just as in Woody and Lehman's earlier experiment, musicians here were played a melody twice, and then had to repeat each one back on their instruments. Also as in Woody and Lehmann's study, participants were assessed by how many more times they requested to hear a melody before they could reproduce it correctly in pitch and rhythm.

However, this experiment goes beyond Woody and Lehmann's work by investigating three innovative avenues: musicians' tendency to rely on notation over aural input; SD's effect on pitch perception; and background factors in SD formation. This was possible, because—unlike in Woody and Lehmann's earlier experiment—participants here reproduced melodies not purely by ear. Instead, they did so across five conditions of notational support, using visual representations of the music that displayed different levels of musical detail. By varying the notational complexity, the extent to which they drew on notational over aural information could be controlled. In addition, this allowed for controlling for pitch and rhythm as separate variables, in order to gather insights on how SD and perception differences for pitch/rhythm might be related. Importantly, while Woody and Lehmann tested both classical and vernacular musicians, here only professional classical musicians were tested in order to explore SD as a consequence of a score-focussed performance practice—and in order to establish SD tendencies in classical musicians for a later experiment on their swing production (see Chapter 6).

Based on the underlying hypothesis that SD is a tendency and not an absolute, this experimental set-up assumed that most participants would display some level of ear-playing abilities, but would also benefit from visual support in successfully completing the task. This allowed for placing performers on a spectrum between two extremes: Those performers requiring consistently few listening attempts across the test would tend towards the score-independent extreme of the spectrum, since an increase or decrease in the level of visual aid would show little effect on their abilities to learn music by ear. In contrast those musicians consistently requiring many listening attempts, or a decrease in listening attempts with an increase in notational detail, would tend towards the score-dependent extreme of the spectrum. In order to quantify these results and judge participants' relative position between these extremes, a formula was used to convert their task performance to a rating on a scale indicating low to high SD. This formula takes account of the number of listening requests in each condition and weights them by the concurrent condition's difficulty for playing by ear. This way, a nuanced assessment of each performer's SD tendencies was established, which could then be used for further investigations.

5.2. Hypotheses

Based on the literature and theoretical considerations presented earlier, three hypotheses were formed:

- **Hypothesis 1:** Score dependency is a tendency and classical musicians are tendentially relatively SD, based on their enculturation in a notation-focussed performance culture. Specifically, it was assumed that the sample of classical musicians would score relatively highly, i.e. closer to the end of the scale signifying high SD.
- **Hypothesis 2:** Relatively SDMs find pitch more difficult to identify by ear than rhythm, but that this effect is mitigated by interaction with notation. However, it was assumed that this effect would be relative, depending on cognitive load: *how much* pitch and rhythm information had to be aurally reproduced would be a greater factor in setting difficulty than *which* single element had to be reproduced. This was reflected in the numbering of conditions from C1 to C5 (from most to least difficult).
- **Hypothesis 3:** SD results from long-term engagement in notation-focussed practices, but is mitigated by musicians' participation in ear-playing practices.

5.3. Methods

Participants

20 professional classical instrumentalists living in Germany, Denmark, the UK, and Ireland (mean age: 39, std. dev.: 12.06, range: 23-75; 9 female) were recruited by opportunity sampling (via ads on social media and by snowball sampling through personal contacts). Participants were considered 'professional' if they primarily lived from performing or teaching as instrumentalists, or if they were instrumental students at conservatory. The sample represented ten keyboard (8 x piano, 1x organ, 1 x accordion), eight string (4 x cello, 2 x violas, 2 x violins), and two wind instruments (1 x recorder, 1 x saxophone in E-flat). Singers were not recruited, due to concerns that manipulating an external instrument and manipulating a physical feature of one's body may represent different cognitive mechanisms (see Gudmundsdottir 2010; Fine, Berry, and Rosner 2006). Participants were screened for strong notational literacy by sending them an excerpt of a complex score and asking if they would be comfortable sight-reading it. All of them confirmed, so no participants were excluded based on this screening.[50] Due to the limited sample size (n=20) all data has to be treated cautiously; outcomes may be treated as indicative, but not as absolute, even at high significance levels.

Materials

An online participant questionnaire was prepared using Google Forms (Google LLC, 2008), asking for free text-answers to biographical questions and self-ratings on musical skills and background activities.[51]

For experimental materials, eight melodies were composed (seven for the experiment, one for task practice; c. 4 bars in length, diatonic, in 4/4, 100-120 BPM) and fully notated in the notation software Finale 25 (MakeMusic, 2016). Using the software's Steinway piano sound, a MIDI performance of each melody was exported as a WAV-file and converted to an MP3-file. The melodies were designed to include small difficulties for an ear-playing scenario, e.g. an

[50] Two additional participants were recruited for a pilot study. After the pilot study was conducted, experimental methods were adjusted and their data was discarded. In a preliminary effort to explore whether musical expertise alone should be used as a recruitment factor rather than professional context, three experienced amateur instrumentalists were also recruited and tested. However, their results differed noticeably from those of professional instrumentalists, and so their data was discarded too.

[51] See Appendix for a blank questionnaire.

unusual interval skip or a rhythmic irregularity. A senior ear-training professor working at a national conservatoire checked all the melodies and made suggestions for how to equalise difficulty levels across all of them, which were implemented in every case. For each melody, five notational realisations were created, one each for the five experimental conditions numbered C1–C5. Figure 5.1 shows an example of a melody scored this way.[52] [53]

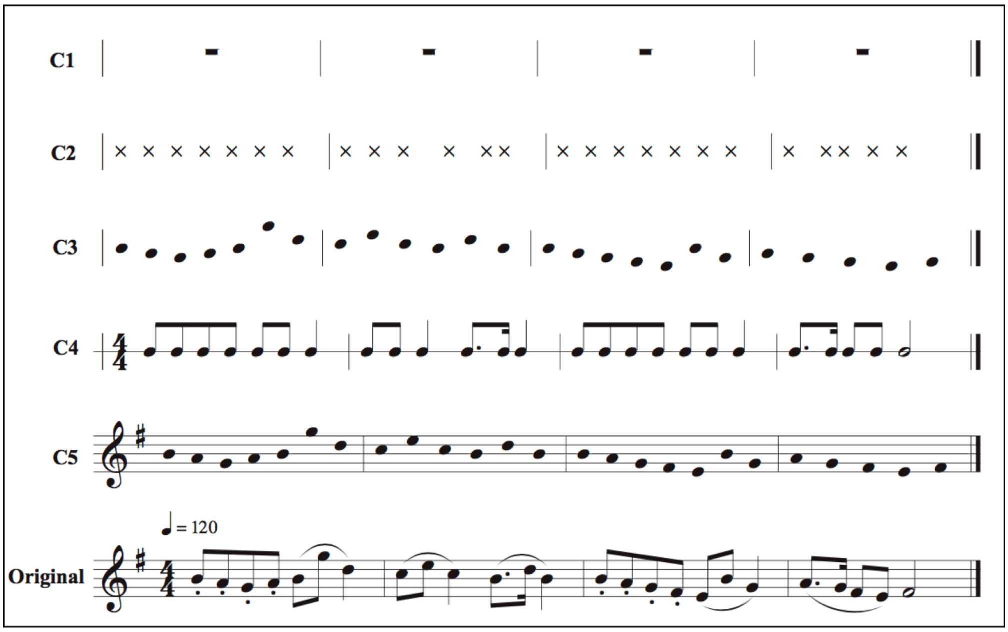

Figure 5.1: Example of a melody's visual representations for experimental conditions C1-C5.
C1 = blank bars (no pitch or rhythm content); C2 = rhythmic outline only; C3 = melodic outline only; C4 = full rhythm only; C5 = full pitches only; Original = melody as originally scored.

These five conditions were used to control for how much rhythm or pitch information participants had to reproduce by ear alone in each condition. Since all participants had been screened for strong music literacy skills, it could be assumed that they would fluently read any notated information from the score. Consequently, it could be assumed that they would only need

[52] See Appendix for all notation materials.
[53] These notational materials were presented in the G-clef at natural pitch for all non-transposing instruments that read that clef. Transposed versions were created as relevant for transposing instruments, ensuring that the aurally provided pitch information would match the information presented in the notation at relative pitch. For instruments playing from the bass clef, octave-transposed versions were created in that clef.

to reproduce information by ear that was not already displayed in notation. This meant that their task performance in playing by ear could later be linked to any pitch/rhythm information that was not displayed in notation, i.e. had to be reproduced by ear alone. Pitch and rhythm were the only musical features of interest evaluated here, as these were deemed easiest to assess objectively. [54]

Conditions C1-C5 were ranked in anticipation of task difficulty for each. This ranking assumed that difficulty would decrease from C1 to C5. The ranking was based on the information content provided in each task: While C5 and C4 provided full transcriptions of pitch and rhythm respectively, C3 and C2 only provided partial outlines of each, with C1 providing no pitch/rhythm information. The assumed difficulty ranking therefore reflected the two assumptions that form Hypothesis 3: First, that participants would struggle more with aurally replication pitch than rhythm; second, that the amount of missing information content to reproduce would outweigh the assumed pitch-rhythm hierarchy (i.e. that aurally reproducing all pitch content (C4) would still be easier than reproducing a combination of pitch and rhythm content together (C3).

Procedure

In preparation for each experimental session, each participant was randomly allocated five of the seven composed melodies.[55] Each of the five allocated melodies was also randomly allocated one of the five notational conditions, so that all conditions were represented.[56] About a week before

[54] Originally, two additional notations were featured in the experiment: C6 = melody without expression markings, and C7 = full transcription. These two conditions were dropped early in the experiment, as they produced no meaningful data. Participants' performance in all conditions was dependent on how quickly they could reproduce the transcribed melody by ear with aid of the partial notation. For C6, participants' articulation of expression markings was highly idiosyncratic and therefore objective judgement on whether they reproduced the melody with correctly articulated expression markings or not was deemed impossible. For C7, participants' strong sight-reading skills meant that they had no need to rely on playing by ear, rendering results meaningless.

[55] After having tested ten out of twenty participants, the preliminary data was reviewed in order to prevent any inherent bias in difficulty. The two melodies that required least/most requested playbacks were determined to be potentially biasing and as a precaution were excluded going forward. For the remaining participants these two melodies were replaced at random with two remaining melodies in the pool.

[56] For all randomisation processes, the list function on the website random.org [accessed between 01 March and 30 June 2019] or more often its mobile app for the Android mobile platform called 'Certified True Randomisers' version 1.2.12 were used. Random.og uses atmospheric noise to produce orderings that are more random than those based on purely mathematical formulas.

the experiment, participants were emailed a link to the online questionnaire and asked to complete it before the experiment.

The experiment was conducted in each participant's practice environment with mobile equipment, in order to ensure a naturalistic environment that would help participants feel comfortable, as well as to encourage availability. Times and settings were agreed in advance in order to ensure an uninterrupted quiet environment suitable for concentration and recording. Participants were reminded that their identity would be kept anonymous and were asked to sign consent forms.[57] Participants were asked whether they consented to the session being recorded on audio, to which all agreed. They were explained the experimental process and were given a Participant Information Sheet[58] with a summary of the procedure, but did not receive a full explanation of the background until after completion, in order to prevent performance bias. We conducted the task once in a practice run to ensure they had understood the process and were comfortable with the process; this was also used to check volume levels for playback and recording.

Task performance for each condition followed the same procedure: Participants were handed the notational transcription of a melody, as predetermined by the randomised order. Then they were played the MIDI-piano recording of this melody twice. They were told the melody's first pitch (transposed for transposing instruments), allowing them to find it in a suitable range on their instrument if they preferred transposing the melody by octaves. Then participants were asked to reproduce the melody in pitch and rhythm on their instruments, while referring to the transcriptions if necessary.

In addition to hearing two playbacks of each melody as part of the experimental setup, participants could request to hear the playback again until they achieved accurate reproduction in pitch and rhythm. However, in order to avoid task fatigue, the number of **requested playbacks (RPs)** was limited to five (resulting in seven playbacks total, including the two as part of the setup). The number of RPs required for successful task completion were noted on paper and—since all experimental sessions were sound-recorded with permission of each participant—later cross-checked with the audio recordings. If correct reproduction in pitch and melody was not

[57] Participant Consent Form for Experiments, Faculty of Music, University of Cambridge: 2018-19; Participant Consent Form for Interviews, Faculty of Music, University of Cambridge: 2018-19; the latter was co-signed by the researcher.
[58] See Appendix for the Participant Information Sheet.

achieved after five RPs, the final number of RPs was noted down as ‘6’, indicating that a participant would require at least six playbacks for task completion in this condition. In order to avoid unnecessary frustration and associated task fatigue, participants could also choose to skip the task for the current condition after several attempts, as long as they were certain they could not achieve task completion within five RPs; in this case the number of RPs for this condition was noted as 6.

Short post-experimental interviews were conducted with each participant to gain their impression of the process and give them the opportunity to reflect on their performance and possible factors involved. These interviews were recorded with permission of the participants.

The equipment used was an Apple MacBook Pro 2011 laptop, AKG K451 headphones, a Sennheiser E835 microphone mounted on a portable stand, and a Behringer U-Phoria UMC404HD audio interface. The sessions were recorded using the software Apple Logic Pro 9. Each participant could choose to hear the melodies via headphones or laptop speakers, and good listening conditions were ensured for each option.

5.4. Results

In order to demonstrate specific effects of SD and address Hypothesis 1 and 2, first I will outline results for the entire sample and then for each subsample (relatively SDM or SIM). Significance levels were set at p<=0.05.[59]

Differences in pitch and rhythm reproduction for all participants

The mean number of requested playbacks (RPs) per condition was calculated for each condition (see Table 5.1).

Condition	Mean RPs	Std. Dev.	Minimum	Maximum
C1	4.2	1.91	1	6
C2	3.8	2.09	1	6
C3	2.6	1.88	0	6
C4	3.15	1.98	1	6
C5	1.55	1.64	0	6

Table 5.1: Summary statistics for each condition
Shown are the mean requested playbacks (RPs), the standard deviation and the minimum and maximum scores in each condition. The data is sorted by difficulty level, listing conditions as C1-C5.

The data in each condition was inspected for its distribution shape, using the Shapiro-Wilkes test. The assumptions of a normal distribution could not be rejected for conditions C1-4, but were significantly rejected for C5 ($p = 0.01658$). Therefore differences in requested playbacks (RPs) across all conditions were assessed using the non-parametric Friedman test. The differences between conditions were highly significant (Friedman = 51.92, Kendall = 0.55, $p = 0.0001$).

Experimental conditions had been numbered C1-C5 in anticipation of a supposed decreasing difficulty level, from most (C1) to least difficult (C5), as expressed in most to fewest RPs required for task completion. This assumption was made based on the mode of presentation: C5 and C4 provided full transcriptions of pitch and rhythm respectively, while C3 and C2 provided merely partial outlines of each, and C1 provided no information on either. The ordering therefore reflects that within mode of presentation, pitch was expected to be more difficult to reproduce aurally than rhythm. However, it was also expected that, where partial information for one and all information for the other factor had to be reproduced (in C3 and C2), the factor with

[59] All statistics for this thesis were calculated using the software Microsoft Excel for Mac 2011 and the statistics software package StataCorp StataIC 15.1 for Mac.

most missing content would be the more difficult one to reproduce. Therefore it was surprising that the ordered ranking from fewest to most RPs in practice was not C5-C1, but rather C5, *C3, C4*, C2, C1, as can be seen in Table 5.2. This ordering showed that pitch was always more difficult to reproduce aurally than rhythm, even when only partial pitch but all rhythm content had to be reproduced.

Ordered ranking by mean RPs (low to high)	1 Mean RPs: 1.55	2 Mean RPs: 2.6	3 Mean RPs: 3.15	4 Mean RPs: 3.8	5 Mean RPs: 4.2
Condition	C5	C3	C4	C2	C1
Information displayed	Full pitches	Melodic outline	Full rhythm	Rhythmic outline	Blank bars
Information not displayed (to be reproduced aurally)	Full rhythm	Partial pitch, full rhythm	Full pitch	Partial rhythm, full pitch	Full pitch, full rhythm

Table 5.2: Conditions ordered by playback requests (RPs) from low to high for all participants
The table also shows what pitch or rhythm information was displayed in music notation in each condition, as well as what pitch or rhythm information was purposefully not displayed and instead had to be identified aurally by participants.

Conditions displaying at least some pitch information (and therefore requiring participants to aurally reproduce all rhythm information, C5 and C3) were ranked at positions 1 and 2 (fewest and second-fewest RPs). Conditions presenting at least some rhythm information (and therefore requiring aural reproduction of all pitch information, C4 and C2) were ranked as 3 and 4. The condition that provided no pitch/rhythm information (C1) was ranked as 5. Therefore, results show that rhythm always remained the easier factor to reproduce and only added to difficulty levels when all pitch information already had to be identified. If mean RPs are taken as an indication of task difficulty, their ranking suggests that participants found it overall more difficult to reproduce pitch rather than rhythm information by ear, regardless of mode of presentation.

In order to check whether this ordering and its associated pitch/rhythm division were significant, all conditions were tested pairwise. Since the purpose was to generate comparable data for ranking, and since C5 did not feature a normal distribution, a non-parametric test was chosen with the Wilcoxon matched-pairs signed-rank test.[60] Results are shown in Table 5.3.

Conditions	C1	C2	C3	C4	C5
C1	– –				
C2	z = 1.02 p = 0.3080	– –			
C3	z = 2.92 p = 0.0035	z = 2.69 p = 0.0071	– –		
C4	z = 2.27 p = 0.0234	z = 2.31 P = 0.0209	z = -1.85 p = 0.0644	– –	
C5	z = 3.48 p = 0.0005	z = 3.15 p = 0.0016	z = 2.21 p = 0.0268	z = 3.09 p = 0.002	– –

Table 5.3: Results from Wilcoxon matched-pairs signed-rank tests
z-scores and rounded p-values are provided for each condition. Non-significant values outside the set significant level of p<=0.05 are highlighted in red.

Table 5.4 shows the difficulty ranking from Table 5.2 amended with the data presented in Table 5.3.

[60] Bonferroni and related post-hoc corrections for repeated hypothesis testing were considered, but rejected as they would have increased the risk of a type II error beyond reason—given the small sample and small number of comparisons, the necessity of these Wilcoxon comparisons for establishing a baseline for later hypothesis testing (i.e. building the SDR formula), and the importance of the individual test results for later research design (i.e. Chapter 6's experiment). Instead, exact p-values are provided and discussed. Armstrong (2014) reports on the controversy surrounding post-hoc testing and increasing the risk of a type II error in the interest of avoiding a type I error. He recommends against it under the following conditions, which match the rationales given above: *'No correction would be advised in the following circumstances: • if the study is restricted to a small number of planned comparisons. • if a study is exploratory involving post-hoc testing of unplanned comparisons which are regarded as hypotheses for further investigation. • if multiple usage of a simple test such as 't' or 'r' is envisaged, if it is the results of the individual tests that are important. Instead, the exact p values for each individual test should be quoted and discussed appropriately.'* (2014, 505)

<table>
<tr><td>Difficulty ranking (low to high)</td><td>1</td><td colspan="3">2 & 3
(shared)</td><td colspan="2">4 & 5
(shared)</td></tr>
<tr><td>Mean RPs (rounded) low to high</td><td>1.55</td><td colspan="3">2.6 / 3.15</td><td colspan="2">3.8 / 4.2</td></tr>
<tr><td>Condition</td><td>C5</td><td colspan="3">C3 / C4</td><td colspan="2">C2 / C1</td></tr>
<tr><td>Information displayed</td><td>Full pitch</td><td colspan="3">Melodic outline /
Full rhythm</td><td colspan="2">Rhythmic outline /
Blank bars</td></tr>
<tr><td>Information not displayed (to be reproduced aurally)</td><td>Full rhythm</td><td colspan="3">Partial pitch, full rhythm /
Full pitch</td><td colspan="2">Partial rhythm, full pitch /
Full pitch, full rhythm</td></tr>
<tr><td>Wilcoxon p-value for neighbouring conditions on ranking</td><td colspan="2">C5 & C3 p=0.0268
C5 & C4 p=0.0020</td><td>C3 & C4
p=0.0644</td><td colspan="2">C3 & C2 p=0.0071
C3 & C1 p=0.0035
C4 & C2 p=0.0209
C4 & C1 p=0.0234</td><td>C2 & C1
p=0.308</td></tr>
</table>

Table 5.4: Ranked conditions for all participants
Conditions ranked by difficulty from low to high, as indicated by mean requested playbacks (RPs) and grouped according to significance levels resulting from Wilcoxon matched-pairs signed-rank tests. Non-significant p-values are highlighted in red. The table also shows what pitch or rhythm information was displayed in notation for each condition, but also which information was purposefully not displayed and instead had to be identified aurally by participants.

As Table 5.3 and 5.4 show, the differences between C1 and C2 are clearly non-significant (p=0.308). This means that participants found reproducing melodies where remaining rhythm information as well as all pitch information had to be identified (C2) *not* significantly easier than reproducing melodies where all rhythm and all pitch information had to be identified (C1). This indicates that the rhythmic outline provided in C2 was of no significant help to participants. Differences between C3 and C4 were also not significant.[61]

Consequently, since the differences between C2 and C1 as well as C3 and C4 were not significant, the conditions within each pairing were ranked equally in difficulty despite their different mean RPs. As a result, the significant difficulty ordering in Table 5.4 is C5 – C3/C4 – C2/C1. Looking at Table 5.4, it is noticeable that many conditions where pitch information had to be identified aurally were ranked higher than where rhythm had to be identified. All together, the ordered ranking of RPs, the highly significant outcome of the Friedman test for the overall

[61] However, differences between C3 and C4 approached significance (p = 0.0644). This could be related to the small sample size (n=20) and so possibly could become significant in a larger sample.

data, and the outcomes of the pairwise Wilcoxon tests suggest that reproducing pitch was more difficult than reproducing rhythm information for this population sample.

Assessing levels of SD

In order to explore how this effect may differ between relatively SDMs and SIMs, the task performance results were used to determine each participant's placement on a spectrum from not SD to fully SD. This was done by producing a **score-dependency rating (from hereon: SDR)**, which represented each participant's tendency to rely on visual over aural information. In order to produce the SDR, each condition was weighted, using its experimentally established difficulty ranking as the weighting factor. Since C2 and C1 shared the ranks 4 and 5, they were each assigned the factor 4.5 for weighting due to their clearly non-significant differences. C3 and C4 were likewise assigned the shared factor 2.5. Then participants' RPs for each condition were multiplied by the condition's difficulty rank. Results were added together and the sum was divided by 15 to produce a result on a scale of 0-6, then elevated to a scale of 1-7 by adding 1. This can be expressed as the formula:

$$SDR = (RP_{C5}*1 + RP_{C3}*2.5 + RP_{C4}*2.5 + RP_{C2}*4.5 + RP_{C1}*4.5) / 15 +1$$

Results were then rounded to two decimal places. The extremes of the scale were interpreted and labelled as follows:

- 1 = no RPs needed in any condition; labelled as 'very score-independent',
- 7 = six or more RPs needed in every condition; labelled as 'very score-dependent'.

By assessing participants based on difficulty levels experimentally established by their own performance as a group, it was possible to assess their individual tendencies to rely on notation over aural faculties in comparison to their peers. The use of difficulty ranks for weights in the SDR formula also meant that RPs had a different effect on participants' scores in different conditions: Requesting a playback in C5 merely elevated the final SDR by 0.067 on the 1–7 scale, while requesting a playback in C1 or C2 elevated the final SDR by 0.3, counting more than four times as much. This made it much more likely for participants to gain a higher final SDR if they required more RPs in the more difficult conditions. That effect was a deliberate part of the formula's design, since it accounted for performers' differing ear-playing abilities: performers who requested few playbacks in conditions with less notational support demonstrated strong ear-playing abilities, and so the formula awarded them less points and they received a lower SDR; performers who requested few playbacks only in conditions with more notational support proved that they were relatively SD, and so the formula awarded them more points and they received a higher SDR. The resulting SDRs per participant are shown in Table 5.5.

Participant rank	C1	C2	C3	C4	C5	SDR
1	1	2	0	1	0	2.07
2	2	1	1	1	3	2.43
3	3	1	1	1	2	2.67
4	1	2	3	2	1	2.77
5	3	1	1	2	1	2.8
6	4	2	1	1	1	3.2
7	1	4	4	1	0	3.33
8	6	2	1	1	0	3.67
9	3	1	2	6	2	3.73
10	5	3	2	2	0	4.07
11	3	5	2	4	4	4.67
12	5	5	2	3	0	4.83
13	5	6	1	4	0	5.13
14	6	5	2	4	2	5.43
15	6	6	3	3	1	5.67
16	6	6	3	3	2	5.73
17	6	6	5	6	1	6.5
18	6	6	6	6	1	6.67
19	6	6	6	6	4	6.87
20	6	6	6	6	6	7
Mean	**4.20**	**3.80**	**2.60**	**3.15**	**1.55**	**4.46**
						Range: 2.01–7.0

Table 5.5: Participants ranked by score-dependency rating (SDR)
Variables C1-C5 show participants' number of requested playbacks (RPs) for task completion in each condition (min. 0, max. 6, indicating 6 or more RPs required for task completion). SDR shows score-dependency ratings on a scale of 1–7. The data is sorted by SDR from low to high and participants are ranked accordingly.

The mean SDR for this sample was 4.46 (range: 2.07–7, std. dev.: 1.6, std. err.: 0.36). Since a Shapiro-Wilks test for normality indicated that the variable SDR approached a normal distribution (see also the distribution in Figure 5.2), the 95% confidence interval could be calculated as [3.71, 5.21]. Since 4 is the median of the scale, this mean indicates that this sample was slightly more SD than not, though the confidence intervals show that the population mean could be just under 4 or even higher than 5. Adjusting the confidence interval levels showed that a population mean equal to or greater than 4 could only be predicted with 79% confidence. Therefore, the results show that Hypothesis 1 (classical musicians are more SD than not) can be assumed with 79% confidence for a population of classical musicians, which is highly suggestive but not scientifically conclusive.

Notably, the range indicates that no participant scored between 1 and 2 on the SDR scale and therefore no one approximated the lower extreme 'very score-independent'. Figure 5.2 shows a histogram displaying participant distributions by SDRs across the SDR scale of 1–7.

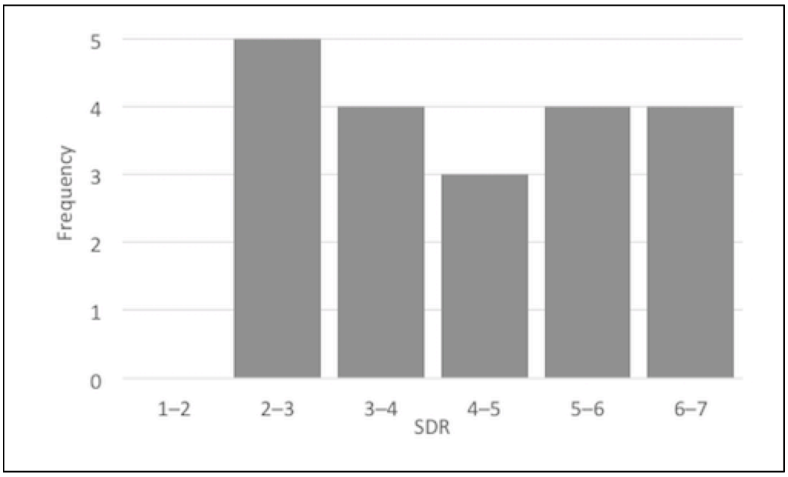

Figure 5.2: Distribution of participants by score-dependency ratings (SDRs)
SDR scale of 1–7, with bins set to 1. SDRs are shown on the x-axis and numbers of participants on the y-axis. No participants scored in the range 1–2, so that bin is empty.

SD’s effect on rhythm and pitch reproduction

In order to test Hypothesis 2 (SDMs find pitch more difficult to reproduce by ear than rhythm), the data was further analysed by dividing the sample. Those participants who scored in the upper half of the SDR scale (SDR >= 4; n = 11) were deemed relatively SDMs; those who scored in the lower half of the scale (SDR <= 3.99; n = 9) were deemed relatively SIMs. As before for the entire sample, Friedman and Wilcoxon matched-pairs signed-rank tests were run on the two sub-samples separately. Results of these tests and the resulting order of conditions are show in Tables 5.6 and 5.7.

<table>
<tr><td>Difficulty ranking (low to high)</td><td colspan="2">1-4</td><td colspan="2">1-5</td><td colspan="2">2-5</td></tr>
<tr><td>Mean RPs (rounded) low to high</td><td colspan="2">1.11</td><td colspan="2">1.56 / 1.78 / 1.78</td><td colspan="2">2.67</td></tr>
<tr><td>Condition</td><td colspan="2">C5</td><td colspan="2">C3 / C4 / C2</td><td colspan="2">C1</td></tr>
<tr><td>Information to be reproduced aurally</td><td colspan="2">Full rhythm</td><td colspan="2">Partial pitch, full rhythm / Full pitch / Partial rhythm, full pitch</td><td colspan="2">Full pitch, full rhythm</td></tr>
<tr><td>Wilcoxon p-value</td><td>C1 & C5, p=0.0296</td><td colspan="2">C1-C4
= no significant differences for any pairs</td><td colspan="2">C2-C5
= no significant differences for any pairs</td><td>C1 & C5, p=0.0296</td></tr>
</table>

Table 5.6: Conditions ranked in difficulty for relatively SIMs (SDR = 1–3.99).
Only C1 and C5 were significantly different from each other, resulting in rankings spread over multiple conditions. Conditions are ranked by difficulty from low to high, as indicated by mean requested playbacks (RPs) and grouped according to significance levels resulting from Wilcoxon matched-pairs signed-rank tests. The table also shows what pitch or rhythm information was purposefully not displayed in each condition and instead had to be identified aurally by participants. Non-significant p-levels are highlighted in red.

Difficulty ranking (low to high)	1	2	3	4 & 5 (shared)
Mean RPs (rounded) low to high	1.91	3.45	4.27	5.45 / 5.45
Condition	C5	C3	C4	C2 / C1
Information to be reproduced aurally	Full rhythm	Partial pitch, full rhythm	Full pitch	Partial rhythm, full pitch / Full pitch, full rhythm
Wilcoxon p-value		C5 & C3, p= 0.027	C3 & C4, p= 0.027	C4 & C2, p=0.01 C4 & C1, p=0.04 C2 & C1, p = 1.0 = no difference

Table 5.7: Conditions ranked in difficulty for SDMs (SDR = 4-7).
Only C2 and C1 were not significantly different from each other, and therefore share a ranking. Conditions are ranked by difficulty from low to high, as indicated by mean requested playbacks (RPs) and grouped according to significance levels resulting from Wilcoxon matched-pairs signed-rank tests. The table also shows what pitch or rhythm information was purposefully not displayed in each condition and instead had to be identified aurally by participants. Non-significant p-levels are highlighted in red.

For the relatively SIMs, the results of the Friedman test indicated no significant difference between conditions overall (Friedman = 4.68, Kendall = 0.12, p=0.7912). In pairwise Wilcoxon tests, none of the conditions were significantly different from the neighbouring conditions on the ordered ranking—with the exception of the two extreme conditions C1 and C5 (p=0.0296) (see Table 5.6). As a result, only C1 and C5 could be ranked, meaning that SIMs found it easier to aurally reproduce rhythm alone than to reproduce pitch *and* rhythm. All significance levels for pairwise comparisons outside of the ranking order (and so not shown in Table 5.6) were *not* significant, confirming again that only C1 and C5 could be ordered meaningfully. This indicates that the SIMs strong ear-playing skills allowed them to perform nearly equally well across conditions overall, regardless of how much information they could derive from notation.

The relatively SDMs' results stood in stark contrast to those of the SIMs. The results of the Friedman test showed that differences between conditions overall were highly significant (Friedman = 26.59, Kendall = 0.53, p=0.003). In pairwise Wilcoxon tests, all ranked conditions were significantly different from neighbouring conditions on the ranking, except that again there was no significant difference between conditions C2 and C1 (see Table 5.7). The difference between C3 and C4, which previously had been just about non-significant for all participants, was now fully significant for SDMs (p=0.027). All significance levels for pairwise comparisons outside of the ranking order (and so not shown in Table 7) *were* significant, confirming the logic of ordering results by mean RPs.

The differences between the two sub-samples are noticeable. For SDMs, almost all conditions were significantly different from neighbouring conditions on the ordering scale and so supported the ordering. For SIMs, on the other hand, only C1 (identify full pitch and rhythm) and C5 (identify full rhythm) were significantly different and could be ordered. One might assume the difference between results in C1 and C5 for SIMs to be an outcome of the increased cognitive load when having to aurally reproduce two audio features (as in C1) instead of one (as in C5). However this does not hold true, since there was no significant difference between C1 (identify full pitch and rhythm) and C3 (identify full pitch) (p= 0.23). Therefore, it is possible that pitch and rhythm do not add equally to a cognitive load for SIMs—however there was no significant difference between C3 (identify pitch) and C5 (identify rhythm) either (p= 0.57). As a result, all that can be said with confidence is that, for this sub-sample, aurally identifying and reproducing only rhythm was significantly easier than reproducing both pitch and rhythm. In summary, there are no clear indications for SIMs finding pitch more difficult to reproduce aurally than rhythm.

However, for SDMs there was a clear difference between reproducing pitch and rhythm by ear. For them, the significant ordering of conditions across multiple conditions showed that aurally reproducing pitch was significantly more difficult than reproducing rhythm. In preparing the experiment, it had been assumed that where elements of both pitch/rhythm had to be reproduced aurally, the factor with the greatest missing information load would control difficulty levels. However, the ranking shows that for SDMs there was a clear effect of concurrent increasing difficulty with increasing demands on reproducing pitch content (as can be seen in Table 5.7): *No pitch – partial pitch – full pitch – full pitch with rhythm*. Rhythm seems to have made less of a contribution to task difficulty, and instead seems to have only added to the cognitive load when pitch content already had to be identified (compare conditions C3 and C2/C1 in Table 5.7). Interestingly, having to reproduce full rhythm with partial pitch (C3) was still easier than reproducing full pitch alone (C4). As a result, for SDMs it was significantly more challenging to identify pitch than rhythm. This was only exceeded by the presumably heightened cognitive load of having to identify another factor in addition to full pitch. The results confirm Hypothesis 2 and even exceed the caveat attached to it, showing that pitch outweighs rhythm in difficulty regardless of how much rhythm information is missing.

In summary, differences between the two sub-samples strongly suggest that SD—or an associated factor—modulates musical perception and/or action processes involved in the aural reproduction of pitch. While the limited sample size prevents any conclusive insights, this finding suggests a strong likelihood that SD detrimentally affects musical perception and action skills. For more concrete evidence, the finding should be investigated with a larger sample size.

SD and biographical factors

Hypothesis 3 was that SD results from long-term engagement in a notation-focussed performance practice, but can be mitigated by participating in musical activities that engender playing by ear. This was assessed by correlating SDR with participant's background data. In addition to generating experimental data, all participants also completed a questionnaire, where they provided answers and self-ratings on musical and biographical background factors.

After converting non-rating responses to meaningful numerical values, the data was correlated with participants' SDRs. Where Shapiro-Wilks tests showed that data extracted from the questionnaire was not normally distributed, the non-parametric Spearman correlation was used instead of the parametric Pearson correlation.[62] The Spearman test produces a measure of correlation expressed as Spearman's rho and an associated significance level. Significant and near-significant results for these correlations are shown in Table 5.8. The following variables were definitively not significant and therefore are not shown in Table 5.8: Primary instrument category (coded as Bowed Strings, Winds, or Keyboards), secondary instrument category (coded as Bowed Strings, Plucked Strings, Winds, or Keyboards), sex, nationality, highest attained level of music education, experience listening to groove-based music, and experience performing groove-based music.

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[62] Where categorical variables were tested, the non-parametric Kruskal-Wallace test was used. None of the results for this test were significant and so are not reported here.

Variable	Spearman's Rho	Significance
Age	r_s= 0.63	p = 0.003
Years of playing music	r_s= 0.58	p = 0.0071
Absolute pitch	r_s= -0.45	p = 0.0491
Experience performing jazz	r_s= -0.46	p = 0.0396

Table 8: Significant and near-significant correlations with SDR.
The table shows the results of Spearman's correlation between SDR and participants' self-ratings on musical and biographical factors. Near-significant values are highlighted in red. For all correlations n=20.

As seen in Table 8, 'Age' and 'Years of playing music' produced a moderate-to-strong positive correlation, with the latter likely being a product of the former. Both 'Age' and 'Years' could have been influenced by an outlier, with one participant being over 70 while all others were at most in their early fifties. That is why the correlation was run again without this participant: Results indicted a slightly weaker, yet still moderate-to-strong positive correlation between 'Age' and SDR (Spearman's rho = 0.57, p = 0.0108) and moderate correlation for 'Years and SDR (Spearman's rho = 0.51 p = 0.0243). This may indicate that long-term involvement in notation-focussed practice may be associated with SD. This supports the first part of Hypothesis 3.

Notably, 'Experience performing jazz' produced a moderate negative correlation. Since this activity usually involves playing by ear and so likely facilitates task performance, this result supports the second part of Hypothesis 3.[63] Therefore, results offer support for the hypothesis that SD develops through long-term engagement with a score-focussed performance practice, but that experience in the ear-playing domain (e.g. jazz) can counteract this development.

'Absolute pitch' similarly produced a moderate negative correlation, likely because it facilitates pitch perception in an ear-playing scenario. However, participants defined the concept of absolute pitch differently while completing the questionnaire: In post-task interviews, several participants admitted indicating they had absolute pitch because they felt they had attained it for their instrument after long and intense domain-related training, though they were not born with it. Therefore it is likely that not all participants had equally well developed absolute pitch and so did not benefitted equally from this skill during task performance. Consequently, this result should be treated cautiously.

[63] In addition, 'Experience improvising' produced a near-significant (p = 0.0632) weak-to-moderate negative correlation (r_s= -0.42; n=20), further supporting this hypothesis.

Participant interviews

In post task interviews, participants talked about their experience of playing by ear. A notable theme was that many had practiced it in their childhood through instrumental or singing exercises, but had not used the skill since. Based on their task performance, many expressed a wish for improving this skill again. Notably, several participants with low SDRs mentioned having experience in improvising, playing jazz or groove-based music in a band, or learning music through the Kodaly method, indicating a training effect for ear-playing. Three musicians specifically mentioned that playing by ear requires practice in their opinion.

Working memory also appeared to be a factor in successful task completion. Six participants mentioned that they found the melodies too long to learn at once, dividing them into smaller segments while listening so that they could encode them a little at a time. They reported that their memory would often fail around the third or fourth bar, apparently reaching their limit for short-term encoding at that stage. It was interesting that strategies for memorising differed among the musicians. Two of them mentioned whistling, humming, or singing in order to help them remember the material better. One person found the accompanying notation distracting and would rather simply have listened without looking at a visual aid. Only one person specifically addressed that identifying rhythms was easier than identifying pitches—while one other person claimed the opposite.

5.5. Discussion

In this experiment, aural reproduction abilities of classical musicians were tested in order to establish a measure for score-dependency. Specifically, it was tested whether there is difference between their aural reproduction skills for pitch and rhythm information, in order to establish whether score-dependency might be linked to limited abilities in reproducing pitch content. Taken together, the findings strongly suggest that SD affects aural pitch but not rhythm reproduction. Less definitively, they also suggest that SD is associated with long-term participation in score-focussed performance practice without engaging in ear-playing activities. As previously stated, due to the limited sample size (n=20) any conclusion based on the data may only be treated as indicative. Significant results will have to be checked in a larger sample in order to draw more confident interpretations.

SD in classical musicians

Hypothesis 1 was that classical musicians are relatively SD due to their notation-focussed performance culture. This sample of classical musicians was slightly more SD than not (sample mean of SDR = 4.46) judging by the chosen performance scale (1–7, median: 4). However, since a population mean equal to or greater than 4 could only be predicted with 79% confidence, the data strongly suggests but does not scientifically conclude that Hypothesis 1 is likely to hold for a population of classical musicians.

However, this sample may be considered *relatively* SD when the data is contextualised by other results. To assess this, the SDR sample mean was converted to mean RPs by reverse-engineering the SDR formula. It was shown to represent an average of 3.46 RPs in every condition. This means, on average participants needed to hear a melody c. 5.5 times (3.46 RPs and two playbacks provided by the experimental setup) in every condition, whether conditions were easy or difficult. In order to remove difficulty levels as a factor, the sample mean was converted to RPs in condition C1 only, setting RPs for all other conditions to 0. The result showed that the sample mean represents a hypothetical 11.53 RPs when no pitch or rhythm information is provided in notation.

There is data to suggest that this is a representative figure for classical musicians. In Woody and Lehman's study comparing classical and vernacular musicians' ear-playing skills (2010), classical musicians required an average of 10.58 RPs (in addition to two provided playbacks for the experimental setup) before accurately reproducing heard melodies. When taking this result and running it through the SDR formula—with a converted score of 10.58 for C1 and 0 for conditions C2–C5—the resulting SDR was 4.174. This falls into the 95% confidence interval for the data presented here and lies within one standard error from the sample mean. Therefore, it provides support for the results gained here being indicative of classical musicians' ear-playing skills. However, it should be noted that the experiment presented here used a different methodology from Woody and Lehman's work (introducing notation and limiting recorded RPs at 6). Therefore full reproduction of Woody and Lehman's experiment by scientific standards has not occurred.

Notably, the SDR range for the data here was 2.07–7.0, so none of the classical musicians approached the lower extreme of 1 (i.e. very score-independent). This might suggest that this scale extreme represents an unreasonable high skill level in aural replication. However Woody and Lehmann's results suggest otherwise: They recorded a mean of 3.83 playbacks for vernacular musicians in their experiment. Converted as above for condition C1 only, this represents a score of 2.15 on the SDR scale. Since this is a mean figure, it suggests that the vernacular musicians are likely to have scored both above and below, i.e. closer to SDR = 1. That suggests that the lower scale extreme does not represent an unrealistic skill level. It also provides some context to the sample mean generated by the classical musicians in this study: They were relatively SD when compared to the vernacular musicians tested by Woody and Lehman. However, due to the different focus of the two studies, Woody and Lehmann's data can only offer suggestive contextualisation to my findings. While it illustrates differences in ear-playing ability between relatively SDMs and SIMs, this type of conversion remains purely academic. Therefore more practical research into ear-playing skills is required to investigate whether the SDR scale is representative of a wider sample of musicians.

Pitch and rhythm reproduction

Hypothesis 2 said that SDMs would find pitch more difficult to reproduce than rhythm. This was confirmed by the data. Results showed that whenever SDMs had to reproduce any pitch information, partially or fully, pitch outweighed rhythm as the greater driving factor in difficulty for them. In contrast, relatively SIMs merely found it more difficult to reproduce both pitch and rhythm than just rhythm. Therefore, while the data offered indications that pitch was more difficult to reproduce for all participants, this effect was strongly exacerbated among SDMs.

It is not clear whether the issue in reproducing pitch for SDMs lies at the music perception or production phase. Harris and de Jong (2015) found that SIMs exhibited significantly greater activations in the bilateral auditory cortex than SDMs, with SDMs showing no better activations than musical laypersons in the right auditory cortex. Particularly the right auditory cortex is predominantly involved in perception (Peretz & Kolinsky, 1993; Thaut, Trimarchi & Parson, 2014) and memorization (Peretz & Zatorre, 2005) of pitch relations. This suggests an issue at the perception stage.

On the other hand, Harris and de Jong (2015) also found that SIMs exhibited stronger activations in the pre-supplementary motor area, an area in which improvisation and top-down motor control activities share the same activations (see Beaty, 2015 for an overview). Externalising music to a device outside the human body is difficult, as evidenced by classical musicians being able to sing tunes by ear, but struggling afterwards to notate them (Davidson, Scripp & Welsh, 1988), play them (Woody & Lehmann, 2010), or name their component notes (Hakim & Bullerjahn, 2018). Woody and Lehman (2010) speculate that classical musicians suffer from a 'cognitive bottleneck' in ear-playing scenarios, making it difficult for them to transform perceived information into motor action. That would explain why classical musicians have longer latency times than jazz musicians in following instructions to finger unexpected chords (Bianco et al., 2018). As a result, this would suggest that the problem lies at the motor production stage. However, as few of these studies addressed score-dependency explicitly, the question remains open.

Both possibilities, perception or motor imagery problems, are supported by the results of a positron emission tomography (PET) conducted by Thaut, Trimarchi and Parson (2014). These authors found that rhythmic activities evoke more widely spread sensory-related activation patterns than pitch activities and so may be more multi-sensory in nature than melody—with rhythm being more closely related to bodily motion than melody. This contextualises Mills and McPherson's (2006, 181-82) claim that playing from notation does not require the same levels of audiation (i.e. creating an inner musical representation) for pitch as it does for rhythm. They propose that it is possible to develop an eye-hand connection that makes it possible to rapidly execute notated pitch instructions without necessarily having to internalise them first. However executing rhythm, they argue, always requires audiating before playing, since musicians must first consider how the rhythm sounds. This is plausible, since on some instruments, pitch can be produced with a single motion (e.g. piano), while rhythm by definition requires multiple events and therefore multiple motions, demanding greater motor planning.

If playing from notation removes the need for in-depth pitch audiation, as Mills and McPherson suggest, this would explain why SDMs experience difficulties in reproducing pitches by ear. It is possible that SDMs receive little or no training effect for pitch audiation when performing from scores, while SIMs engage more often with music in a manner that supports audiation. As pointed out above, this may also be influenced by whether an instrument requires the performer to make more motions for producing rhythm than pitch. As discussed in Chapter 4, instrument-specific perception-action coupling mechanisms are likely to come into play when performers match aural feedback with internal expectations in the process of executing motor sequences, as was especially necessary in this experiment. While no indication for an effect by instrument was found here, the sample may have been too small to produce results when subdividing participants into several instrument types, so a future study is called for.

In summary, it is possible that SDMs have developed such strong psychomotor decoding skills from long-term score-focussed practice that a strong eye-hand connection removes their need to audiate pitch in performance. The training effect of regularly audiating rhythm but not pitch when performing from notation would explain why SDMs in this study found rhythm easier to perceive and/or reproduce by ear. The next section addresses this issue of long-term domain-related involvement.

Musical practice engenders changes in aural perception

Hypothesis 3 said that SD results from long-term engagement in notation-focussed practices, but can be mitigated by participation in ear-playing practices. This was supported by the data, though questions on the causality of SD remain. In addition, SDMs demonstrated difficulty in reproducing pitch also suggests that SD may affect modes of musical cognition and inform a performer's musical 'worldview' by affecting how aural perception and prediction link with associated action mechanisms.

Self-ratings for 'Age' and 'Years of playing music' correlated positively with SDR. This supports the proposed model of SD as an eye-hand connection that increases with time, while long-term engagement in notation-focussed practice engenders increased dependency on notation. In a performance culture where playing by ear is rarely practiced, as suggested by the interviews with the participants, this could possibly develop into a self-sustaining process, in which notational literacy becomes increasingly fluent while ear-playing skills decrease. As extended use of notation is likely to lead to increased notational literacy, which in turn makes future use of notation more likely, this points towards a behavioural feedback loop.

Nonetheless, the data suggest that this feedback loop can be disrupted by engaging in ear-playing activities. Noticeably, 'Experience performing jazz' correlated negatively with SD. This suggests that diverse musical activity stimulates relevant neural areas as it broadens levels of musical expertise. Therefore, a more holistic focus on providing young musicians with a wide variety of musical experiences seems advisable. If such aural practices are not pursued, as Harris and de Jong's data (2015) data suggests, a specialist focus on performing from scores is likely to strengthen an eye-motor connection that over time engenders changes in neural processing and associated cognition. The data presented here indicates that this affects perception and/or action mechanisms.

However, it needs to be pointed out that these are suggested mechanisms only: Correlations can show only relationships between variables, but not causality. An alternative explanation for the positive correlations between both 'Age' and 'Years' with SDR could be that music education has changed over time and that performers from earlier generations were encouraged to participate more in score-based performance practice than younger musicians. This would need to be the focus of a separate study

5.6. Summary: SD affects aural pitch reproduction

This study demonstrated that score-dependency is a tendency of relying on notation in a music-learning context that affects musicians differently, based on their individual musical experiences. It was shown that score-dependency affects aural pitch but not rhythm reproduction. In the next chapter, I will outline a second experiment, in which score-dependency was explored as a factor for classical musicians' swing. Interactions of aural priming and various notational styles were investigated for the same participants tested here, taking their SDRs into account. Results will further contextualise behavioural differences between SIMs and SDMs.

Chapter 6: Effects of aural and notation-based learning mechanisms on classical musicians' swing (Experiment 2)

As noted at the beginning of this thesis, classical musicians are often criticised for struggling to produce swing convincingly. This may be partially due to diverging cultural expectations towards engaging with music notation, as shown in Chapters 2 and 3, given classical music's particularly score-focussed culture. In Chapters 4 and 5, I explored the effects of long-term engagement in such a notation-focussed performance culture, which revealed that some performers are more dependent on using notation than others. Taken together, these issues raise a series of questions: Do score-dependent classical performers particularly struggle to swing because of their preference for notated over aural input? Will such performers swing more if playing from a more detailed form of notation that explicitly states swing's syntax features? Or is the inverse true—will relatively score-independent classical musicians benefit from aural input when playing swing? This chapter will seek to answer these questions by testing for them experimentally. It also clarifies some gaps in the jazz literature—notably by confirming swing's syntax features as laid out based on literature in Chapter 2. In doing so, it also clarifies swing's role as a groove archetype and its relationship to the overall concept of groove.

6.1. Background and aims

The concept of swing as a 'groove archetype' was proposed earlier: a recognisable culturally specific syntactic conceptualisation of music, which in its manifestation aims to induce groove (i.e. the urge to move with music) in listeners (Chapter 2). The swing archetype was defined as consisting of the following syntactic properties: a near-metronomical beat with emphasis on the backbeats, a tempo- or phrasing-dependent unequal subdivision of the beat, and a melodic phrase structure that only partially synchronises with the metronomic beat, instead using offbeat articulation and displacement of notes from their metronomic positions to effectively syncopate and imply the underlying beat structure. However, traditional forms of jazz notation were found limited in helping classical musicians articulate such swing features in a stylistically appropriate manner (Chapter 3). Jazz notation was judged to be likely too imprecise for unenculturated musicians, while classical adaptations of swing are likely too rigid in depicting swing as a fixed 2:1 beat-upbeat ratio. Several more specialised notation styles were explored, including the explicit swing notation, which was designed to explicitly show swing's component techniques.

Score-dependency (SD) was explored theoretically as a factor arising from classical musicians' score-focussed performance practice (Chapter 4). Experimentally gained data supported the hypothesis that SD affects classical musicians differently based on their musical background and training (Chapter 5). The experiment showed that SD musicians had difficulties reproducing pitch but not rhythm by ear on their instruments, suggesting that SD affects music cognition. The presented evidence raises the question whether SD also plays a role in why classical musicians allegedly struggle to swing. Considering that swing is traditionally learned by ear and that established forms of music notation do not help classical musicians swing (see Chapter 3), it is possible that SD performers may benefit from a more explicit form of notation when attempting to swing. However, as score-dependency was shown to primarily affect pitch, it is also possible that swing—as a primarily rhythmic practice—is not affected by SD. In order to clarify this matter, this chapter therefore experimentally investigates how notation affects classical musicians' swing, whether SD plays a role in this process, and whether hearing a jazz performance can augment the information supplied via notation.

In the experiment described below, the same sample of classical musicians as used in the SD experiment (n=20) was recorded while sight-reading jazz tunes from notation under a variety of conditions. Sight-reading represents only one of many possible modes of engaging with the score, but was chosen in order to measure participants' initial engagement with notation. One of the conditions was the notational style used to represent these jazz tunes: Tunes were represented in a minimalist jazz notation style, a more detailed classical style, and a highly detailed explicit style. The aim was to explore whether SD musicians' swing improved with increasingly detailed depiction of swing processes. Since swing is traditionally played by ear, participants were also aurally primed for some jazz tunes by playing them jazz recordings of these tunes, in order to find out if classical musicians' swing improved more with aural priming.

Jazz-enculturated listeners evaluated the participant and jazz recordings, and rated them for how much they enjoyed them or felt that they generated swing and groove, providing explanatory comments for their ratings. Groove was included as a rating factor in order to test the established definition of swing as a groove archetype. Enjoyment was included to investigate whether increased swing is actually a desirable effect, as is commonly assumed. Listener comments were analysed to gain a context for what performance features may have affected the ratings. Several items in particular were analysed for the following: which swing performance features listeners deemed essential for good swing, which of these features were deemed present or missing in classical musicians' swing, and whether different notational styles modulated the frequency and nature of the criticised swing features.

6.2. Hypotheses

Seven hypotheses were formed for this experiment:

- **Hypothesis 1:** Since swing is traditionally learned by ear and depends on spontaneous, unscripted phrasing rather than notational instructions, it was hypothesized that score-dependent musicians (SDMs) would swing less than relatively score-independent musicians (SIMs), as expressed in listener ratings.
- **Hypothesis 2:** It was further hypothesized that swing levels for SDMs would increase with more explicit notational instructions, as this would allow them to infer some of the swing processes by vision that they may be unable to infer by ear.
- **Hypothesis 3:** On the other hand, it was assumed that SIMs' relative independence from notation would render their swing scores immutable to notation.
- **Hypothesis 4:** Given SDMs stronger reliance on scores, it was also hypothesized that their swing performances would be relatively immutable to aural priming, while SIMs' swing would increase with aural priming.
- **Hypothesis 5:** Based on the empirical data gained from the literature, it was expected that jazz listeners' ratings and comments would confirm the posited definition of swing as a groove archetype.
- **Hypothesis 6:** It was also expected that jazz listeners' comments would confirm the swing features that make up swing's syntax, as proposed earlier: Occasional synchronization with a near-metronomical beat sequence, occasional de-synchronization from the beat by using displacement and articulation to syncopate, and an unequal subdivision of the beat.

- **Hypothesis 7:** Finally, it was expected that increased levels of perceived swing would also increase listeners' enjoyment.

6.3. Methods

Participants

The participants used for this experiment were the same as used for the score-dependency experiment. Details are recapped in Box 1.

Box 1: Participants

20 professional classical instrumentalists living in Germany, Denmark, the UK, and Ireland (mean age: 39, std. dev.: 12.06, range: 23-75; 9 female) were recruited through opportunity sampling. Their instruments represented keyboard (8 x piano, 1x organ, 1 x accordion), string (4 x cello, 2 x violas, 2 x violins), and two winds instruments (1 x recorder, 1 x saxophone in E flat).

All participants were screened for adequately strong sight-reading skills by asking them to provide a self-rating based on an example score, since strong music-reading skills were required for the experimental task; however, all participants rated themselves sufficiently highly, so that no participants were disqualified on this basis. Singers were not recruited, due to concerns that sight-singing and sight-reading may represent different cognitive mechanisms (compare Gudmundsdottir 2010; Fine, Berry, and Rosner 2006).

Two additional participants were recruited for an earlier pilot study, after which their data was discarded. Three experienced amateur instrumentalists were also recruited, but their results differed significantly from those of professional performers, and so their data was discarded too.

Due to the limited sample (n=20) results have to be treated cautiously; outcomes may be treated as indicative, but not as absolute, even at high significance levels.

In addition, jazz-enculturated listeners (n=20) were recruited to act as task raters (living in the UK, Denmark, Germany; mean age: 43, age range: 21–75; 4 female). They were recruited by opportunity sampling, using social media advertisements and snowball sampling through personal contacts.[64] In return for their participation, and as a motivation during the arduous and lengthy task, raters received a gift voucher with a value of £20 British pounds (after exchange fees, if applicable) after task completion. This was made possible through funding from the

[64] This created a strong response, with more people interested than required. Candidates were screened by expertise, asking them to provide details on their listening habits, their musical activities, the rough number of how many jazz concerts they had attended, and the rough number of how many jazz tracks they owned or had on their streaming playlists. In selecting raters from the candidate pool, relevant musical activity was given preference over listening experience alone, and live jazz concert attendance was given preference over listening to jazz recordings.

Faculty Board, Faculty of Music, University of Cambridge. Previous to the main data collection, a pilot study was run during which data from two pilot participants was assessed by four pilot raters. After the pilot study, methods were adjusted and the pilot data was discarded.

After the rating tasks for the main experiment were completed, the data was reviewed and it became clear that one rater had not taken the task seriously, consistently providing the same numeric ratings and copy-pasting comments. There is precedence for excluding rating data generated by such 'speeders' who try to complete a rating task as quickly as possible (see Schober & Spiro, 2016). Therefore a suitable alternate rater was recruited from the candidate pool and the corrupted data was replaced with that of the new rater.

Materials

As mentioned, the participants for the swing experiment were the same as in Chapter 5's SD experiment. Therefore, the data on participants' biographical details and musical practices collected via the questionnaire in the SD experiment was also used for the swing experiment.[65]

For experimental materials, five jazz 'standards' or tunes were selected from popular jazz exercise books with accompanying audio CDs featuring expert performances.[66] In anticipation of recruiting participants who do not play polyphonic instruments, only monophonic melodies were chosen.[67] In order to minimise chances that participants might recognise tunes from popular recordings—which could potentially bias their task performance—particularly popular tunes were deliberately avoided.[68] Since beat-upbeat ratios in swing are likely tempo-dependent (see Chapter 2), tunes were further selected by tempo, with two each representing slow and medium

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[65] See Appendix for a blank questionnaire.
[66] Refer to each tune in bibliography for details on the exercise books. Tunes are listed further below.
[67] As Sloboda (1977) points out, even though performers of polyphony-capable instruments may develop additional cognitive skills to deal with polyphony, this should not affect results based on monophonic performance (1977, 123).
[68] In order to avoid popular jazz tunes, several jazz performers were consulted on relatively unknown tunes and a shortlist was drawn up based on the recommendations made. This list was then crosschecked with a variety of online popularity rankings for jazz tunes, as compiled by scholars, educators, practitioners, enthusiasts, and specialist radio stations (in Bibliography as: JazzStandards.com; Jazz24.org; HopeStreetMusicStudios.com; LearnJazzStandards.com; TheWoodshedMusic.com, 2013; The Jazz Workshop North Virginia, 2015).
Final selection was based on a mixture of factors, including: relative obscurity; suitability for assessing swing; length of possible excerpts; and availability in jazz exercise books with audio tracks for ease of transcription and providing material for aural priming during the experimental task. *What's New* was identified as a useful but very popular tune, and so it was used for preparing participants for the experimental task, but not for the actual task itself.

jazz tempo ranges.[69] The selected medium-tempi tunes were labelled M1 and M2 and the slow-tempi tunes S1 and S2, so that participants could not recognise them from their names. One additional slow-to-medium-tempo tune was selected in order to prepare participants for the experimental task. The final selection was:

- **Medium-tempo tune 1 (M1):** *Sentimental Journey* (Green, Brown & Homer, 1944) – c. 104 beats per minute (BPM).
- **Medium-tempo tune 2 (M2):** *I've Heard That Song Before* (Cahn & Styne, 1942) – c. 140 BPM
- **Slow tune 1 (S1):** *Easy Living* (Robin & Rainger, 1937) – c. 62 BPM
- **Slow tune 2 (S2):** *When Sunny Gets Blue,* B-section only (Segal & Fisher, 1956) – c. 62 BPM
- **Practice tune:** *What's New* (Burke & Haggart, 1939) –c. 76 BPM.

Since the tunes were too long for experimental use, an excerpt of one or several complete melodic phrases of c. 30 seconds' length were selected from each one.[70] Each tune's average metronome speed was estimated by analysing its sample performance on the CDs that came with the jazz exercise books. Recording sessions with audible metronome click tracks at the measured tempi were prepared in the recording software Logic Pro 9.

Each selected excerpt was transcribed into three different music notation styles: 'Jazz', 'Classical', and 'Explicit'. Figures 6.1–6.3 show the same four bars of music notated in each

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[69] Tunes at fast jazz tempi (e.g. 180-240 BPM) were avoided, since the experimental task was essentially a sight-reading exercise, in which it is likely that performing culturally unfamiliar music at high speeds will lead to unusually large degrees of performance errors (Kinsler & Carpenter, 1955). This decision was also based on the assumption that the recordings might have to be examined digitally for musical features, taking into account Benadon's (2006) point that assessing BURs from audio recordings created at high tempi is likely to produce large margins of error.

[70] In the case of *When Sunny Gets Blue,* the 'head' or 'A section' (i.e. the primary musical section) was deemed potentially too recognisable based on the author's personal experience, so caution was exercised and phrases from the 'B section' were used instead. During post-task interviews, every participant was asked if they recognised any of the tunes: four participants thought they may have heard a tune before, but three could not say which of the four tunes this referred to, and none could name the tune when asked.

style and recap the differences between styles in terms of music information content (see Chapter 3 for a detailed explanation).[71]

[71] See Appendix for all notated tunes.
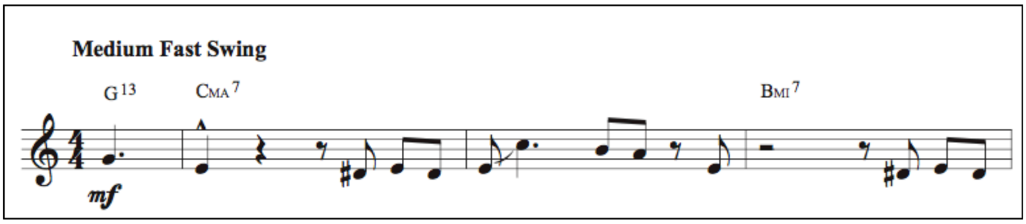
Figure 6.1: Jazz notation
Example of four bars of music from tune M2 (*I've Heard That Song Before,* Cahn & Styne, 1942), transcribed into the Jazz notation style.
This notation style is typically used in notation-based jazz performances: Swing is indicated by instruction only (if at all). The musical text does not specify a BUR or swing, and very few phrase or expression markings are provided. Unlike the other two notation styles, this one features jazz chord symbols above the stave to guide performers in producing improvisations and backing lines.

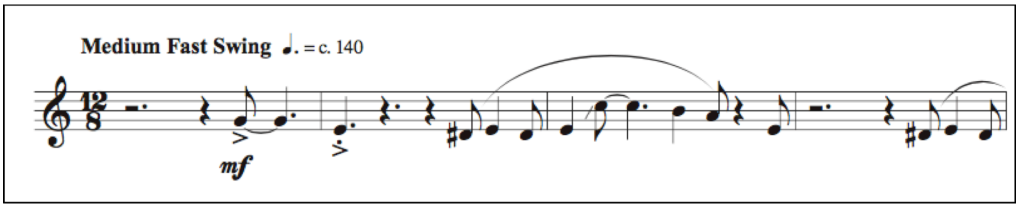

Figure 6.2: Classical notation
Example of four bars of music from tune M2 (*I've Heard That Song Before,* Cahn & Styne, 1942), transcribed into the Classical notation style.
This notation reflects the way jazz is often transcribed for classical performers: Swing is indicated by verbal instruction and by a constant 2:1 BUR (here expressed in the framework of a 12/8 metre to avoid constant triplets, for ease of sight-reading). Phrase and expression markings indicate approximate jazz-enculturated phrasing (as transcribed from the exercise books' sample CDs).

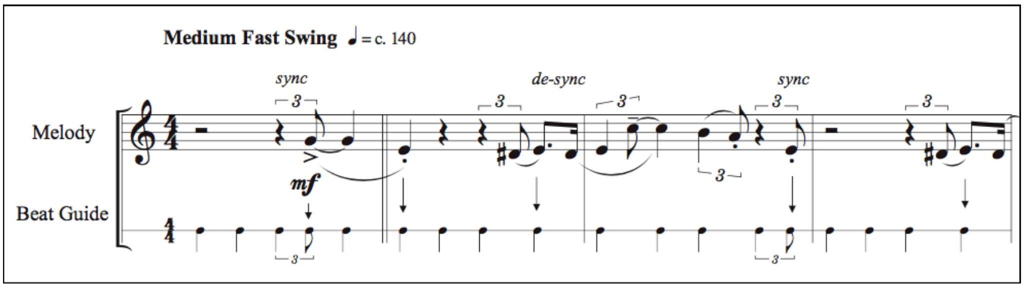

Figure 6.3: Explicit notation
Example of four bars of music from tune M2 (*I've Heard That Song Before,* Cahn & Styne, 1942), transcribed into the Explicit notation style.
This notation was specially created for this experiment to provide a high amount of music information content. All excerpts in this notation style were transcribed directly from the sample CD accompanying the book from which each tune was taken, which featured an expert performance. The music text shown is a close transcription of the sample performance by integrating the audio into the notation programme (MakeMusic Finale 25) and adjusting the notation until the programme's MIDI playback was no longer noticeably different from the simultaneously playing performance.
Deviations from or strong synchronization with the underlying beat and its subdivisions are represented by different means: (1) Changing BURs as appropriate (avoiding tuplets greater than a triplet for ease of sight-reading); (2) Verbal instructions above the score; (3) Reference arrows pointing to an additional staff system, which indicates the piece's underlying beat grid; (4) Early or late attacks are indicated by a combination of fast rhythms and grace notes or grace rests. Tempo markings provide the exact speed. Phrase and expression markings are used to indicate phrasing and accents (transcribed from the expert jazz performance on the exercise books' sample CD).

Setup

For each participant, the swing experiment described here followed on immediately from the score-dependency experiment described in the last chapter. Therefore, several aspects of the methods, including the setup and all the equipment used, were identical to those during the SD experiment. Details are recapped in Box 2.

> **Box 2: Recap of experimental setup and equipment**
>
> **Setup:**
> Questionnaire: Ahead of time, participants completed an online questionnaire using Google Forms, which asked for free text-answers to several biographical questions and for self-ratings on various musical skills and background activities (see Appendix for a blank template).
>
> **Setting:**
> The experiment was conducted in each participant's practice environment with mobile equipment, in order to ensure that they were comfortable and to encourage availability. Provisions were taken to ensure a quiet environment suitable for concentration and recording. Participants were reminded that their identity would be kept anonymous and were asked to sign wavers as required by the Faculty of Music, University of Cambridge for experimental research and interviews (Participant Consent Form for Experiments, Faculty of Music, University of Cambridge: 2018-19; Participant Consent Form for Interviews, Faculty of Music, University of Cambridge: 2018-19; the latter was co-signed by the researcher). They were explained the experimental process and were given a Participant Information Sheet with a summary of the procedure, but did not receive a full explanation of the background until after completion, in order to prevent bias. They conducted the task once in a practice run to ensure they had understood the process and were comfortable with the proceedings; this practice run was also used to check volume levels.
>
> **Equipment:**
> Recording & Playback: The equipment used were an Apple MacBook Pro 2012 laptop, AKG K451 headphones, a Sennheiser E835 microphone mounted on a portable stand, and a Behringer U-Phoria UMC404HD audio interface. The sessions were recorded using the Apple software LogicPro 9. Audio files were played via headphones or laptop speakers, and good listening conditions were ensured for each option.
> For all randomisation processes, the list function on the website random.org [accessed between 01 March and 30 June 2019] or its mobile app for Android phones 'Certified True Randomisers' version 1.2.12 were used. Random.og uses atmospheric noise to produce orders that are more random than those based on computer algorithms.

Procedure

The basic experimental task always followed the same procedure: Participants were given a transcription of a tune, as predetermined by the randomised order, and they had 30 seconds to familiarise themselves with it. Then they were played two bars of the tune's metronome speed to familiarise themselves with the tempo. The metronome was reset. Then the recording process started: First they were counted in for two bars with a metronome, then they sight-read the tune from the transcription and along to the metronome. Each participant performed this task twelve times (for tunes M1, M2, S1 and S2 in three transcriptions each).

The dependent variable of interest was participants' swing levels. The primary independent variable of interest was notational style, with tempo range and aural priming serving as secondary independent variables of interest. In order to ensure that all variables could be controlled for without biasing the outcome, the experimental task as described above was executed in several phases, but all tune and notation orderings within a phase were randomised for every participant to avoid any ordering effects in the data. The experimental structure was divided into two phases: Without and with aural priming conditions. Experimental task performances without priming always preceded those with priming, in order to avoid any carryover effects from primed to non-primed. The exact structure is illustrated in Table 6.1.

Phase	Procedure	Example
1. No aural priming	Participants played three transcriptions of one slow and one medium-tempo jazz tune, in a randomised order.	Tune S1 – Explicit style Tune M2 – Classical style Tune S1 – Classical style Tune M2 – Jazz style Tune M2 – Explicit style Tune S1 – Jazz style
2. Aural priming	Participants were primed with a jazz expert recording of one out of two remaining tunes (medium or slow), then they played that tune in all three notations. The process was repeated for the last remaining tune. The order of tunes and the order of notations for each tune were randomised in advance.	*Priming for tune S2* Tune S2 – Jazz style Tune S2 – Explicit style Tune S2 – Classical style *Priming for tune M1* Tune M1 – Classical style Tune M1 – Jazz style Tune M1 – Explicit style

Table 6.1: Experimental structure

Environmental validity

Several factors of environmental validity had to be weighed against conditions required for successful data collection. In this experiment it was necessary to use an external tactus-providing mechanism in order to guarantee the same tempo across all recordings of one tune. Therefore a metronome was used to provide the steady beat required for swing, which in a performance scenario usually would be provided by a backing band or, in a solo performance, a performer's internal sense of timing.[72]

It was also necessary to measure participants' first, immediate responses to the notational styles in order to gauge their effects on swing levels. In a professional recording scenario, classical performers would usually first play through a score several times to eliminate any performance errors and make diacritical markings to engage more deeply with the score. In this regard, sight-reading represents only one of many possible modes of engaging with the score. However, due to the established interference effect of long-term working memory in performers (Ericsson & Kintsch, 1995; Lehmann & Ericsson, 1993; Lehmann & Kopiez, 2016), unnecessarily repeated exposure to the notational styles over the course of the experimental session would have likely caused a learning effect that might have altered the effect of notation styles on swing levels. To avoid such learning effects, participants here were only given 30 seconds of study time before playing from a musical score, which corresponded to the real-time duration of each excerpt. This meant that participants only had just enough time to look through the score in musical real time in order to familiarise themselves with the notational style, but not enough to rehearse or annotate any difficult passages.

For the same reason of avoiding learning effects, participants were also instructed not to repeat material when making an error during sight-reading. If they made an error, participants were supposed to ignore it and keep on playing. If the error was severe enough to make them stop or lose their place, they should wait until the metronome had counted out a full bar or two and then continue on from where they had stopped. To minimise the effect of such errors on ratings, raters were instructed to disregard any obvious performance errors likely based on sight-reading while assessing the recordings.

As in Chapter 5's experiment, semi-structured interviews were conducted with each participant after the conclusion of the experiment. These interviews were recorded for later review with expressed permission of each participant. The aim of the interviews was to collect contextual information that could be used to interpret the data, as well as give participants' the

[72] Although a playback track with jazz band accompaniment would have offered more environmental validity for participants, the backing track might have induced swing in participant's performance. This could have diminished any effects of notational styles or aural priming on perceived swing levels, which were the central purpose of this experiment. Therefore, and since it was shown that a metronome does not negatively affect novice jazz learners when compared to a backing track (Morrison, Treviño & Sielert, 2008), the decision was made to use a metronome instead of a backing track.

opportunity to reflect on their performance and comment on any musical or biographical factors that may have impacted it.

Rating sessions

After all experimental sessions were concluded, all recordings were exported to MP3-files. In order to allow enculturated jazz listeners to rate the participant recordings, online questionnaires were prepared on the platform Qualtrics[73]. In these questionnaires, the listeners were asked to provide biographical information, a definition of what swing is to them, and a definition of how their concept of swing was connected to the term groove (which was defined as the urge to move with the music). They were then asked to rate participant recordings and the expert recordings used for aural priming.[74] Listeners were asked to rate every recording for three factors: Enjoyment ('How much did you enjoy listening to the performance?'), Swing ('How much does the performance swing?'), and Groove ('How much does the performance groove?'). All three factors were ranked using a 1–7 Likert scale. The Enjoyment rating was always collected first in order to prevent the presence or absence of swing or groove influencing perceived levels of enjoyment. Listeners were also asked to justify their swing ratings in each case by leaving explanatory comments. They were asked to provide both a subjective reasoning ('Why does or doesn't the performance swing in your opinion?') and an optional technical reasoning ('Are there any specific technical aspects in this performance that make it swing more or less?').

In order to avoid priming listeners' expectations, no definitions for the terms 'enjoy' or 'swing' were provided. Since the literature provides no coherent definition of what swing is, all

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[73] QualtricsXM, 2019. URL: www.qualtrics.com/

[74] Since the experiment produced a high total number of recordings (N=240), it was not possible for let all listeners rate all performer recordings. The pilot study had revealed that a listener needed c. 60-90 minutes to complete a questionnaire with 24 participant recordings, so that rating any more would likely result in raters' fatigue. That is why every listener rated 24 participant recordings, 12 from two performers each. The recordings were distributed so that every listener rated two different participants, but that no two listeners ever rated the same participant pair. In turn, every participant was rated by a unique pairing of two listeners, making the overall system robust against individual rating errors. In order to provide a listener with a comparable recording set, it was endeavoured to match recordings by instrument (e.g. from two pianists), instrumental type (e.g. from two keyboard instruments), or timbre (e.g. from two instruments with sustained wind sound), though in some few cases this was not possible. Since no two listeners rated the same two participants, all listeners were also asked to rate the four expert jazz recordings used to prime participants, as this ensured at least one small dataset common to all raters.

listeners were instead asked to provide a personal definition of the term, in order to gain an empirical understanding of how jazz listeners define swing. However, given that in some languages (e.g. Danish, Swedish) and jazz practices the terms swing and groove are used synonymously, it was necessary to provide raters with a definition of the term 'groove': *'Groove is here meant as inducing the pleasant urge to move along with the music'.* This definition is widely used in the literature (e.g. Monson 1996; Pressing 2002; Madison, 2006; Janata, Tomic, & Haberman, 2012).

6.4. Results

Rater agreement

In order to establish the validity of ratings for later hypothesis testing, rater agreement was examined by calculating intraclass correlation coefficient (ICC) estimates[75] [76] and their 95% confidence intervals in the software package StataIC.[77] In this experimental setup, 20 performers

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[75] Traditionally, ordinal data, as represented by the ratings here, would be more appropriately computed using a weighted version of Cohen's kappa. However, kappa was seen as inappropriate here, since it treats the data as categorical with the weighting merely applying an ordinal ranking to these categories (Viera & Garrett, 2005). The data collected here was based on a Likert-scale, where separate numbers on the scale do not represent ranked separate categories but rather degrees of agreement with an underlying premise, and so the data was treated as interval-level and not ordered categorical. That suggested running a Pearson correlation, however this would have produced correlation coefficients for agreement between each rater pairing instead of the entire group, and would only represent consistency (i.e. shared directionality among ratings) without taking absolute differences between ratings into account, which were both of interest here. Another option, factor analysis, would have been possible, but only for the overall data combining ratings for the factors Enjoyment, Swing, and Groove. Scores for each of these factors could not have been computed, as data on any sub-factors for each of these were not available. Therefore the decision was made to use the ICC instead. Unlike kappa, it does not assume the data to be categorical in nature. And unlike the Pearson correlation, it can be used to compute agreement between both individual raters and among an entire rater group, and can be used to compute both absolute and consistent agreement (for details, see Shrout & Fleiss, 1979). Unlike factor analysis, it could be applied to the overall data and the individual factors. In addition, its 95% confidence intervals can be calculated simply and used to interpret a possible population mean, providing a measure easily generalizable to a population of raters of the same kind (Koo & Li, 2016). In summary, the ICC was found to be the most appropriate test for the questions explored by this experiment.

[76] The ICC indicates a figure between 0 and 1 or -1, where 0 indicates no better than random agreement, 1 indicates perfect agreement, and -1 indicates perfect disagreement between raters. According to Koo and Li, in medical research absolute ICC values of 'less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability' (2016, 158). However, it must be considered that music appreciation and aesthetic assessment of the kind required here are inherently subjective acts and are therefore likely to yield lower or more widely spread results than would be acceptable in medical research.

[77] As already mentioned in Chapters 2 and 5: All statistics for this thesis were calculated using the software Microsoft Excel for Mac 2011 and the statistics software package StataCorp StataIC 15.1 for Mac.

produced sets of 12 recordings each, creating an overall dataset of N=240 recordings. However, since these were not rated by all raters, rater agreement estimates were run on ratings provided for the expert jazz recordings used to prime participants (n=4), which were rated by all raters and therefore represent a shared dataset.[78]

In order to examine ratings for the factors Enjoyment, Swing, and Groove and generalise them to a wider population of raters, the ICC and its 95% CI were estimated based on a mean-rating (k=20), consistency-agreement, two-way random-effects model. The two-way random effects model used here assumes that raters have been randomly selected to represent a larger population of similar raters and so allows generalising results to that population of raters. Since the jazz listeners were recruited based on opportunity sampling among jazz listener communities and screened by expertise, it was assumed they formed a representative sample from the population of experienced jazz listeners.

The model was run separately for ratings based on the factors Enjoyment, Swing, Groove, as well as for the complete dataset featuring all three ratings. Using ratings for Enjoyment as targets (n=4), the ICC was 0.36 and the 95% CI was [-1.16, 0.95]. These results are nearly as diverse as could be, indicating that the directionality of ratings ranged from extreme disagreement to near-perfect agreement. While the figure of -1.16 would usually suggest a measurement problem, given that it exceeds the ICC boundary of -1, here it was not surprising, as the results merely illustrate that enjoyment of music is highly subjective, with preferences

[78] A rater agreement estimation was run on ratings provided for participant recordings. Because not all listeners rated all the participant recordings, a rater agreement figure indicating the experiment's reproducibility with other raters from the same population could not be calculated for this particular dataset—this was done with another dataset instead, as outlined in the main text. Nonetheless, running a rater agreement estimation on ratings for participant recordings still allowed for establishing within-sample rater agreement. This was possible by using not the individual recordings but rather the rating conditions as targets for ICC estimation, since the rating conditions were common to all listeners. There were n=36 conditions: One of four tunes (M1, M2, S1, S2), played from one of three notation styles (Jazz, Classical, Explicit), rated for one of three factors (Enjoyment, Swing, Groove) (4 x 3 x 3 = 36). These n=36 conditions were chosen as targets for ICC estimation. Since every listener rated two different performers, sharing each half of their dataset with one other rater, this calculation assumed that the number of raters was double (k=40), since each rater was part of two rater pairings. The estimation of the ICC and its 95% confidence interval (CI) was done using a mean-rating (k=40), absolute-agreement, one-way random-effects model. The ICC was 0.80 and the CI was [0.69, 0.88], indicating moderate-to-good absolute agreement within this rater sample for ratings given for the 36 conditions, despite basing their ratings on different audio recordings. Because every listener rated each condition based on recordings from two participants, the dataset contained multiple ratings by each listener for each condition, and so it was not possible to separate ratings by the three rating factors Enjoyment, Swing, and Groove. However, this was addressed in the main rater agreement calculation reported in the main text. In summary, when examining ratings given for participant recordings, this experienced jazz listener sample showed moderate to good absolute agreement in their ratings per conditions, regardless of which specific recordings prompted these ratings.

varying strongly between listeners even when they are enculturated in the same genre. This mirrors how listeners with similar musical enculturation still interpret musical performances very differently, as also found in a jazz context by Schober and Spiro (2016).

When using Groove ratings as targets (n=4), the ICC was 0.54 and the CI was [-0.56, 0.97], which indicates moderate disagreement to near-excellent agreement. This suggests that, despite being given a definition of the term 'groove', listeners likely did not share a common understanding of which performances induced groove. Since groove is meant to induce the pleasurable urge to move with music, this result may be tied to their individualistic interpretations of which performances were found enjoyable.

When using Swing ratings as targets (n=4), the ICC was 0.81 and the CI was [0.36, 0.99], indicating slight to near-perfect agreement. Given that the term 'swing' was not defined for listeners, instead requiring them to apply their personal understanding of the term, these results suggest that there is an overall (though possibly vague) shared understanding between jazz-enculturated listeners as to what 'swing' is. This result is not entirely surprising, given that all raters were experienced jazz listeners. How this common understanding of swing among listeners can be defined is discussed further below, in the section presenting an analysis the definitions and comments provided by the listeners.

When using ratings for all three factors together as targets (n=12), the estimated ICC based on ratings for the expert jazz recordings was 0.65 for absolute agreement, with a 95% CI of [0.33, 0.87]. For consistent agreement,[79] the ICC was 0.70 with a CI of [0.38, 0.90]. Since the two-way random effects model allows generalising the results to a population of raters with similar characteristics (i.e. experienced jazz listeners), we can say with low to good confidence that other jazz-enculturated listeners would provide the same absolute ratings for these recordings, or low to near excellent confidence that other jazz-enculturated listeners' ratings would feature the same directionality under the same conditions.

At first glance, these CIs and their wide-ranging interpretation ('low to near excellent confidence') may appear to question the reproducibility of the gained ratings. However, it is important to remember that the interpretative terms of the numerical values used here are taken

[79] The two-way ICC model can also be based on a 'consistency-agreement' rather than 'absolute-agreement' definition. While the 'absolute-agreement' definition indicates whether raters provided the *same* ratings, the 'consistency-agreement' definition chosen here indicates whether scores from raters differ from each other by a constant value (i.e. indicating whether ratings share directionality despite not sharing absolute values).

from medical standards (specifically from Koo and Li, 2016). As a result, these should be considered conservative by music research standards, given that music appreciation and aesthetic assessment of the kind required here are inherently based on greater levels of subjectivity—as mentioned in Chapter 2, a stylistic concept (or 'groove archetype') such as swing is socially negotiated, not objectively measured. Taking this into account, the 95% confidence for a *population* mean lying somewhere between 0.38 and 0.90 suggests that the findings presented here are likely not merely due to chance (as both extremes and any potential mean still lie within acceptable distance from 0). Therefore they should be reproducible in a population of comparable raters, although the wide spread of the CI naturally limits in how far the extent of their reproducibility can be assessed. In any case, due to the limited target numbers and the limited sample size used here, all presented results should naturally be treated cautiously.

In summary, when examining ratings given for the expert jazz recordings, the data indicated no shared agreement on which recordings produced higher Enjoyment and Groove, though the data did indicate a slight to near-perfect shared perception of Swing. There was low to near excellent confidence that a wider population of experienced jazz listeners would rate the expert jazz recordings similarly.

Ratings for expert jazz recordings

For expert recordings,[80] mean ratings for each factor per recording were produced. Table 6.1 summarizes the results for expert recordings.

[80] All jazz listeners (n=20) rated both participant recordings and four expert jazz recordings for the factors Enjoyment, Swing, and Groove (in that order) on a Likert-scale of 1–7 with 4 as median scale position. However, since the expert recordings were performed by a full jazz band and the participant recordings by a single melody instrument with metronome click, these two types of recordings should not and were not compared directly. Therefore, data for them is presented separately.

	Enjoyment	Swing	Groove
Overall			
Mean	6.01	5.58	5.53
Std. Dev.	1.04	1.31	1.36
Range	3–7	1–7	1–7
95% C.I.	5.78–6.24	5.28–5.87	5.22–5.83
–Medium tempi			
Mean	5.85	5.95	5.8
Std. Dev.	1.12	0.93	1.16
Range	3–7	4–7	2–7
95% C.I.	5.49–6.28	5.65–6.25	5.43–6.17
–Slow tempi			
Mean	6.18	5.2	5.25
Std. Dev.	0.93	1.52	1.50
Range	4–7	1–7	1–7
95% C.I.	5.88–6.47	4.71–5.69	4.77–5.73

Table 6.1: Summary statistics for listener ratings of expert jazz recordings, with subsets for slow and medium tempo ranges

The data was analysed for differences by tempo ranges. A Kruskal-Wallis test revealed that tempo's effect on ratings was not significant for Enjoyment. However it was significant for Swing ($t(1)=4.771$, $p=0.0289$) and approached significance for Groove ($t(1) = 2.901$, $p=0.0885$), in both cases with medium tempi causing higher ratings than slow tempi.

Ratings for participant recordings

For participant recordings, which were each rated by two different listeners, the ratings from the two listeners were averaged for every recording to produce one mean rating for each factor per recording. Then these mean ratings per recording were averaged for each factor, tempo range, and notational style per participant, taking participants' individual score-dependency rating (SDR) and their classification as relatively score-dependent or score-independent musicians (SDMs and SIMs) into account (see Chapter 5 for details on score-dependency ratings and classifications). Ratings were further differentiated by whether recordings were produced under conditions of aural priming or not.

Summary statistics for factors Enjoyment, Swing and Groove

Overall analysis of the averaged ratings for the three rating factors revealed that listener pairs gave highest ratings for the factor Enjoyment (mean: 3.65, range: 2.04–4.92, std. dev.: 0.85, 95% CI: [3.26, 4.05]), followed by Swing (mean: 3.53, range: 1.59–4.96, std. dev.: 0.93, 95% CI: [3.09, 3.96]), and finally followed by Groove (mean: 3.10, range: 1.67–4.58, std. dev.: 0.75, 95% CI: [2.75, 3.45]).

Effects of score-dependency on ratings

Hypothesis 1 stated that SDMs would receive lower swing ratings than SIMs. During the earlier SD experiment (see last chapter), all participating performers had been classified either as relatively score-dependent musicians (SDMs, i.e. scoring SDR>=4.01) or as relatively score-independent musicians (SIMs, i.e. scoring SDR<=4.00). Although independent samples t-tests revealed that scores for overall Enjoyment, Swing, and Groove ratings were consistently lower for SDMs, the differences between groups were not significant. There was also no significant effect for SD by notational style, not even when examined for medium and slow tempi separately. Neither were there any significant results for correlations between participants' individual SD levels and ratings by individual notational styles. This indicates that a musician's level of SD does not have a significant effect on listeners' observed Enjoyment, Swing, or Groove levels in their playing. Therefore Hypothesis 1 was not confirmed.

Effects of notational style

Hypothesis 2 stated that swing ratings for SDMs would increase when they played from very detailed notation. Hypothesis 3 stated that ratings for SIMs would not be affected by notational styles. Therefore, it was of interest to find out if notational style could affect performer recordings to the point that it influenced listener ratings. Every participant recording was made based on either the jazz, classical, or explicit notational style. Therefore listener ratings for Enjoyment, Swing, and Groove per recording were analysed based on which notational style had been used to produce that recording. Subsets of the data were examined based on tempo range and by whether participants were classified as SDMs or SIMs.

Mean ratings for each notational style per factor were examined and the notational styles were ranked from highest to lowest mean rating for each data subset. Then all notation pairings within a ranking were further examined by paired-samples t-tests (or, in the case of non-parametric data, Wilcoxon signed rank sum tests). Holm-Bonferroni post-hoc corrections for repeated hypothesis testing were applied to the lowest hierarchical test levels (i.e. score-dependency group x tempo group).[81] The results made it possible to establish whether the differences between mean ratings within a ranking were significant. As an additional check, Friedman tests were conducted on every ranking to indicate whether there were significant differences between conditions, however they confirmed the results gained from the t-tests in every case and are therefore not elaborated on here. The resulting rankings are presented in Table 6.2.

[81] Since the post-hoc corrections assume statistical independence of the t-test/Wilcoxon test results, they could only be applied to the lowest hierarchical test levels (i.e. score-dependency group x tempo group), as all other results are composite scores and therefore dependent on these.

<table>
<tr><th></th><th>Enjoyment</th><th>Swing</th><th>Groove</th></tr>
<tr><td>Overall</td><td>(CN || JN) > EN
(3.79 || 3.56) > 3.23</td><td>(CN || JN) > EN
(3.78 || 3.56) > 3.23</td><td>(CN || JN) > EN
(3.31 || 3.28) > 2.71</td></tr>
<tr><td>–SDMs</td><td>(CN > EN) || JN
(3.63 > 3.05) || 3.35</td><td>(CN > EN) || JN
(3.63 > 3.05) || 3.35</td><td>(CN || JN) > EN
(3.19 || 3.18) > 2.56</td></tr>
<tr><td>–SIMs</td><td>(JN || CN) > EN
(4.04 || 3.93) > 3.51</td><td>CN || JN || EN
3.98 || 3.81 || 3.46
(i.e. no sign. ordering)</td><td>CN || JN || EN
3.46 || 3.39 || 2.91
(i.e. no sign. ordering)</td></tr>
<tr><td>—Slow tempi</td><td>CN > JN > EN
3.79 > 3.49 > 2.99</td><td>CN > JN > EN
3.43 > 2.98 > 2.55</td><td>(CN || JN) > EN
(2.78 || 2.70) > 2.14</td></tr>
<tr><td>—–SDMs at slow tempi</td><td>(CN > EN) || JN [a]
(3.55 > 2.81) || 3.25</td><td>(CN > EN) || JN
(3.25 > 2.61) || 2.73</td><td>JN || CN || EN
2.55 || 2.50 || 2.23
(i.e. no sign. ordering)</td></tr>
<tr><td>—–SIMs at slow tempi</td><td>(CN || JN) > EN [b]
(4.08 || 3.78) > 3.19</td><td>(CN || JN) > EN
(3.64 || 3.28) > 2.47</td><td>(CN || JN) > EN
(3.11 || 2.89) > 2.03</td></tr>
<tr><td>—Medium tempi</td><td>(JN > EN) || CN
(4.06 > 3.68) || 3.91</td><td>CN || JN || EN
4.15 || 4.14 || 3.91
(i.e. no sign. ordering)</td><td>(JN || CN) > EN
(3.85 || 3.85) > 3.29</td></tr>
<tr><td>—–SDMs at medium tempi</td><td>(CN > EN) || JN
4.02 > 3.55 || 3.86</td><td>CN || JN || EN [c]
4.0 || 3.98 || 3.48
(i.e. no sign. ordering)</td><td>(CN || JN) > EN
(3.89 || 3.82) > 2.89</td></tr>
<tr><td>—–SIMs at medium tempi</td><td>(JN > CN) || EN
(4.30 > 3.77) || 3.83</td><td>EN || CN || JN
4.44 || 4.33 || 4.33
(i.e. no sign. ordering)</td><td>JN || CN || EN
3.89 || 3.81 || 3.78
(i.e. no sign. ordering)</td></tr>
</table>

Table 6.2: Notational styles ranked by mean ratings.
Rankings of notational styles per category are shown on top, their corresponding mean ratings below. Notational styles separated by double lines || are not significantly different from each other at p<=0.05. For ease of reading, results for relatively score-dependent musicians (SDMs) are shown in green and for relatively score-independent musicians (SIMs) in blue.
Symbol key: JN = Jazz notation, CN = Classical notation, EN = Explicit notation.

[a] Differences between CN and JN approached significance at p=0.08, suggesting a ranking of CN > (JN || EN) at this significance level.
[b] Differences between CN and JN approached significance at p=0.07, suggesting a ranking of CN > JN > EN at this significance level.
[c] Differences between JN and EN as well as CN and EN approached significance at p=0.07 for each, suggesting a ranking of (CN || JN) > EN at this significance level.

The results presented in Table 6.2 show which notational styles contributed most to higher ratings for the factors Enjoyment, Swing, and Groove. The data indicates that Jazz and Classical notations mostly contributed to high ratings, but their means were rarely significantly different from each other. When they were different, the Classical notation scored higher, particularly at slow tempi. The Explicit notation generally received lowest ratings or caused no significantly higher ratings than the other two notation styles. When separating by SD levels, SDMs seemed to score highest with the classical notation, though there was never a clearly significant difference to the jazz notation. SIMs, on the other hand, seemed to have no clear high-scoring notation: For them, the only identifiable trend was that at slow tempi the explicit notation scored lowest; at medium tempi this only held for Enjoyment, with no notation scoring significantly higher than any other for Swing or Groove.

Several observations can be drawn from these results. Hypothesis 3 was confirmed, since SIMs seem to be truly more independent from the musical score than SDMs, scoring highly with a greater variety of notational styles. SDMs seemed to benefit more consistently from the classical notation format, though often there was no significant difference to the jazz notation style. For SDMs, the classical notation caused most consistently high ratings for Enjoyment and Swing, followed by the jazz notation, which was never significantly better than the explicit notation (though this trend did not hold for Groove ratings). For SIMs, the classical notation never caused significantly greater ratings than the jazz and at medium tempo even the explicit notation. It is noticeable, that the explicit notation did not benefit the SDMs at all, consistently scoring lowest among the notational styles, while for SIMs this was only true at slow tempi. This means that Hypothesis 2 could not be confirmed.

Therefore, SIMs' independence from written notation seems to make them more adept at playing from a variety of notation styles, even very complex ones, particularly at medium tempi. SDMs, on the other hand, seem to rely much more heavily on the rhythmic instructions encoded in the classical notation style, which offers more detail than the jazz notation, but less information to process than the explicit notation. In summary, despite SD causing no significant differences in overall Enjoyment, Swing, or Groove ratings, it appears to modulate notation preferences.

Effects of aural priming on ratings

Hypothesis 4 stated that only SIMs, but not SDMs, would be influenced by aural priming. Therefore it was of interest to find out whether hearing an expert rendition of a jazz tune could noticeably influence musicians' interpretation of this tune from notation. All participants played one medium- and one slow-tempo jazz tune excerpt under the condition of aural priming, meaning they were played an expert jazz rendition of the excerpt immediately before sight-reading it from all three notation styles. Independent-sample t-tests (or, for non-parametric data, Wilcoxon-Mann-Whitney tests) were run to check if aural priming made a difference to Enjoyment, Swing, and Groove ratings. Tempo range, tune, notation style, and musicians' relative SD were also taken into account as additional variables. Aural priming had no significant effect on ratings for any of these variables individually.

However, when considering several variables together, various effects of aural priming were observed on all three factors Enjoyment, Swing, and Groove—with aural priming mostly *lowering* scores. For SDMs performing medium-tempo melody M1 from classical notation, aural priming caused significantly lower ratings for Swing (p=0.008), and Groove (p=0.02). Another negative effect was noted for Enjoyment ratings when tune S2 was played using jazz notation (p=0.05). Priming also approached a negative effect for performers playing the slow tune S1.[82]

In most cases, aural priming made no difference to ratings, and in the few cases where priming did make a difference, it primarily affected scores negatively. This may suggest that in specific circumstances, aural priming distracts musicians more than it helps, causing them to play in a manner less engaging to listeners. It is noticeable that priming seemed to have no effect at all on the explicit notational style. This is possibly due to musicians' reduced inner hearing with greater attentional draw when performing from particularly complex notation (Kopiez & Lee, 2006). On the whole, Hypothesis 4 could not be confirmed, with both SIMs *and* SDMs remaining largely unaffected by aural priming.

[82] For all performers when playing the slow tune S1, priming approached negative impact on Enjoyment overall (p=0.08). Playing S1 from jazz notation, a negative effect was approached for Swing (p=0.06) and Groove (p=0.07). Playing S1 from classical notation, priming's negative effect on ratings approached significance for Swing (p=0.07) and Groove (p=0.07), but not Enjoyment. In the case of Swing, priming likely only affected score-*in*dependent (p=0.07) but not dependent musicians.

Effects of tempo range on ratings

In order to prepare for testing swing's syntax structure (Hypothesis 5), the effect of tempo on ratings was estimated. Paired-sample t-tests were run separately on ratings for recordings produced at slow and at medium tempi. Results showed that tempo's effect on listeners' Enjoyment levels approached significance (p=0.0585), with higher scores at medium tempi (medium tempi mean: 3.88; slow mean: 3.42). Listeners perceived significantly higher Swing levels at medium tempi (mean: 4.07) than at slow tempi (mean: 2.98; p=0.0004). Similarly, Groove was perceived to be significantly higher at medium tempi (mean: 3.66) than at slow tempi (mean: 2.54; p=0.0001). As a result, the data indicates that perceptions of both Swing and Groove were highly influenced by tempo. Hypothesis 5 will be tested in more detail below.

Jazz listeners' comments

In order to prepare for testing hypotheses 5 and 6, it was explored what musical traits could contribute to jazz listeners' perception of swing and groove. Before beginning their rating task, listeners had been asked to define (1) what swing is to them and (2) how their concept of swing may relate to groove. In addition, during the rating task, they were asked not just to provide numerical ratings, but also leave explanatory comments for each rated recording. They were asked (a) why the recording did or did not swing in their opinion and (b) (optional) what technical aspects might have contributed to this effect.

Features ascribed to swing

Listeners' definitions of (1) what swing is to them (n=20) were analysed for recurring perceived features of swing. When separately surveying their definitions of (2) how swing is related to groove (n=20), more features ascribed to swing were found. Therefore the decision was made to include both definitions 1 and 2 together for this analysis. All mentioned features of swing were noted and quantified. Synonymous expressions of a feature were collected together under an umbrella term.[83] This produced nine features in total that listeners ascribe to swing:

- Unequal beat-upbeat ratios
- Upbeat emphasis
- Backbeat emphasis
- Fast tempo
- Rhythmic elasticity
- An urge to move/dance
- A sense of forward motion
- A particular rhythmic feeling
- A style of jazz.

Many listeners mentioned several features at once. In order to gain an understanding of which features were most prevalent across listeners, Figure 6.4 shows how many listeners mentioned each feature.

[83] E.g. sentences such as 'Shuffle - the first 1/8 being just a bit longer than the second' and 'I would define swing it as an uneven but regular distribution of equal notes in time' were both counted towards the umbrella term 'Unequal beat-upbeat ratios'.

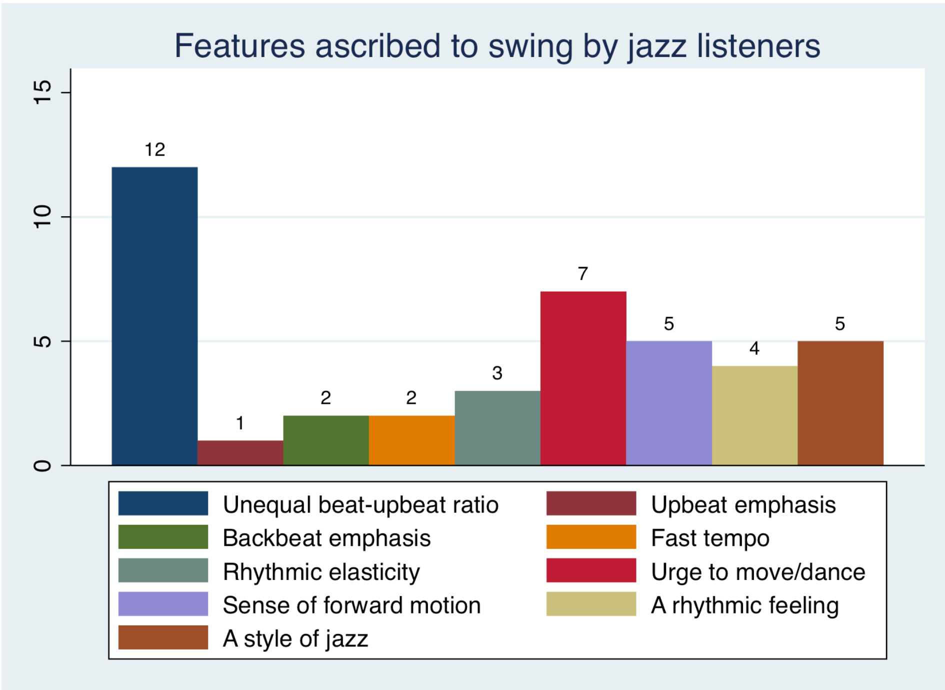

Figure 6.4: Features ascribed to swing by jazz listeners, with number of listeners mentioning each feature

The data shown in Figure 6.4 allows for extrapolating the features most frequently associated with swing by enculturated jazz listeners: Out of 20 consulted jazz listeners, 12 (60%) associated unequal beat-upbeat ratios, seven (35%) an urge to move or dance, and five (25%) a sense of forward motion and a style of jazz. This distribution suggests that listeners consider swing as a primarily rhythmic phenomenon.

The relationship between swing and groove as perceived by jazz listeners

Hypothesis 5 stated that swing is a groove archetype. In order to better understand the relationship between swing and groove, listeners' had been asked to define what relationship their concept of swing had with the term 'groove' (with groove being explicitly defined as the urge to move with the music). As before, comments were analysed and synonymous expressions of one concept were gathered under an umbrella term. Based on this method, five types of relationship between swing and groove were identified in the comments:

- Swing and groove are the same concept
- Swing and groove are unrelated
- Swing is a form of expressing groove
- Swing heightens the sense of groove
- Swing is an essential feature of groove.

Again, several listeners expressed several concepts at once. Figure 6.5 shows how many listeners mentioned each type of relationship.

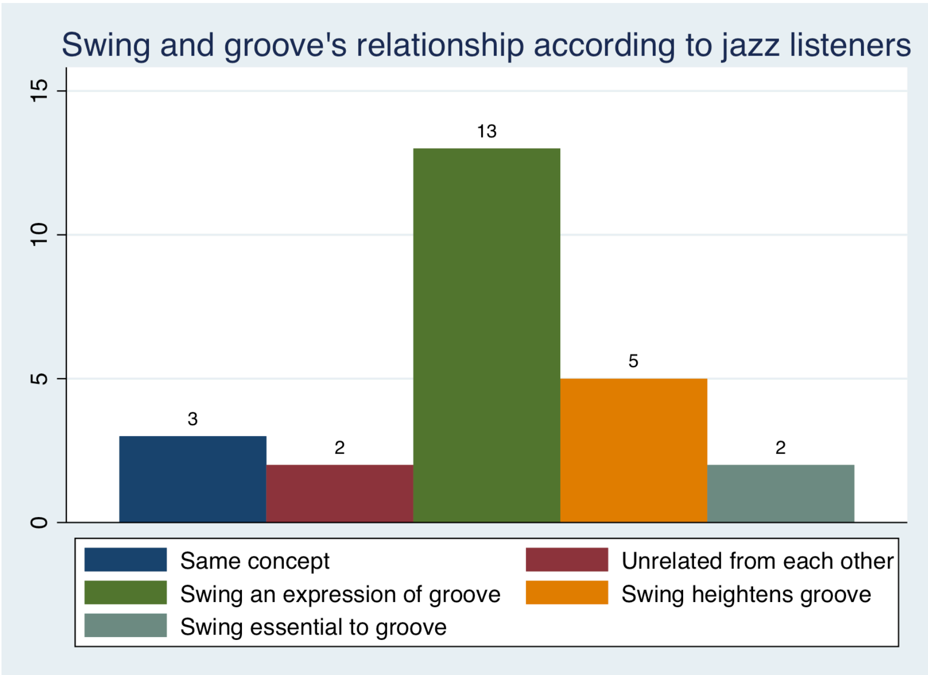

Figure 6.5: Topics mentioned in how enculturated jazz listeners' evaluate how their definition of swing relates to the term 'groove' (defined as an urge to move with music), with frequency of mention.

Taking the top three results from Figure 6.4, 13 out of 20 enculturated jazz listeners (65%) believed swing to be a form of expressing groove, with five (25%) believing swing to heighten groove, while three (15%) believed swing and groove to represent the same concept. This indicates a deep-seated connection between swing and groove in the minds of the majority of listeners, which will be further explored below when running regression analyses to explore the relationship between enjoyment, swing, and groove. This supports Hypothesis 5 that swing is a groove archetype, i.e. a culturally specific expression of groove. An additional test for this hypothesis is discussed further below.

Positive and negative features in classical musicians' swing

Hypothesis 6 stated that swing's syntax consists of occasional synchronization with a near-metronomic beat sequence, occasional de-synchronization from the beat by using displacement and articulation to syncopate, and an unequal subdivision of the beat. During the rating session, listeners were asked not only to provide a numerical rating but also to provide explanatory comments on why they felt a recording did or did not swing and (optionally) what technical aspects may have contributed to this. In order to test hypothesis 6, both types of comments were analysed together. Several technical features of swing performance were identified in the comments and were grouped into the following eight umbrella categories:

- Eighth-note ratio (length of eighth notes or beat-upbeat ratios)
- Articulation (attack, accent and articulation of notes)
- Deviation from beat (varying the rhythm deliberately or playing deliberately off the metronomic beat position)
- Synchronization with beat (synchronising with the metronomic beat position, outlining the metronomic beat position, or producing groove)
- Timbre
- Dynamics
- Flow (producing a sense of rhythmic or musical flow)
- Fast-tempo preference.

These features were mentioned both in a positive context (features were present and contributed to good swing) and in negative contexts (features were absent or needed improvement for good swing). Therefore, it was of interest to explore how significantly these swing features affected listeners' swing ratings positively or negatively.

In order to do this, an analysis was run for each context separately. Every rating for the factor Swing was examined by whether the rater concurrently mentioned a swing feature; a mentioned feature was coded with the value 1 and all unmentioned features with 0. This provided an empirical basis for correlating swing features with the concurrent rating, using the nonparametric Spearman correlation. Results of these correlations are shown in Table 6.3. It was also quantified how often each feature was mentioned in each context, as shown in Figure 6.6.

Swing feature & context	**Spearman's rho**	**Significance**
Eighth-note relationship		
- *positive* context	0.37	p=0.00001
- *negative* context	-0.26	p=0.00001
Articulation		
- *positive*	0.33	p=0.00001
- *negative*	-0.14	p=0.002
Deviation from beat		
- *positive*	0.42	p=0.00001
- *negative*	-0.22	p=0.00001
Synchronization with beat		
- *positive*	0.30	p=0.00001
- *negative*	-0.19	p=0.00001
Timbre		
- *positive*	0.10	p=0.0305
- *negative*	no sig. results	no sig. results
Dynamics		
- *positive*	0.10	p=0.0405
- *negative*	-0.10	p=0.0226
Flow production		
- *positive*	no sig. results	no sig. results
- *negative*	no sig. results	no sig. results
Fast-tempo preference		
- *positive*	0.27	p=0.00001
- *negative*	-0.17	p=0.0002

Table 6.3: Correlations of positively and negatively mentioned swing features with Swing ratings
Results of Spearman correlations between jazz listeners' ratings for the factor Swing and swing features concurrently mentioned in a positive or negative context.

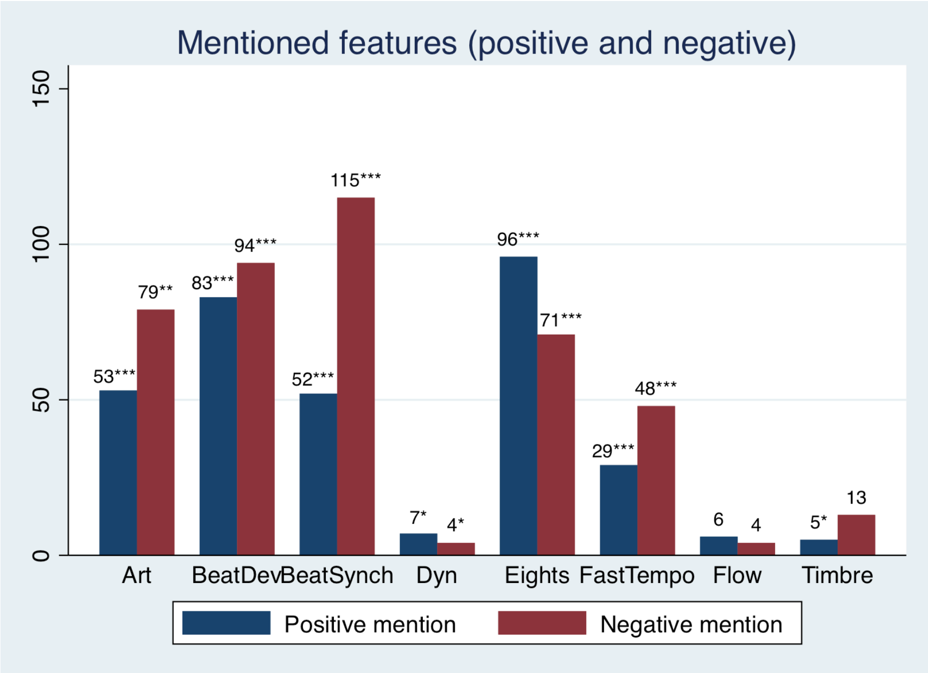

Figure 6.6: Swing features pointed out by enculturated jazz listeners in the evaluation of classical musicians' swing, with frequency of mention in both positive and negative contexts. Stars indicate significant correlations with ratings for the factor Swing at p<=0.05 (*), p<=0.01 (**), and p<=0.001(***).
Symbol key: Art = articulation; BeatDev = Deviation from beat; BeatSynch = Synchronization with beat; Dyn = Dynamics; Eights = Eighth-note ratio; FastTempo = Fast-tempo preference

Combining insights gained from Tables 6.3 and Figure 6.6, only the five most mentioned features in both positive and negative contexts were significantly and at least slightly correlated (Spearman's rho > 0.10) with listener ratings for the factor Swing. There is a noticeable discrepancy between positive and negative mentions for 'synchronization with the beat', with 115 negative but only 53 positive mentions. Since this is the largest discrepancy between positive and negative mentions with a negative skew, it suggests that good synchronization is the feature listeners found most in need of improvement in classical musicians' swing performance.

The five most mentioned features appeared both in praise and in criticism of classical musicians' swing. Their mention in both contexts suggests that these features likely represent the elements that enculturated jazz listeners consider essential to successful swing, independently of what performer type produces them. Therefore it was of interest to explore what features most affected listeners' swing ratings regardless of positive/negative context. That is why Table 6.4

shows them ranked by the effect size of their correlation coefficients for positive and negative contexts separately in the first two columns. The third column shows them ranked by an overall effect size, created by adding together the absolute values of the positive and negative coefficients. This indicates which swing features most affected ratings, positively or negatively, for the factor Swing.

Rank	Positive	Negative	Overall
1.	Deviation from beat (0.42)	Eighth-note relationship (-0.26)	Deviation from beat (Combined effect: 0.64)
2.	Eighth-note relationship (0.37)	Deviation from beat (-0.22)	Eighth-note relationship (Combined effect: 0.63)
3.	Articulation (0.33)	Synchronization with beat (-0.19)	Synchronization with beat (Combined effect: 0.49)
4.	Synchronization with beat (0.30)	Articulation (-0.14)	Articulation (Combined effect: 0.47)
5.	Fast-tempo preference (0.27)	Fast-tempo preference (-0.17)	Fast-tempo preference (Combined effect: 0.44)

Table 6.4: Swing features in positive and negative contexts, ranked by their Spearman coefficients for correlations with ratings for factor Swing (noted in parentheses). A ranking according to combined absolute effect size is presented in the fourth column 'Overall'.

As a result, the combined effect size—made up of absolute values from both positive and negative contexts—indicates which factors had the greatest overall relationship with ratings. Considering that these ratings are based on recordings by relatively jazz-unenculturated performers, the features ranked in this last column are likely what the jazz listeners consider only the most important basic features required for successful swing. Since this ranking is based on mentions drawn from both praise and criticism, it expresses which basic features listeners pay special attention to when asked to evaluate swing. Therefore, it can be expected that listeners may change the mode in which they employ these features (positive/negative) according to the swing proficiency displayed, but that they will apply these features as minimum criteria to any jazz performance. Consequently, these results have relevance beyond the classical recording context. As a result, the third column in Table 6.4 can be considered a ranking of the most important basic swing features according to jazz listeners. As such, they represent the very basic syntax for swing. The results support Hypothesis 6, although the preference for a faster tempo had not been anticipated to be such a core feature of swing, which is why it will be explored further in the next section.

Tempo's influence on listener comments

Analyses presented earlier showed that listeners regarded tempo as an important factor in swing production, with higher tempi correlating significantly with higher swing ratings, which had not been anticipated in the formulation of the hypotheses. Therefore it was of interest to see which aspects in classical musicians' swing may have contributed to this perception. To explore this possibility, critical (i.e. negative) listener comments were correlated with swing ratings at slow and medium tempo ranges separately. Results are presented in Table 6.5. It was also quantified how many times listeners mentioned each feature critically, which is shown in Figure 6.7.

Swing feature	Slow	Medium
Eighth-note relationship		
Spearman's rho	-0.24	-0.25
p-value	0.0002	0.0001
Articulation	-0.15	not significant
Spearman's rho	0.0181	
p-value		
Deviation from beat	-0.13	-0.30
Spearman's rho	0.0499	0.00001
p-value		
Synchronization with beat		
Spearman's rho	-0.25	-0.13
p-value	0.0001	0.0377
Timbre		
Spearman's rho		
p-value	not significant	not significant
Dynamics		
Spearman's rho	-0.12	
p-value	0.0538	no mentions
Flow production		
Spearman's rho	not significant	not significant
p-value		
Fast-tempo preference		
Spearman's rho	-0.14	
p-value	0.0272	not significant

Table 6.5: Correlations of negatively mentioned swing features with Swing ratings by tempo range
Results of Spearman correlations between jazz listeners' ratings for the factor Swing and swing features concurrently mentioned in a negative context, divided by tempo range.

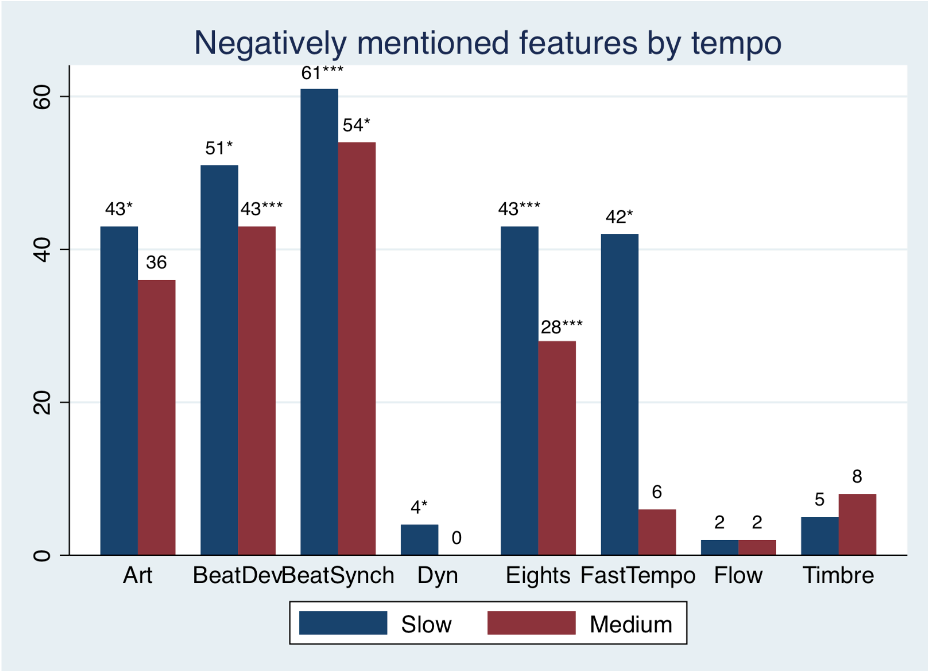

Figure 6.7: Negatively mentioned swing features by tempo, with frequency of mention. Stars indicate significant correlations with ratings for factor Swing at p<=0.05 (*), p<=0.01 (**), and p<=0.001(***).
Symbol key: Art = Articulation; BeatDev = Deviation from beat; BeatSynch = Synchronization with beat; Dyn = Dynamics; Eights = Eighth-note ratio; FastTempo = Fast-tempo preference

The data presented in Table 6.5 shows that there are considerable differences between tempi ranges in how performances were criticised. Only correlations for the feature 'Eighth-note relationship' are almost the same for both tempo ranges. 'Synchronization with beat' is correlated more strongly at slow (Spearman's rho: -0.25) than at medium tempi (-0.13), whereas the reverse is true for 'Deviation from beat' (slow: -0.13, medium: -0.30). The features articulation, timbre, and dynamics were not significantly correlated with Swing ratings at medium tempi, but were so at slow tempi. Figure 6.7 shows that most swing features were mentioned less in a critical context at medium tempi. Data presented earlier indicated that Swing and Groove ratings were significantly higher for medium tempi, and the data here contextualises this by indicating that all features but Flow and Timbre were criticised less at medium tempi.

Notation's influence on listener comments

In order to establish to what extent performer swing is connected to notation, listener comments were also analysed by which features jazz listeners were most critical of. This could be taken as an indication of whether the different forms of swing notation modulated the quality of classical performer's swing. In order to accomplish this, ratings by notation were correlated with concurrently made critical comments. Results are presented in Table 6.6 and Figure 6.8.

Swing feature		Spearman's rho	Significance
Eighth-note relationship			
	JN	-0.38	p=0.00001
	CN	-0.17	p=0.0283
	EN	-0.24	p=0.0025
Articulation			
	JN	no sig. results	no sig. results
	CN	-0.18	p=0.0222
	EN	-0.20	p=0.01
Deviation from beat			
	JN	-0.29	p=0.0002
	CN	-0.25	p=0.0015
	EN	no sig. results	no sig. results [a]
Synchronization with beat			
	JN	-0.23	p=0.003
	CN	no sig. results	no sig. results [b]
	EN	-0.19	p=0.0154
Timbre			
	JN	no sig. results	no sig. results no
	CN	no sig. results	sig. results no
	EN	no sig. results	sig. results
Dynamics			
	JN	no sig. results	no sig. results
	CN	-0.16	p=0.049
	EN	no sig. results	no sig. results
Flow production			
	JN	no sig. results	no sig. results no
	CN	no sig. results	sig. results no
	EN	no sig. results	sig. results
Fast-tempo preference			
	JN	-0.21	p=0.0078
	CN	-0.22	p=0.0053
	EN	no sig. results	no sig. results

Table 6.6: Correlations of negatively mentioned swing features with Swing ratings by notational style
Results of Spearman correlations between jazz listeners' ratings for the factor Swing and swing features concurrently mentioned in a negative context, as divided by different notational styles used to generate the recordings. For ease of reading, each notation style and its results have a separate colour.
Symbol key: JN = jazz notation; CN = classical notation; EN = explicit notation

[a] Results approached significance at Spearman's rho: -0.15, p=0.056
[b] Results approached significance at Spearman's rho: -0.14, p=0.0713

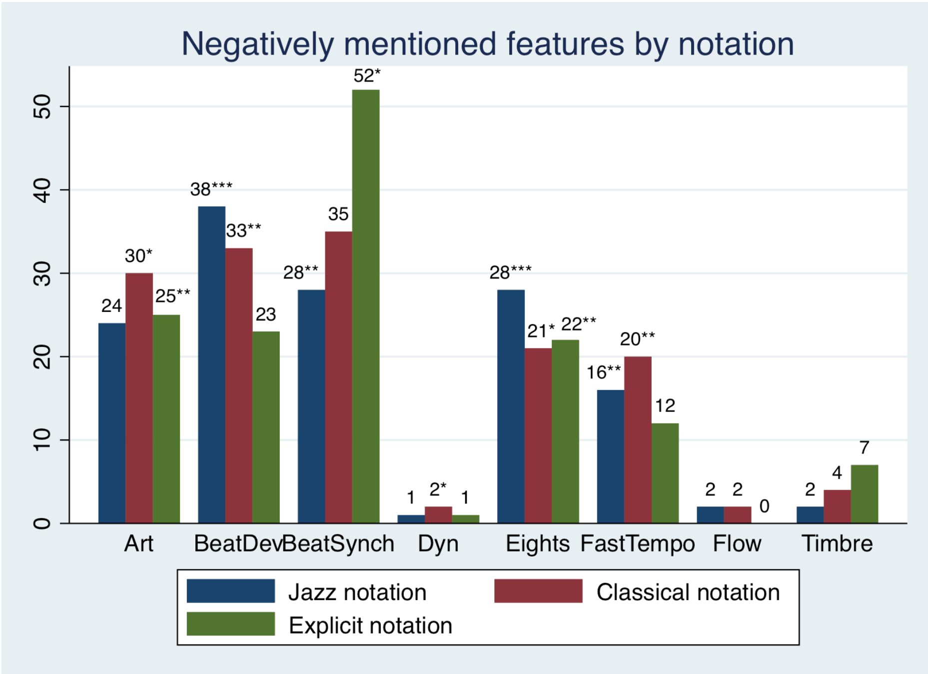

Figure 6.8: Negatively mentioned swing features by notational style, with frequency of mention. Stars indicate significant correlations with ratings for factor Swing at p<=0.05 (*), p<=0.01 (**), and p<=0.001(***).
Symbol key: Art = Articulation; BeatDev = Deviation from beat; BeatSynch = Synchronization with beat; Dyn = Dynamics; Eights = Eighth-note ratio; FastTempo = Fast-tempo preference

When comparing Table 6.6 and Figure 6.8, it is noticeable that the most frequently criticised swing features are not always those most correlated with Swing ratings. This suggests that despite their frequent mention, some features were either considered less influential or that their association with ratings was mitigated by other factors in the performance. Therefore, in order to illustrate the exact nature of each notation style's influence, Table 6.7 below ranks the top five criticised features for each notational style separately, ranking them by correlation coefficient without taking into account how often they were mentioned.

Rank	Jazz Notation	Classical Notation	Explicit Notation
1.	Eighth-note relationship (-0.38)	Deviation from beat (-0.25)	Eighth-note relationship (-0.24)
2.	Deviation from beat (-0.29)	Fast-tempo preference (-0.22)	Articulation (-0.20)
3.	Synchronization with beat (-0.23)	Articulation (-0.18)	Synchronization with beat (-0.19)
4.	Fast-tempo preference (-0.21)	Eighth-note relationship (-0.17)	n/a [a]
5.	n/a	Dynamics (-0.16) [b]	n/a

Table 6.7: Criticised swing features for each notational style ranked from highest to lowest negative correlation with ratings for factor Swing. Spearman's rho correlation coefficients are provided in parentheses.

[a] Approached significance at p=0.056: Deviation from beat (-0.15)
[b] Approached significance at p=0.0713: Synchronization with beat (-0.14)

As Table 6.7 shows, notational style did modulate the nature of listener criticism and affected how strongly a feature was associated with perceived swing levels. Figure 6.8 also showed that the frequency of the criticism was modulated by notation style. Therefore it appears that certain aspects of swing can be scripted for performance by unenculturated players, but that notation style influences how successful the script is implemented in performance.

Interactions of Enjoyment, Swing, and Groove

Hypothesis 7 stated that increased swing would increase enjoyment. Since swing and groove are likely contributors to enjoyment when listening to jazz, it was analysed whether enculturated jazz listeners regarded the factors Enjoyment, Swing, and Groove as interdependent or separate phenomena. Since this question required no analysis by performer type or SD level, notation, or tempo, here all collected ratings could be used (i.e. all ratings provided by 20 jazz listeners for 24 participant recordings each as well as four expert jazz recordings; n=560 per factor). The results showed that Enjoyment was the highest rated factor (mean: 3.99, std. dev.: 1.91, range: 1–7, 95% CI: [3.83, 4.15]), followed by Swing (mean: 3.82, std. dev.: 2.05, range: 1–7, 95% CI: [3.65, 3.99]), and then followed by Groove (mean: 3.45, std. dev.: 2.02, range: 1–7, 95% CI: [3.28, 3.61]).

Since the rating data for all three factors was non-parametric, a Friedman test was used to estimate whether ratings for factors Enjoyment, Swing, and Groove differed significantly from each other overall. The differences between them were shown to be highly significant (Friedman = 1.4e+03, Kendall = 0.8285, p=0.00001). Pairwise comparison by Wilcoxon sign rank test revealed that all three factors were significantly different from each other individually (Enjoyment & Swing: p=0.02; Swing & Groove: p=0.00001; Groove & Enjoyment: p=0.00001). These results indicate that the jazz listeners treated them separately and therefore likely regarded all three as separate phenomena. However, a series of Spearman correlations revealed that the factors were also likely regarded as highly related by listeners, with strong positive correlations found for all combinations (Enjoyment & Swing: Spearman's Rho = 0.75 at p=0.00001; Swing & Groove: Spearman's Rho = 0.82 at p= 0.00001; Groove & Enjoyment: Spearman's Rho = 0.77 at p=0.00001).

Therefore these results suggest that enculturated jazz listeners consider enjoyment, swing, and groove in music as separate but highly related phenomena. Particularly interesting is that swing and groove are considered separate phenomena since they are sometimes interchangeably used in jazz practice, which may indicate that swing represents either a very particular cultural expression of the wider concept of groove or an entirely separate concept. It was also noticeable that significance values for differences between Swing and Enjoyment were less significant than those for other factor combinations (p=0.02 vs. p=0.00001), which may point to an especially close relationship between experiences of enjoyment and swing in jazz music. Alternatively, this could also explained by the fact that only groove was defined as a term, leading listeners to treat the undefined terms of swing and enjoyment as related.

In order to explore if there may have been such a interdependence of factors, and especially if enjoyment in jazz music could be explained as a function of perceived levels of swing and groove, non-parametric regressions with bootstrapped confidence intervals were run on several factor combinations. First, ratings for Groove were used to predict Swing, in order to see if groove may be an underlying trait of swing. Groove was shown to be a highly significant predictor of Swing (p=0.0001) with a coefficient of 1.0 (95% CI: [0.91, 1.14]), meaning a one-step increase in Groove ratings predicted a one-step increase in Swing ratings. This model explained 69% of the variance in Swing ratings. On the other hand, when Swing was used to predict Groove, it was shown to be an equally significant (p=0.0001) but less powerful predictor (coefficient: 0.83; 95% CI: [0.74, 0.89]), predicting slightly less variance in Groove than vice versa (68%). Groove ratings' higher power to predict Swing ratings (and the upper limit of the CI of the Groove coefficient exceeding 1 at 1.14) indicates that swing is possibly a representative function of groove rather than groove a function of swing. In addition to listener comments presented earlier, this supports Hypothesis 5 (swing is a groove archetype).

Another non-parametric regression with bootstrapped confidence intervals was run to check if the factors Swing and Groove could predict Enjoyment. Swing and Groove were both found to be highly significant predictors (both p=0.00001), with a one-unit increase in Swing predicting a 0.49-unit increase in Enjoyment (95% CI: [0.35, 0.60]), while a one-unit increase in Groove predicted a 0.31-unit increase in Enjoyment (95% CI: [0.19, 0.46]). Overall, this model explained 66% of the variance in Enjoyment ratings.

However, since earlier results suggested that Swing could be a representative function of Groove, Swing alone and Groove alone were each used to predict Enjoyment. Results showed that neither factor alone was able to explain a similarly high percentage of Enjoyment's variance (swing alone: 57%; groove alone: 60%). As a result, it is likely that a large part of listeners' enjoyment in jazz music stems from the presence of both swing and groove—meaning that even if swing is a representative function of groove and contributes significantly to enjoyment levels, groove still contributes something independently to enjoyment levels that swing alone cannot. Overall, Hypothesis 7 (increased swing also increases listener enjoyment) was confirmed.

Relationships between listener ratings and performers background

In order to identify participant traits that may have contributed to the rating outcomes, participants' self-ratings on several musical and biographical background factors[84] were correlated with ratings. Pearson's correlation or, for data with a non-parametric distribution, the Spearman correlation was used. Any correlations not reported here did not reach significance.

[84] These included primary instrument, secondary instrument, sex, nationality, age, years of playing music, highest attained level of music education, experience listening to groove-based music, experience performing groove-based music, experience performing jazz, experience improvising, and absolute pitch.

Among musical background factors, only sight-reading correlated significantly with ratings. Sight-reading correlated positively with Swing overall (Spearman's rho: 0.59, p=0.0063), swing for jazz notation (0.54, p=0.0139) and classical notation (0.47, p=0.00359), and Groove overall (0.49, p=0.028).

Among biographical factors, performer age produced a number of correlations with ratings. Age and Enjoyment ratings were negatively correlated with moderate effect for explicit notation (Spearman's rho = -0.59; p=0.0059)[85]. Age also correlated negatively with Swing ratings for classical notation (Spearman's rho = -0.53; p=0.0161), explicit notation (Spearman's rho = -0.60; p=0.0048), and therefore all recordings regardless of notation (Spearman's rho = -0.48; p=0.0339). A similar effect was found for Groove ratings, which also correlated negatively with classical notation (Spearman's rho = -0.44; p=0.05), explicit notation (Spearman's rho = -0.68; p=0.0011), and therefore also overall (Spearman's rho = -0.49; p=0.0267).

As a result, age (or a related hidden factor) seems to have a negative effect on producing enjoyment from explicit notation and producing swing and groove from either classical or explicit notation. As mentioned in the last chapter, score-dependency ratings (SDR) and age were strongly correlated, as were SDR and years of practicing music. However, here SDR was not significantly correlated with Enjoyment/Swing/Groove ratings, indicating that the noted relationship between age and these factors is of a separate nature—likely sociological (e.g. changes in music education methods) or cultural (e.g. more limited exposure to music of different genres during formative years), given by how musical and biographical factors interacted: Age was negatively correlated with experience performing jazz (Spearman's rho = -0.4518, p=0.0455) and listening to groove-based music (Spearman's rho = -0.57, p=0.0091).

Participant interviews

After task completion, all performers (n=20) were engaged in semi-structured interviews and encouraged to give their perspective on how they experienced the task. While much of the conversation was unstructured, all participants were asked the same standardised questions:

- Did you recognise any of the jazz tunes?

[85] This likely contributed to a weak-to-moderate negative effect approaching significance for all notation styles (Spearman's rho -0.40; p=0.0778).

- How would you define swing?
- How would you define groove?
- Did aural priming make a difference in your performance approach?
- Which notation style helped you swing most?
- Did any of the swing techniques in the explicit notation help you swing?

Performers' responses are quantified here to provide greater context for individual analyses above. It should be noted that not all performers always wished to provide an answer to these questions, and so ambiguous answers were not included in the quantification.

In response to the first question, which all participants answered, four participants replied that they might have heard one of the four jazz tunes before. However, three could not pinpoint which one of the four tunes they referred to, and none could recall the tune's name in reality. In response to their definition of swing, ten classical musicians referred to the feeling this inspires in performance, with many of them and most others referring to syncopation, dotted notes, triplets, or flexible upbeats in their elaborations. With regards to Groove, many musicians expressed a connection to beats or movement, though three did not know the term well enough to define it, and four found it synonymous with swing.

Regarding aural priming, twelve found that it informed their performance—which contrasts with results earlier showing that raters could not perceive a significant effect of priming on enjoyment, swing, or groove levels, unless it affected them negatively. This may be a case of where a performer's attitude may influence their subjective impression of a performance, without causing an effect audible to an audience, as also fond in a jazz context by Schober and Spiro (2016). Five of the classical performers reported finding their instrument notably different or more difficult to use in jazz, with several reporting that hearing the reference recording helped them compensate for this by imitating the expert trumpeter or saxophonist's phrasing.

Another case of diverging performer and listener experiences became apparent in performers' responses to the last two standardised questions. Notably, seventeen of the twenty participants expressed that they found the jazz notation style easiest to play from for generating swing, as it afforded them most interpretative freedom, with one stating that it de-emphasised explicit rhythmic counting compared to the other styles. Only one performer explicitly stated preferring the classical notation, with seven of them finding it confusing to read or unnecessarily didactic with it’s explicit 2:1 BUR. This result contrasts with the higher swing ratings for SIMs playing from the classical notation at slow tempi, possibly indicating that classical performers may understand the principles involved in swing, but lack the practical experience to adequately realise them. Interestingly, three performers found that triplets in a 4/4 metre would have perhaps provided a better conceptual framework for swing than a 12/8 metre, though one performer stated the opposite.

There were also several comments on the explicit notation style: Ten of the twenty performers stated that they found it too distracting, intellectual, or overloaded for swinging in this exercise, with four stating that it encouraged overly strict adherence to the notated instructions. Perhaps this was due to the short preparation time provided in this experiment, since nine participants also stated that the explicit notation could be a useful tool if one had more preparation time, tried to faithfully learn the solo it was transcribed from, or needed to remember details before a performance. Six stated that the pressure of the sight-reading task prevented them from engaging with the ‘synch’/’desynch’ markings or the beat guide staff. These markings were found helpful by three performers, while three found that they contradicted the precise notation of the explicit notation. Five found the beat guide a useful addition in principle, while three found its inclusion unnecessary, claiming that the metric framework already provided the same information.

6.5. Discussion

In this experiment, 20 classical musicians were recorded while sight-reading excerpts from jazz tunes. They recorded each tune using different forms of swing notation. Jazz-enculturated listeners rated these recordings for perceived levels of enjoyment, swing and groove in that order, and left explanatory comments. On average, the highest rated factor was Enjoyment, followed by Swing, and finally Groove. Correlations and significance tests suggested that listeners regarded these three factors as separate but strongly linked phenomena in jazz. As swing was shown to be a strong predictor of enjoyment levels, the traditional assumption that increased swing also equals increased enjoyment for jazz listeners (Hypothesis 7) was confirmed.

Notational and aural learning mechanisms

The hypothesis that relatively score-dependent musicians would produce lower swing scores (Hypothesis 1) was not confirmed. While SDMs consistently produced lower scores than SIMs for factors Enjoyment, Swing, and Groove across all notational styles and tempi, none of these differences were statistically significant. This is possibly a consequence of expert jazz raters giving generally low ratings (Dateseris et al., 2019), which may have created a ceiling effect here. Rater comments indicated that swing seems to be primarily a temporal effect, with the top three factors defining swing being reported as unequal BURs (60%), an urge to move or dance (35%), and a sense of forward motion (25%). The conception of swing as a primarily rhythmic phenomenon may explain why musicians' SD levels had no significant effect on performance ratings, since SD was shown in Chapter 4 to primarily affect aural pitch rather than rhythm reproduction.

Notably, neither SIMs nor SDMs benefitted from the detailed rhythmic information contained in the explicit notational style. This may be an effect of the experimental design: Nine participants reported in post-task interviews that the explicit notation could be useful if much more preparation time was given than the provided 30 seconds. Several participants expressed that the time-pressure prevented them from paying attention to non-standard notation techniques in the explicit notation, meaning they simply followed the notation in the main staff. This focus on more familiar visual information agrees with theories of visual task prioritisation based on cognitive load (Giesbrecht, Bundesen, Kyllingbsbaek, 2014). Therefore it remains unclear whether the comparatively low ratings for performances based on the explicit notation are due to the notation's inability to engender swing, or due to it presenting too much information to process while sight-reading. Consequently, the hypothesis that SDMs' swing levels would increase with increasingly detailed notation (Hypothesis 2) was not confirmed.

SDMs seemed to perform best with the classical notation style at slow but not medium tempi, though the pattern was not quite clear. It is possible that, given their reliance on notation and the pressures of sight-reading, the classical notation offered a sufficient but not excessive amount of musical detail. SIMs, on the other hand, showed almost no particular preference for any notation at any tempo, confirming the hypothesis that their swing levels are relatively immutable from notational changes (Hypothesis 3). As strong sight-reading is frequently associated with improvisation skills (see Chapter 4 for an overview), these performers may be simply stronger sight-readers and generally more flexible musicians.[86]

However, SIMs' superior ear-playing skills did not seem to help them improve their swing by hearing a jazz recording, since aural priming had no positive effect on ratings for either SIMs or SDMs (rejecting Hypothesis 4). In fact, in several cases aural priming had a significant negative effect on ratings. Again, this may be due to the stress inherent in a sight-reading exercise, since Kopiez and Lee (2006) found that inner hearing in musicians reduces when they sight-read complex notation. Therefore the pressure of the task may have led to notation exerting a strong cognitive draw from which aural priming distracted.

The swing groove archetype and its syntax

In comments, the majority of listeners (65%) expressed that for them swing is a representation of groove. This supports the hypothesis of swing as a groove archetype—a culturally specific manifestation of groove (Hypothesis 5). That hypothesis was further supported by groove being a more powerful predictor for swing (coefficient 1.0) than vice versa (0.83). The predictor values suggest that groove as a basic underlying concept explains swing well, while swing as a specific expression of groove cannot explain all aspects of groove.

Results of regression analyses using swing and groove jointly to predict enjoyment ratings further corroborated this. Swing was revealed to be a stronger predictor (coefficient: 0.49) for enjoyment ratings than groove (0.31). This can be interpreted as an effect of cultural expression: Groove is a more universal concept and therefore may be harder to define for jazz listeners, while swing as a culturally specific expression of groove may appear more understandable. Rater agreement figures showed that jazz listeners agree more on what swing is than on what groove is, despite being given an explicit definition of groove, indicating that groove may represent a larger and more vaguely defined umbrella concept. However, swing alone could not explain the variance in enjoyment ratings to the same level that swing and groove explained together. This, too, supports the hypothesis of swing as a groove archetype—

[86]In this experiment 'experience improvising' yielded no significant correlations with ratings or other performer background factors. However, may be due to the fact that the term 'improvisation' was deliberately not defined in the questionnaire, and so also encompassed jazz domain-unrelated activity. This was a deliberate choice in designing the questionnaire, as it was of interest whether improvisation as an unscripted activity generally predisposes performers for better performance in an aurally-based discipline like swing. The data indicated that this is not so.

since swing is a very particular, culturally specific expression of the more general concept groove, other aspects of groove not expressed by swing contribute to enjoyment levels independently.

Rater comments also indicated the most important factors in gaining higher swing ratings (from most to least important): deliberately deviating from the beat; appropriate judgement of eighth-note lengths or BURs; good synchronization with the underlying rhythmic beat sequence; appropriate articulation; a faster tempo. With rater agreement figures indicating that listeners shared a common understanding of swing to a degree, this confirms the syntax for the swing archetype as outlined in Chapter 2: Only partial synchronisation between phrase structure and beat sequence, tempo- or phrasing-dependent unequal subdivision of the beat, and the effective use of articulation (and rhythm) to effectively syncopate and circumscribe a near-metronomical beat pattern (Hypothesis 6). However, this definition did not take into account a preference for medium over slow tempi, which was not indicated by the literature. Why faster tempo might contribute to perception of swing is discussed in the next section.

It is important to note that the swing definition found in this experiment was based on recordings by relatively jazz-unenculturated performers and therefore focuses on the basic minimum criteria listeners expect from swing. If reproducing this experiment with expert jazz performers, one might find that listeners attend to more advanced swing features.

Enculturated timing structures

Ratings for swing and groove were significantly higher at medium than at slow tempi. While Janata, Tomic, and Haberman (2012) found that listeners give higher groove ratings for higher-tempo songs, Madison (2006) found groove ratings to be fairly independent of tempo. This disagreement could be an effect of different syntax configurations in varying groove styles. London's (2012) concept of tempo-metric types—'flavours' of different metric subdivisions that change with tempo due to stable perceptual limits for rhythm—suggests that the stylistic features of some groove styles may be more easily perceived at higher tempi than others.

Correlations between swing ratings and critiqued swing features (Table 6.5) suggested that this is true for swing. For example, playing independently from the underlying pulse was twice as strongly correlated with swing ratings at medium than at slow tempi. On the other hand, synchronizing with the pulse was correlated more highly at slow tempi. These results could indicate that swing pulse perception at slow tempi is more difficult and therefore demands less deviation from the beat than at faster tempi. This could be explained by perception being limited for event onsets spaced very far apart or very closely together at tempo extremes (London, 2012, 27). As shown by Corcoran and Frieler (2020), swing BURs and other uneven tactus subdivisions become increasingly even with tempo. This, the authors suggest, may indicate that performers avoid playing upbeats too short for rhythmic perception at high tempi, as this would hinder entrainment. Consequently, they argue, slow and medium tempi may possibly afford listeners more capacity and perhaps a preference for greater rhythmic deviation from the pulse in swing.

That would also explain the higher groove ratings at higher tempi in this experiment. As mentioned in Chapter 2, groove and syncopation form a relationship expressed by an inverted U-shape (Sioros et al., 2014; Witek et al., 2014), similar to BURs and tempo. Therefore, it is possible that jazz soloists manage the syncopated effect of swing subdivisions microrhythmically to optimise entrainment and consequently groove at specific tempi. This is likely an advanced technique that the jazz-unenculturated classical performers tested here did not master yet, since jazz listeners criticised the way they handled beat subdivisions both at slow *and* medium tempi. However, these thoughts remain speculative until further research can illuminate them, since the experiment here only included slow and medium but not fast jazz tempi.

The data also provides indications for how experiences of time and musical flow differ across genre practices. Jazz listeners criticised how classical musicians neither sufficiently departed from nor synchronized with a steady beat. From a classical musician's perspective, this mixed critique may appear contradictory: Rubato and holding a steady beat are both common practices in classical music, but are rarely applied simultaneously, as they are in jazz (Ashley 2002).

This apparent contradiction indicates that swing depends on complex mechanisms involving both low-level (e.g. steady beat) and high-level features (e.g. microrhythmic deviation from beat). It is possible that listeners' acceptance of such opposing concepts hinges on there being an implied hierarchical difference between them (i.e. low vs. high), which temporarily gives preference to one of them. Jazz-enculturated listeners and performers may temporarily override their desire for articulation of a steady beat in melodies when jazz performers de-synchronise from the rhythm band, because it likely causes heightened feelings of reward when performers finally re-synchronise. This process could be described as a form of temporal cognitive dissonance and resolution. Such feelings of tension and resolution in swing mirror other, non-rhythmic aspects in music (e.g. harmony) and likely contribute to music enjoyment by validating successful event prediction (Vuust & Kringelbach, 2010). The data suggests that jazz-unenculturated musicians may not be privy to such higher-level techniques, as these require greater enculturation.

Scripting swing across cultural boundaries

Results show that overall there is no significant difference between the classical and the jazz notation style in how effectively they help classical musicians swing. However, at slow tempi the classical notation style is clearly the most effective one, which is likely due to its positive effect on SDMs specifically. All three notation styles affected jazz listener comments differently, meaning that notational style modulated the nature, magnitude, and number of swing features criticized in classical musicians' performances. This suggests that each style has strengths and weaknesses at scripting the different component techniques of swing.

By comparing the data to each notational style's properties, it becomes clearer which swing features can or cannot be successfully scripted by the different forms of notation. For example, it is noticeable that the jazz notation depicts even quavers without any hint at how they should be swung, and correspondingly its most correlated criticised feature is the manner in which participants elongated their eight-notes or beat-upbeat ratios (BURs). A similar, if less severe, effect was found for the explicit notation, which provides very detailed and therefore perhaps overly prescriptive instructions on BURs. In the same manner, it is noticeable that the feature 'Deviation from beat' was not significant for performances based on the explicit notation, but was among the top most problematic features for the jazz and classical notational styles. These two both provide evenly notated rhythms (a 1:1 BUR in jazz and a 2:1 BUR in classical notation) in contrast to the more changeable rhythms of the explicit notation, and so their more static context may have encouraged overly literal beat-focussed interpretations.

'Synchronizing with the beat' was an item of critique for the jazz and explicit notations, while the classical notation with its very stable 2:1 BUR configuration did not draw this criticism. Again, the unequivocal BUR in the classical notation may have encouraged performing more in synch with the beat or may have engendered stronger entrainment among listeners.

Regardless of notation, 'synchronization with the beat' was the feature that exhibited the greatest overall discrepancy between positive and negative comments, with 115 negative but only 53 positive mentions. This suggests that listeners found good synchronization with the underlying beat sequence the feature most in need of improvement in classical musicians' swing.

Noticeably, 'articulation' was not a correlated criticised feature for jazz notation. Paradoxically, jazz notation is the only notational style that provides only a minimum of articulation and phrasing markings. It is possible that this freedom may have encouraged more spontaneous phrasing among participants, which may have benefited their swing. Both jazz and classical notations seem to have withstood faster tempi better than the more dense explicit notation, since these two correlated mildly with a preference for hearing the tunes played faster.

Therefore all three notation styles appear to have different advantages and disadvantages. Together they suggest that some low-level temporal features of musical time can be scripted across cultural divides—presumably by communicating culturally shared mechanisms via means that the target performer group can decode (e.g. synchronising with the beat). However, more culturally unique and motorically subtle high-level features (e.g. deviation from beat, eighth-note relationship, both primary criticisms) likely require greater exposure to culturally specific mannerisms than scripted instruction can provide.

Performer background affects swing production

Since five of the participants reported finding their instrument notably different or more difficult to use in jazz, with several reporting that hearing the reference recording helped them compensate for this, it is likely that instrument-specific perception-action coupling mechanisms come into play. As mentioned in Chapter 4, various instrumental types may differ in the way they bring sensorimotor and aural feedback to bear on ongoing motor action sequences, thereby affecting microrhythmic placement (see also Keller, Dalla Bella & Koch, 2010, on aural expectations and tactile responses among musicians). However, just like in Chapter 5, no effect by instrument was found here, possibly due to the very small sub-sample sizes when dividing participants by instrument group.

Experience with improvisation, which was deliberately not defined further as a term in order to include any form of improvisation, did not produce any correlations. This indicates that only culturally relevant experience in improvisation benefitted performers in a jazz context. As a result, it seems that not all forms of musical improvisation involve the same mechanisms. This calls for a comparative study on how different forms of improvisation affect music cognition differently.

Increasing performer age was shown to have a negative correlation with swing and groove ratings when based on classical and explicit notation. While age was strongly correlated with SD in last chapter's experiment, SD in turn did not produce similar negative correlations with swing and groove scores. Therefore, there may be another, hidden factor that is correlated with both age and SD. This could be a factor in education or performance practice, which affects young and older musicians differently, or it could be a social factor—for example, easier access to recordings from diverse musical genre among younger players due to changes in technology, or a more accepting culture of performing in both classical and groove-based contexts in recent times compared to earlier. This is suggested by age negatively correlating with experience performing jazz and listening to groove-based music.

6.6. Summary: SD affects musicians' notation preferences but not swing

In conclusion, this experiment has shown that swing is likely a culturally specific expression of groove and that its theoretical delineation as a groove archetype holds in practice. The experiment identified the swing features that jazz listeners likely consider most important for swing, thereby confirming the swing syntax laid out in Chapter 2 and extending it by a preference for medium over slow tempi. It also identified the swing features that classical musicians' likely struggle most to realise. However, participants' swing was found not to be significantly affected by SD. The previous chapter's results—which demonstrated that SD affects pitch but not rhythm—may explain this, since raters considered swing a primarily rhythmic phenomenon.

The findings also illuminate how different forms of notation affect classical musicians' swing, modulating which features listeners criticised. Therefore the results imply that certain basic swing features can be scripted for intercultural performance practice, but that more high-level features require a more direct form of enculturation. Results suggest that best practice for notating jazz for performance by classical musicians is to use the established classical notation of swing with a fixed 2:1 BUR and some phrase and articulation markings, at least at slow tempi or when only short preparation times are available. The established jazz practice of combining audio examples and jazz notation to learn tunes was shown to be less effective: Aural priming was revealed to be more distracting than helpful for classical musicians when performing jazz from notation under time pressure. In the following chapter, I will address the implications of the two conducted experiments in this and the previous chapter and suggest relevant avenues for future research.

Chapter 7: Conclusion and future outlook

In Chapter 1, I asked what aspects of the way classical musicians learn and engage with music might challenge the way they can transfer their musical skills to domain-unrelated areas, using the specific example of playing with swing. The previous chapters explored this question, focussing on the relationship between aural reproduction skills and classical musicians' notation-focussed practice. Experiments showed that score-dependency (SD) reduces musicians' aural reproduction skills for pitch but not rhythm. Consequently, SD was shown not to affect swing as perceived by enculturated jazz listeners. By establishing an empirically footed definition of swing, it was possible to show that notation can be used to script some low-level but not higher-level elements of swing, affecting which swing features jazz listeners criticise.

This demonstrated that music enculturation manifests itself in diverging forms of learning and performance behaviour across different performance cultures. Swing is traditionally learned by ear, but aural priming with professional jazz performances had no positive overall impact on classical musicians' swing. This indicates that learning high-level phrasing behaviour, as is commonly understood, requires long-term enculturation. Notation—while a powerful mediation tool in many ways—is limited in the extent to which it can communicate high-level performance features. As a result, it appears that no notational innovation will remove the need to learn culturally specific performance mannerisms by ear. This raises a series of philosophical questions regarding music performance and enculturation, which I will explore further in this chapter as a basis for suggesting possible future research directions.

7.1. Score-dependency as reliance on technology

The first issue to explore is whether it is wise to rely exclusively on notation for learning new music. While score-dependent performers probably have little need or opportunity to replicate pitches by ear, it is nonetheless surprising that expert performers—who spend hours practicing their instrumental skills with tonal music every day—are unable to translate tonal melodic pitch sequences effectively to their instrument. After all, aural replication is a skill that is centrally important to most music cultures, and which is instinctively pursued by technically much less accomplished musicians and virtually all early music-learners. More importantly, it is strongly reminiscent of other aural imitation mechanisms rooted deeply in human behaviour—for example, early speech (Cross, 2003).

In that regard, SD can be described as a symptom of overlearning. Ong (2002) proposed that both music and language notation can be considered a technology. Therefore, relatively score-dependent musicians can be considered hyper-specialised workers with expertise in very particular tasks within their chosen field of work. In this context, the concept of music notation as a form of technology implies that the musicians have mastered engaging with notation as others master engaging with a tool. However, as is common in other domains, over-reliance on a particular technology or tool can lead to dependency and hyper-specialisation in task performance over time, limiting the ability to engage in the task without it.

With that in mind, it is noticeable that Western classical music seems to be the only music culture that engages with the minutia of notation to this degree. Two reasons for this may be the high technical and coordinative complexity involved in performing classical compositions or the ease with which notation can be disseminated, the latter of which is seen as a factor in the disappearance of improvisation skills in classical music (Moore, 1992). Both these concepts—scripting complex task procedures and ease of disseminating instructional scripts—are highly reminiscent of how Ong (2002) describes the development of language literacy. This in turn poses questions about how increasingly complex use of Western staff notation for task specialisation and scripting behaviour reflects wider Western philosophies of efficiency and standardisation (see Cook, 2014, 265-70 for a discussion of the score as an analogy for managerial organisation).

However, from a music action perspective, one could argue that the eye-hand coordination involved in score-dependency represents an effect of overlearning that negates more holistic experiences of music. Cognitively speaking—at least with regard to pitch—SD relies on engaging with symbolic representations instead of aural interactions, which mirrors developments in other arenas of orality vs. literacy (see Ong, 2002, for an in-depth discussion). This is not to negate the many other social and embodied aspects found in score-based classical music performance or the usefulness of music literacy as a skill. Instead, I wish to suggest that SD, as a form of particular task specialisation, represents a subtle cognitive shift in how music is cognitively processed—away from an instinctive improvisational and imitative form of music-making (as demonstrated by countless autodidact garage bands) to a more instruction-driven and therefore formalised understanding of music. This posits SD as a form of overlearning, in which a wider aural—and therefore possibly more strongly embodied—engagement with music is reduced by creating a dependency on a particular technology, in this case music notation.

7.2. Future research

In order to explore this concept further, several questions need experimental investigation. For one, it remains unclear whether SDMs' difficulty in aural pitch replication is a perception or action problem: the literature provides indication for both possibilities (see the Discussion section of Chapter 5). The same applies for my conception of SD as a consequence of long-term engagement in notation-focussed performance culture without engaging in mitigating ear-playing scenarios. While there is much circumstantial evidence to suggest this as a viable model, the indications provided by Chapter 5's SD experiment remain merely suggestive. As mentioned there, it is possible that other, hidden factors are at play that are based in social or educational backgrounds, which require exploring. In addition, it is also unclear whether a performer's specific instrument could be involved in facilitating or offsetting SD. While I discussed some of the possibilities with reference to visuo-spatial instrumental layout and motor feedback, the SD experiment did not indicate an effect by instrument. However, much suggests that certain modes of making music (e.g. producing overtones on a brass instrument) may be conducive to generating stronger ear-hand connections.

Many of these open issues likely result from the low sample size as well as the experimental methods chosen for this thesis. For example, it was noticeable that SDMs scored lower for enjoyment, swing, and groove in Chapter 6's swing experiment, which fits some of the proposed hypotheses. However, the statistical tests did not indicate any significant differences between SDMs and SIMs, and no correlation was found between musicians' score-dependency ratings and their performance ratings. This could indicate that the sample size and the mode of assessment was inappropriate for this particular question. This is also a possibility for results about the experimental explicit notation, which nine out of 20 musicians reported as potentially useful but inappropriately dense for a sight-reading task as was conducted here. Therefore a larger sample size and alternative methods are called for in order to address several of these open questions.

One useful avenue of research would be to gather more biological indicators for long-term reliance on notation as a factor in SD. One possibility would be to use neuroimaging techniques in order to investigate how effects of musical specialisation (including SD and ear-playing expertise) might modulate rhythm and pitch processing in the long term. One concrete possibility—utilising early right anterior negativity (ERAN)'s sensitivity towards music syntax violations—could be to explore how SD modulates ERAN responses to pitch and rhythm deviants at different stages of music involvement. While several studies have addressed how genre expertise can modulate sensitivity to aural features using mismatch negativity (e.g. Sepännen, et al., 2007; Tervaniemi, et al., 2001; Vuust et al., 2012) a study such as described could more directly investigate the long-term effects of music learning methods (aural vs. written) on the aural prediction of music syntax. Perhaps the swing definition established here could be useful for that kind of investigation, however first it would require reproduction with expert jazz rather than classical performers.

With a much more long-term view, such research could be increasingly directed at investigating whether similar cognitive mechanisms also apply in other domains of aural vs. script-based learning, for example language (as briefly touched on above). Returning to Lilliestam's quote cited in Chapter 4, when notation is introduced,

> Does the form of music and the way music is made change? Do note-reading musicians think about and conceptualise music differently than those who do [not] read and write music? Changes in these respects undoubtedly do appear, but the question is which changes and how do they come about?
> (1996, 198)

There is much left to explore.

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Appendix

1. **Participant questionnaire template**
2. **Participant information sheet**
3. **Score-dependency experiment melodies and materials**
4. **Swing experiment notations**

'Keeping Score': Swing notations for non-jazz musicians – preparatory questionnaire

Researcher: Chris Corcoran, University of Cambridge

Thank you for agreeing to participate in my experiment! In preparation for the experimental tasks, please fill in this brief questionnaire.

As your participation is entirely voluntary, you are free to withdraw at any time for any reason. Aside from providing a name and primary instrument, you are free to skip any questions you do not wish to answer.

By participating in this questionnaire, you agree that your submitted data will be stored on electronic media or on paper and it may contribute to scientific publications and presentations. By participating, you also agree that the data can be made available anonymously for other researchers, both inside and outside the Centre for Music and Science and Faculty of Music (University of Cambridge). These data will not be linked to you as an individual. Your data will be treated with full confidentiality and, if published, it will not be identifiable as yours.

If you have any questions, you are always welcome to email me at

With thanks,
Chris Corcoran, PhD student, Faculty of Music, University of Cambridge

* Required

UNIVERSITY OF
CAMBRIDGE

Questionnaire

1. **Please give your name (required).** *
   This is for my record-keeping only. Any data you provide will not be associated with your name in any publication. Should this data ever be shared with other researchers, your name will not be disclosed to them and you will remain fully anonymous.

2. **What instrument do you primarily play? (required)** *

3. **What other instrument do you play or have you played at one time?**

4. **What is your age?**

5. **As what gender do you identify?**
Mark only one oval.
- Female
- Male

6. **What is your nationality?**

7. **How many years have you played music?**
All manner of musical practice or instruction count, including first musical steps and early practice years.

8. **What is the highest degree of music education you received?**

9. **Please provide your level of music sight-reading ability.**
Mark only one oval.

	1	2	3	4	5	6	7	
I cannot sight-read at all.	⬭	⬭	⬭	⬭	⬭	⬭	⬭	I can fluently sight-read through complex scores.

10. **Would you feel comfortable sight-reading the music shown in the 'Melody' staff in this image?**

Sample - N3

1. Swing Level arrows indicate increased or decreased swing, also reflected roughly in notation.
2. Beat Guide arrows indicate when to play exactly on a beat or subdivision.
3. Grace notes are played on the beat. Grace notes and grace rests therefore slightly delay the main note.

Mark only one oval.

- ⬭ Yes
- ⬭ No

11. **How much do you deliberately listen to groove-based music?**

Groove is here meant as the urge to move to the beat, as commonly found in jazz, pop, rock, blues, etc.

Mark only one oval.

	1	2	3	4	5	6	7	
I try to avoid deliberately listening to groove-based music.	◯	◯	◯	◯	◯	◯	◯	I deliberately listen to groove-based music daily.

12. **How often do you perform groove-based music?**

Same definition for Groove as before: Groove is here meant as the urge to move to the beat, as commonly found in jazz, pop, rock, blues, etc.

Mark only one oval.

	1	2	3	4	5	6	7	
I have never performed groove-based music.	◯	◯	◯	◯	◯	◯	◯	I frequently perform groove-based music.

13. **How often do you perform jazz music?**

Mark only one oval.

	1	2	3	4	5	6	7	
I have never performed jazz music.	◯	◯	◯	◯	◯	◯	◯	I frequently perform jazz music.

14. **Last question: How often do you improvise when playing – practising or performing – music?**

This includes any form of musical improvisation.

Mark only one oval.

	1	2	3	4	5	6	7	
I have never improvised when playing music.	◯	◯	◯	◯	◯	◯	◯	I frequently improvise when playing music.

Skip to "Thank you!."

Thank you!

Your help is very much appreciated. This questionnaire is now complete. If you have any questions at all, please don't hesitate to contact me:

Participant Information Sheet for experiment:
'Keeping Score': Swing notations for non-jazz musicians

04 February 2019

Dear Participant,

Many thanks for showing interest in this project! The following is a description of the experimental tasks involved. Please remember that your participation is entirely voluntary and you may choose to withdraw at any time and for any reason. Your data will be treated with full confidentiality and will not be identifiable as yours in the final thesis—including in the event of publication.

The aim of the experiment is to identify how notation reading and listening skills interact in classical musicians. It also deals with how different styles of jazz notation influence the playing of non-jazz musicians. It should take about an hour and involves the following steps:

Short online questionnaire – before the experiment

First, please fill in a short questionnaire. I will send it to you by email ahead of time. The aim is to gain some insight on your musical preference and background. You may choose to omit questions you do not wish to answer.

Listening and repeating task – Duration: c. 25 mins

In this task, you will be asked to listen to seven short melodies and repeat each one back to me on your instrument after hearing it, while I record you for reference. For most melodies, you will also receive some form of music score to aid you, showing anything from a little to a lot of musical detail. You can request to hear a melody again as often as you require to play it back correctly, but at most up to five times. I will make a note of how many times you wish to hear a melody. Then you will be asked to play each melody from notation for later comparison.
The aim is to find out how much your aural skills and your notation-reading skills interact in performance.

Performance tasks – Duration: c. 20 mins

In this task, you will be asked to sight-read four short jazz tunes, each notated in three different notational styles, while I record you. When you are given the score for a tune, you have thirty seconds to study it, during which you may play your instrument. For some tunes, you will also be played a jazz recording first for reference. Then you will be asked to perform each score along to a metronome while I record you for later analysis. These audio recordings of you will be completely anonymised (separated from your name) for my research purposes. Your permission will be sought first should I ever wish to play any anonymised excerpts in the course of a presentation outside this experiment.
The aim is to find out which notational style induces most swing in your performance, and whether it makes a difference if you hear a jazz reference recording first.

Informal interview – Duration: up to c. 10 mins

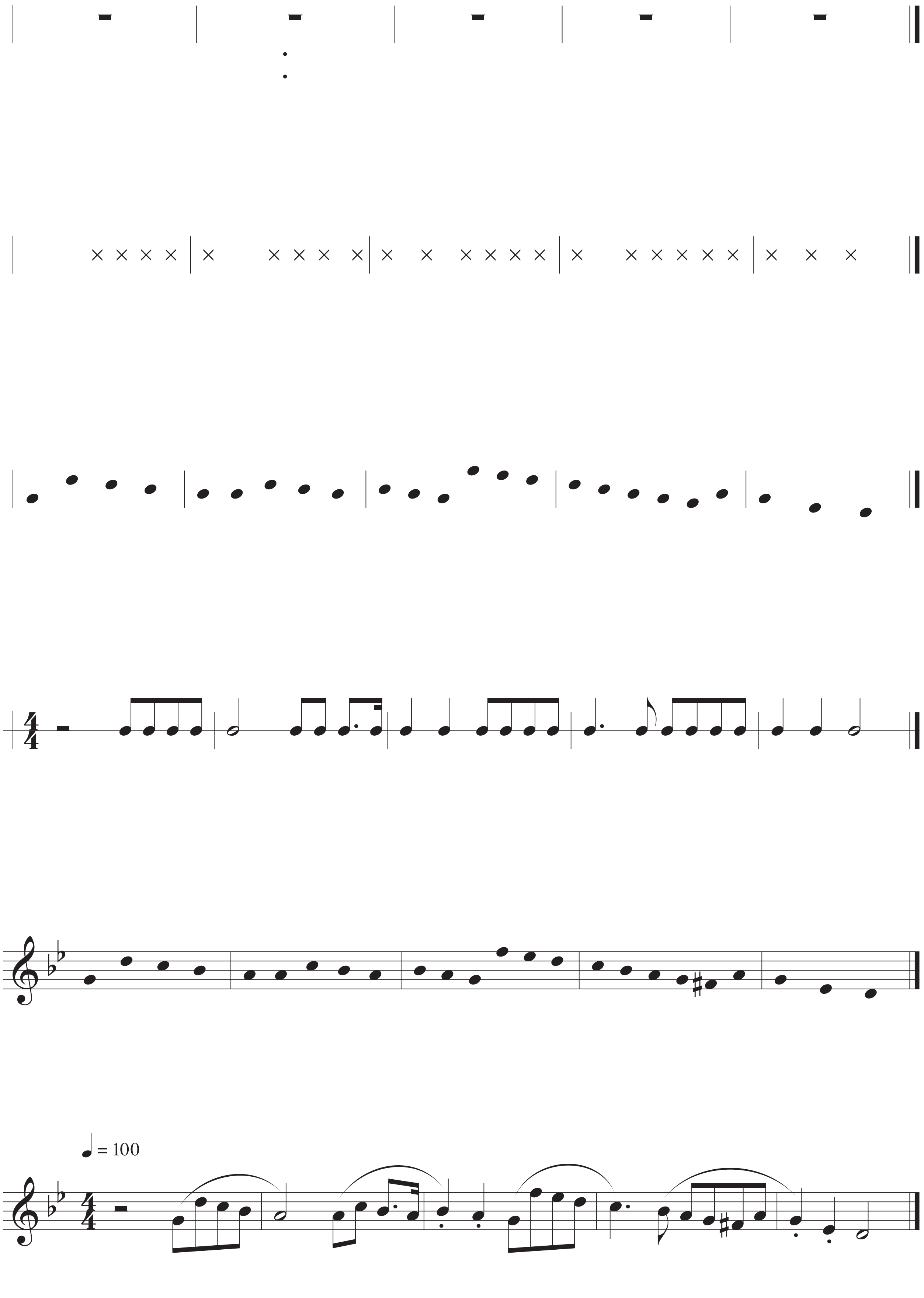
Following the experimental task, I would like to conduct a very brief and informal interview with you. The aim is simply for you to have a chance to express your opinion on the proceedings. I hope to gain more context about your performance and the techniques you applied during the experiment.
I would like to make an audio recording of the interview for ease of note keeping, but you may decline to be recorded if you prefer. In that case I will ask if I may keep written notes, which you may also decline.

Once these steps are complete, the anonymised recordings from the performance task will be passed on to a group of jazz listeners, who will judge which of the notation styles caused most swing in your playing. Their comments and ratings will also be used for a statistical examination of how aural skills and score-reading are likely to interact. I would be happy to provide you with further details on the project and its wider context, if you so wish.

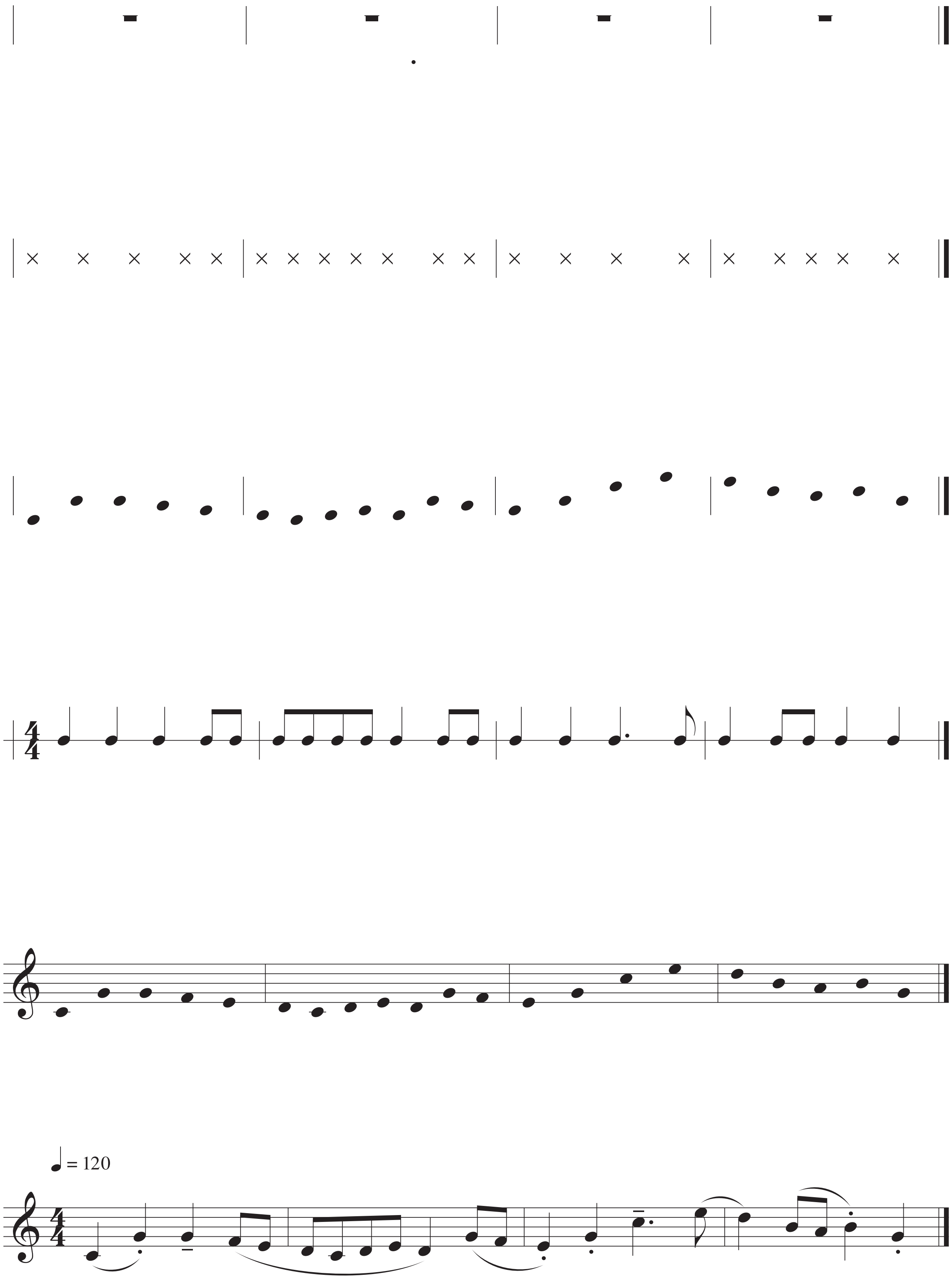
With thanks for your support,

Chris Corcoran

SD Preparation Melody



SD Melody 1



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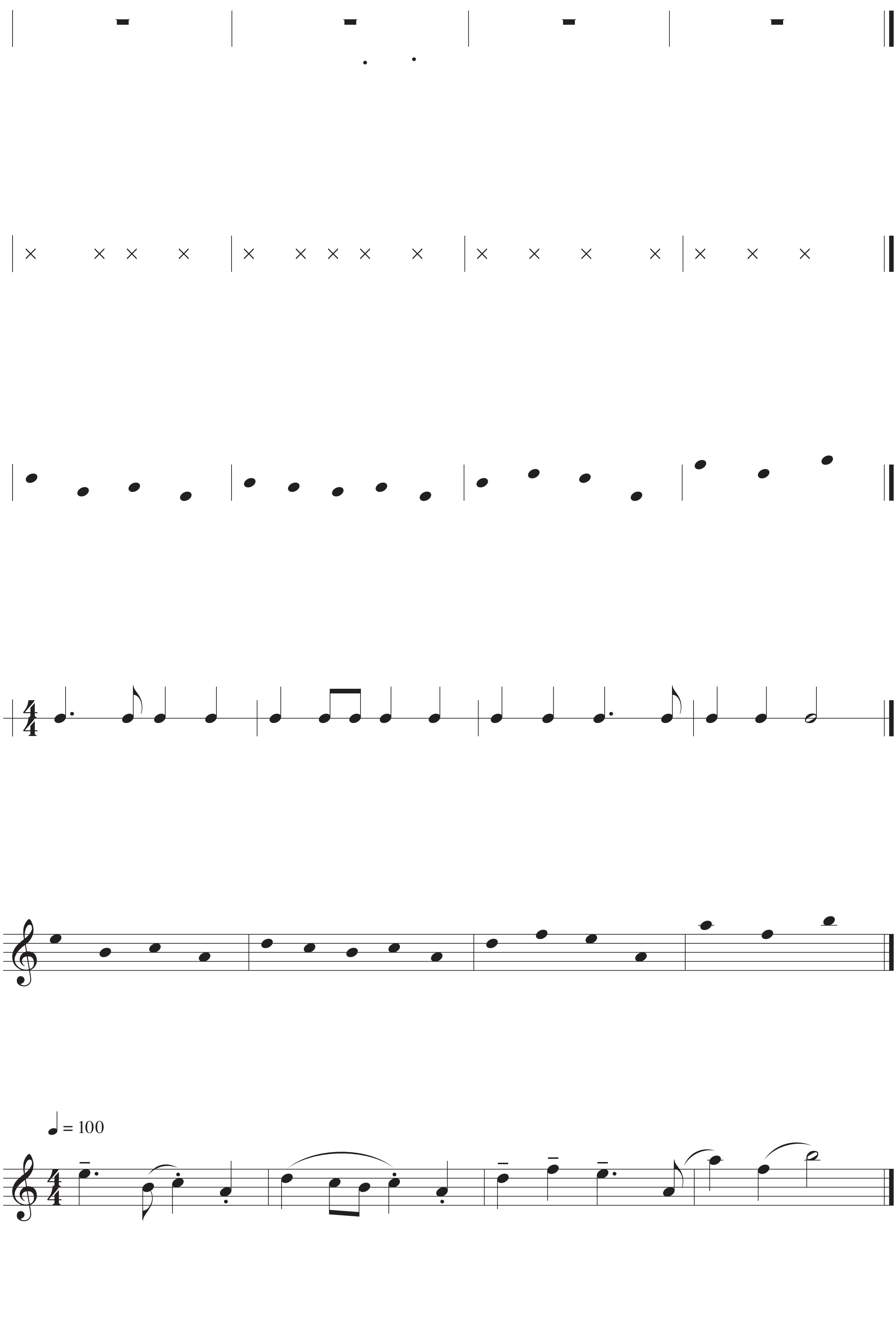
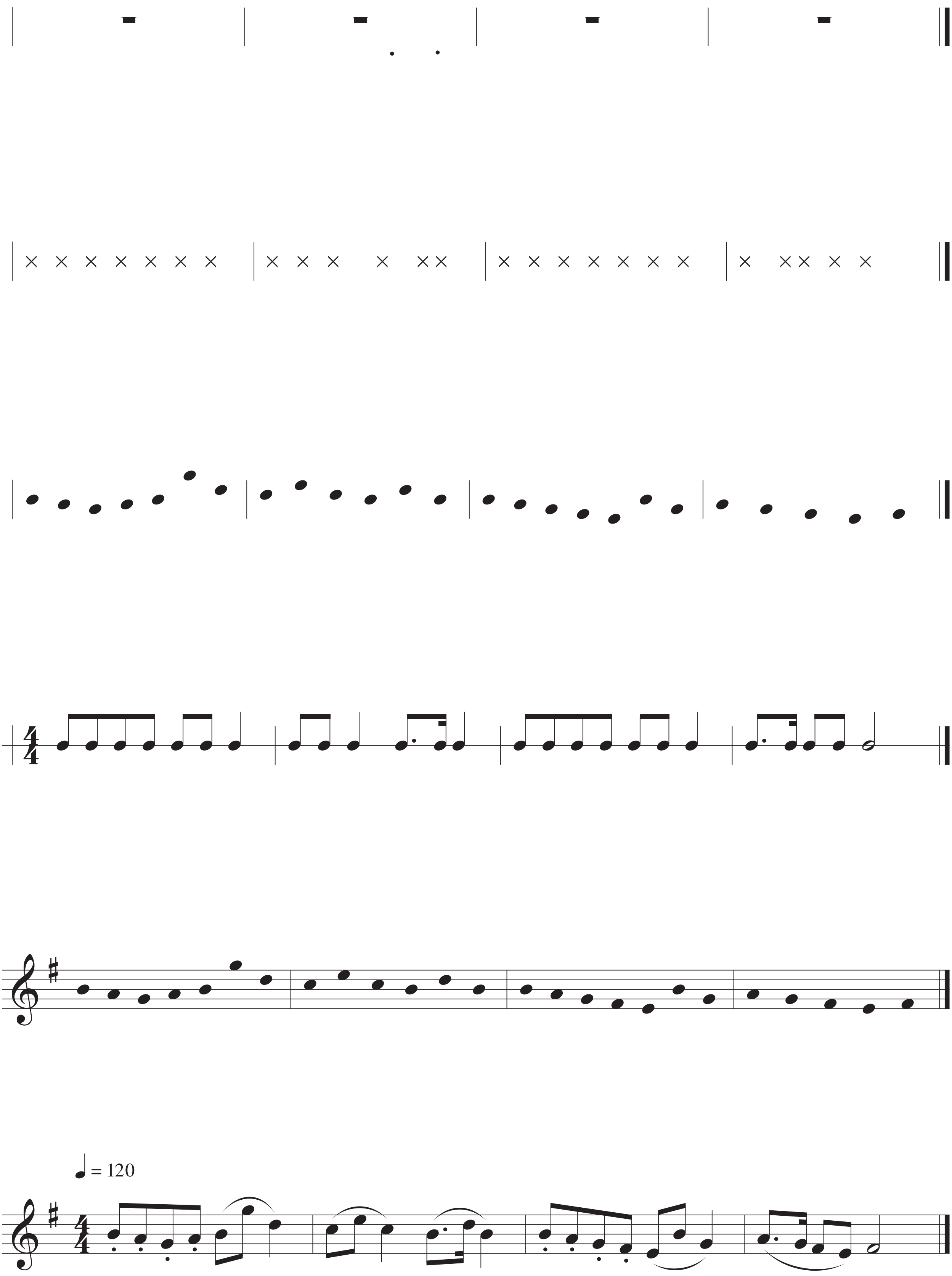
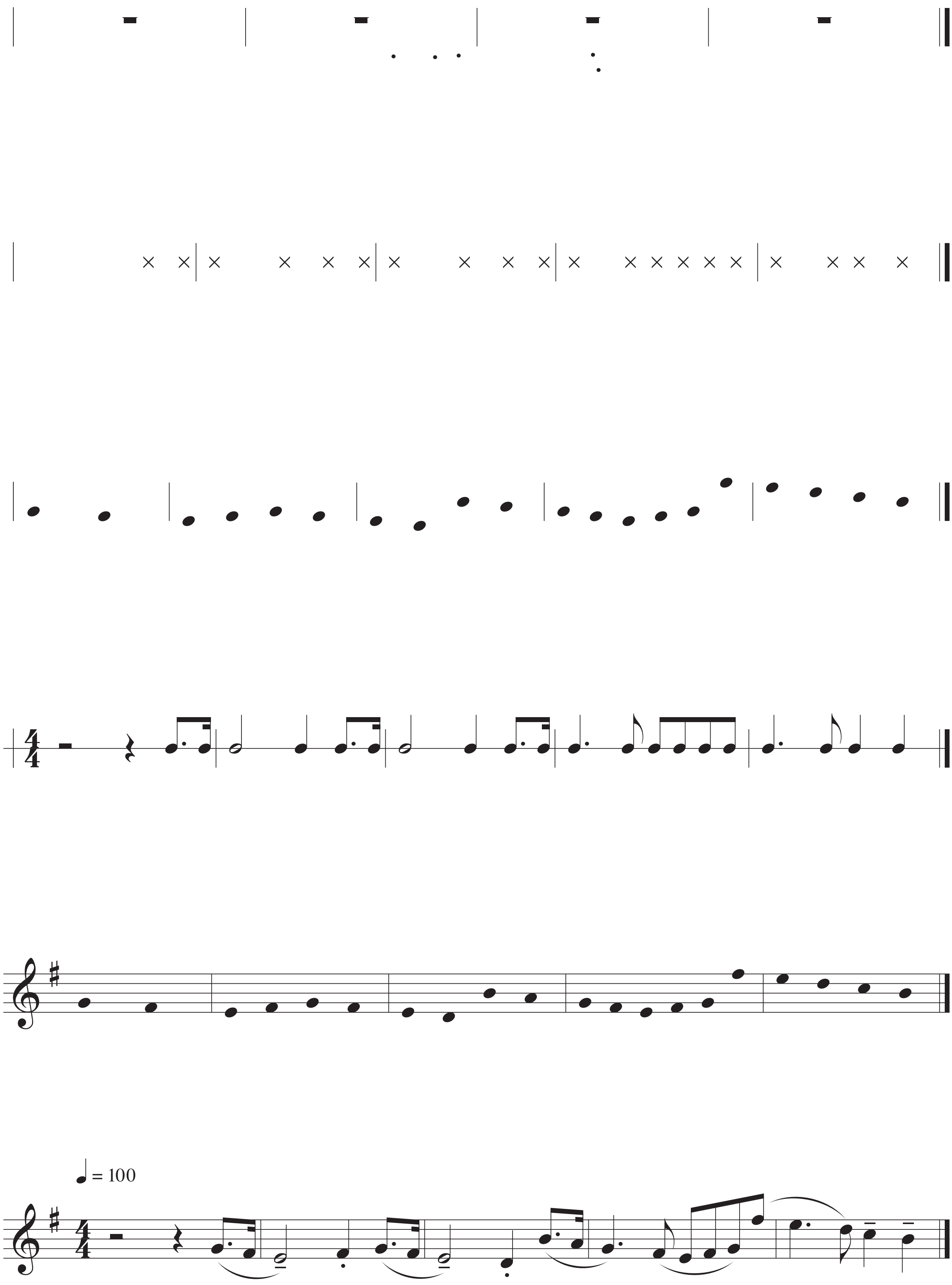


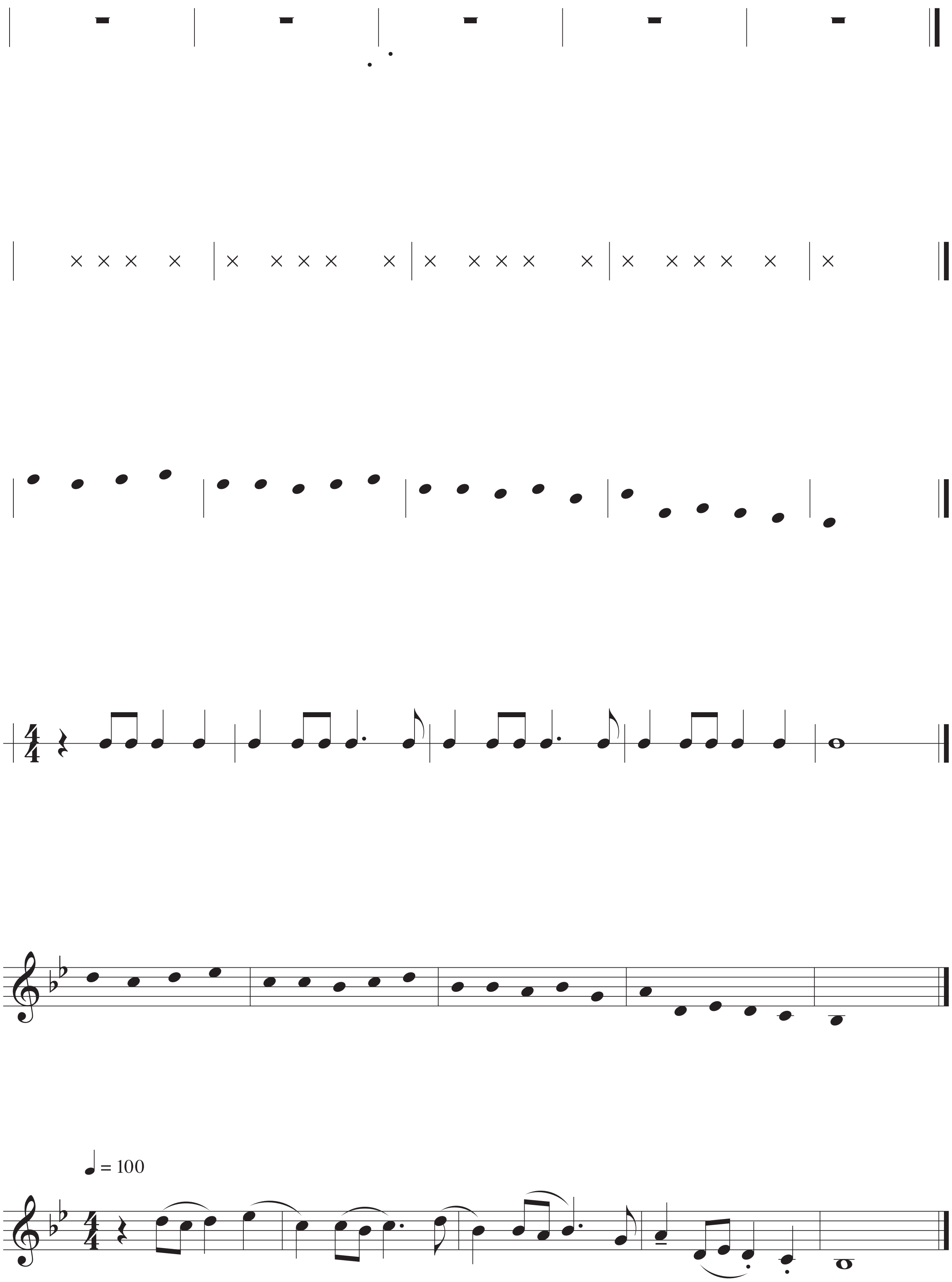
SD Melody 3



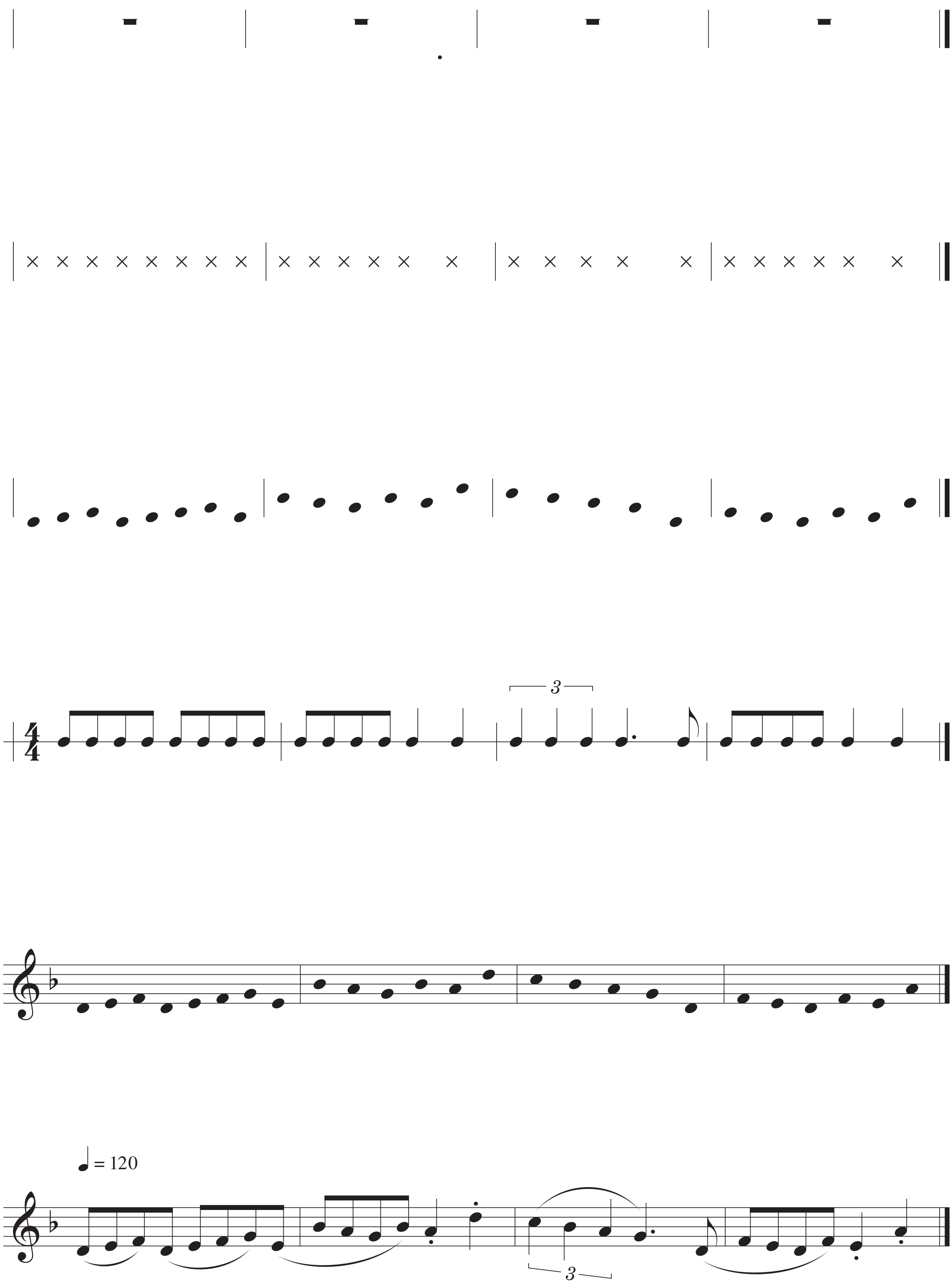
SD Melody 4



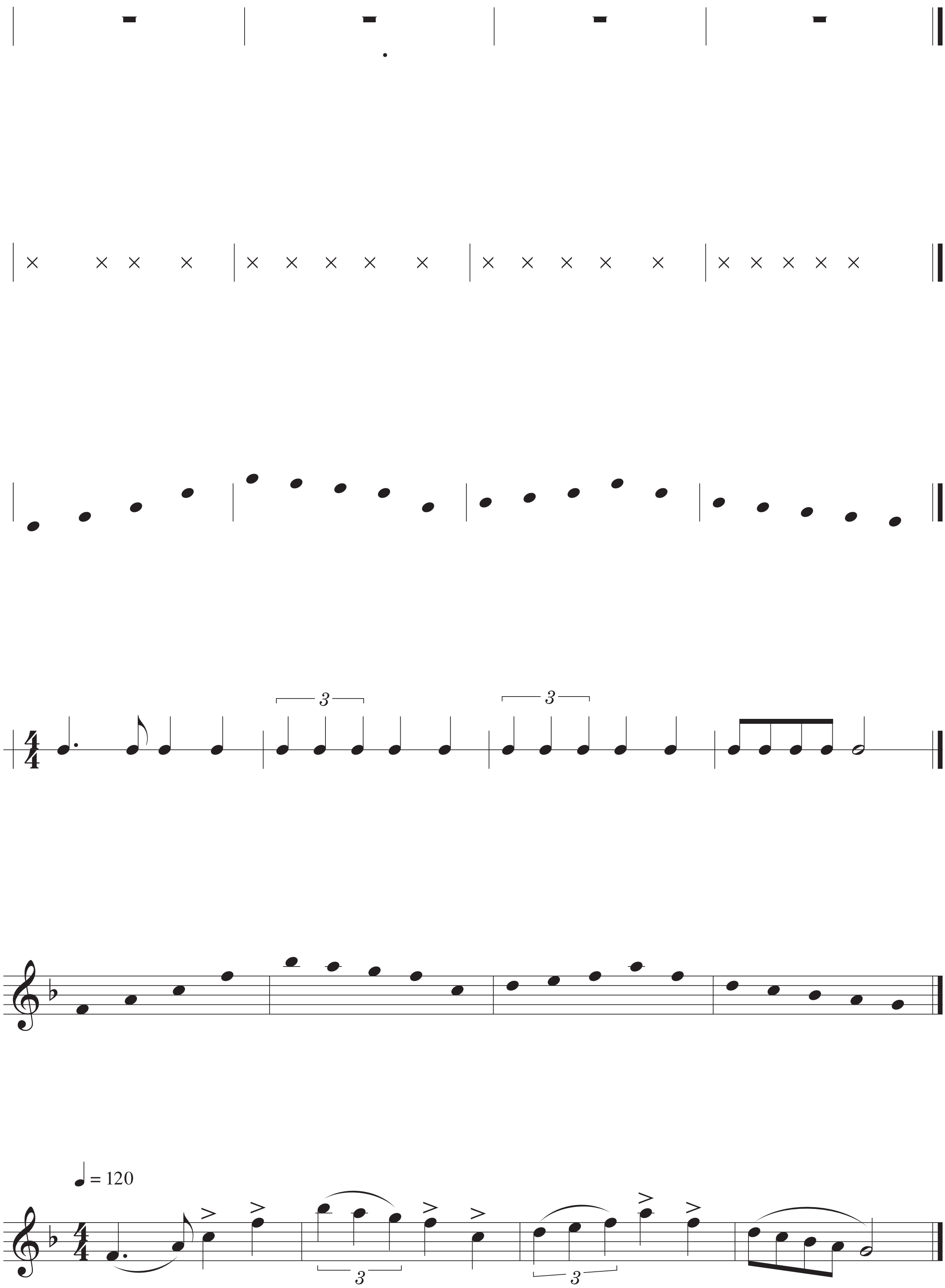
SD Melody 5



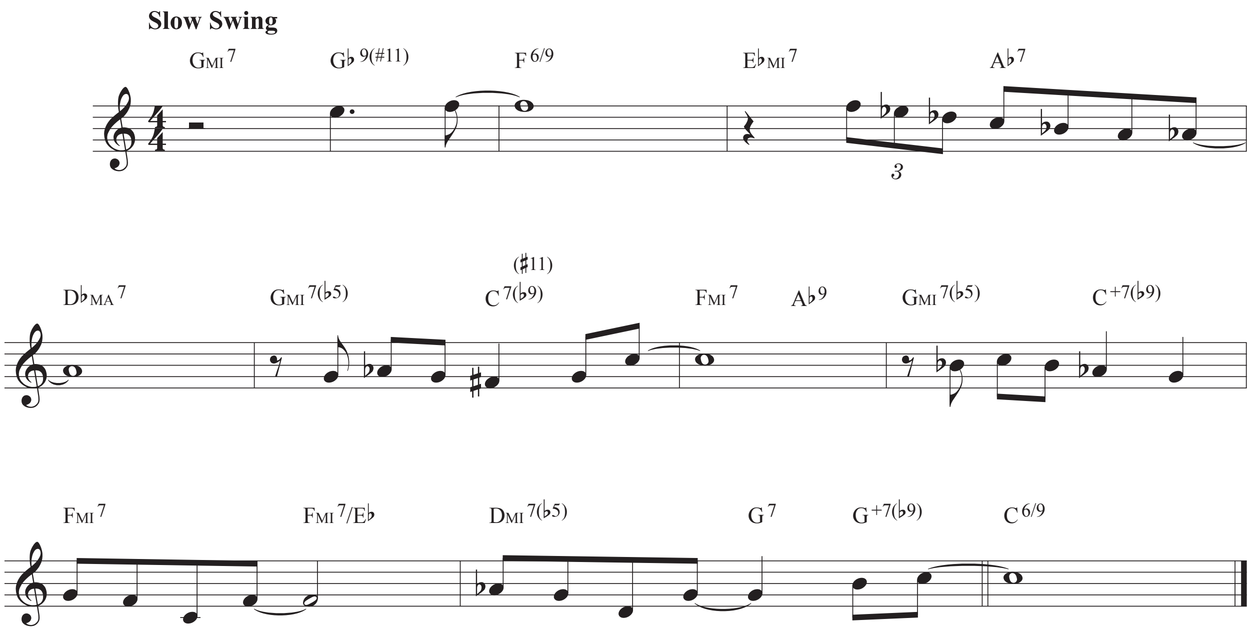
SD Melody 6

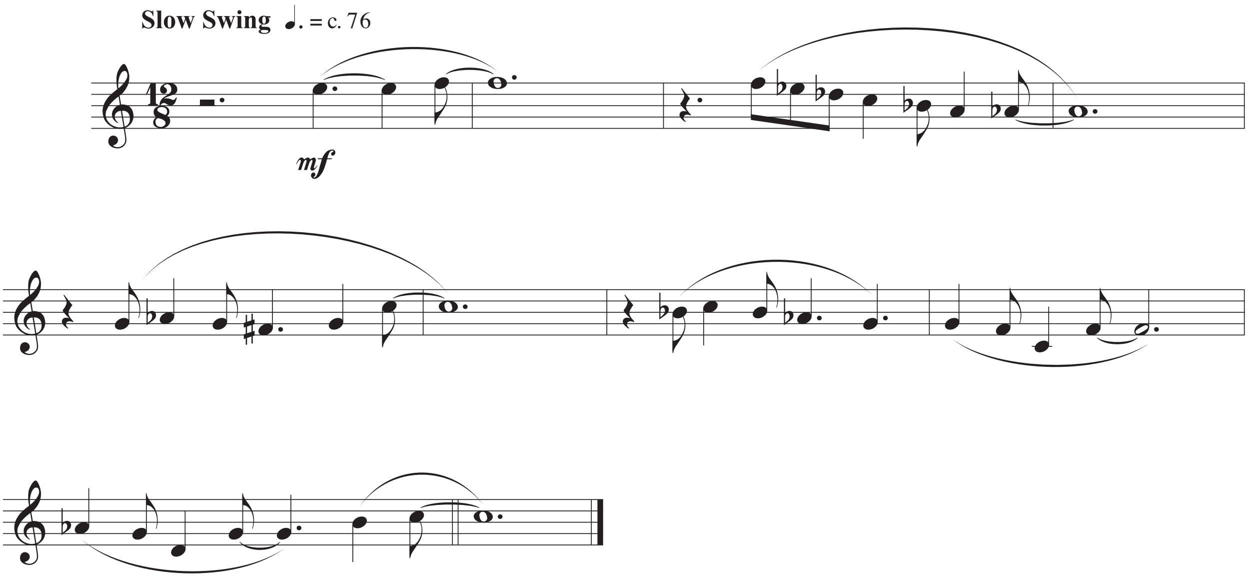


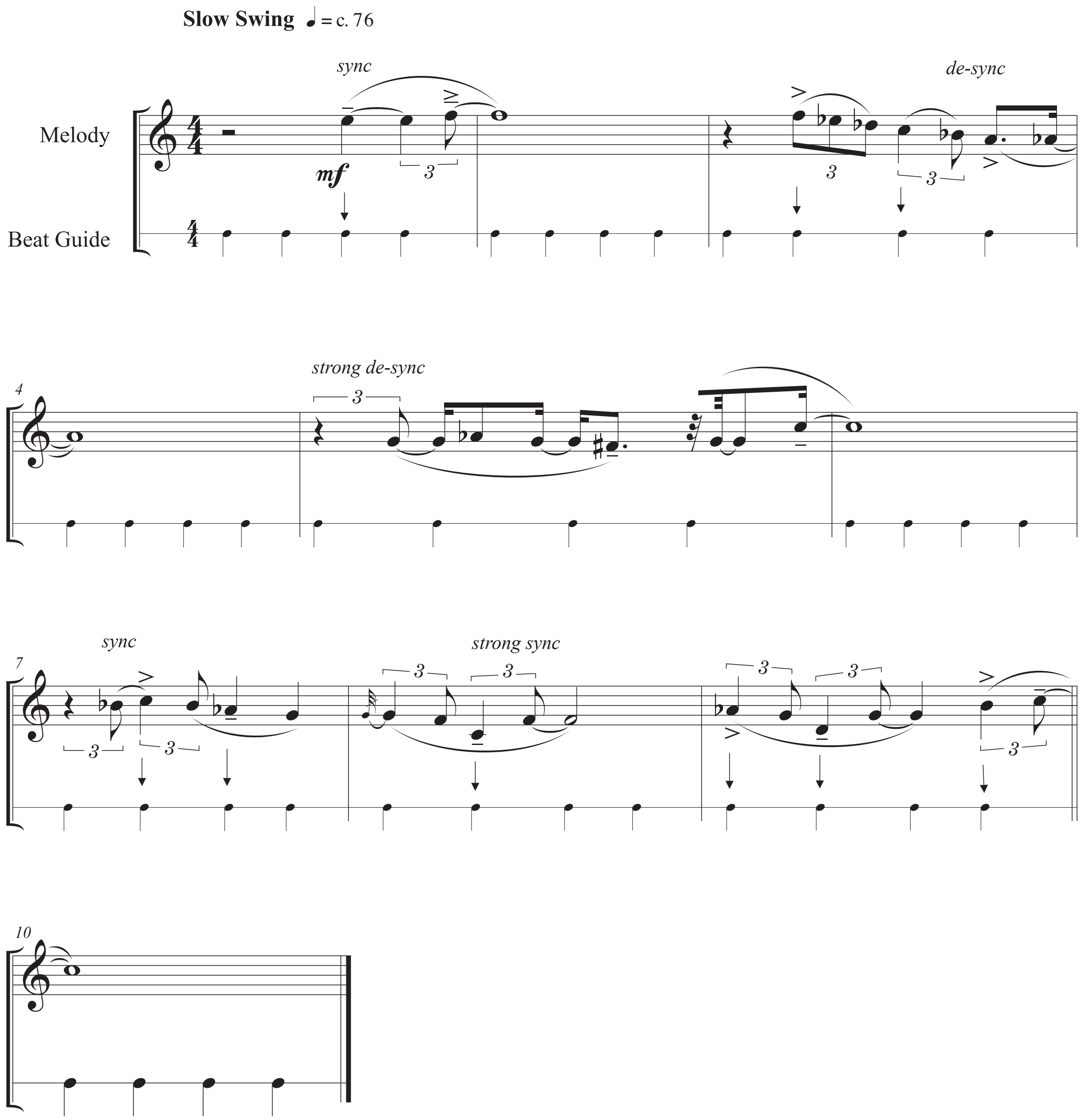
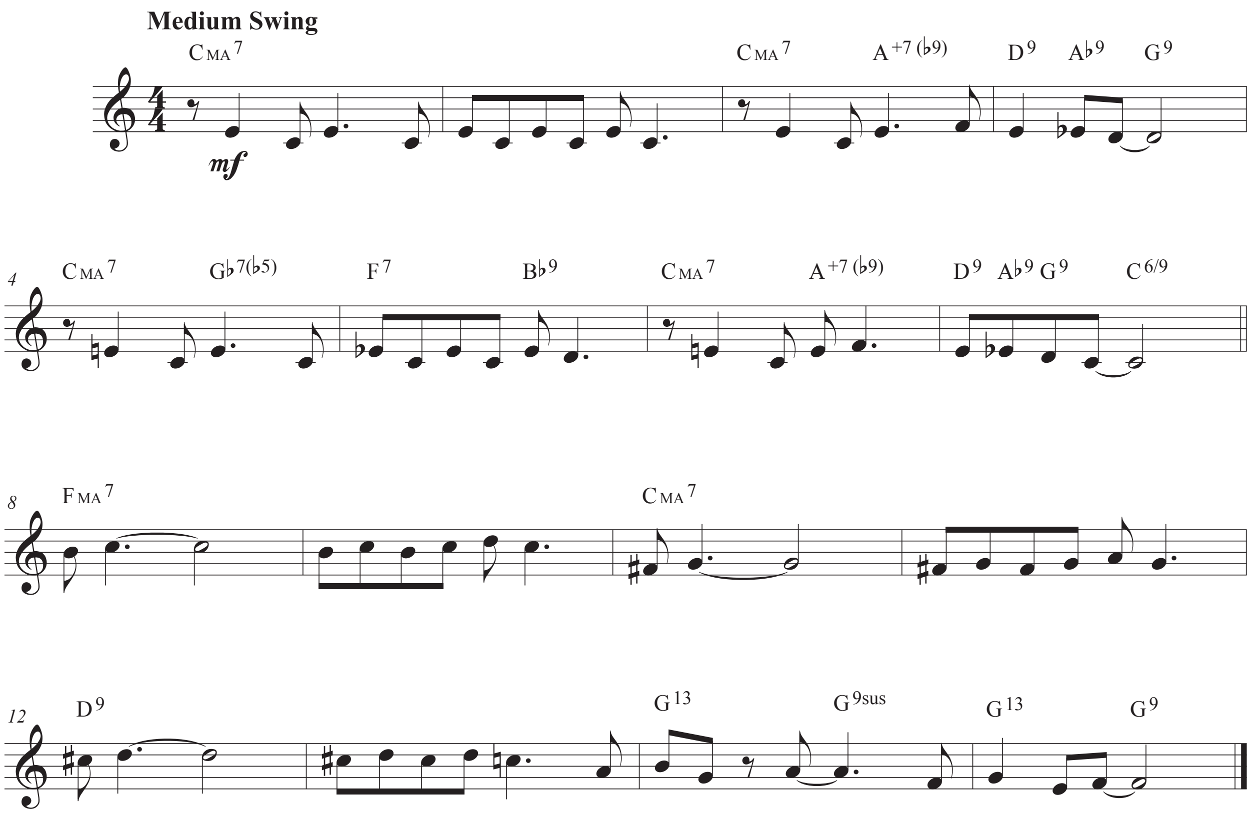
SD Melody 7



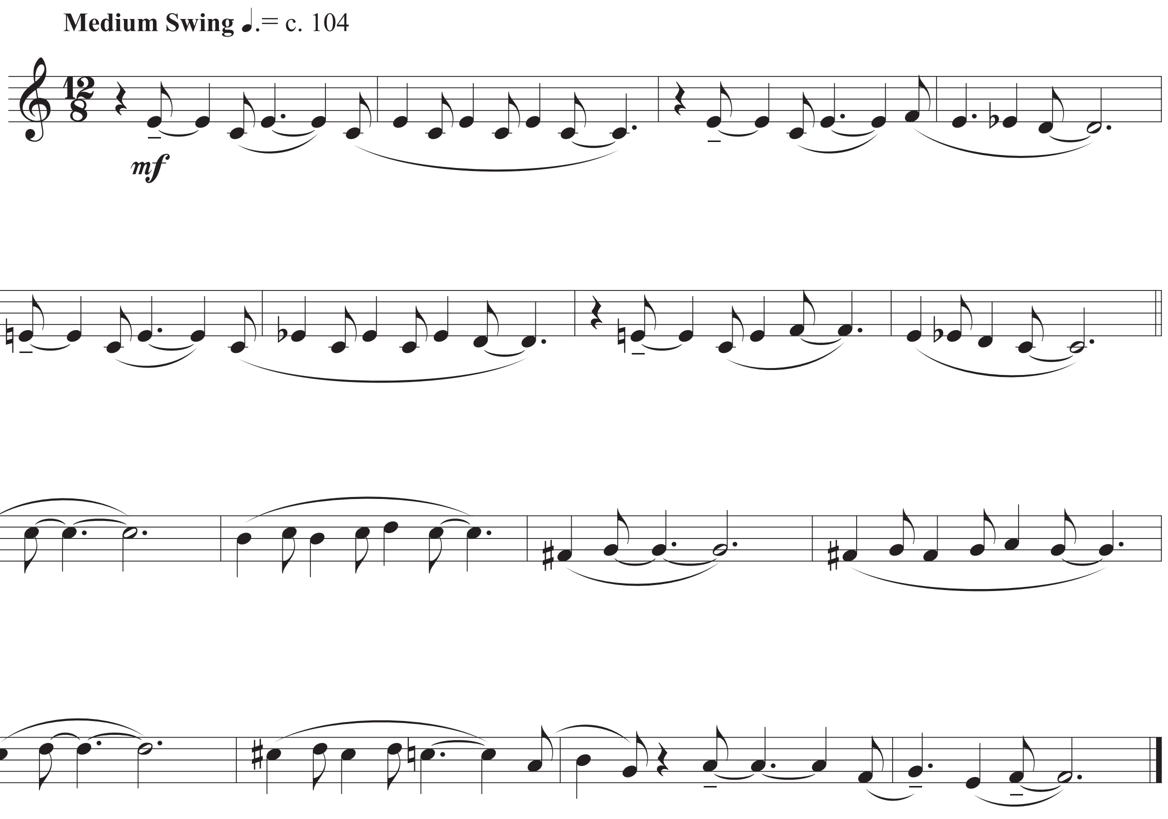
Sample - N1

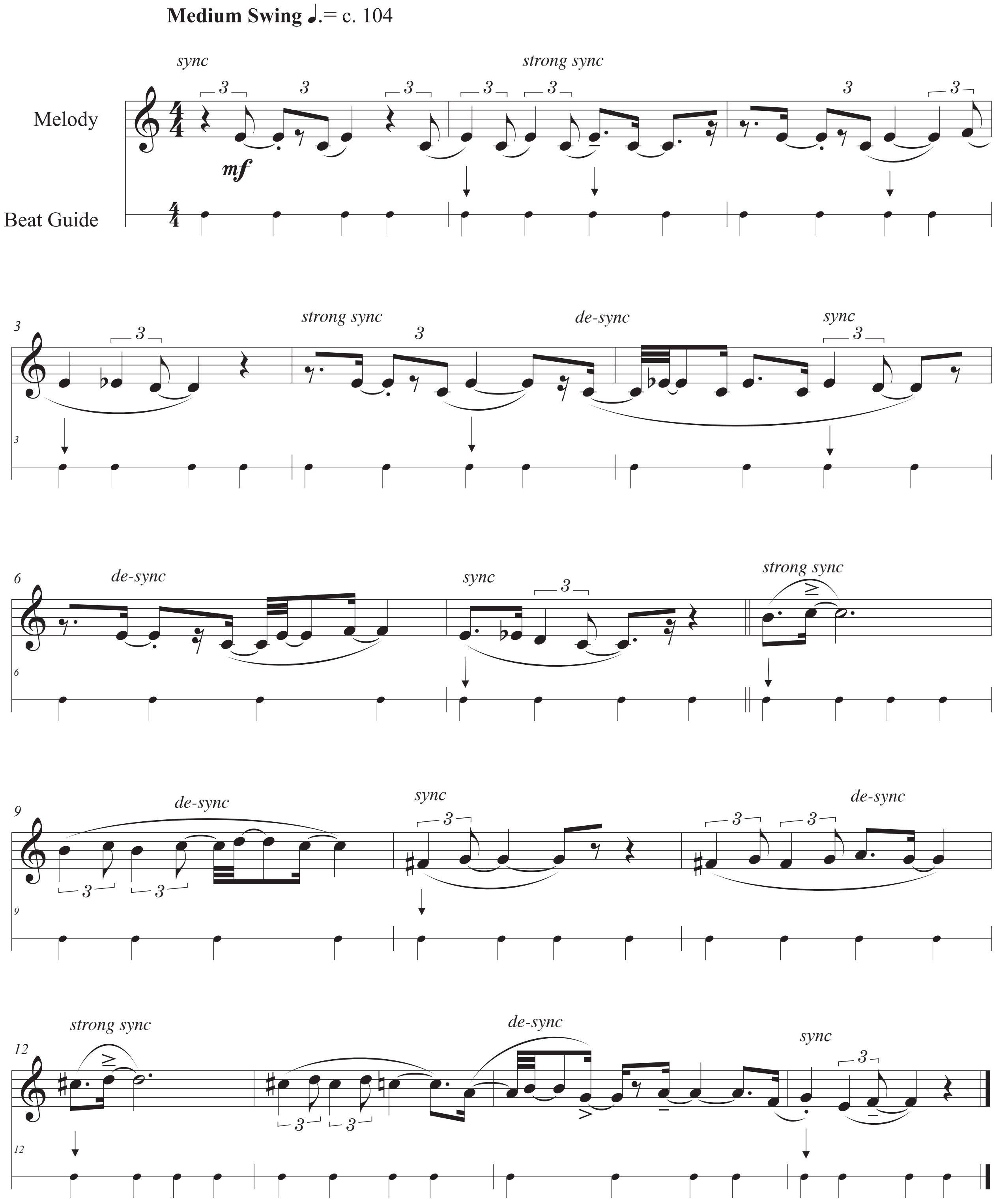

Slow Swing
GMI 7
G♭ 9(#11)
F 6/9
E♭MI 7
A♭7
3
D♭MA 7
GMI 7(♭5)
C 7(♭9) (♯11)
FMI 7
A♭9
GMI 7(♭5)
C +7(♭9)
FMI 7
FMI 7/E♭
DMI 7(♭5)
G 7
G +7(♭9)
C 6/9

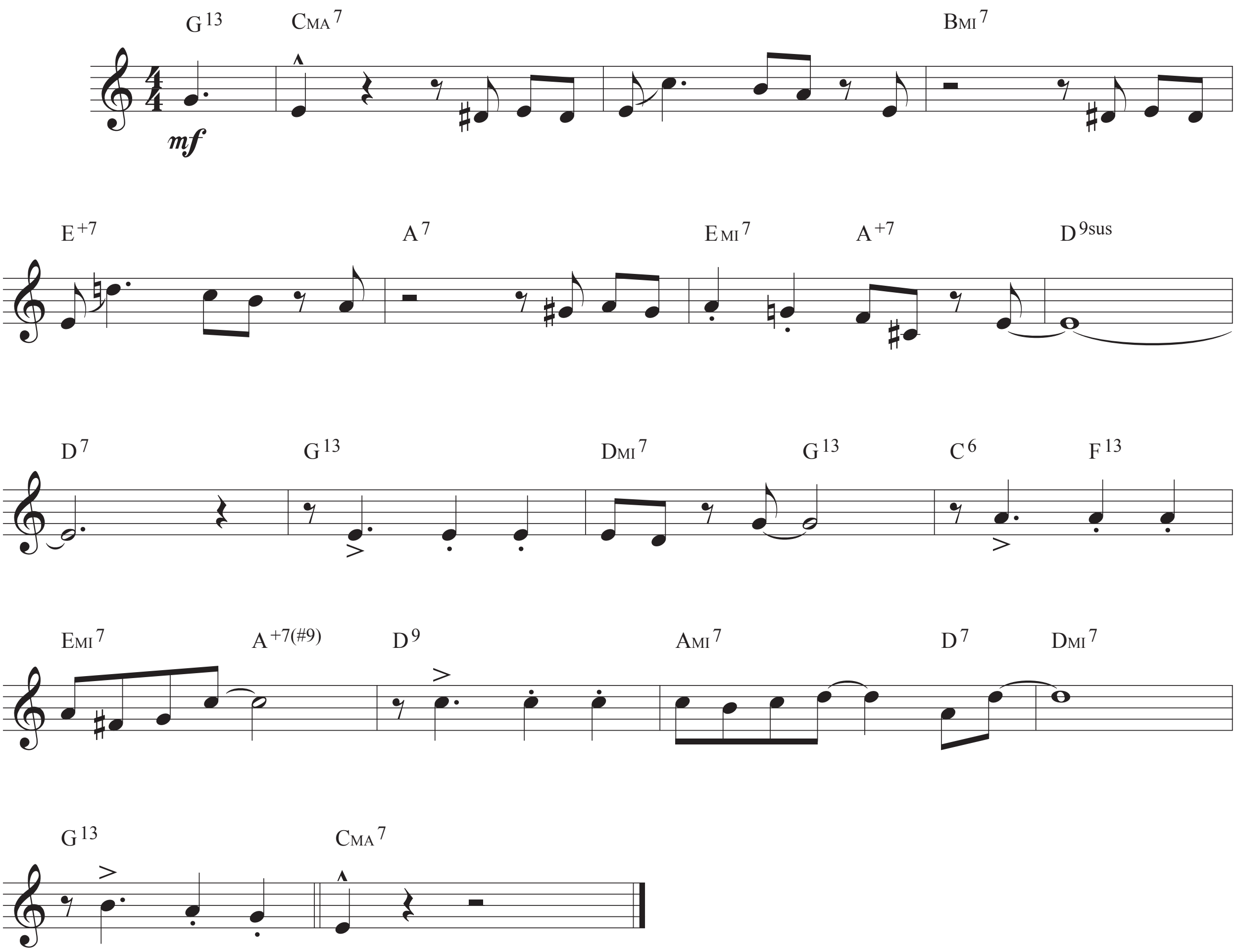
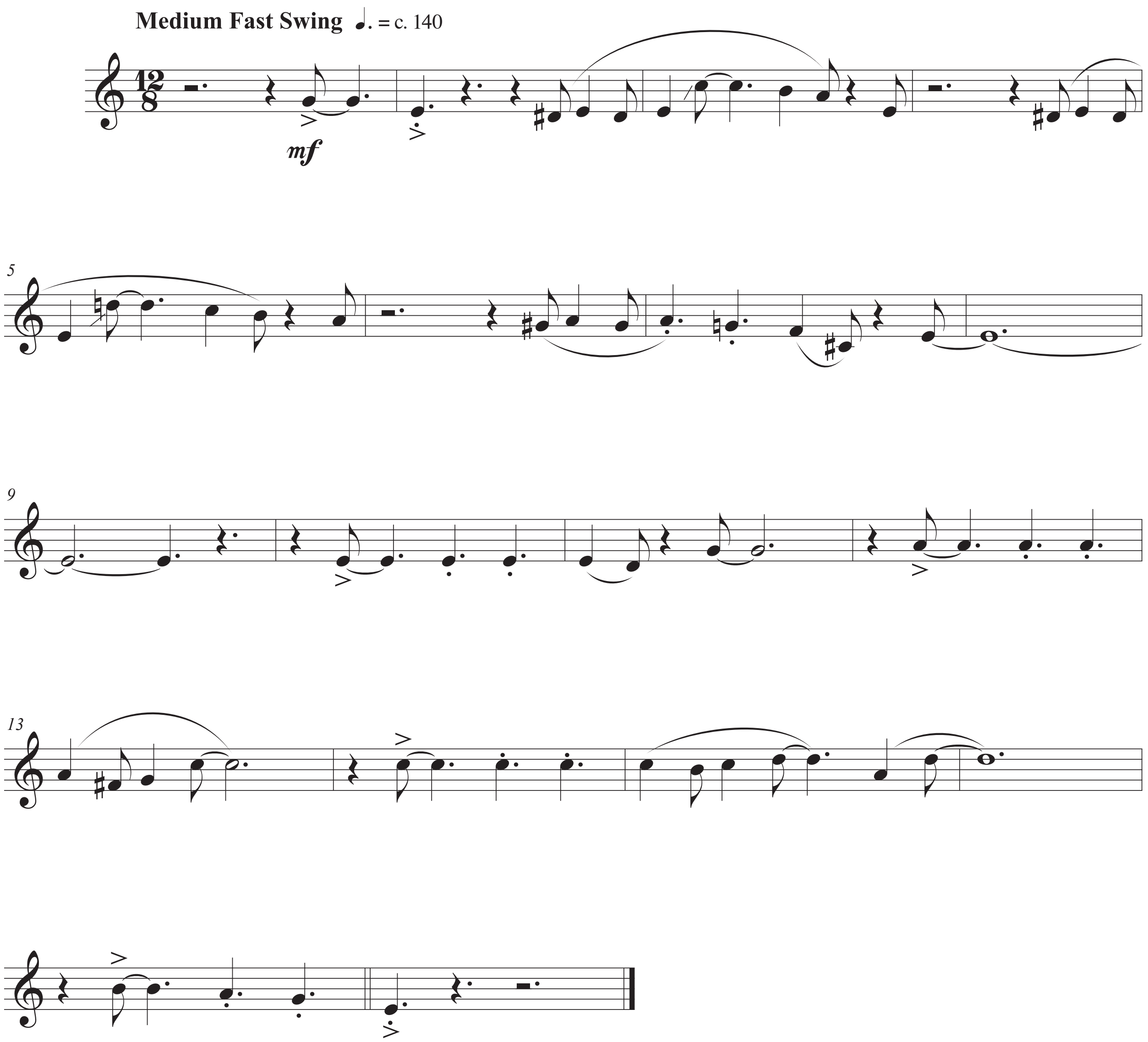
Sample - N2

Sample - N3

1. 'sync' / 'de-sync' above staff indicates increased / decreased synchronization with the beat.
2. Beat Guide arrows indicate when to play exactly on a specific beat or subdivision.
3. Grace notes are to be played before the beat.

M1 - N1


Medium Swing
CMA7
mf
CMA7 A+7(♭9)
D9 A♭9 G9
4
CMA7 G♭7(♭5)
F7 B♭9
CMA7 A+7(♭9)
D9 A♭9 G9 C6/9
8
FMA7
CMA7
12
D9
G13 G9sus
G13 G9

M1 - N2

M1 - N3

1. 'sync' / 'de-sync' above staff indicates increased / decreased synchronization with the beat.
2. Beat Guide arrows indicate when to play exactly on a specific beat or subdivision.
3. Grace notes are to be played before the beat.

M2 - N1

Medium Fast Swing

M2 - N2

M2 - N3

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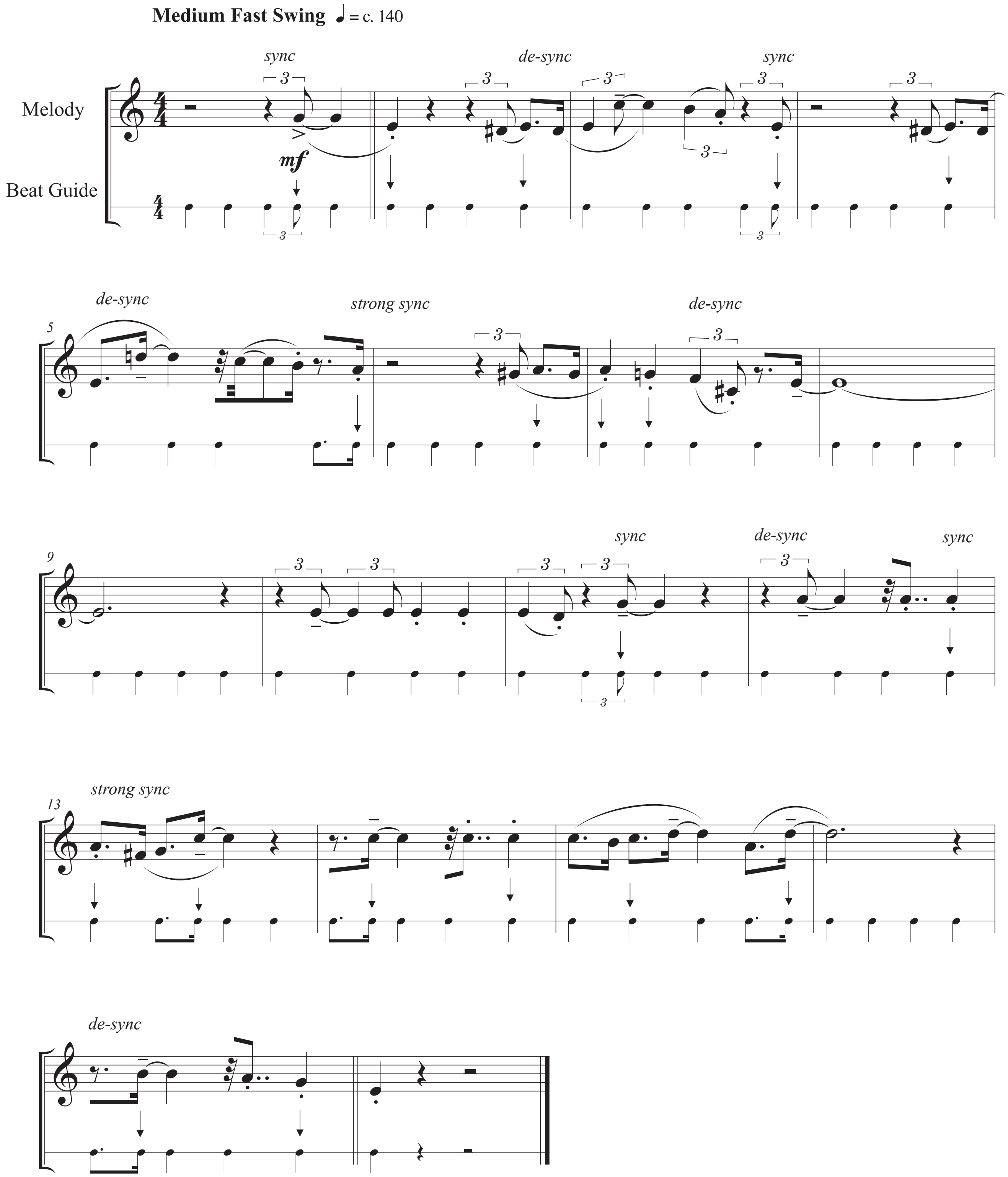
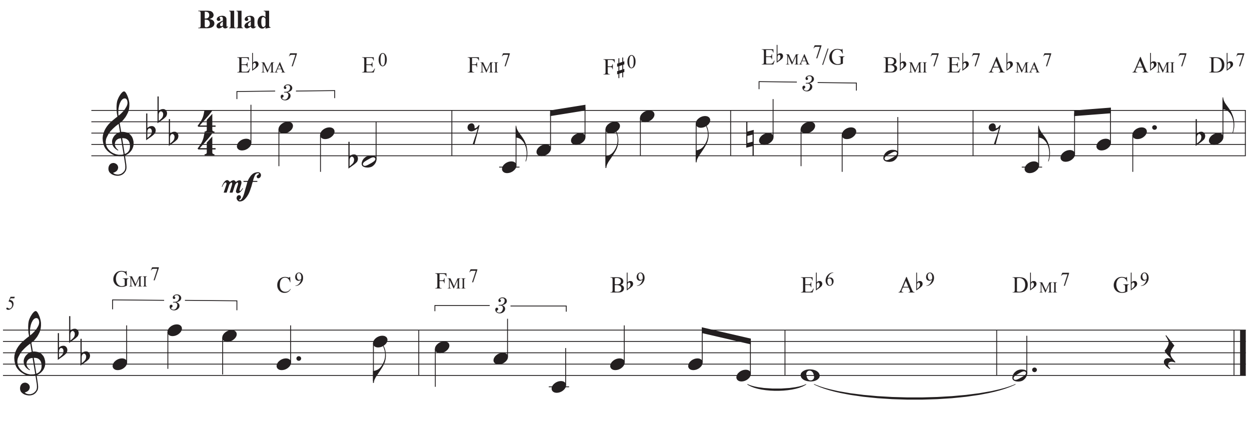
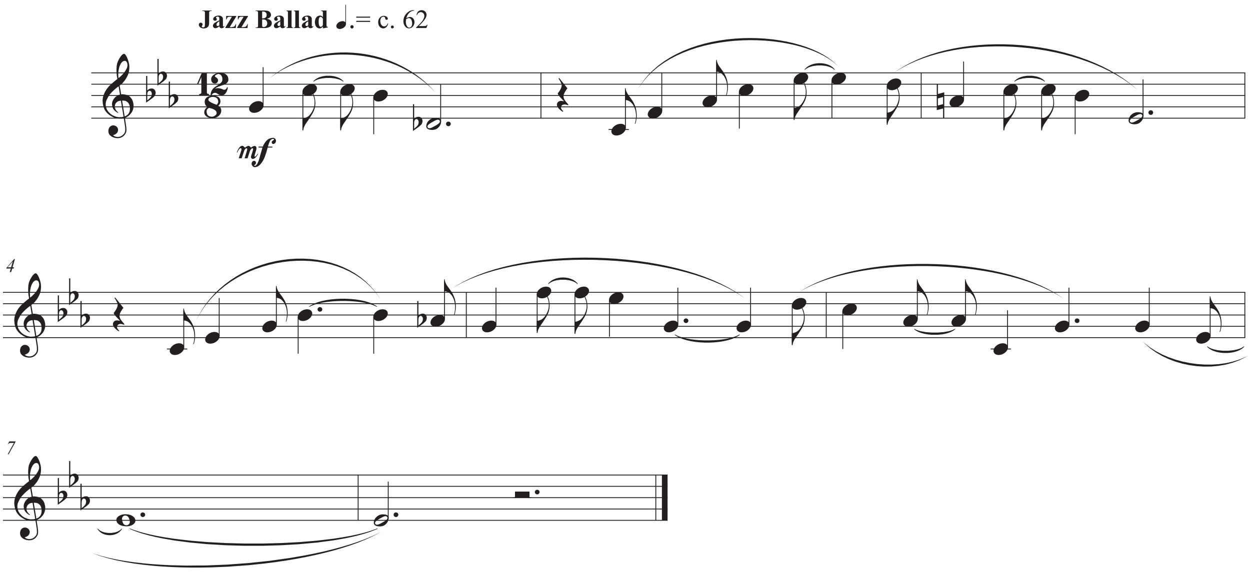
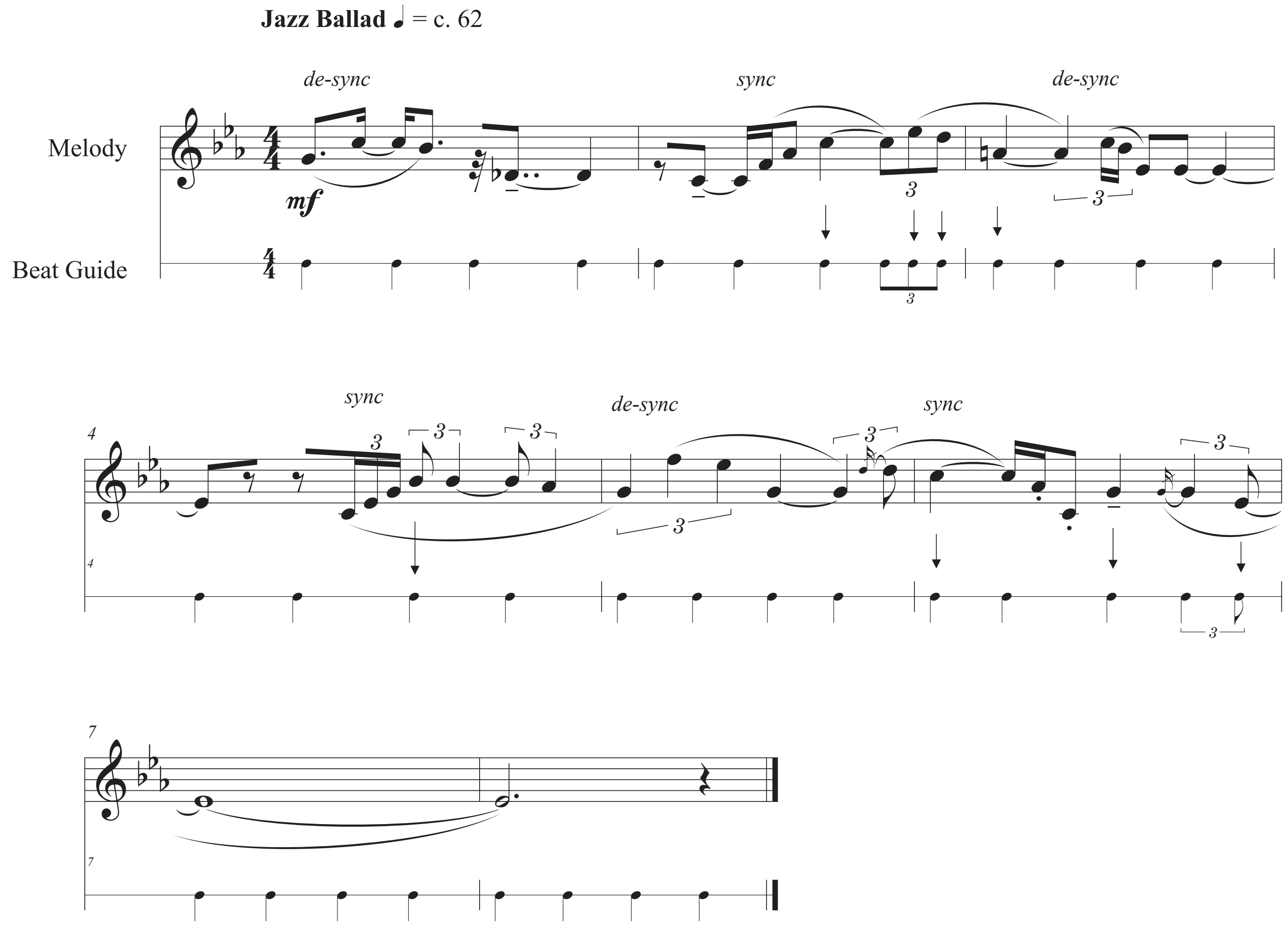
2. Beat Guide arrows indicate when to play exactly on a specific beat or subdivision.
3. Grace notes are to be played before the beat.

S1 - N1

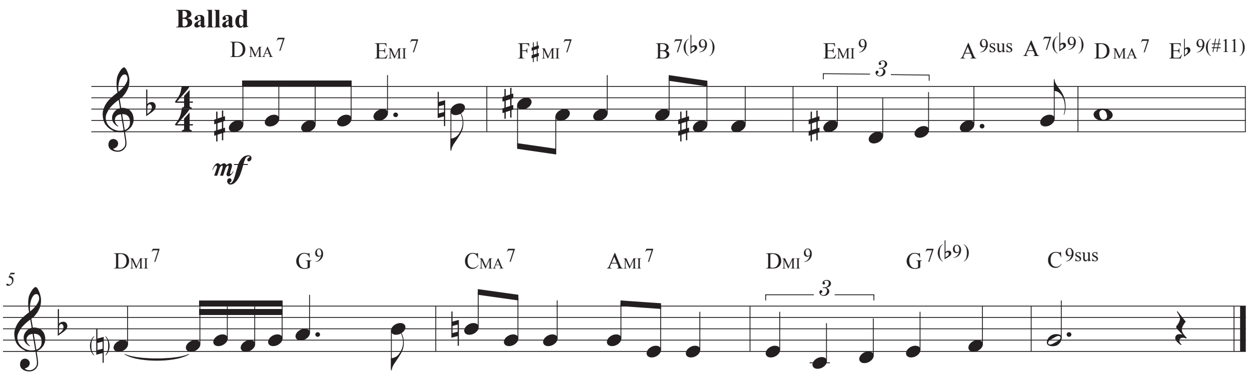

Ballad
E♭MA 7
E 0
FMI 7
F♯0
E♭MA 7/G
B♭MI 7
E♭7
A♭MA 7
A♭MI 7
D♭7
mf
5
GMI 7
C 9
FMI 7
B♭9
E♭6
A♭9
D♭MI 7
G♭9

S1 - N2

S1 - N3

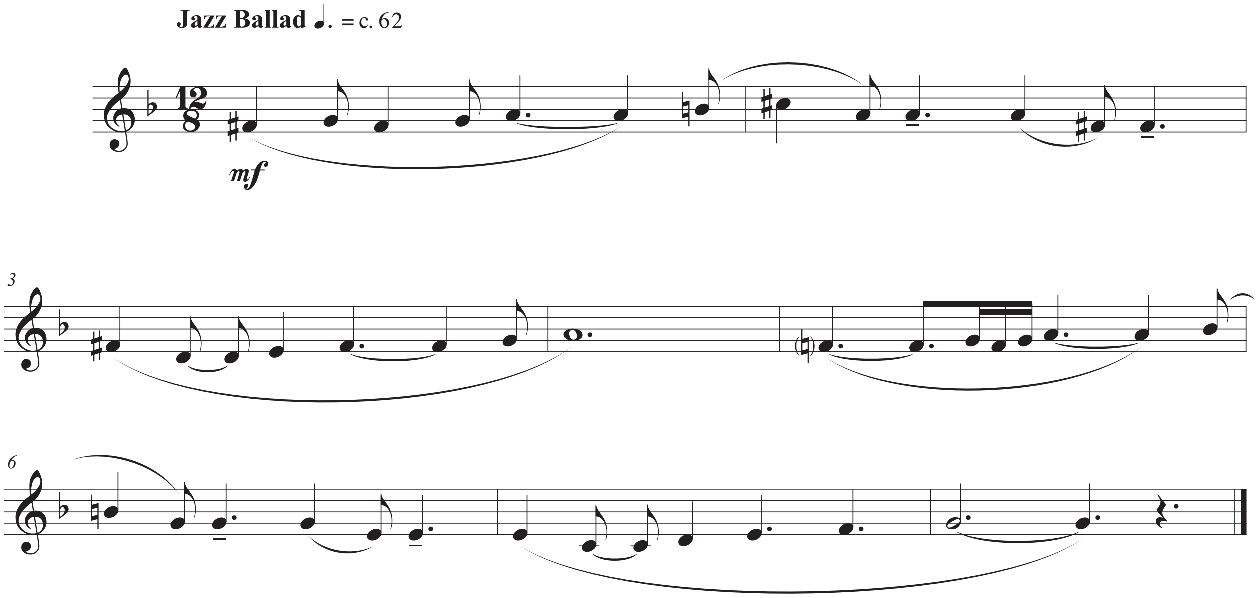
1. 'sync' / 'de-sync' above staff indicates increased / decreased synchronization with the beat.
2. Beat Guide arrows indicate when to play exactly on a specific beat or subdivision.
3. Grace notes are to be played before the beat.



S2 - N1


Ballad
DMA7 EMI7 F♯MI7 B7(♭9) EMI9 A9sus A7(♭9) DMA7 E♭9(#11)
mf
3
5
DMI7 G9 CMA7 AMI7 DMI9 G7(♭9) C9sus
3

S2 - N2



S2 - N3

1. 'sync' / 'de-sync' above staff indicates increased / decreased synchronization with the beat.
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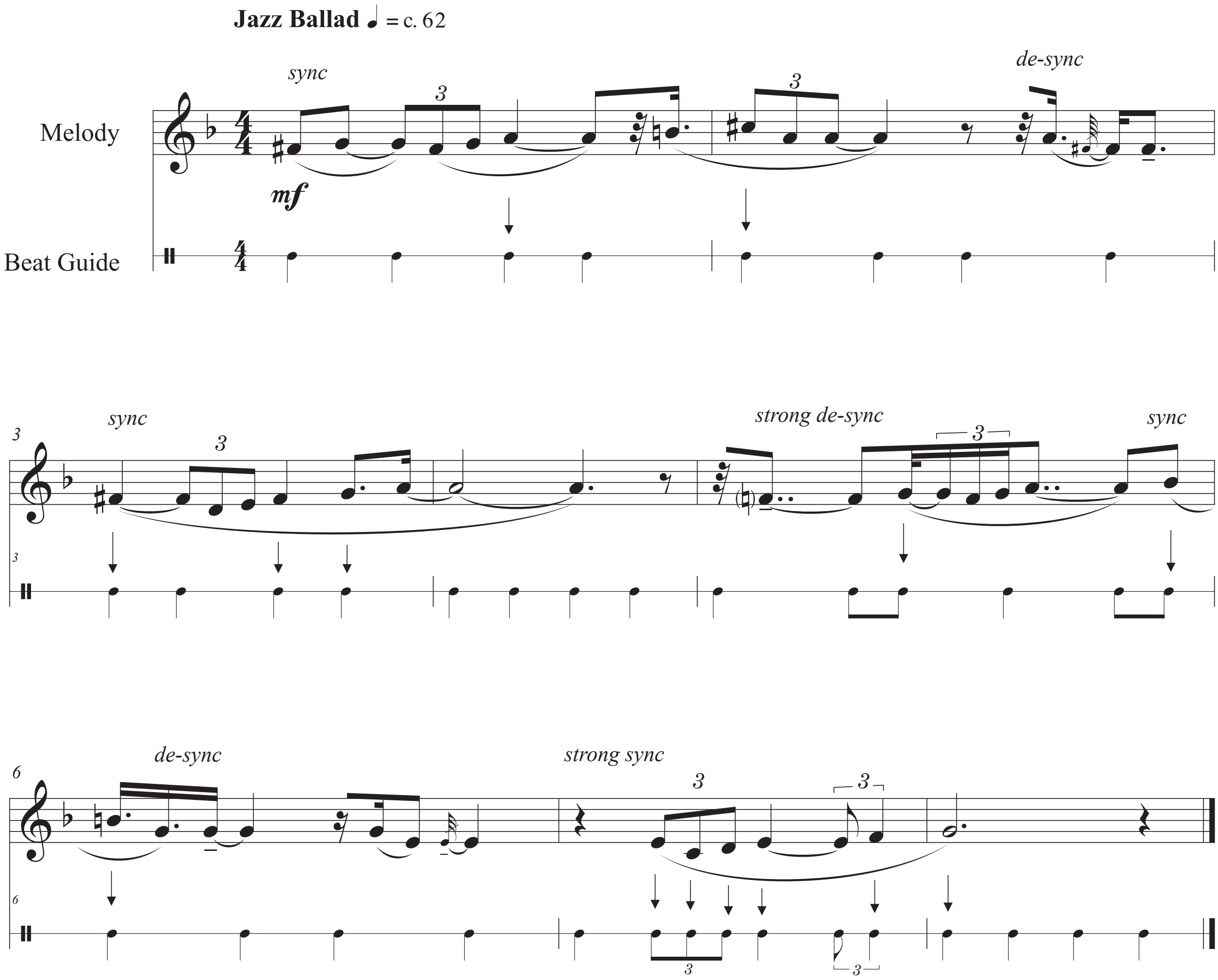
3. Grace notes are to be played before the beat.

COMPOSITION PORTFOLIO

Investigating the Application of Groove Rhythms in Contemporary Classical Composition

Christopher Farrel Rory Corcoran
St Edmund's College

– Portfolio Commentary –

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1. Introduction

I have always had one foot in the worlds of classical and of popular music, playing both electric and classical guitar. As an electric guitarist playing in bands, I improvise solos and add spontaneous or partially pre-determined rhythm parts to relatively static forms based on cyclical harmonies. As a (by now former) classical guitarist, I performed notated through-composed music that focussed on formal development through harmonic changes and contrapuntal variation. While developing as a composer, I spent several years focussing on writing music that drew more strongly on the latter practice, which was probably also an outcome of the formal settings in which I studied composition. However, eventually I realised that this did not fully represent my musical passions, and I began exploring musically how my interest in formal development and popular music rhythms could be synergised. This PhD composition portfolio reflects that exploration in depth.

1.1. Cyclical groove features vs. formal development

The terms ‘popular music’ and ‘classical music’ are admittedly problematic genre distinctions.[1] However, despite their largely socially constructed differences, these performing traditions do differ in many of their aims and the techniques involved in manifesting their compositional philosophies. Addressing those differences requires creating a division along stylistic lines in order to compare and contrast the perceived stylistic features. Therefore—although I personally regard music as a spectrum on which various performance traditions emphasise shared aspects differently—for the purpose of this commentary I will maintain the following distinction: Notated and at least sectionally through-composed ‘classical’ music versus largely aurally performed, repetition-based and movement-oriented ‘popular’ music.

[1] I am aware of the divisive cultural and social opinions involved in distinguishing between so-called ‘popular’ (here defined to include Afro-American music traditions and their offshoots, including jazz) and ‘classical’ musics (here taken to mean Western art music composition traditions). Even the assumption that all the relevant sub-disciplines could be contained in these two terms is a sweeping generalisation. These are relative social constructs that often paradoxically describe overlapping fields of musical activity (see also Cook, 2014, 241 on distinctions between types of musical works).

One of the chief aims of popular music styles is inducing the sense of 'groove' in listeners,[2] which Janata, Tomic, and Haberman (2011) describe as sensorimotor coupling with positive affect—in this context, dancing or moving to the music (e.g. nodding the head or tapping a foot) and deriving enjoyment from the process. In order to facilitate this, these styles rely on a certain degree of predictability and cyclical arrangement. This cyclicality is an essential part of groove as defined by Pressing (2002):

> Groove or feel forms a kinetic framework for reliable prediction of events and time pattern communication, and its power is cemented by repetition and engendered movement. Various characteristic rhythmic devices achieve their effects in relation to it. They do this by manipulating expectancy with techniques producing perceptual rivalry and multiplicity, using direct temporal manipulations of musical materials […] (308)

Taking Pressing's definition and expanding it to the cultural domain, musical configurations known as 'grooves' are idiomatic rhythmic patterns that are used to engender a sense of motion in listeners. As patterns, they by definition rely on repetition, which cannot be avoided when establishing a groove.[3]

This philosophy of literal repetition is at odds with Western classical music's historically increasing focus on exploring formal variation and development. Consequently, this is problematic for composers wishing to incorporate grooves into contemporary Western art music styles and yet avoid ongoing literal repetition—particularly if the composer aims to through-compose. One of the most challenging aspects in this regard is the metrical symmetry imposed by most groove patterns. Since groove configurations are highly metrically dependent and rely on repetition for effect, they are particularly sensitive to metric changes, which makes variation

---

[2] This is expressed by how 'popular' music is also formally called 'rhythmic' music in Scandinavia. While this term is problematic in and of itself—since no one could claim that other music is not rhythmic—Vuust et al. (2010) point out that the term acknowledges popular music's deep roots in facilitating social group activities, chiefly among them dancing: 'The association between "rhythmic" music and motion, and the focus on rhythm, meter and the sensation of swing in this style of music, is the rationale behind the term "rhythmic".' (220)

[3] This is partially rooted in groove's dependence on metric regularity, since as London puts it 'meter is a musically particular form of entrainment or attunement, a synchronization of some aspect of our biological activity with regularly recurring events in the environment' (2012, 4). As London's comment suggests, meter can only be perceived if it recurs, as listeners otherwise cannot synchronise with it. Although a listener's perception of meter might not necessarily be a desired outcome in many musical contexts, grooves are *patterns* of emphasised notes and are meant to be perceived as such. Grooves therefore depend on listeners observing the regularity of the pattern by forming a physical awareness of the ongoing sub-division of the meter. London calls patterns of metric sub-divisions, such as groove rhythms, 'metrical types' and describes them as 'a particular organization of metrical cycles' (2012, 60), which again highlights their cyclical nature.

and development more challenging. The composer has to carefully consider the rhythmic flow of the groove, since as Butterfield (2006) suggests, even a minute change in inflection may alter the groove's rhythmic makeup and affect its power. Crucially, this might remove the 'swinging' or 'groovy' components that made the groove's inclusion worthwhile in the first place (paras 48-52). Therefore, combining groove with formal variation can be difficult.

1.2. Intercultural crossover practices in modern composition

Intercultural or 'crossover' compositions utilising groove rhythms have been created since the early 20th century. Prominent exponents include Seiber, Ravel, Stravinsky, Milhaud, Weill, Gershwin, and Copland, who all at one point integrated some elements from the jazz practices of their day into their scores. These early experiments, however, were aesthetically controversial for their unilateral appropriation of jazz (e.g. Banks, 1970a, 596; 1970b, 60; Ehle and Ehle, 1972, 23). Taking such criticism into account, composer Gunther Schuller formalised the concept of 'third stream music' to codify and stylise a musical space that would cover activities neither firmly rooted in classical music nor in jazz. Schuller called for third stream to combine 'the improvisational spontaneity and rhythmic vitality of jazz with the compositional procedures and techniques acquired in Western music during 700 years of development' (Schuller, 1961, 115). The new genre had to be 'born out of respect for and full dedication to both the musics it attempts to fuse' (116), calling for a genuine and thorough engagement with the techniques and practices that informed the identities of the main 'streams':

> Third Stream is nothing if it fails to amalgamate at the most authentic and fundamental levels. It is not intended to be a music of paste-overs and add-ons; it is not intended to be a music which superficially mixes a bit of this with a bit of that. (1981, 120)

This aim is problematic, since it demands expertise in several fields from both composers and performers. As performer behaviour is shaped by practice, performers from one cultural background may articulate music from another culture in a way that is seen as inappropriate or uninspiring by an audience (see also London, 2012, 157 for a more detailed analysis). That may have led to the common accusation that classical musicians struggle to groove or swing (e.g.

Banks 1970b; Joyner, 2000; London, 2012, 157; Schuller, 1961; Sussman & Abene, 2012; Turnage & Lewis, 2008).[4]

In light of this issue, many third-stream pieces do not actually fuse music from both performance traditions, but rather present them side-by-side. As a result, prominent pieces throughout third stream history often feature jazz performers in the manner of the Baroque concerto grosso—dividing performers into a larger classical ensemble and a smaller jazz band (Ehle & Ehle, 197; Hair, 2007; Sussman and Abene, 2012, 62). In this setup, often the groove material is only given to the band, with the orchestra merely providing sustained backing notes or phrasing around the band's rhythms. Examples abound, with prominent pieces being Turnage & Scofield's *Scorched* (2001), Dankworth and Seiber's *Improvisations for Jazz Band and Symphony Orchestra* (1961), or Schuller's own *Conversations* (1959). This approach likely results from the different musical enculturation classical and jazz players experience, which results in different phrasing behaviour and so could lead to clashing phrasing styles: 'I am convinced that one should not expect orchestral musicians to deal with jazz phrasing, and equally sure that one should not inhibit jazz musicians from their natural inclinations in dealing with a phrase. Let each party do what he can best achieve.' (Banks, 1970a, 61)

However, this is not merely a logistical problem, but also a compositional one, since composers hesitate to integrate groove-based music directly into their orchestral writing. Perhaps one of the most prominent examples of this in recent history is Mark-Anthony Turnage's collaboration with jazz guitarist John Scofield, *Scorched* (1996-2001) for jazz trio and orchestra. The piece alternates between jazz band performances of iconic recordings by Scofield and carefully worked out orchestral variations on these recordings by Turnage. In many movements, Turnage opts for the concerto grosso approach, so that whenever the band enters, the orchestra noticeably is relegated to a supporting role (providing background material through long sustained tones, the occasional scale run, backing figures). The orchestra rarely is used to build groove on its own. In purely orchestral passages, or passages where the jazz instruments support the orchestra rather than the other way around, Turnage's idiosyncratic rhythmic scoring for

[4] That problem is the focus of my empirical thesis, and therefore will not be discussed here in detail. Instead, in keeping with the PhD project's title, here I will discuss how the techniques of groove-based structures can be used and subverted creatively in predetermined compositions written for notation-reading musicians.

orchestra deliberately distorts any repetition beyond easy recognition and therefore suppresses groove.

As a result, in movements such as ‘Kubrick’, ‘Nocturnal Mission’, and ‘Fat Lip 2’ the orchestra is not used to build groove until the jazz drummer grooves in the musical foreground. Occasionally, the jazz performers will be used to support building non-groove orchestral material, as in ‘Trim’, where the electric guitar is used to support the orchestra quietly on specific chords. The movement ‘Let’s Say We Did’ more successfully integrates the two, with the guitar soloing over orchestral textures, but here too the jazz instruments keep to themselves, the guitar only sharing composed melody lines with a jazz saxophone. Only in the last two movements does Turnage use classical performers for building groove: In ‘Polo Towers’ a subset of the orchestra is used to play together with the jazz band, but it is really only in the last movement ‘Protocol’ where the orchestra finally is allowed to actively contribute to building groove in association with the drum set and electric bass (though still not without jazz instruments). Here solos are integrated well into the orchestral texture, allowing the orchestra to develop interesting material behind the jazz solos rather than just background music.

In summary, for the purposes of building groove among classical performers and therefore creating a true integration of jazz and classical music, Turnage’s approach to orchestral writing in this piece showcases two problems: Often the scoring is too tentative, since the orchestra rarely contributes to groove without a jazz band to guide them; at other times, it is overly worked out, since purely orchestral passages sacrifice groove in the interest of intricate motivic development by distorting all repetitive elements. More integrated approaches are presented by composers such as Steve Martland or Louis Andriessen and other proponents of ‘post-minimalism’—here band and orchestral instruments are frequently blended together more successfully. However, the caveat for these pieces is that they are usually so heavily rooted in repetitive structures that formal motivic development, which Turnage handles most successfully, is hindered and unfolds only slowly over long stretches of time. Therefore, as becomes clear from Turnage’s example, Schuller’s aim of fusing rhythmic impetus from popular music traditions and procedures from classical music requires a delicate balance, given how musical traditions manifest in particular performer skills and behaviour.

1.3. My portfolio: Artistic goals and pieces

The described conflict also points towards the conceptual flaws in third stream as a formal concept (see Joyner, 2000, for an in-depth analysis), due to its dependence on a variety of occasionally contradicting performance traditions. As a result, I hesitate to label my own compositional practice as 'third stream', since it does not have at its heart a particular genre-political agenda that Schuller proposes and instead simply aims to express my diverse musical training and experiences. Nonetheless, Schuller's aim to fuse the rhythmic impetus of groove-based music with classical music's approaches towards formal development is also my chief concern, since it is the main obstacle to integrating my dual background in my compositions.

Therefore, the goal of this PhD portfolio was to explore how contemporary classical music's aim for musical development can be reconciled with popular music's need for cyclical motion and relatively static forms. In particular, I wished to explore how to avoid the concerto grosso approach outlined above and instead use an integrated approach, in which groove-based material is shared and built by both popular and classical music instruments. Consequently, in this commentary, I will avoid aesthetic discussions on differences between popular and classical styles. Instead, I will use a more technical approach to the subject matter, utilising my background as a performer and composer in both popular and classical music. Although this will naturally involve an evaluation of the aesthetics involved, I will focus on technique as the underlying mechanism that defines aesthetics.

Therefore this commentary will outline my approaches to the challenge of integrating the techniques of groove and development-oriented composition, without sacrificing their engaging qualities. Consequently, my goals for this portfolio were to create music that can:

- Unfold formally without hindrance by literal repetition, but groove nonetheless
- Allow listeners to enjoy the excitement of anticipating salient occurrences in a steady beat sequence, but simultaneously manage to subvert that sequence
- Change meters with regularity and ease without attenuating the flow and forward momentum of groove gained through syncopation
- Create syncopated rhythms by counter-intuitively applying sustaining instruments
- Use an extended and changeable harmonic language and yet feature the tonal elements required to create a predictable groove.

The partial portfolio presented here includes four compositions, which address different aspects of these overall goals. All four pieces have a distinct focus, as described further below, but all of them explore the use of groove rhythms in a contemporary music context:

- *Different Kind of Scene* for mixed jazz ensemble: This piece was commissioned by and written for Club Inégales in London. The club's resident ensemble, Notes Inégales, is a mixture of a jazz band and a chamber ensemble, allowing me to combine traditional approaches to groove for jazz band (e.g. only giving verbal instructions to the drummer) and more explicitly notated ideas. Notes Inégales practice a form of free improvisation, which allows the conductor only to regulate the overall form of the improvisation with gestures, but not the generated musical materials. This presented a challenge to my desire for writing a notated piece, and therefore this composition features both notated elements and moments of expanded improvisation. Its formal build-up is useful for showing how groove and improvisation can be used to develop form.
- *Electric Quintet* for electric guitar and sting quartet: This piece was written for the classical guitarist Heiko Ossig, who wished to expand his practice to the electric guitar (my own main instrument). Therefore it showcases many different electric guitar techniques and frames them by using the strings to imitate or contextualise them. Groove is created by using the sustaining strings in non-idiomatic ways, so that they can explore untraditional territory and in doing so create an appropriate setting for the guitar techniques. The groove materials in this piece are used to control formal development and variation to a more advanced degree than in *Different Kind of Scene*.
- *Deep Blue Windows* for viola and piano: This piece was written for the leader of violas of the Irish National Symphony Orchestra, Adele Govier, and the orchestra's pianist, Fergal Caulfield. It fuses elements of rock groove with aspects of chamber music in a very lyrical manner.
- *Symphonic Synchopathology* for orchestra. This piece was written specifically for the composition portfolio in order to explicitly address how groove may be used in a large-scale composition. As the name suggests, the piece is a study of syncopation in a symphonic setting. Each movement explores different ways of using groove-based material for largely sustaining instruments and how this can be developed through a

variety of formal designs. As the piece has not yet been performed, only a MIDI realisation of it exists to date.

In the commentary below, I will first outline the technical challenges I encountered in composing with groove and illustrate how I have addressed this locally in the different compositions. Then I will point out briefly how these localised ideas contribute to the overall formal development of each piece.

2. Challenges and solutions to composing with grooves

This chapter presents my approaches towards locally subverting or utilising groove rhythms in technically innovative ways that help avoid literal repetition in favour of motivic development.

2.1. Adapting traditional groove techniques

In the following bullet points, I will elaborate on the most important techniques involved in groove production, as found in many Afro-American musics. I will demonstrate how I have sought to use each technique creatively in my pieces, aiming to maintain groove's forward momentum while avoiding literal repetition.

- **Emphasis on the backbeats** (beats 2 and 4 in a quadruple metric context) commonly found in most Afro-American and related styles. Butterfield (2006) suggests that deliberately anticipating or delaying backbeat attacks creates a sense of forward drive or a laid-back feeling by strengthening or attenuating the backbeat's anacrustic function toward the ensuing downbeat. See the blue arrows in Figures 1 and 2 for examples of where accenting backbeats drives the rhythmical momentum, with anticipations adding additional salience through syncopation.
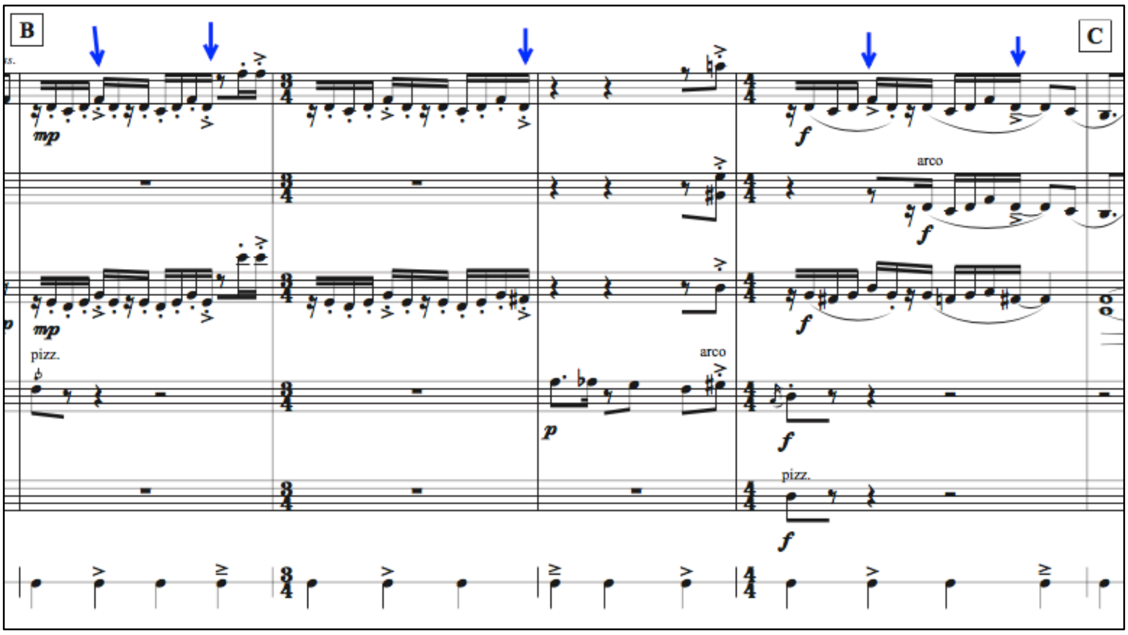
Figure 1: ***Symphonic Synchopathology,*** **Mov. I, bars 8–11, strings**

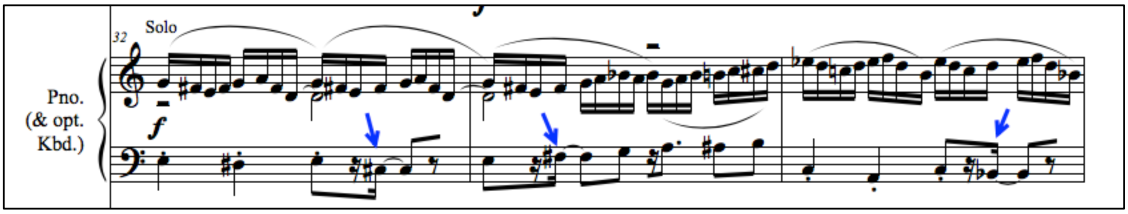

Figure 2: ***Different Kind of Scene*****, bars 32-34, piano part**

Figures 2 and 3 also demonstrate how backbeats can be conceptualised differently in non-symmetrical meters. In Figure 3 (below), a 7/4 meter distorts the backbeat emphasis: In all bars of Figure 3, beats 3, 6, and 7 are treated as 'backbeats', i.e. produce an anacrusis effect that directs attention to the next beat. Beat 3's high piano note directs attention to the ensuing harmony change on beat 4. This process is repeated on beat 6, however this is followed by an even higher and attentionally even more salient note in beat 7 in the viola, which disrupts any perceived triple meter and redirects attention towards the ensuing downbeat in the next bar.

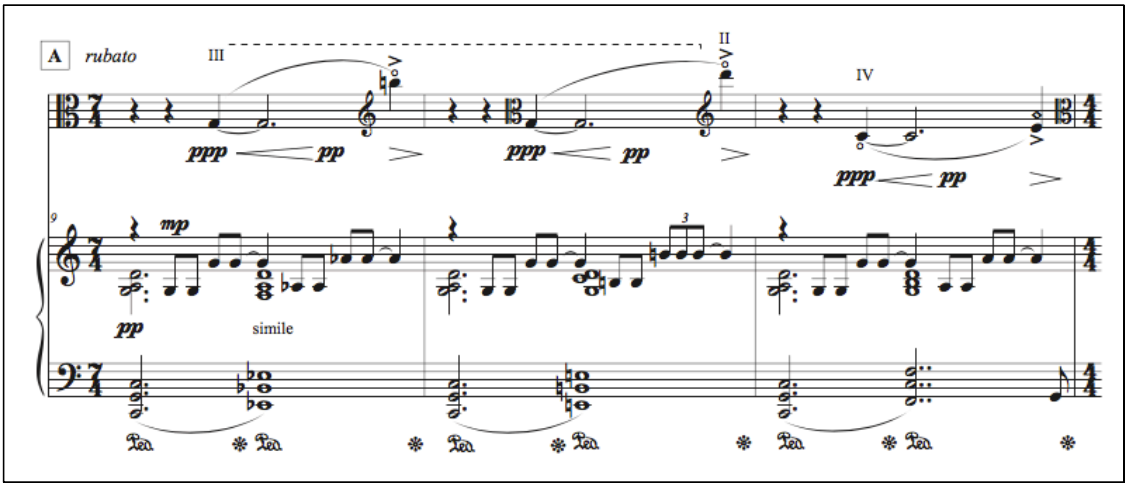

Figure 3: *Deep Blue Windows*, bars 9–11

- **Unequal subdivisions of the beat** (in jazz often called **'swing quavers'**), which feature a long 'downbeat' and a short 'upbeat' portion. The short upbeat, according to Butterfield (2011), functions anacrustically, i.e. in a way analogous to an upbeat, directing listener attention to the next beat and therefore lending a sense of forward propulsion to the groove. As a result, Butterfield argues, the 'upbeat' belongs rhythmically to the ensuing and not the previous 'downbeat'. See Figure 4, where upbeats in quadruplet and triple-groupings are alternatingly tied to the previous or the ensuing note to play with rhythmic momentum.
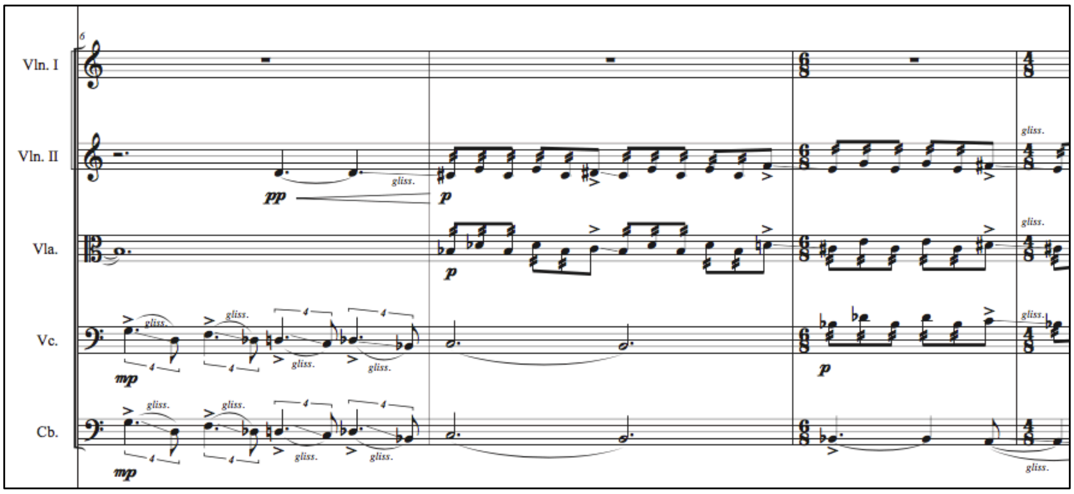
Figure 4: ***Symphonic Synchopathology,*** **Mov. IV, bars 6–8, strings**

It is also interesting to amend traditional grooves in order to explore new rhythmic possibilities—see Figure 5, where a traditional swing rhythm in 12/16 is alternatingly shortened by one semiquaver, then by two semiquavers. This allows for an interesting re-configuration of the rhythmic matrix without losing the sense of forward motion that makes swing so engaging to listeners.
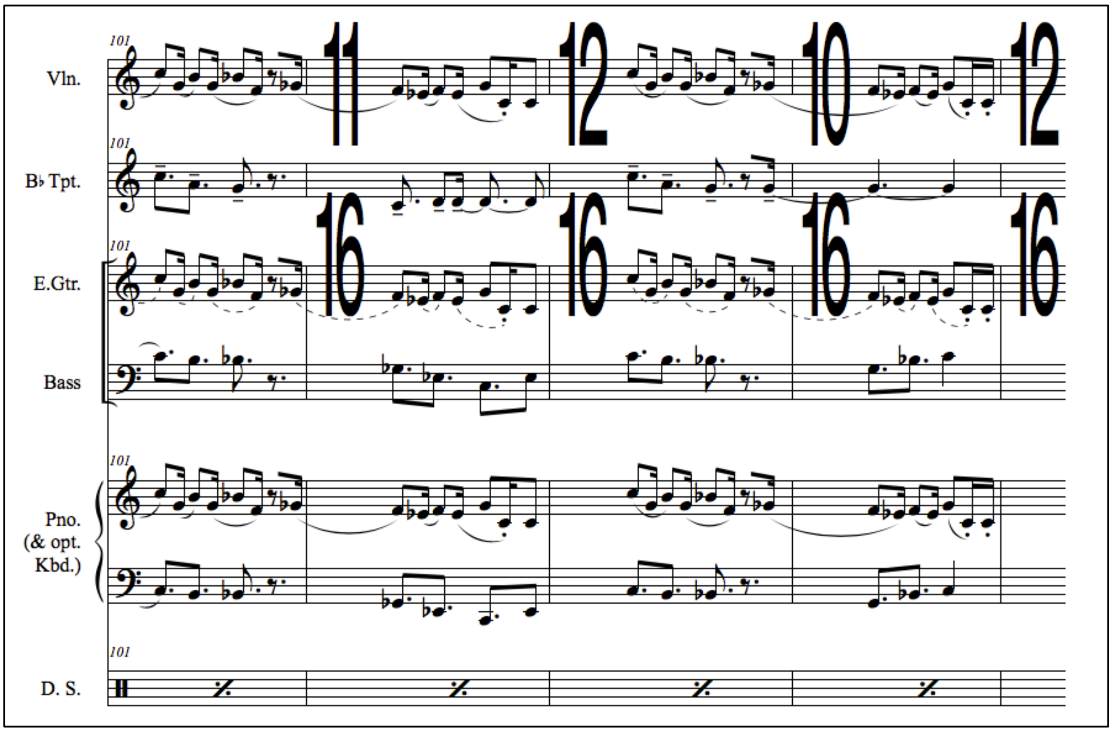
Figure 5: ***Different Kind of Scene*****, bars 101-104**

- **Syncopations immediately before an ensuing beat** which may imply the beat, creating a 'virtual perception' of it even if it is not actually articulated (Butterfield, 2006, para 25). Not articulating a circumscribed beat can be used to powerful effect, as it still drives backbeat anacrusis due to the backbeat's virtual perception. This occurs frequently in my music. A useful example can be seen clearly in Figure 6, where the guitar increasingly syncopates rather than articulates beats, until sharp staccato semiquaver attacks add additional backbeat anacrusis, even though the backbeats are only virtually perceived.

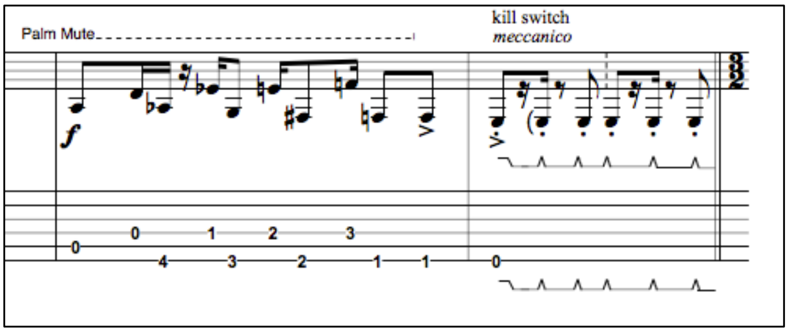

Figure 6: *Electric Quintet*, bars 73-74, guitar

In Figure 7 the flutes only ever articulate attacks on beats 1 and 4 in each bar, creating virtual perceptions of beats 2 and 3.

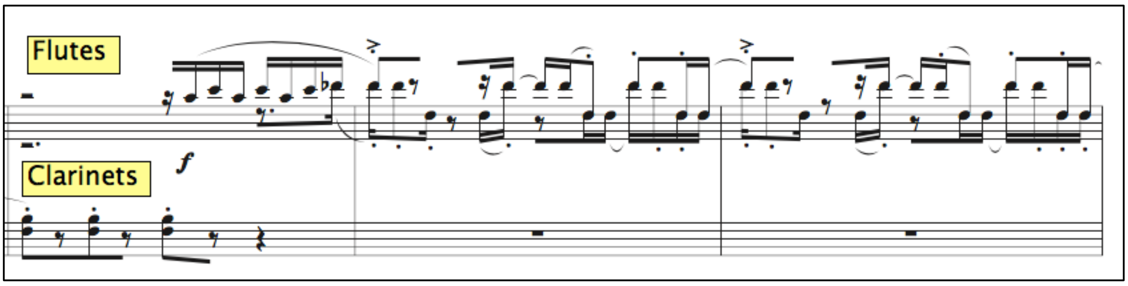

Figure 7: *Symphonic Syncopathology*, Mov. III, bars 38–40, flutes and clarinets

- **Downbeat delay,** which causes a sense of speeding up against a fully articulated beat sequence, as common in jazz (Ashley, 2002; Friberg and Sundström, 2002). In Figure 8 low strings articulate the downbeat every second bar, whereas the melodic figure in the first violins (top staff) is always played a semiquaver late. The sense of speeding up is additionally exacerbated by contracting the 4/4 meter to 3/4 and 3/16, which makes the ensuing downbeat appear early.
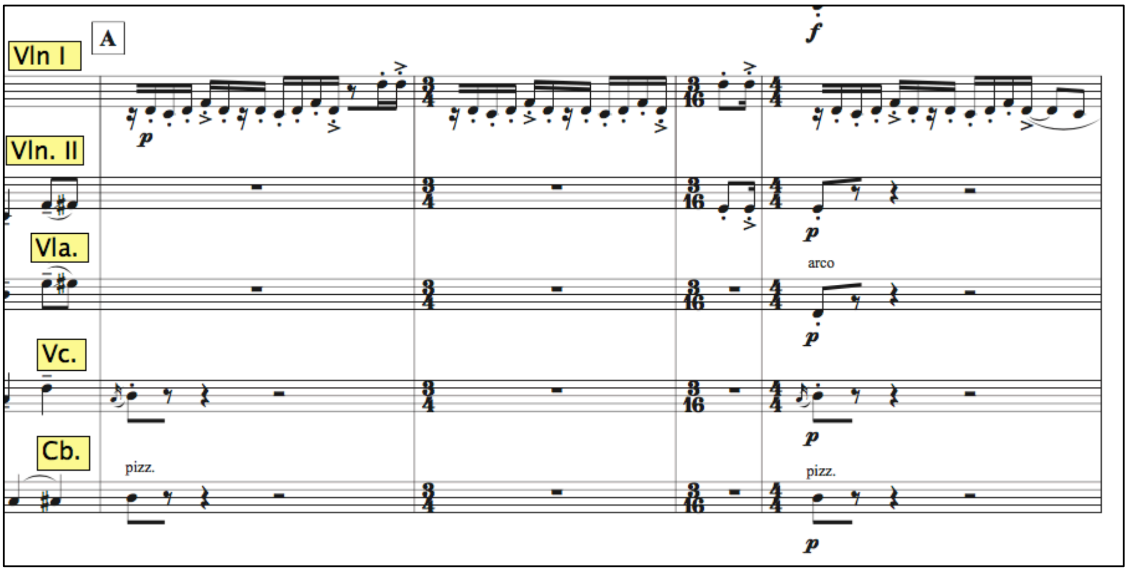
Figure 8: *Symphonic Syncopathology*, Mov. I, strings

2.2. Changing the significance of groove notes

All the presented techniques involved in groove production require a degree of repetition in order to be effective, since forward momentum is easily lost if the cyclical nature of the groove is broken too hastily. This is particularly problematic if the composer wishes to unfold the music by developing musical material in a linear fashion, as is common in classical music, rather than by layering musical lines over repeated occurrences, as is common in popular music, and yet still wishes to maintain the engaging forward momentum generated by the groove.

One interesting approach to avoid this is changing the role of a groove's individual notes, so that they still continue to occur but now initiate some form of change. Since groove is strongly dependent on regular meters, changing the bar length can change the 'flavour' of individual notes that make up the groove. See Figure 9, where bar 14 repeats the groove rhythm found in bar 12, but contracts the metre to 7/8, thereby changing the role of the final note. This shortens the final note to a quaver, making it a full anacrusis to bar 15 while also subverting the ongoing crotchet beat. The rhythmic momentum is maintained because every note of the groove is articulated, but the significance of the note has slightly changed.
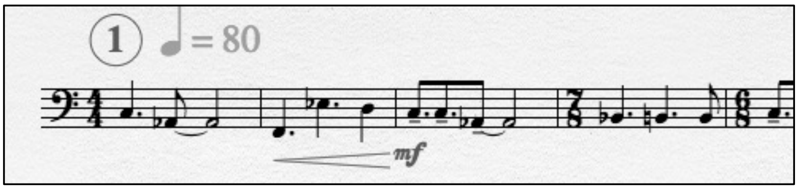
Figure 9: *Different Kind of Scene*, bars 11-15, bass guitar part

2.3. Manipulating unarticulated space

Another way to play with groove notes is to shorten or extend unarticulated space (time during which no new note onsets occur, though notes might be sustained). Figure 10 shows how unarticulated space is systematically contracted on every reoccurrence of the rhythmic figure to heighten tension.
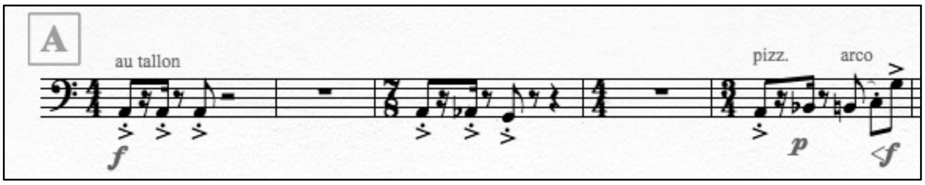
Figure 10: *Electric Quintet*, bars 1-7, cello part

In Figure 11, the second half of bar 13 features unarticulated space. Bar 15 mirrors this rhythm, but removes an entire crotchet of unarticulated space and fills the reminder with articulated subdivision to clarify the contraction.
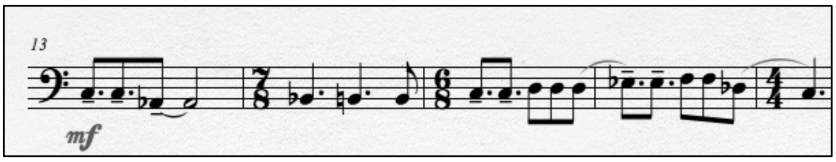
Figure 11: *Different Kind of Scene*, bars 13-17, bass guitar part

Figure 12 demonstrates how this same unarticulated space can also be extended rather than contracted for ease of tension, providing a degree of metric ambiguity as to when the rhythm will be reinitiated.

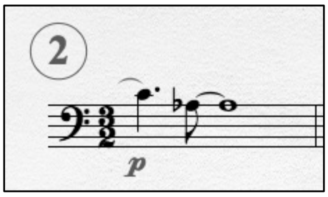

Figure 12: *Different Kind of Scene*, bar 23, bass guitar part

2.4. Articulating metric subdivisions

As shown in Figure 11 previously unarticulated space was not just contracted but also filled with new event onsets. This impacts the sense of groove, since London points out that articulating sub-tactus divisions improves listener awareness of how the new meter spaces beats, as is common in music cultures featuring non-isochronous meters (i.e. meters with uneven beat lengths) (2012, 104). In Figure 13, semiquavers are nearly always articulated to facilitate groove perception of alternating 15/16 and 7/8-meters.
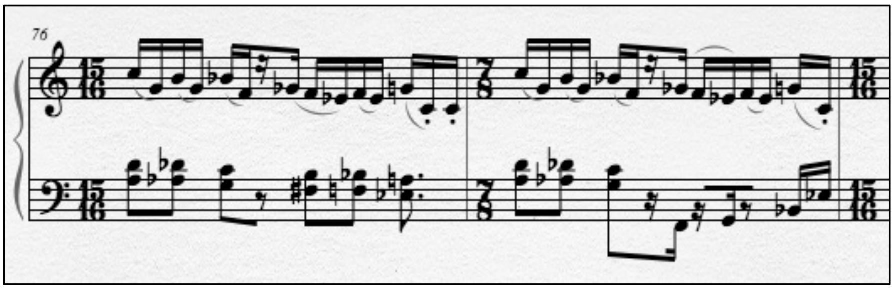
Figure 13: *Different Kind of Scene*, bars 76-77, piano part

A similar strategy of articulating subdivisions occurs in Figure 14, where bar length is continuously contracted by a semiquaver.
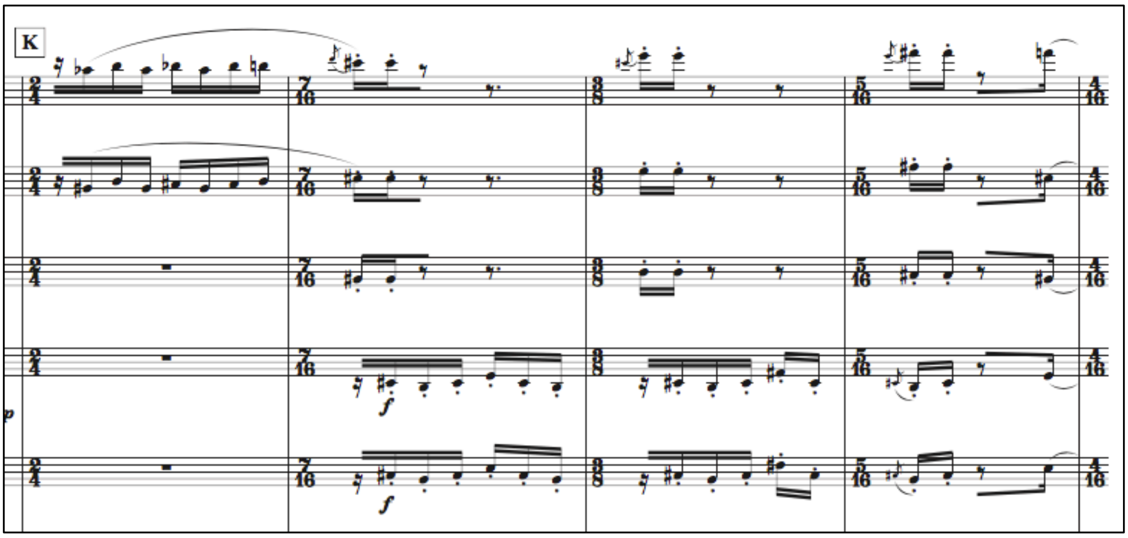
Figure 14: *Symphonic Synchopathology*, Mov. III, bars 95–98, winds

In Figure 15, the rhythm is sped up on the final contracted note of a bar in the treble parts to illuminate a change between alternating 9/16 and 4/8 bars; the rhythm in the bass parts simply contracts unarticulated space.
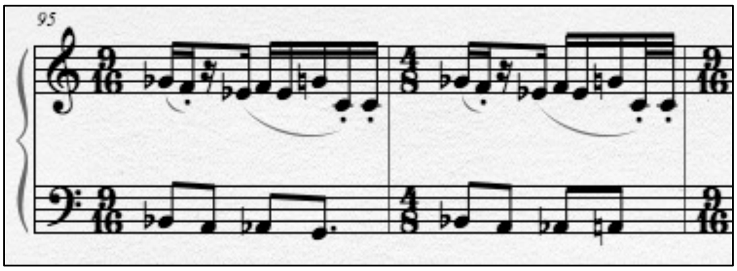
Figure 15: *Different Kind of Scene*, bars 95-96, piano part

2.5. Chromatic voice leading around tonal centres

A groove is not merely a rhythmically configuration—it also heavily depends on cyclical harmonies that allow for listeners to anticipate key pitches on or around salient rhythmic positions in the bar or cycle. Consequently, groove-based music often requires the harmony to return to a stable root chord on certain salient rhythmic positions.[5] While this can be restrictive, the regularity of such tonal centres allows for exploring the music in between chromatically.

Consider Figure 16, where the already established groove in the guitar part demands a root chord at the beginning of every second bar (or rather roughly every eight crotchet beats). The music is returning from the temporary root chord E flat major 7 at the beginning of bar 58 to the root chord of D minor in bar 60. This allows for two bars of chromatic voice leading and shifting interval relationships between those two positions, with parallel chord shifts leading back to the required chord in time.[6]

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[5] This practice of approaching tonal centres has led me to conceptualise harmony in what I think of as the 'rubber band' approach: imagine the tonic root exerting a gravitational pull towards any note within a tritone above or below. This pull is like a stretched rubber band that encourages returning to the root via chromatic movement. In this context, the minor 2nd acts as a leading note with the same downward force that the major 7th exerts upwards. The other notes of the triad (and, often, the dominant seventh) exert similar pull on notes around them, though with less force—here, the appropriate analogy is perhaps a thinner rubber band.

[6] Voices follow the 'rubber band' principle here, with all instruments but the cello approaching target tonic chord notes by a semitone step.

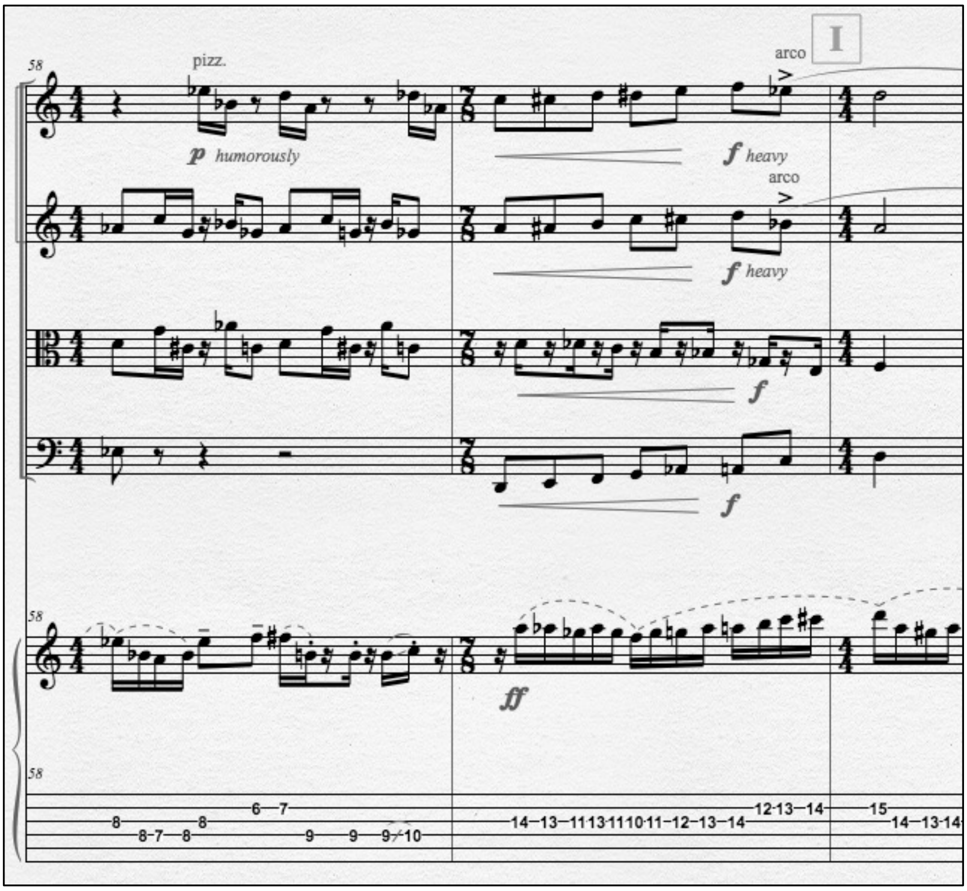



Figure 16: *Electric Quintet*, bars 58-60

2.6. Obscuring recurring harmonies

In order to create more interesting harmonic effects than always retuning to stable harmony chords, one can also obscure or subvert these tonal resting points. For example, the jazz practice of chord extensions can be combined with the idea of polytonality, which allows the composer to add interesting ambiguities. Figure 17 shows a passage featuring melodic material that was previously stated with a C minor accompaniment.

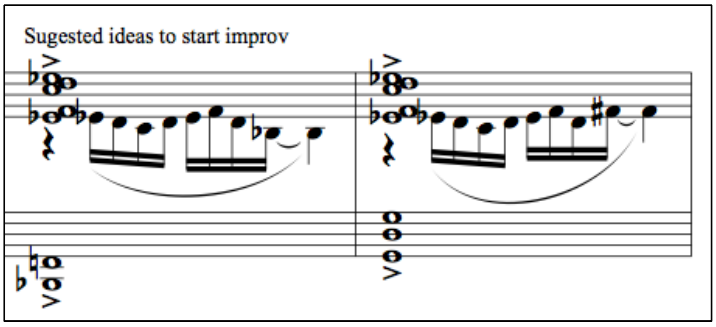


Figure 17: *Different Kind of Scene*, bars 110-111, all melody instruments

In order to add more colourful harmonies, it is now accompanied in the treble lines by a cluster chord around a C minor dyad (root and a doubled third, no fifth) with an added fourth and an added ninth, which provide a degree of ambiguity. Although the earlier C minor context strongly suggests that this chord is C minor with chord extensions, the foreign notes obscure this conclusion. In addition, the bass lines shift between empty fifths on B flat and G, while the treble chord remains constant. This way, the melodic material that was once in C minor now becomes ambiguous, floating between polychords that form a B flat major chord with added fourths and ninths (B-flat add9 add11), but which could also hold hints of extended C minor 7 or F7 chords over Bb.[7]

The jazz practice of soloing 'inside/outside' can be applied similarly to melody. In a jazz solo, 'inside/outside' involves the soloist consciously moving away from the prevalent scale to build up tension before providing release by returning to it at an appropriate moment. When applied as a polytonal concept, this idea can be used for obscuring tonal harmony. In Figure 18, the trumpet 'steps outside' the established G mixolydian harmony and instead plays E-flat minor, before returning to the original key on the last two notes of each phrase. In combination with the syncopated 5/8 groove, the falling chromatic bass line ending on the dissonant F-sharp, and the upward glissandi ending on the notes F and A-flat in the other instruments, the previously established and safe G mixolydian scale is subverted.

[7] Technically, it could also be a tonally ambiguous G chord with a suspended fourth, added sixths, and a dominant seventh (G7 sus4 add13), which still holds hints of C minor, or even (more tenuously) E-flat major 13 with added notes.

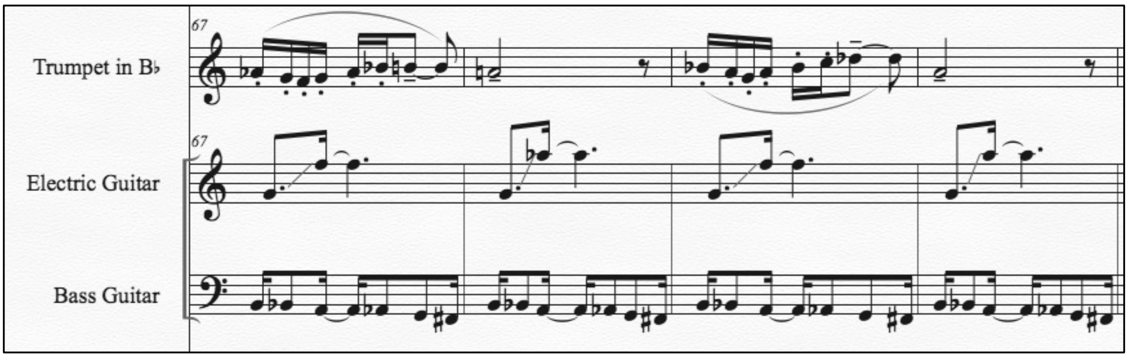



Figure 18: *Different Kind of Scene*, bars 67-70, Bb trumpet (transposing) with electric guitar and bass

This concludes the section on how the cyclical nature of groove can be developed and subverted locally. In the next section, I will explore how groove-based materials can be combined with formal development in the vein of classical music.

3. Integrating groove with formal development

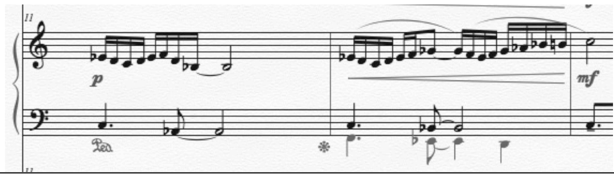
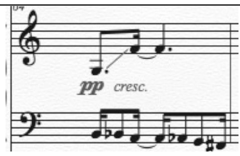
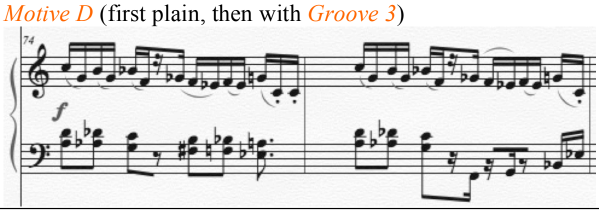
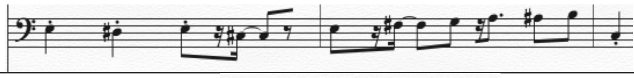
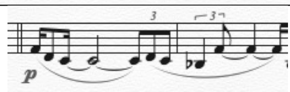
The main formal challenges in combining elements from popular and classical music composition have to do with the conflicting nature of some of the most iconic aspects of both traditions: motivic development versus groove-based repetition, predetermined formal design versus improvisational spontaneity. Since the cyclical nature of groove-based music presents a challenge to the development of melodic material, it by extension also impacts form. In this section I will briefly discuss the form of each submitted piece and point out how it fuses groove-based material with long-form development.

3.1. *Different Kind of Scene*

Improvisational passages, both for soloing musicians or for group improvisation, are conceptually and formally challenging: They remove control from the composer, who only sets up context but must leave space for the performer's own musical ideas. When composing *Different Kind of Scene*, I felt that the precondition to engage with the ensemble Notes Inégales' free group improvisation practice[8] was difficult to reconcile with my aims of composing a notated piece. Here, the formal challenge was to carve out moments suitable for free improvisation and integrate them in a meaningful way within a larger compositional structure. Table 1 provides an overview of *Different Kind of Scene*'s structure.

[8] Reminder: The musicians improvise and the conductor can only indicate with gestures how the material is shaped, but not what materials are being played.

Table 1: Structure of *Different Kind of Scene*

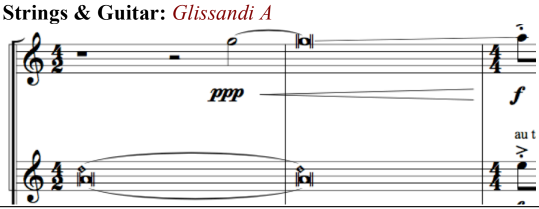
BARS (& REHEARSAL MARKS)	SECTION TYPE	MATERIALS USED
1-10	Introduction	*Motive A* 
11-22 (RM 1)	Exposition	*Motive A*
23-31 (RM 2)	Development	*Motive A*
32-40 (RM 3)	Development (continued)	*Motive A* with *Groove 1* 
40-45 (RM 4)	Transition	introducing *Motive B* 
46 (IMPROV)	**– Improvisation –**	on *Motive A*
47-54 (RM 5)	Exposition	*Motive B*
55-60 (RM 6)	Development	*Motive B*
61-63	Recapitulation	*Motive B*
64-71 (RM 7)	**– Transition –**	introducing *Motive C* and *Groove 2* 
72-77 (RM 8)	Exposition	*Motive D* (first plain, then with *Groove 3*) 
78-89 (RM 9)	Development	*Motive D* and *Groove 3*
89 (IMPROV)	**– Improvisation –**	on *Motive D*
90-91	Recapitulation	*Motive D*
Repeated: 92-108 (SOLOS)	**– Solos –**	Comp on *Motive D* and *Groove 3*
109 (RM 11)	Transition	*Motive D*
110-114 (IMPROV)	**– Improvisation –**	over *Motives A, D*
115-123	Recapitulation	*Motives A, B, D*
124-End	**Finally: Coda**	*Motives A, B, C, D* stacked over *Groove 2*; *D* becomes the dominant motive and leads to the end.

As can be seen in Table 1, in this piece I developed grooves and related motivic material roughly along the lines of a miniature sonata form—applying the term ‘sonata form’ in the loosest sense to merely reflect the order in which material is treated: Exposition, Development, Recapitulation, Coda (with occasional introductions or transitions). In the process, the potential of improvisation to disrupt composed music and frustrate a sense of formal closure became an advantage: The sonata form is never fully realised for any of the four motives, since the closure of reaching a Coda section is always frustrated by improvisations, solos, or transitions. These interrupt the formal scheme and restart it by acting as a kind of ‘reset button’, almost always transitioning away to a new Exposition section with new material. Different grooves here play an important function in signalling the beginning of new Exposition. Only at the very end of the piece does the final improvisation give way to a recap of all four motives before providing them with closure in a shared Coda.

In the preliminary note, the musicians are instructed to use earlier musical material for their improvisations. Therefore, the resulting improvisations act as both meaningful forms of self-expression for performers and also function within the form as transitions to new material. My intention was to use improvisation’s disruptive potential and harness it as an advantage by making it a deliberate and integrated part of the form. While this approach was successful, in performance it also became clear that this is not a subtle effect: On the submitted recording, it can be clearly heard when the band plays notated music and when they improvise, as the Notes Inégales’ group improvisation practice (where the musicians create musical material themselves and the conductor can only coordinate them through gestures) offer very little avenues of control for a composer. Perhaps more specific improvisation instructions might have led to a more blended effect.

3.2. *Electric Quintet*

In this piece, the form was developed as a means for solving problems arising from cross-cultural instrumentation. When developing *Electric Quintet*, which is primarily a piece that compares and contrasts techniques and sounds of a string quartet with that of an electric guitar, the challenge was to develop a form that could adequately facilitate juxtaposing instrumental techniques and timbres. Therefore, I used groove-based musical material in a way that would drive the music forward but would also keep the material recognisable when filtered through a variety of techniques. Table 2 shows an overview of the piece's structure.

Table 2: Structure of *Electric Quintet*

TEMPO	BARS	SECTION TYPE	JUXTAPOSITION OF INSTRUMENTAL TECHNIQUES
FAST	1-2	**Introduction**	**Strings & Guitar:** *Glissandi A* 
	3-10 (A)	**Exposition**	**Strings:** carry Motive A against Stabs A **Guitar:** kill switch effect on Stabs A 
	11-29 (B)	**Variation 1: Development**	**Strings:** carry Motive A,  then Stabs B **Guitar:** rock chords and legato techniques; *(then swap positions)*
	30-48 (C–F)	**Var. 2: Loose string fugue**	**Strings:** play loose fugue on Motive A **Guitar:** independent accompaniment (non-fugal) with rock syncopations and glissandi
	49-52 (G)	**Var. 3: Loose string canon**	**Strings:** play loose four-bar canon on Motive A **Guitar:** *tacet*
	53-62 (H&I)	**Var. 4: Guitar solo**	**Strings:** Varying accompaniment  (incl. pizzicato Motive B) **Guitar:** Solo on Motive A
	63-74 (J&K)	**Var. 5: Melody vs. stabs**	**Strings:** develop Motive A and Motive B **Guitar:** variations on Stabs B and Motive B

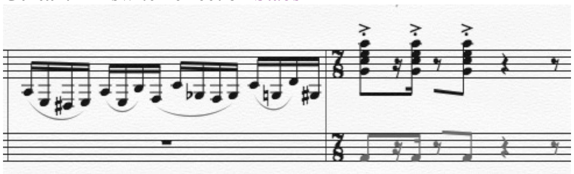
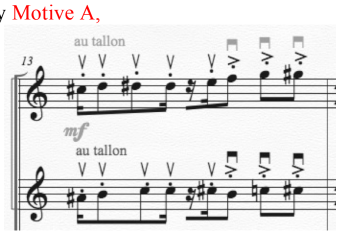
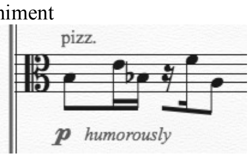
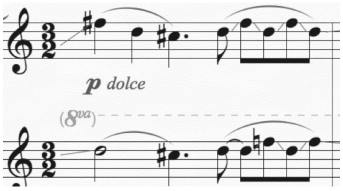
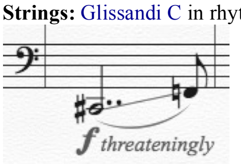



Table 2 (continued)

TEMPO	BARS	SECTION TYPE	JUXTAPOSITION OF INSTRUMENTAL TECHNIQUES
SLOW	75-83 (L)	**Var. 6: Glissandi chords**	**Strings:** Glissandi chords based on Motive A **Guitar:** bendings on Motive A
	84-91 (M)	**Var. 7: *Dolce* melody**	**Strings:** Motive A variation as *dolce* melody; chromatic voice-crossing *Glissandi B* in violins  **Guitar:** plays falling chromatic line in bendings
	92-98 (N)	**Var. 8: Rising glissandi**	**Strings:** Glissandi C in rhythm of Stabs A  **Guitar:** *tacet*
	99-103 (O)	**Var. 9: Harmonics**	**Strings:** Motive A in harmonics, in the rhythm of Stabs A **Guitar:** *tacet*
FAST	104-105	**Recapitulation of *Introduction***	**Strings & Guitar:** *Glissandi A*
	106-115 (P)	**Recap of *Exposition***	**Strings:** kill switch effect on Stabs A **Guitar:** carry Motive A *(swapped earlier roles)*
	115-122 (Q)	**Recap of *Var. 1: Development***	**Strings & Guitar:** Take turns as soloists on Motive A over Stabs A
	123-136 (R&S)	**Finale 1**	Recap of material from *Var. 4* & *7* **Strings:** *Glissandi C,* then Motive A rises out of Stabs A **Guitar:** Stabs A
	137-141 (T)	**Finale 2**	Recap of material from *Vars. 2, 6, 7* **Strings:** rising *Glissandi C*, then violins play Motive A stylised with *Glissandi B* **Guitar:** joins vla & cellos to provide rhythms to violins
	142-End	**Ending**	**Strings:** *tacet* **Guitar:** finishes piece by playing repeated Stabs A with the kill switch technique

As shown in Table 2, *Electric Quintet* is based on a variation form. This allowed me to apply string and guitar techniques in a variety of contexts, while ensuring that musical content would remain identifiable—even when used non-idiomatically. Some non-idiomatic writing took the string performers a little time to get used to during the recording process, but it was necessary in order to mirror electric guitar techniques effectively in the string quartet writing. Using shared material between all the instruments also allowed shifting the focus away from differing techniques toward musical development by concentrating on diverse treatment of material, timbres, section forms, and tempi.

3.3. Deep Blue Windows

This piece focussed on subverting and developing the traditional rock groove  by slowing it down and articulating it as lyrically as possible. The piece presents the groove in percussive sounds at the beginning, then converts it to melodic material of alternating low and high notes, often articulated as harmonics by the viola. Meter changes cause the emphasis of the rock beat to shift between backbeats and beats 1 & 3. Since emphasis on the latter is common in pre-20th century classical music, this allowed me to play both with traditional chamber music phrasing and groove-based phrasing ideas. Table 3 shows the structure of the piece.

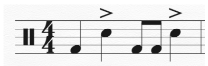
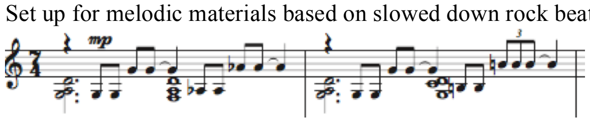
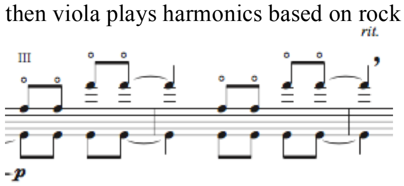
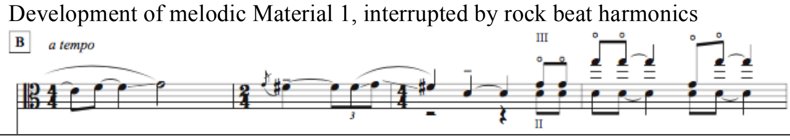
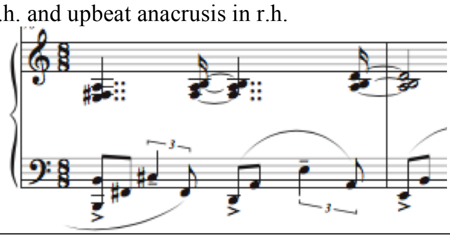
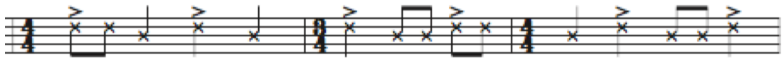
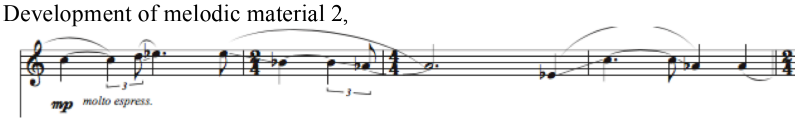



Table 3: Structure of *Deep Blue Windows*

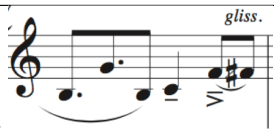
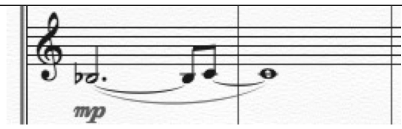
OVERALL SECTION	BARS	MUSICAL DEVELOPMENTS
A	1-8 (Opening)	Piano sets up harmony, viola sets up slowed down rock beat groove with col legno attacks, shifting between classical emphasis on beats 1&3 and popular music emphasis on beats 2&4 
	9-18 (A)	Set up for melodic materials based on slowed down rock beat,  then viola plays harmonics based on rock beat 
	19-34 (B)	Development of melodic Material 1, interrupted by rock beat harmonics 
	35-47 (C)	Development of melodic material 2,  then again interrupted by rock beat materials
	48-65 (D)	Development of section B, interrupted by rock beat materials
	66-69 (E)	Development of section C, leads to full rock beat emphasis on next section
B	70-75 (F)	Rock-style viola solo over traditional rock chord progression I-III-IV-VI-VII/bII, piano materials have fully realised rock beat's groove with backbeat emphasis in l.h. and upbeat anacrusis in r.h. 
	76-83 (G)	Development of rock beat harmonics, structural breakdown
A'	84-92 (H)	Restatement of Opening and section A
	93-end (I)	Rock beat harmonics peter out to the end

As shown in Table 3, the rock beat material is brought back in various forms between other melodic material, and so the structure can be seen as a loose rondo form nested within a larger A–B–A structure. Eventually the rock beat is fully realised in a rock-style solo for the viola, which forms the piece's B section, before the formal structure fragments and the composition returns to its opening material for a shortened A section.

3.4. *Symphonic Synchopathology*

This piece was written as an in-depth exploration of syncopated groove materials in an orchestral context. The largely sustaining instrumentation of an orchestra makes creating the sharply attacked syncopations required for groove more difficult. In order to counteract this, I provided a 'Beat Guide' staff below the orchestral score, so that conductors and performers can gain an instant understanding of the desired rhythmic impetus. Formally, I approached each movement differently:

- **Movement I** rocks back and forth between two distinct types of groove-based material, before finally ending with very different, non-groove based material (see Table 4). This ending was necessary in order to introduce a different musical flavour after having articulated the other two types of material several times. Groove is primarily articulated by sharp string attacks, with slight metric changes manipulating its regularity.

Table 4: Structure of *Symphonic Synchopathology*, Mov. I

REHEARSAL MARKS	MUSICAL DEVELOPMENTS
Opening	Foreshadows Material 2
A	States Material 1  , then hints at Material 2
B	Develops section A (Material 1)
C	Begins to state Material 2 
D	Restates Material 1
E	Develops section D (Material 1)
F	Transition, then fully states Material 2
G	Develops Material 2
H	Material 2 becomes Material 3 
I	Material 3 is developed in polymeters

- **Movement II** utilises a rondo form. Similar to the improvisation in *Different Kind of Scene*, the opening groove-based motive regularly interrupts development sections. This means that the opening material is heard several times, and so, like in Movement I, Movement II eventually takes a turn towards completely new material in the final section to provide a new idea. The groove in the recurring motivic material is primarily expressed by a 3-3-2 rhythm articulated by staccato woodwinds, which produces a sharp sense of backbeat anticipation.

Table 5: Structure of *Symphonic Synchopathology*, Mov. II

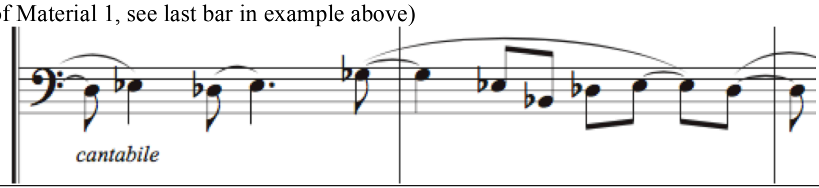
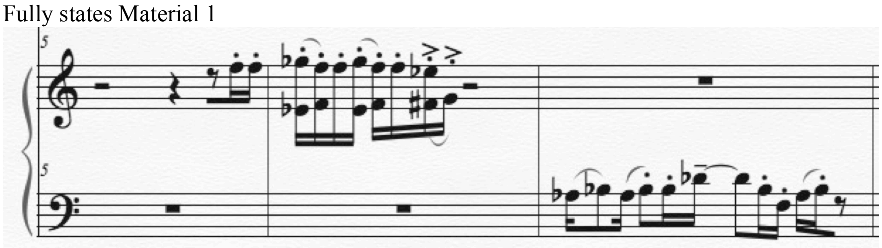
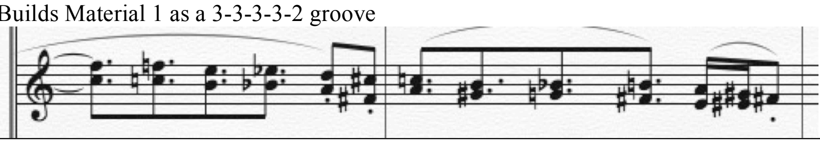
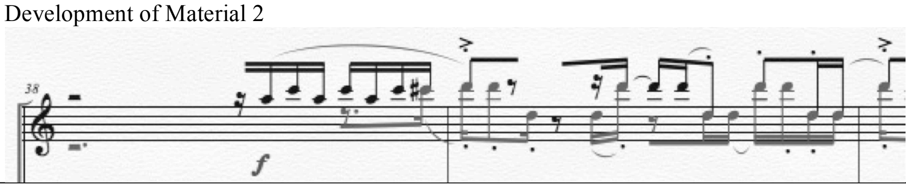
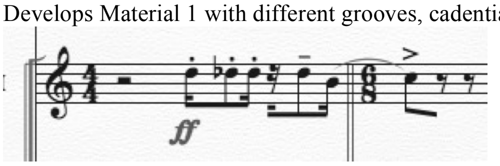
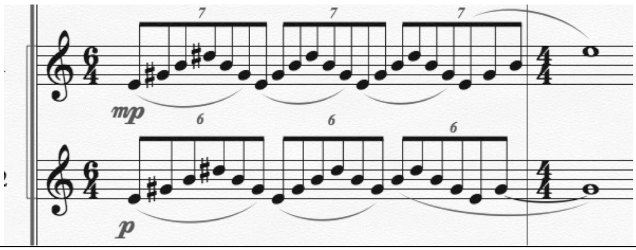
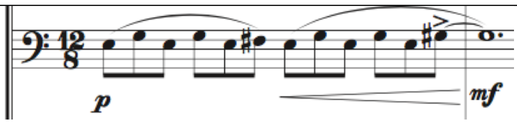
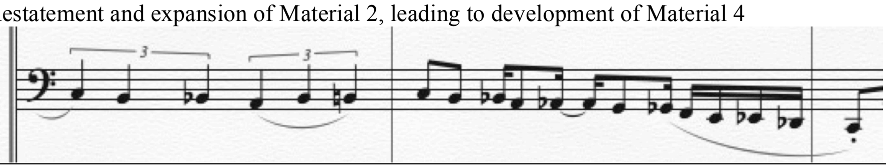
REHEARSAL MARKS	MUSICAL DEVELOPMENTS
Opening	Builds Material 1
A	Fully states Material 1 
B	Development 1 based on Material 1
C	Transition
D	Restatement of Material 1
E	Development 2
F	Restatement of Material 1
G	Development 3
H	Further development of section G in polymeters
I	Restatement of Material 1 and Development 4
J	Further development of section I
K	Cadence and restatement of Material 1
L	Further development of section J
M	Material 2 grows out of the last development as a cello melody (based on the second half of Material 1, see last bar in example above) 

- **Movement III** develops its material continuously, with sections progressively building upon each other. Building on Movement II's 3-3-2 rhythms, the groove here is dominated by 3-3-3-3-2 rhythms that provide an even more heightened sense of syncopation. Groove is developed by placing sustaining low string sounds against pizzicato strings and percussion textures.

Table 6: Structure of *Symphonic Synchopathology*, Mov. III

REHEARSAL MARKS	MUSICAL DEVELOPMENTS
Opening	Builds Material 1 as a 3-3-3-3-2 groove 
A	Develops Material 1
B	Further development
C	New material 2 is generated from section B
D	Material 2 is fully realised
E	Development of Material 2 
F	Transition and re-building groove
G	Development of Material 1
H	Leads back to Material 2
I	Music from section D is restated (Material 2)
J	Further development of that music (Material 2)
K	Material 2 is rhythmically contracted to final cadence

- After the strong syncopations of Movement III, **Movement IV** opens with material that is quite distinct from the other movements in mood (solemn rather than upbeat) and rhythm (triple meter rather than quadruple meter). This material is put through several metrical and tempo changes to shift the underlying groove. The movement also takes material that is used as a form of temporary cadence in the other movements and expands upon it. Eventually this cadential material is converted to backing music for a solo section, in which a regular groove is articulated by bongo and conga rhythms. The section features several fully notated solos (with space for optional improvised solos) that eventually build to a fortissimo finale.

Table 4: Structure of *Symphonic Synchopathology*, Mov. IV

REHEARSAL MARKS	MUSICAL DEVELOPMENTS
Opening	Builds Material 1 in 12/8 
A	Builds groove derived from Material 1
B	Develops Material 1 with different grooves, cadential Material 2 briefly stated 
C	Further development, clarinets hint at Material 3 (bar 27)
D	Material 2 used as cadence, Material 1 developed
E	Further development of Material 1 with new groove
F	Expands on section E
G	Cadential material 2 restated
H	Transition, builds on Material 2
I	Picks up brief idea stated in clarinets in section C (bar 27), expands it as polyrhythmic Material 3 
J	Restatement and expansion of Material 2, leading to development of Material 4 
K	Solo section, over Material 4
L	Ideas generated by notated solos are developed and expanded
M	Further development, then builds cadential Material 2 to a tutti finale

4. Conclusion

In summary, this portfolio represents four pieces that satisfy my artistic goals set out in section 1.3. As shown in the last section, they offer formal development without hindrance by literal repetition, but groove nonetheless. As shown in Chapter 2, they feature various strategies to allow listeners to enjoy the excitement of anticipating salient occurrences in a steady beat sequence, but simultaneously manage to subvert that beat sequence. They accomplish this by changing meters regularly while maintaining flow and forward momentum gained through syncopation. And, as was shown in the last chapter, they create syncopated rhythms by counter-intuitively applying sustaining instruments, as is especially notable in how the string quartet is utilised in *Electric Quintet*. All of the pieces feature an extended and changeable harmonic language that yet provides the tonal elements required to create predictable groove harmonies. While each one of them is quite different from the others in terms of design and formal layout, together they present several approaches towards fusing groove-based material with classical music techniques for notation-reading musicians.

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Different Kind of Scene

for mixed jazz ensemble

by Chris Corcoran

Instrumentation

Violin
Trumpet in B♭
Electric Guitar
Bass Guitar
Piano (with optional electric keyboard doubling the bass part)
Drum Set

Duration

c. 10 minutes + time for improvisations and solos

Performance Notes

Different Kind of Scene was written in 2015 as part of my creative residency with Club Inégales and was premiered by the club's house band Notes Inégales.

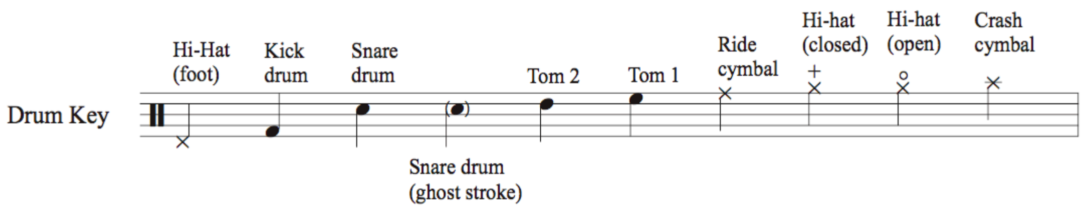
Notes Inégales frequently practice their own kind of free group improvisation, during which they depart from the written score and instead improvise under the leadership of a conductor, who shapes the direction and instrumentation of the improvisation with gestures. As a result, this score features several bars marked with the sign IMPROV, which are moments for spontaneous group improvisation. Improvisations should take the melodic material presented before and after each IMPROV section as a basis, in order to tie these sections more stronglyinto the piece as a whole. To this end, I have provided materials with which to start the improvisations.

In addition, the section from rehearsal mark 10 until 11 features a traditional jazz solo section for soloists to improvise over a repeating background. Ensembles may choose amongst themselves which performers or instruments will solo, in which order they will do this, and how many repeats each soloist gets. The suggested background materials here can be performed for some solos, all solos, or be omitted altogether, but the bass guitar part is fixed in order to ensure a stable harmonic background at all times.

As is common in several jazz styles, the drummer has been provided with a basic groove and a rough description of what style of beat is needed, rather than a through-composed part. Deviation from and development of the notated grooves is expected and desired.

The electric guitar part shows dotted slurs for phrase markings and regular slurs for pull-offs or glissandi.

Chris Corcoran, January 2016
(updated November 2020)

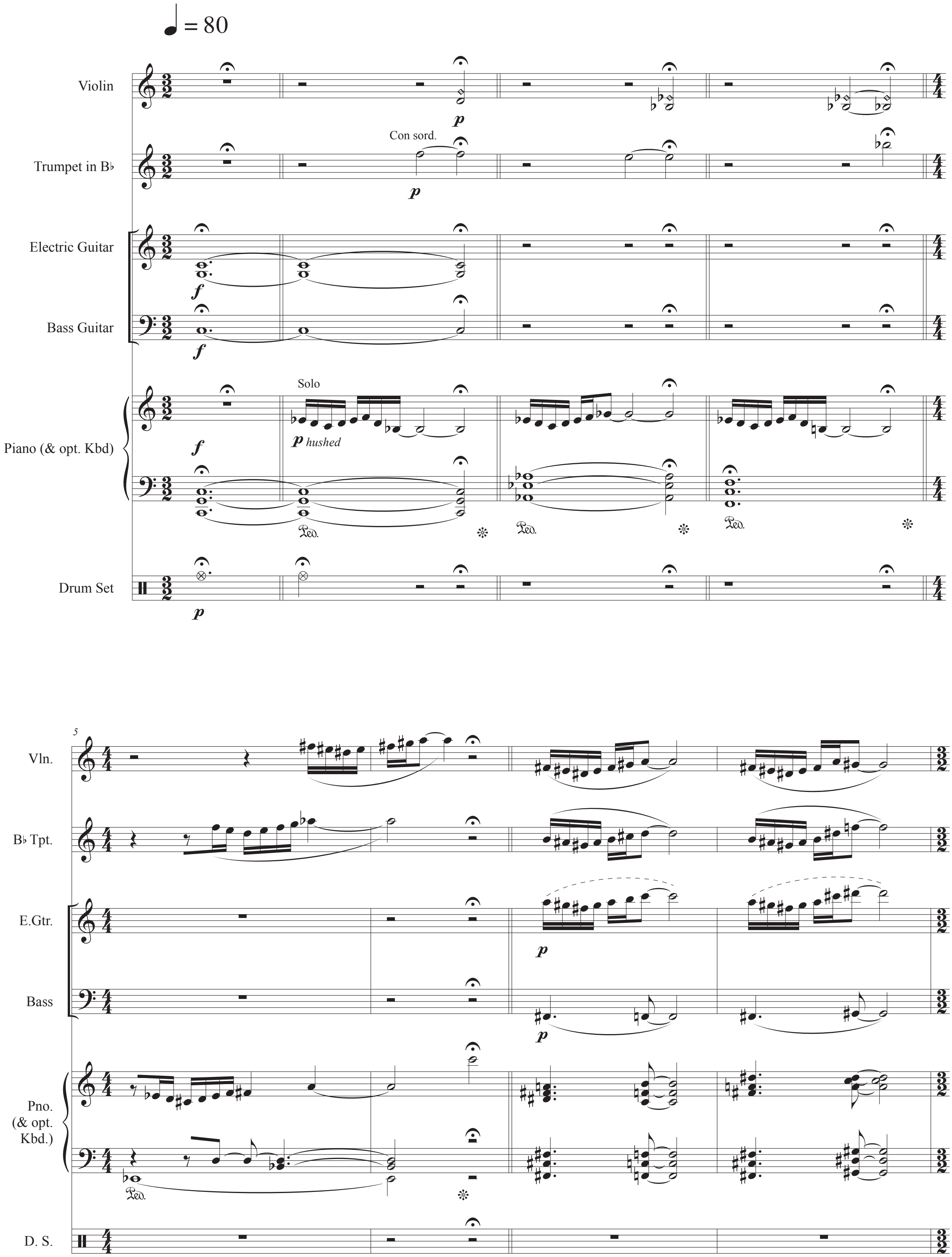
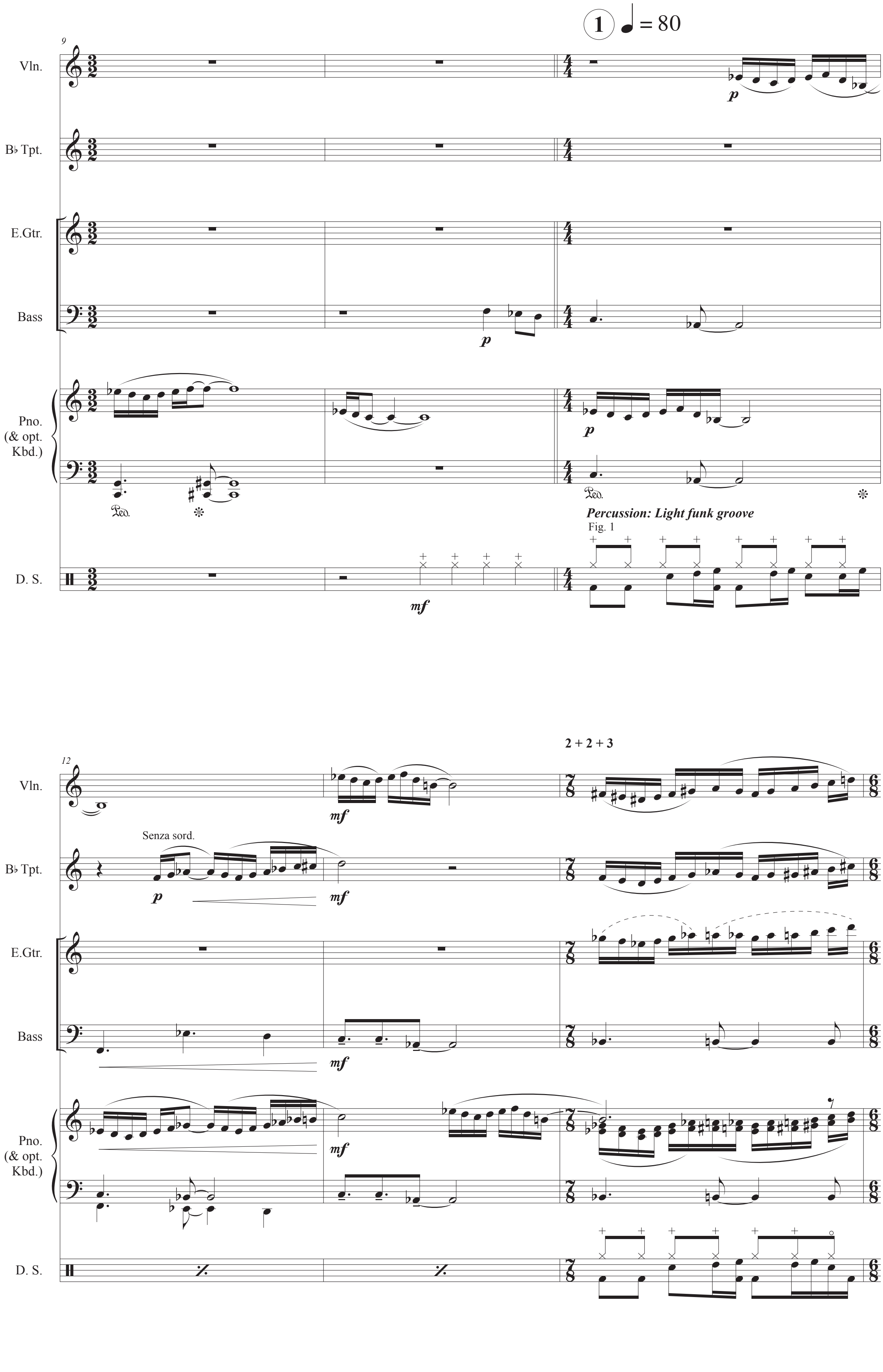


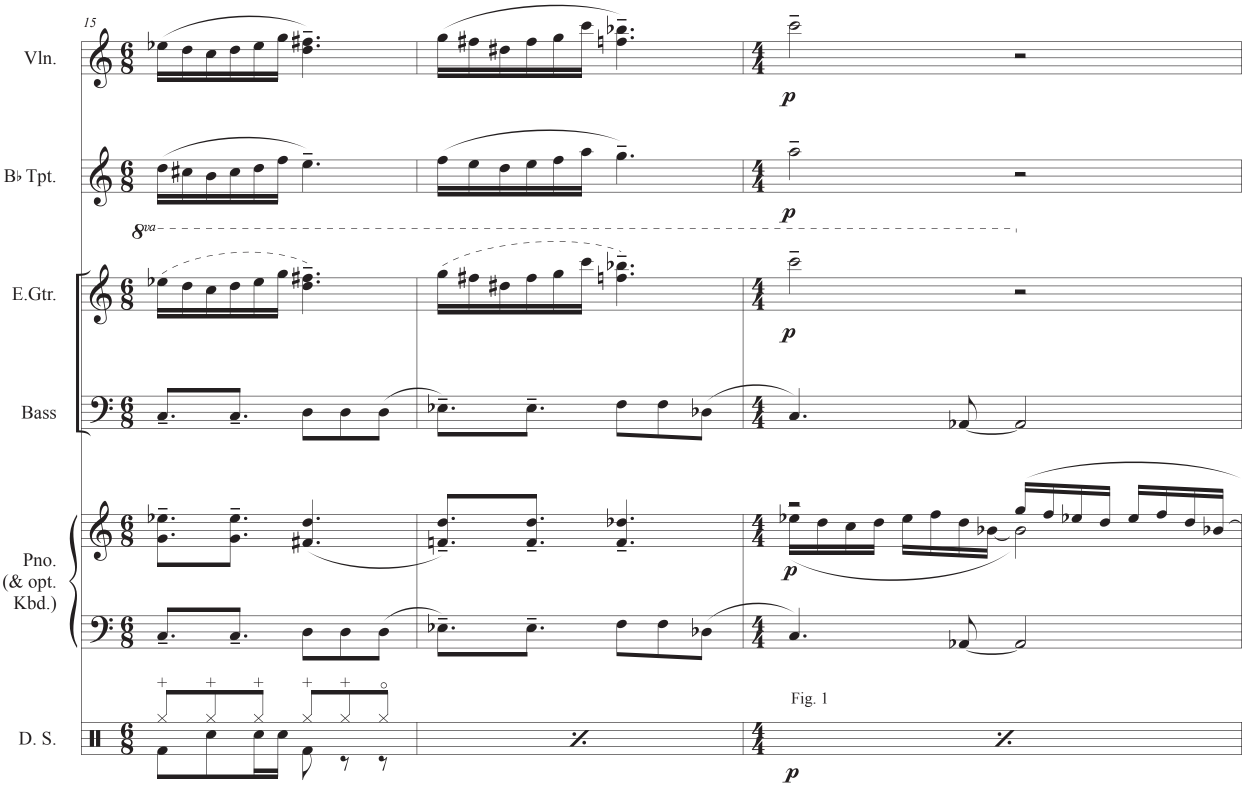
Full score

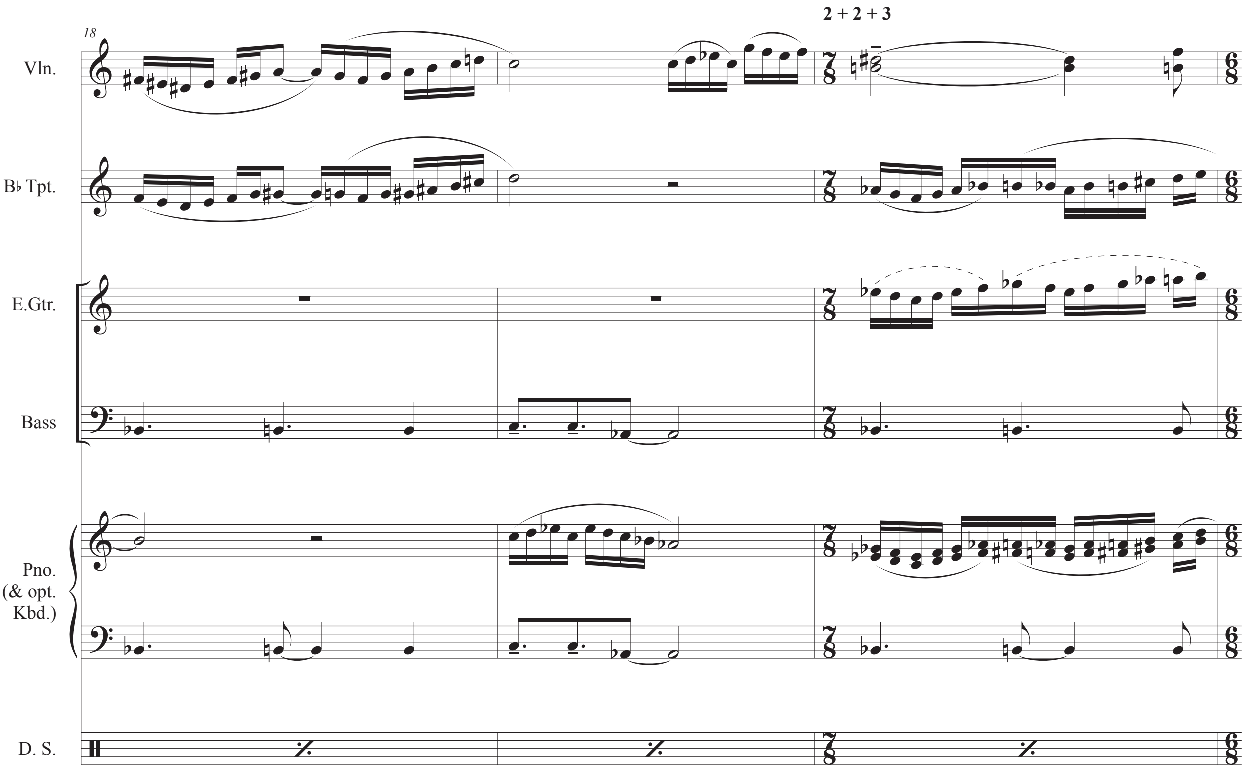
Different Kind of Scene

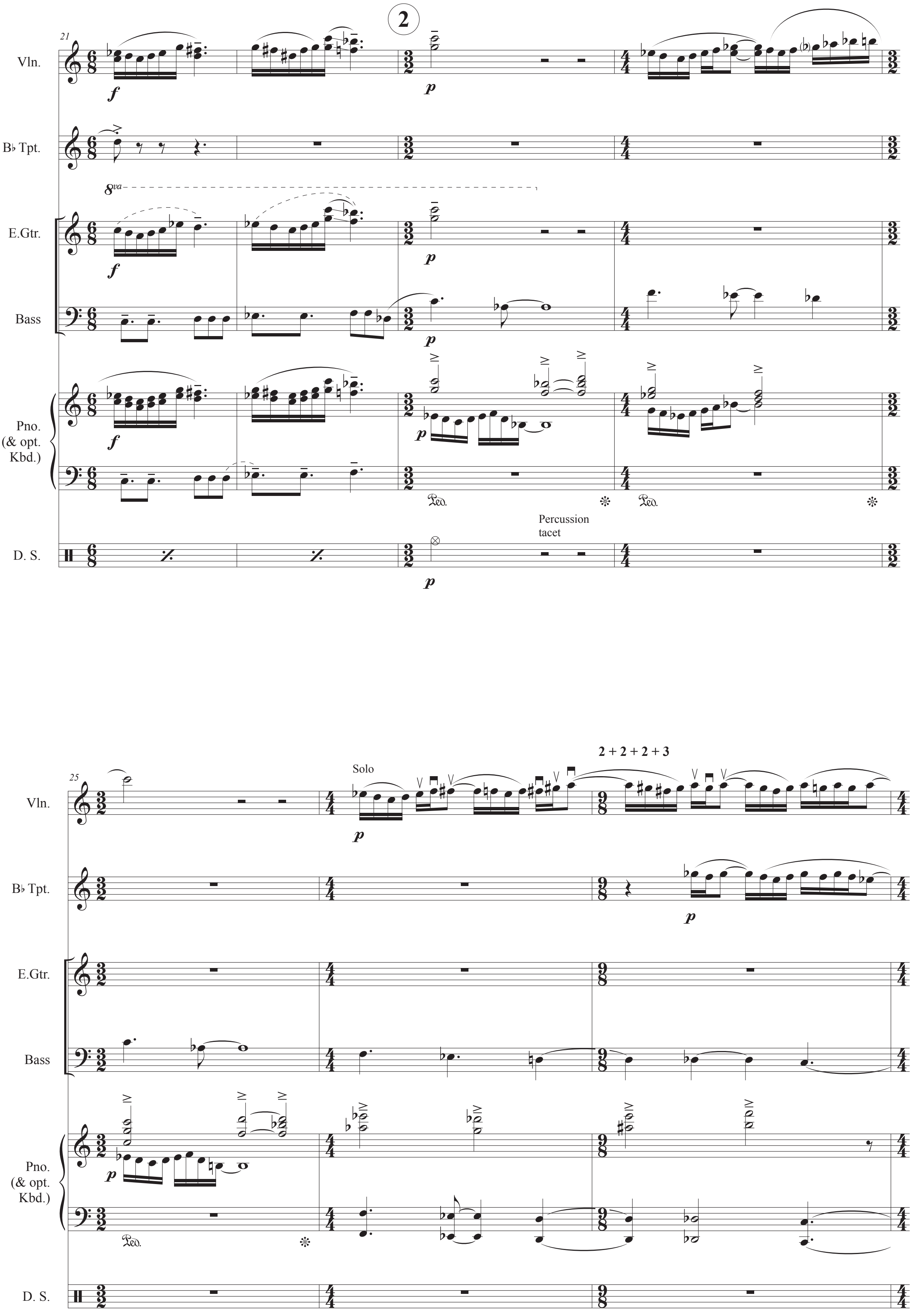
Transposing Score

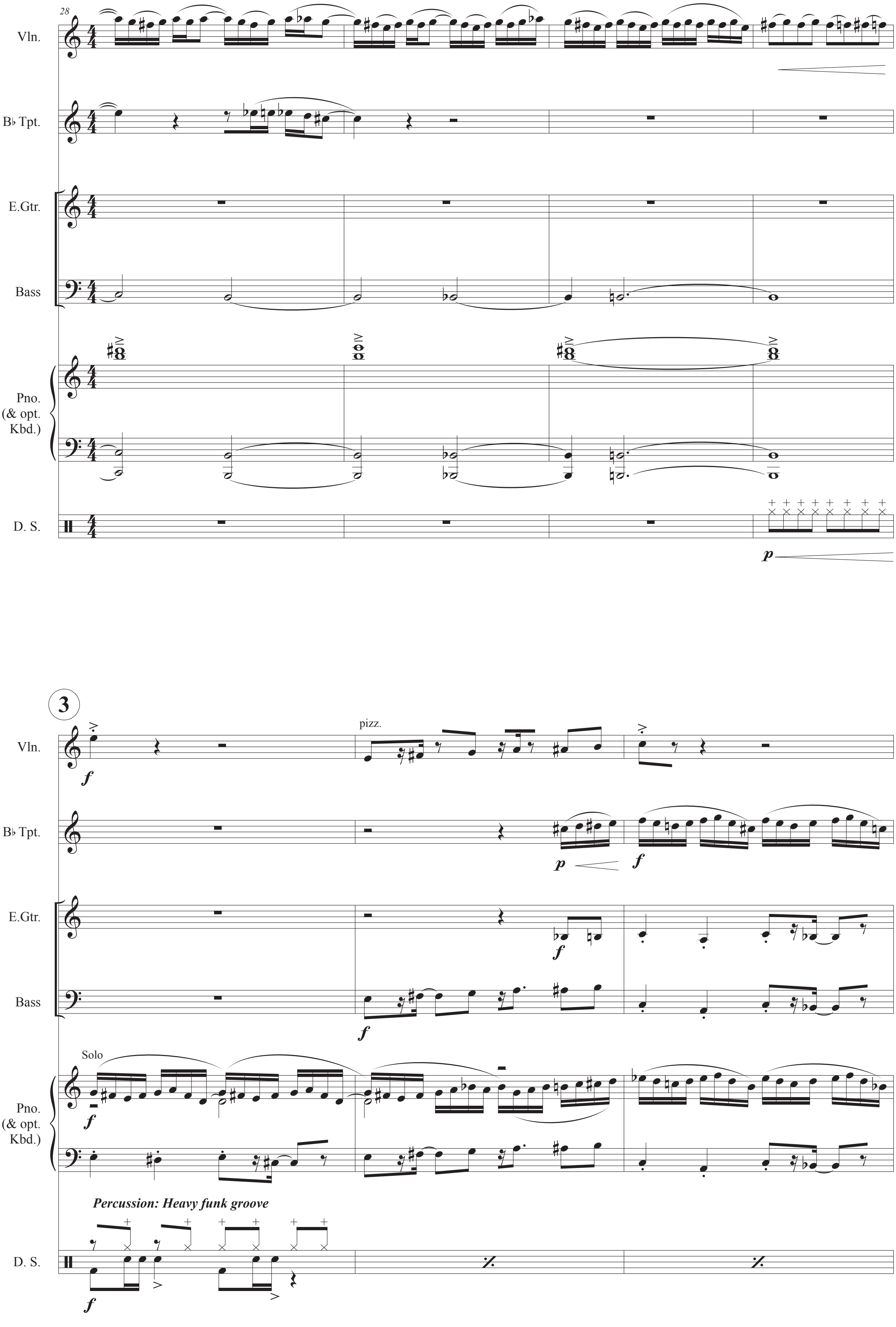
Chris Corcoran

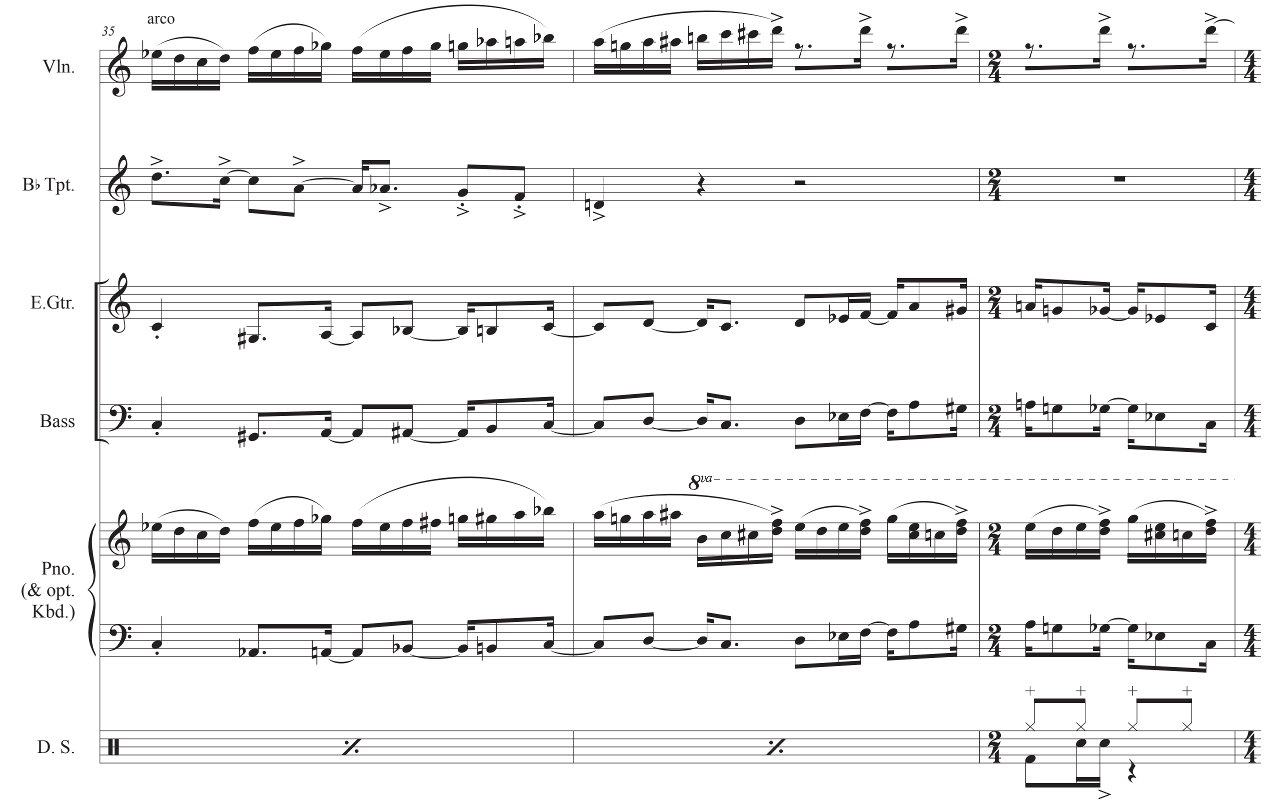


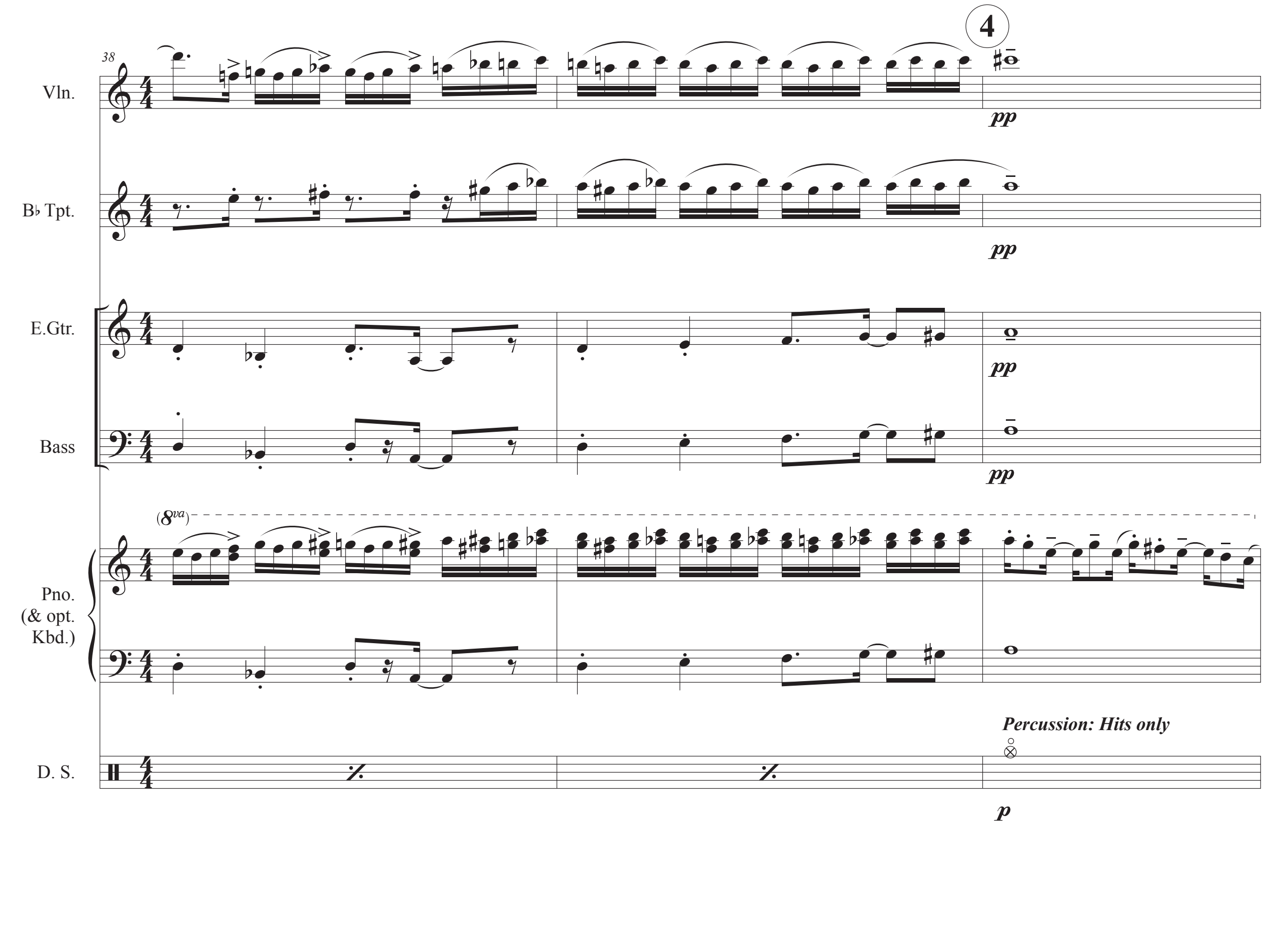

1 ♩ = 80
9
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
p
mf
Percussion: Light funk groove
Fig. 1
12
Senza sord.
2 + 2 + 3


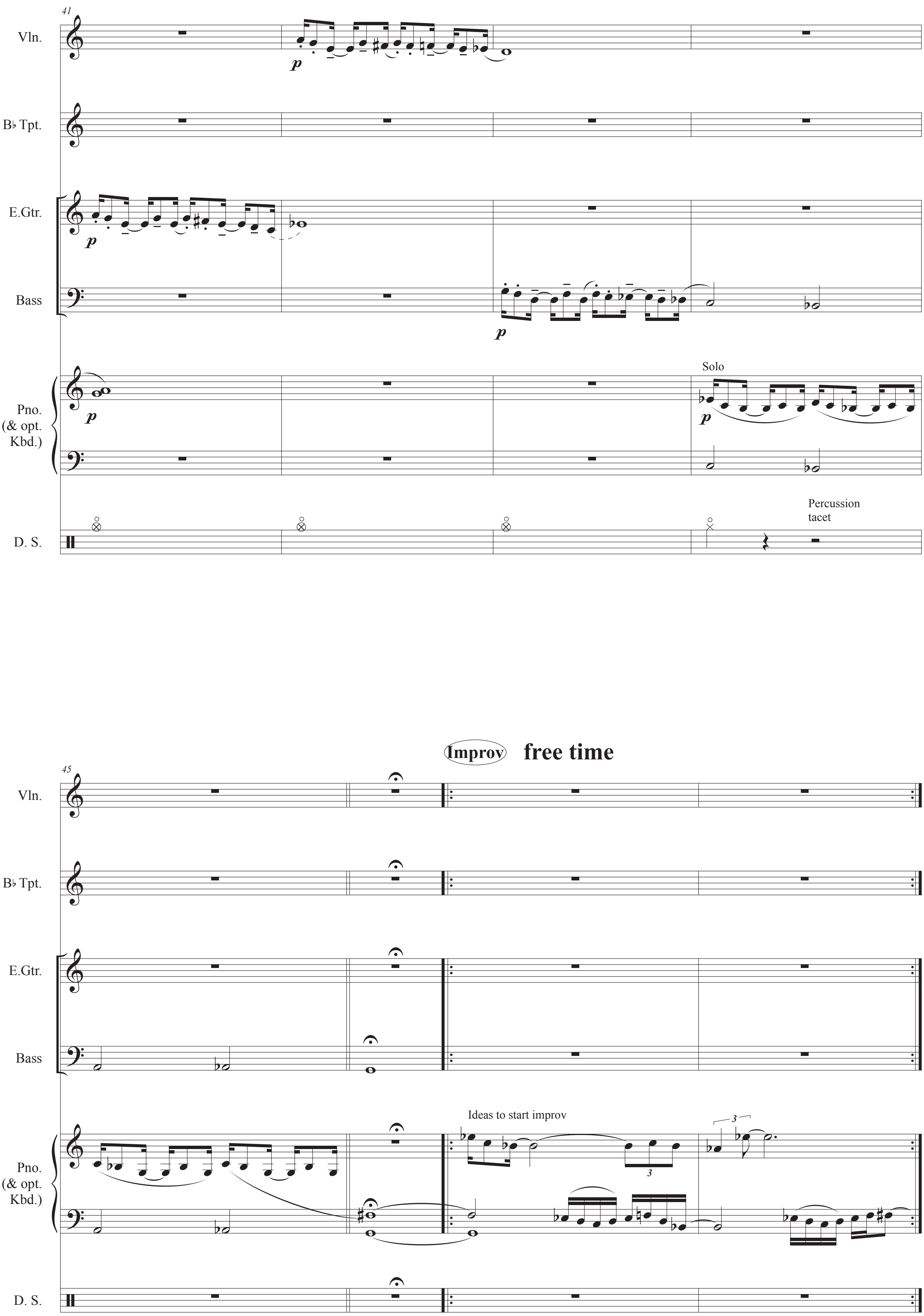
15
Vln.
B♭ Tpt.
8va
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
Fig. 1
p
p
p
p
p


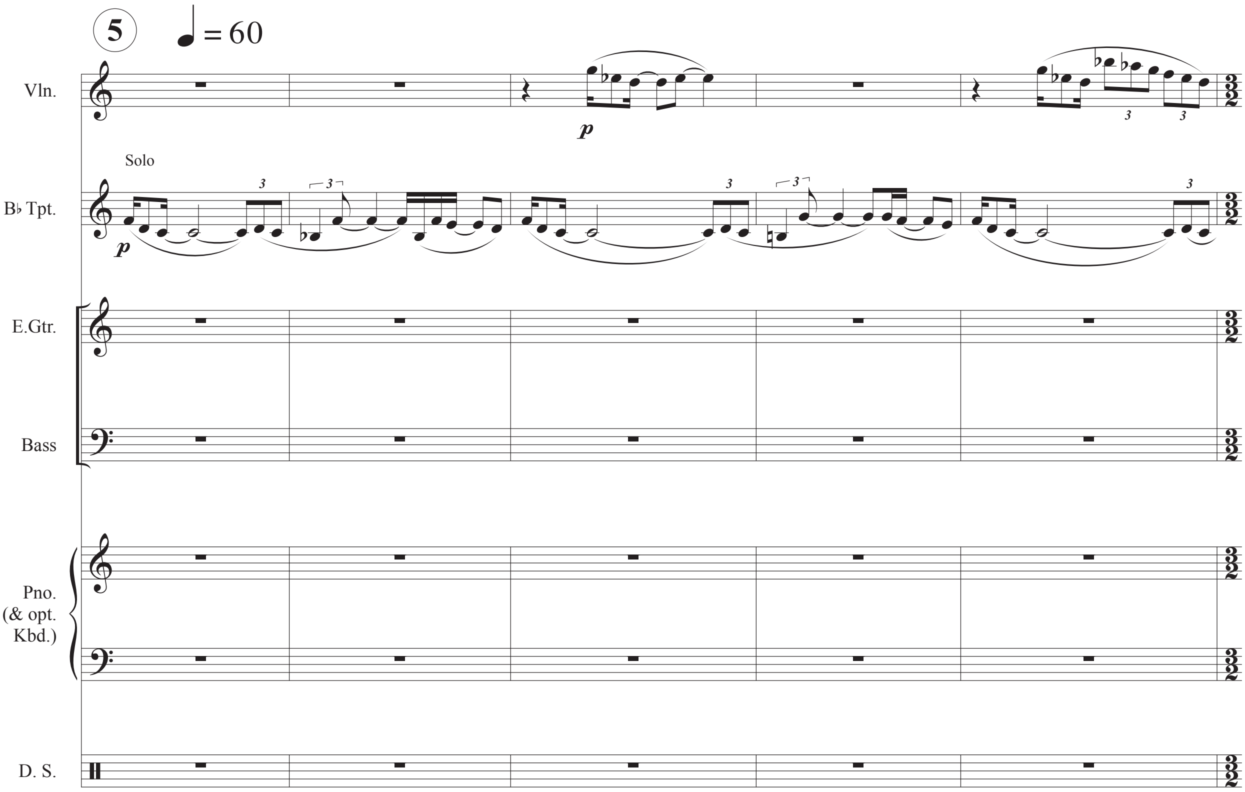
18
2 + 2 + 3
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


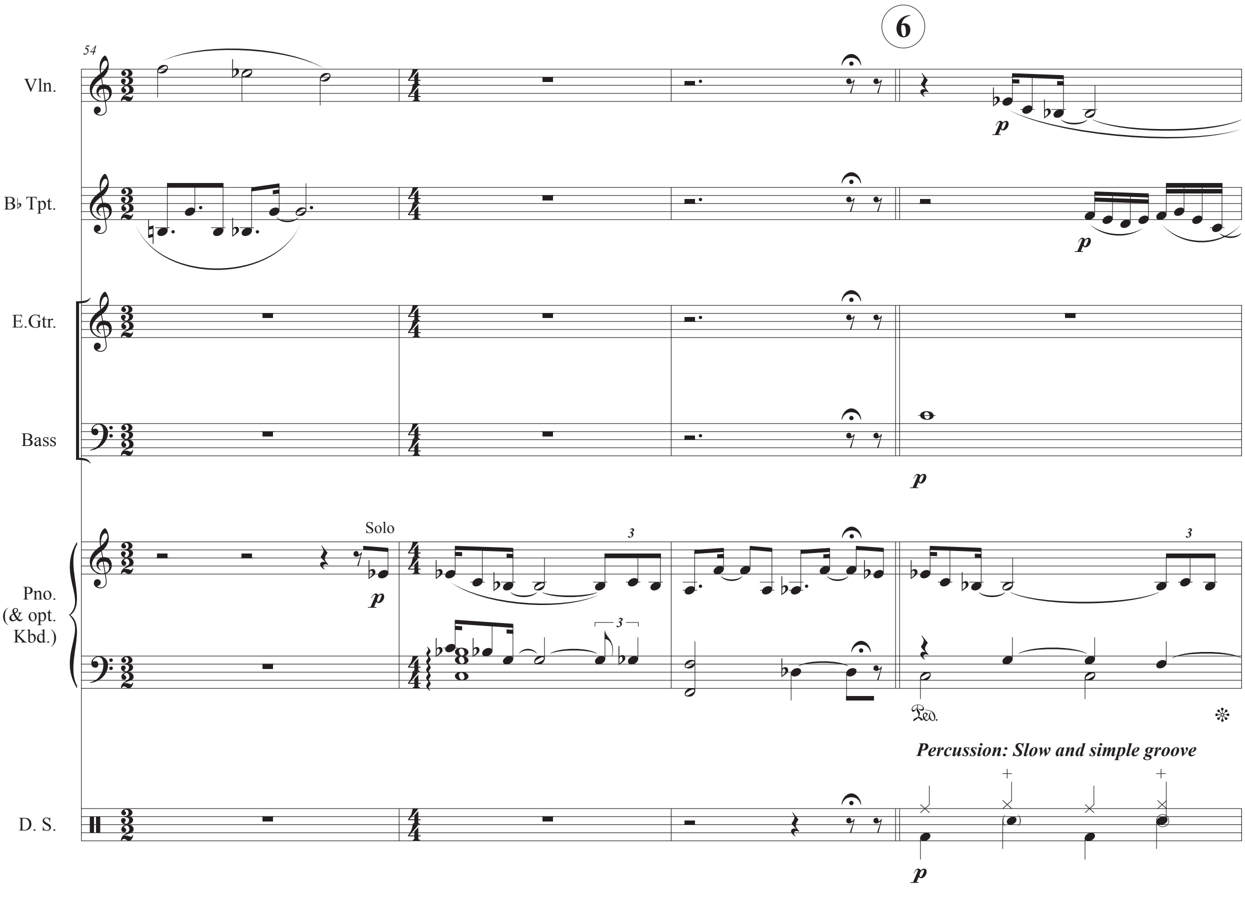
21
2
Vln.
B♭ Tpt.
8va
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
Percussion
tacet
D. S.
25
Solo
2 + 2 + 2 + 3
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


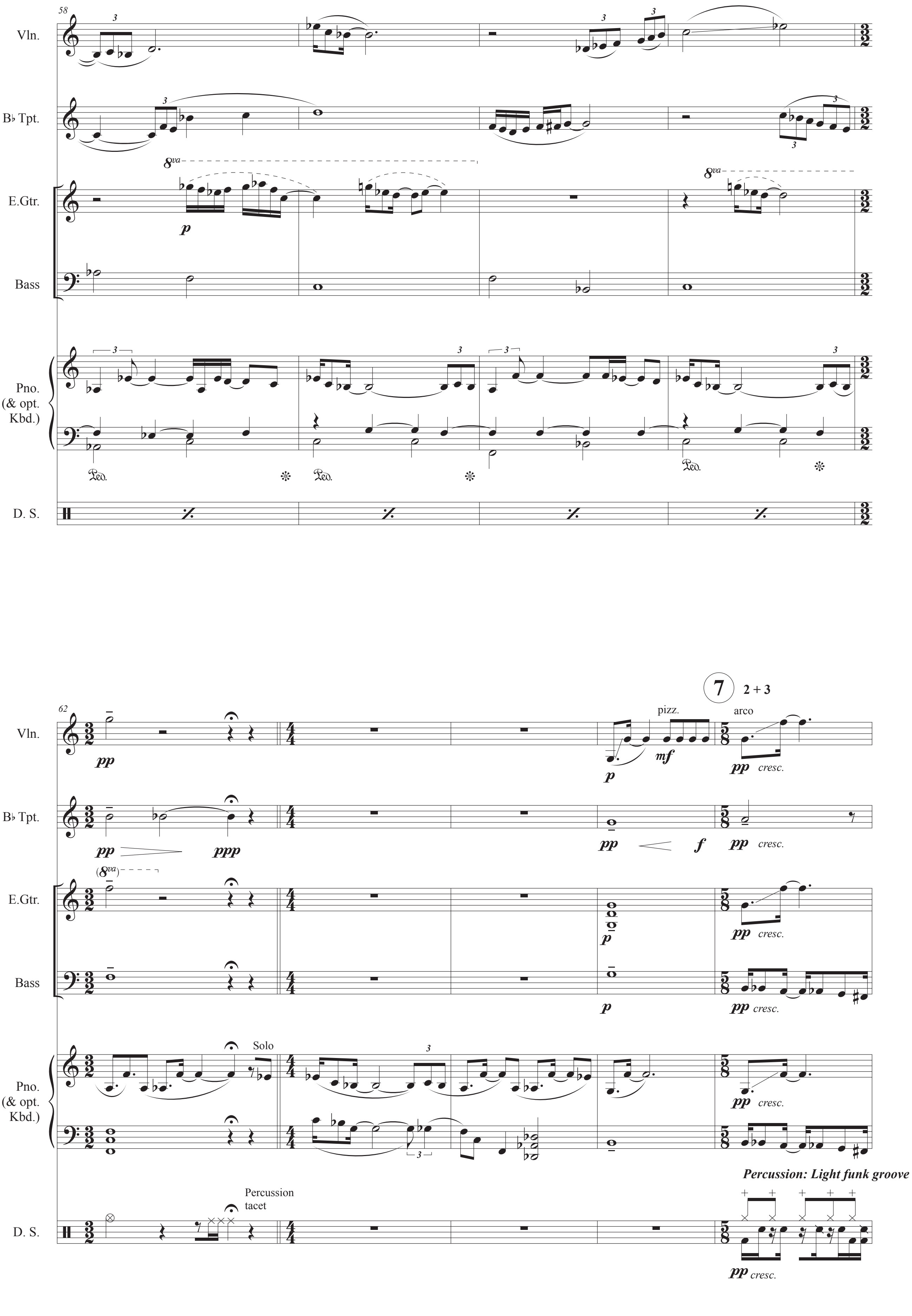
28
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
p
3
pizz.
f
p
f
f
f
Solo
f
Percussion: Heavy funk groove
f


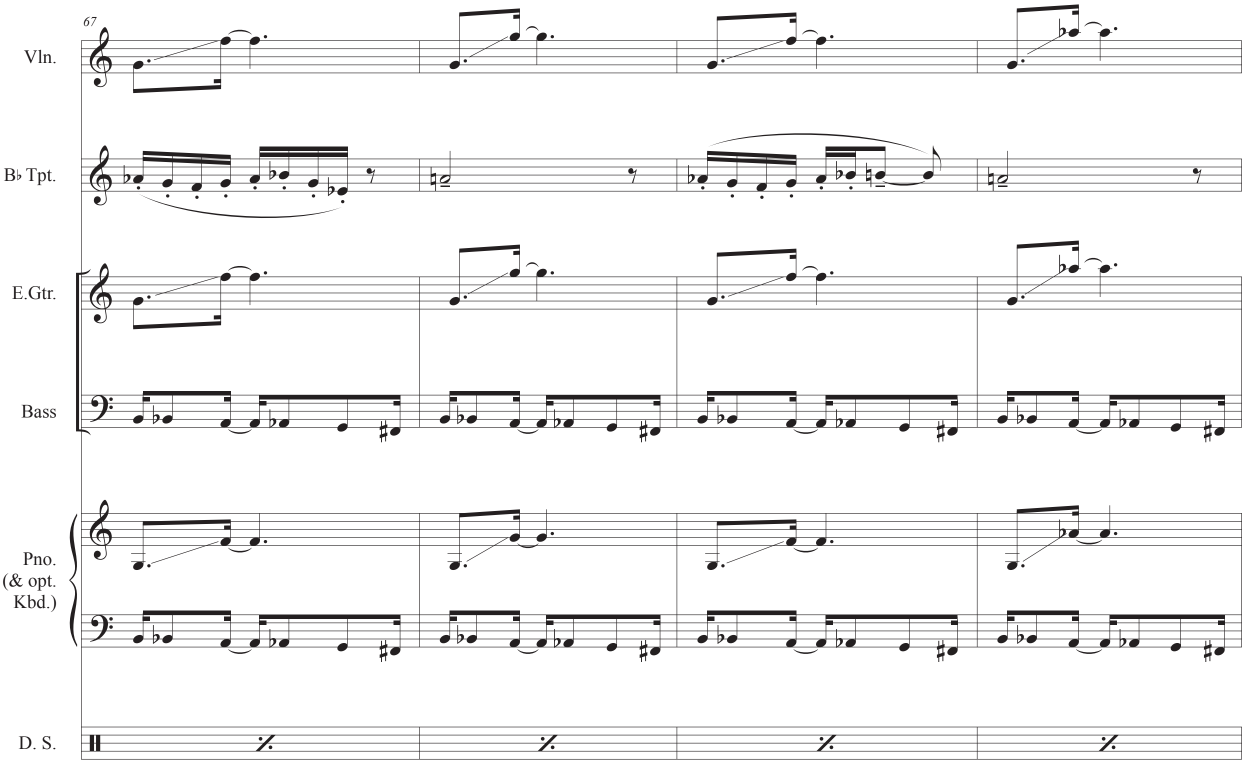
35
arco
Vln.
B♭ Tpt.
E.Gtr.
Bass
8va
Pno.
(& opt.
Kbd.)
D. S.


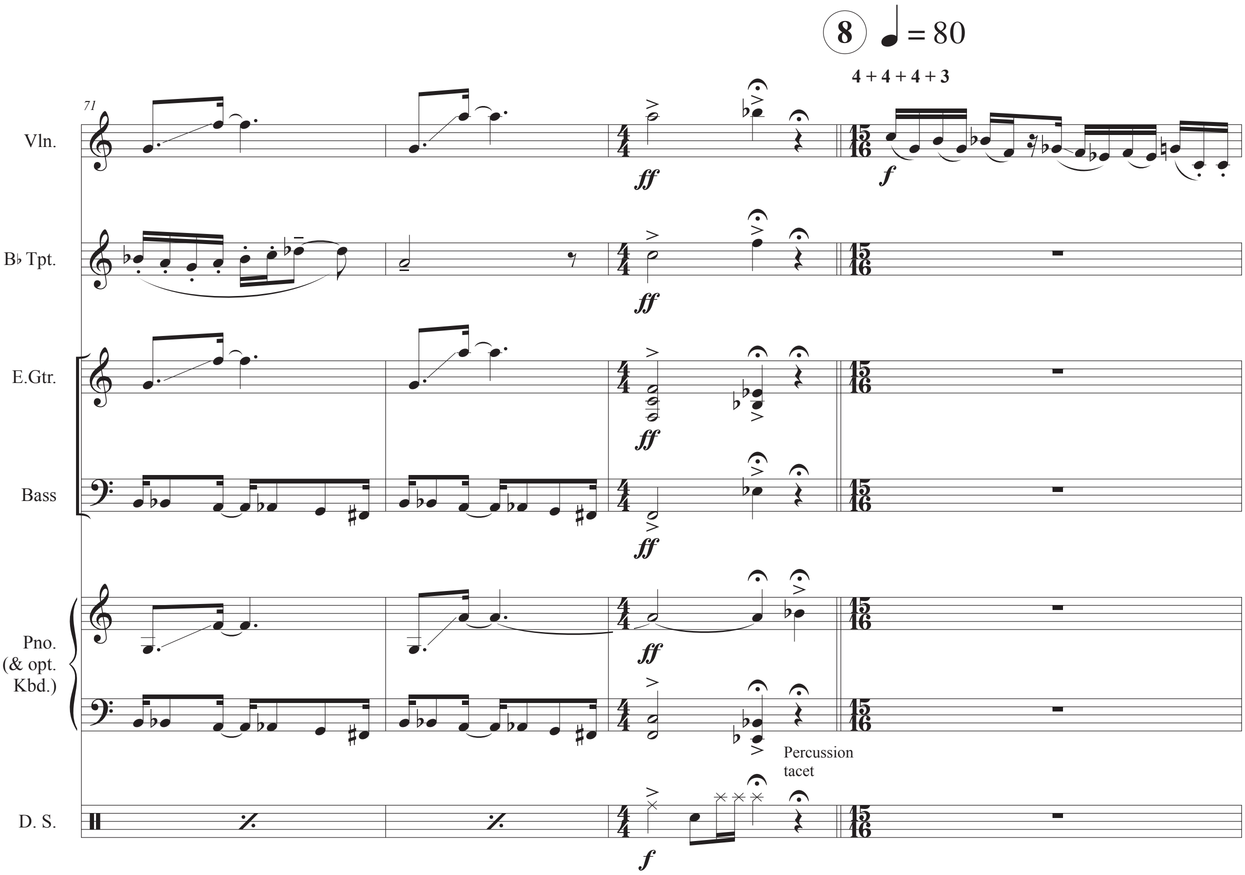
38
4
Vln.
pp
B♭ Tpt.
pp
E.Gtr.
pp
Bass
pp
(8va)
Pno.
(& opt.
Kbd.)
Percussion: Hits only
D. S.
p


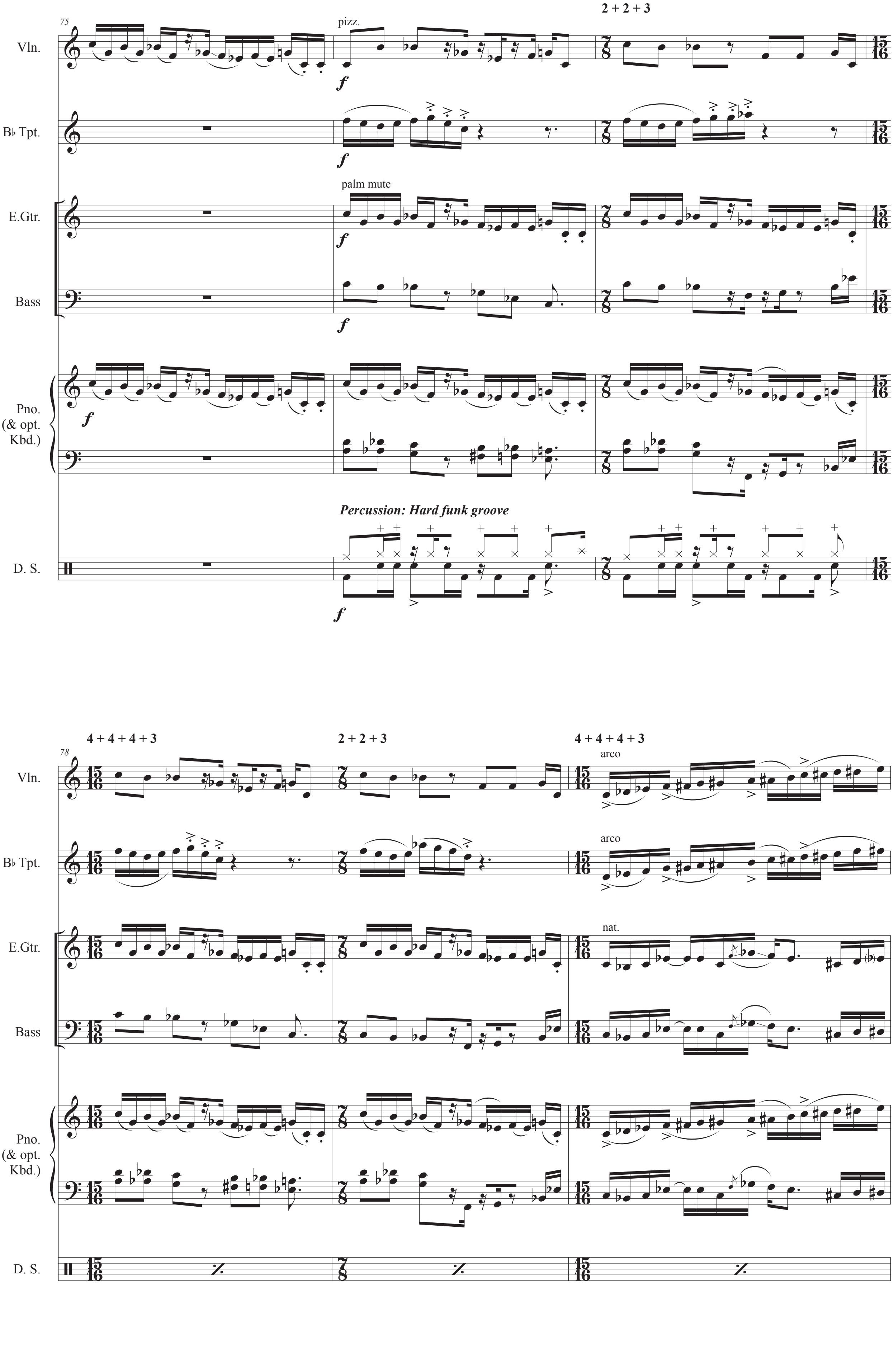
41
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
p
Solo
Percussion
tacet
45
Improv
free time
Ideas to start improv
3


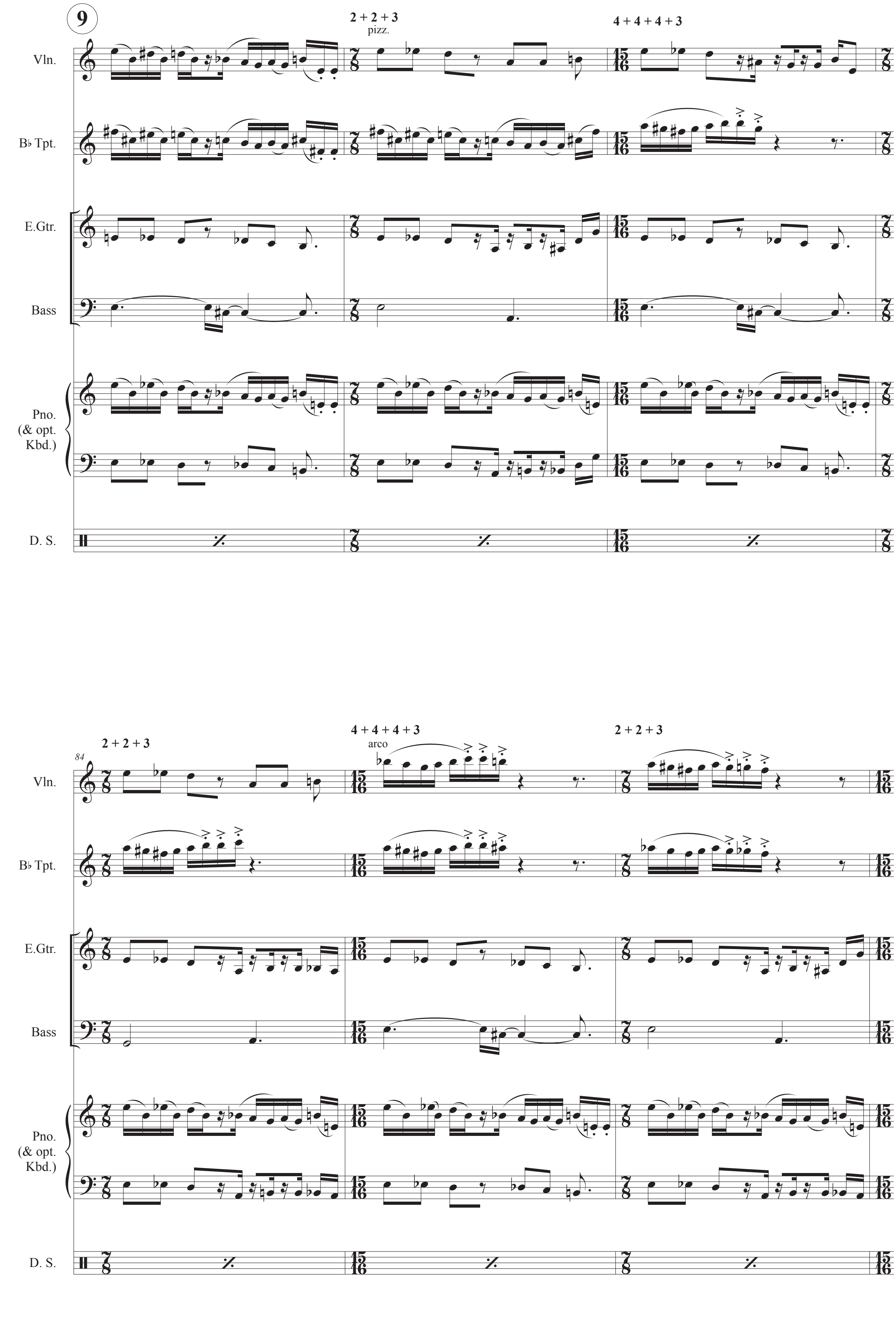
5
♩ = 60
Vln.
p
Solo
B♭ Tpt.
p
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


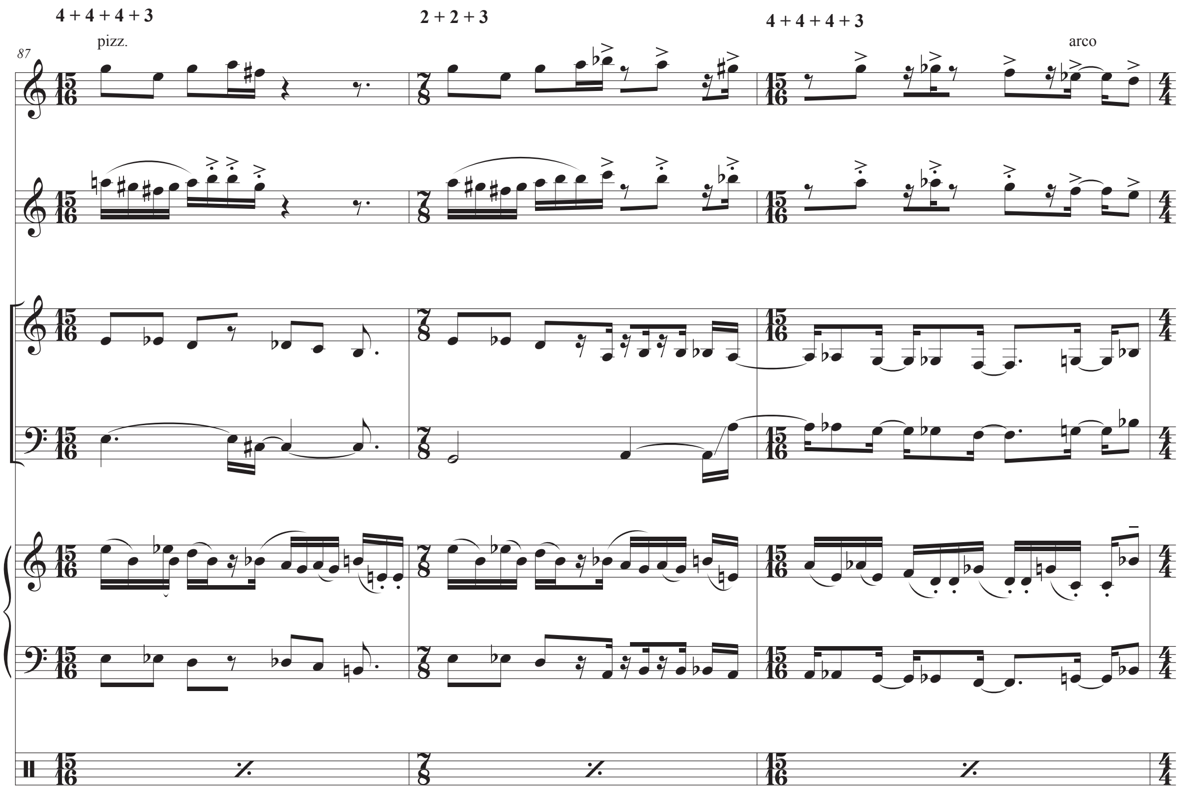
54
6
Vln.
p
B♭ Tpt.
p
E.Gtr.
Bass
p
Solo
p
Pno.
(& opt.
Kbd.)
Ped.
Percussion: Slow and simple groove
D. S.
p


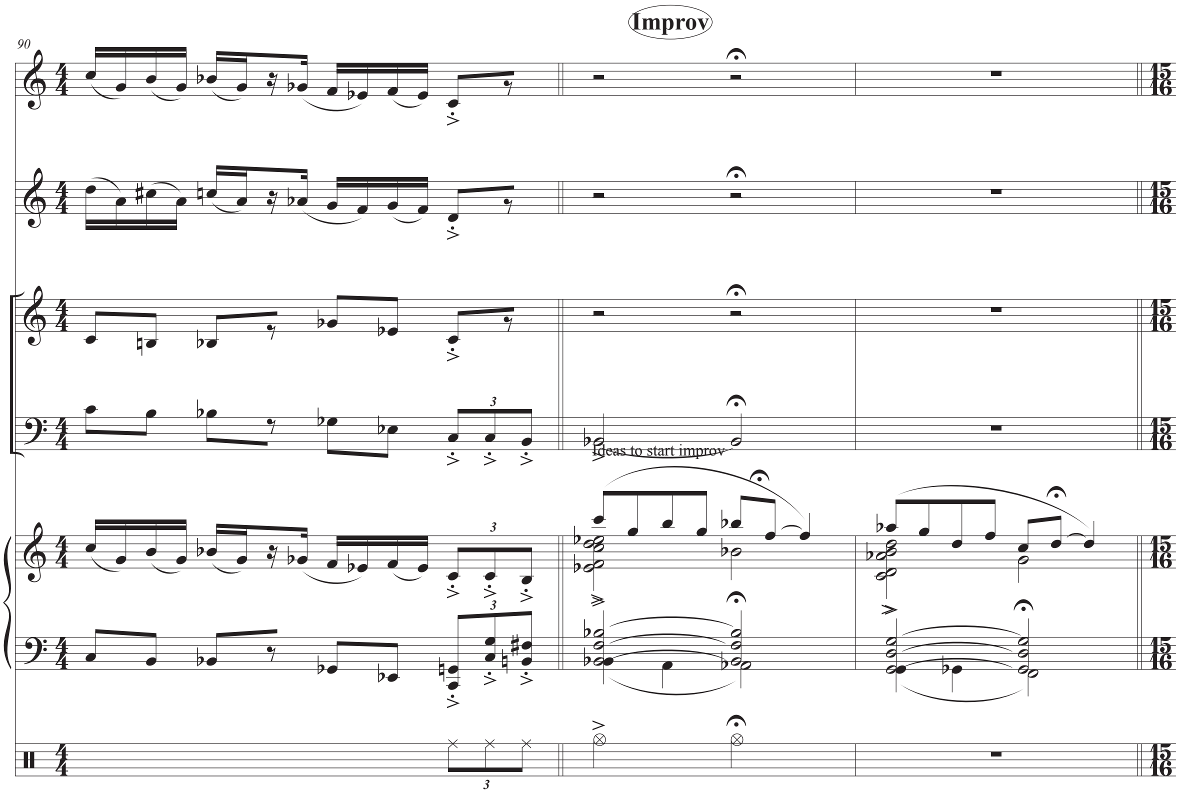
58
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
8va
p
Ped.
62
7
2 + 3
pizz.
arco
pp
ppp
mf
f
cresc.
(8va)
Solo
Percussion
tacet
Percussion: Light funk groove


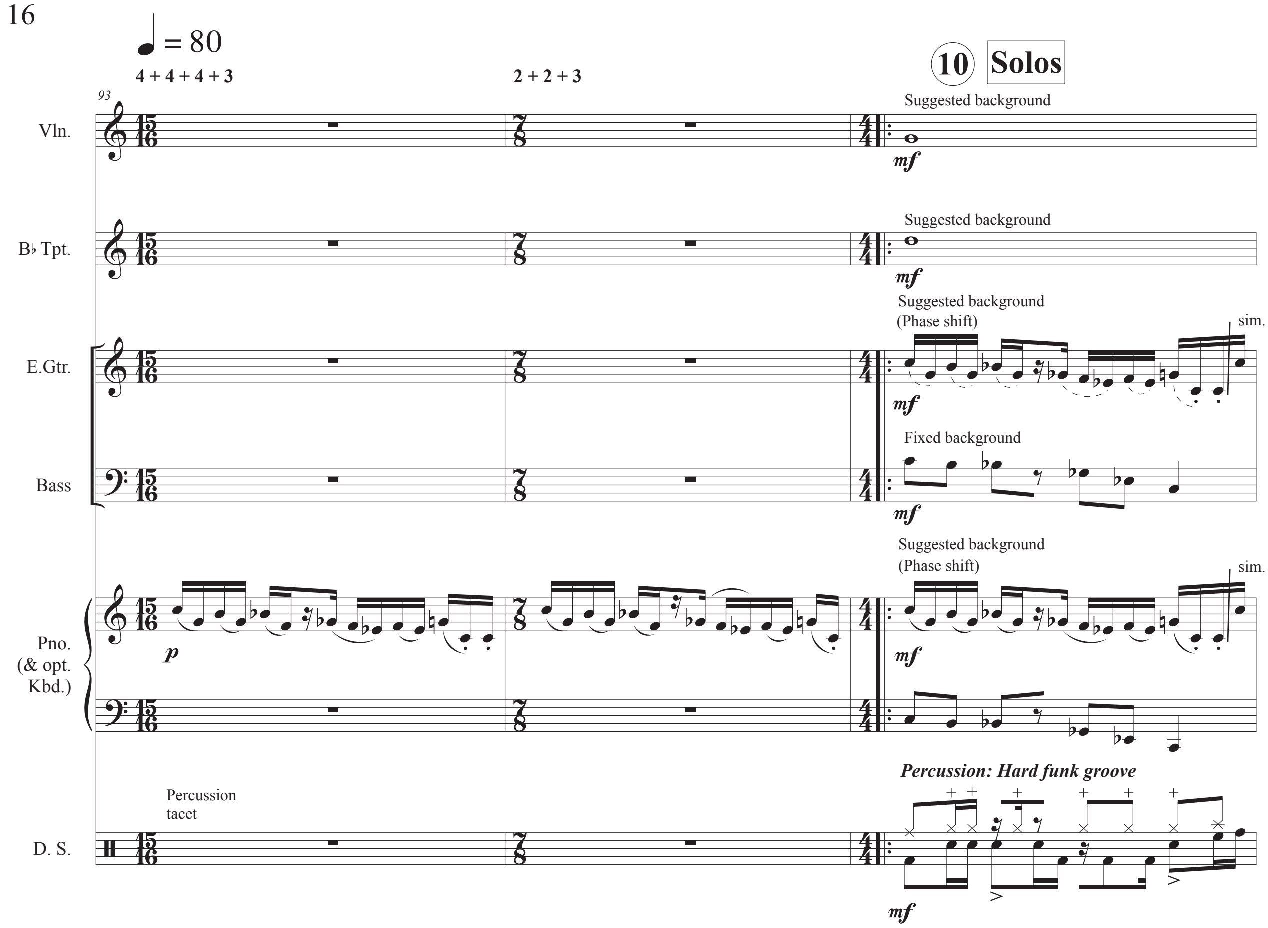
67
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


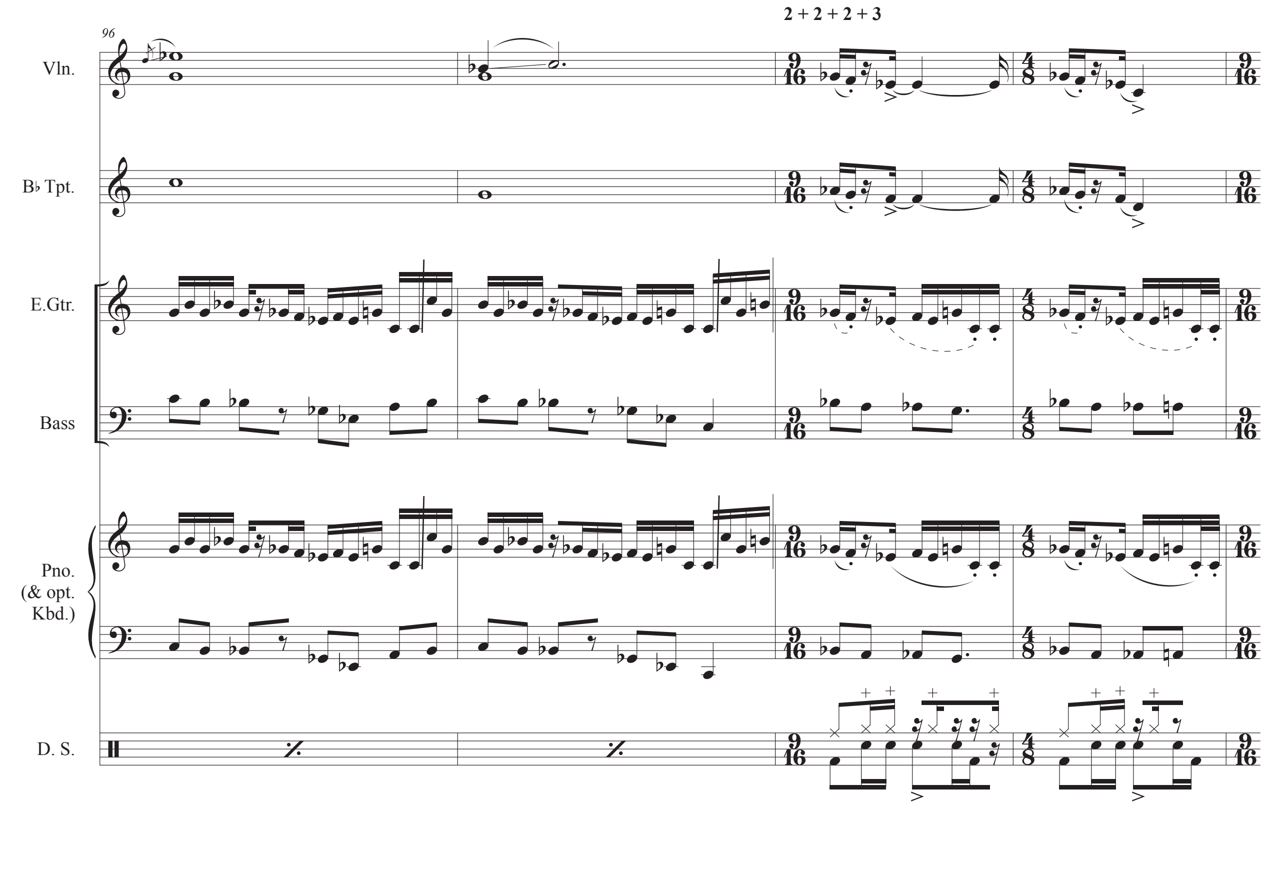
8
= 80
4 + 4 + 4 + 3
71
Vln.
ff
f
B♭ Tpt.
ff
E.Gtr.
ff
Bass
ff
Pno.
(& opt.
Kbd.)
ff
Percussion
tacet
D. S.
f


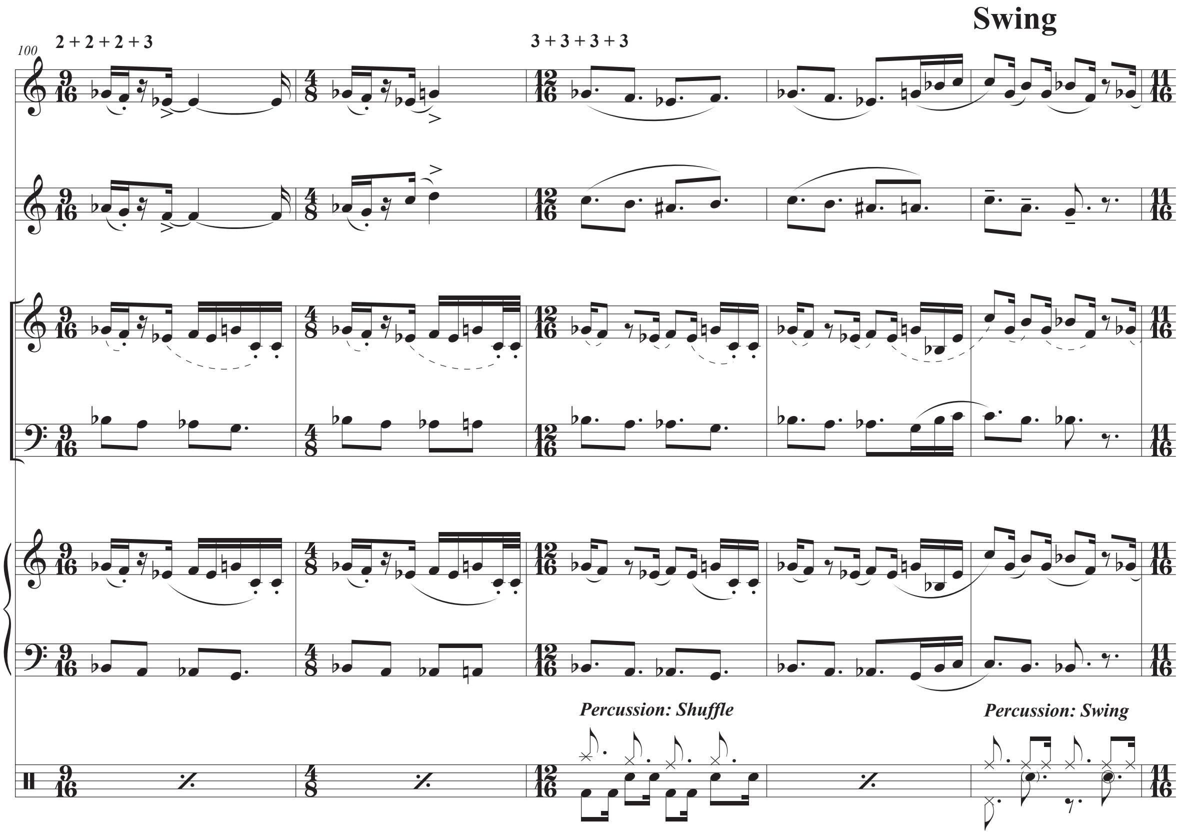
75
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
pizz.
palm mute
Percussion: Hard funk groove
2 + 2 + 3
78
4 + 4 + 4 + 3
2 + 2 + 3
4 + 4 + 4 + 3
arco
arco
nat.


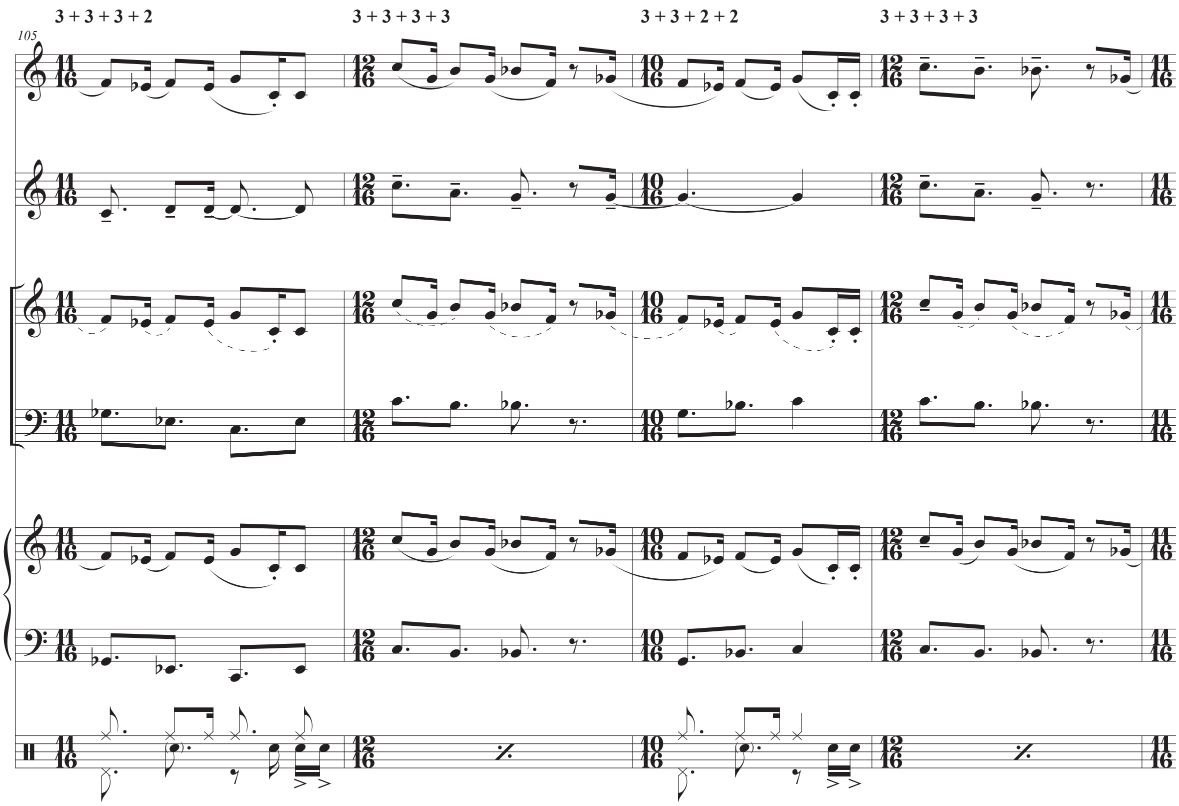
9
2 + 2 + 3
pizz.
4 + 4 + 4 + 3
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
84
2 + 2 + 3
4 + 4 + 4 + 3
arco
2 + 2 + 3


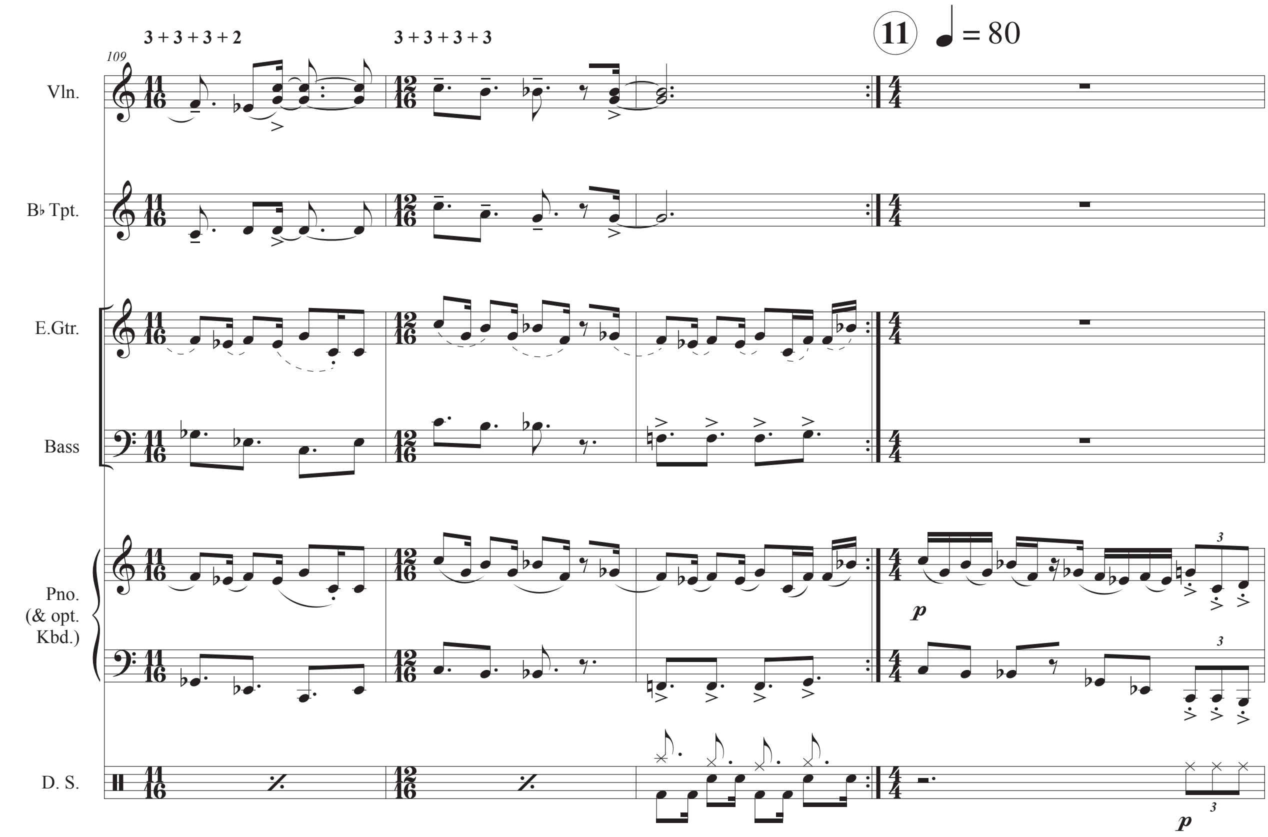
4 + 4 + 4 + 3
2 + 2 + 3
4 + 4 + 4 + 3
pizz.
arco
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


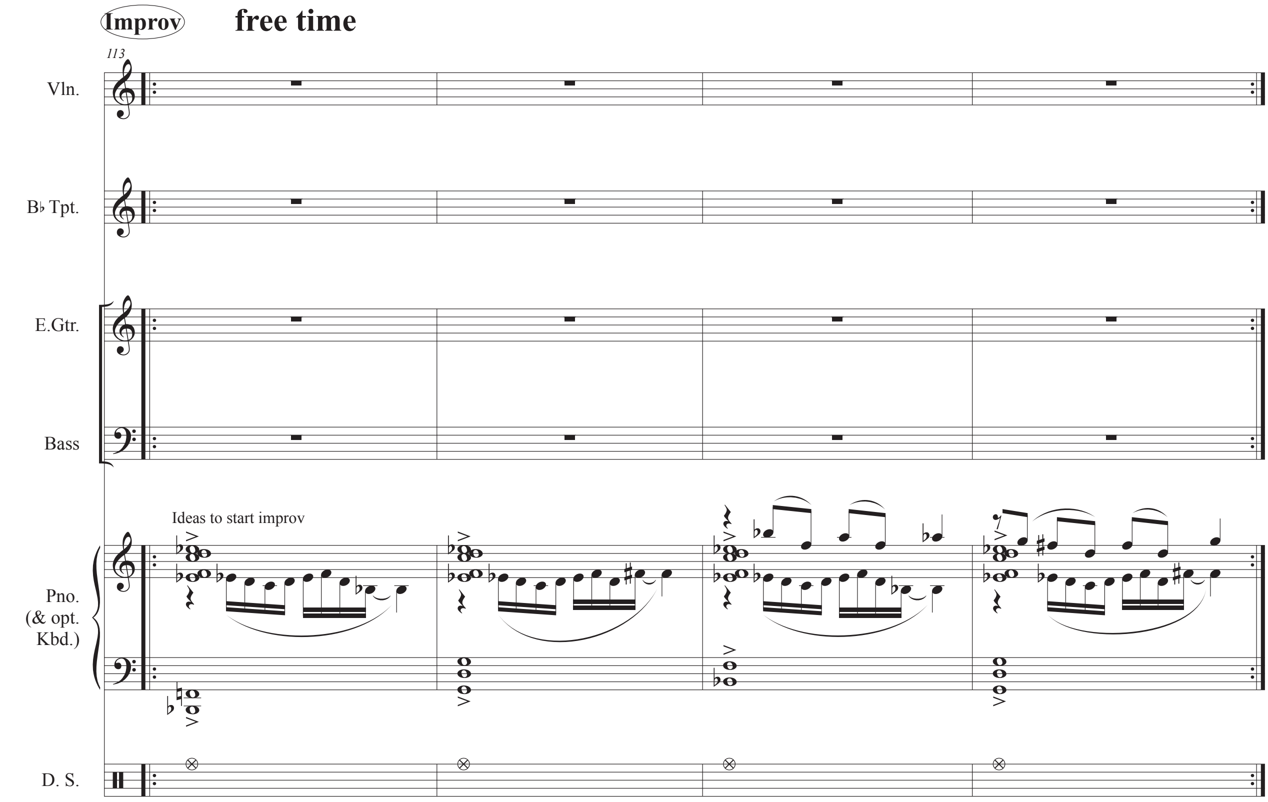
Improv
Vln.
B♭ Tpt.
E.Gtr.
Bass
Ideas to start improv
Pno.
(& opt.
Kbd.)
D. S.


= 80
4 + 4 + 4 + 3
2 + 2 + 3
10
Solos
93
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
Suggested background
mf
Suggested background
mf
Suggested background
(Phase shift)
sim.
mf
Fixed background
mf
p
Suggested background
(Phase shift)
sim.
mf
Percussion
tacet
Percussion: Hard funk groove
mf


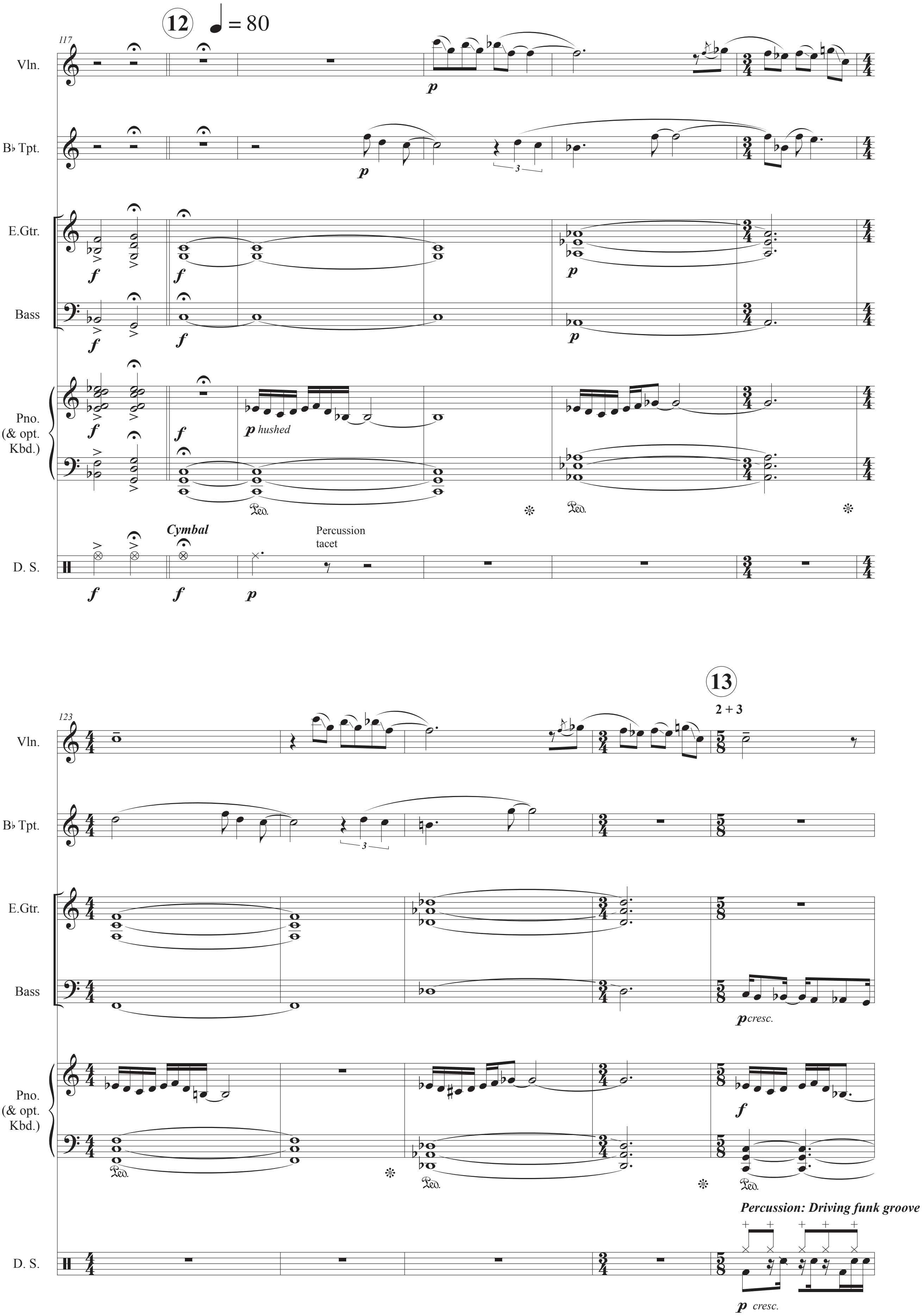
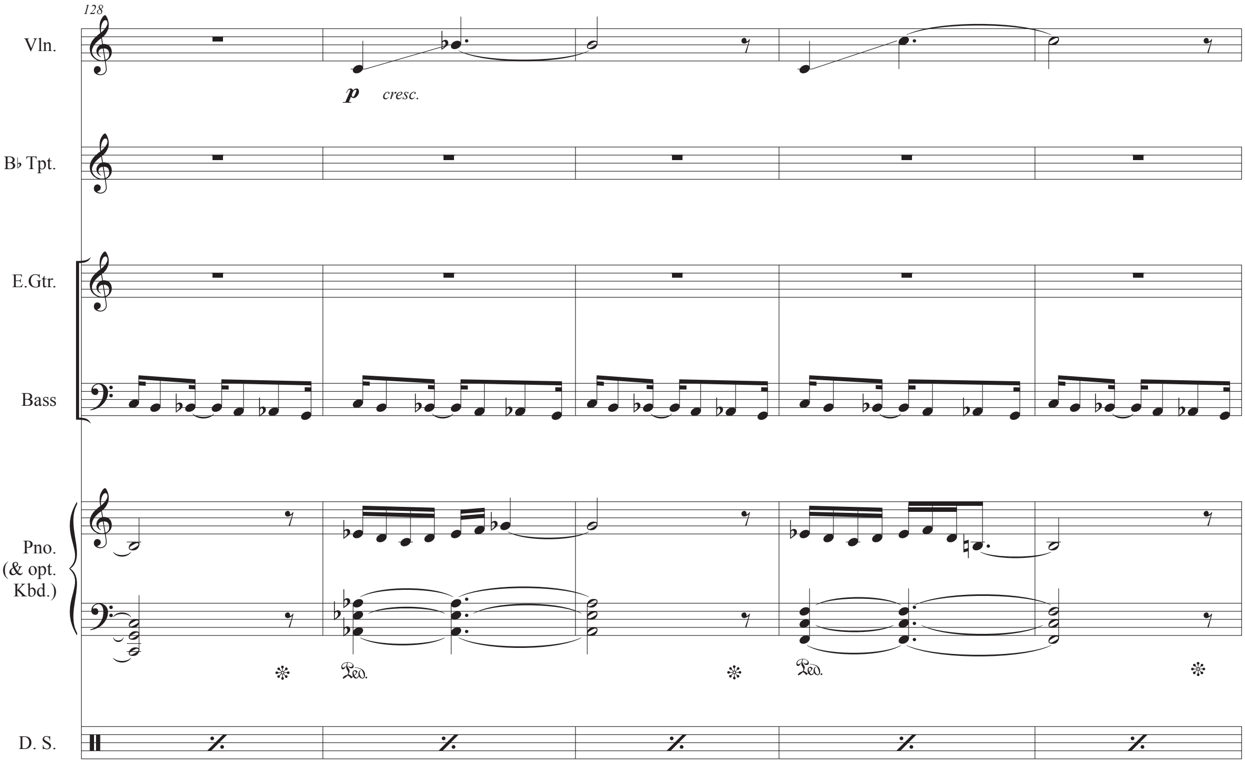
96
2 + 2 + 2 + 3
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


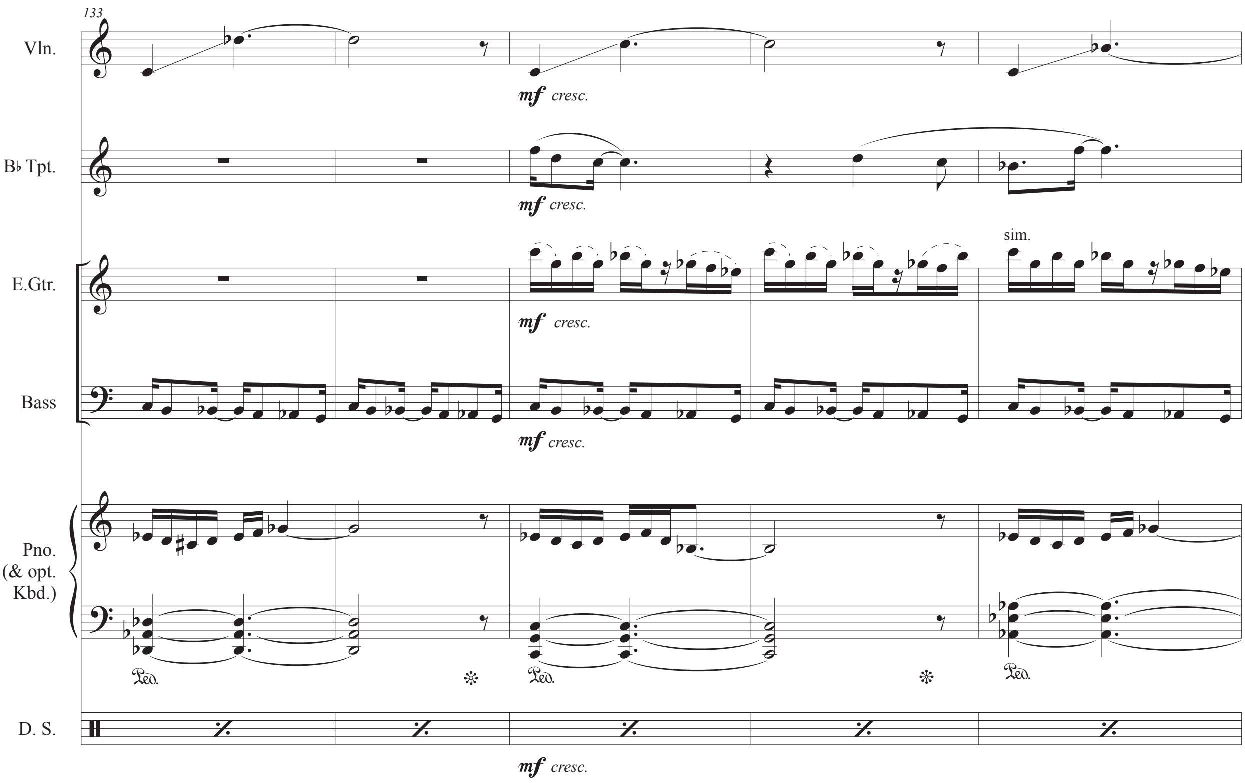
Swing
100
2 + 2 + 2 + 3
3 + 3 + 3 + 3
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
Percussion: Shuffle
Percussion: Swing
D. S.


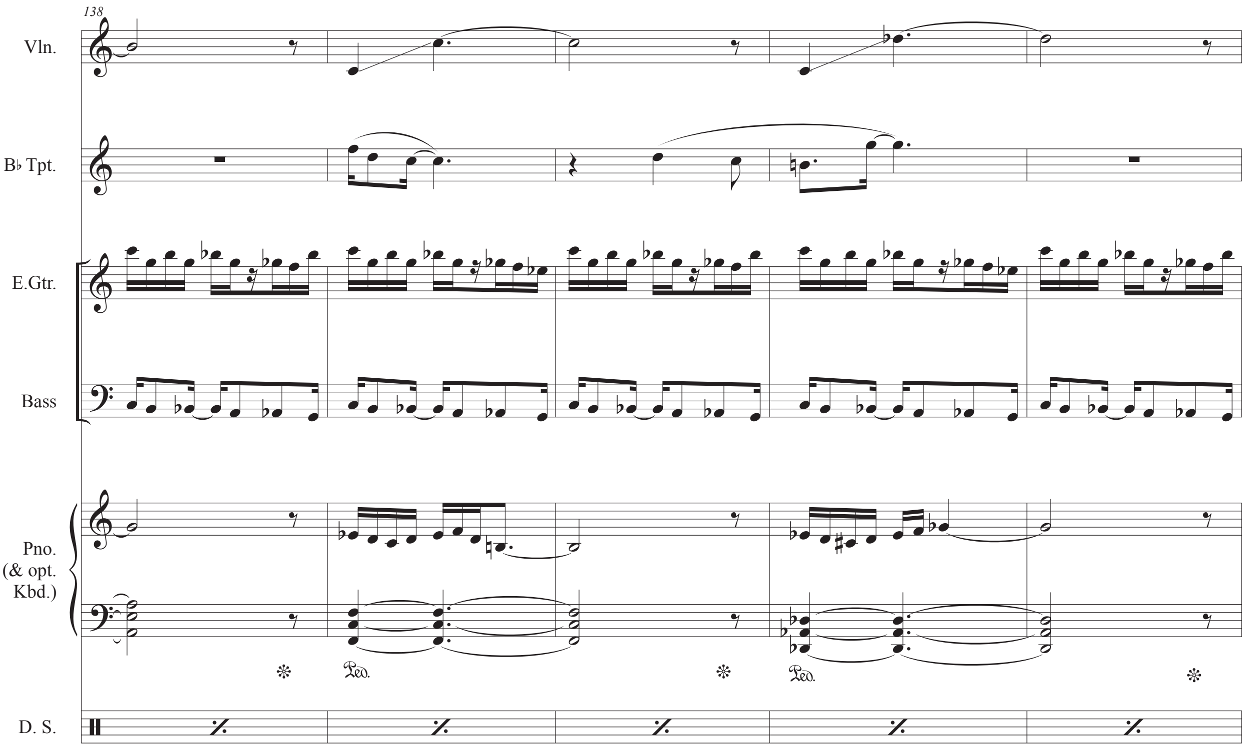
105
3 + 3 + 3 + 2
3 + 3 + 3 + 3
3 + 3 + 2 + 2
3 + 3 + 3 + 3
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


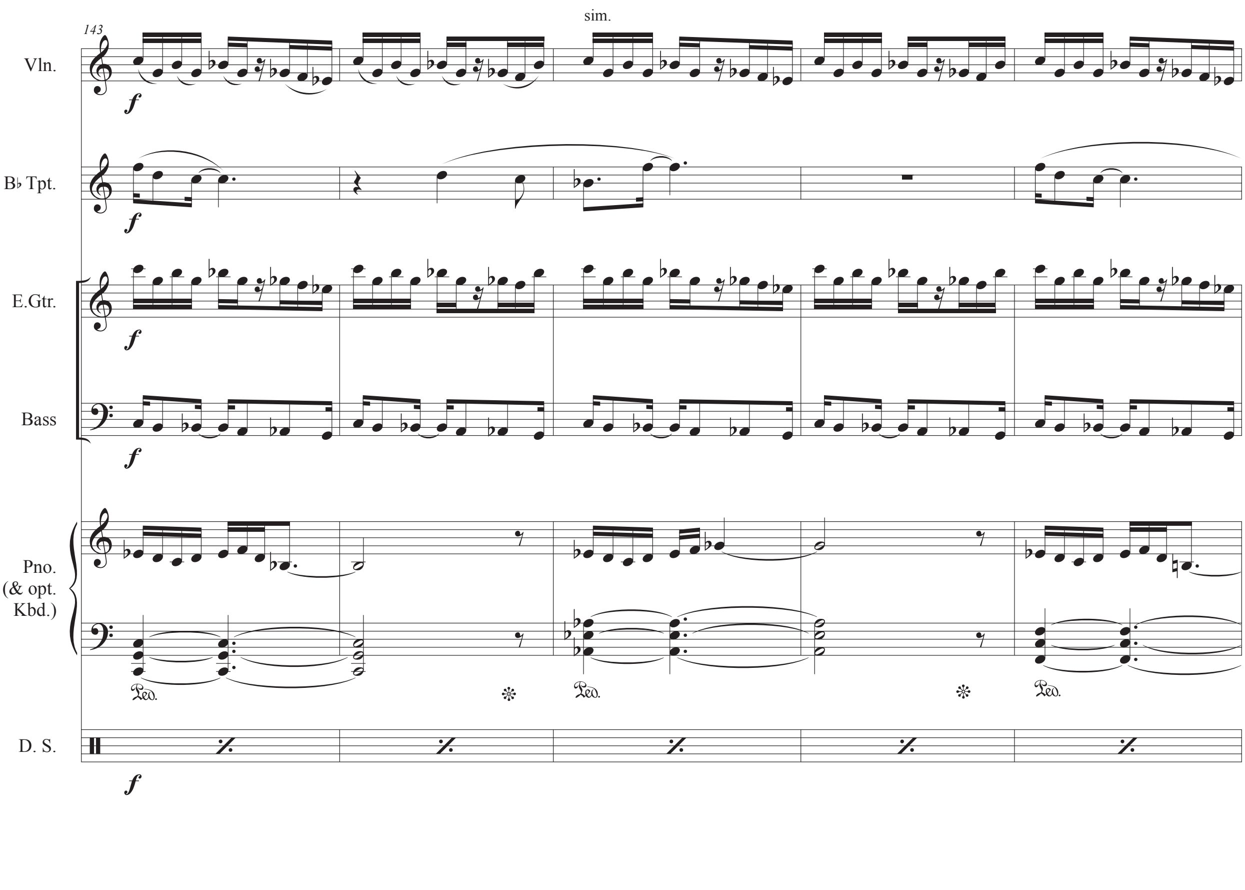
3 + 3 + 3 + 2
3 + 3 + 3 + 3
11
= 80
109
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
p


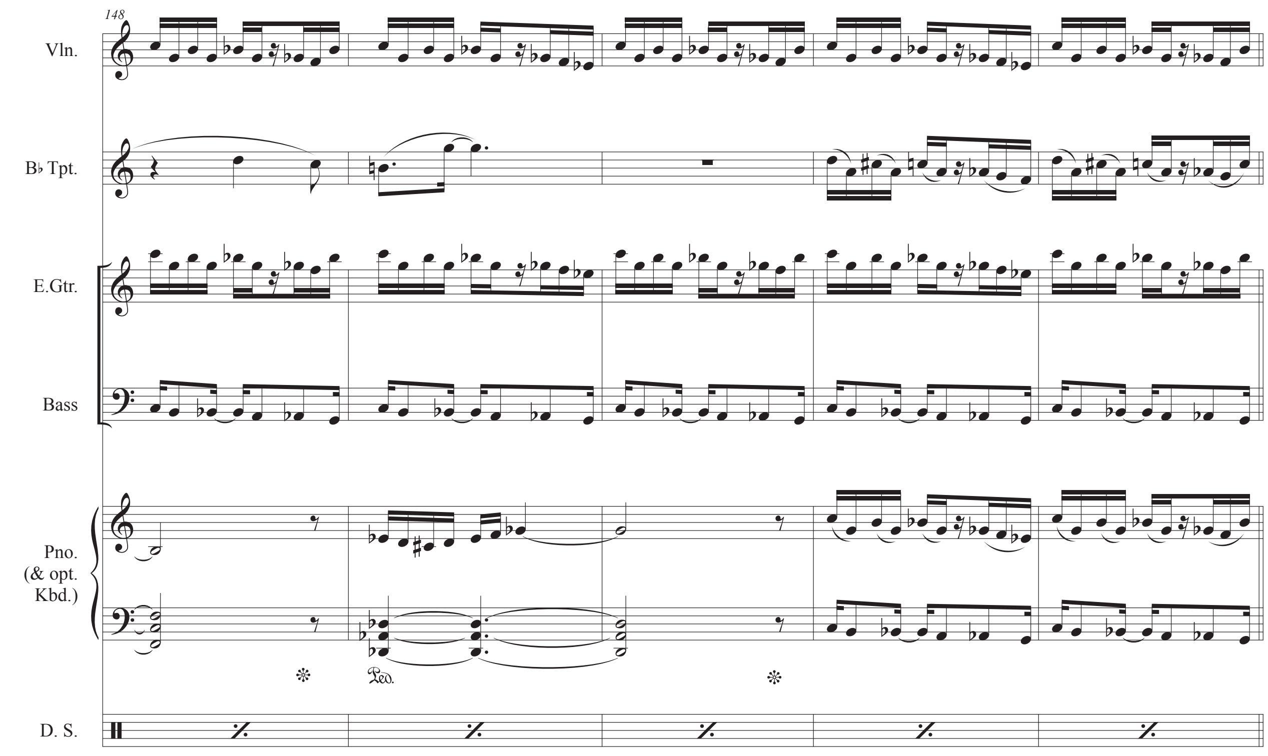
Improv
free time
113
Vln.
B♭ Tpt.
E.Gtr.
Bass
Ideas to start improv
Pno.
(& opt.
Kbd.)
D. S.

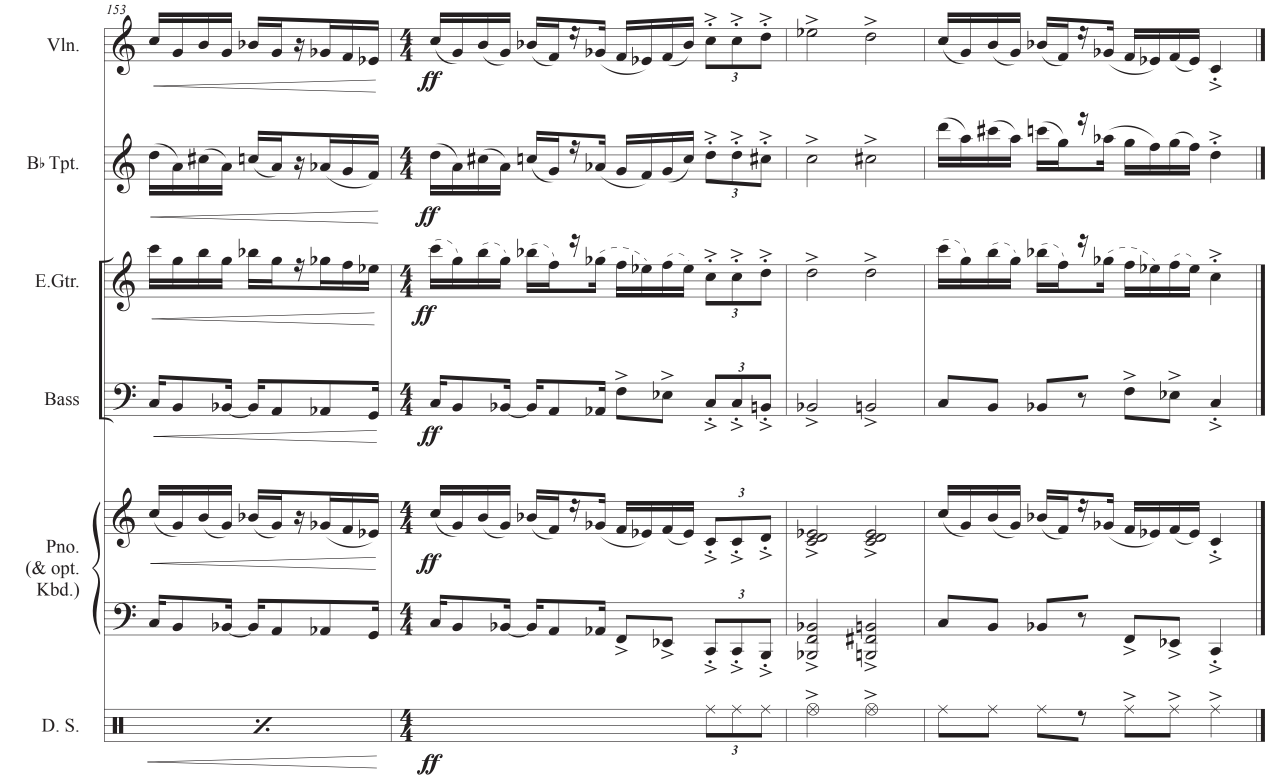

12
♩= 80
117
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
p hushed
Cymbal
Percussion
tacet
123
13
2 + 3
p cresc.
Percussion: Driving funk groove
p cresc.


128
Vln.
p cresc.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.


133
Vln.
mf cresc.
B♭ Tpt.
mf cresc.
sim.
E.Gtr.
mf cresc.
Bass
mf cresc.
Pno.
(& opt.
Kbd.)
D. S.
mf cresc.


138
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
Ped.
Ped.
D. S.


143
sim.
Vln.
f
B♭ Tpt.
f
E.Gtr.
f
Bass
f
Pno.
(& opt.
Kbd.)
Ped.
Ped.
Ped.
D. S.
f


148
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
Ped.
D. S.


153
Vln.
B♭ Tpt.
E.Gtr.
Bass
Pno.
(& opt.
Kbd.)
D. S.
4
4
ff
3

Electric Quintet

for electric guitar and string quartet

by Chris Corcoran

Instrumentation

Violin 1
Violin 2
Viola
Cello
Electric Guitar

Duration

c. 7 mins

Performance Instructions

Groove and Beat Emphasis

The sections from the opening until rehearsal mark L and from P until the end of the piece should be played with a 'rock groove' feel. This means that a quasi-metronomic pulse (as negotiated amongst the ensemble) with strong bodily emphasis should underpin the performance. Moving a limb or nodding the head in time with the beat are strongly recommended to achieve this sense of physicality. Beats 2 and 4 should receive stronger accents than beats 1 and 3 in a 4/4-context. The section from mark L to P is in relatively free time and may be interpreted with rubato.

Guitar

The electric guitar part is to be performed with an overdriven or distorted sound when the guitar's volume knob is turned up fully.

Please note that the guitar part features prominent use of the 'kill switch' effect. A kill switch is a device which interrupts the transmission of sound from the guitar's magnetic pickup to the amplifier and which can be manipulated to rythmic effect.
It can either be a permanently installed feature on the instrument in form of a button, or it can be simulated: Using a guitar featuring two pickups, a two- or three-way toggle switch, and separate volume knobs for each pickup (such as a Gibson Les Paul-style guitar), turn up one pickup and fully turn down the other one, then rythmically disrupt any sustained note by toggling the switch back and forth between the active and the muted pickup.

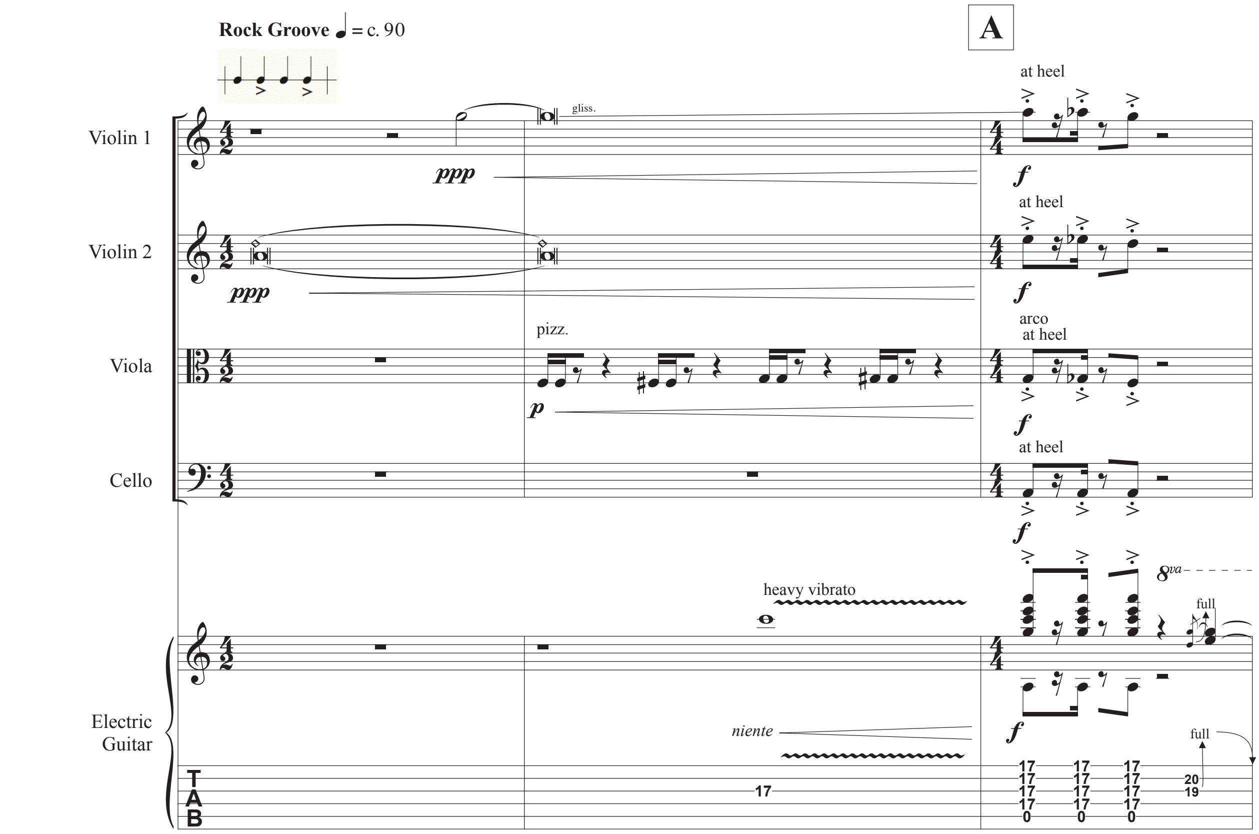
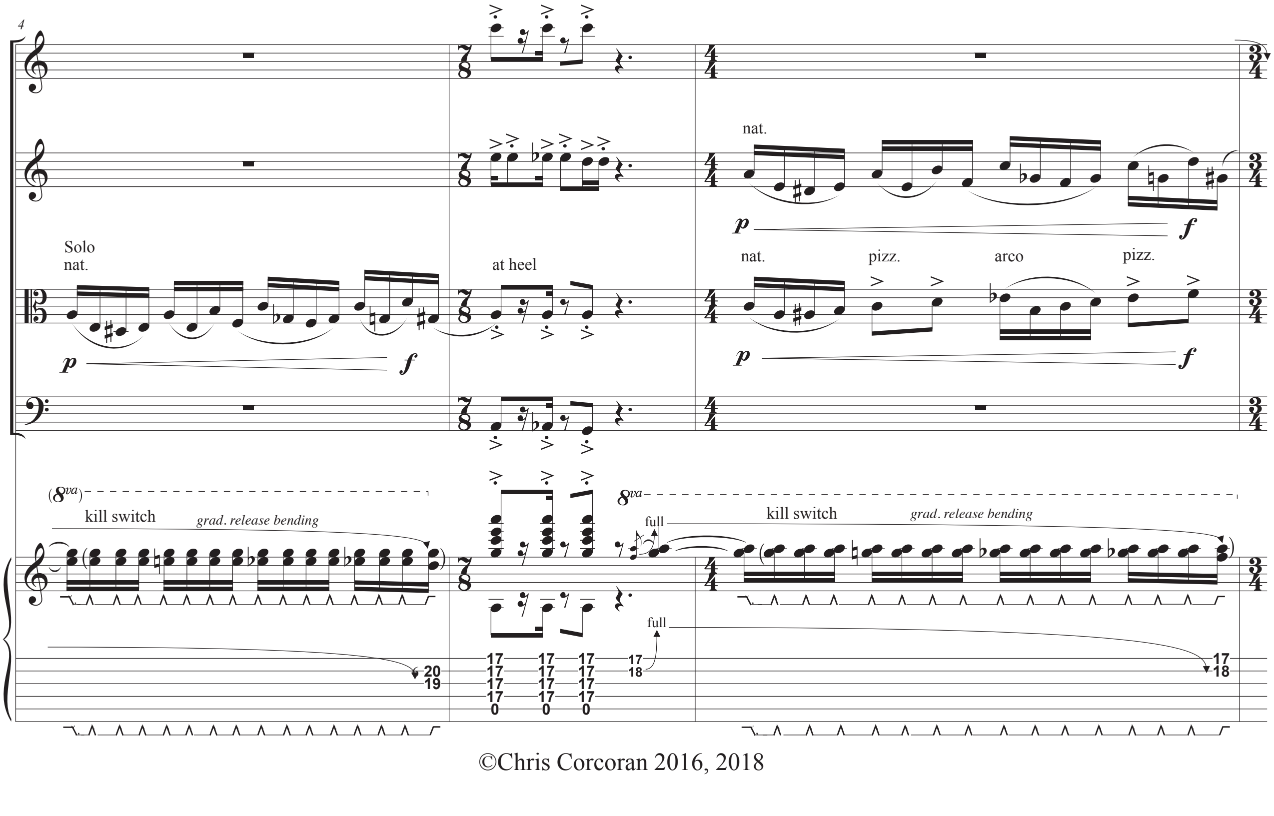
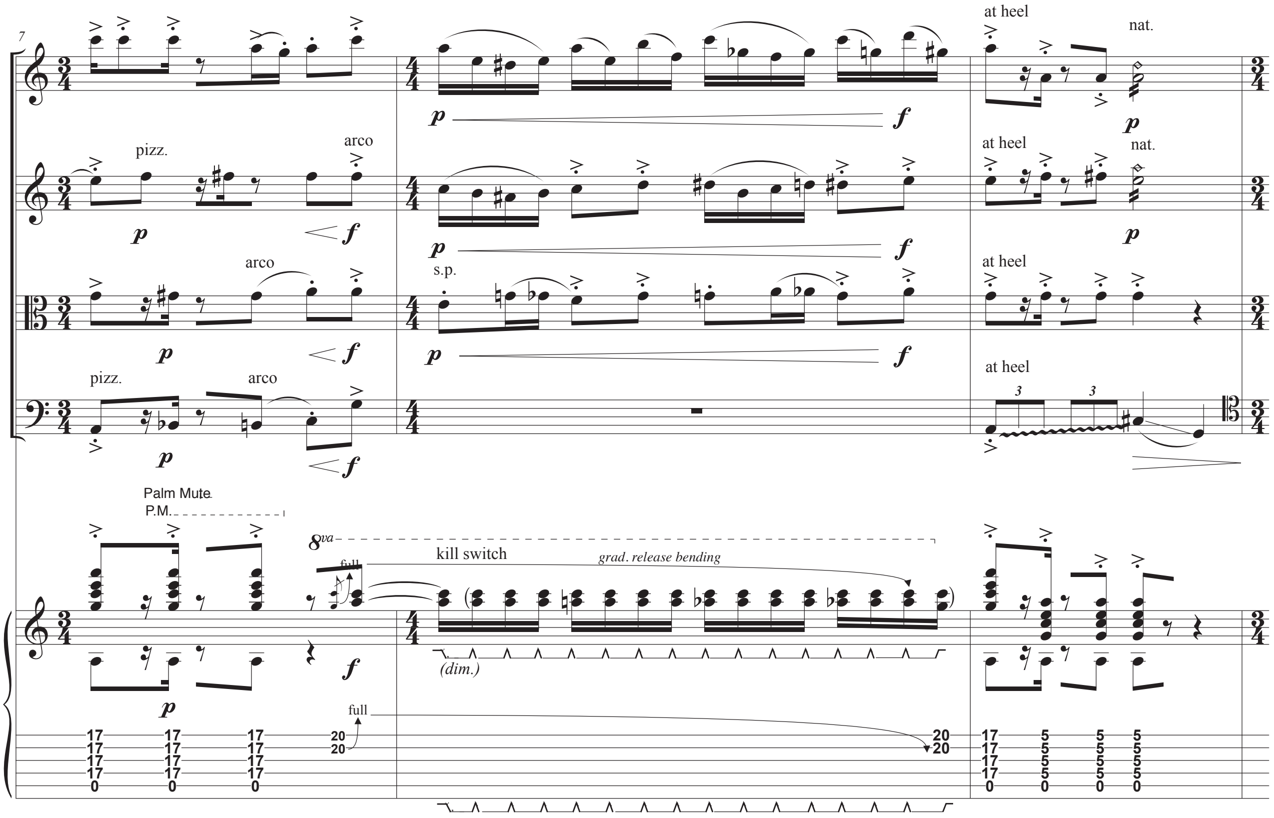
Dotted phrase markings in the guitar part indicate phrasing only and should not be read as slurs.

Score

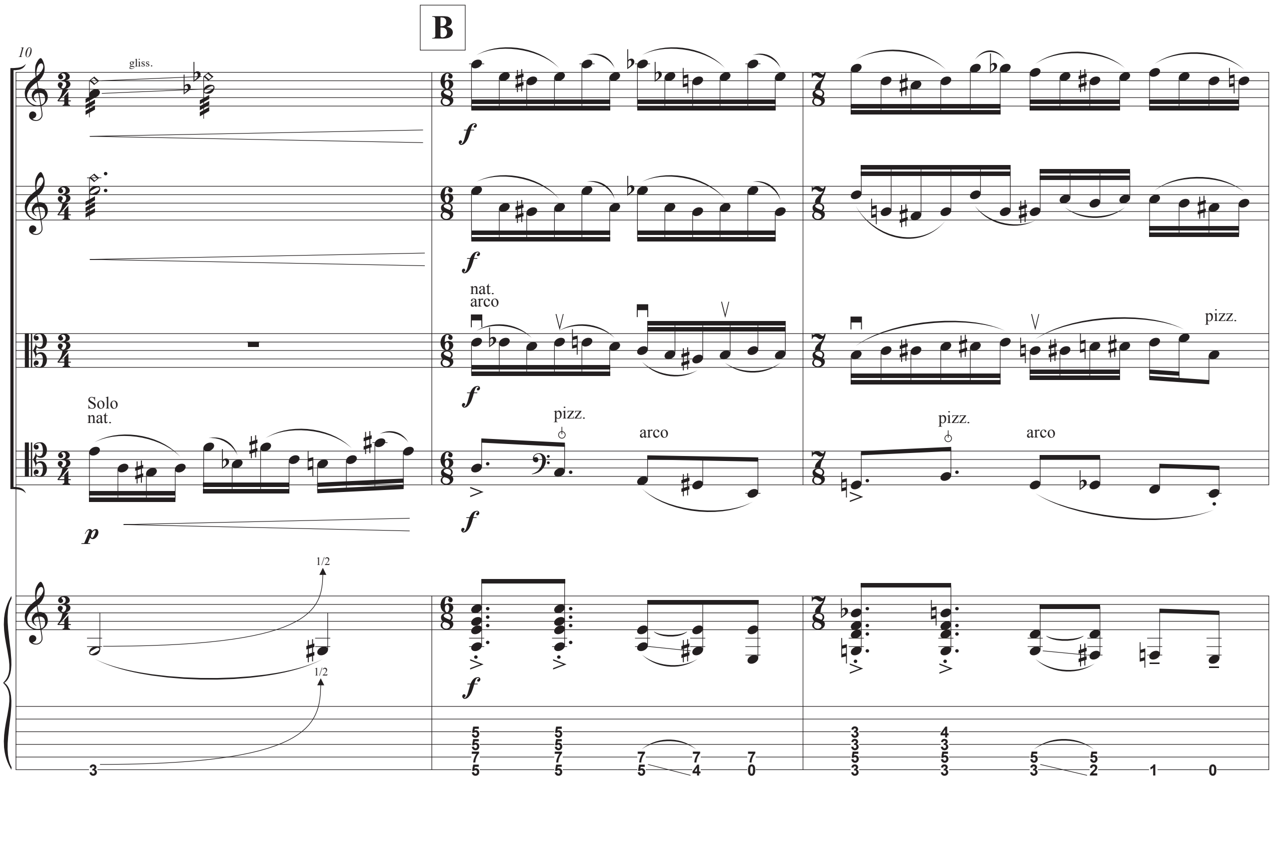
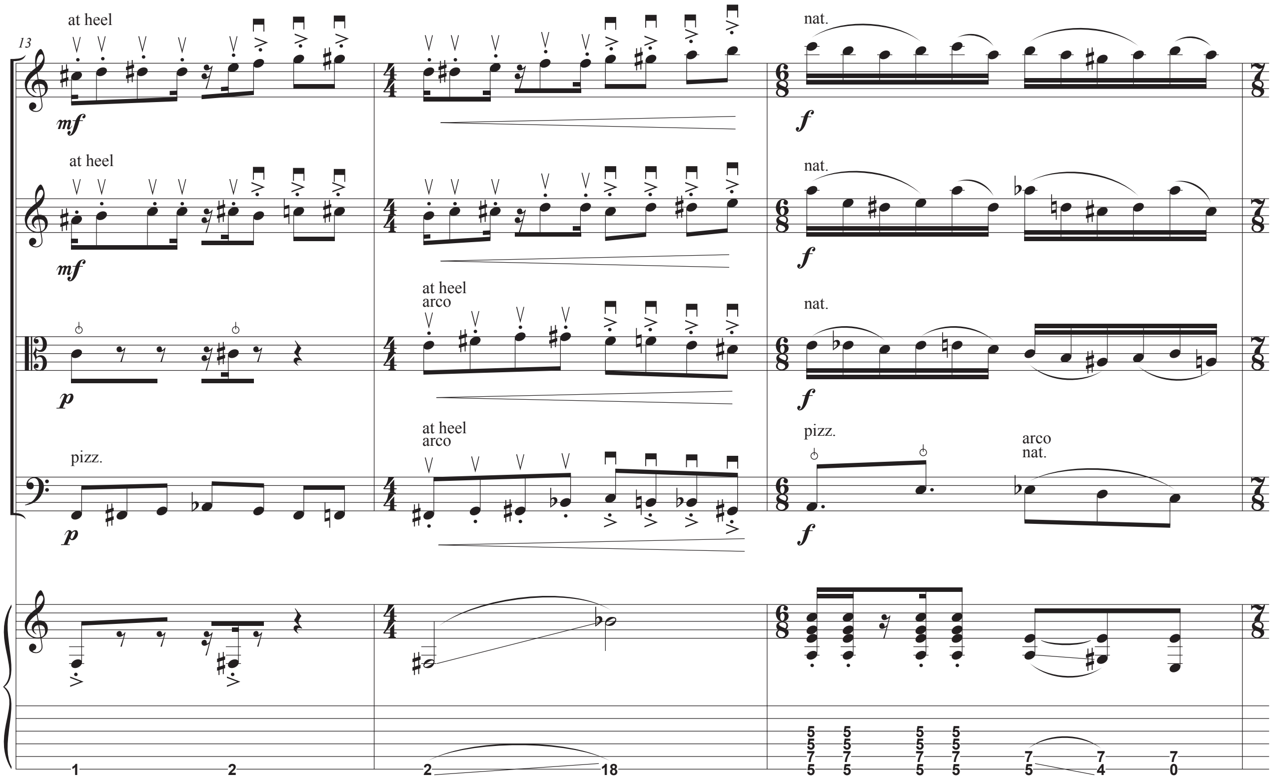
written for the guitarist Heiko Ossig

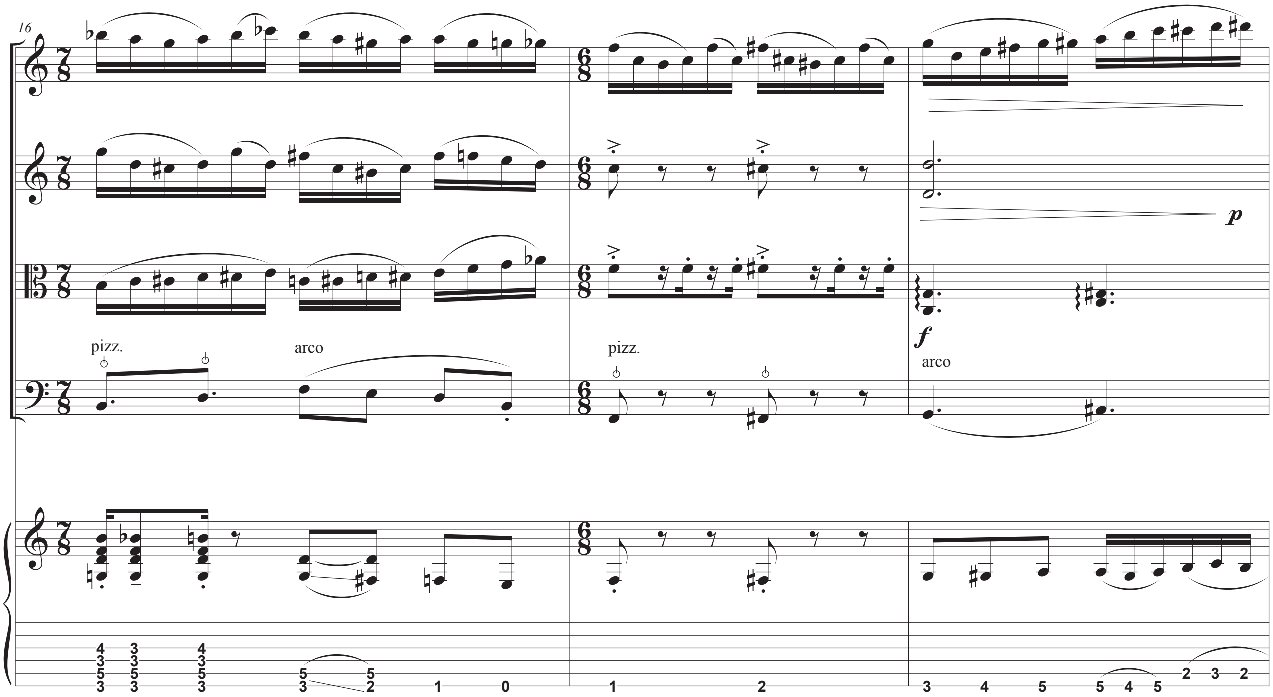
Electric Quintet

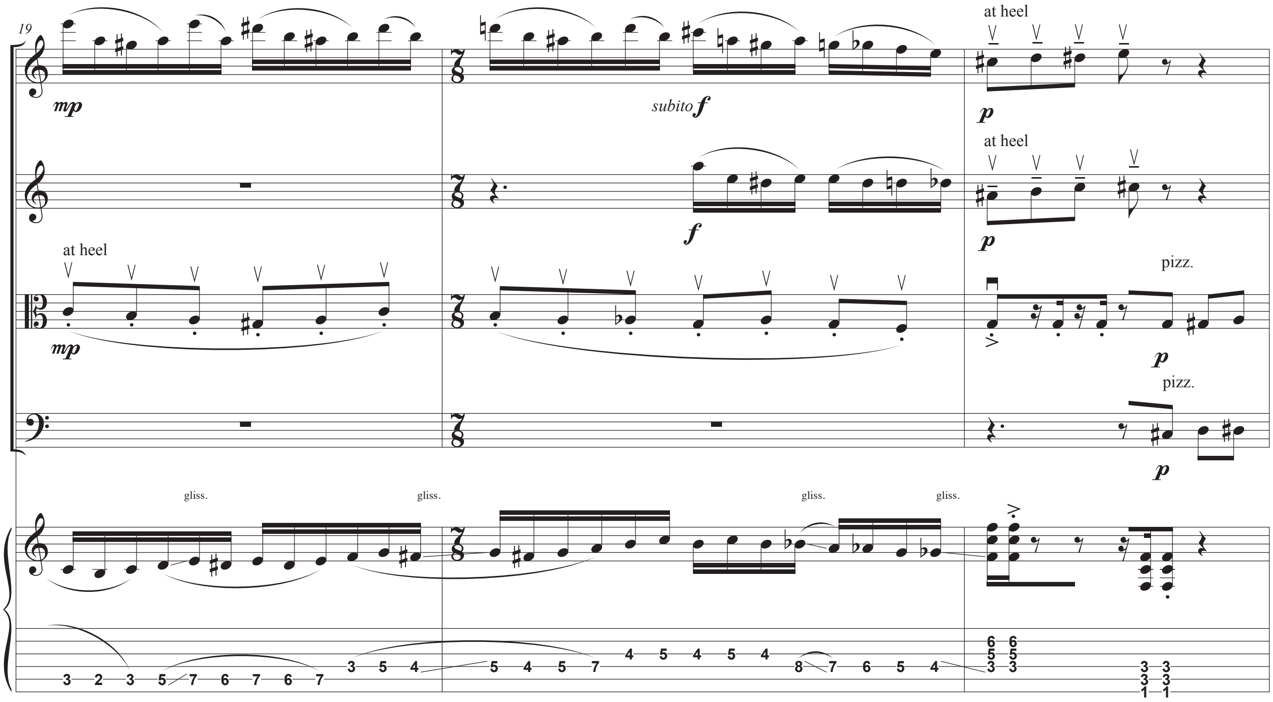
for electric guitar and string quartet

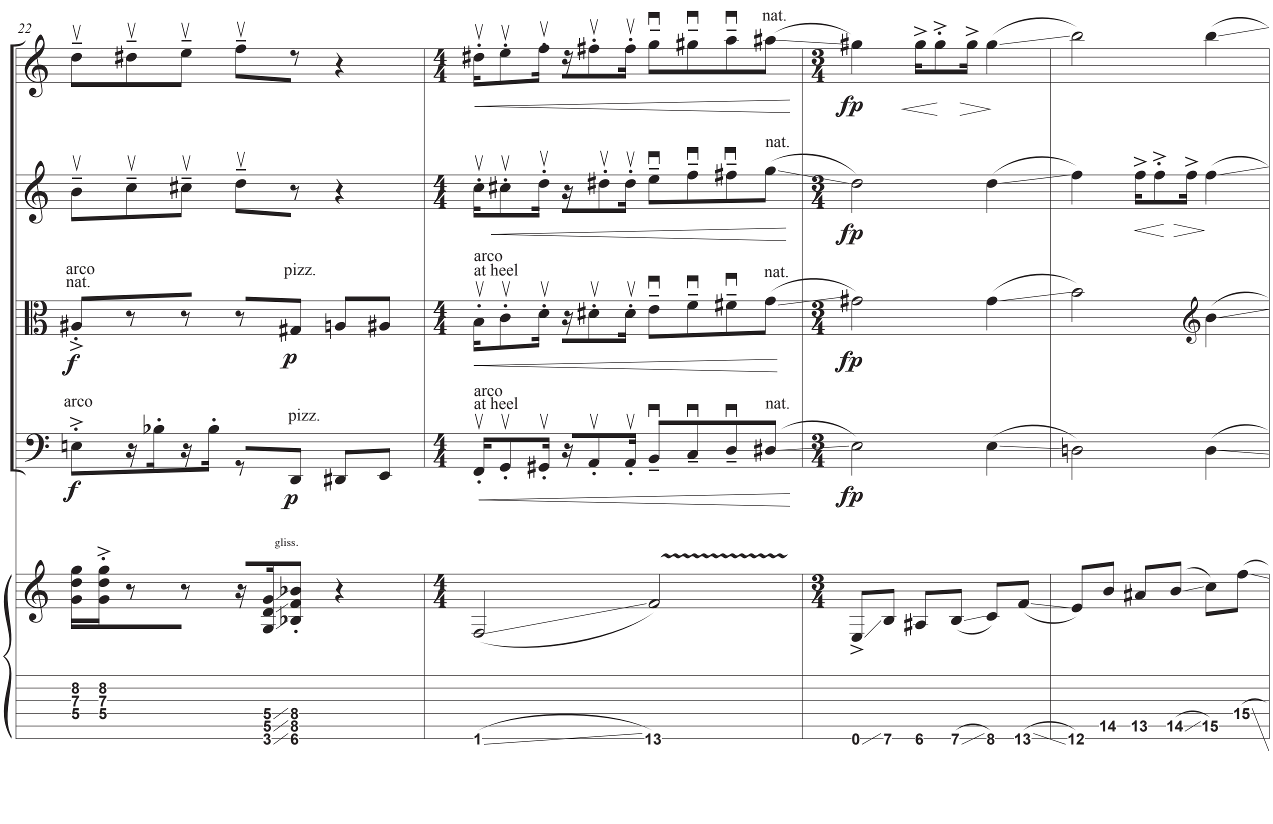
Chris Corcoran



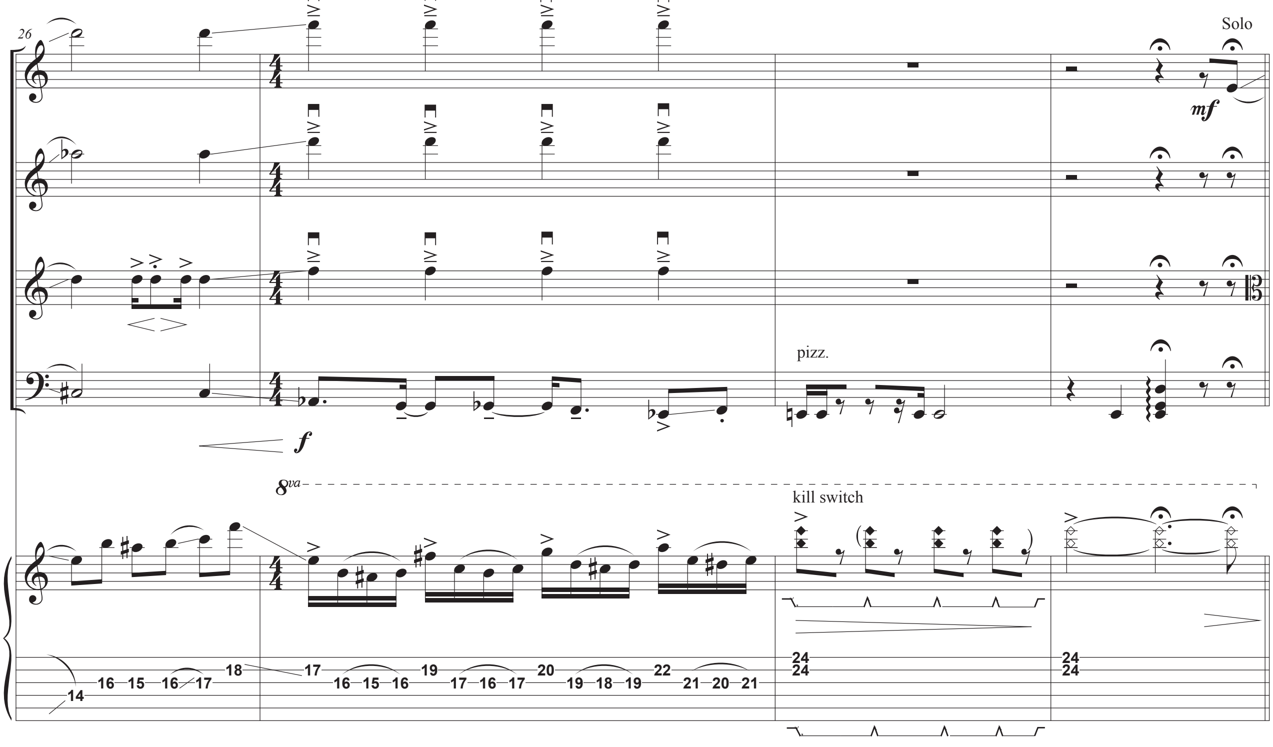

pizz.
arco
at heel
nat.
s.p.
Palm Mute
P.M.
8va
full
kill switch
grad. release bending
(dim.)

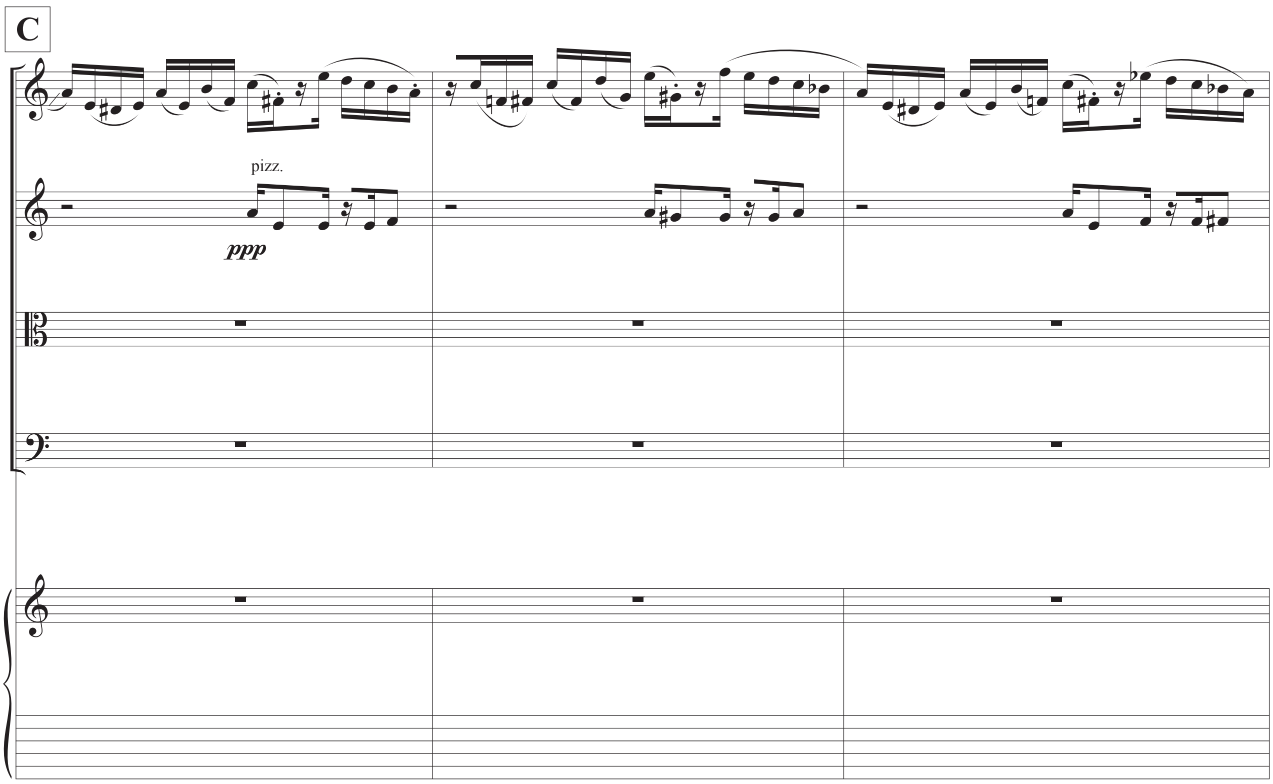

B
gliss.
nat.
arco
pizz.
Solo
1/2
full


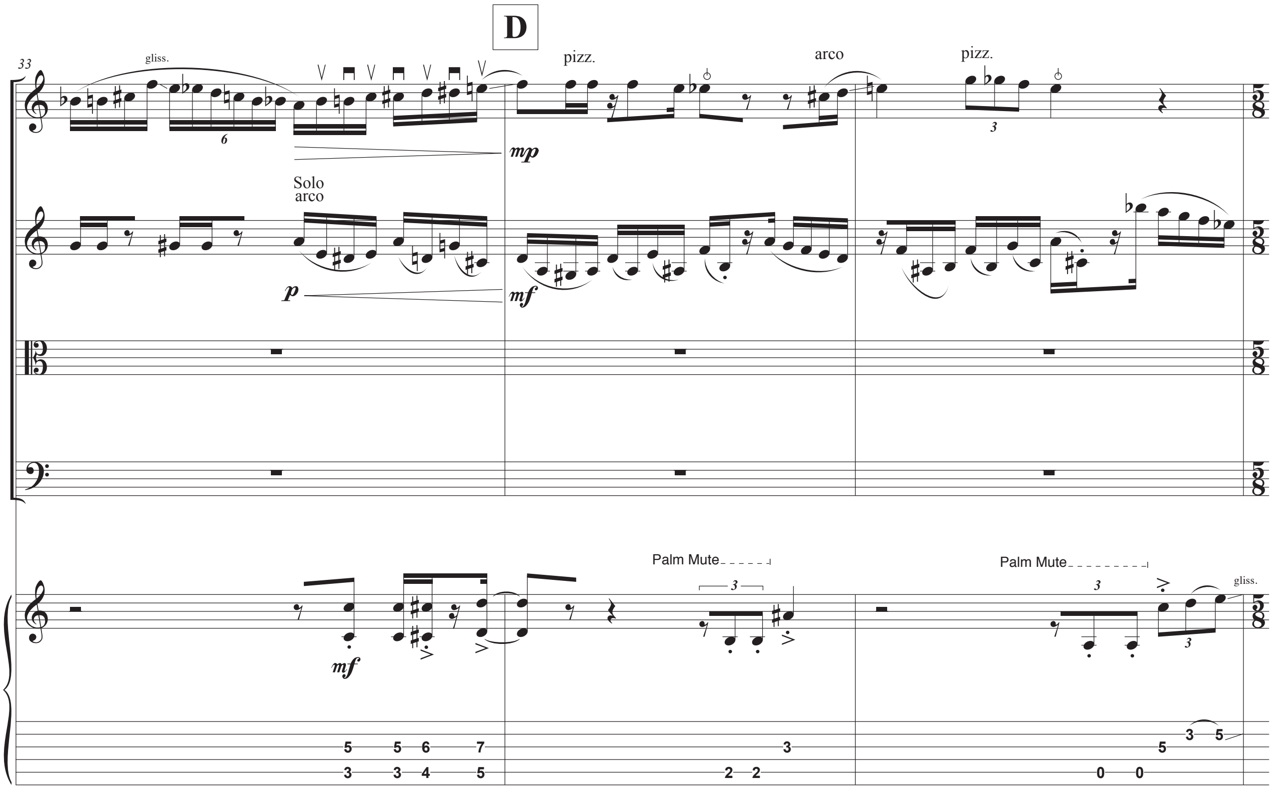
13
at heel
mf
at heel
mf
p
pizz.
p
at heel
arco
at heel
arco
nat.
f
nat.
f
nat.
f
pizz.
arco
nat.
f


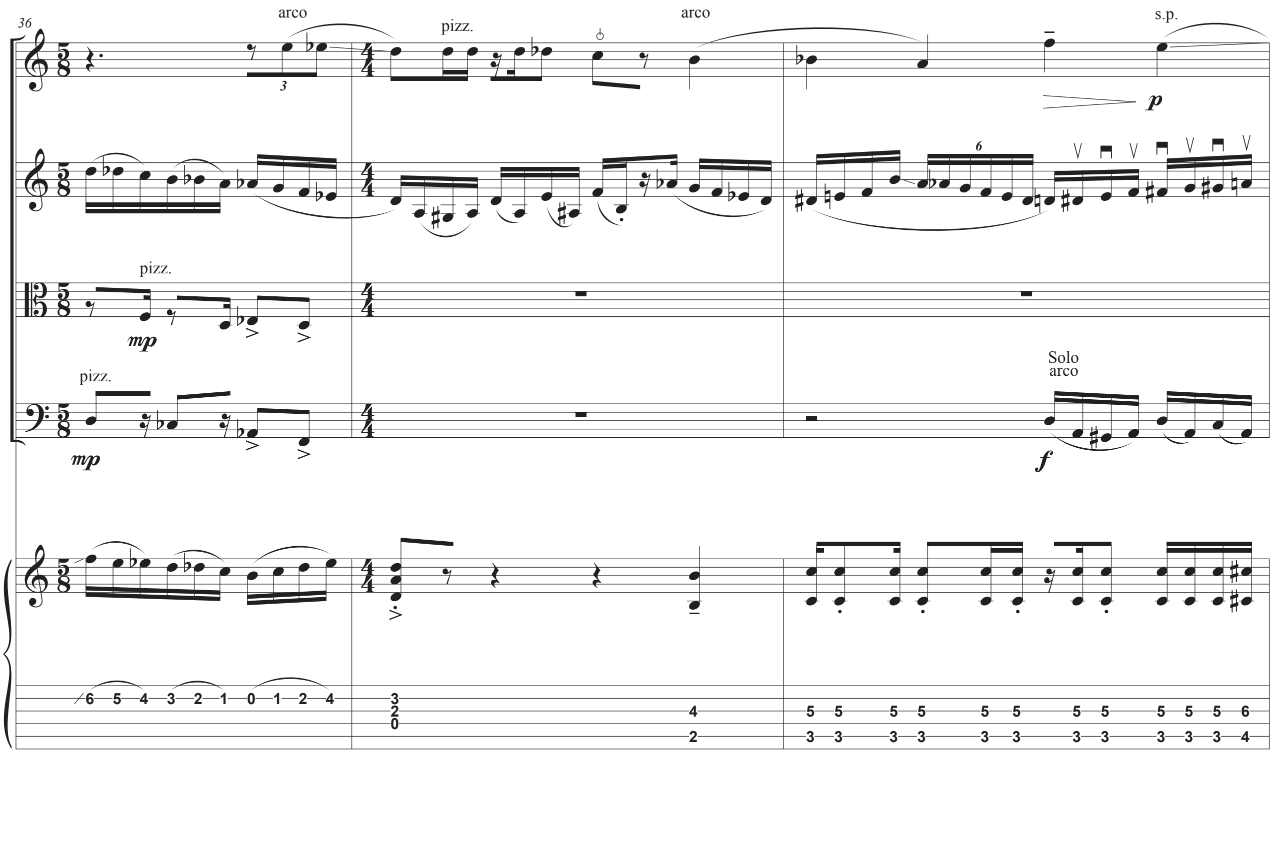
16
pizz.
arco
pizz.
p
f
arco


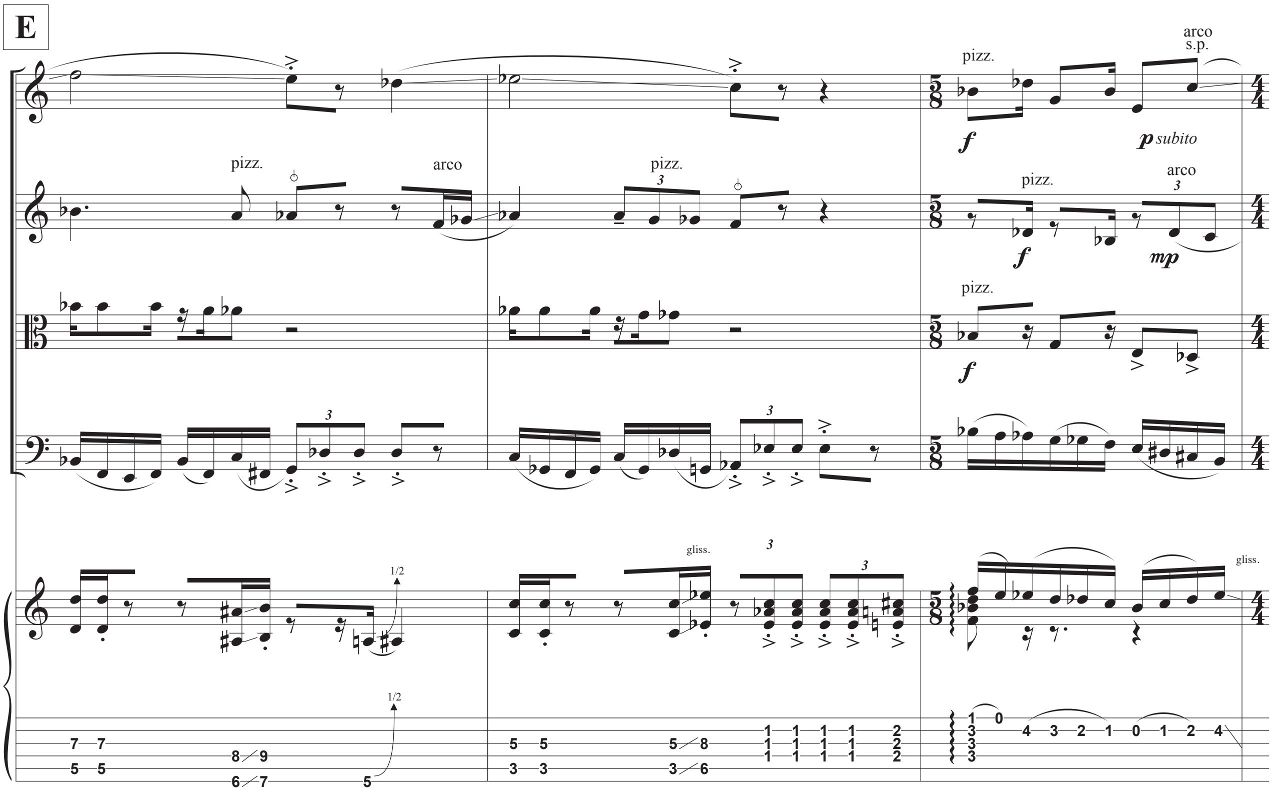
19
mp
subito f
at heel
p
f
at heel
mp
pizz.
p
pizz.
p
gliss.
gliss.
gliss.
gliss.


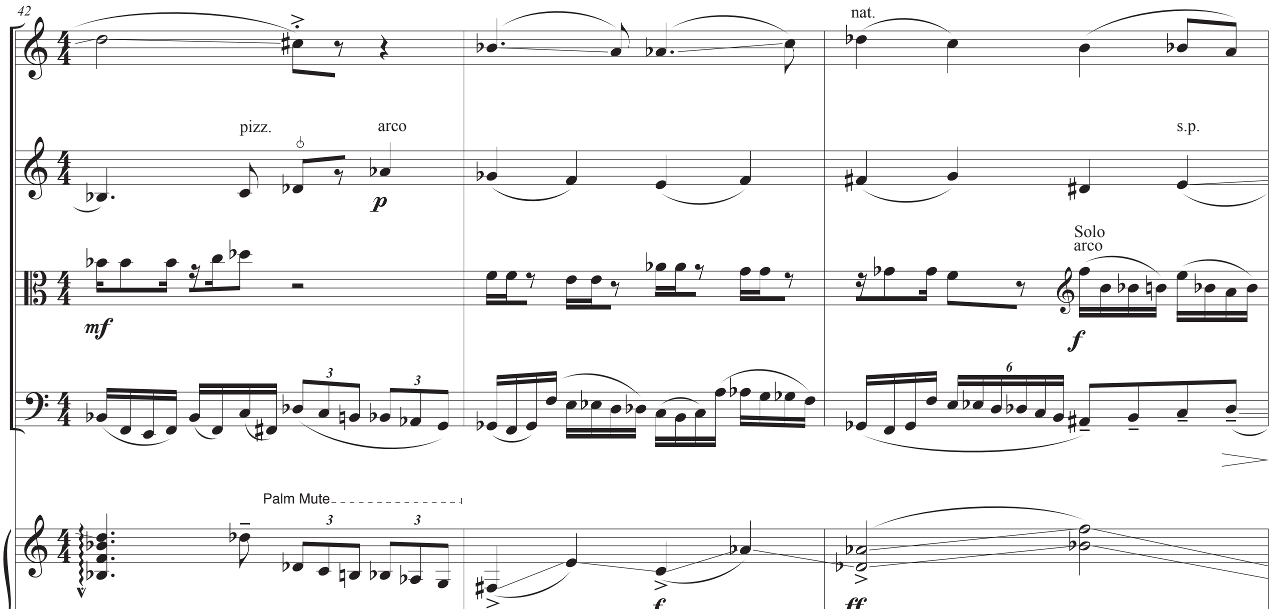
22
nat.
fp
nat.
fp
arco
nat.
pizz.
f
p
arco
at heel
nat.
fp
arco
pizz.
f
p
arco
at heel
nat.
fp
gliss.


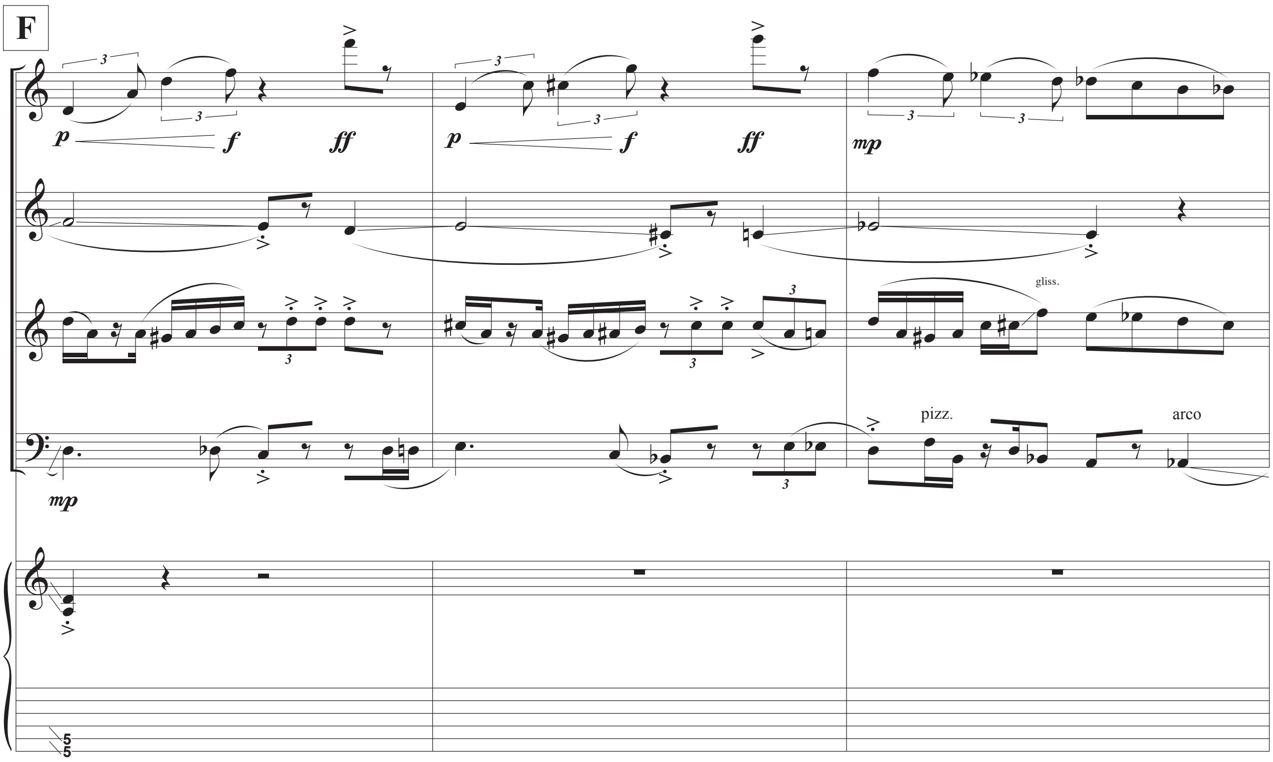
26
Solo
pizz.
8va
kill switch


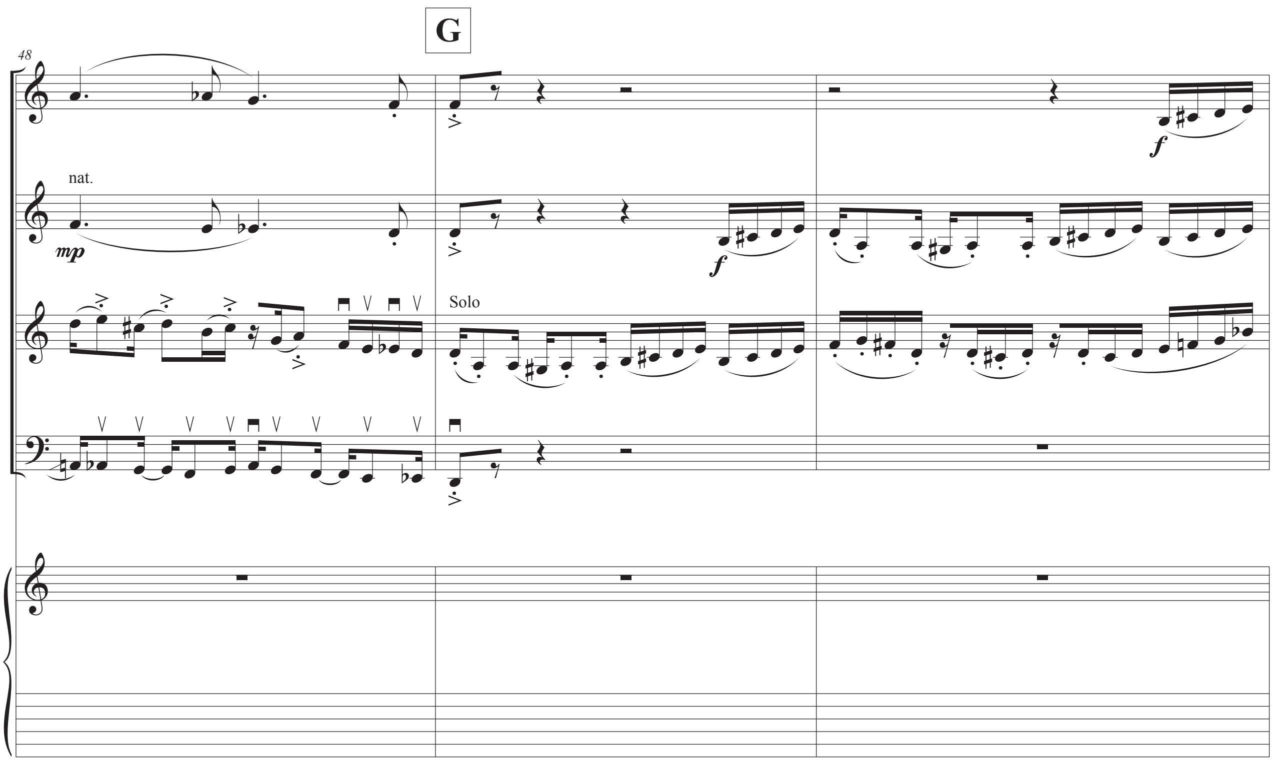
C
pizz.


D
33
gliss.
pizz.
arco
pizz.
mp
Solo
arco
p
mf
Palm Mute
Palm Mute
mf
gliss.


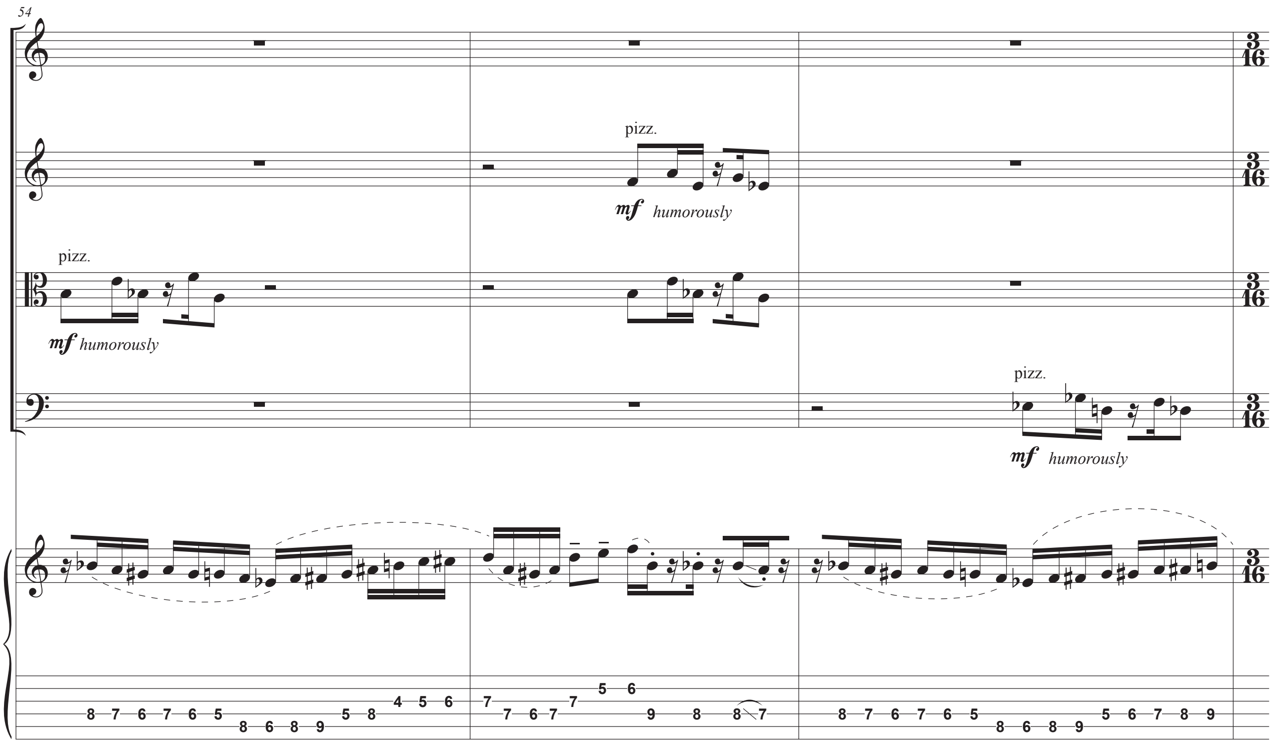
36
arco
pizz.
arco
s.p.
p
pizz.
mp
pizz.
mp
Solo
arco
f


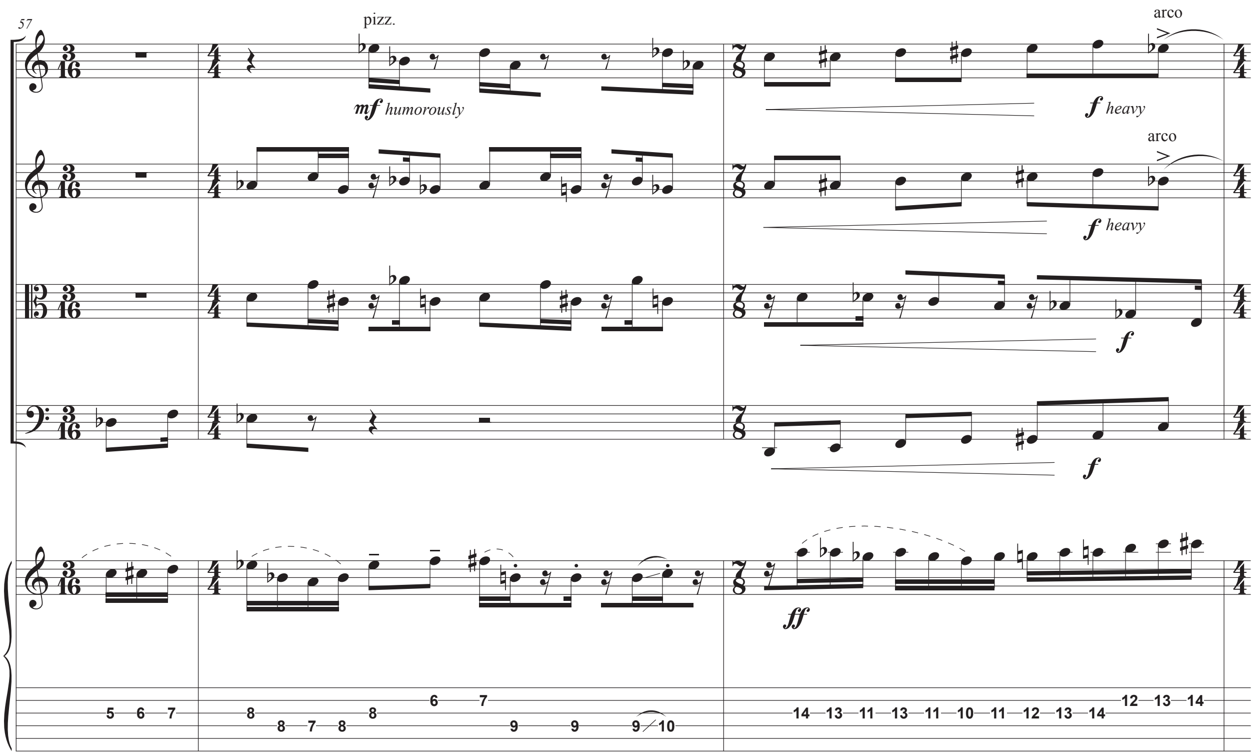
E
pizz.
arco
s.p.
p subito
pizz.
arco
mp
pizz.
gliss.
1/2


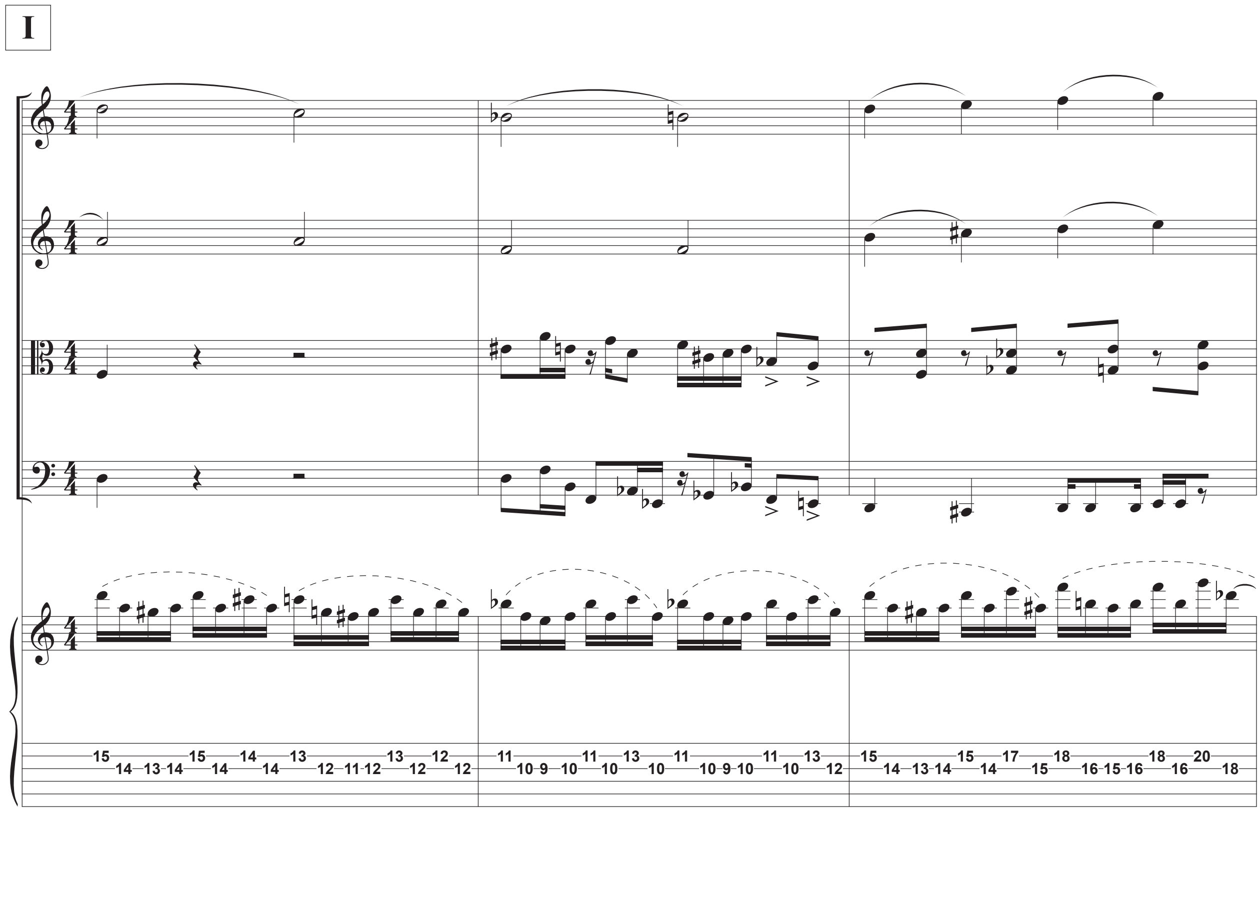
42
pizz.
arco
nat.
s.p.
Solo
arco
mf
Palm Mute
ff


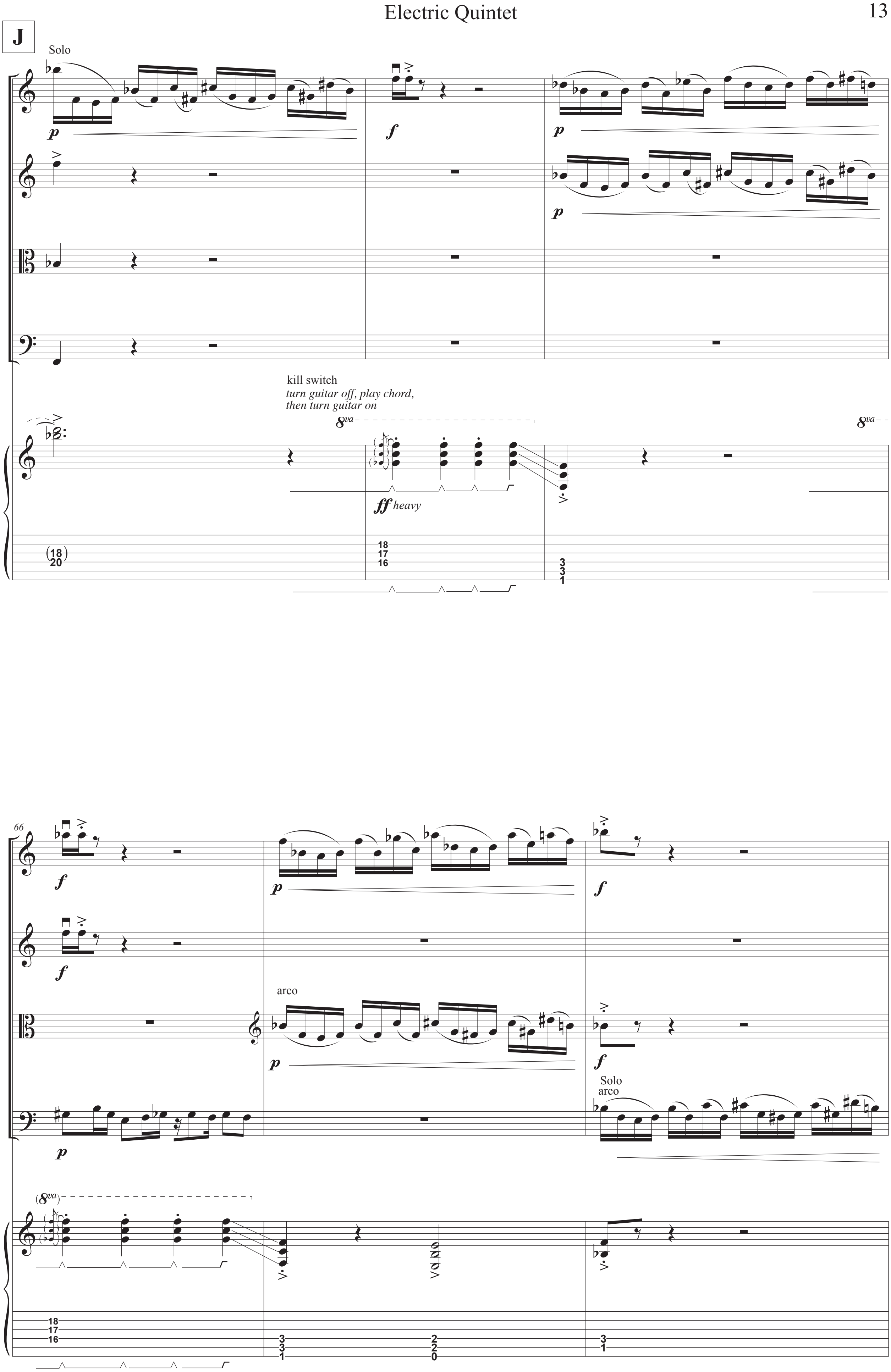
F
p
f
ff
mp
gliss.
pizz.
arco


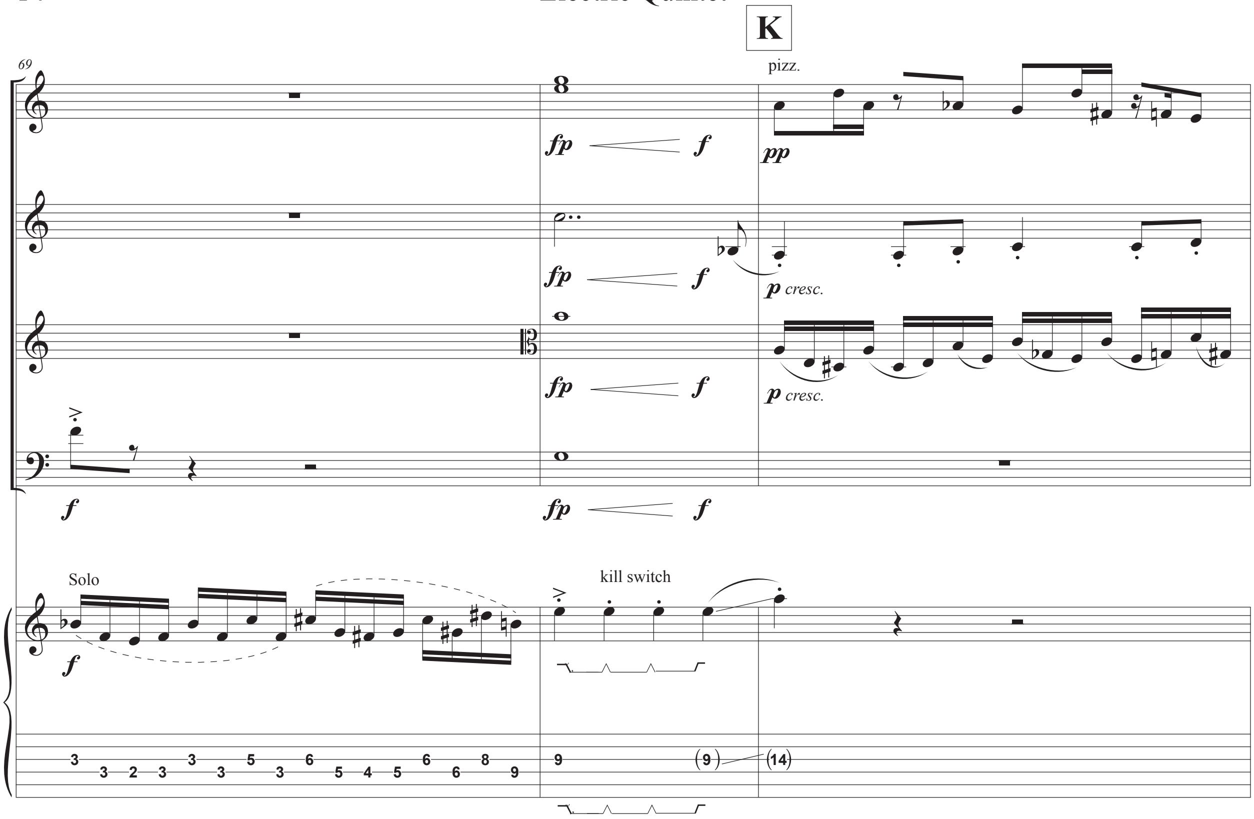
48
G
nat.
mp
f
Solo

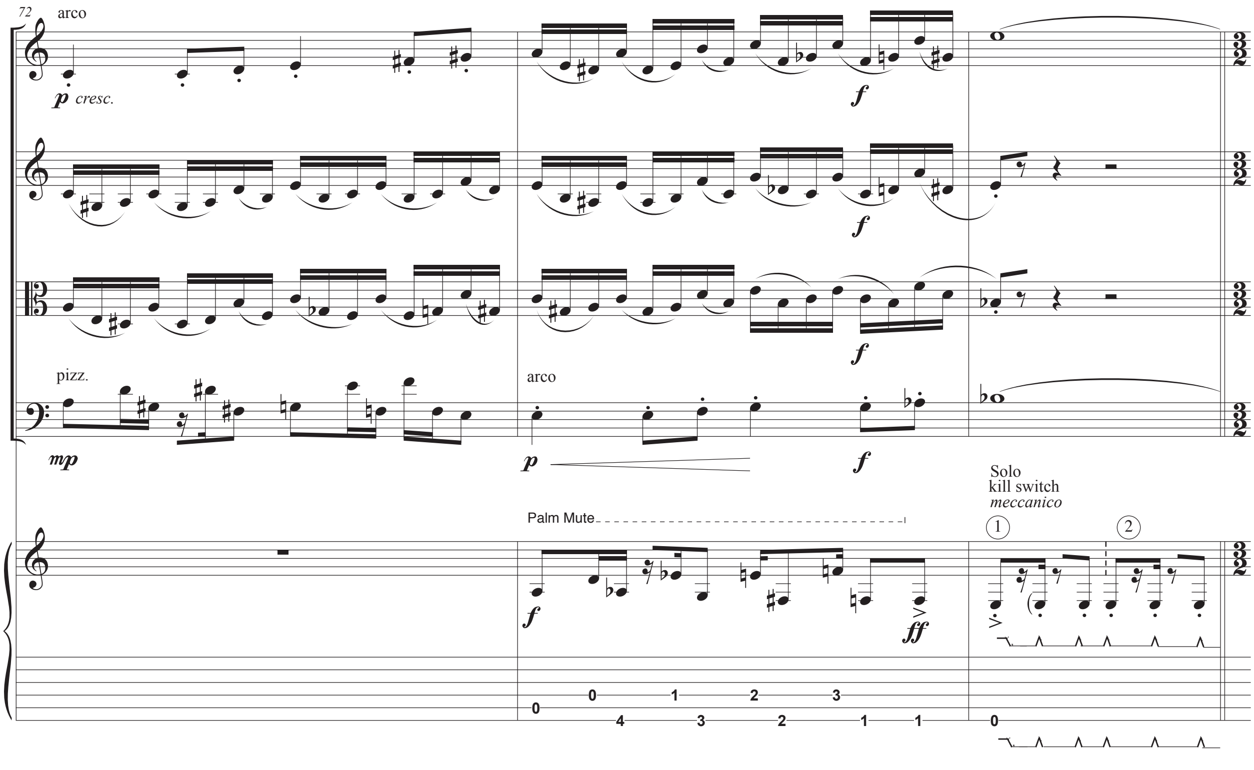

H
51
f
Solo
f


54
pizz.
mf humorously
pizz.
mf humorously
pizz.
mf humorously


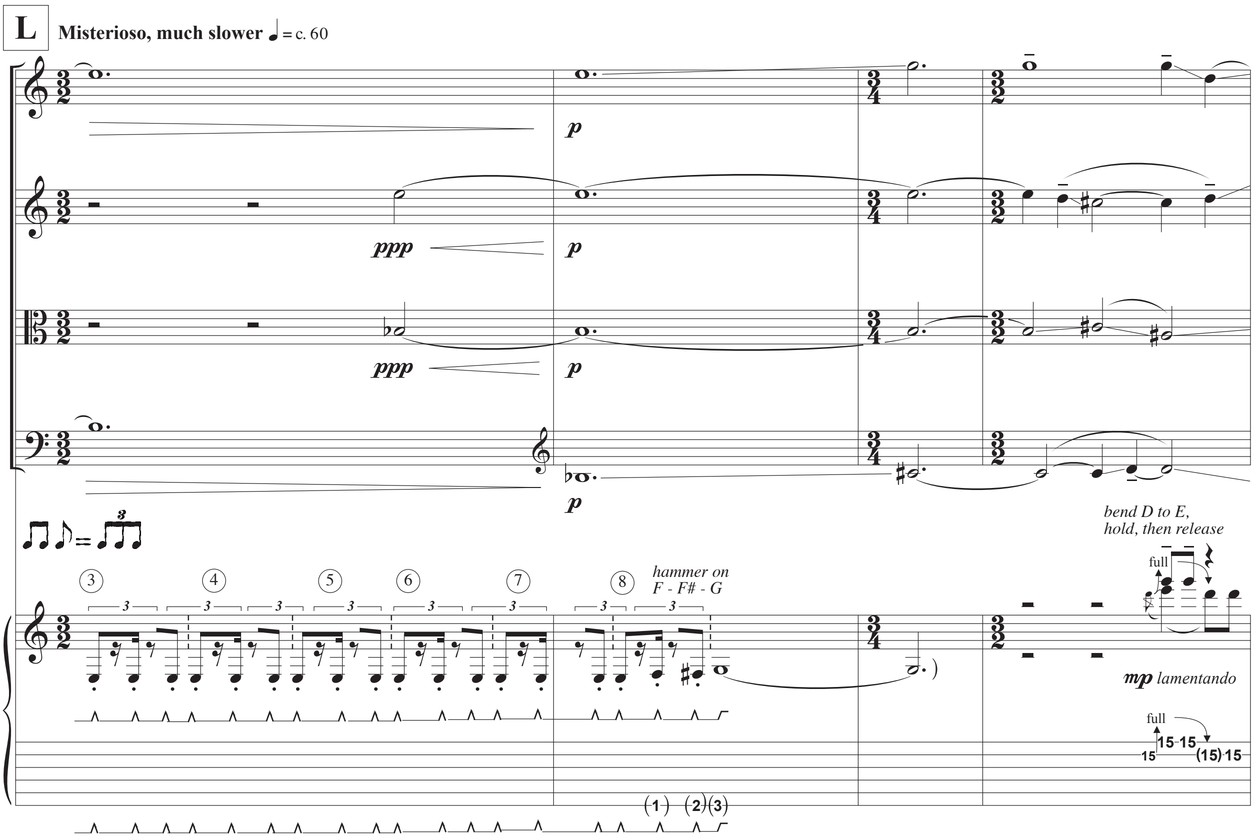
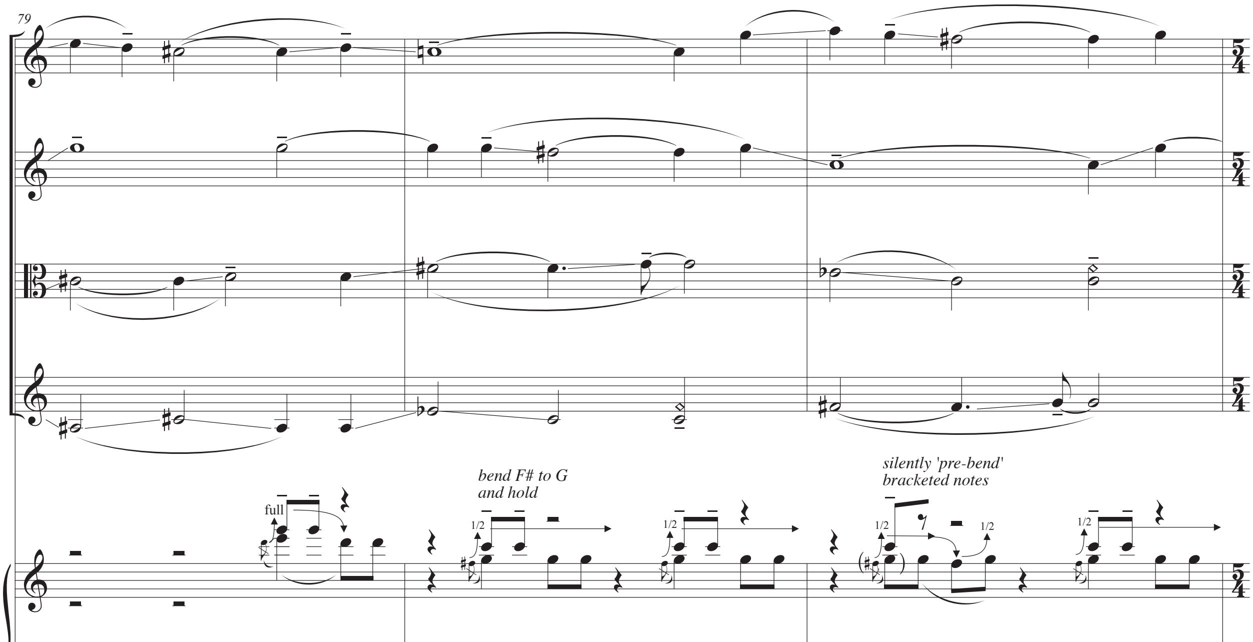
57
pizz.
mf humorously
arco
f heavy
arco
f heavy
f
f
ff


I


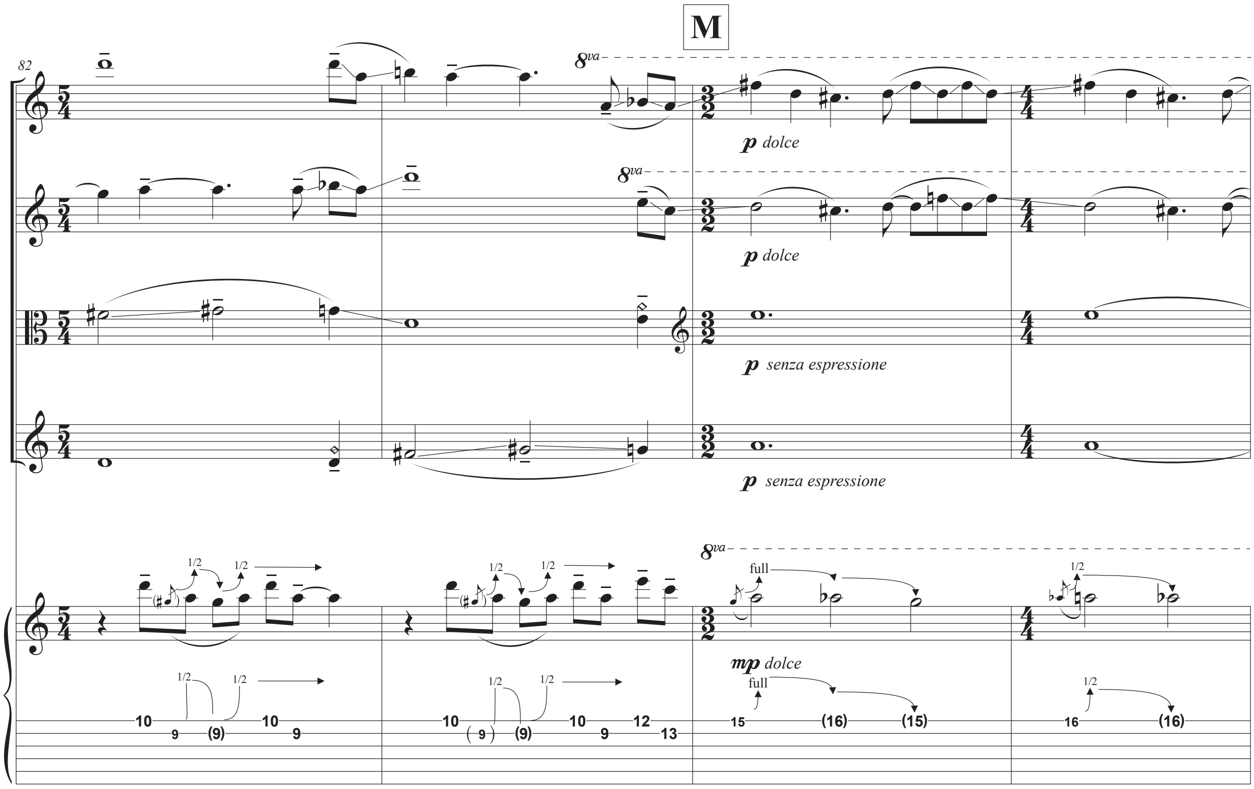
J
Solo
kill switch
turn guitar off, play chord,
then turn guitar on
heavy
66
arco
Solo
arco


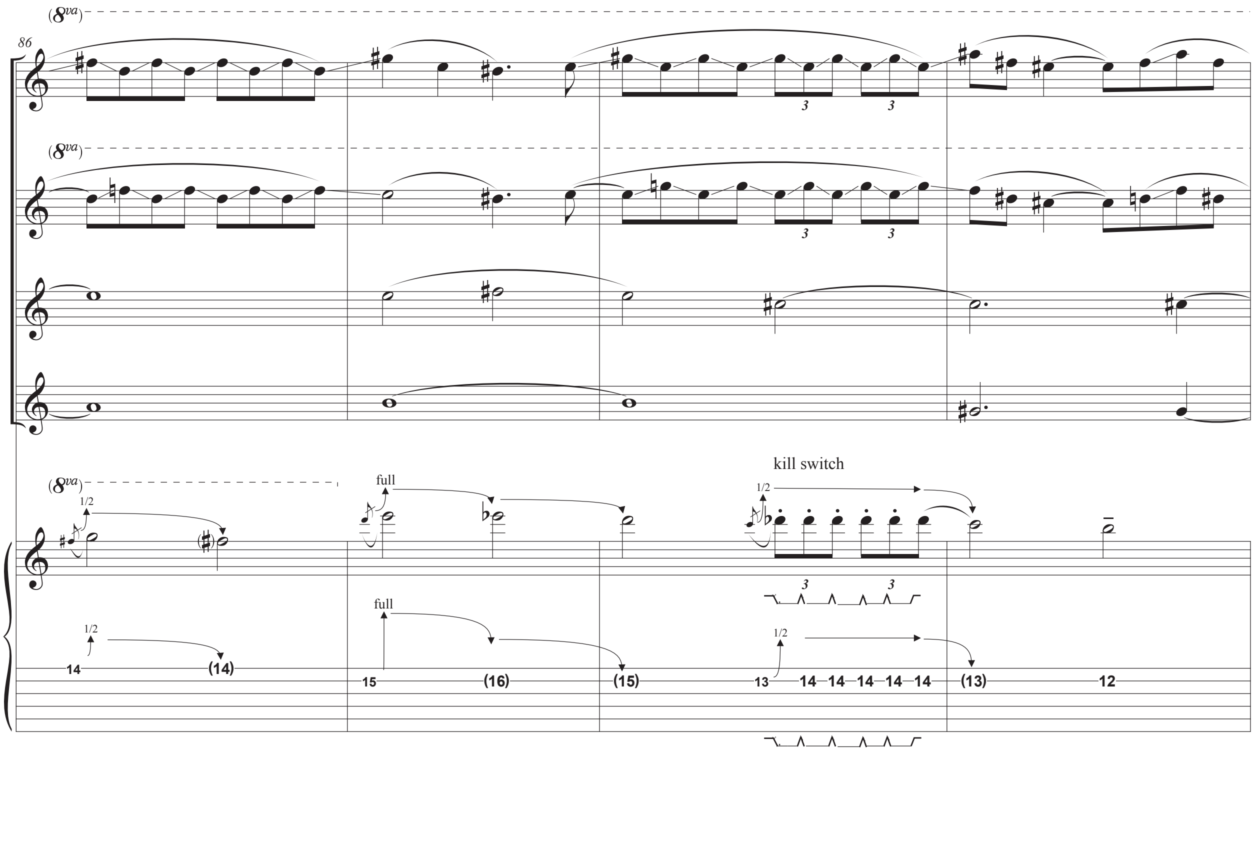
K
69
pizz.
fp
f
pp
p cresc.
p cresc.
Solo
kill switch


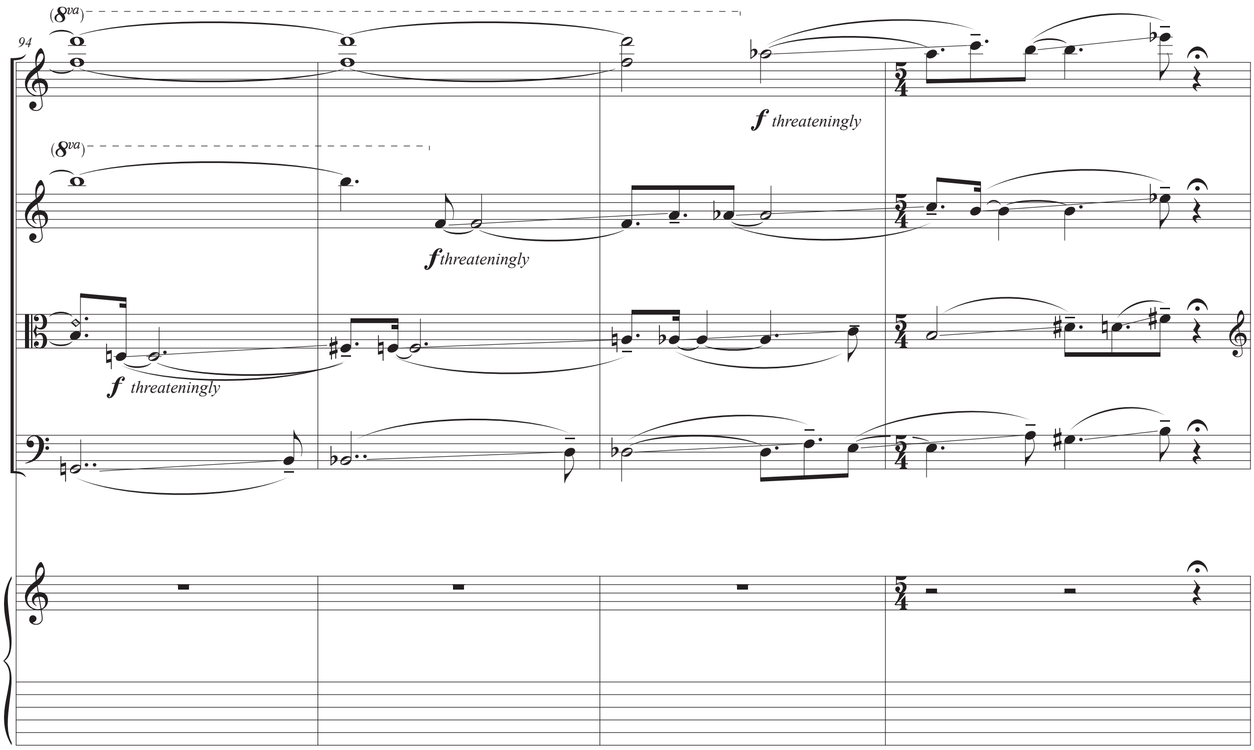
72
arco
p cresc.
pizz.
mp
arco
p
f
Palm Mute
ff
Solo
kill switch
meccanico

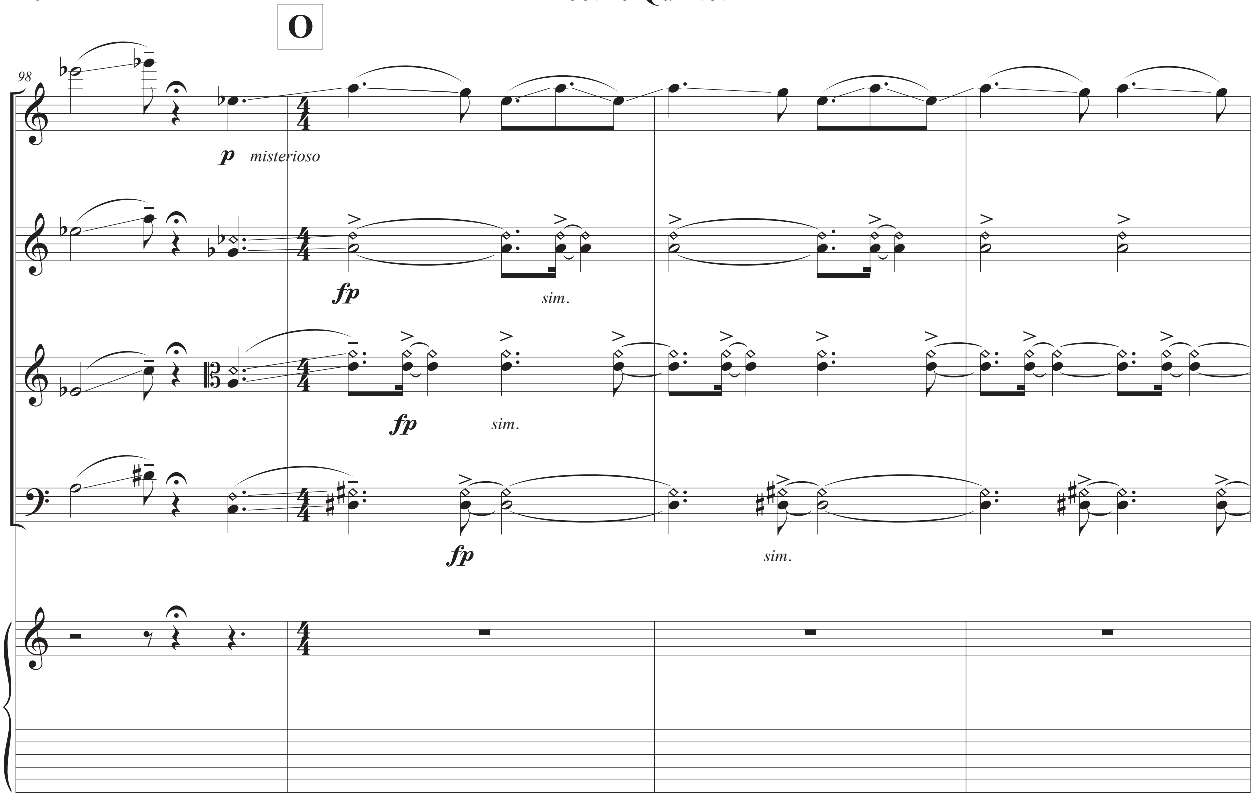

L
Misterioso, much slower ♩= c. 60
p
ppp
p
ppp
p
p
hammer on
F - F# - G
bend D to E,
hold, then release
full
mp lamentando
full
15 15 15 (15) 15
(1) (2) (3)


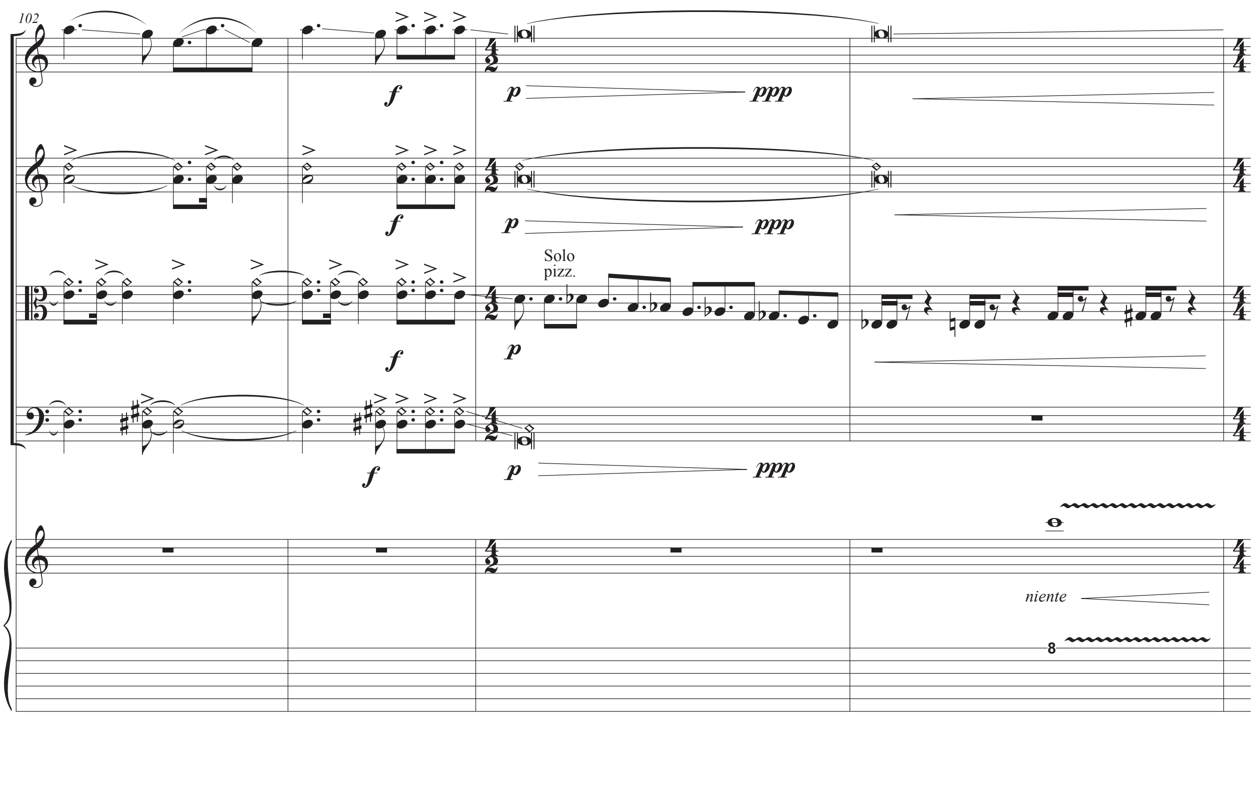
79
full
bend F# to G
and hold
1/2
silently 'pre-bend'
bracketed notes
full
15 15 15 (15) 15
8 8 7 7 7
(7) 7 (7) (7)


M
82
8va
p dolce
p dolce
p senza espressione
p senza espressione
mp dolce
full
1/2

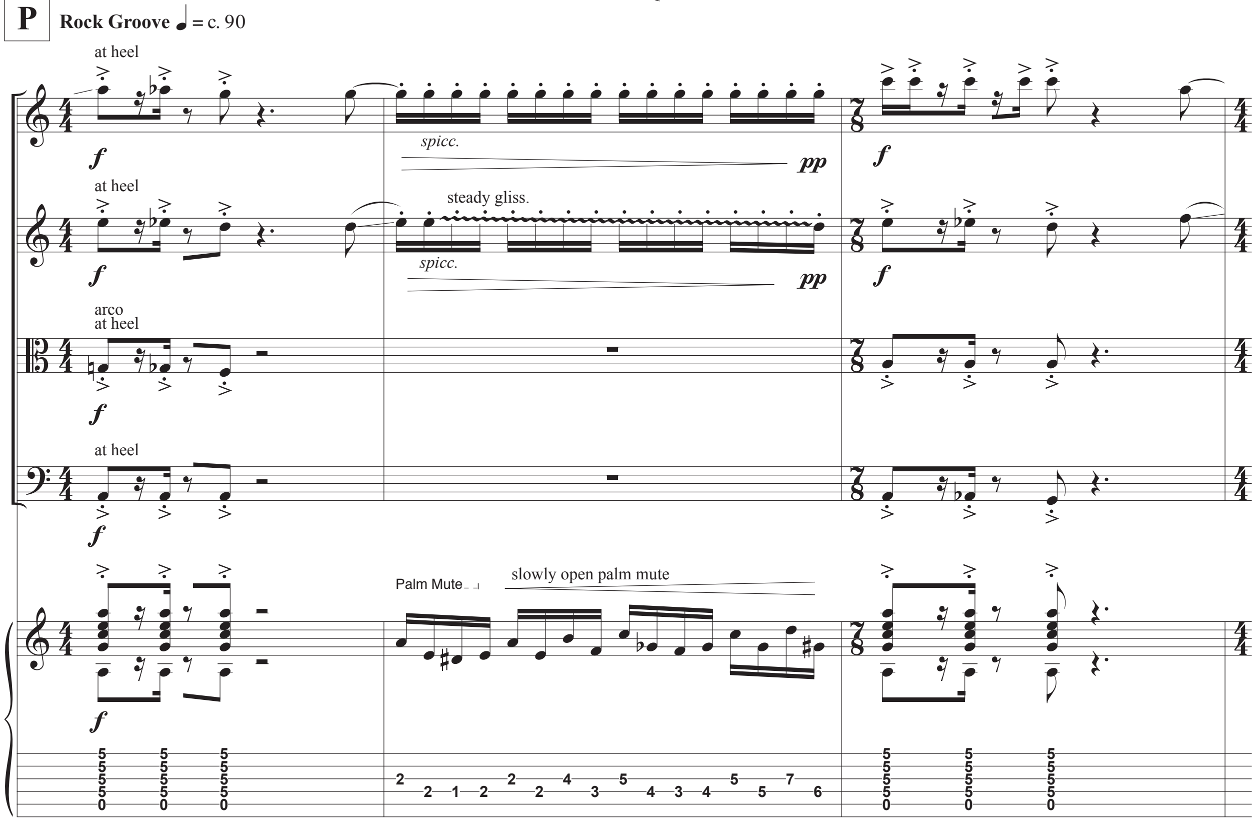
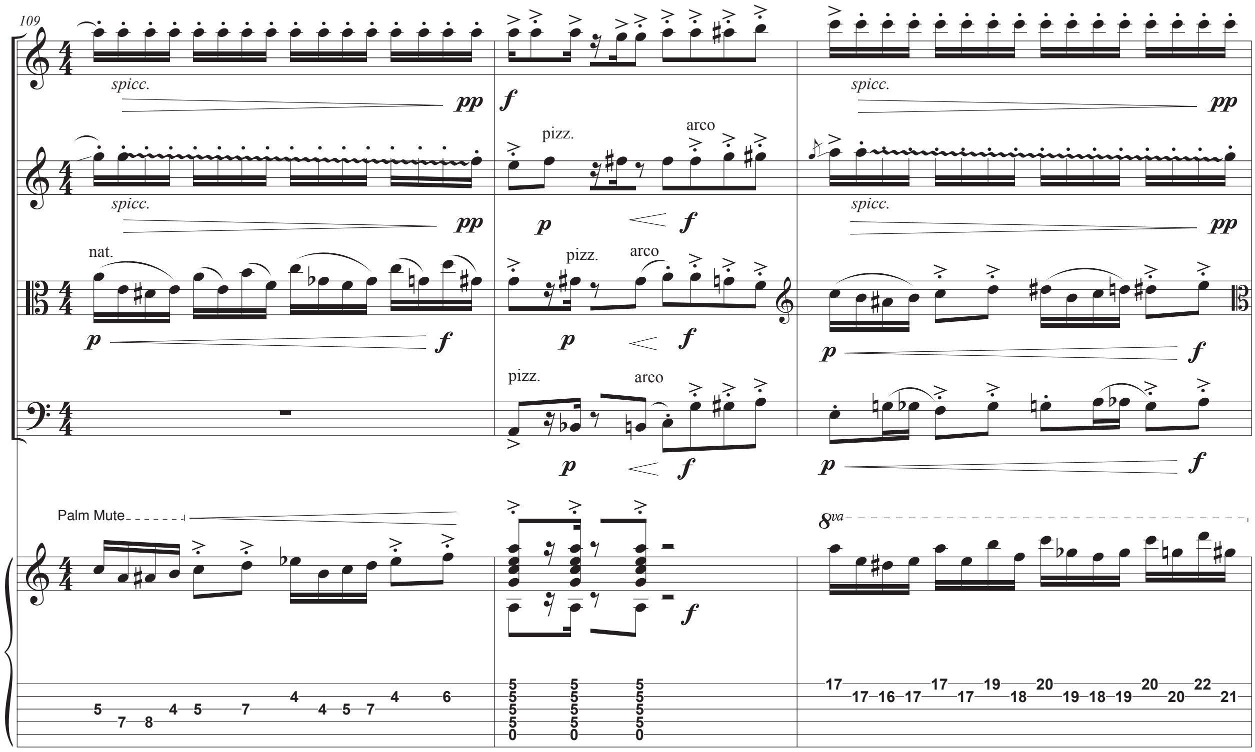

86
(8va)
full
1/2
kill switch

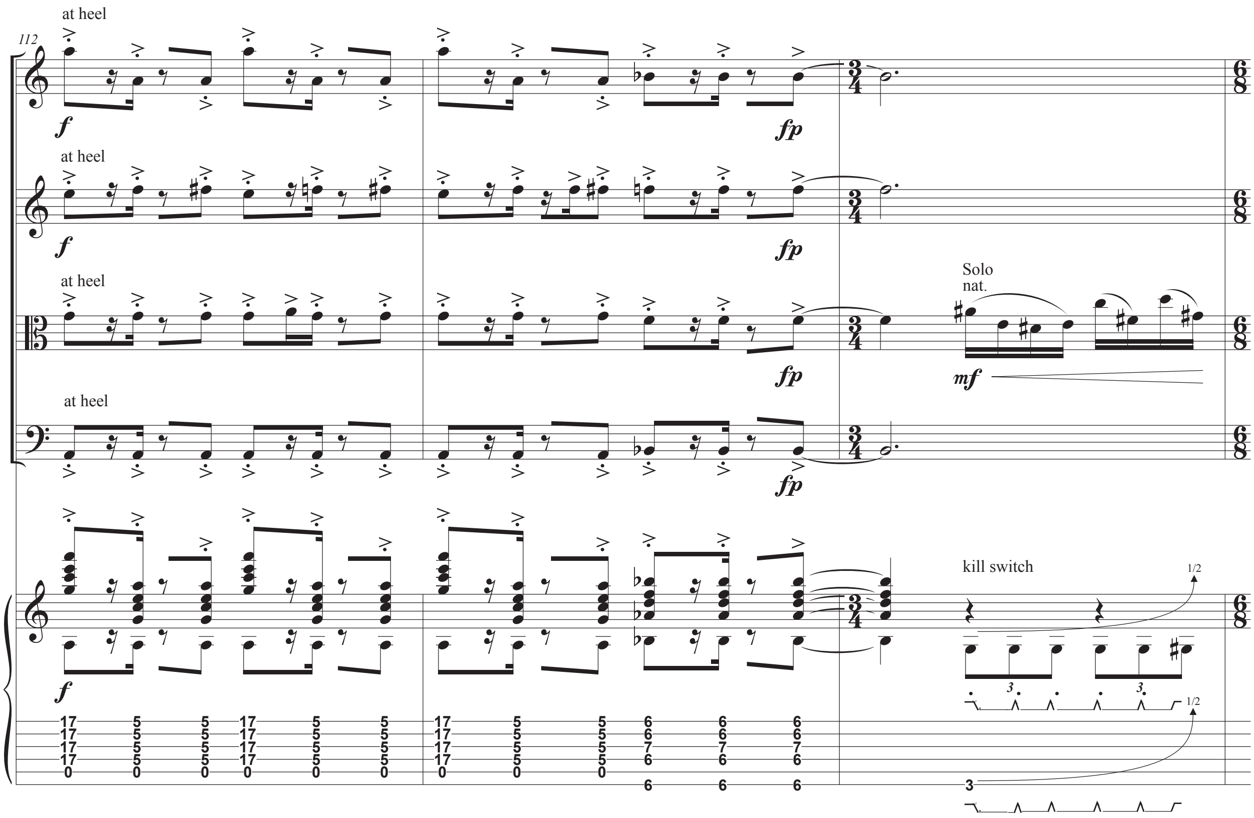

N
Faster ♩ = c. 90
(8va)
90
cresc.
(8va)
cresc.
fp senza espressione
fp senza espressione
fp senza espressione
f threateningly
1/2
1/2
1/2
1/2
11
10
9
7
6
5
7
7
(7)


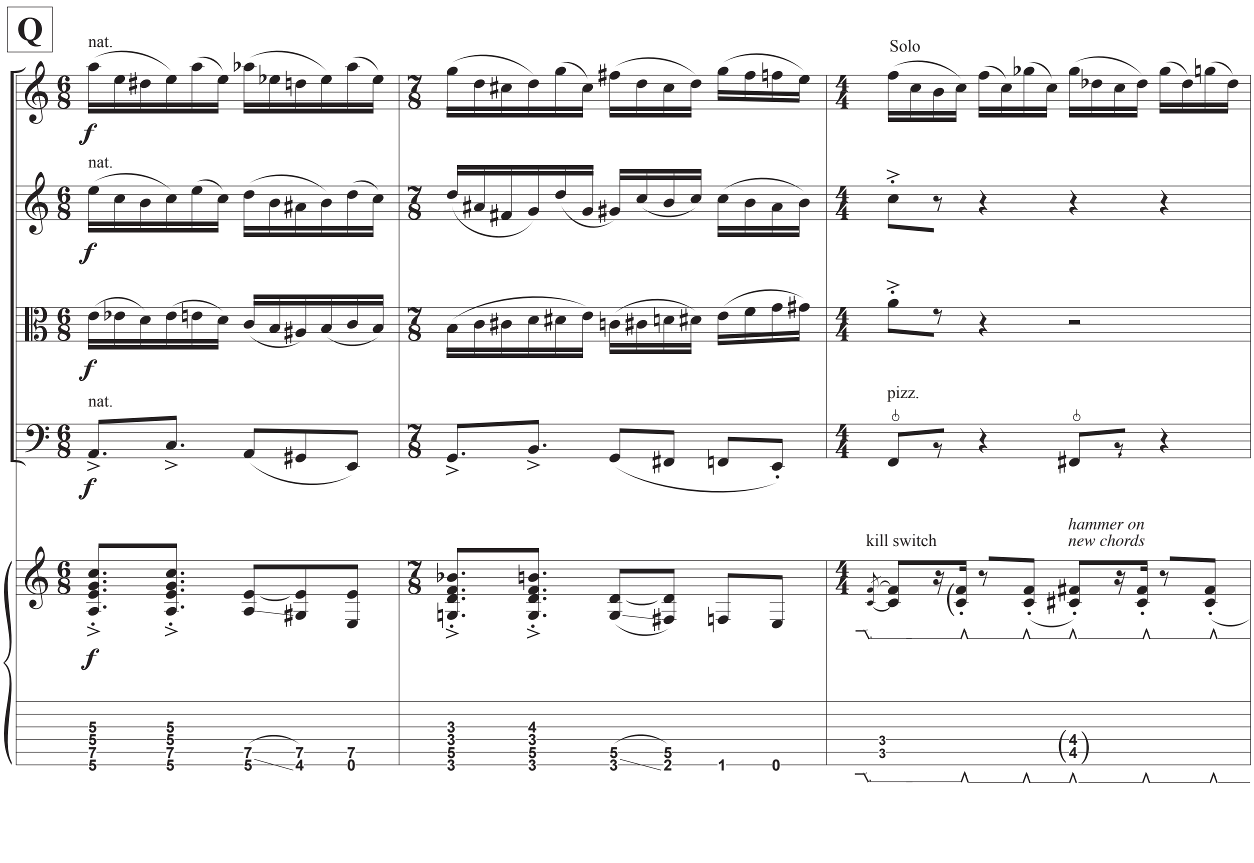
(8va)
94
f threateningly
(8va)
f threateningly
f threateningly
5
4


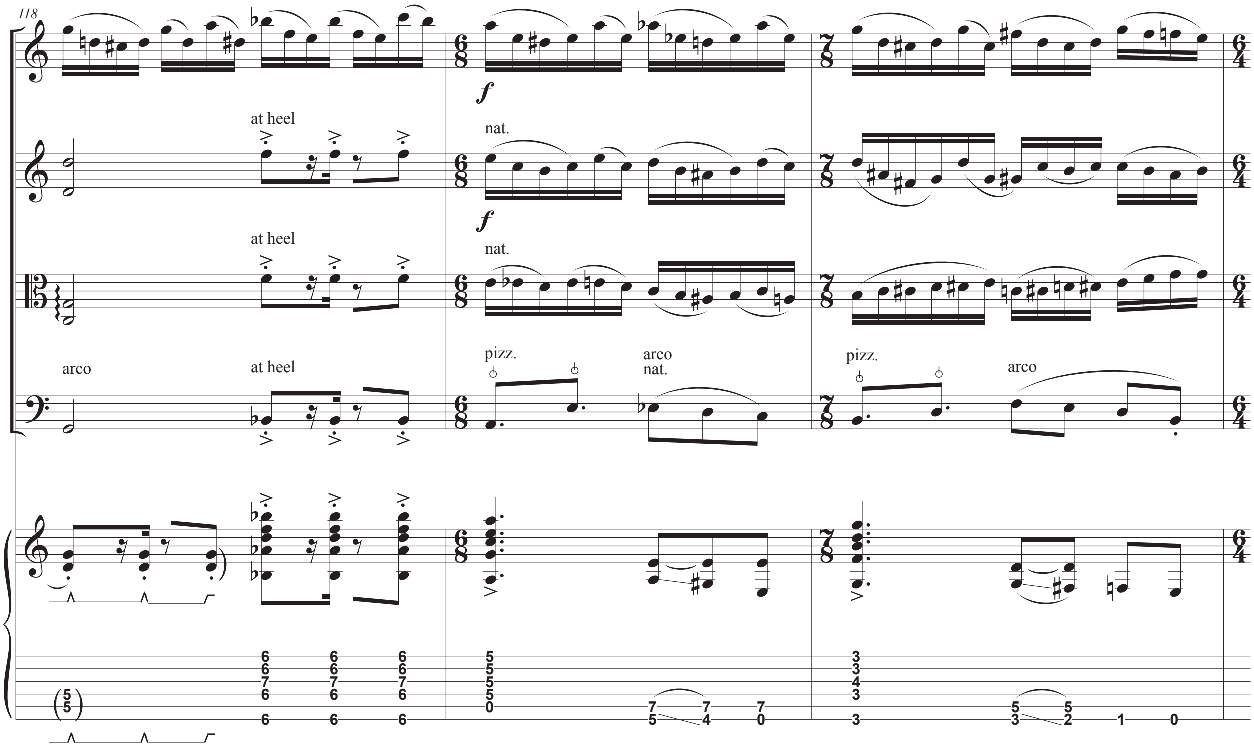
O
98
p misterioso
fp
sim.
fp
sim.
fp
sim.


102
f
p
ppp
f
p
ppp
Solo
pizz.
f
p
f
p
ppp
niente
8

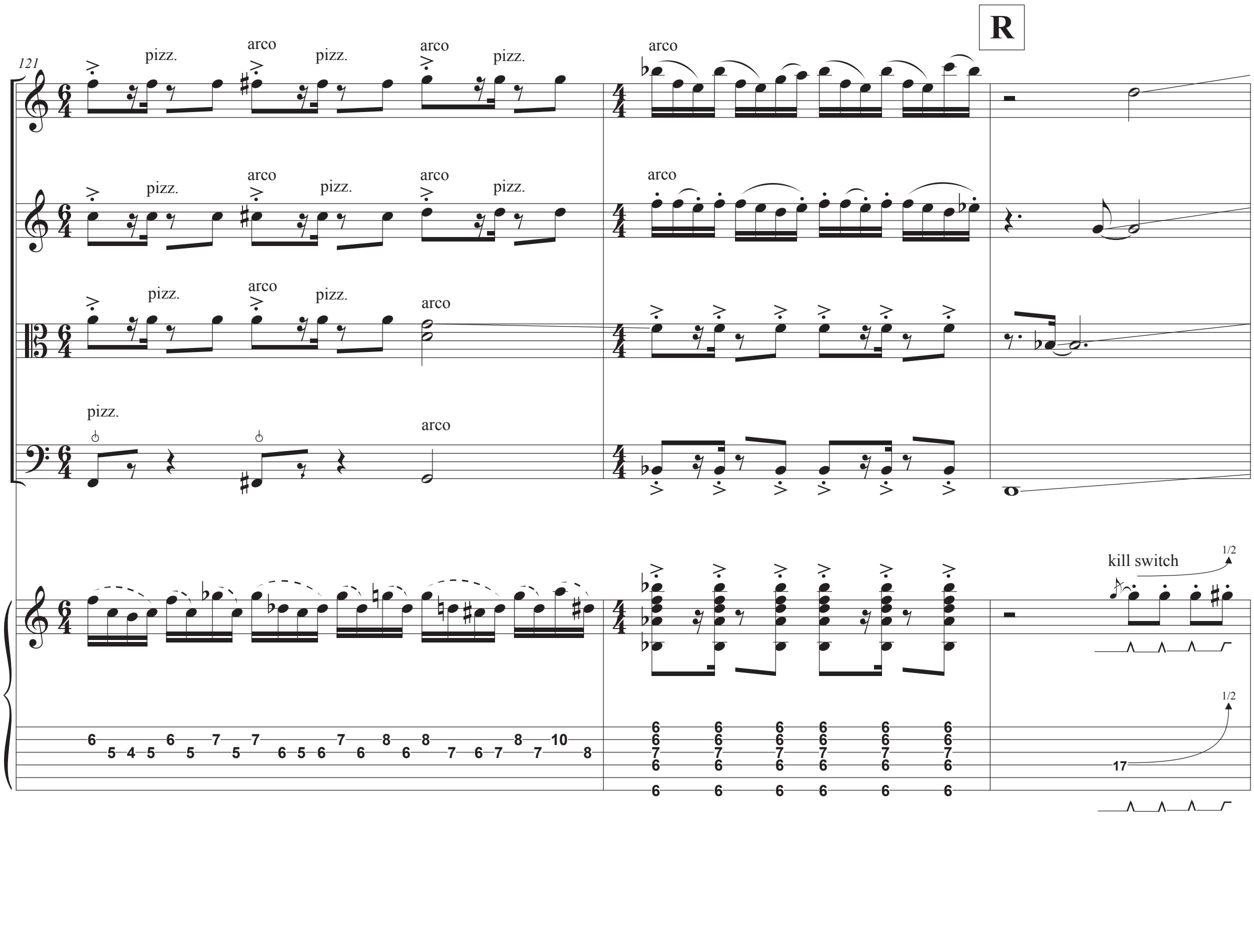
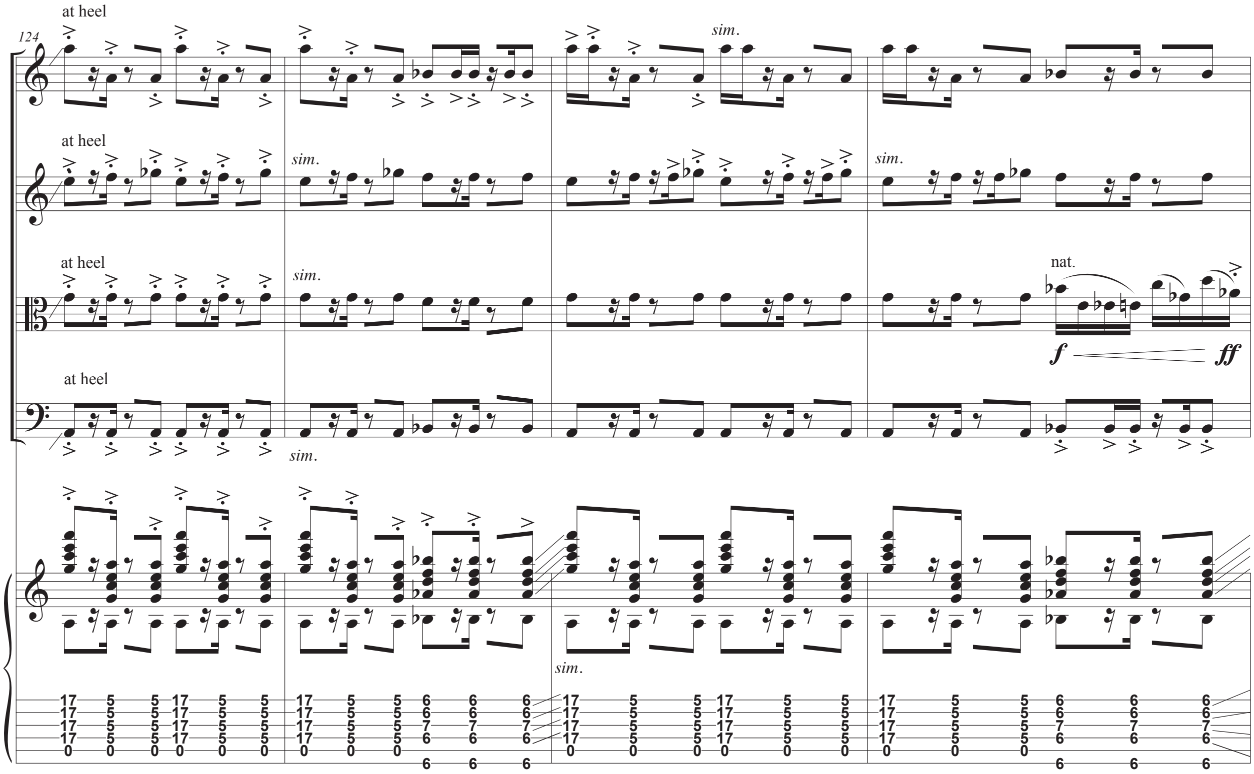

P
Rock Groove ♩ = c. 90
at heel
spicc.
pp
steady gliss.
arco
Palm Mute
slowly open palm mute


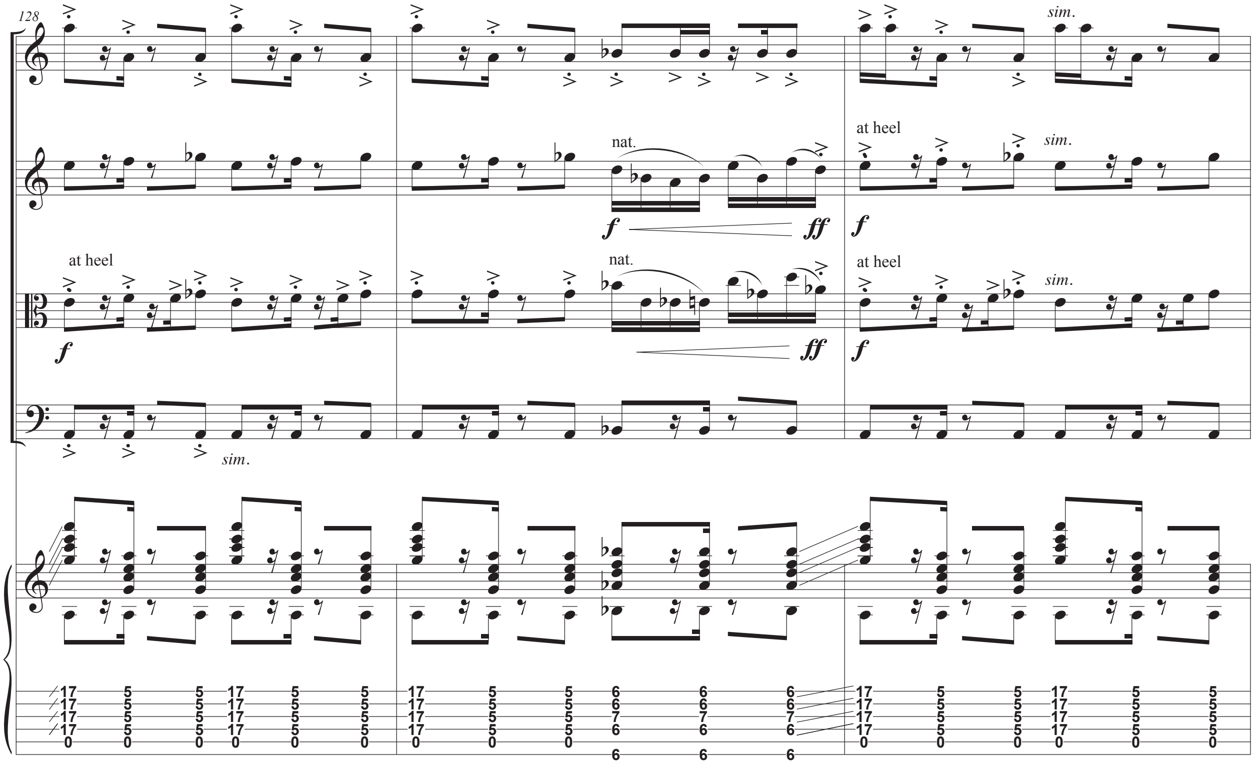
109
spicc.
pp
pizz.
arco
nat.
Palm Mute
8va


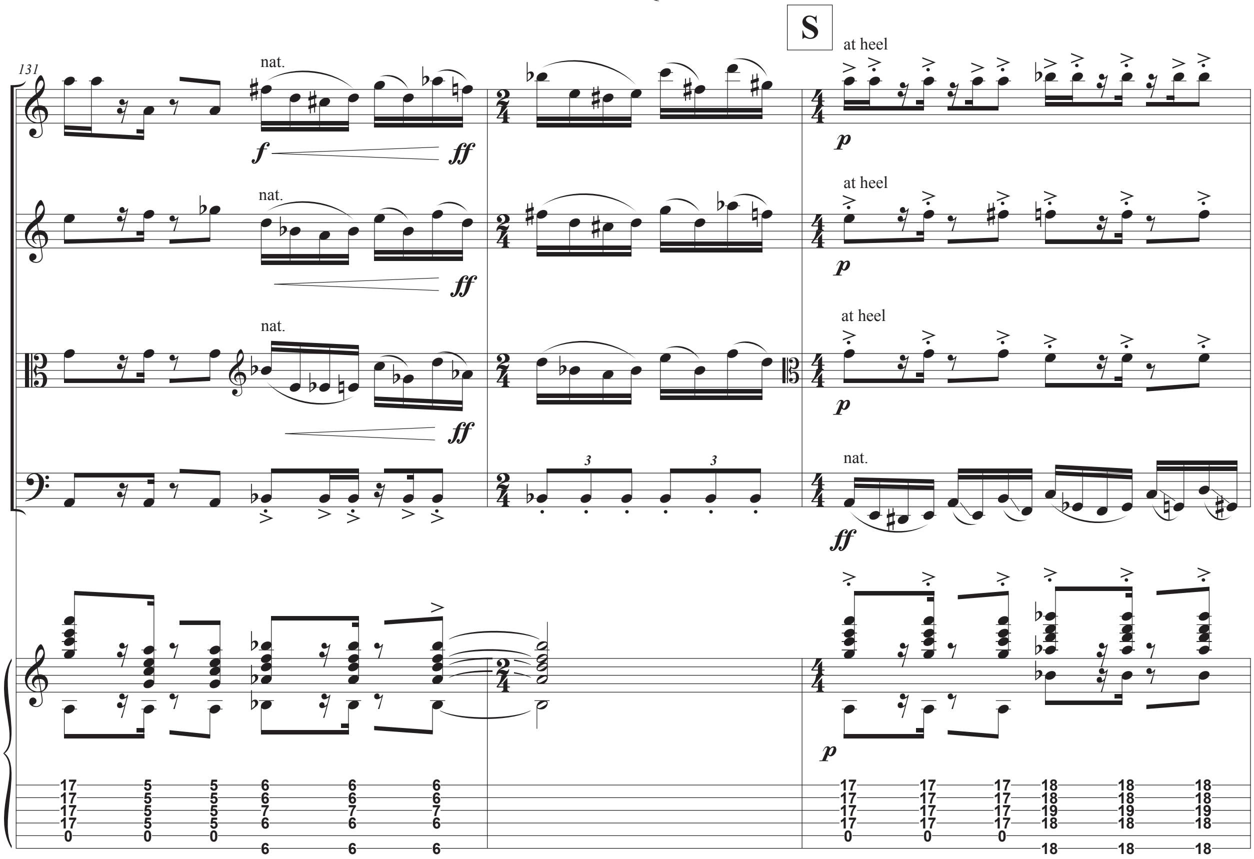
112
at heel
at heel
at heel
at heel
f
fp
Solo
nat.
mf
kill switch
1/2


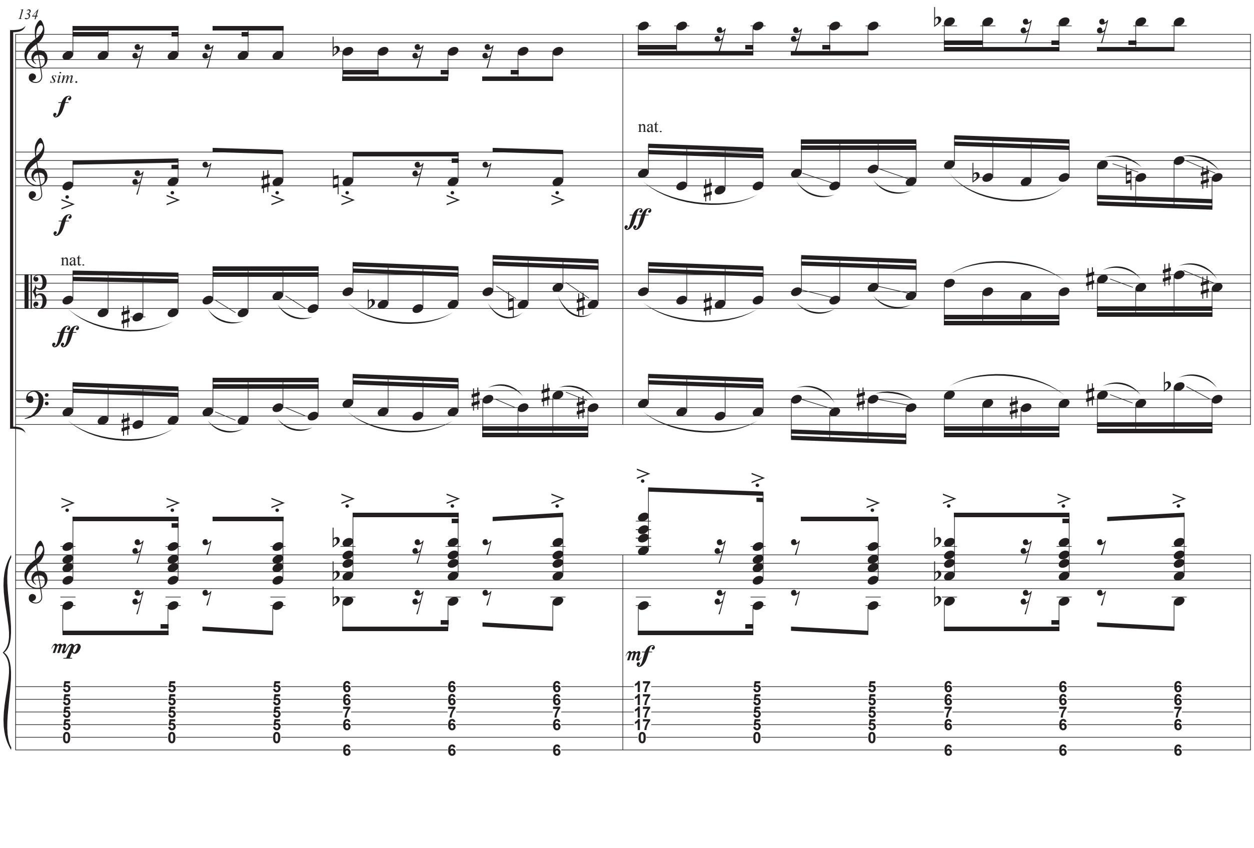
Q
nat.
nat.
nat.
f
Solo
pizz.
kill switch
hammer on
new chords


118
at heel
at heel
arco
at heel
nat.
nat.
pizz.
arco
nat.
pizz.
arco
f

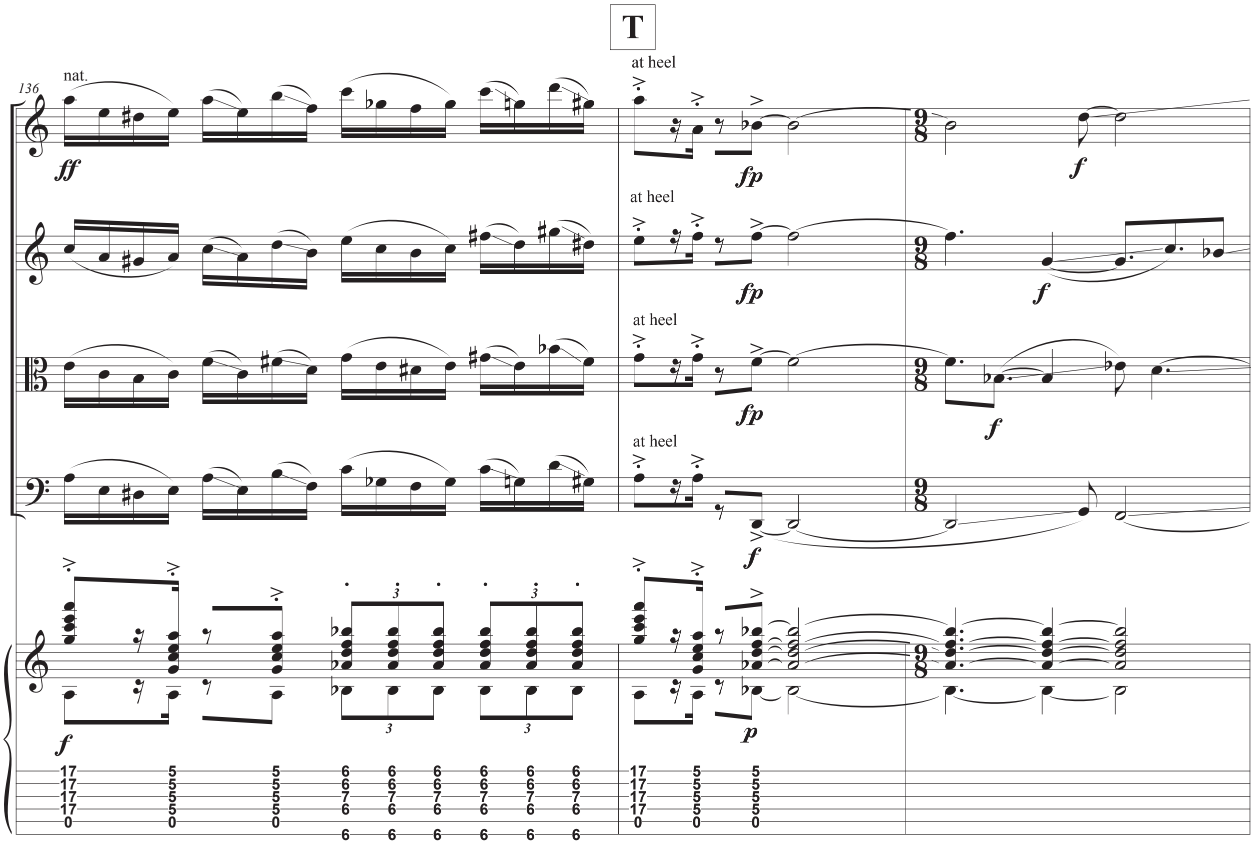
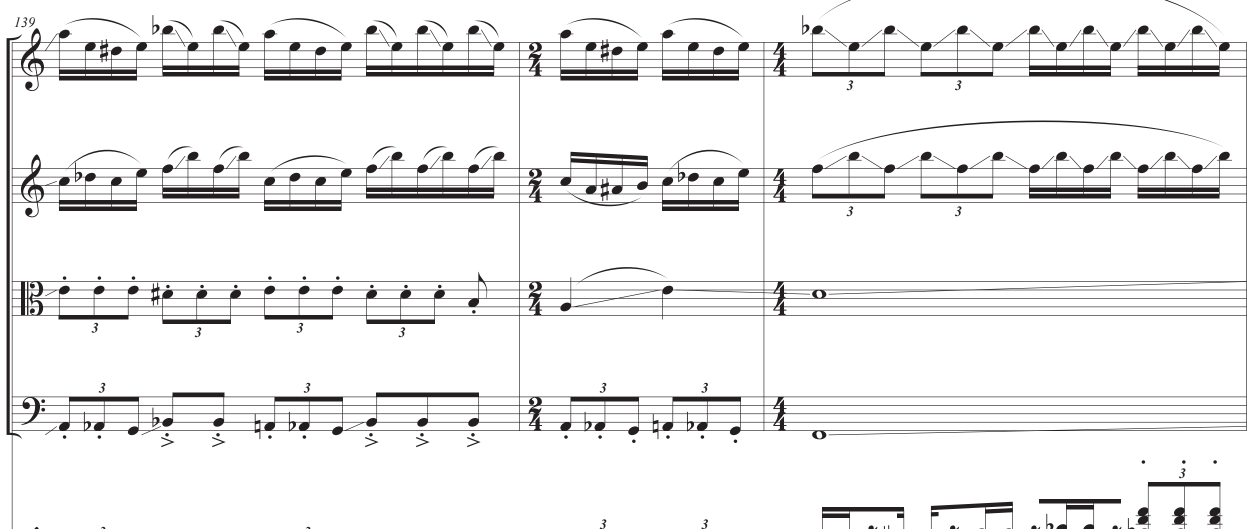

121
R
pizz.
arco
arco
kill switch
1/2


124
at heel
sim.
at heel
sim.
at heel
sim.
nat.
f
ff
at heel
sim.
sim.


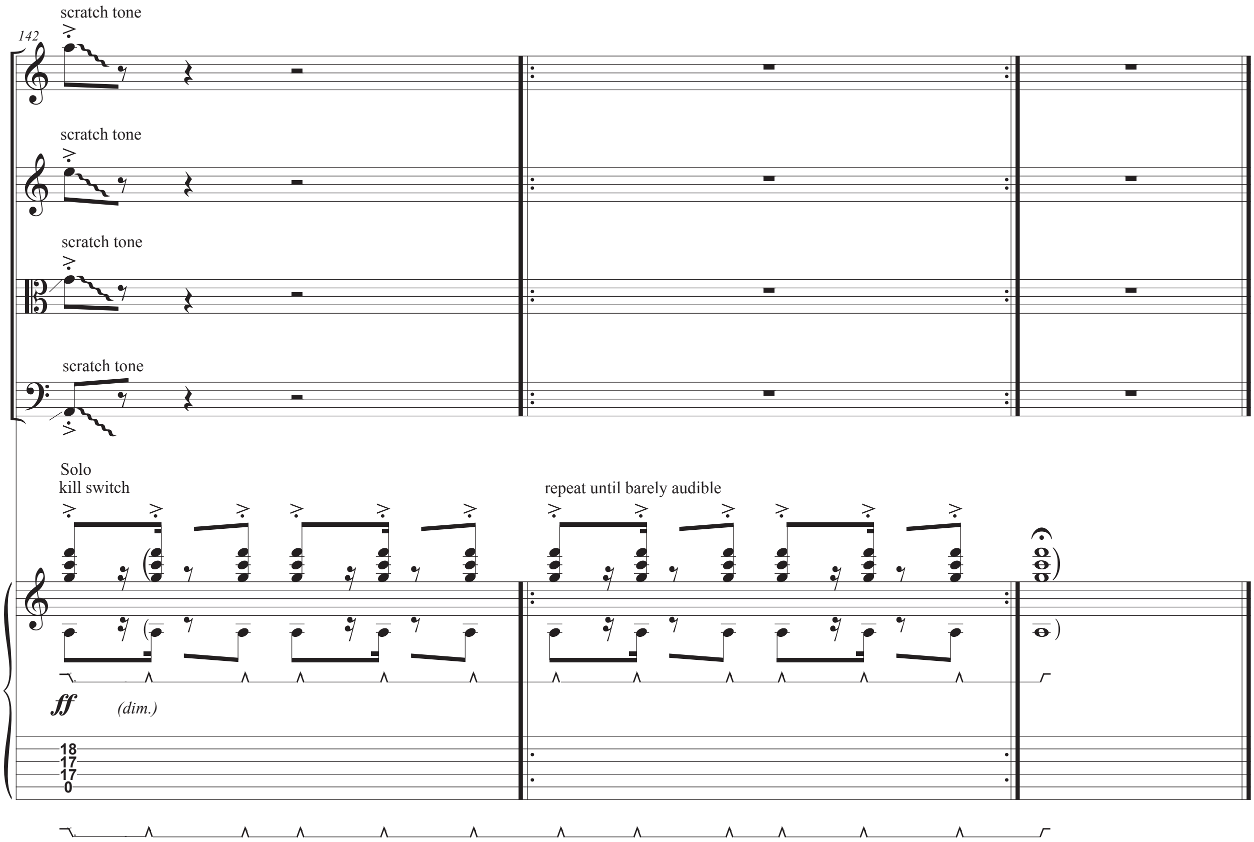
128
sim.
nat.
f
ff
at heel
sim.
f
at heel
f
nat.
ff
at heel
sim.
f
sim.


S
131
nat.
at heel
nat.
at heel
nat.
at heel
nat.
3
3
f
ff
ff
ff
p
p
p
ff
p


134
sim.
f
f
nat.
ff
nat.
ff
mp
mf


T
136
nat.
at heel
at heel
at heel
at heel


139


142
scratch tone
scratch tone
scratch tone
scratch tone
Solo
kill switch
repeat until barely audible
ff
(dim.)
18
17
17
0

Deep Blue Windows

for viola and piano

by Chris Corcoran
(2018)

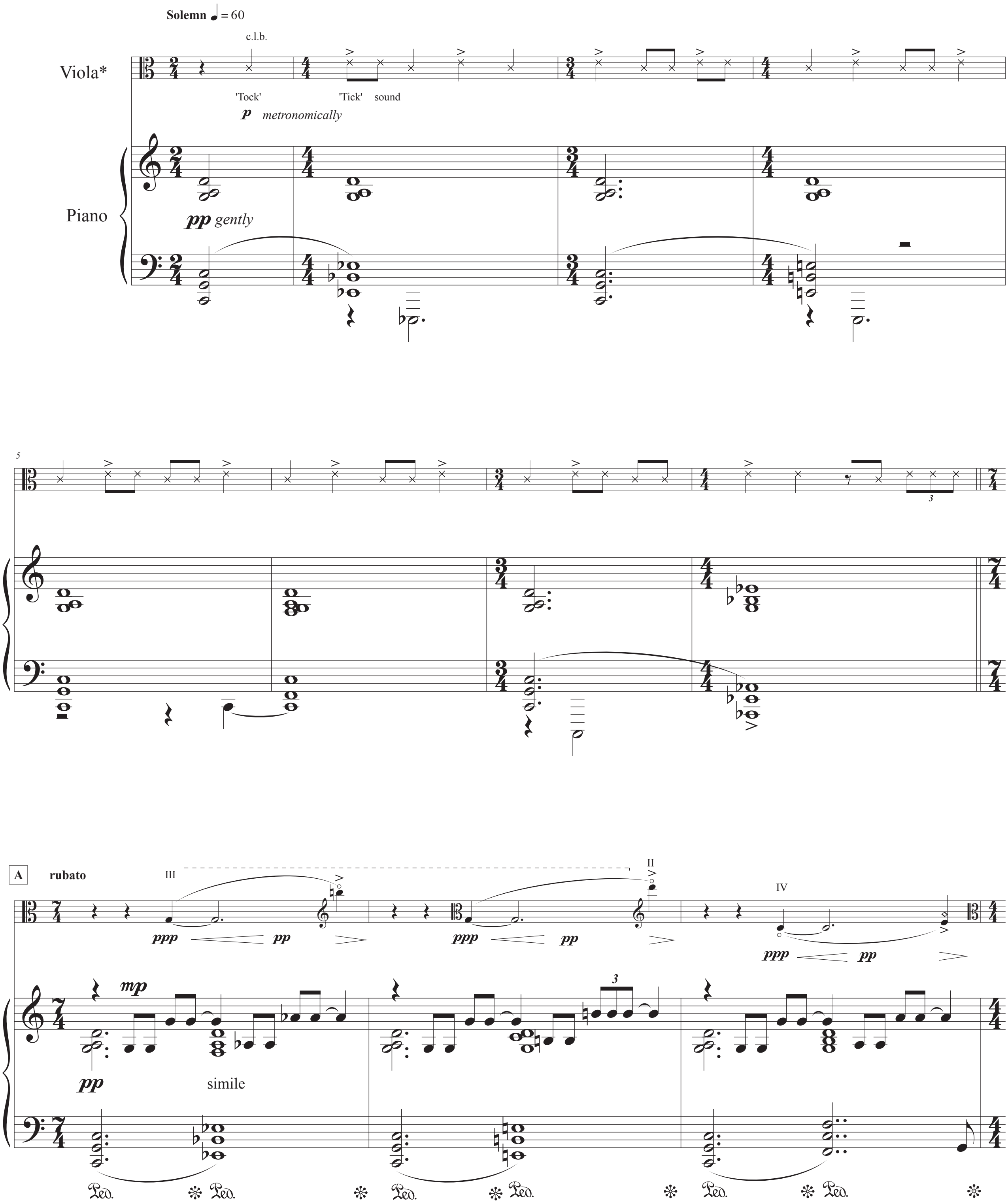
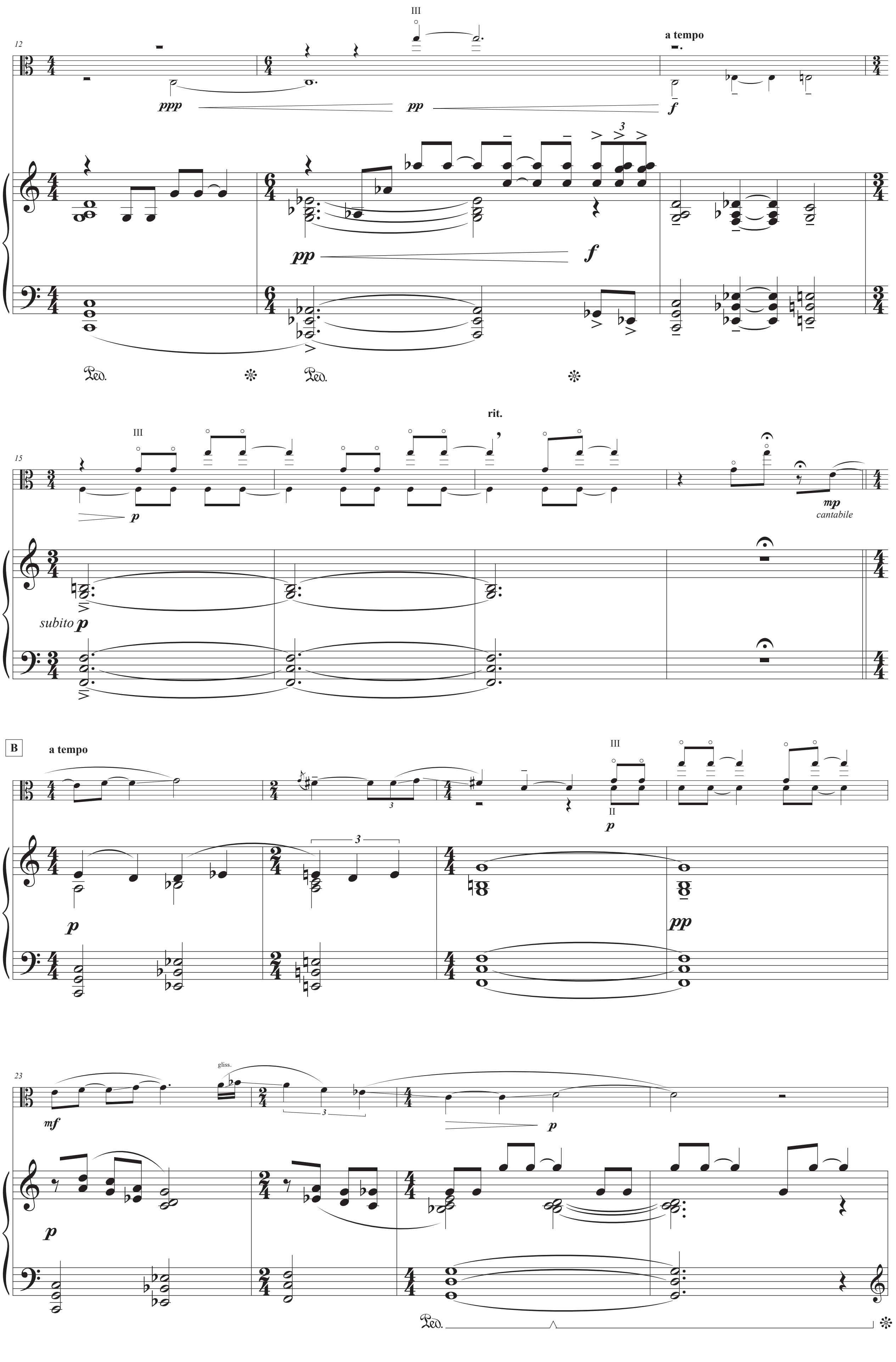
Duration: c. 6 mins 30 secs

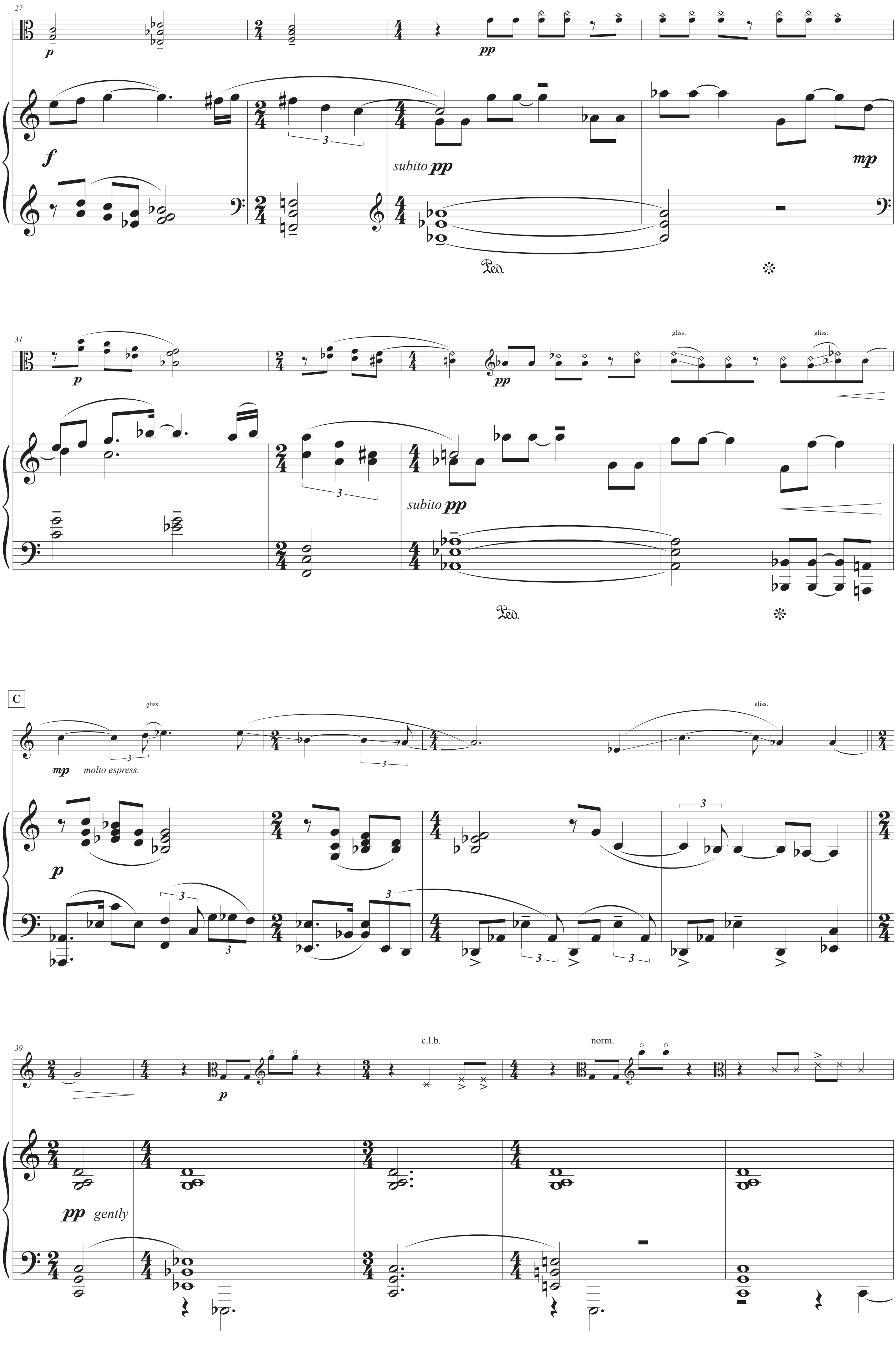
Score

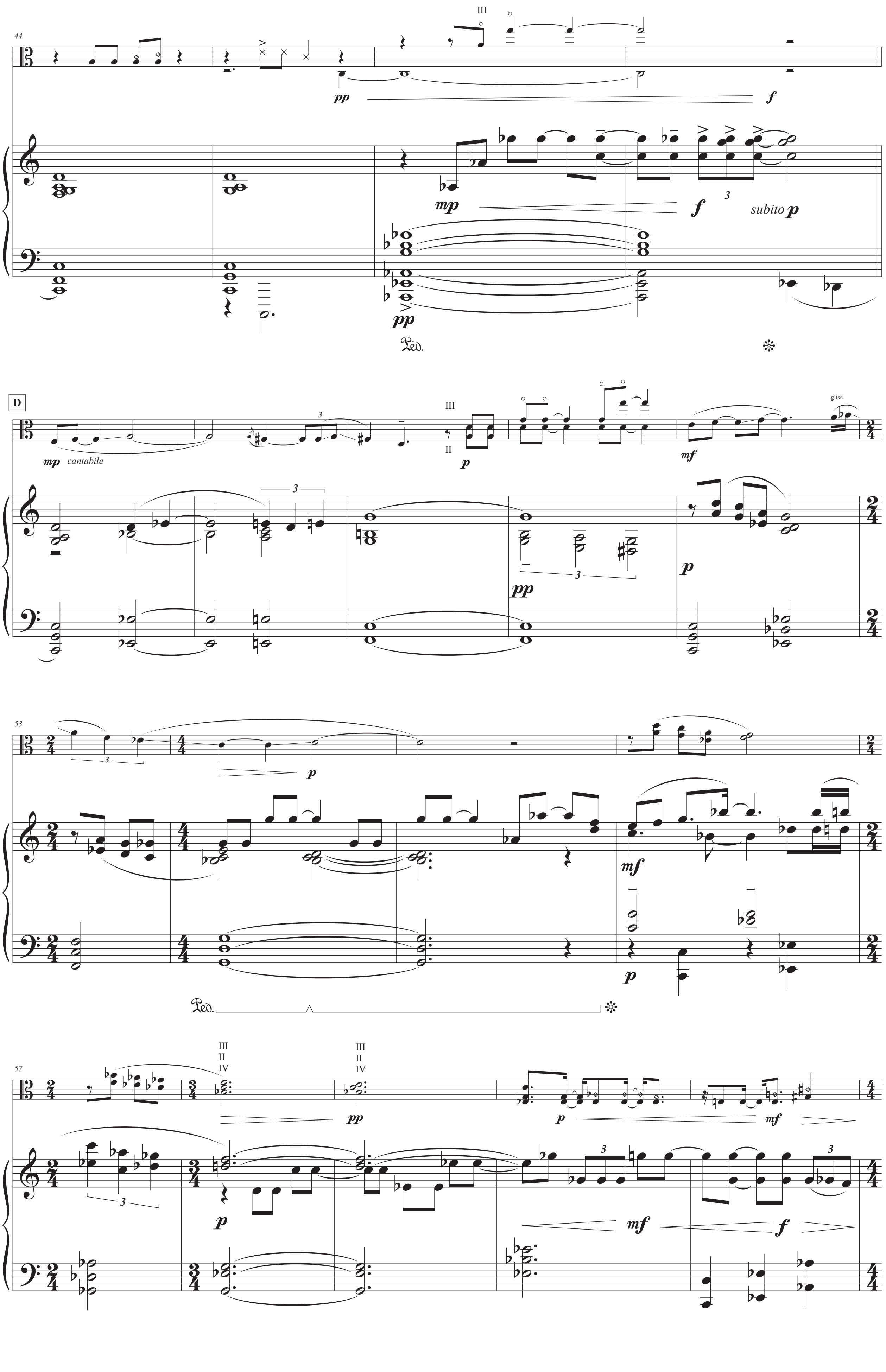
Written for Adele Govier and Fergal Caulfield
for concerts in Orvieto and Bolsena, Italy, in 2018

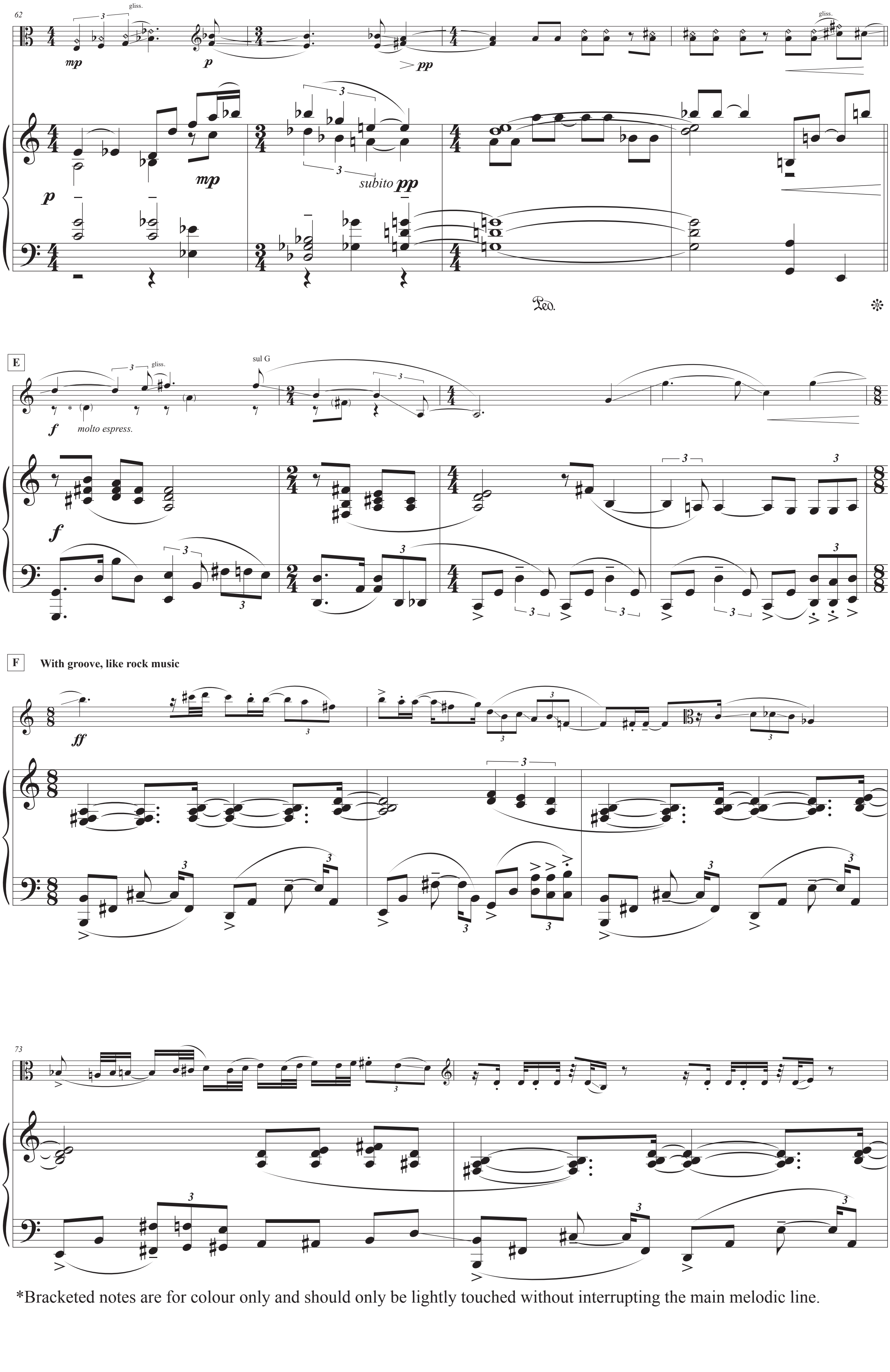
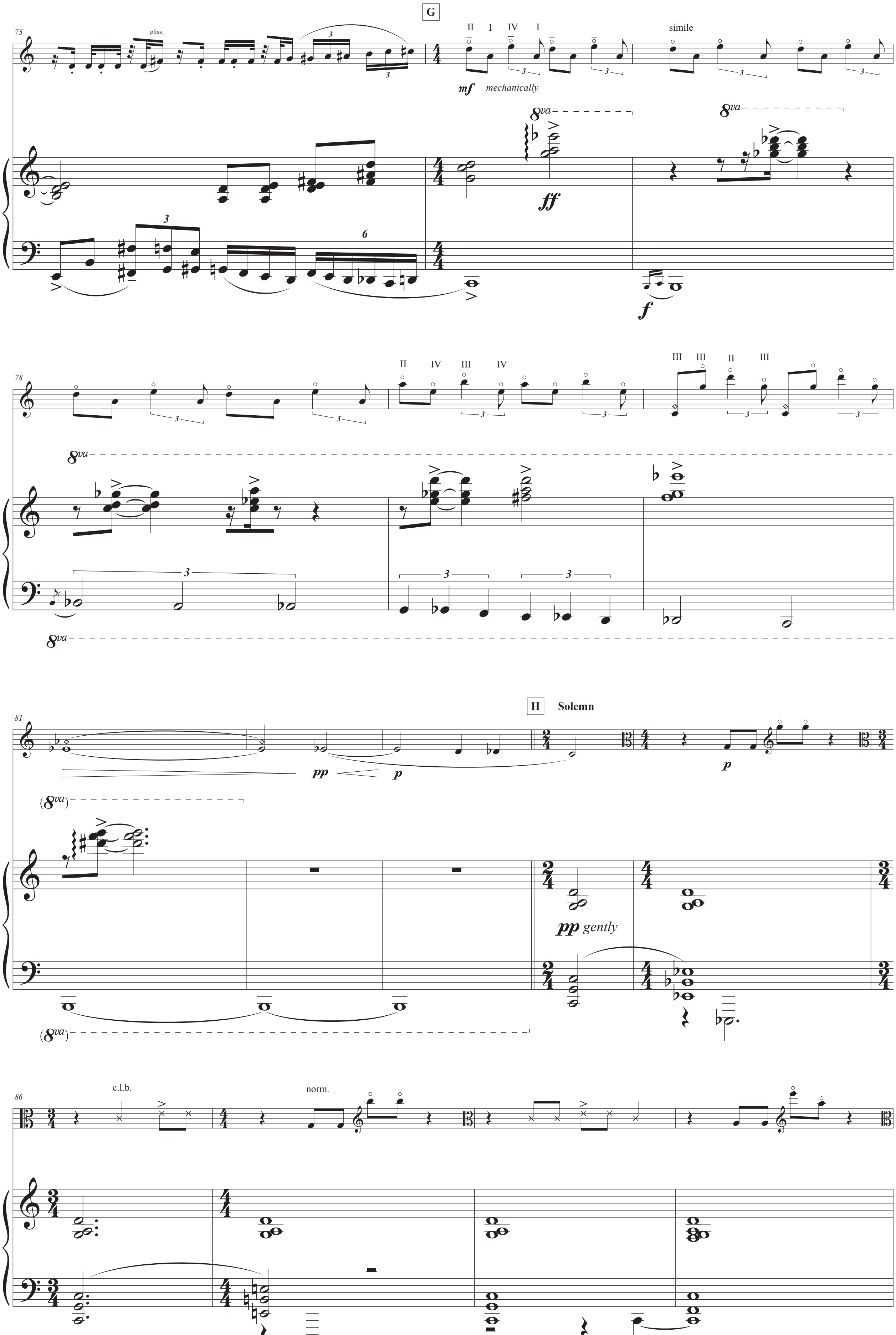
Deep Blue Windows

Chris Corcoran

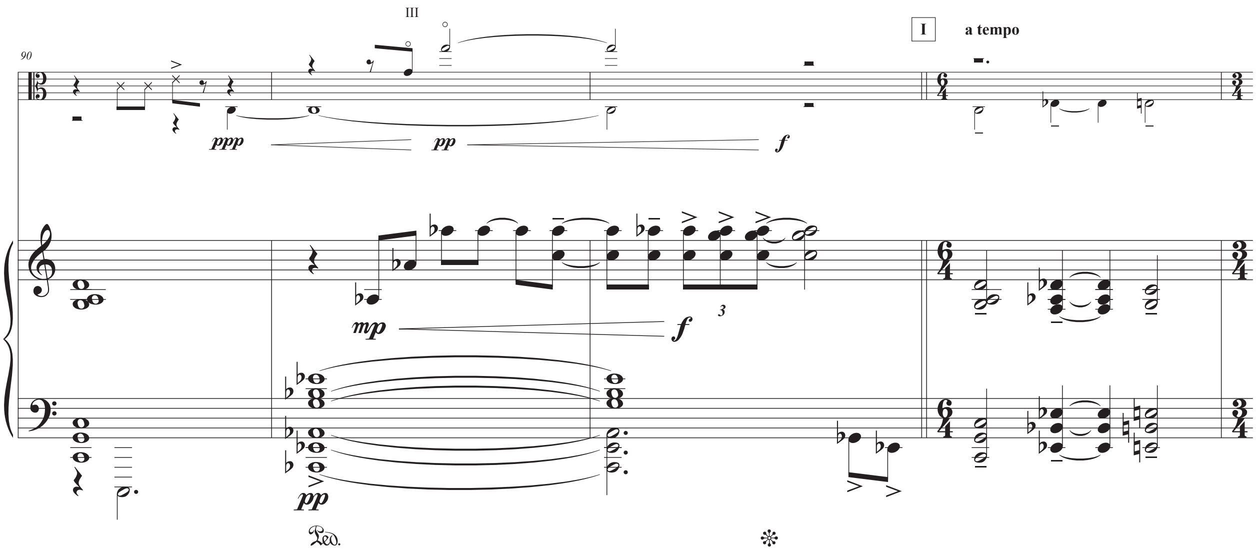
Dedicated to my parents and my wife

*The G string on the viola is to be tuned fractionally sharp, so that the harmonics from bar 94 to the end are in tune with the piano part.


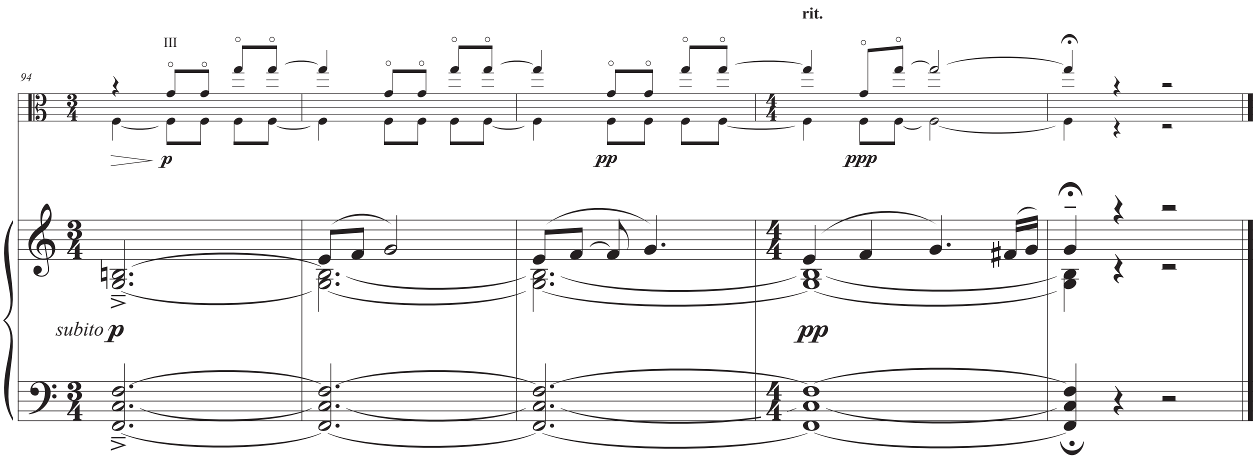
12
III
ppp
pp
f
a tempo
pp
f
Ped.
Ped.
15
III
rit.
p
mp
cantabile
subito p
B
a tempo
III
II
p
p
pp
23
gliss.
mf
p
p
p
Ped.


27
p
pp
f
subito pp
mp
Ped.
31
gliss.
C
mp
molto espress.
39
c.l.b.
norm.
pp
gently


44
III
pp
f
mp
f
3
subito p
pp
Ped.
D
mp cantabile
3
III
II
p
mf
gliss.
3
pp
p
53
3
p
mf
p
Ped.
57
III
II
IV
pp
p
mf
f

*Bracketed notes are for colour only and should only be lightly touched without interrupting the main melodic line.


75
gliss.
G
II I IV I
simile
mf mechanically
8va
ff
f
78
II IV III IV
III III II III
81
H Solemn
pp
p
(8va)
pp gently
86
c.l.b.
norm.


90
III
I
a tempo
ppp
pp
f
mp
f
3
pp
Ped.


94
III
rit.
p
pp
ppp
subito p
pp

Symphonic Synchopathology

A symphonic study on my passion for syncopation
in four movements

by Chris Corcoran

Instrumentation

Piccolo
2 Flutes
2 Oboes
2 Clarinets
Bass Clarinet
2 Bassoons
Contrabassoon

4 Horns in F
3 Trumpets in C
3 Trombones
Tuba

Timpani (5 kettles)
2 Percussionists
(bass drum, bongos, conga, snare drum, triangle,
glockenspiel, marimba, vibraphone, tubular bells)
(optional: 2 specialist percussionists for bongos & conga)

Harp
Violin I
Violin II
Viola
Cello
Contrabass
(with C extension or low 5th string)

The score is notated in C. Piccolo, glockenspiel, and contrabasses transpose up/down an octave as is customary.

The material is inspired by groove- and backbeat-based music, which not all orchestral musicians and conductors may be familiar with. The term 'groove' stems from African-American music and in modern psychology literature is defined as the force in music that makes listeners want to move. In order to convey groove, it is *very* strongly recommended that all performers try to move a limb (either visibly, i.e. tapping a foot or nodding the head, or invisibly, i.e. wriggling the toes) with the beat of the music. The composer is convinced that this will strengthen--rather than distract from--the musical performance.

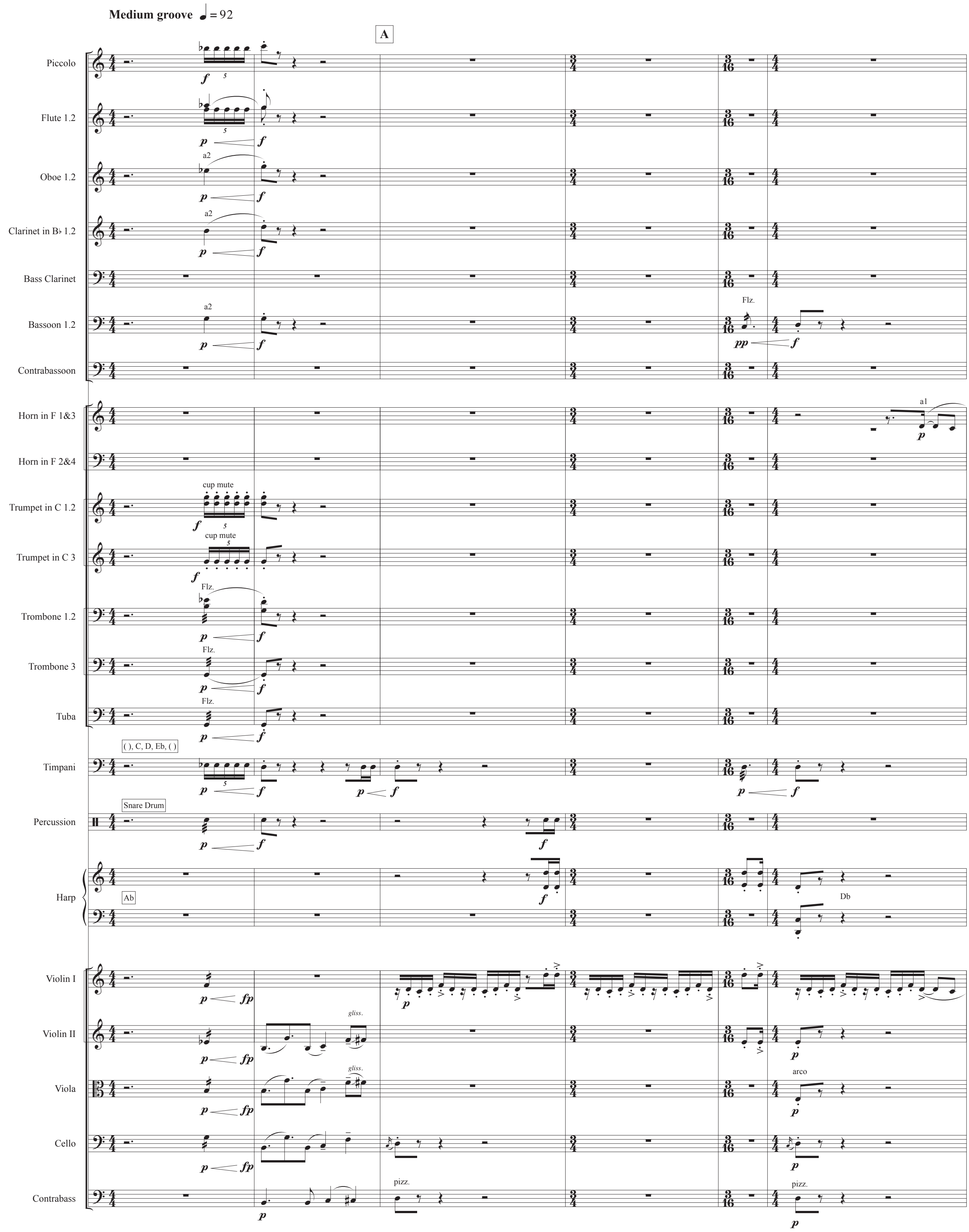
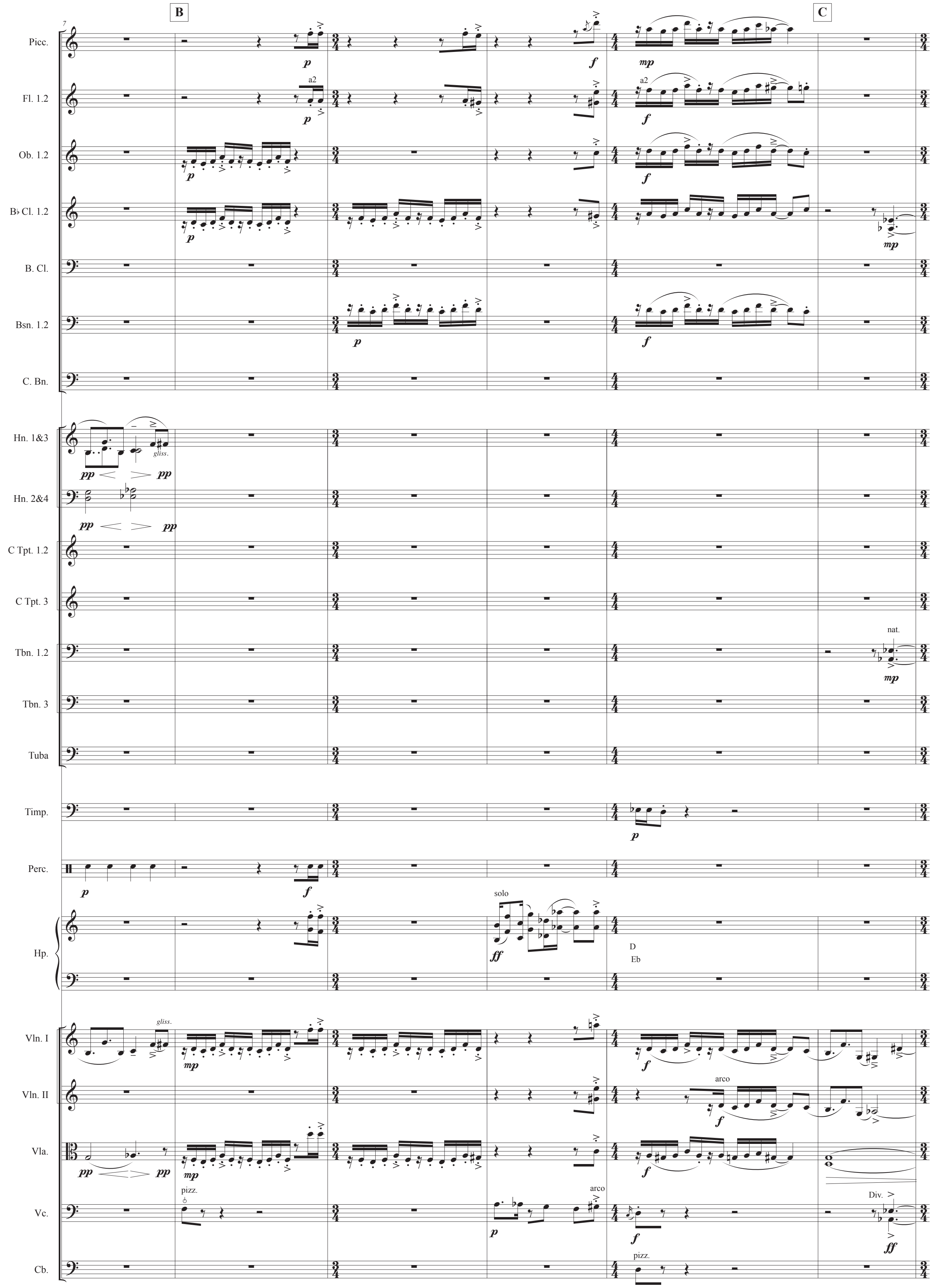
The finale of Mov. IV includes a solo section with several notated solos, but performers may also improvise a solo, if they so wish. In that case, the section should be repeated as necessary. The written solos should be played after the improvisations, since the written solos are essential to the composed form.

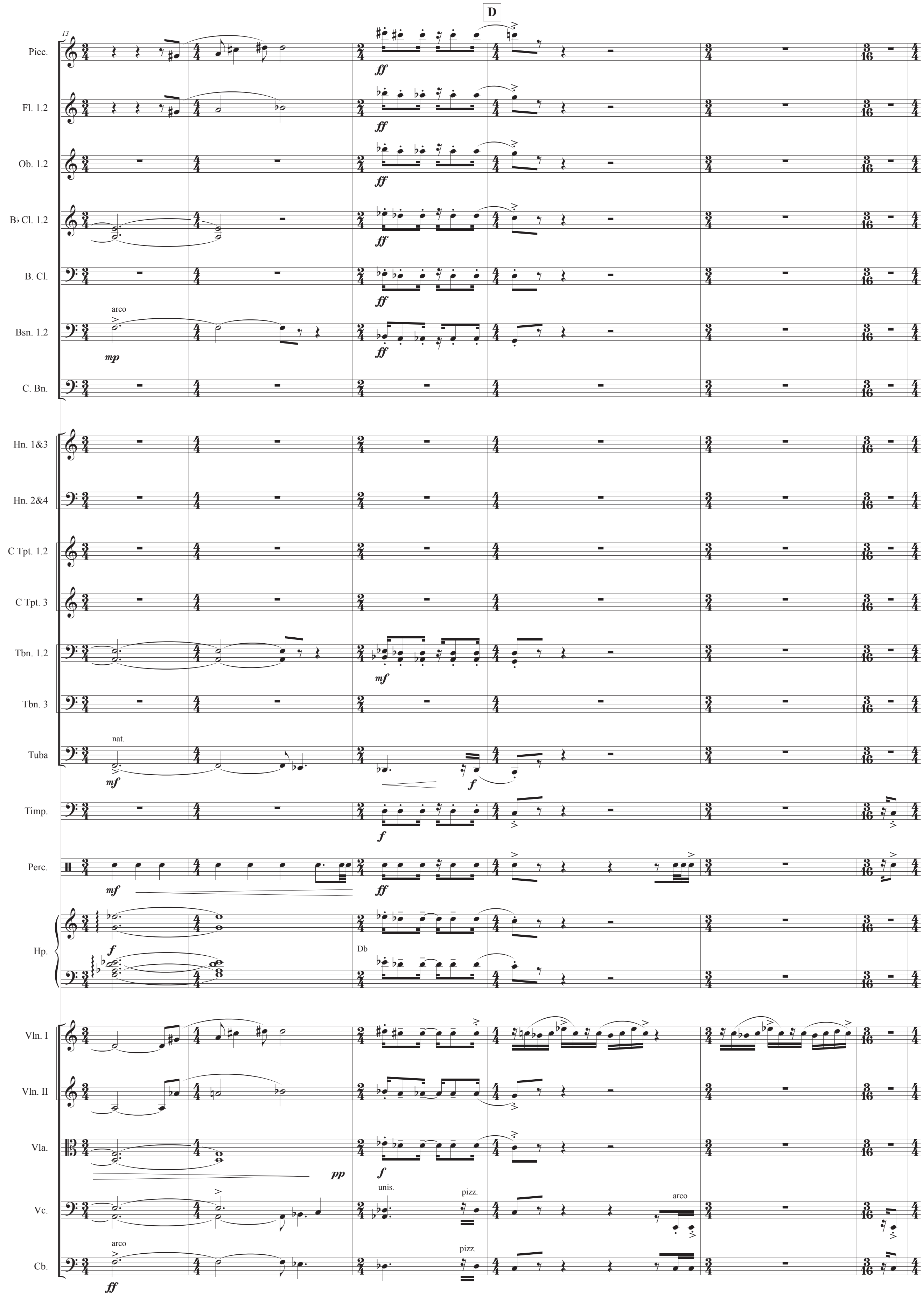
Score

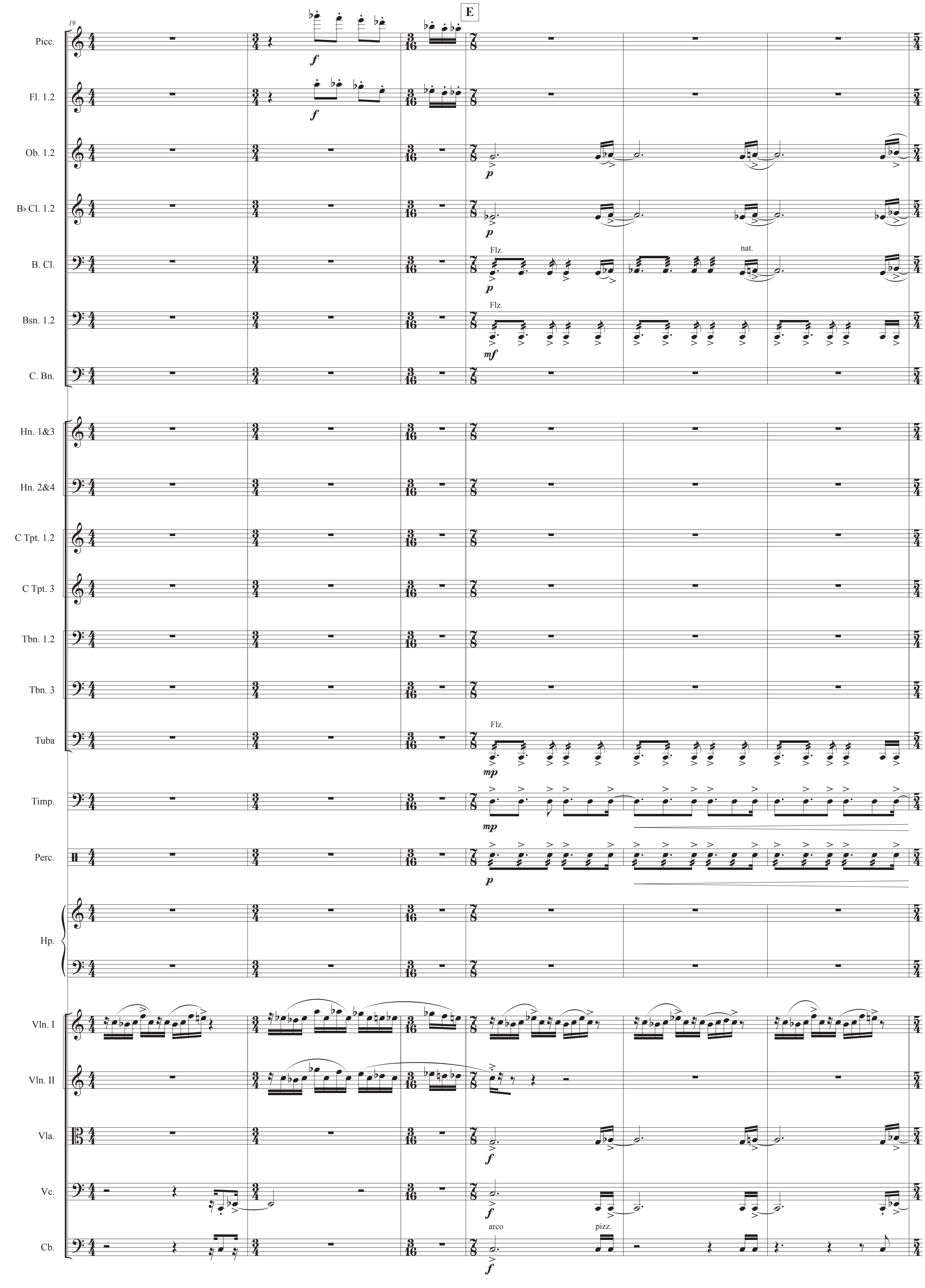
Symphonic Synchopathology

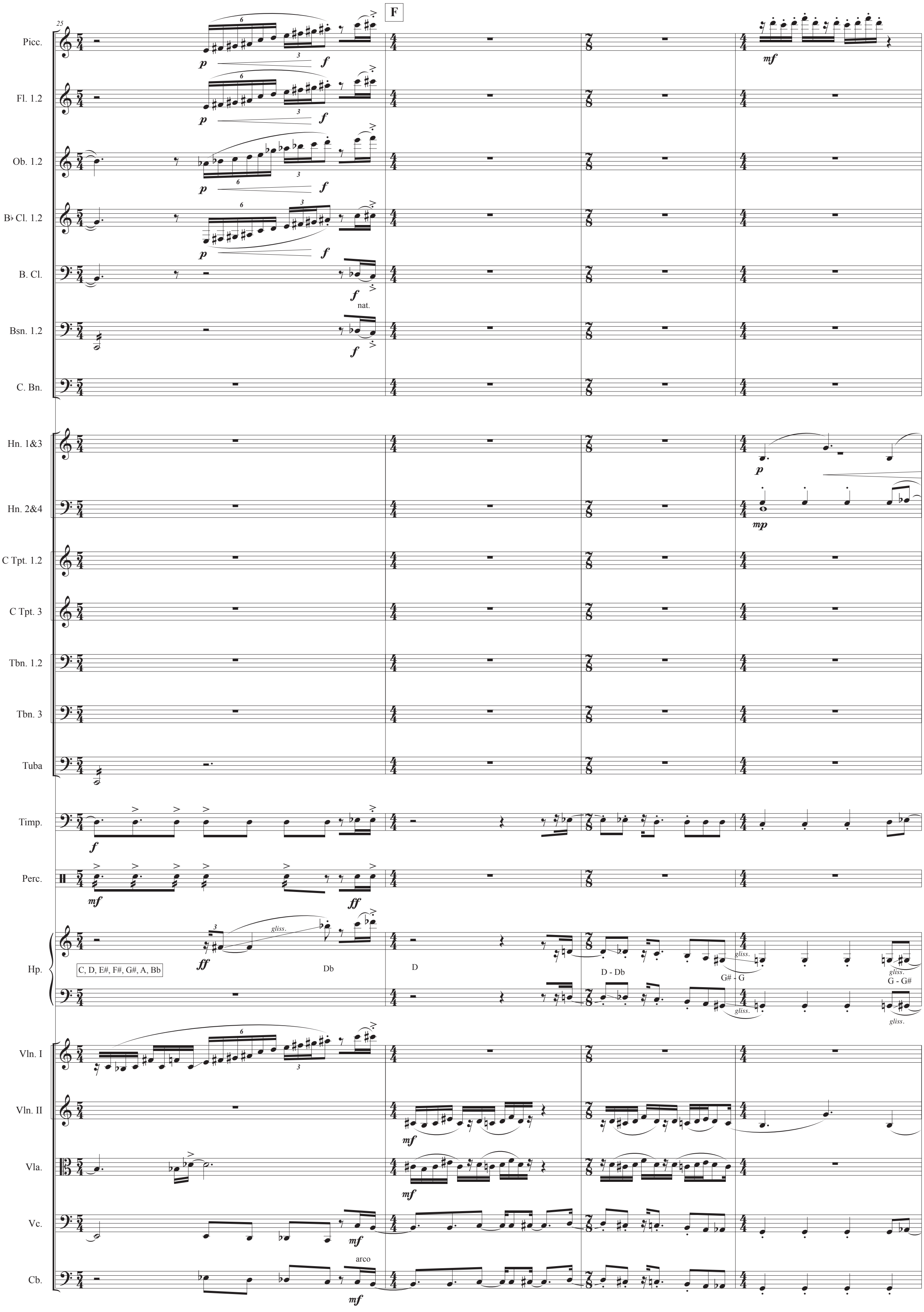
Score in C

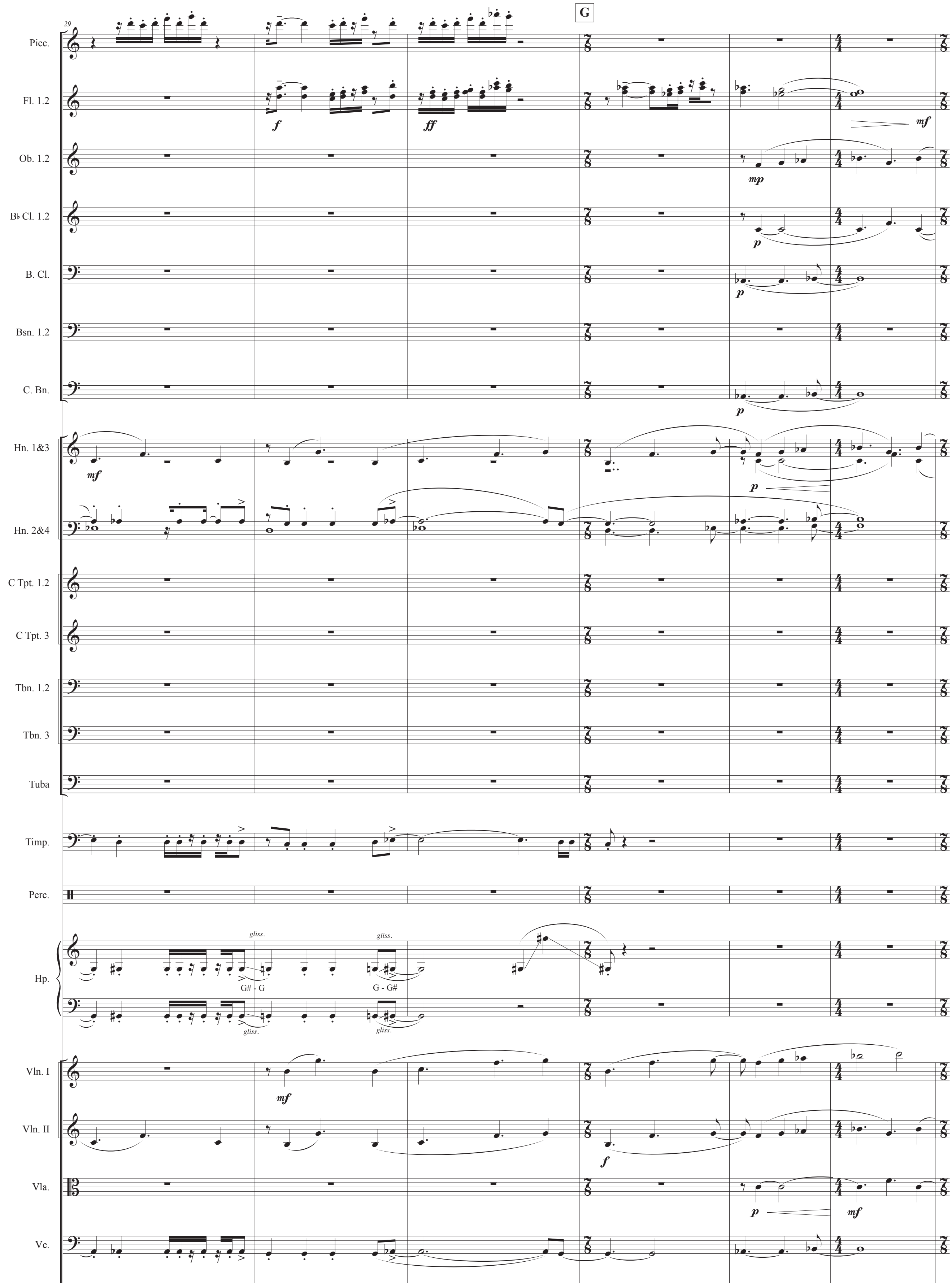
Chris Corcoran

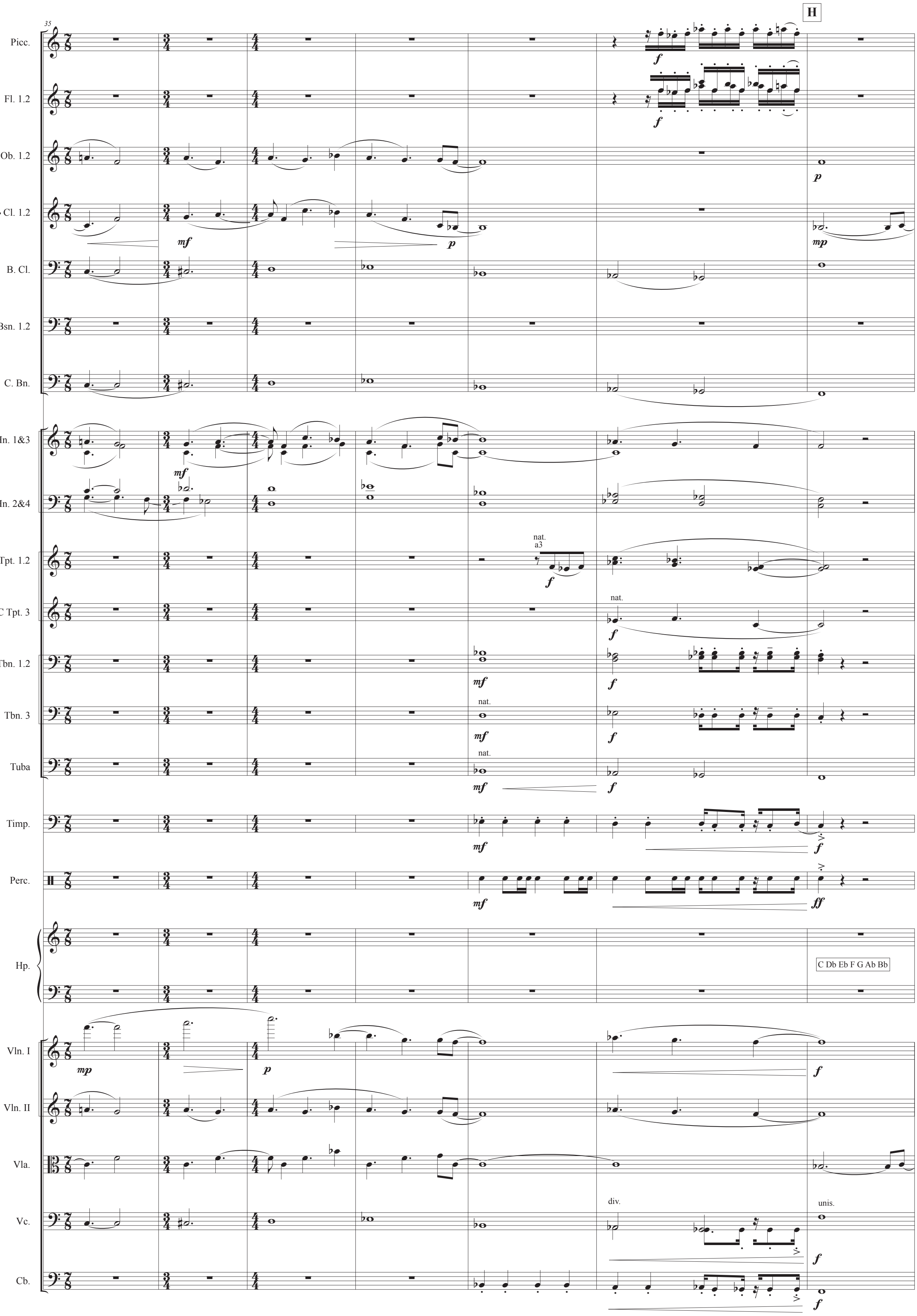
I. One is off


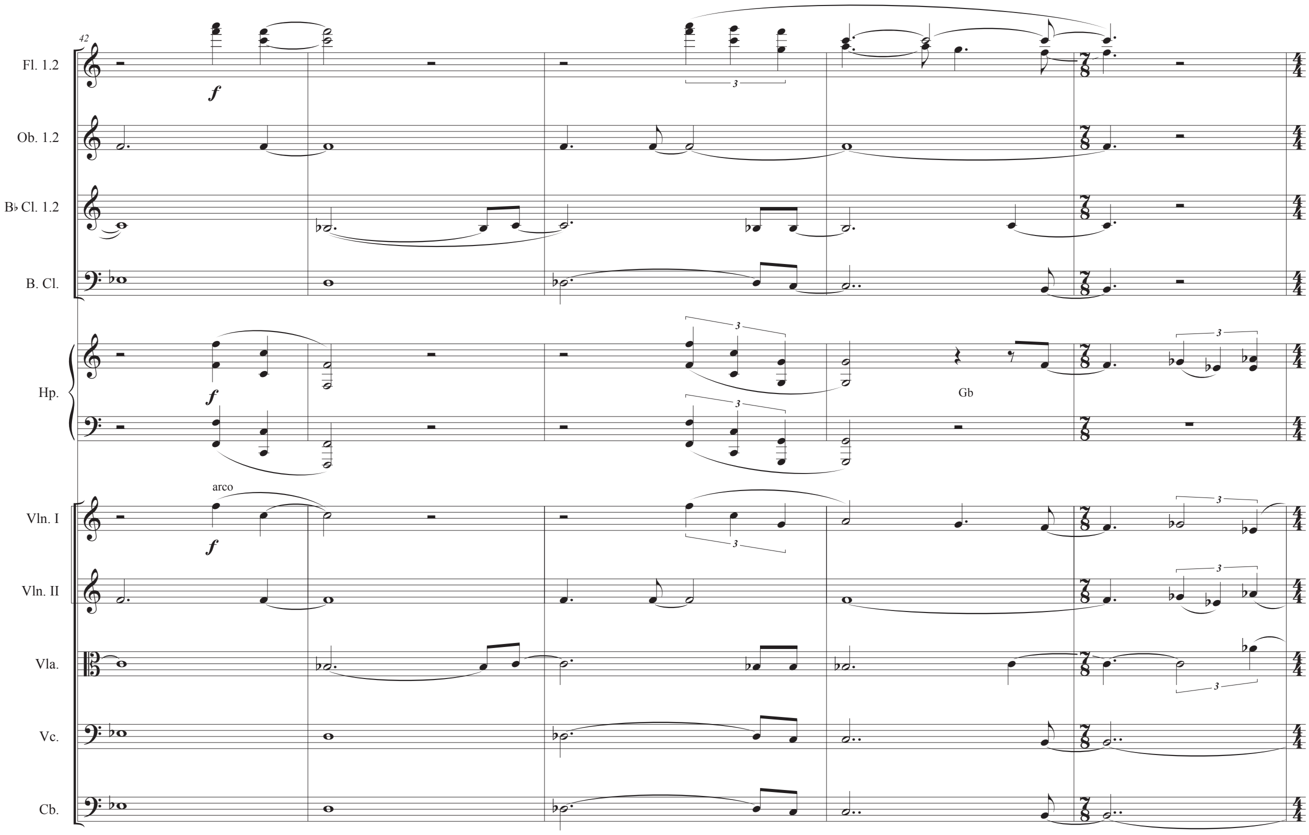
B
C
7
Picc.
Fl. 1.2
a2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
gliss.
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
nat.
Tbn. 3
Tuba
Timp.
Perc.
solo
Hp.
D
Eb
Vln. I
gliss.
Vln. II
arco
Vla.
Vc.
pizz.
arco
Div.
Cb.
pizz.


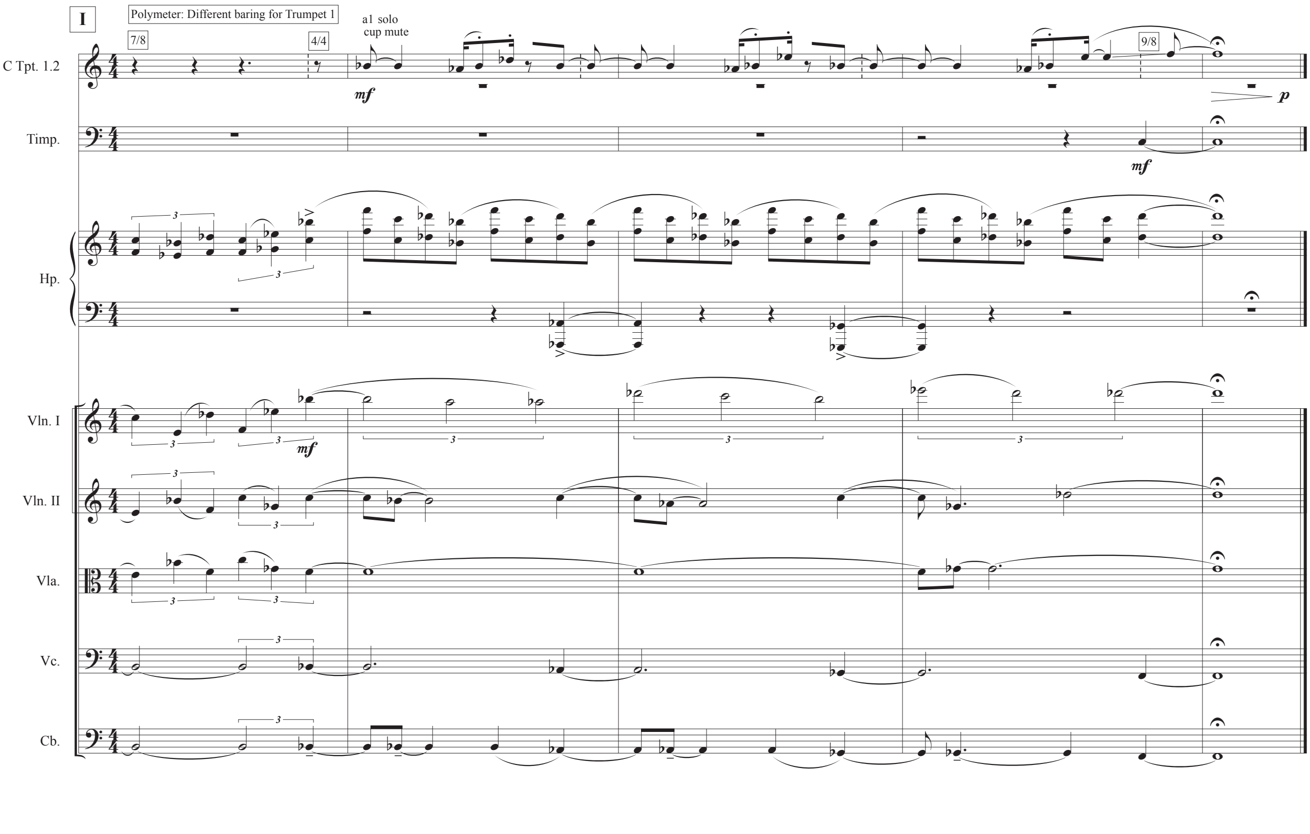
D
13
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco
nat.
Db
unis.
pizz.
arco
pizz.
arco
ff
mp
mf
f
pp


19
E
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
Flz.
nat.
arco
pizz.


25
F
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
nat.
arco
gliss.
C, D, E#, F#, G#, A, Bb
Db
D
D - Db
G# - G
G - G#
p
f
mf
mp
ff


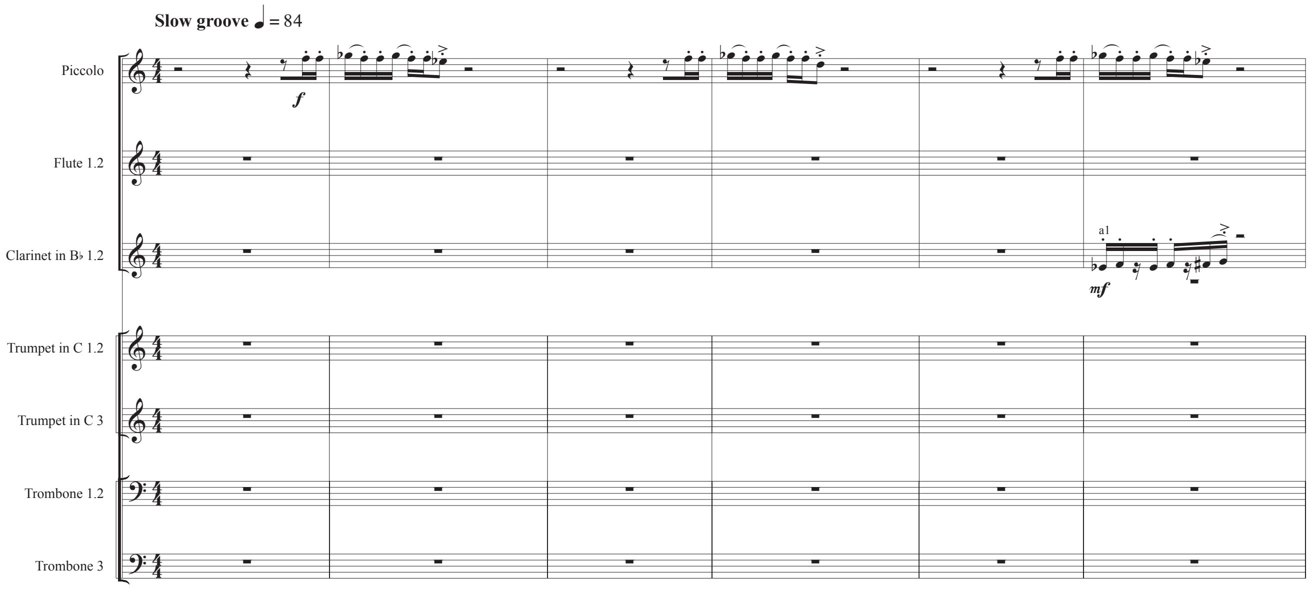
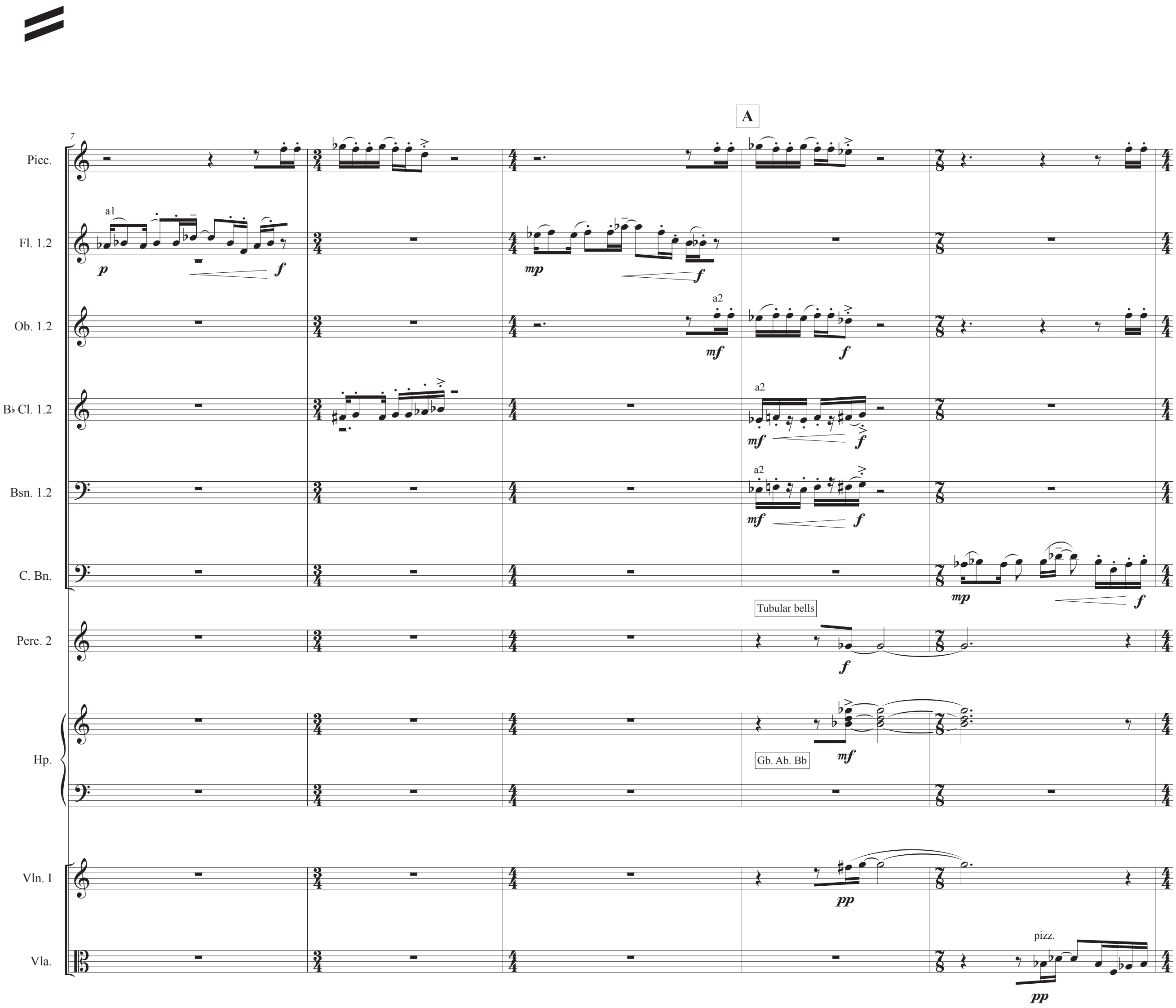
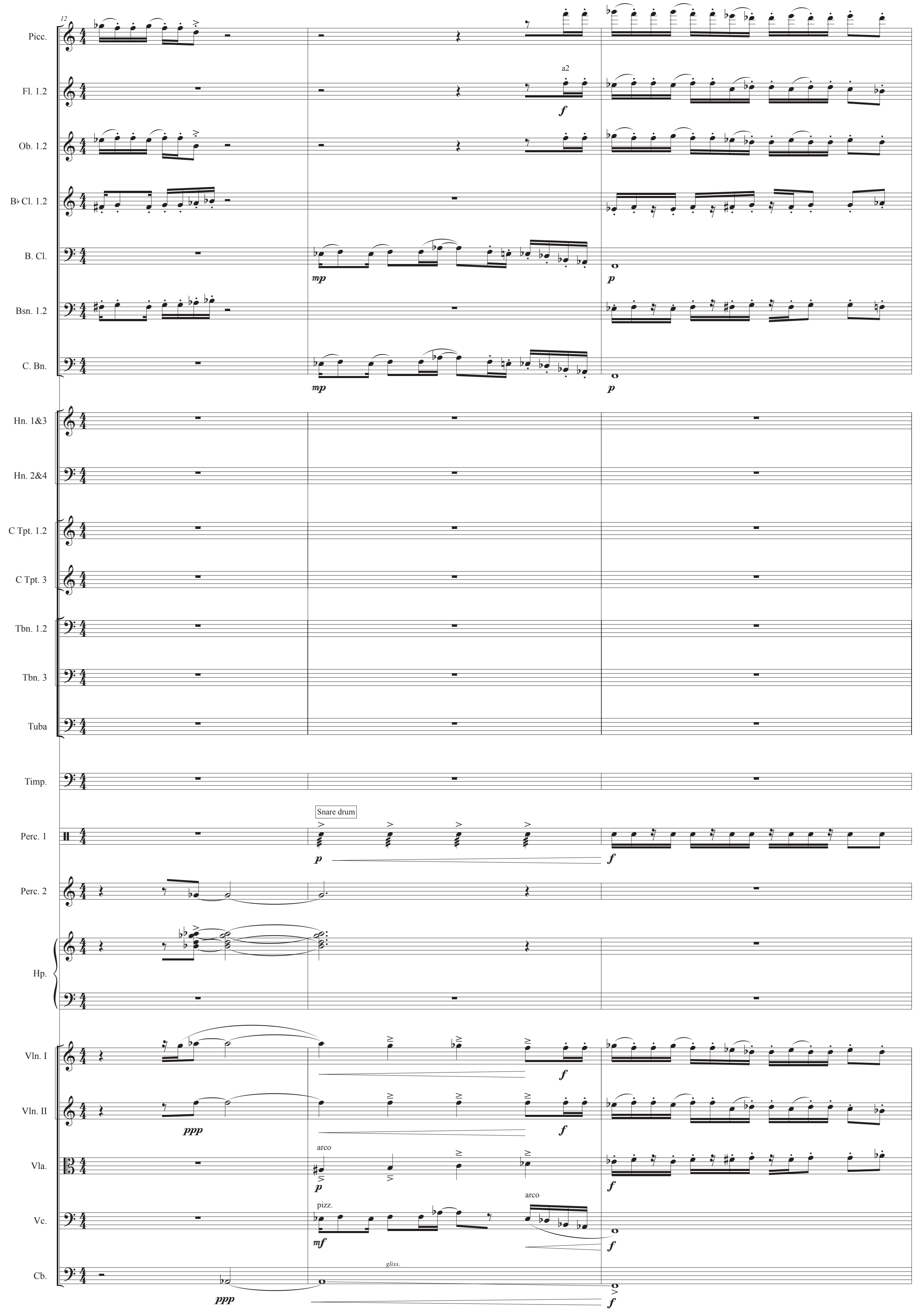
29
G
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
f
ff
mf
mp
p
gliss.
G# - G
G - G#


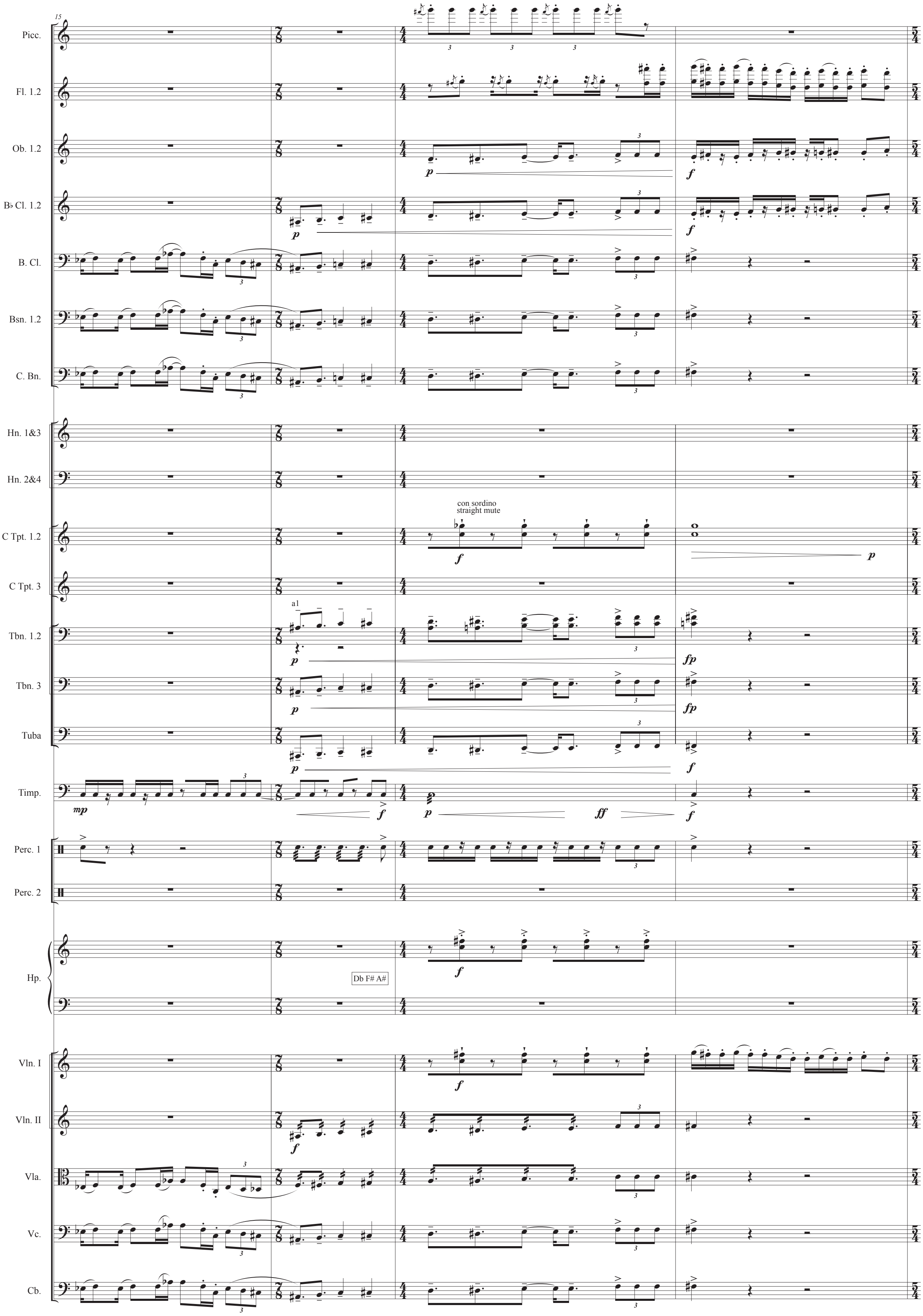
35
H
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
nat.
a3
div.
unis.
C Db Eb F G Ab Bb


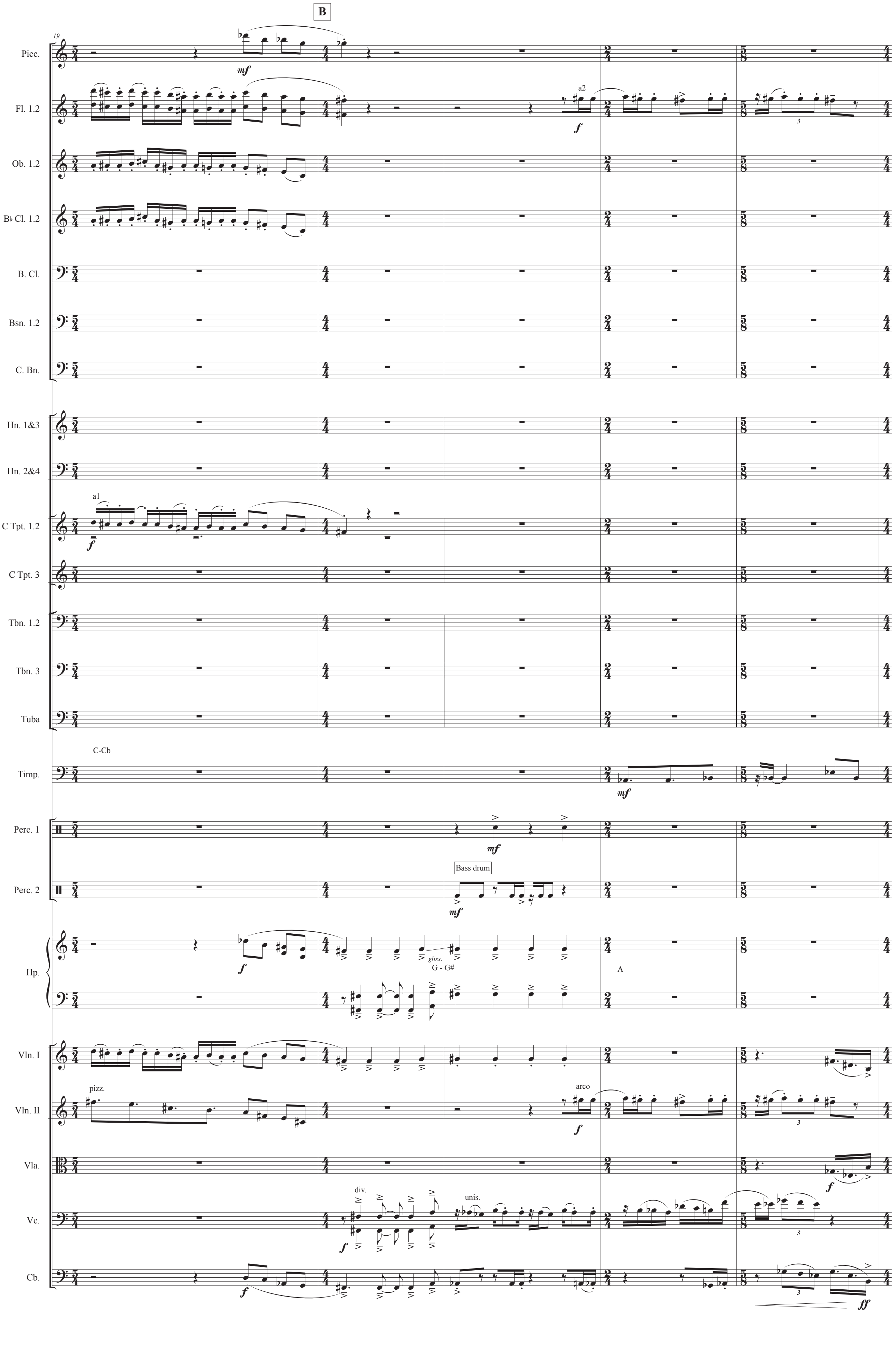
42
Fl. 1.2
f
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Hp.
f
Gb
arco
Vln. I
f
Vln. II
Vla.
Vc.
Cb.


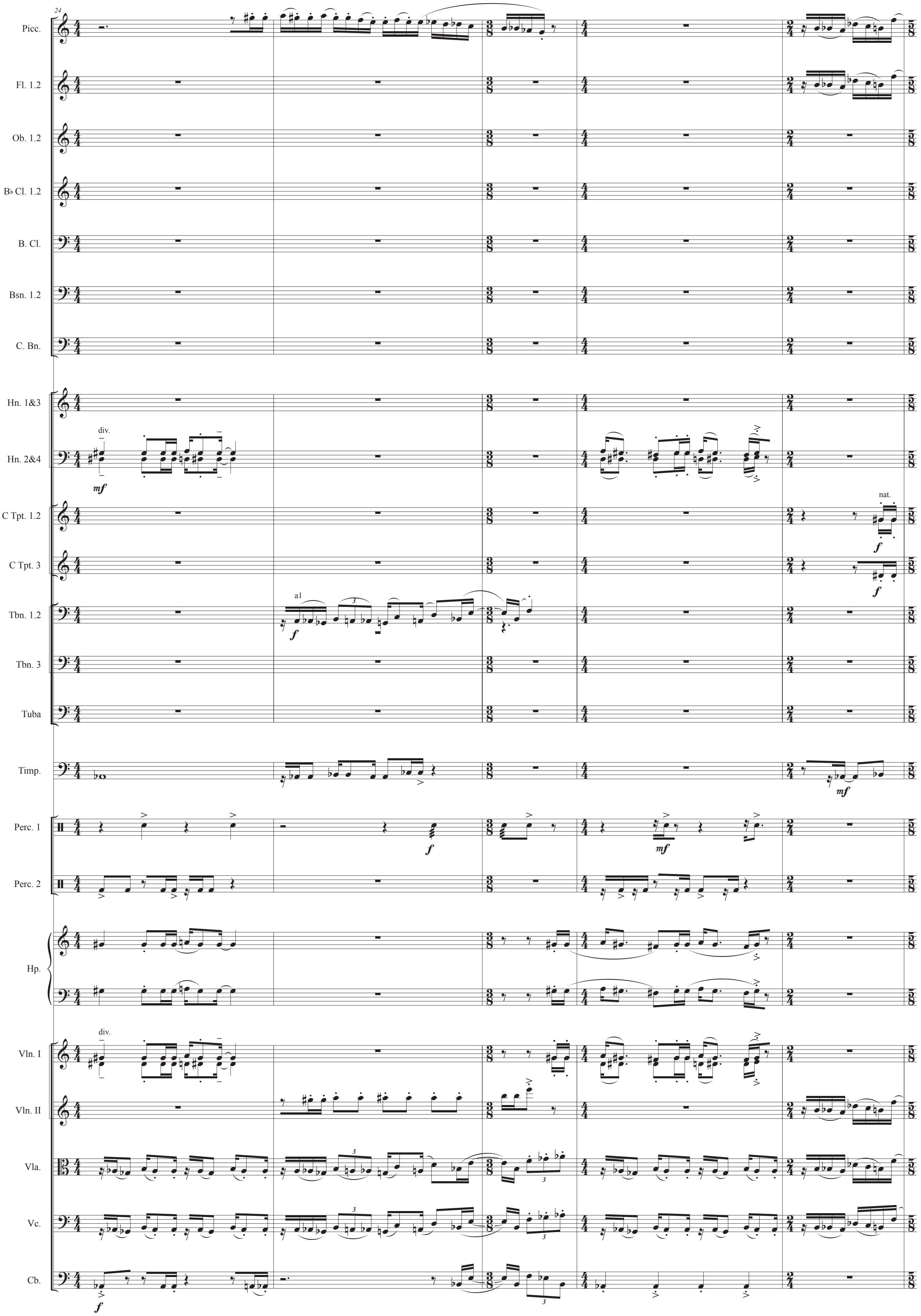
I
Polymeter: Different baring for Trumpet 1
7/8
4/4
a1 solo
cup mute
9/8
C Tpt. 1.2
mf
p
Timp.
mf
Hp.
Vln. I
mf
Vln. II
Vla.
Vc.
Cb.

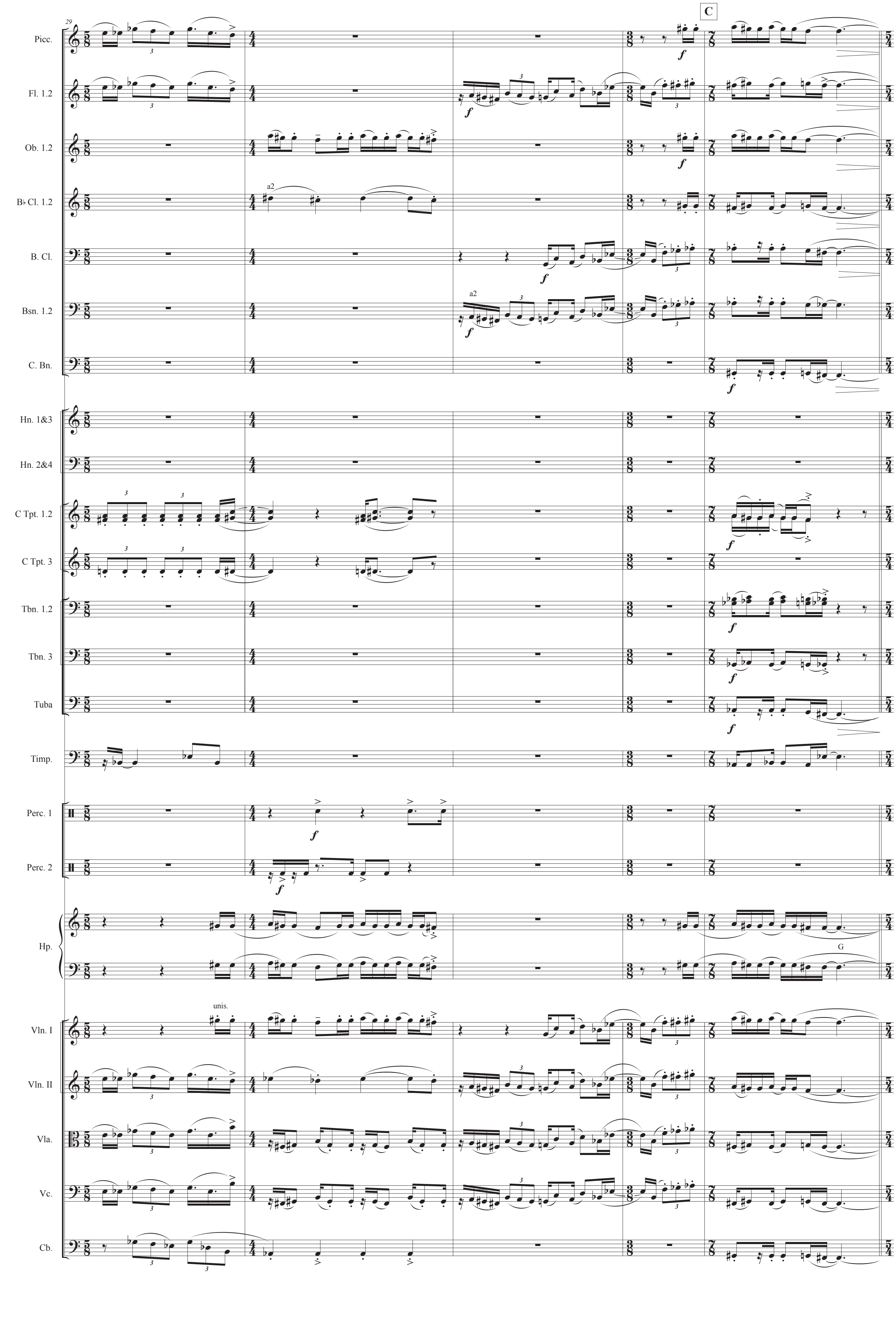
II. And-a 3-3 one-off

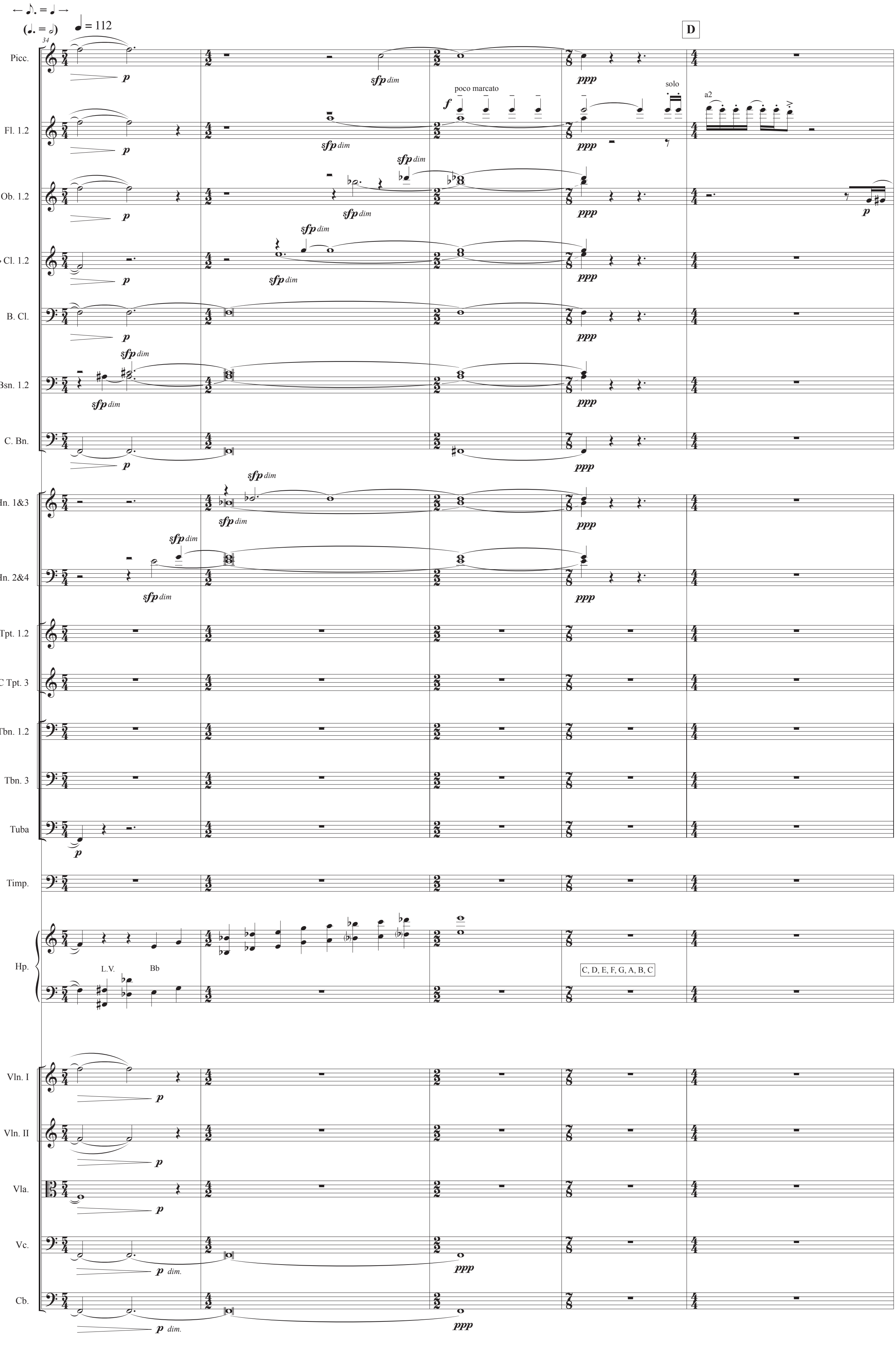



12
Picc.
Fl. 1.2
a2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Snare drum
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
arco
Vc.
pizz.
arco
Cb.
gliss.
mp
p
f
ppp
mf


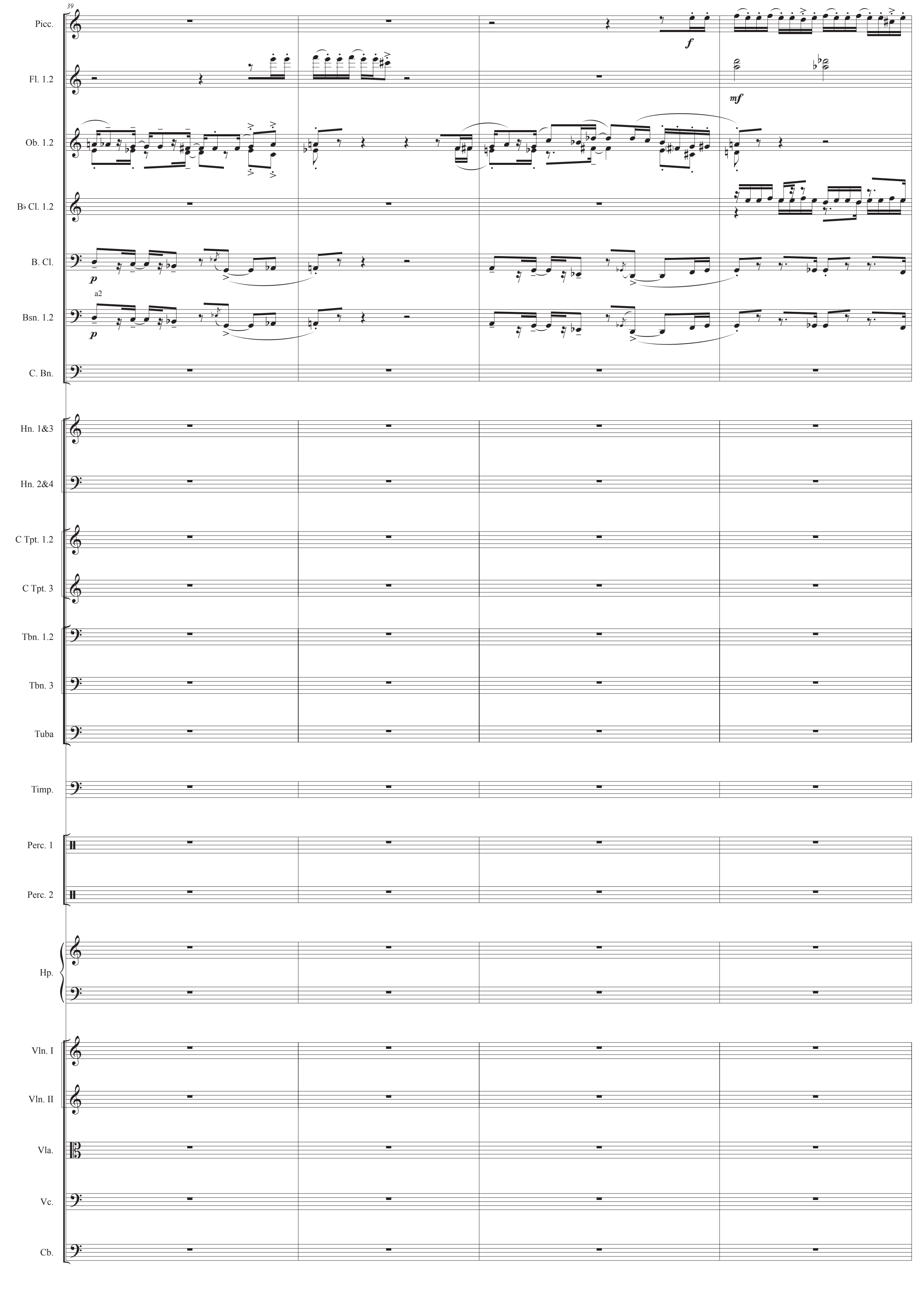
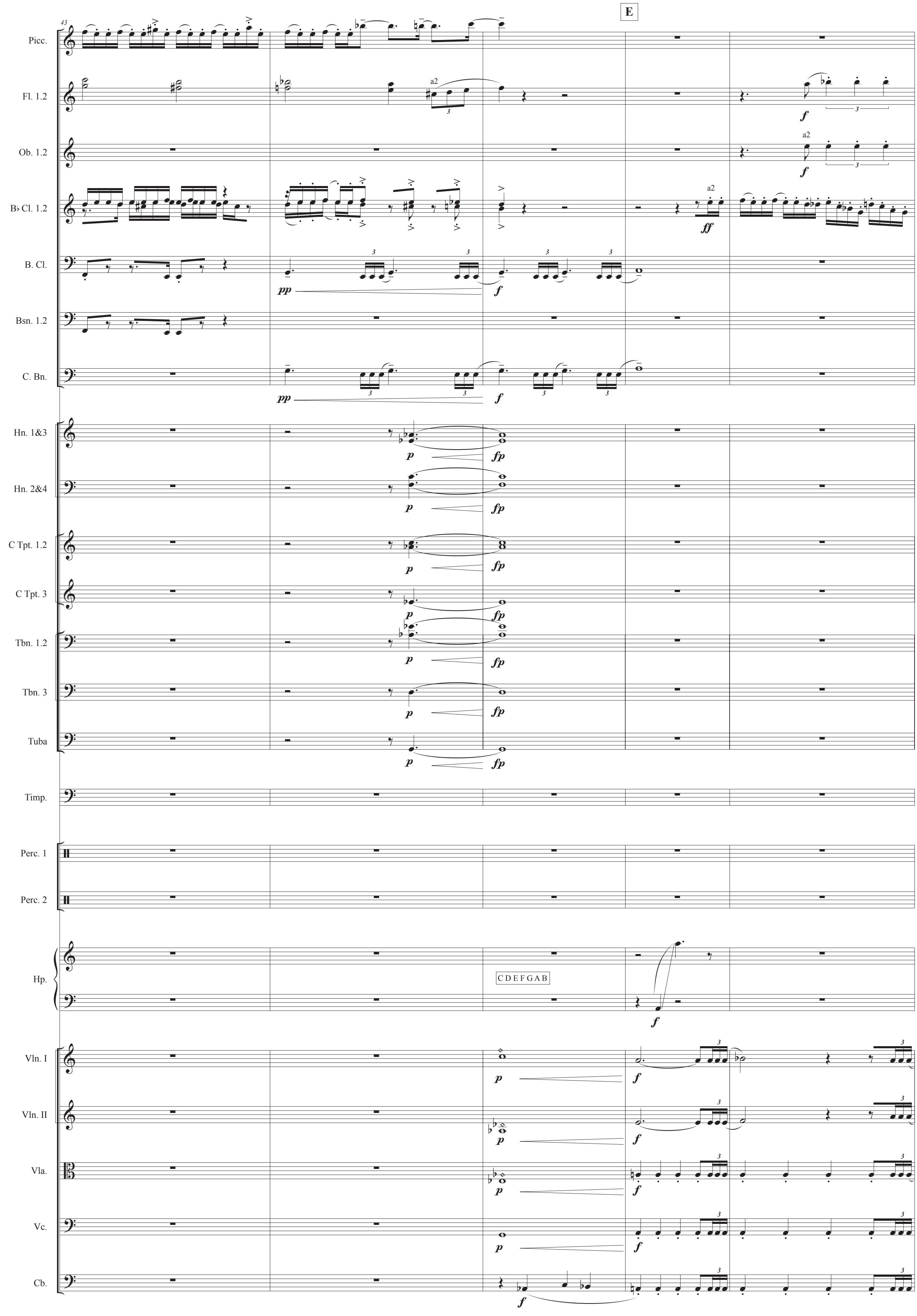
15
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
con sordino
straight mute
C Tpt. 1.2
C Tpt. 3
a1
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Db F# A#
Vln. I
Vln. II
Vla.
Vc.
Cb.


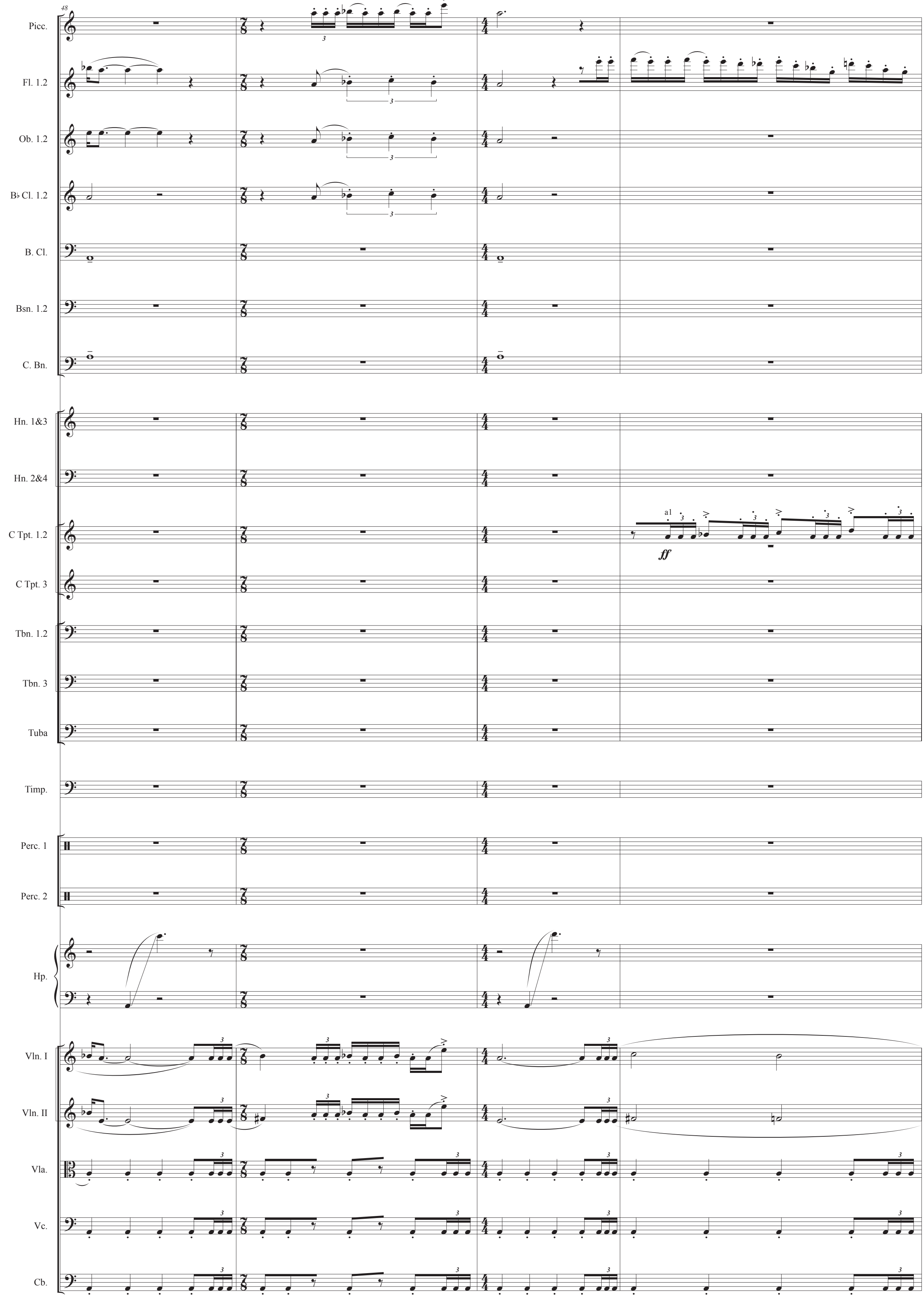
B
19
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
mf
a2
f
a1
C-Cb
Bass drum
gliss.
G - G#
A
pizz.
arco
div.
unis.
ff


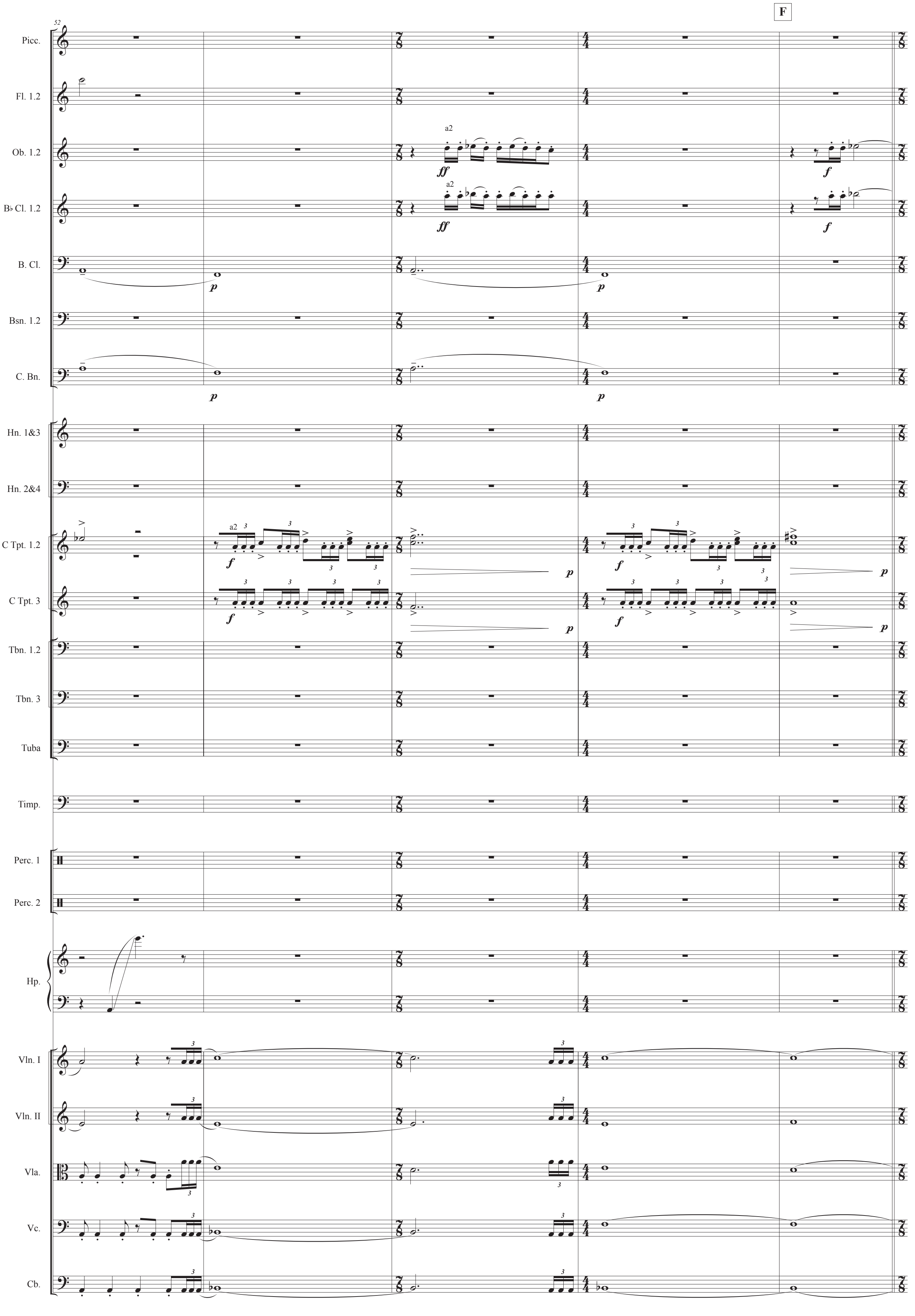
24
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
div.
mf
C Tpt. 1.2
nat.
f
C Tpt. 3
f
Tbn. 1.2
a1
f
Tbn. 3
Tuba
Timp.
mf
Perc. 1
f
mf
Perc. 2
Hp.
Vln. I
div.
Vln. II
Vla.
Vc.
Cb.
f


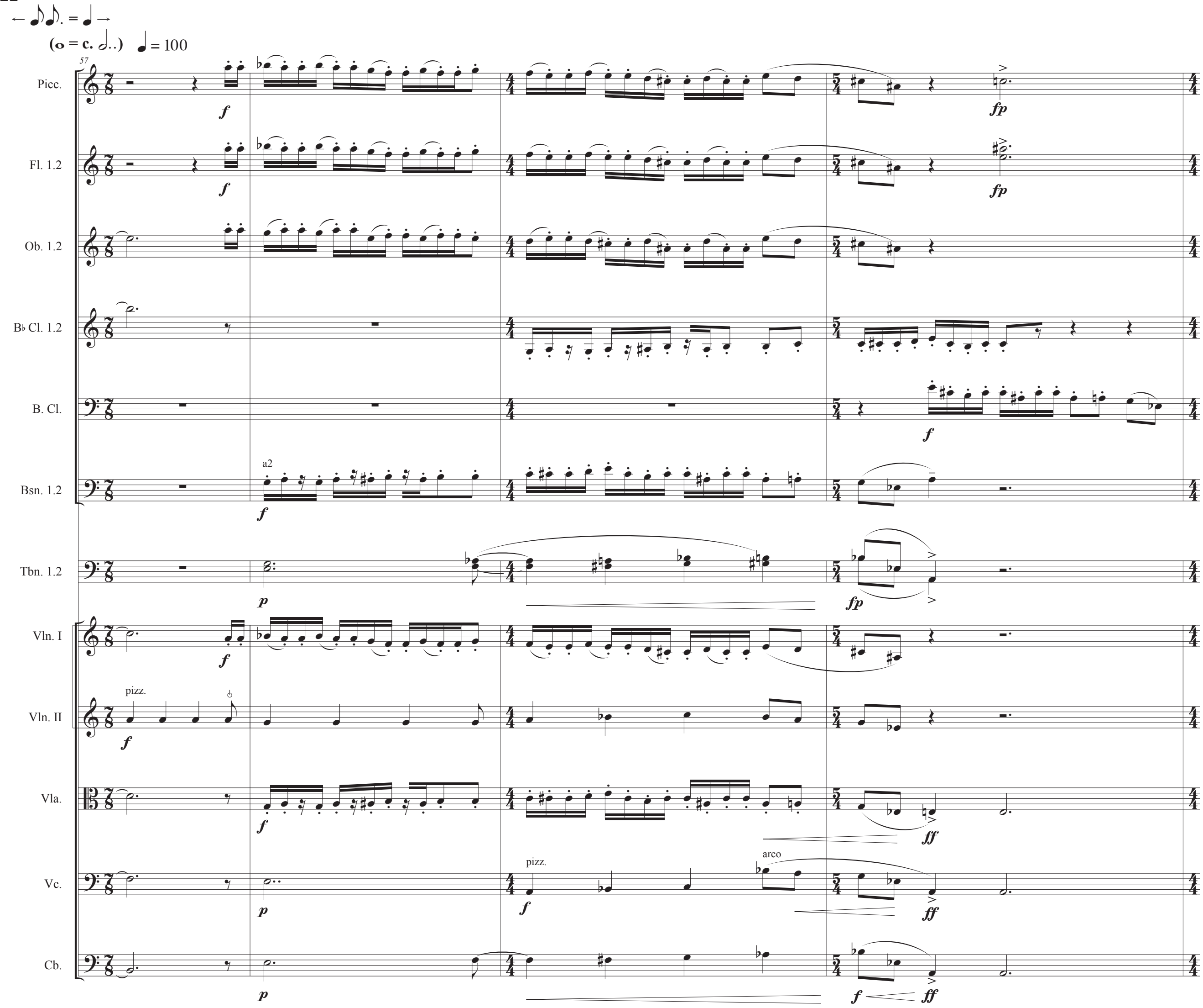
29
C
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
a2
B. Cl.
Bsn. 1.2
a2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
G
unis.
Vln. I
Vln. II
Vla.
Vc.
Cb.


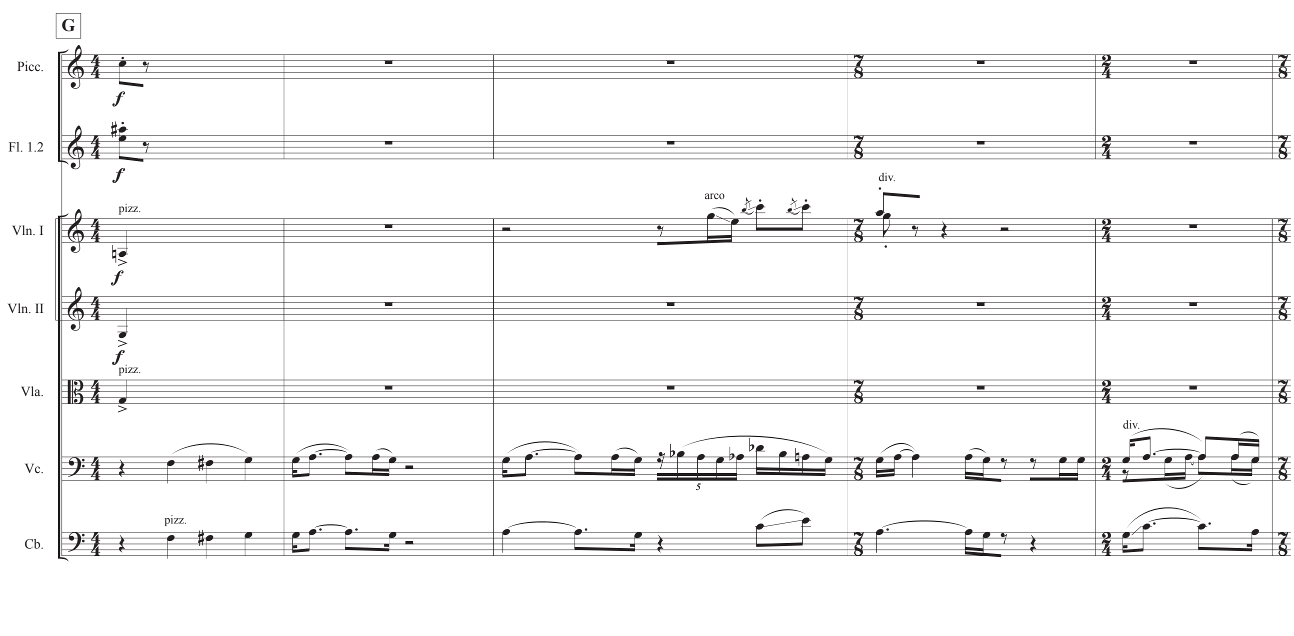
♩ = 112
D
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
poco marcato
solo
a2
sfp dim
L.V.
Bb
C, D, E, F, G, A, B, C
dim.

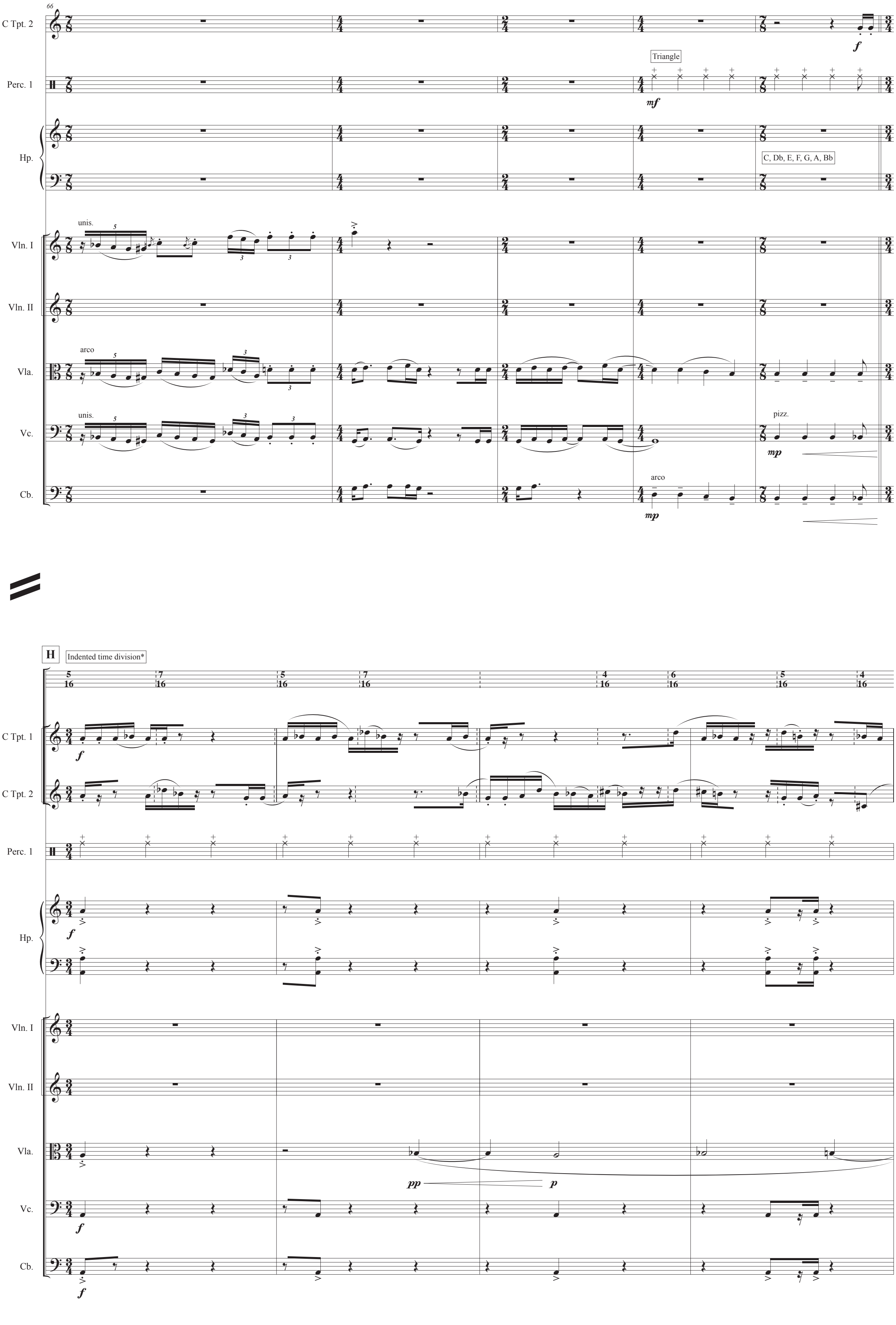

39
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
a2
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
f
mf
p
p


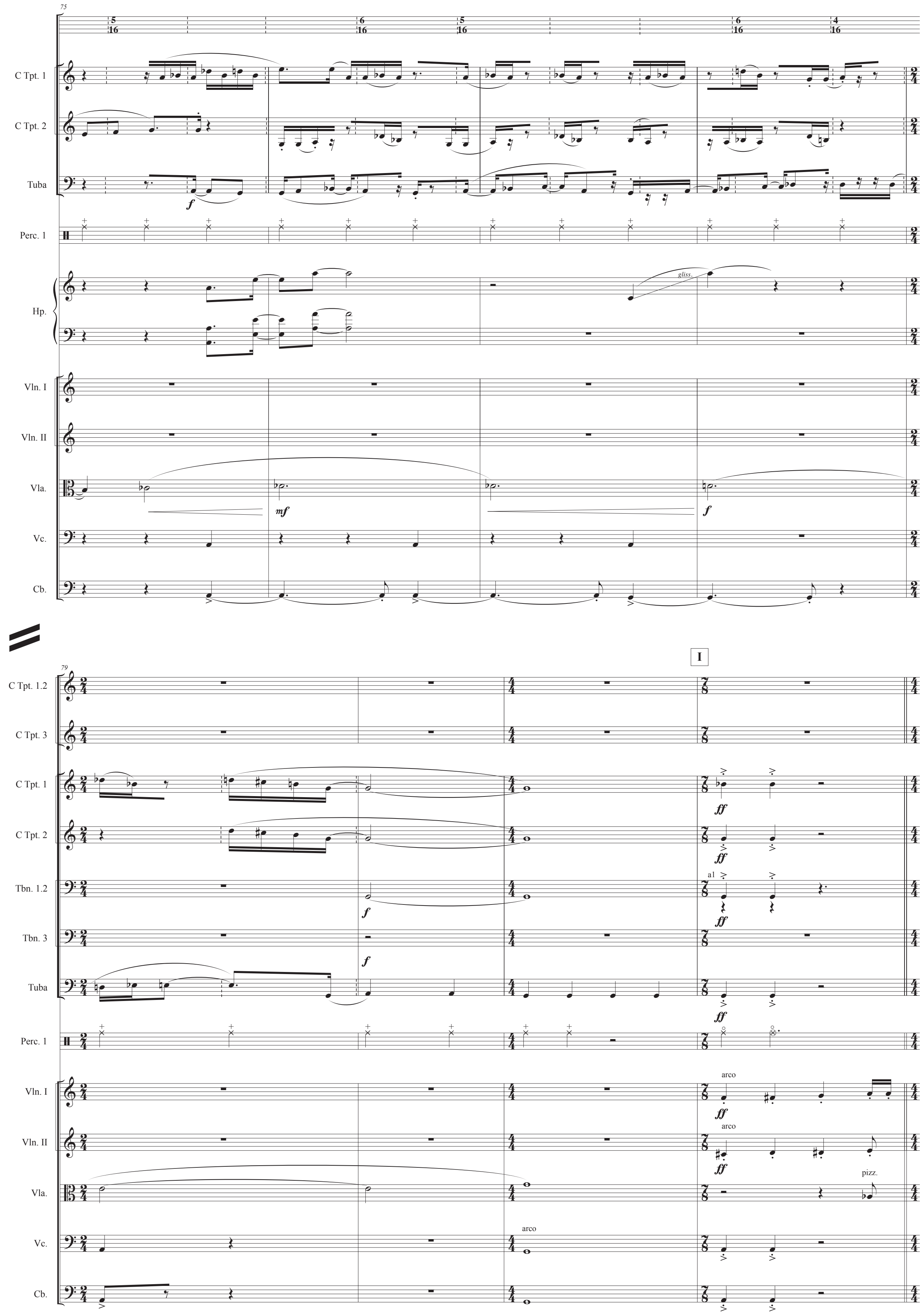
43
E
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
C D E F G A B
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
pp
f
ff
p
fp


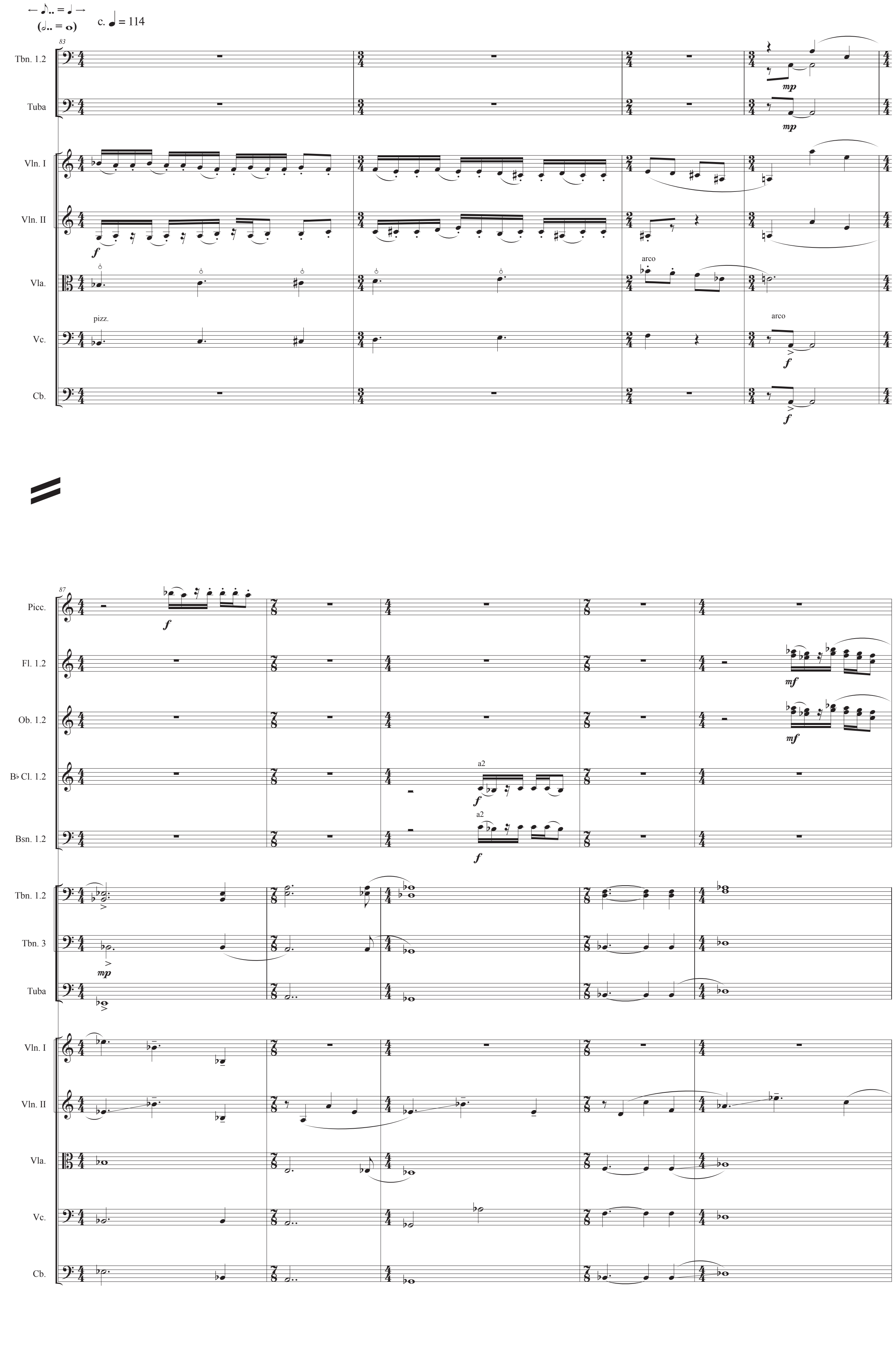
48
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
a1
ff
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.


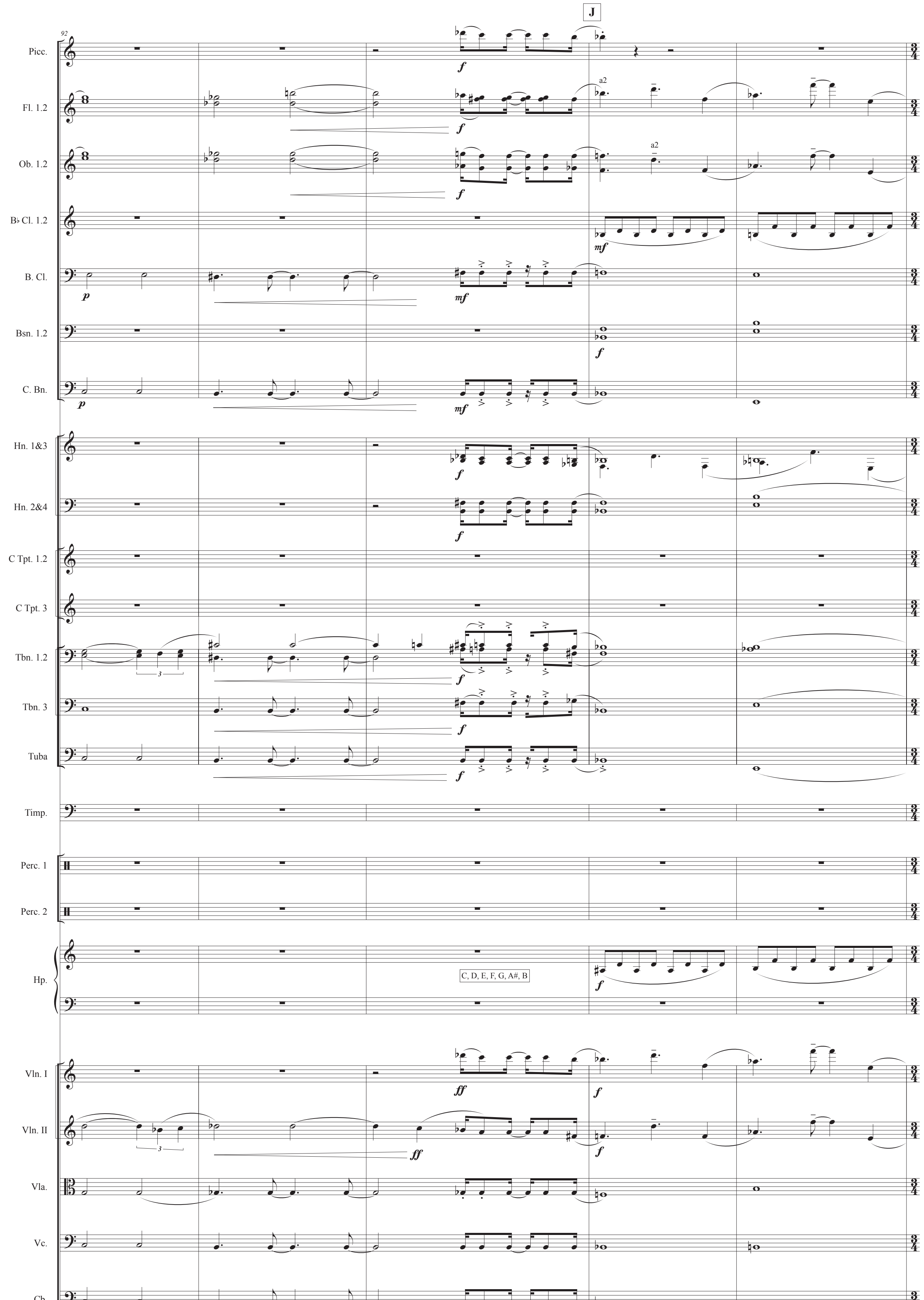
F
52
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
ff
f
p


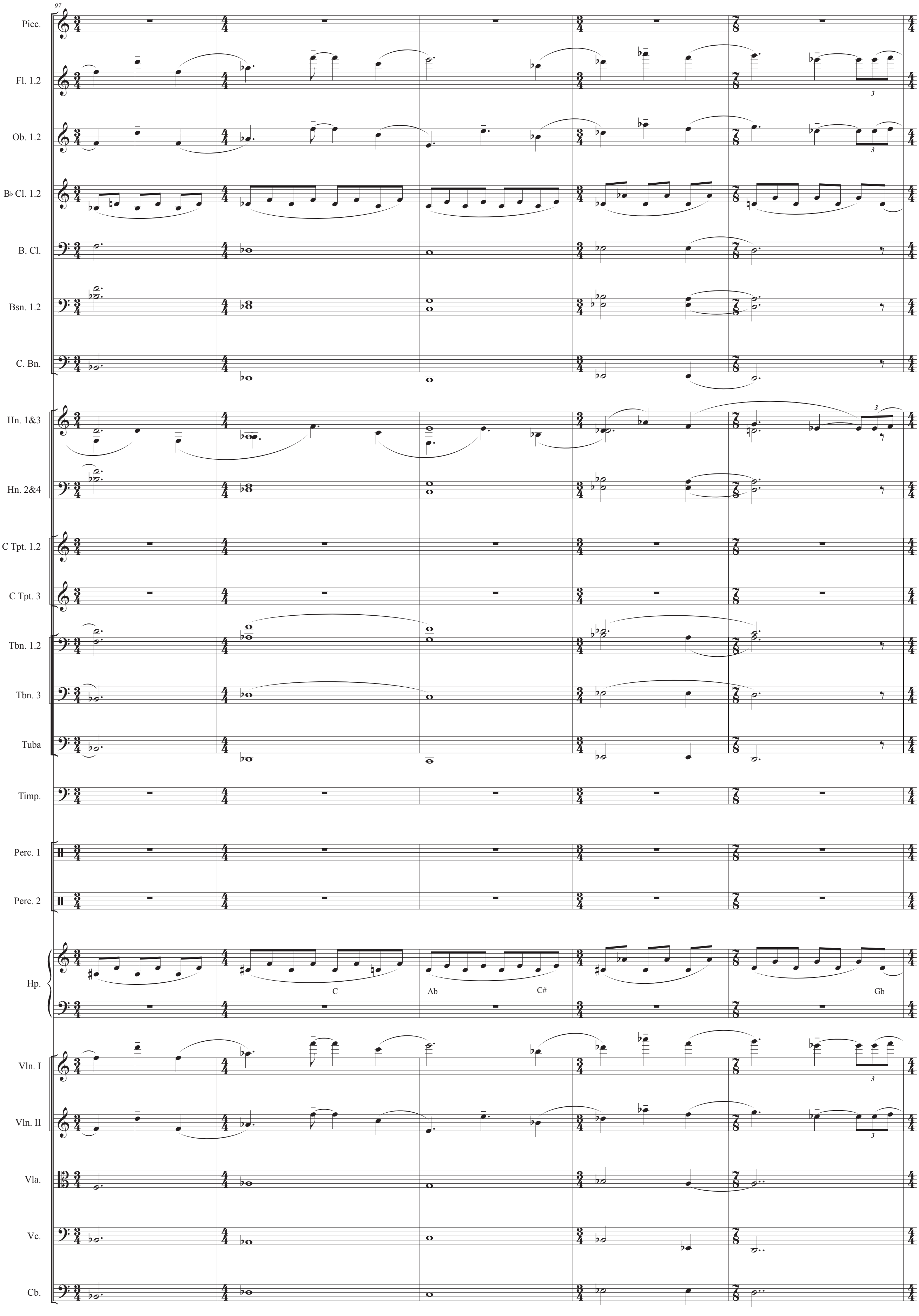
(o = c. 𝅗𝅥..) ♩ = 100
57
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
a2
Tbn. 1.2
Vln. I
Vln. II
pizz.
Vla.
Vc.
pizz.
arco
Cb.


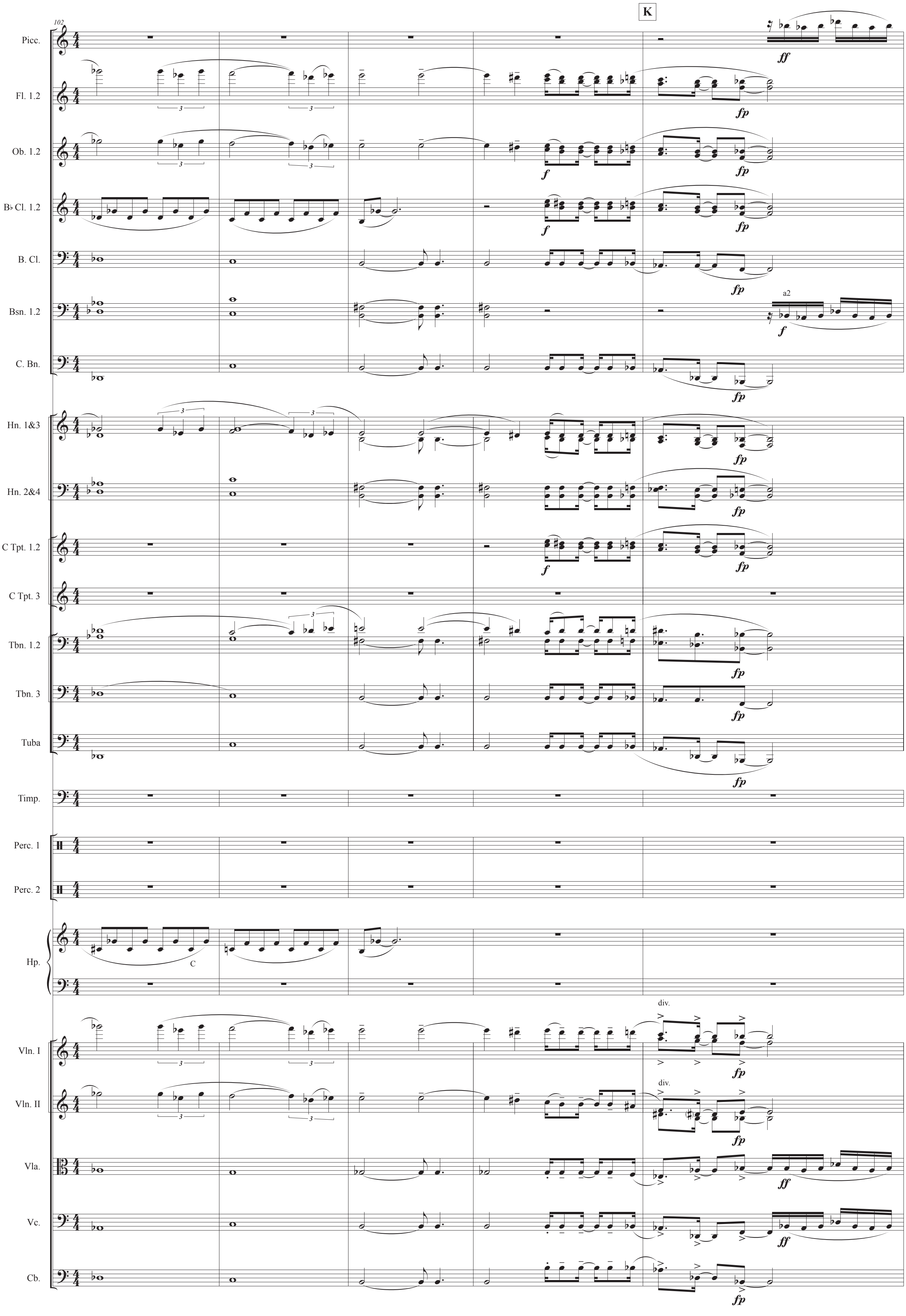
G
Picc.
Fl. 1.2
Vln. I
pizz.
arco
div.
Vln. II
Vla.
pizz.
Vc.
div.
Cb.
pizz.


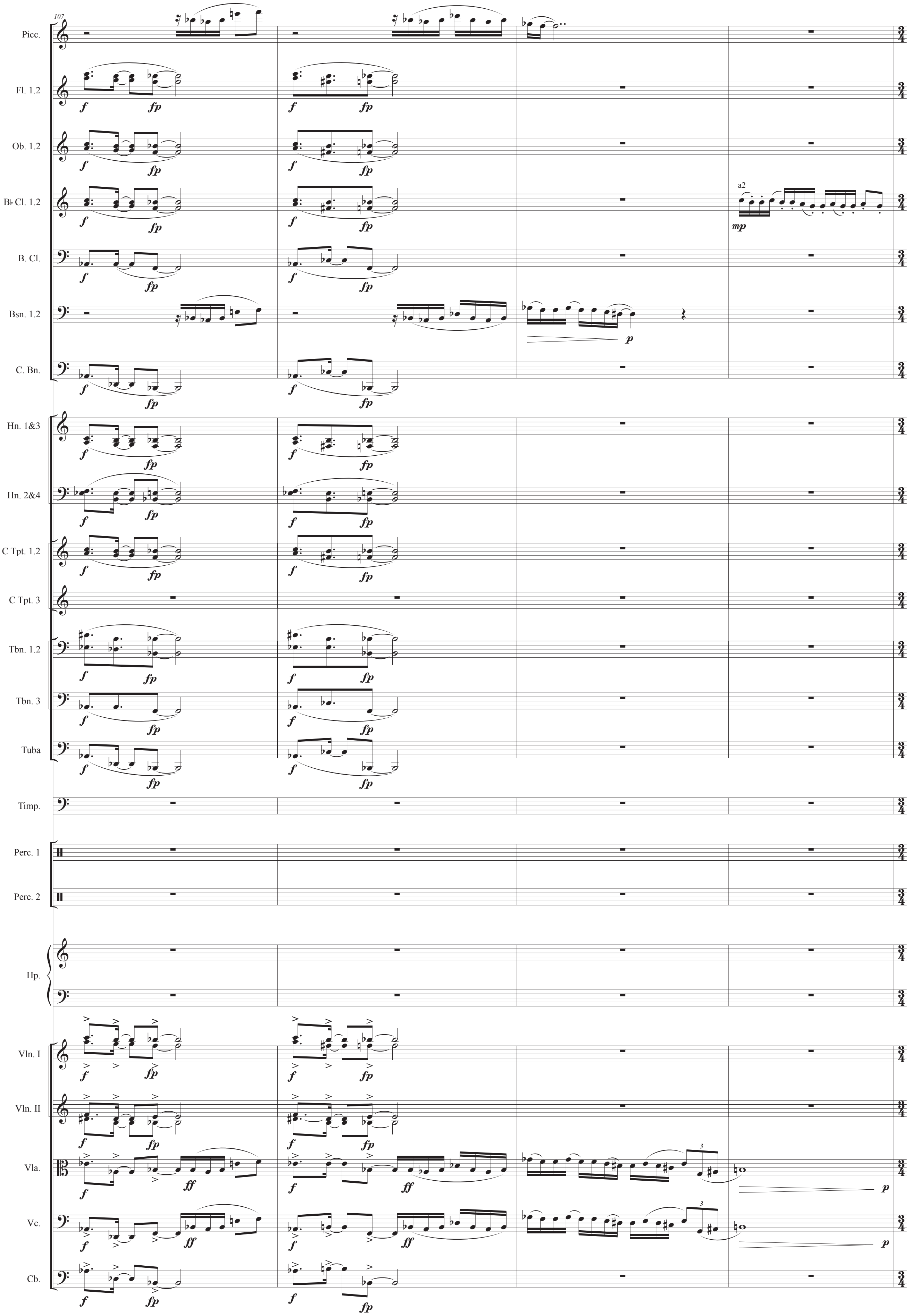
66
C Tpt. 2
Perc. 1
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
Triangle
mf
f
C, Db, E, F, G, A, Bb
unis.
arco
pizz.
mp
H
Indented time division*
C Tpt. 1
pp
p


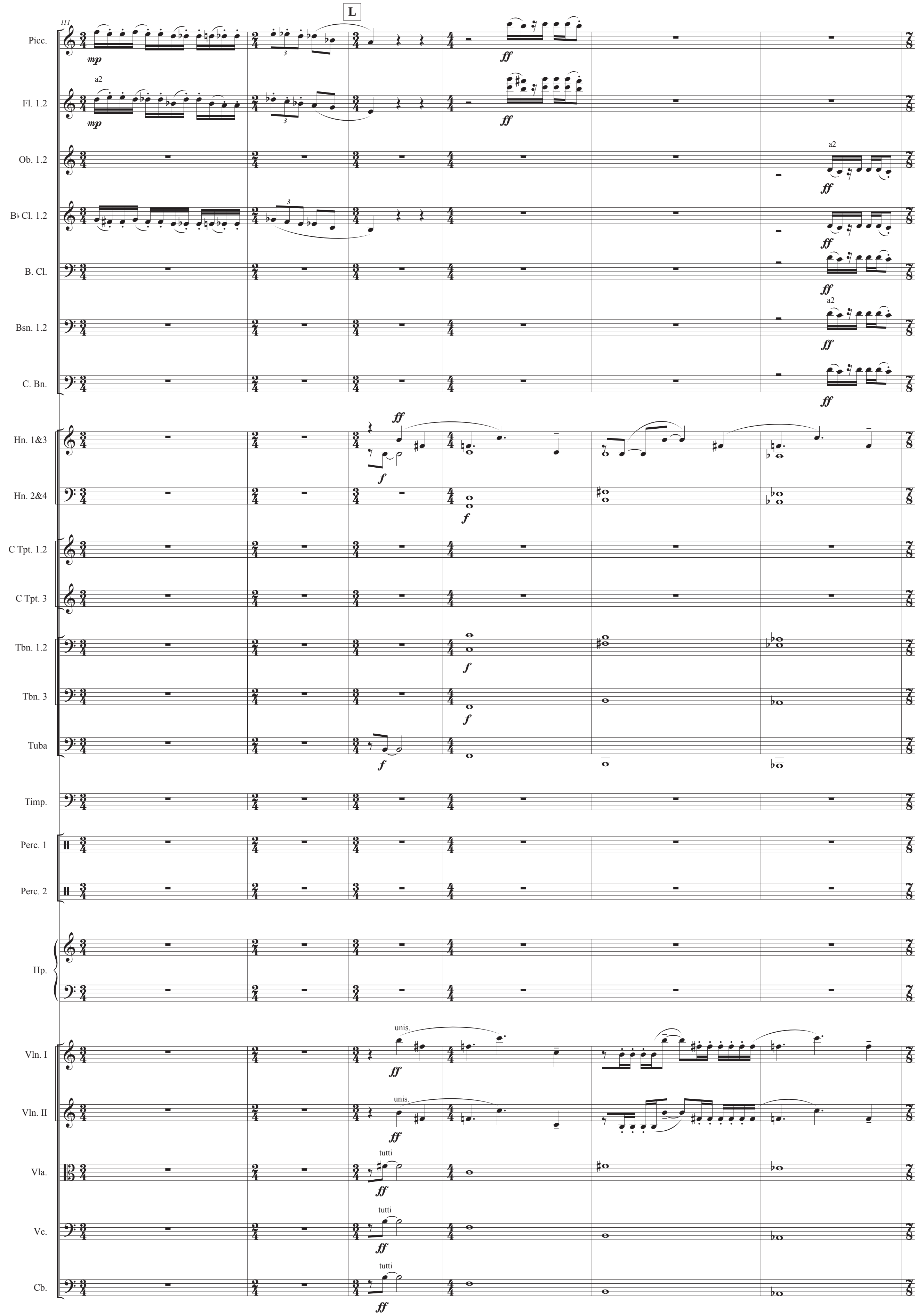
75
C Tpt. 1
C Tpt. 2
Tuba
Perc. 1
Hp.
gliss.
Vln. I
Vln. II
Vla.
mf
f
Vc.
Cb.
79
I
C Tpt. 1.2
C Tpt. 3
C Tpt. 1
ff
C Tpt. 2
Tbn. 1.2
a1
Tbn. 3
Tuba
Perc. 1
Vln. I
arco
Vln. II
arco
Vla.
pizz.
Vc.
arco
Cb.


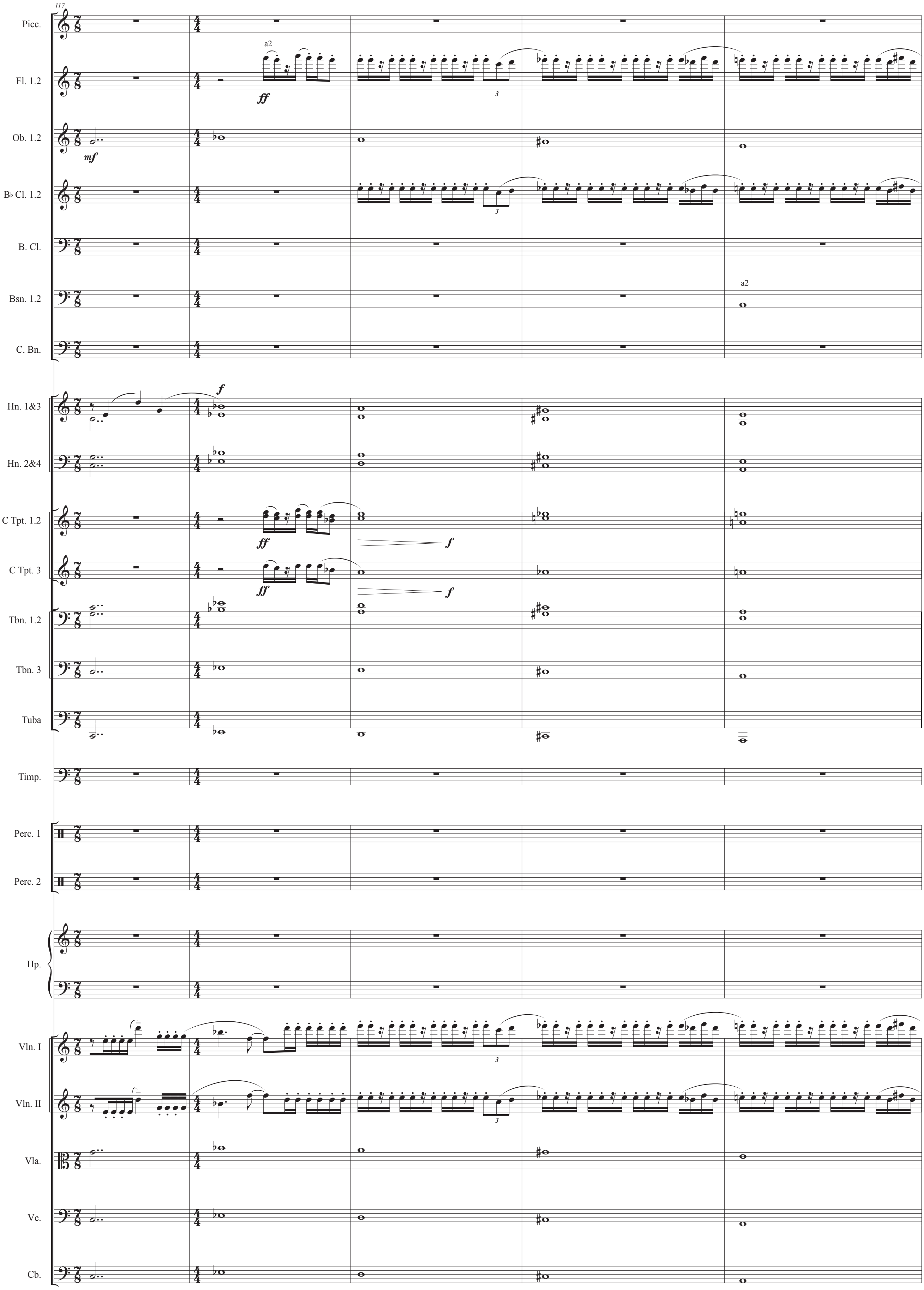
c. ♩ = 114
83
Tbn. 1.2
Tuba
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco
pizz.
arco
87
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
Bsn. 1.2
Tbn. 1.2
Tbn. 3
Tuba
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
a2


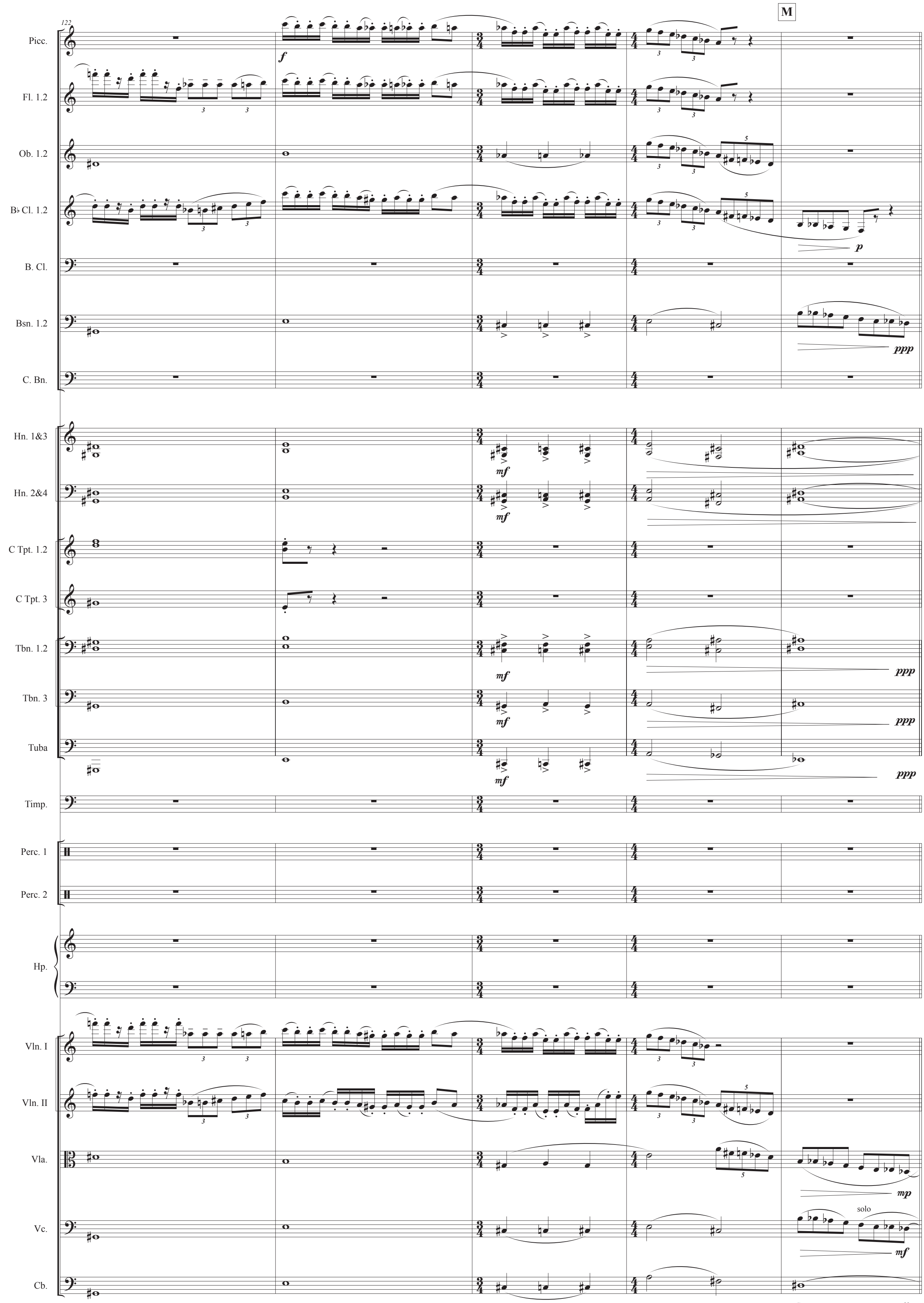
J
92
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
C, D, E, F, G, A#, B


97
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
C
Ab
C#
Gb
Vln. I
Vln. II
Vla.
Vc.
Cb.


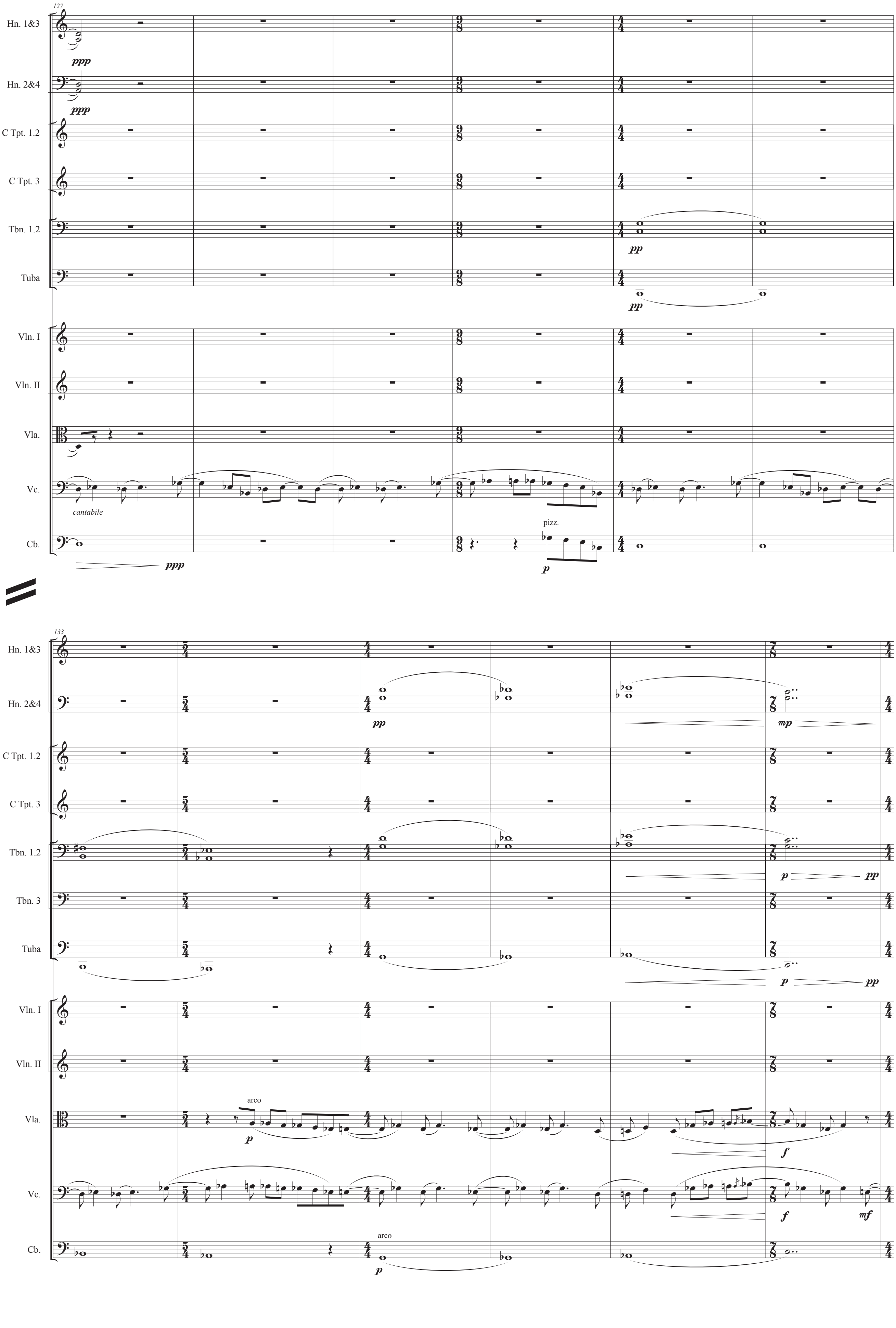
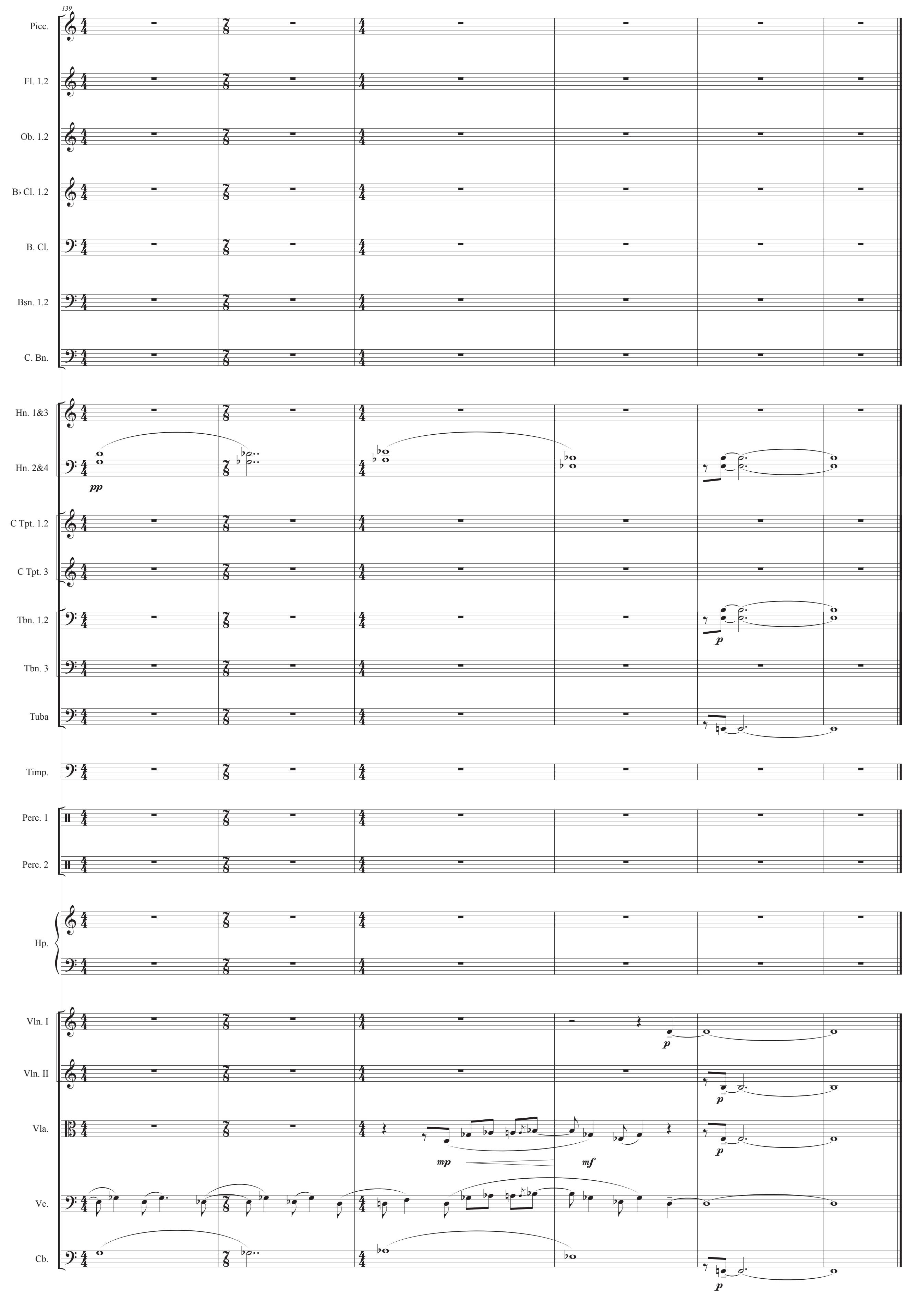
102
K
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
ff
fp
f
a2
C
div.


107
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
f
fp
ff
mp
p


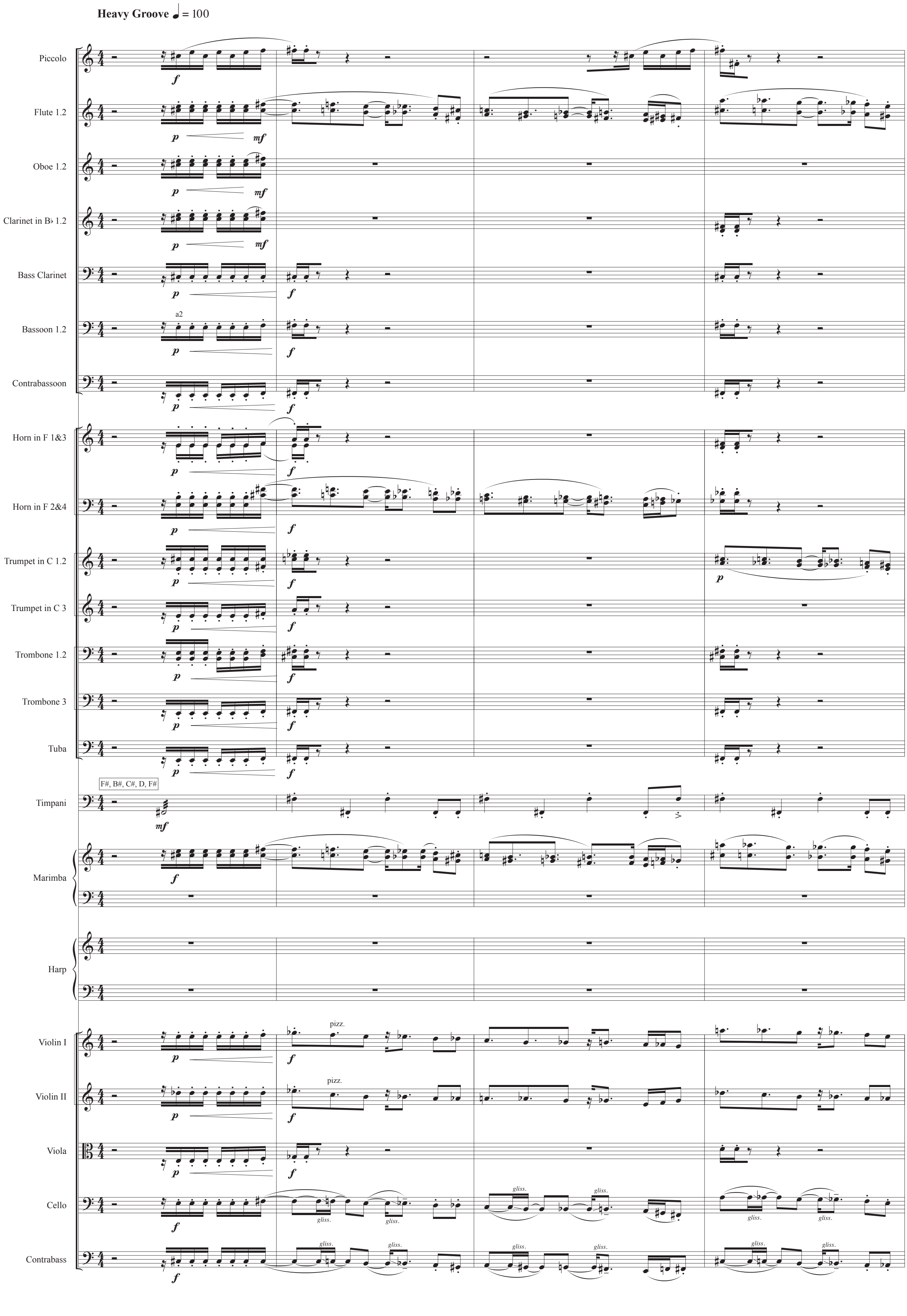
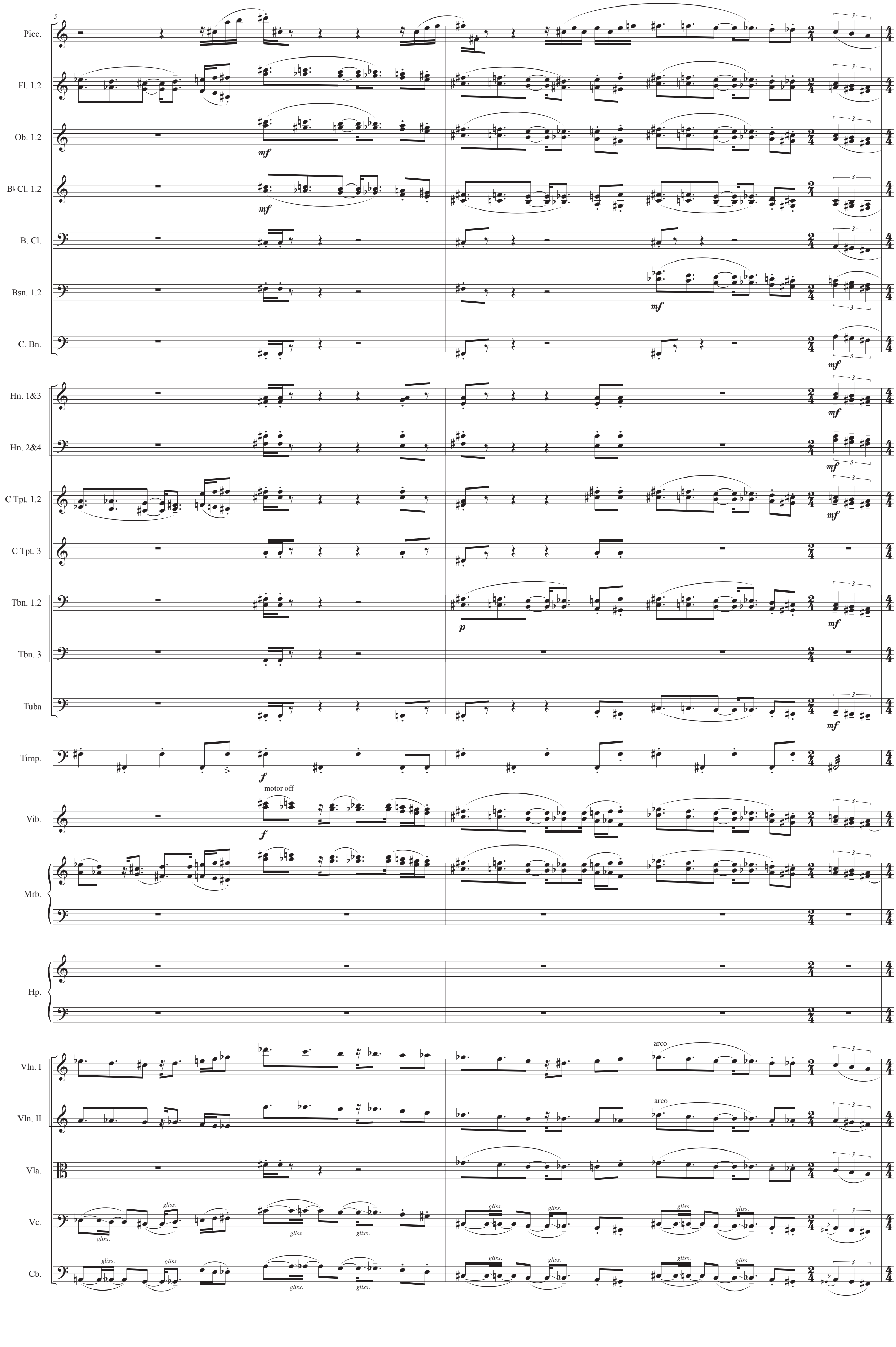
111
L
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
mp
ff
f
unis.
tutti


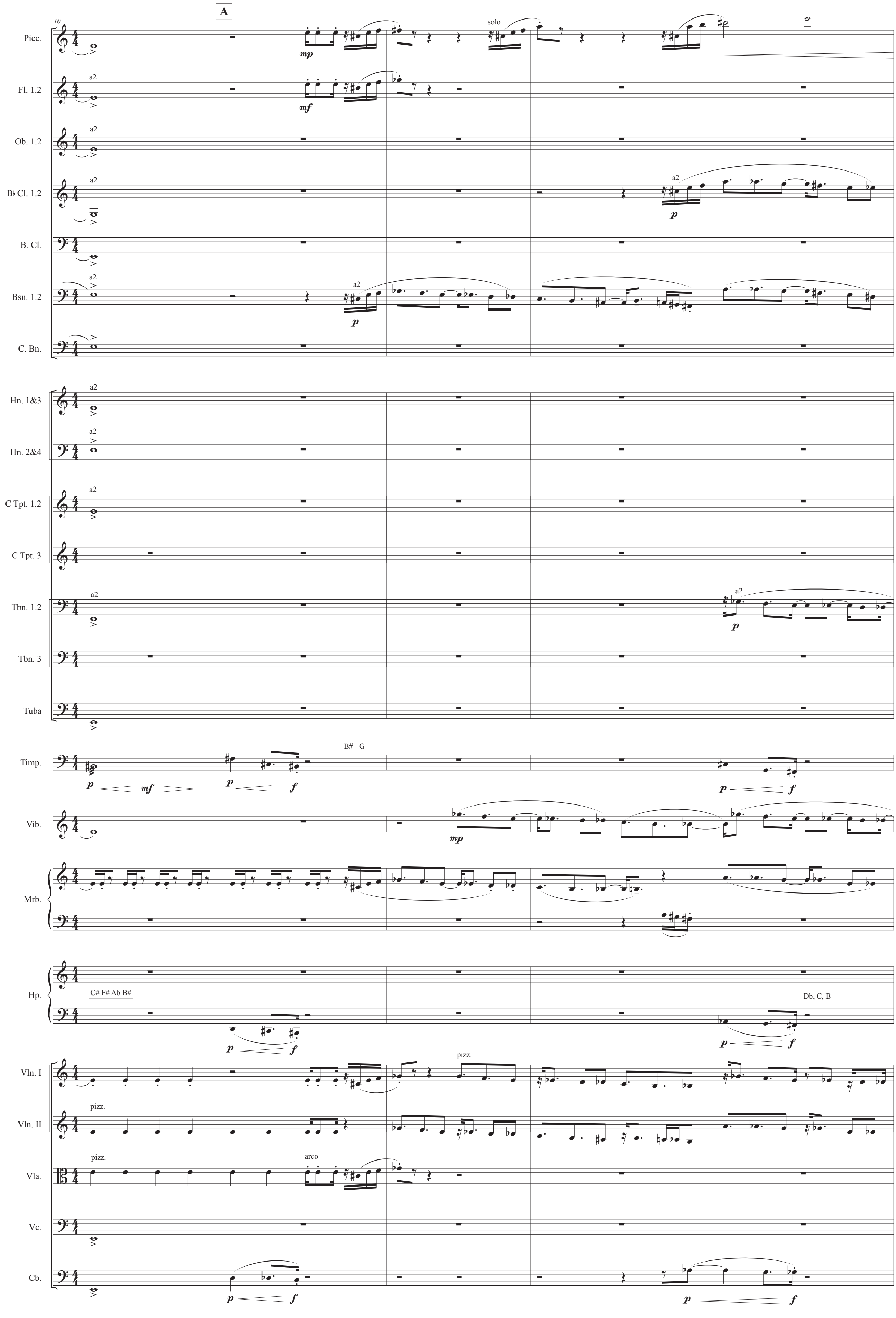
117
Picc.
Fl. 1.2
a2
ff
3
Ob. 1.2
mf
B♭ Cl. 1.2
3
B. Cl.
Bsn. 1.2
a2
C. Bn.
Hn. 1&3
f
Hn. 2&4
C Tpt. 1.2
ff
f
C Tpt. 3
ff
f
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
3
Vln. II
3
Vla.
Vc.
Cb.


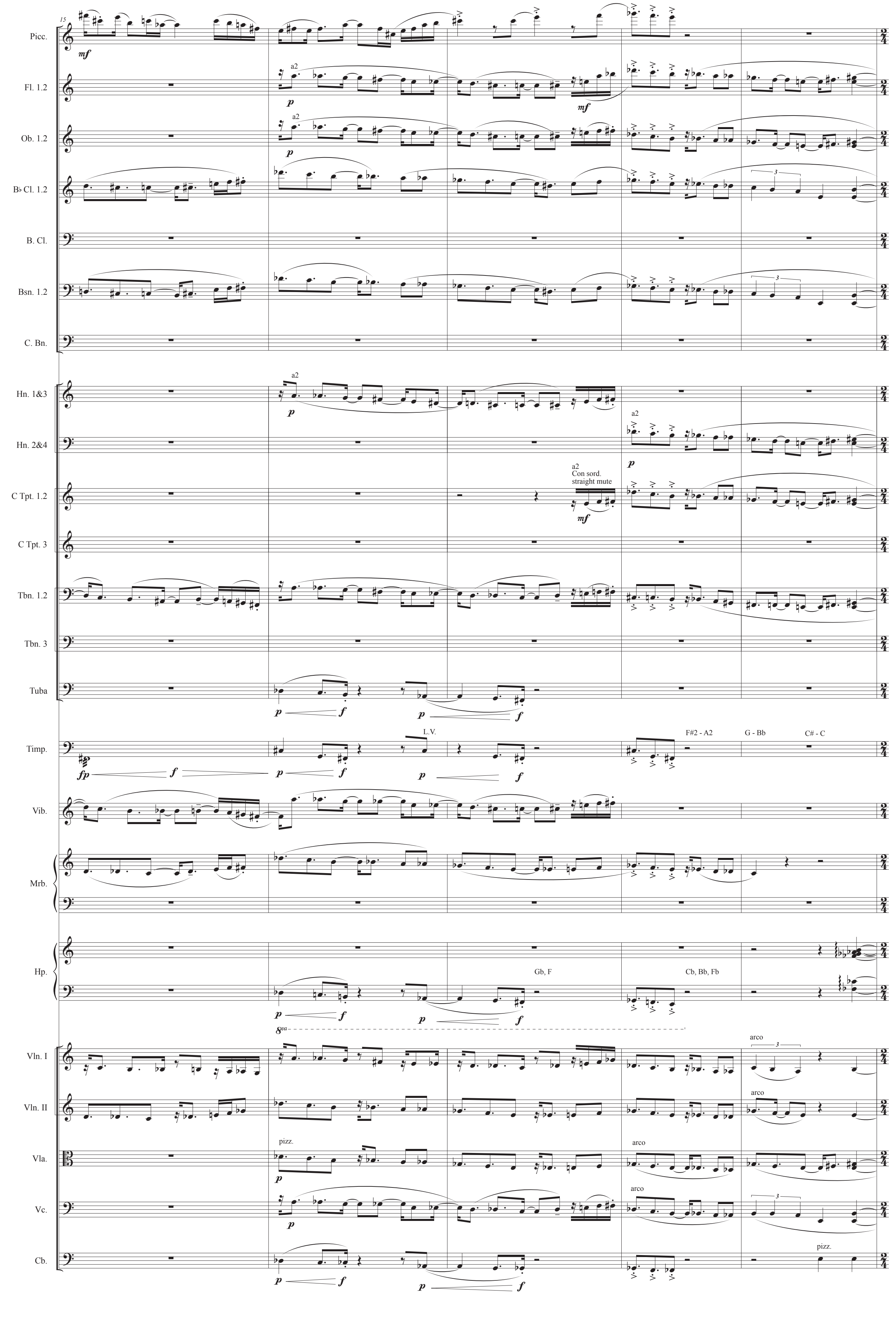
122
M
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
solo
f
mf
p
mp
ppp


127
Hn. 1&3
ppp
Hn. 2&4
ppp
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
pp
Tuba
pp
Vln. I
Vln. II
Vla.
Vc.
cantabile
Cb.
ppp
pizz.
p
133
Hn. 1&3
Hn. 2&4
pp
mp
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
p
pp
Tbn. 3
Tuba
p
pp
Vln. I
Vln. II
Vla.
arco
p
f
Vc.
f
mf
Cb.
arco
p


139
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
pp
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
p
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
p
Vln. II
p
Vla.
mp
mf
p
Vc.
Cb.
p

III. A-two a-three a-four a-one-a


5
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Vib.
Mrb.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
mf
p
f
motor off
arco
gliss.


10
A
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Vib.
Mrb.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
solo
B# - G
C# F# Ab B#
Db, C, B
pizz.
arco


15
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Vib.
Mrb.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
a2
a2
a2
a2
Con sord.
straight mute
L.V.
F#2 - A2
G - Bb
C# - C
Gb, F
Cb, Bb, Fb
8va
pizz.
arco
arco
arco
arco
arco
pizz.
mf
p
p
p
p
mf
p
mf
p
f
p
f
fp
f
p
f
p
f
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f
p
f
p
f
p
f
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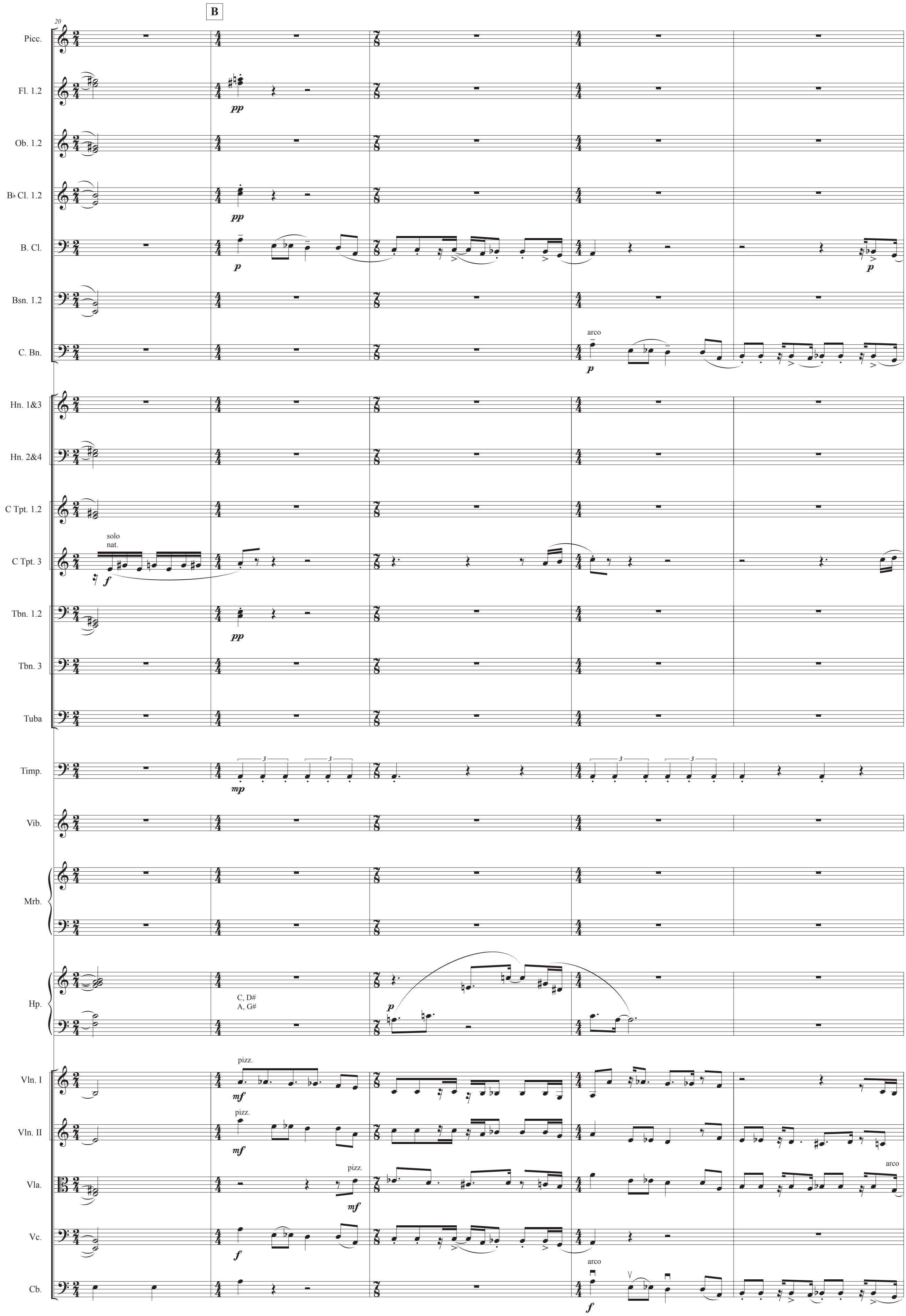
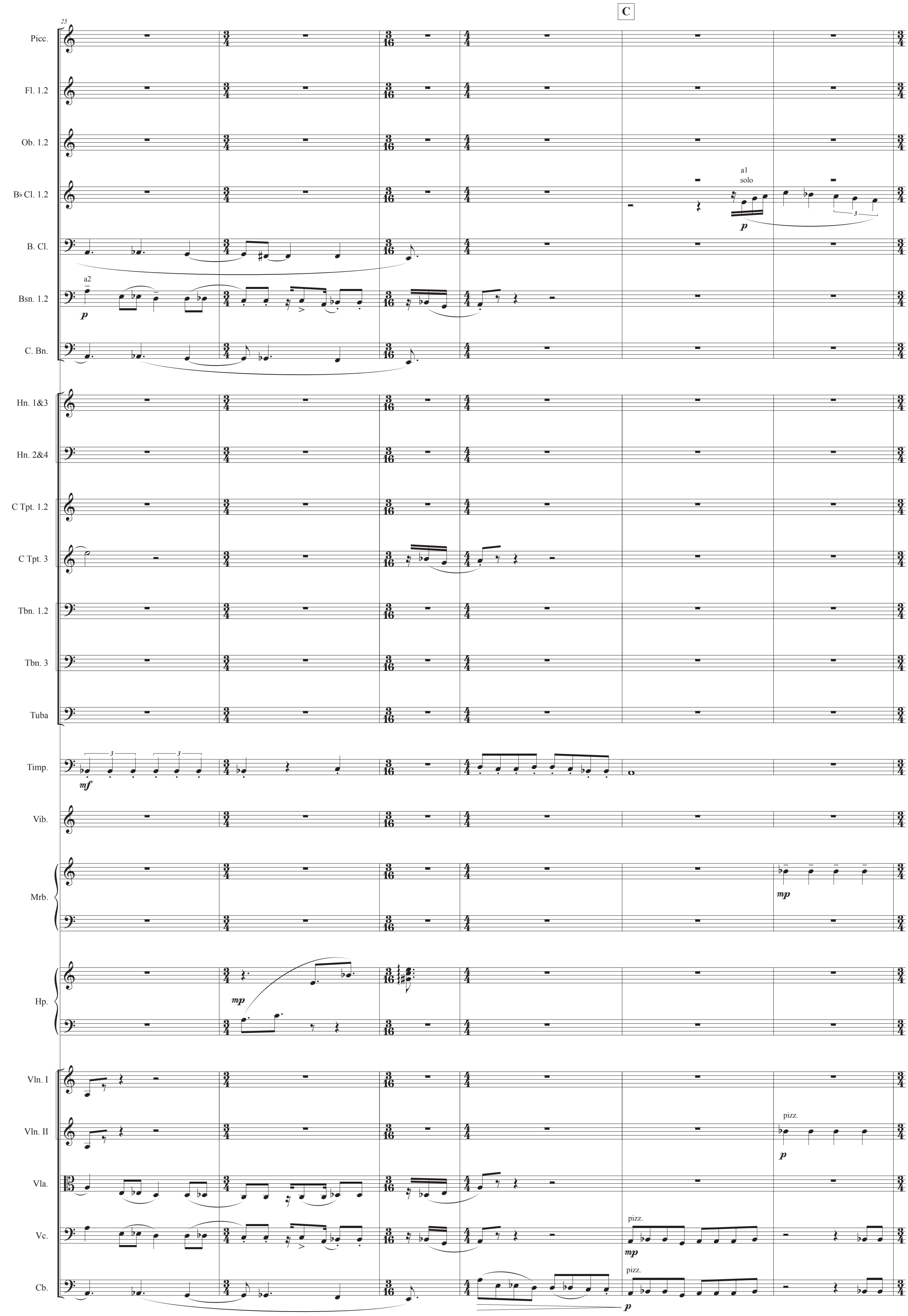
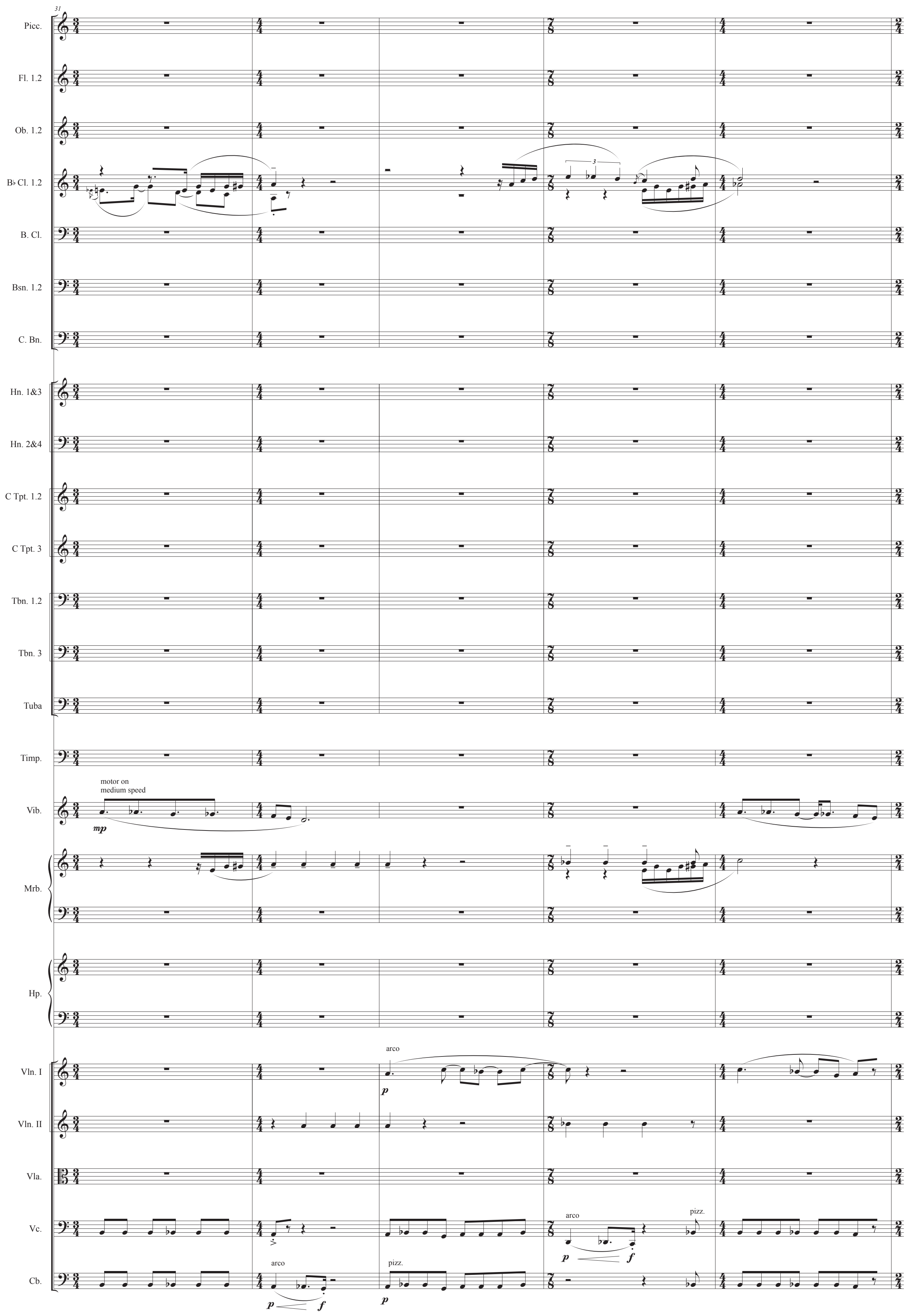
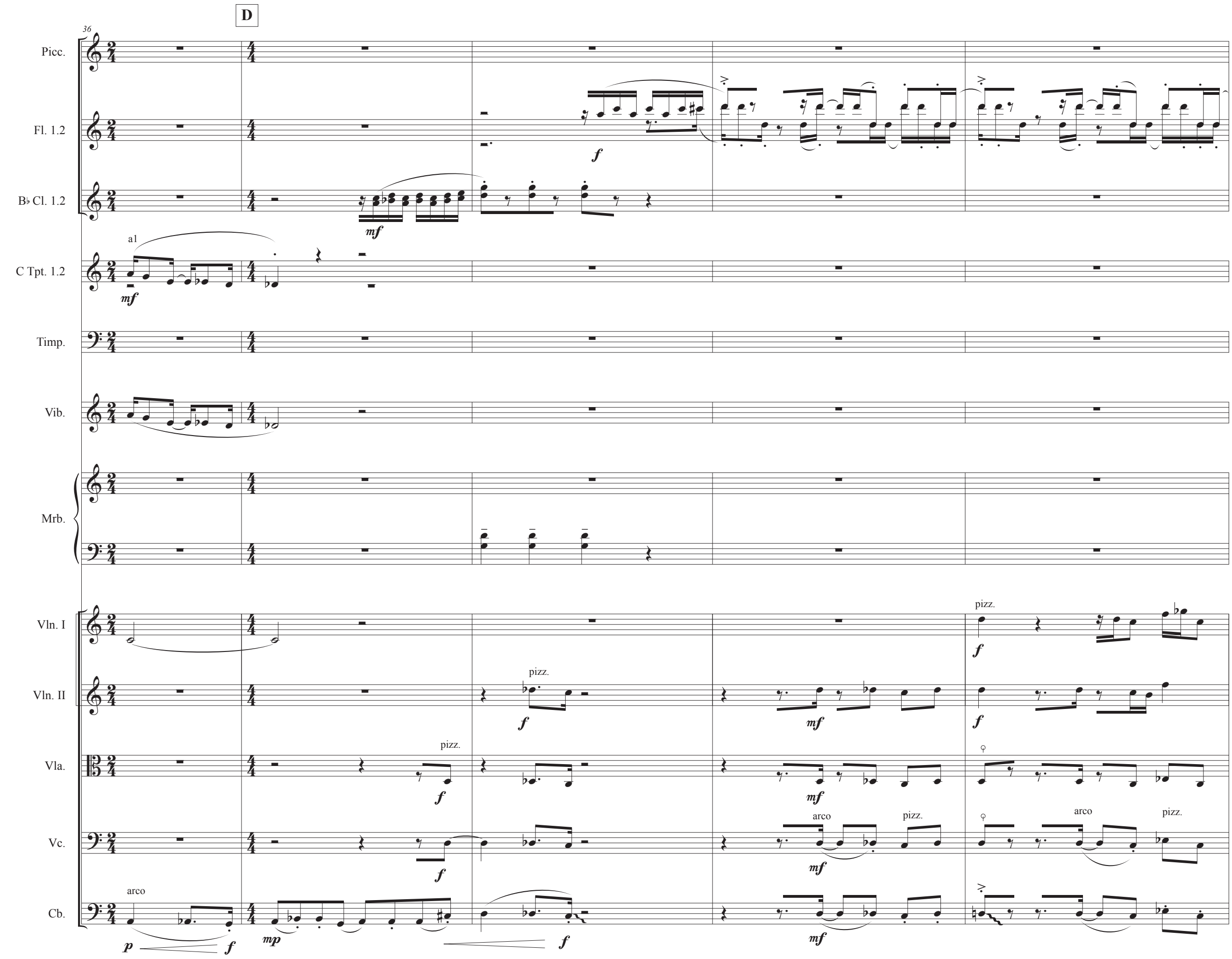
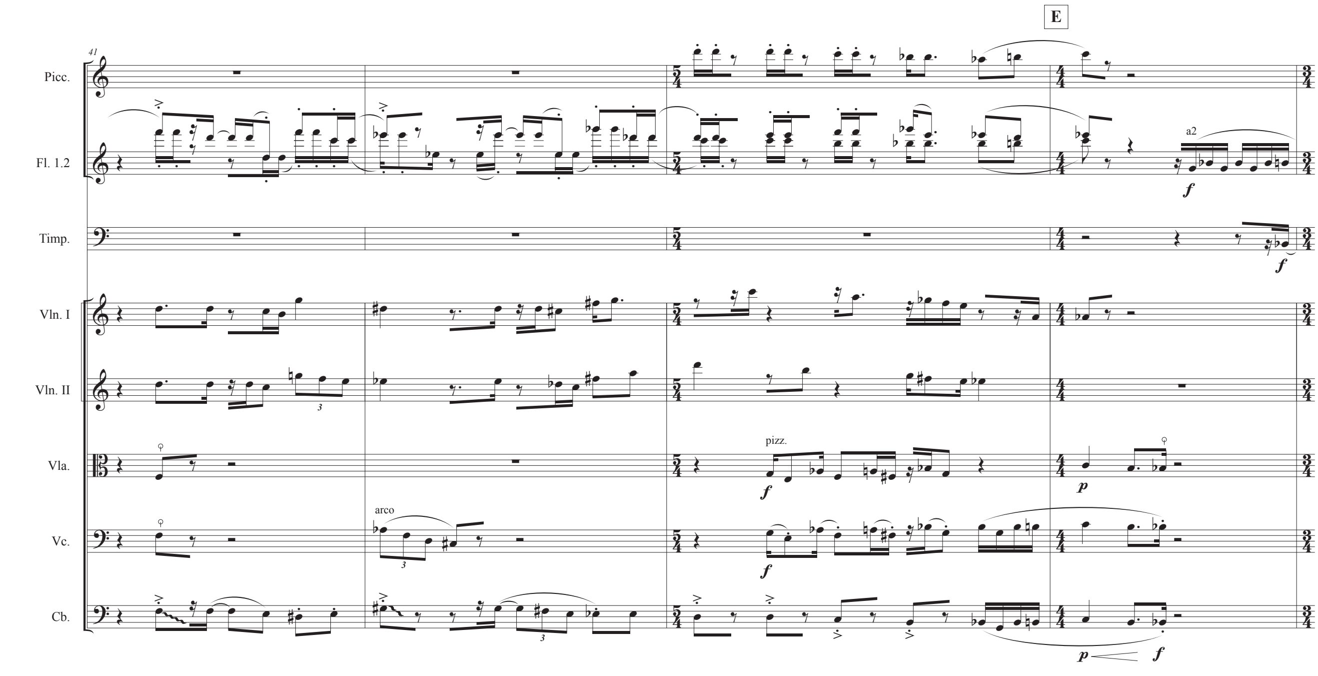
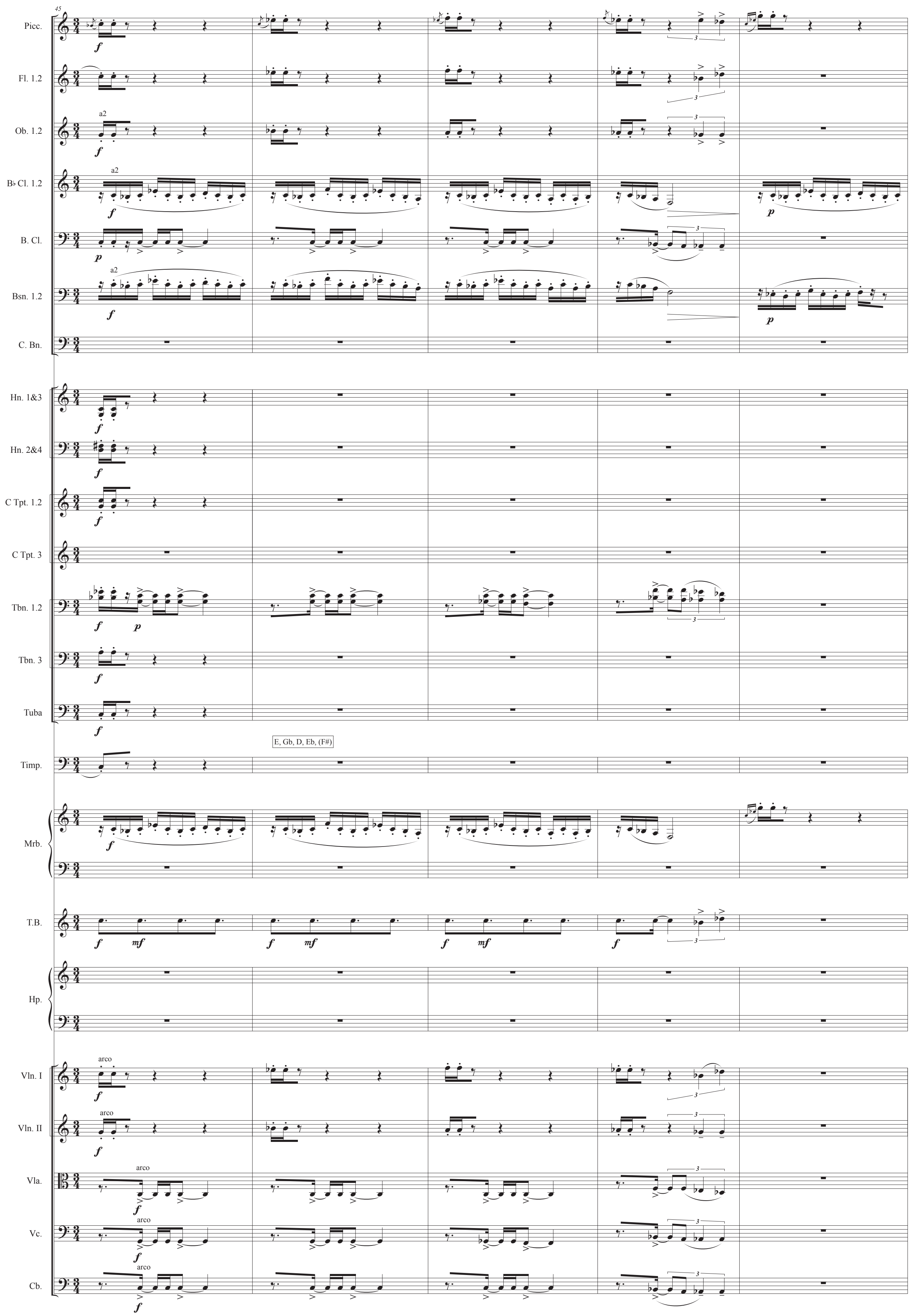
p
p
f
p
f


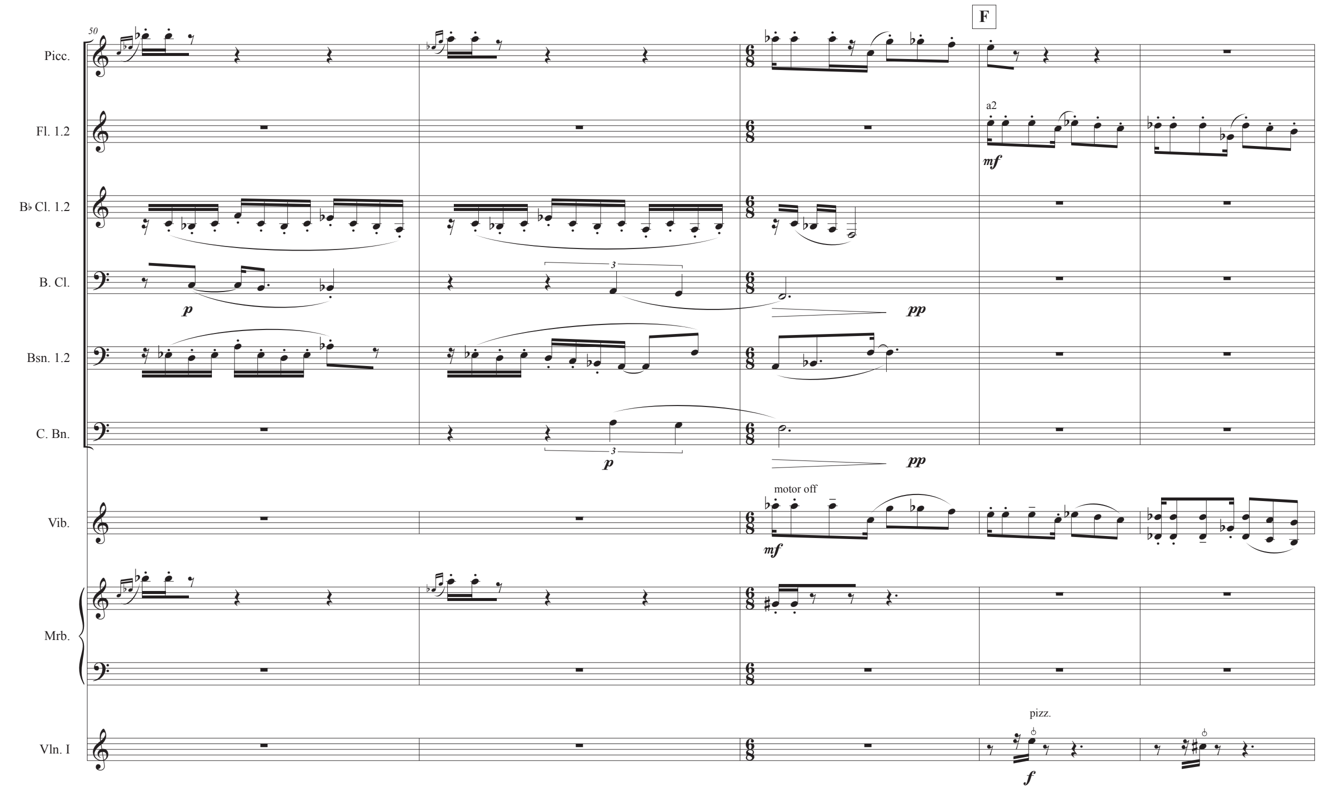
B
20
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Vib.
Mrb.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
pp
p
arco
solo
nat.
f
mp
C, D#
A, G#
pizz.
mf


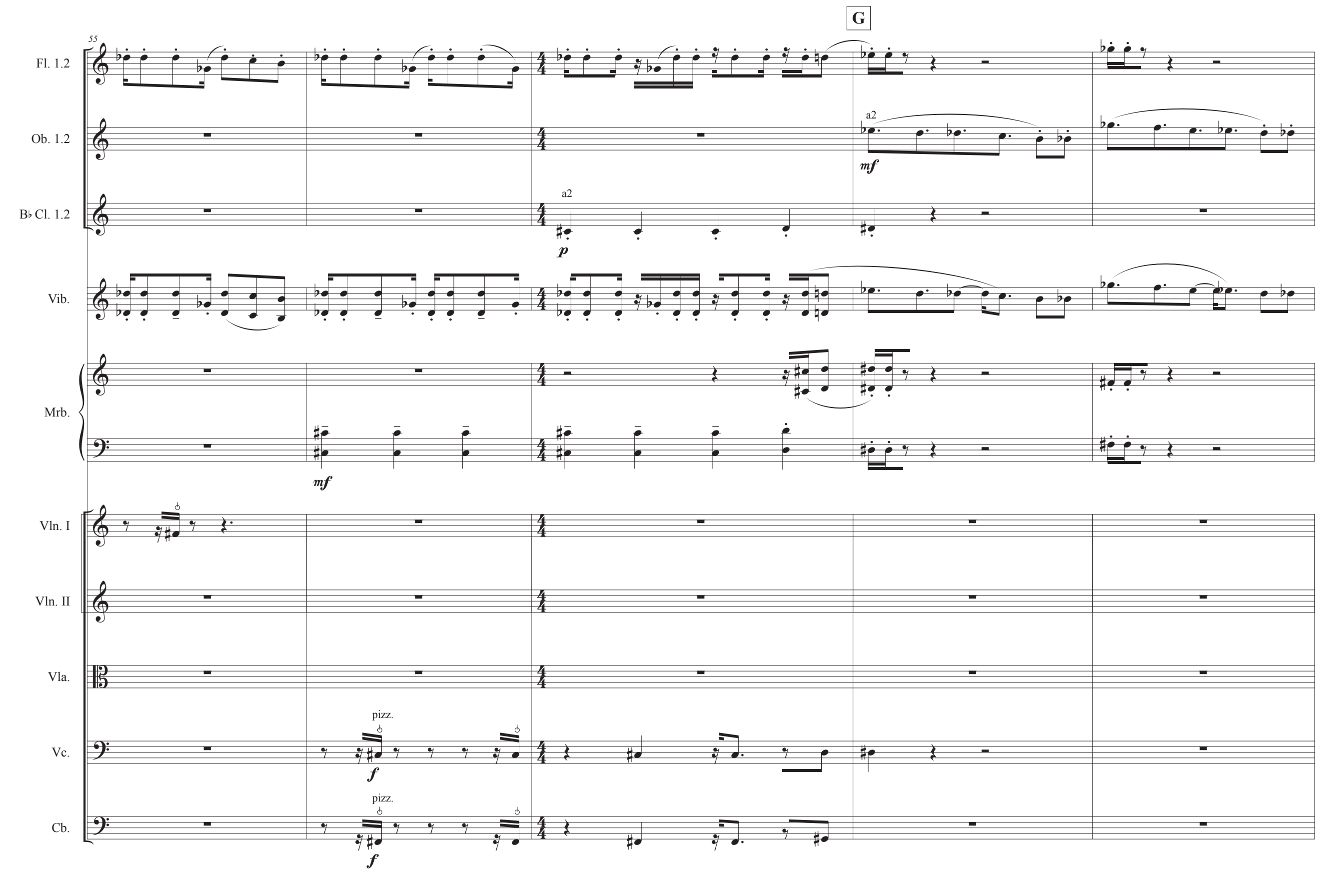
C
25
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
a1
solo
p
B. Cl.
Bsn. 1.2
a2
p
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
mf
Vib.
Mrb.
mp
Hp.
mp
Vln. I
Vln. II
pizz.
p
Vla.
Vc.
pizz.
mp
Cb.
pizz.
p

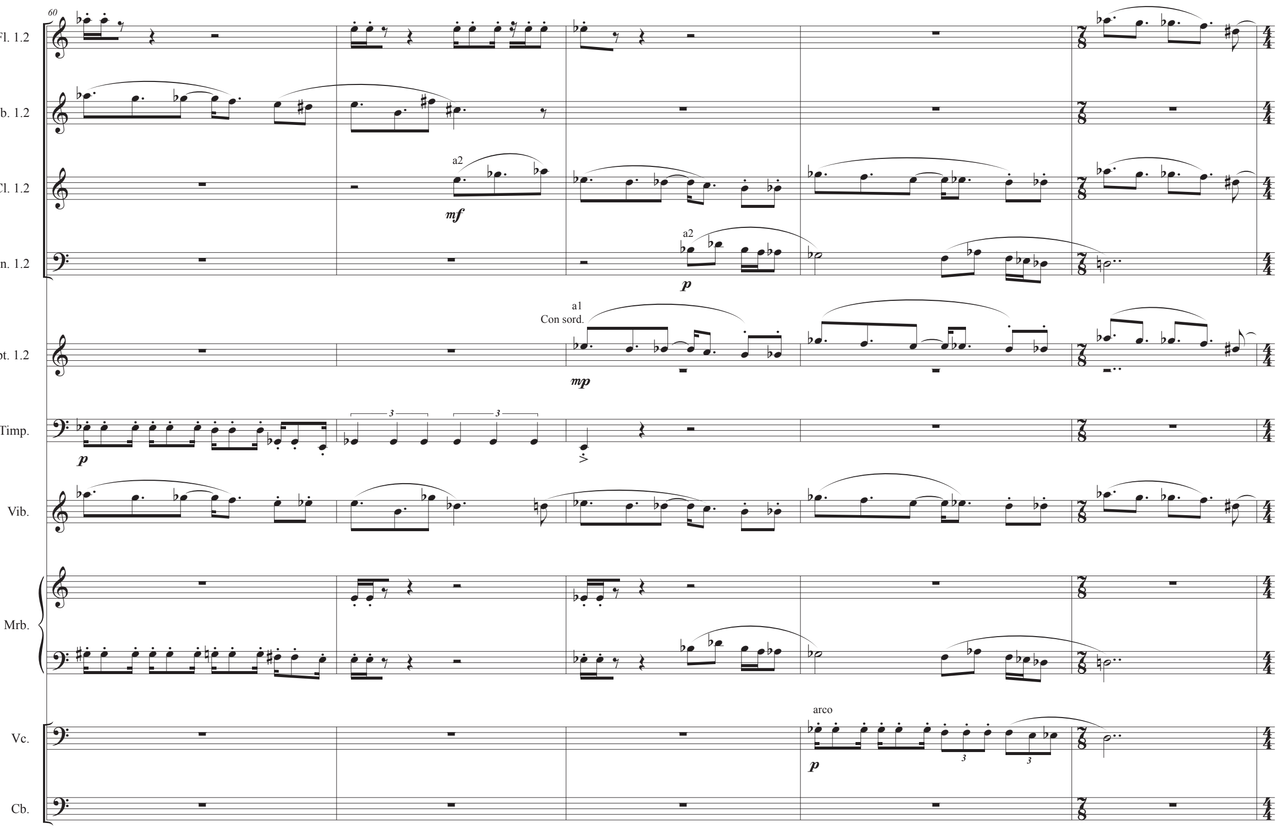

31
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Vib.
motor on
medium speed
mp
Mrb.
Hp.
Vln. I
arco
p
Vln. II
Vla.
Vc.
arco
p
f
pizz.
Cb.
arco
p
f
pizz.
p


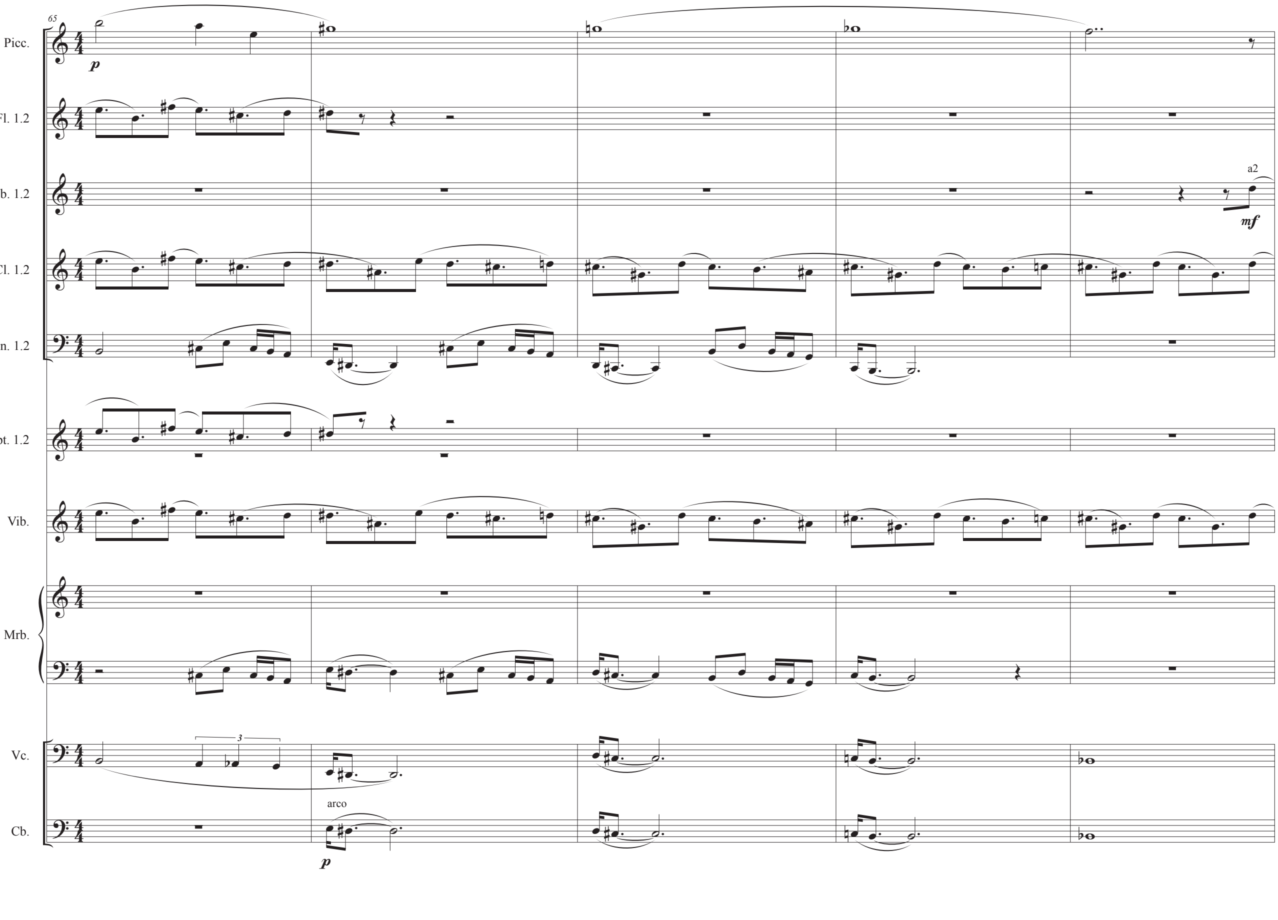
D
36
Picc.
Fl. 1.2
B♭ Cl. 1.2
C Tpt. 1.2
Timp.
Vib.
Mrb.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a1
mf
f
pizz.
arco
mf
p
mp


E
41
Picc.
Fl. 1.2
Timp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
f
pizz.
arco
p


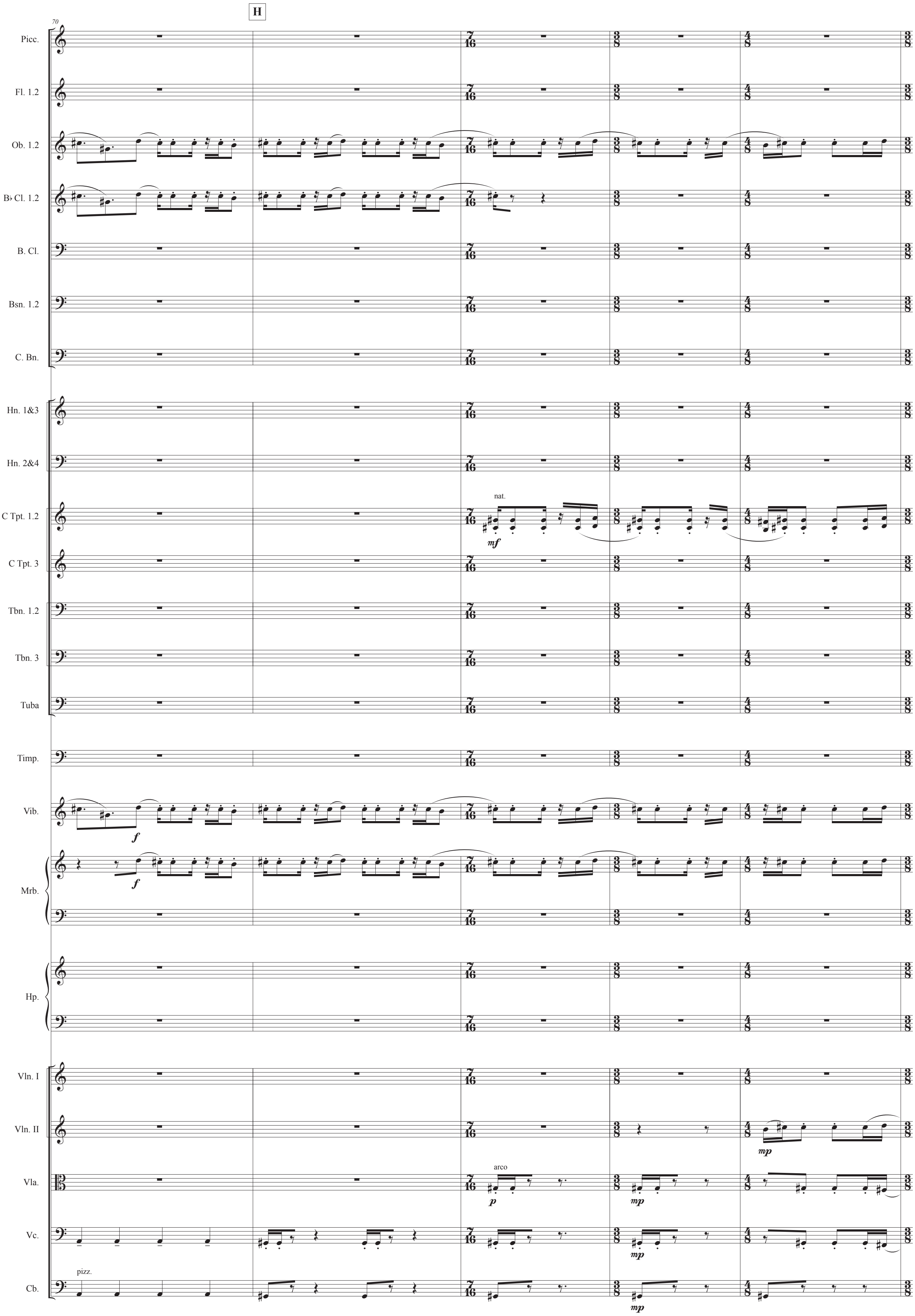
45
Picc.
Fl. 1.2
Ob. 1.2
a2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
E, Gb, D, Eb, (F#)
Timp.
Mrb.
T.B.
Hp.
arco
Vln. I
Vln. II
Vla.
Vc.
Cb.


50
F
Picc.
Fl. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Vib.
Mrb.
Vln. I
a2
motor off
pizz.


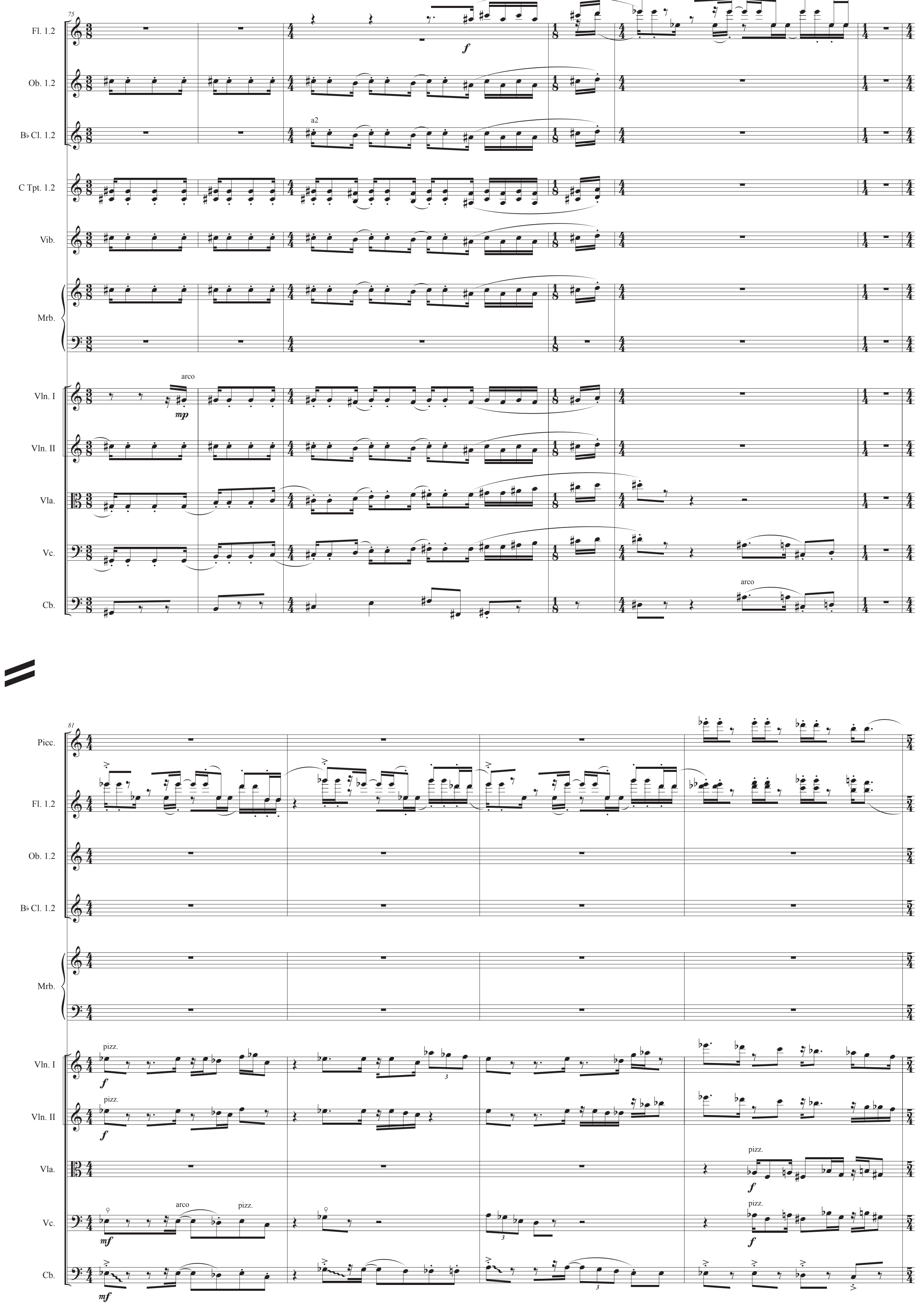
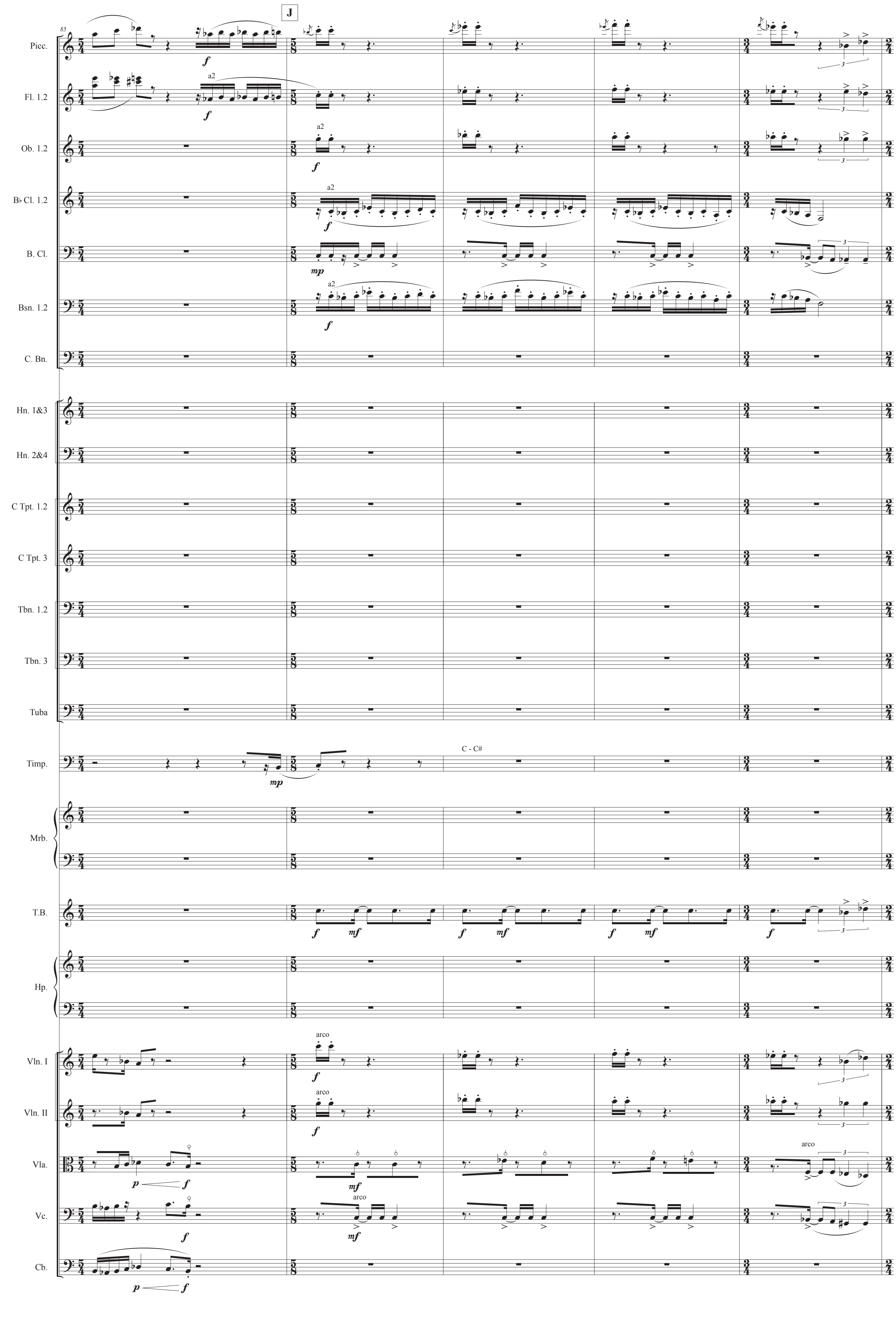
55
G
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
Vib.
Mrb.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
pizz.
pizz.


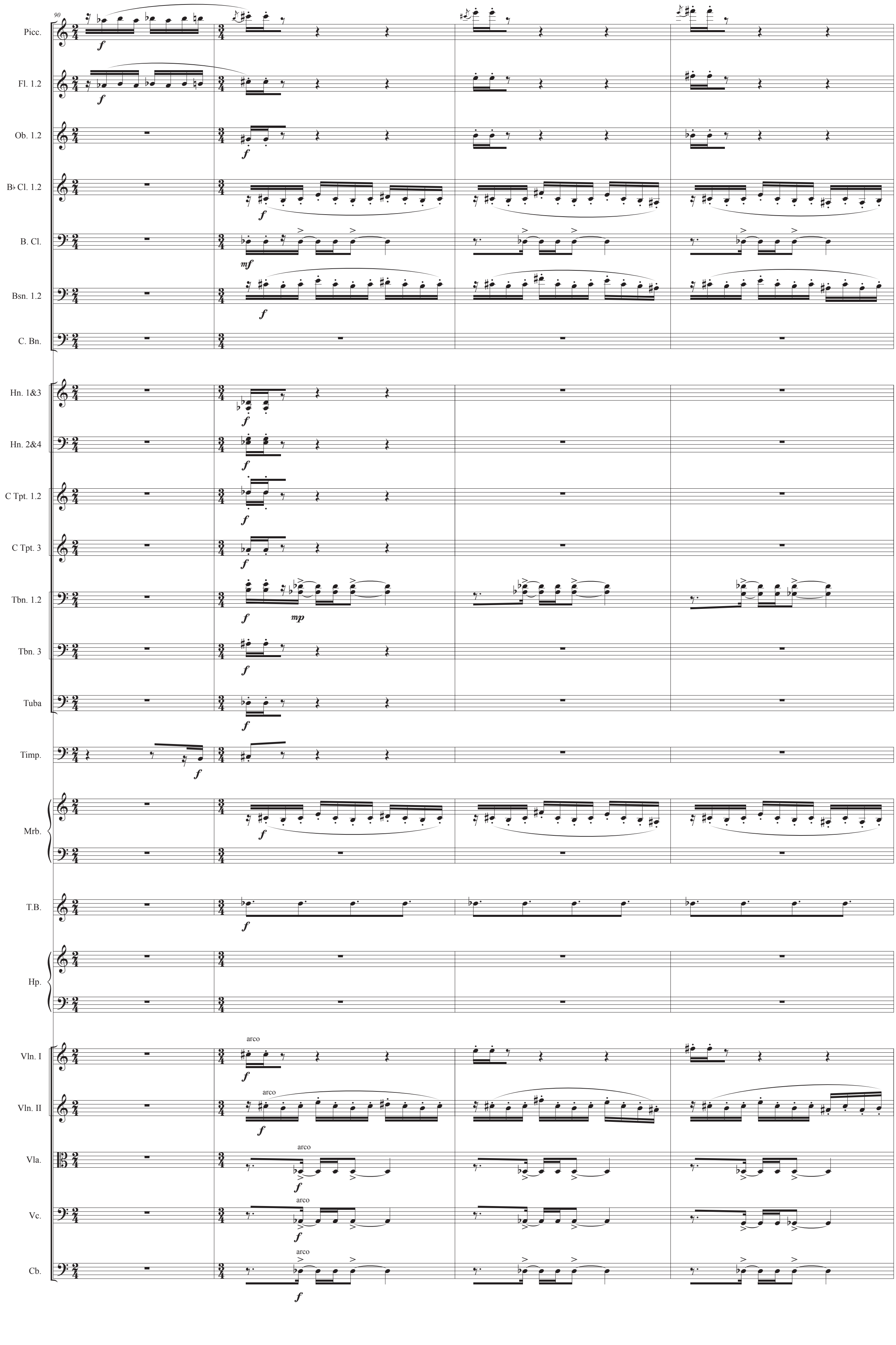
60
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
Bsn. 1.2
C Tpt. 1.2
Timp.
Vib.
Mrb.
Vc.
Cb.
a2
mf
a2
p
a1
Con sord.
mp
p
arco
p


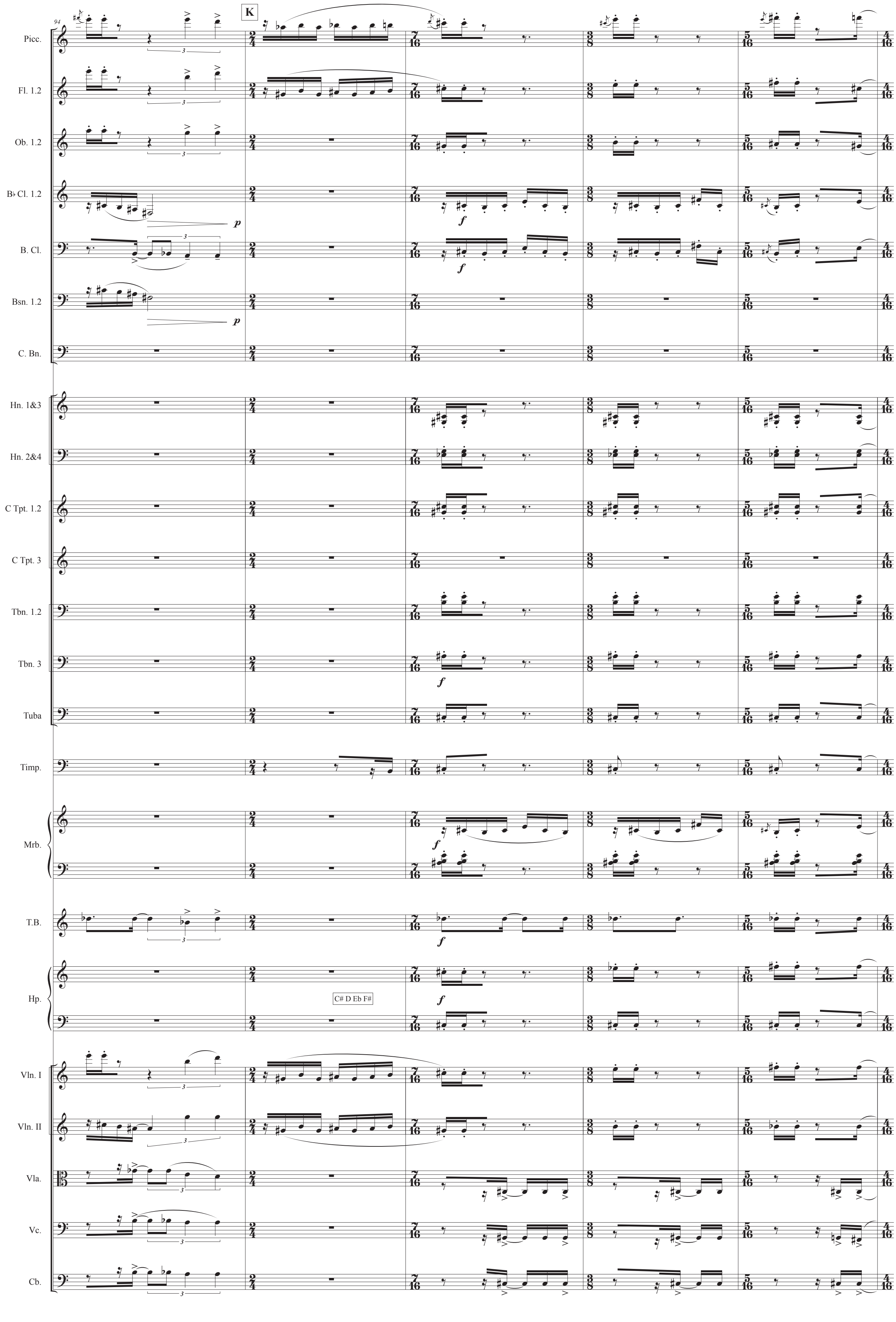
65
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
Bsn. 1.2
C Tpt. 1.2
Vib.
Mrb.
Vc.
Cb.
p
a2
mf
arco
p

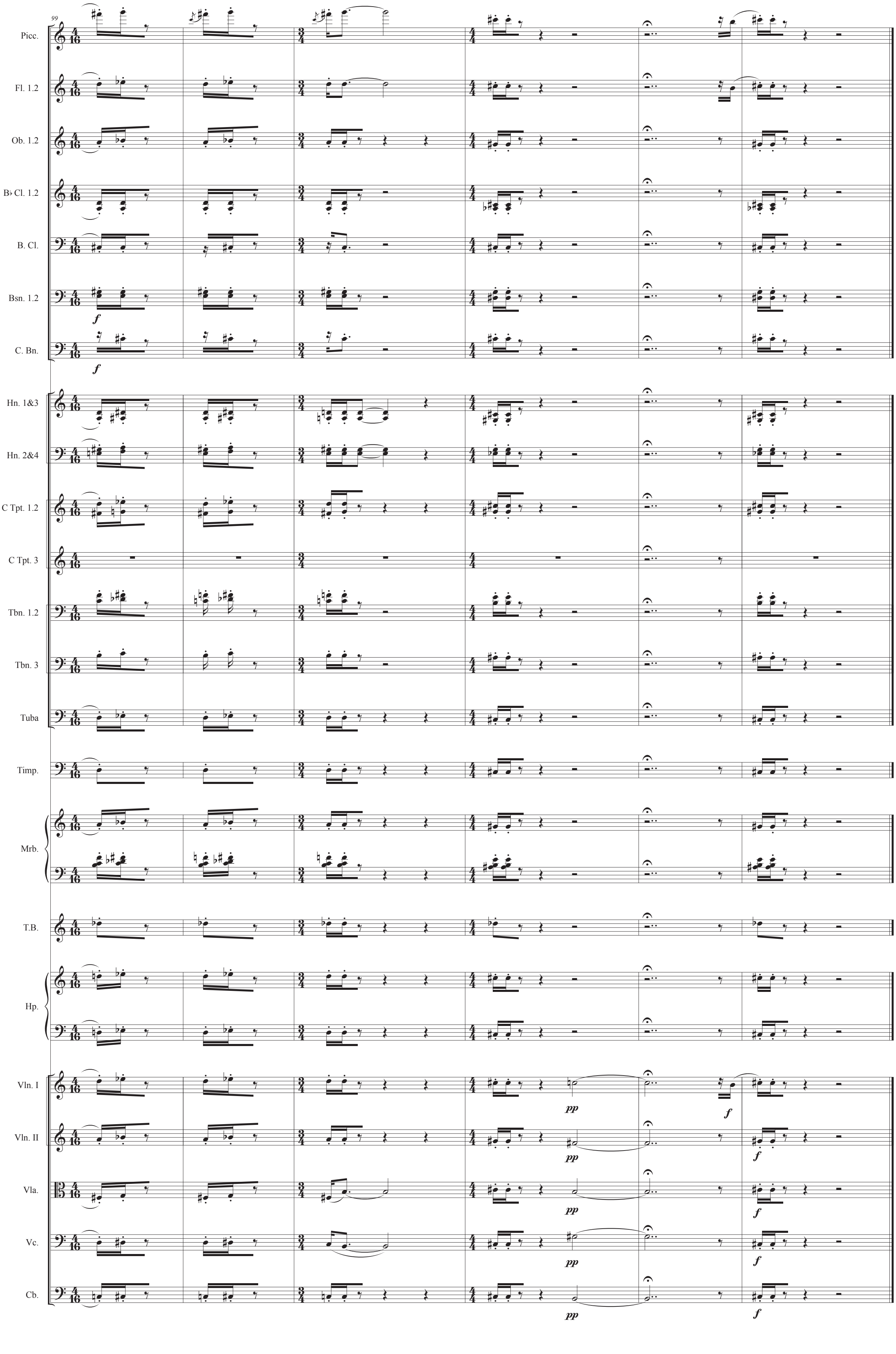


70
H
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
nat.
mf
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Vib.
f
Mrb.
f
Hp.
Vln. I
Vln. II
mp
Vla.
arco
p
mp
Vc.
mp
Cb.
pizz.
mp

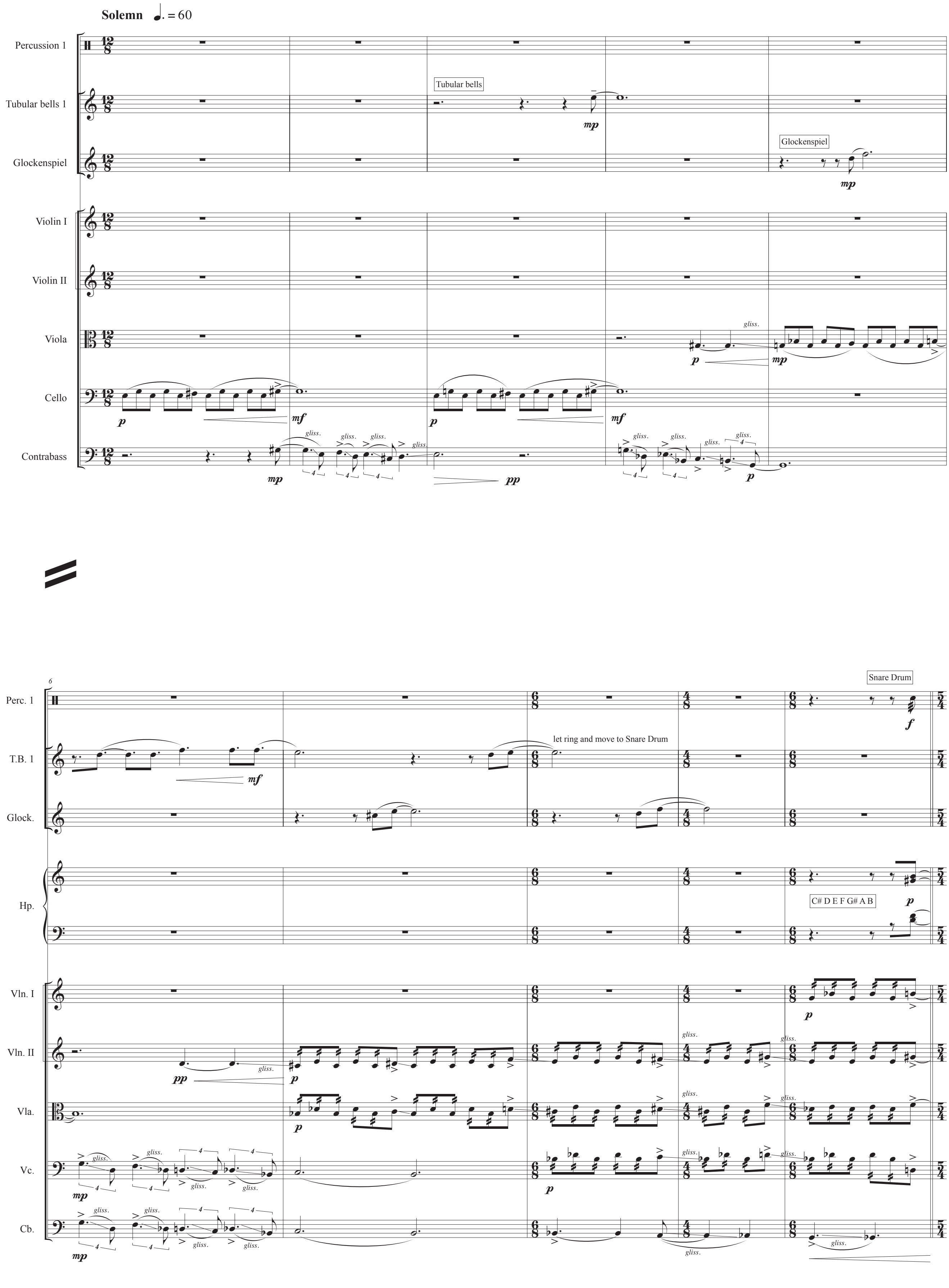
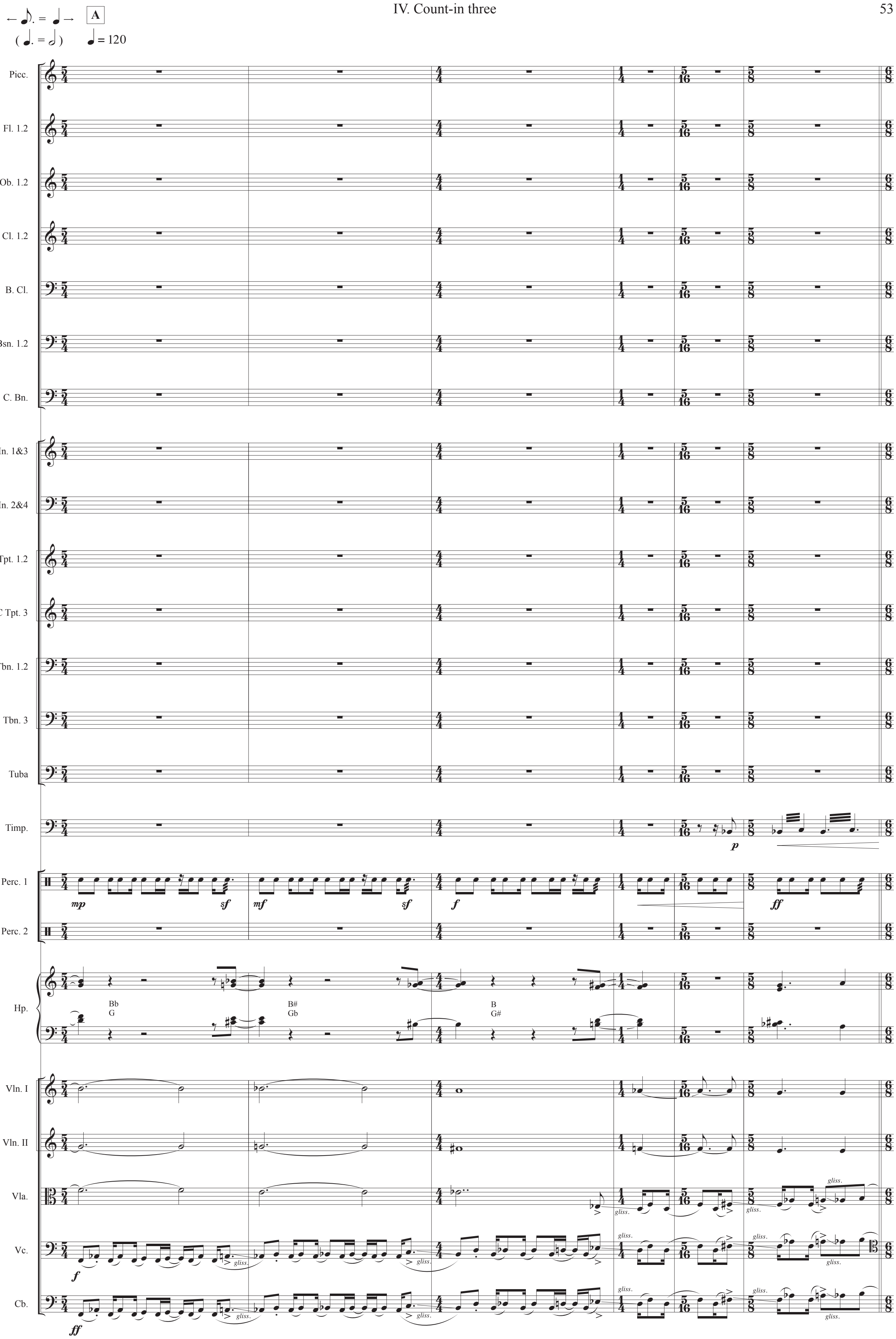

75
I
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
a2
C Tpt. 1.2
Vib.
Mrb.
Vln. I
arco
mp
Vln. II
Vla.
Vc.
arco
Cb.
f
81
Picc.
pizz.
pizz.
arco
mf


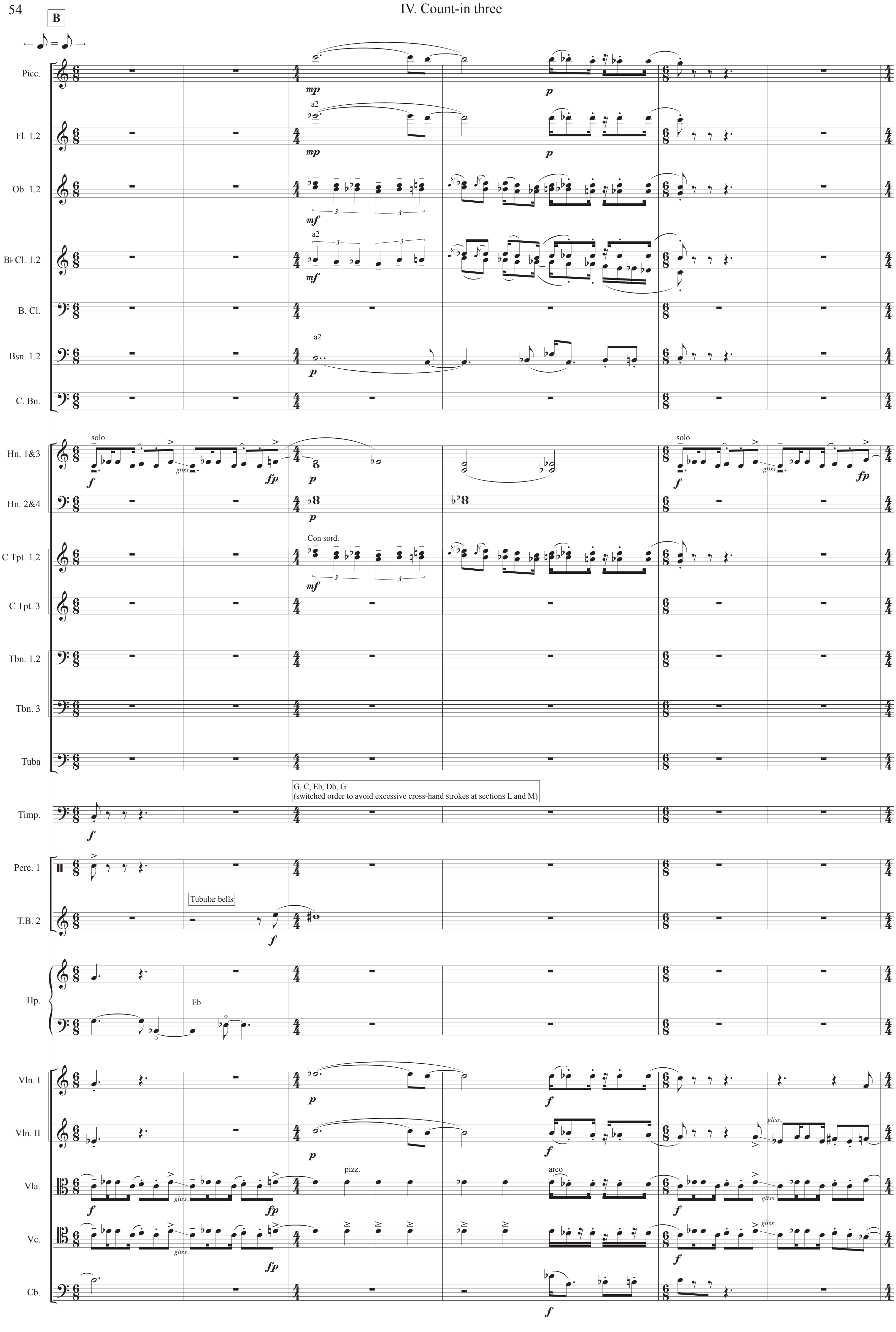
85
J
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Mrb.
T.B.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
C - C#
arco


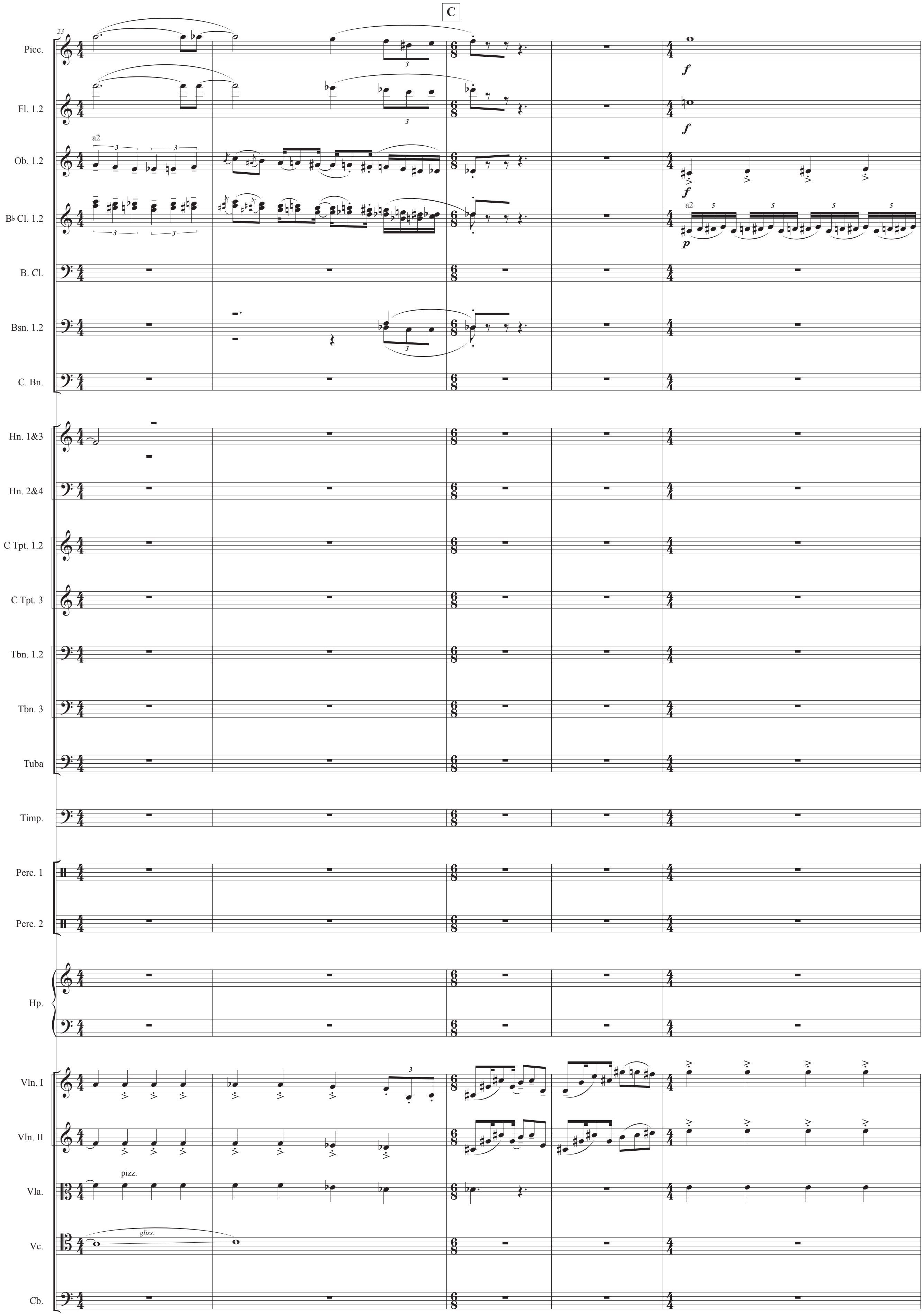
90
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Mrb.
T.B.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco
f
mf
mp


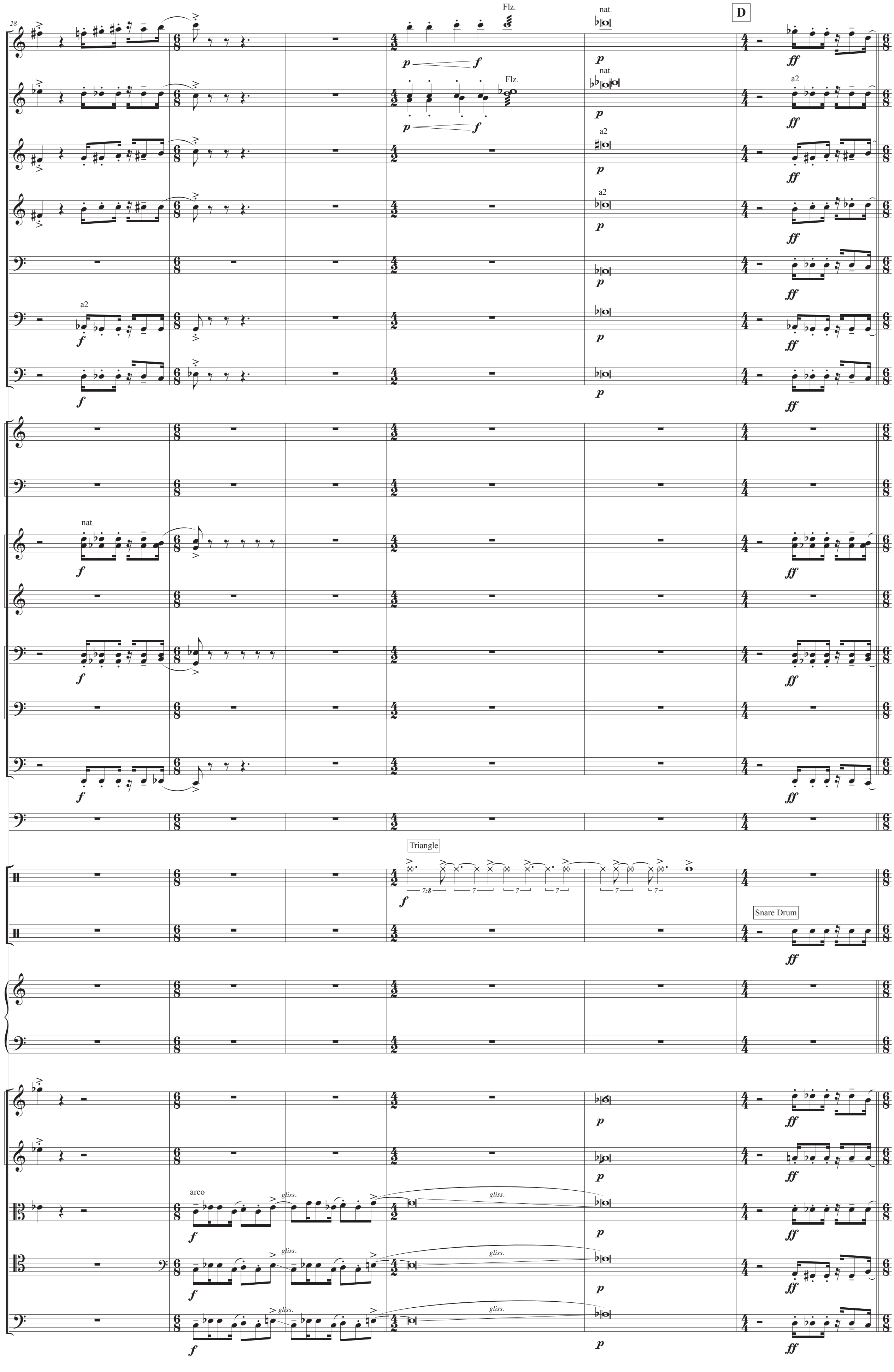
94
K
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Mrb.
T.B.
Hp.
C# D Eb F#
Vln. I
Vln. II
Vla.
Vc.
Cb.


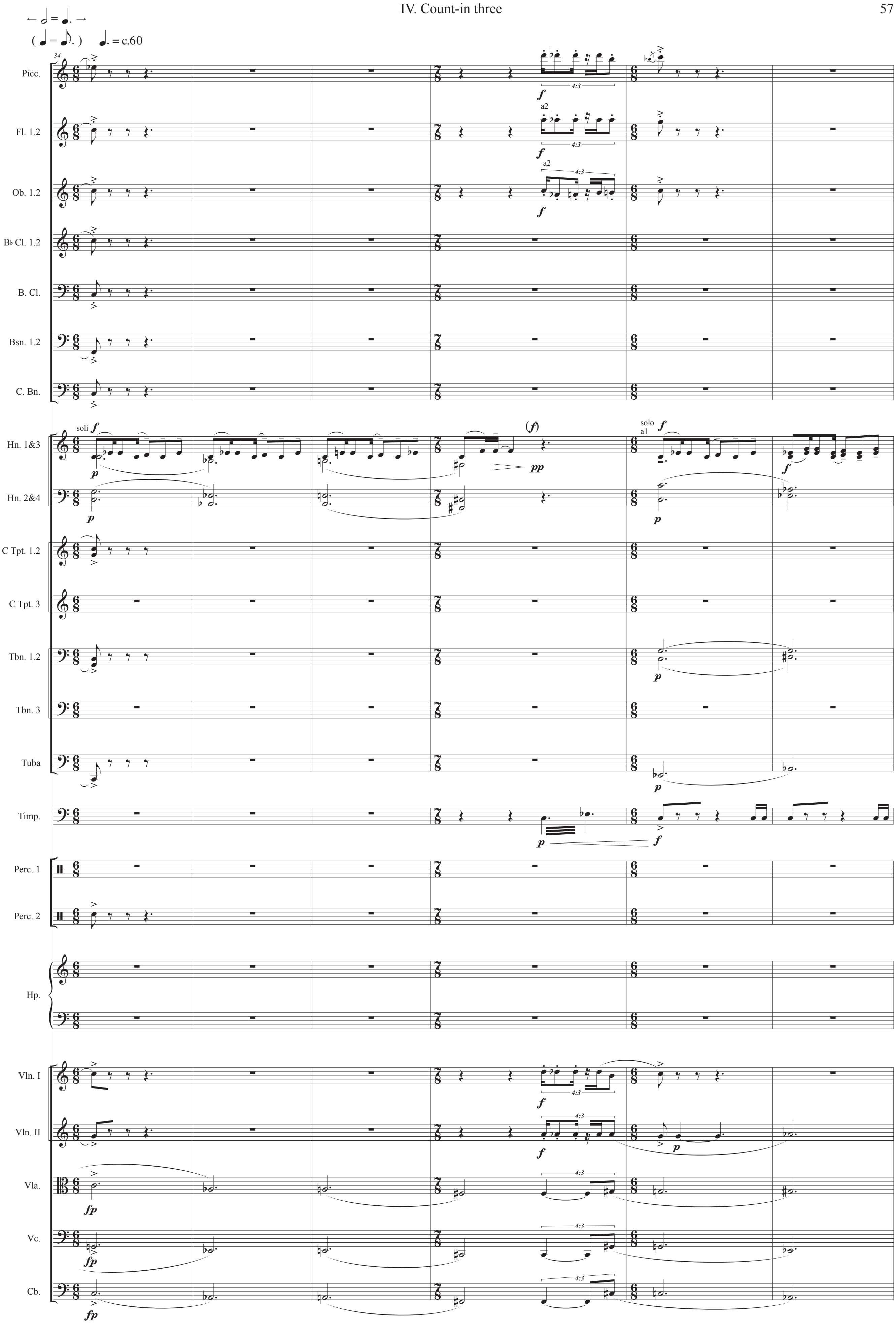
99
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
f
C. Bn.
f
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Mrb.
T.B.
Hp.
Vln. I
pp
f
Vln. II
pp
f
Vla.
pp
f
Vc.
pp
f
Cb.
pp
f

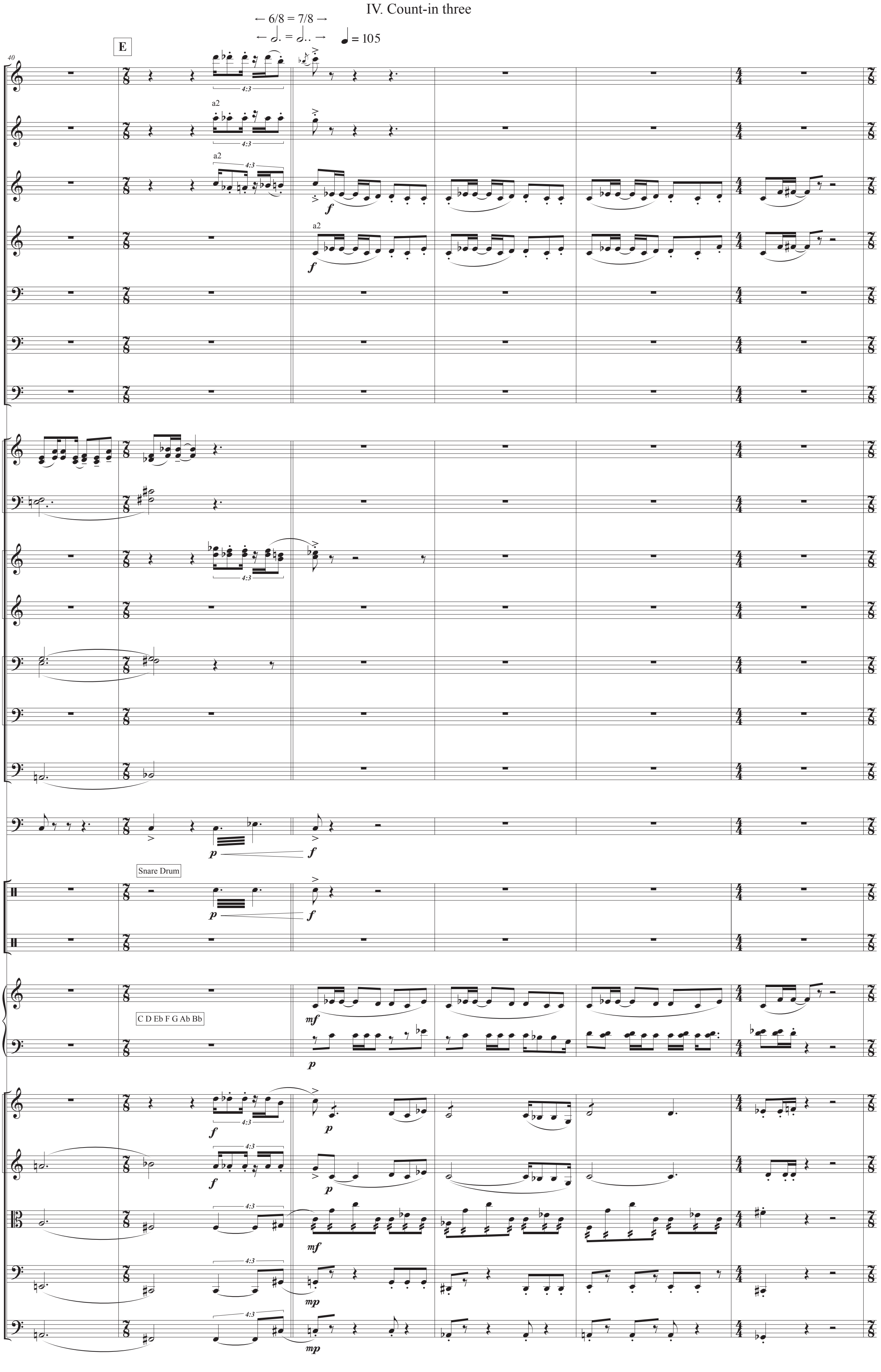
IV. Count-in three


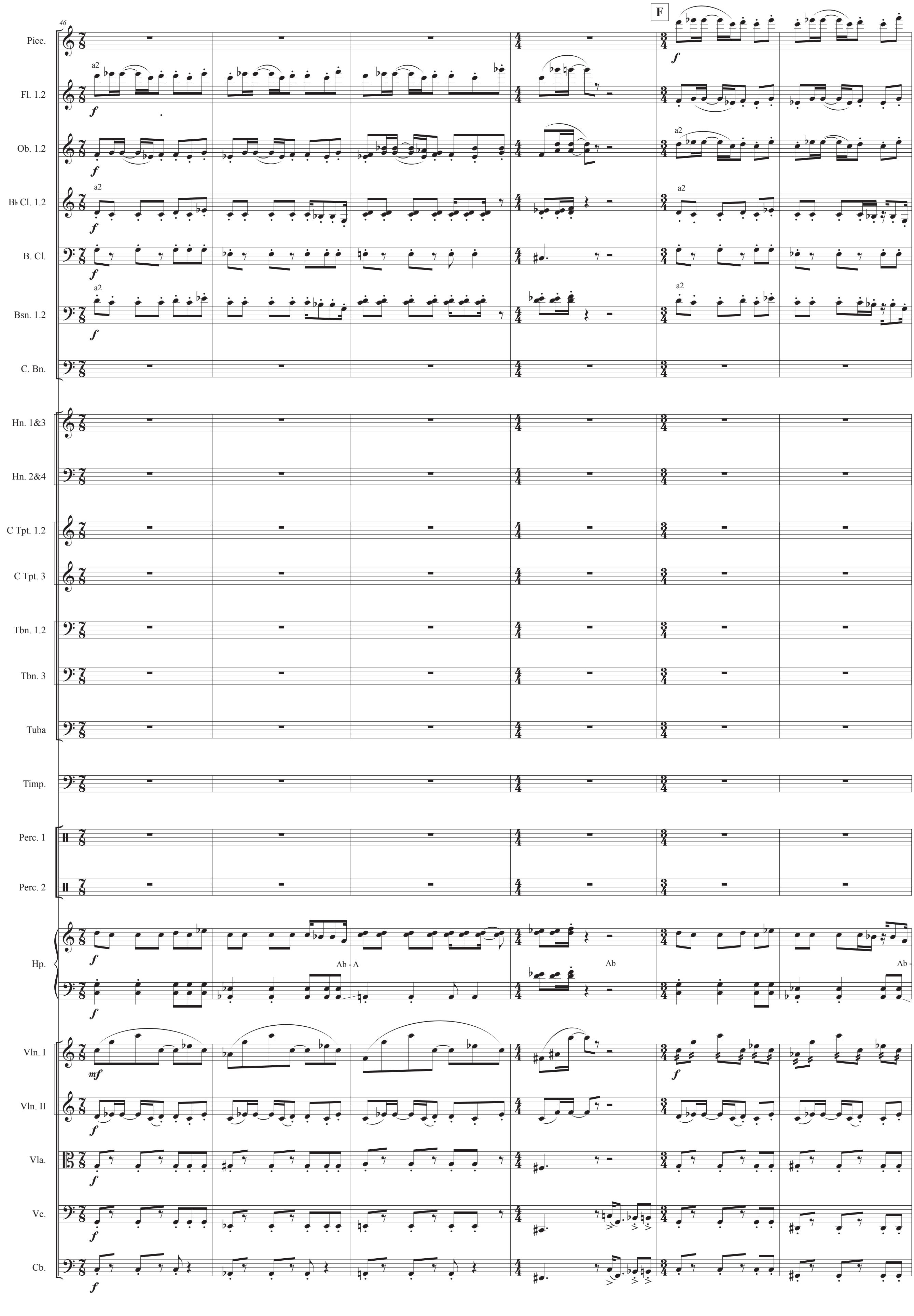
A
♩ = 120
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Bb
G
B#
Gb
B
G#
Vln. I
Vln. II
Vla.
Vc.
Cb.
mp
sf
mf
f
ff
p
gliss.


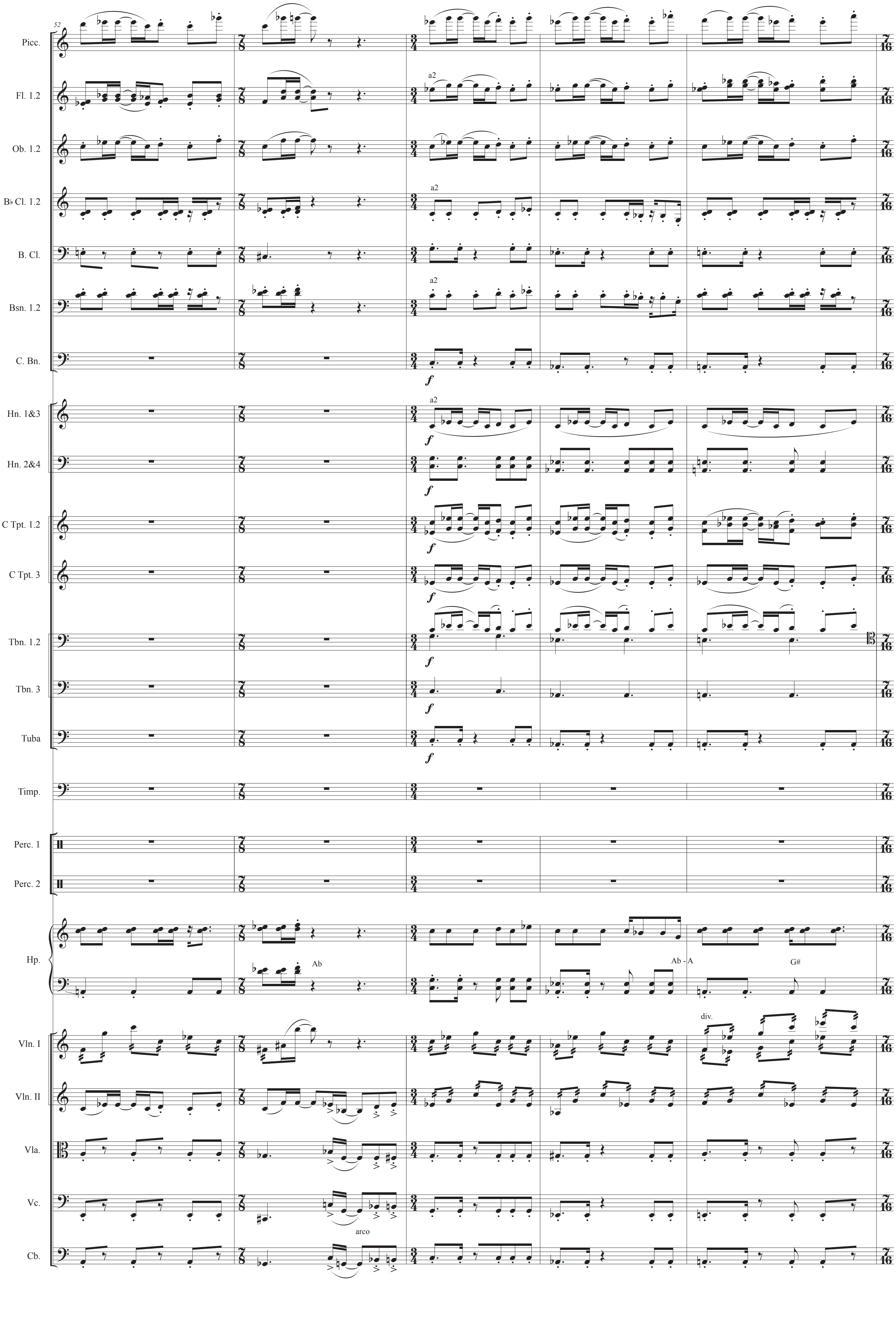
B
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
T.B. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
solo
gliss.
Con sord.
G, C, Eb, Db, G
(switched order to avoid excessive cross-hand strokes at sections L and M)
Tubular bells
Eb
pizz.
arco


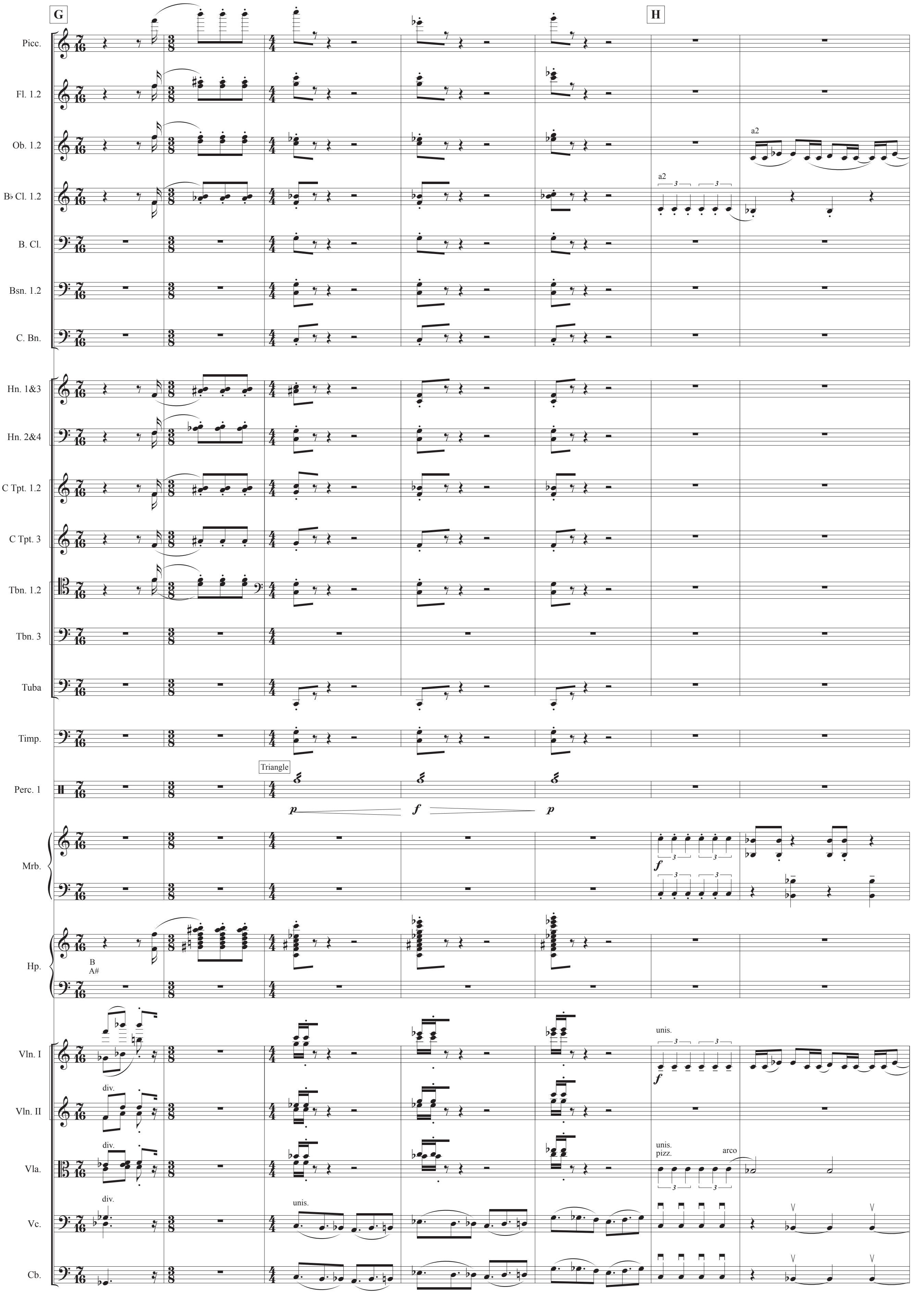
C
23
Picc.
Fl. 1.2
Ob. 1.2
a2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
pizz.
Vc.
gliss.
Cb.


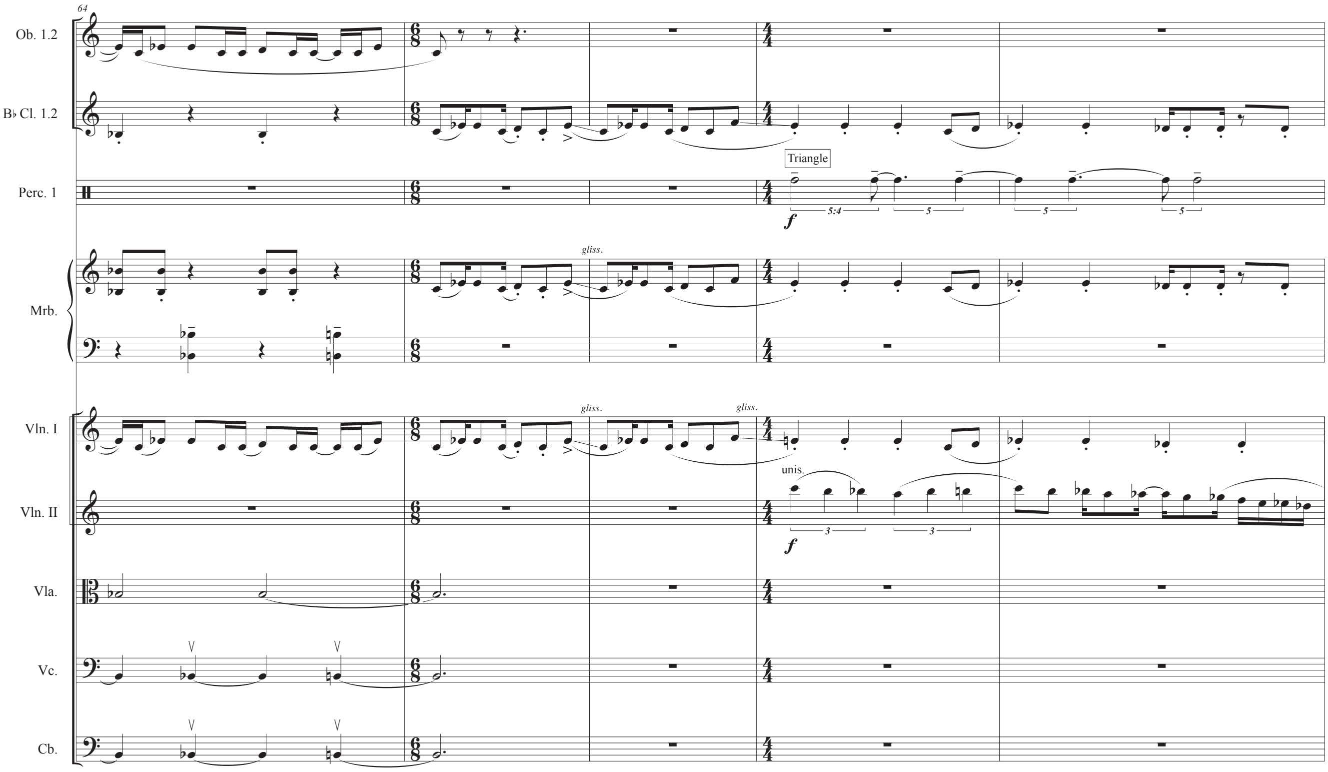
28
D
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
Flz.
nat.
a2
Triangle
Snare Drum
arco
gliss.


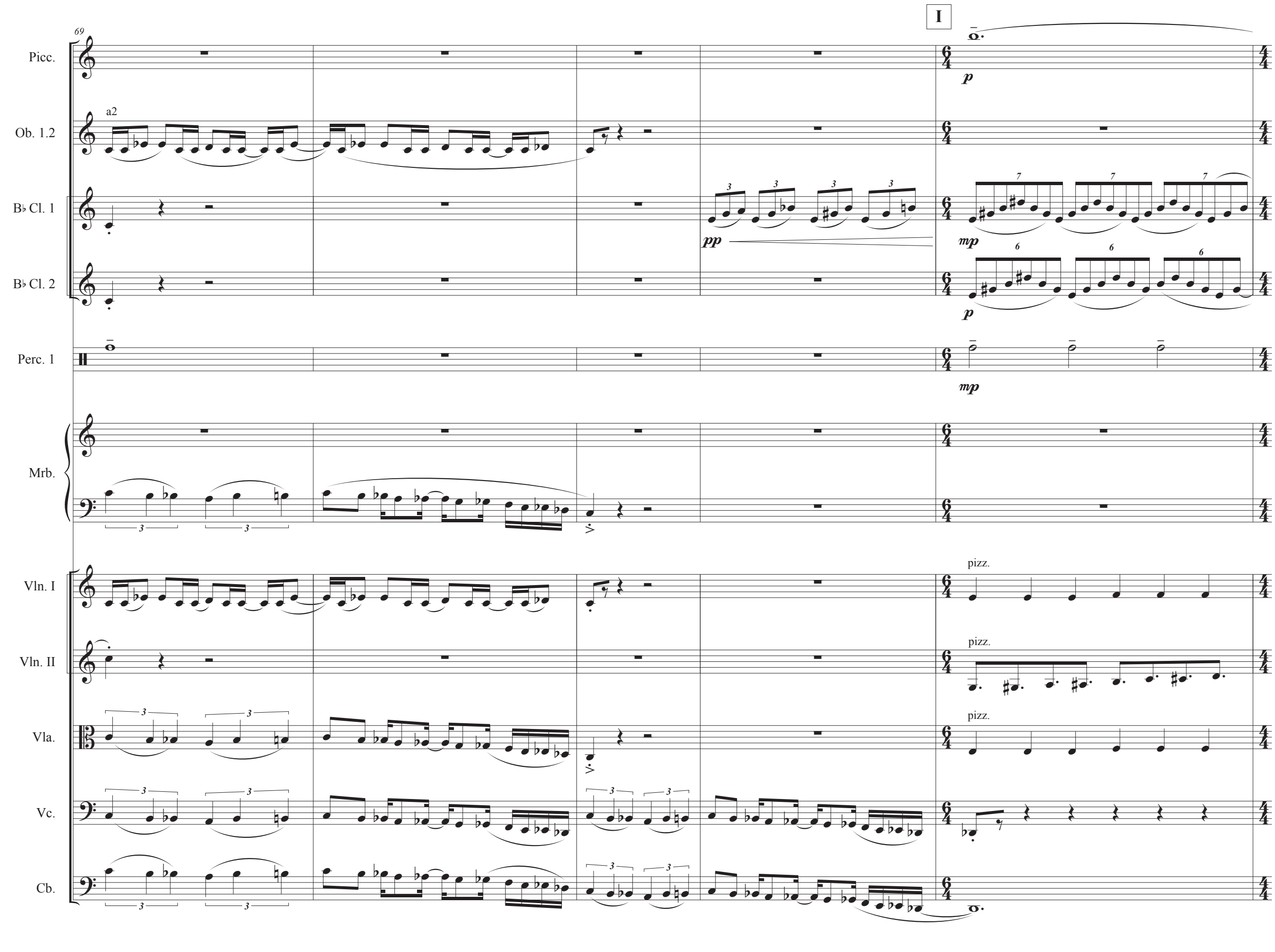
♩. = c.60
Picc.
Fl. 1.2
a2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
soli
solo
a1
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.


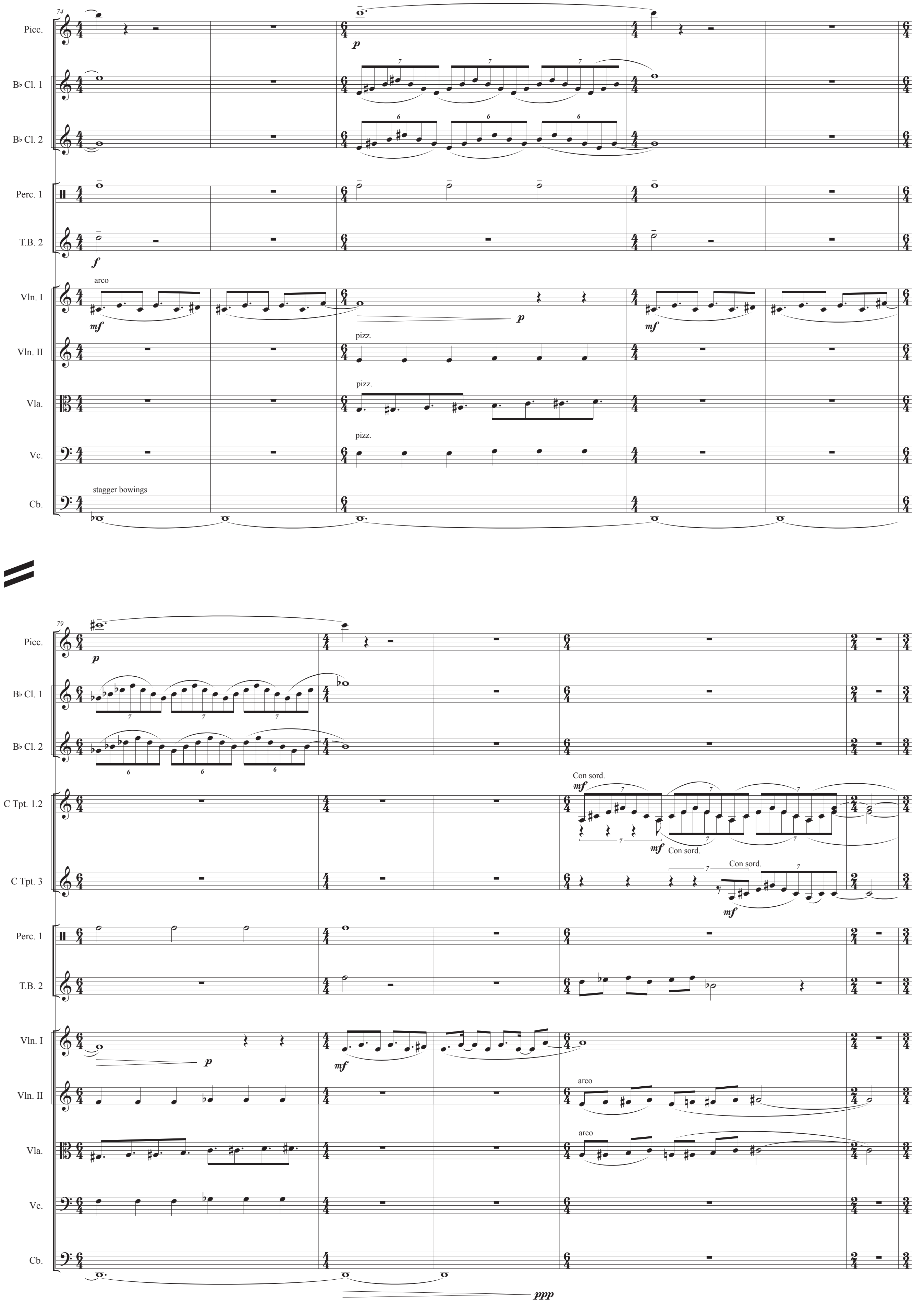
← 6/8 = 7/8 →
= 105
E
40
Picc.
Fl. 1.2
a2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Snare Drum
Perc. 1
Perc. 2
Hp.
C D Eb F G Ab Bb
Vln. I
Vln. II
Vla.
Vc.
Cb.


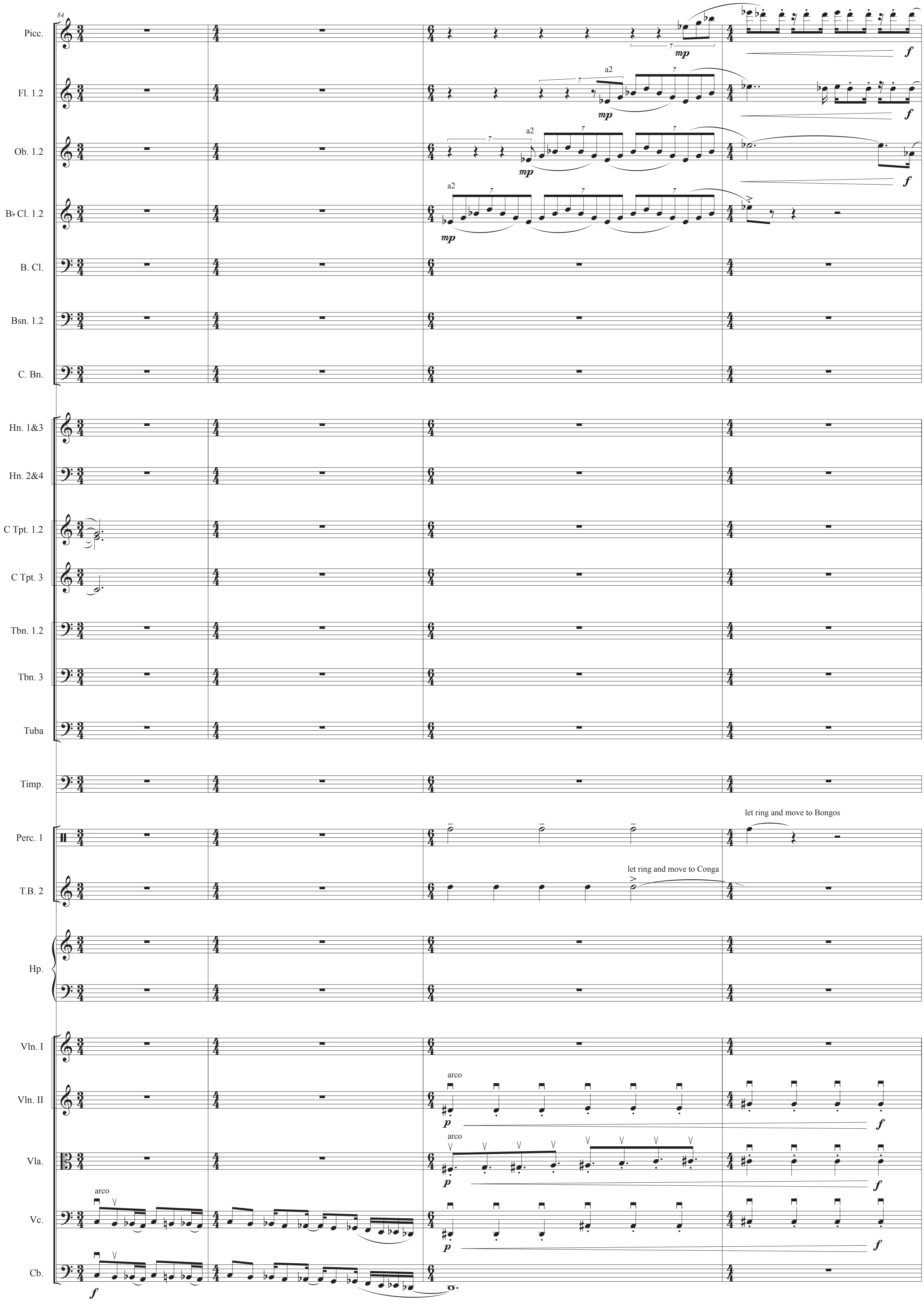
46
F
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
f
mf
Ab - A
Ab


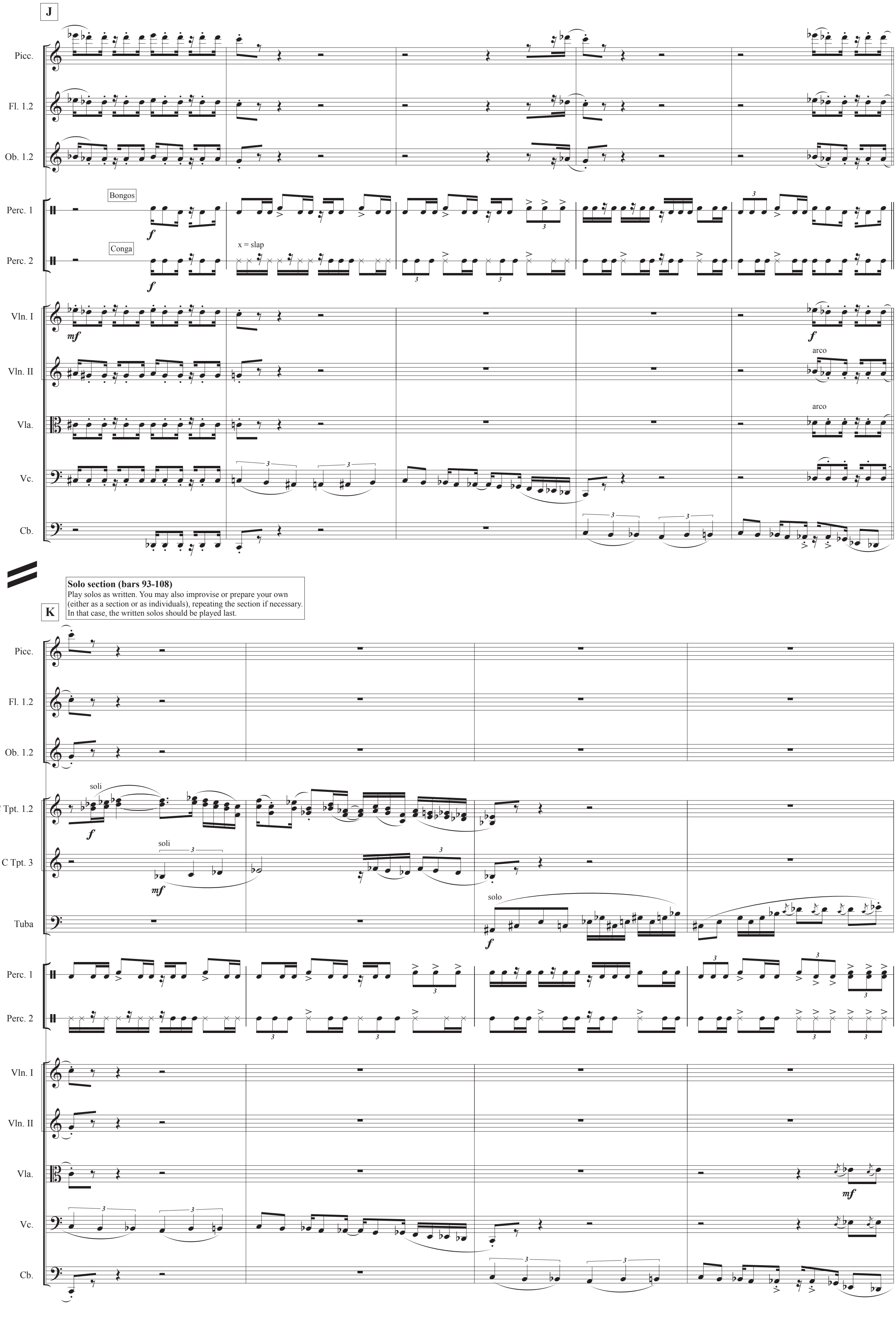
52
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
f
Ab
Ab - A
G#
div.
arco


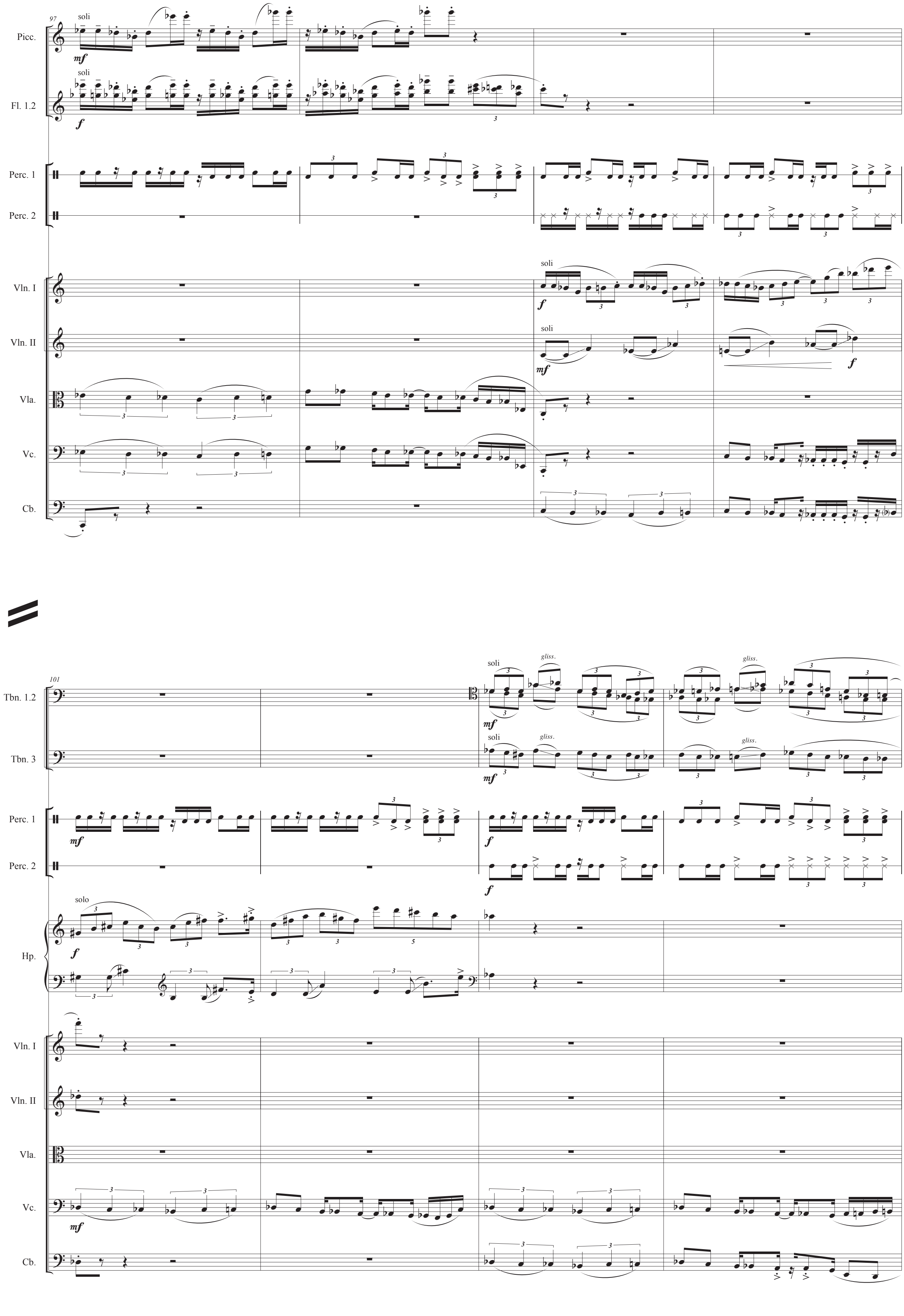
G
H
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Mrb.
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
Triangle
p
f
B
A#
div.
unis.
pizz.
arco


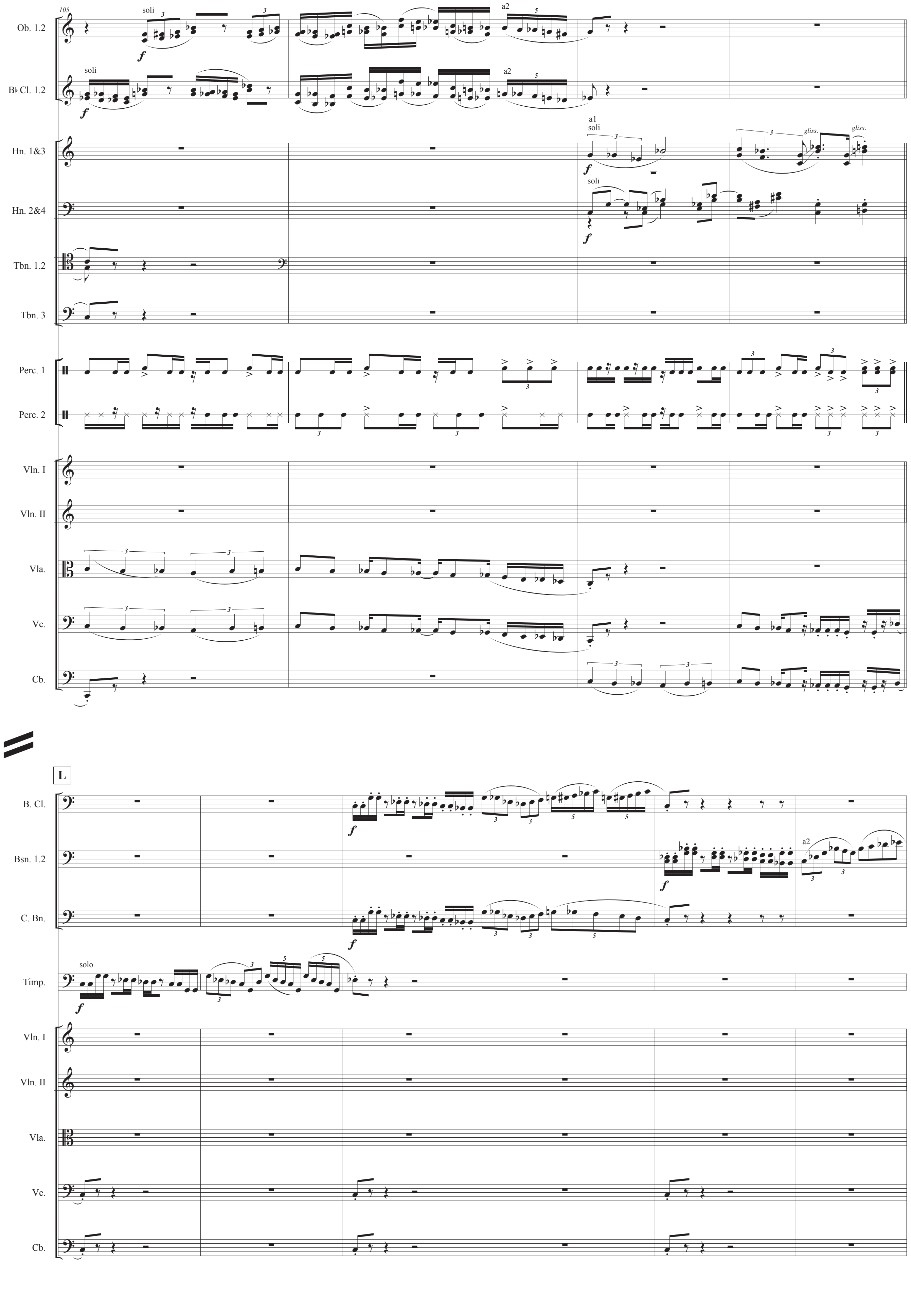
64
Ob. 1.2
B♭ Cl. 1.2
Perc. 1
Triangle
5:4
5
f
Mrb.
gliss.
Vln. I
gliss.
Vln. II
unis.
3
f
Vla.
Vc.
Cb.


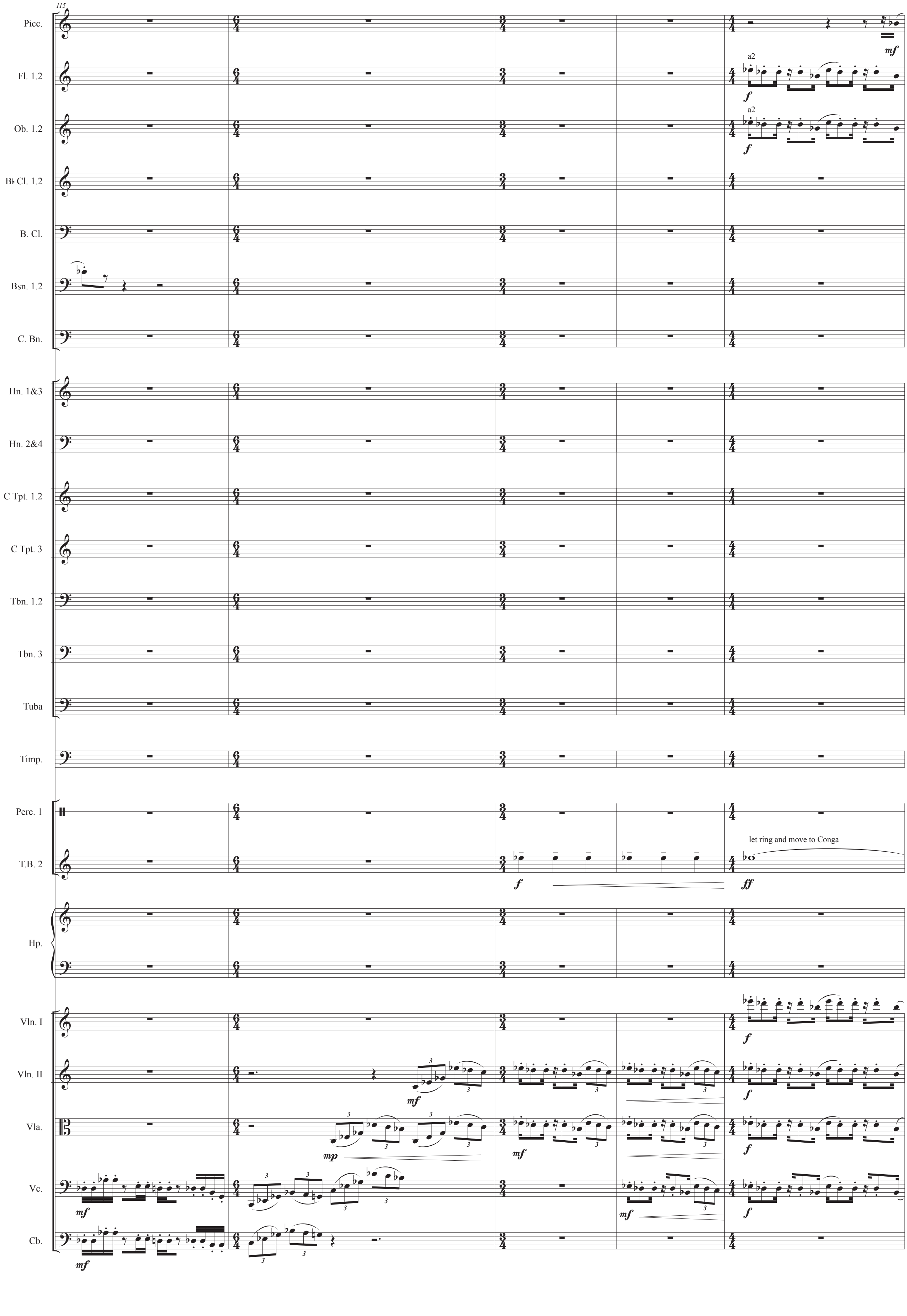
69
I
Picc.
p
Ob. 1.2
a2
B♭ Cl. 1
pp
7
mp
B♭ Cl. 2
6
p
Perc. 1
mp
Mrb.
Vln. I
pizz.
Vln. II
pizz.
Vla.
pizz.
Vc.
Cb.


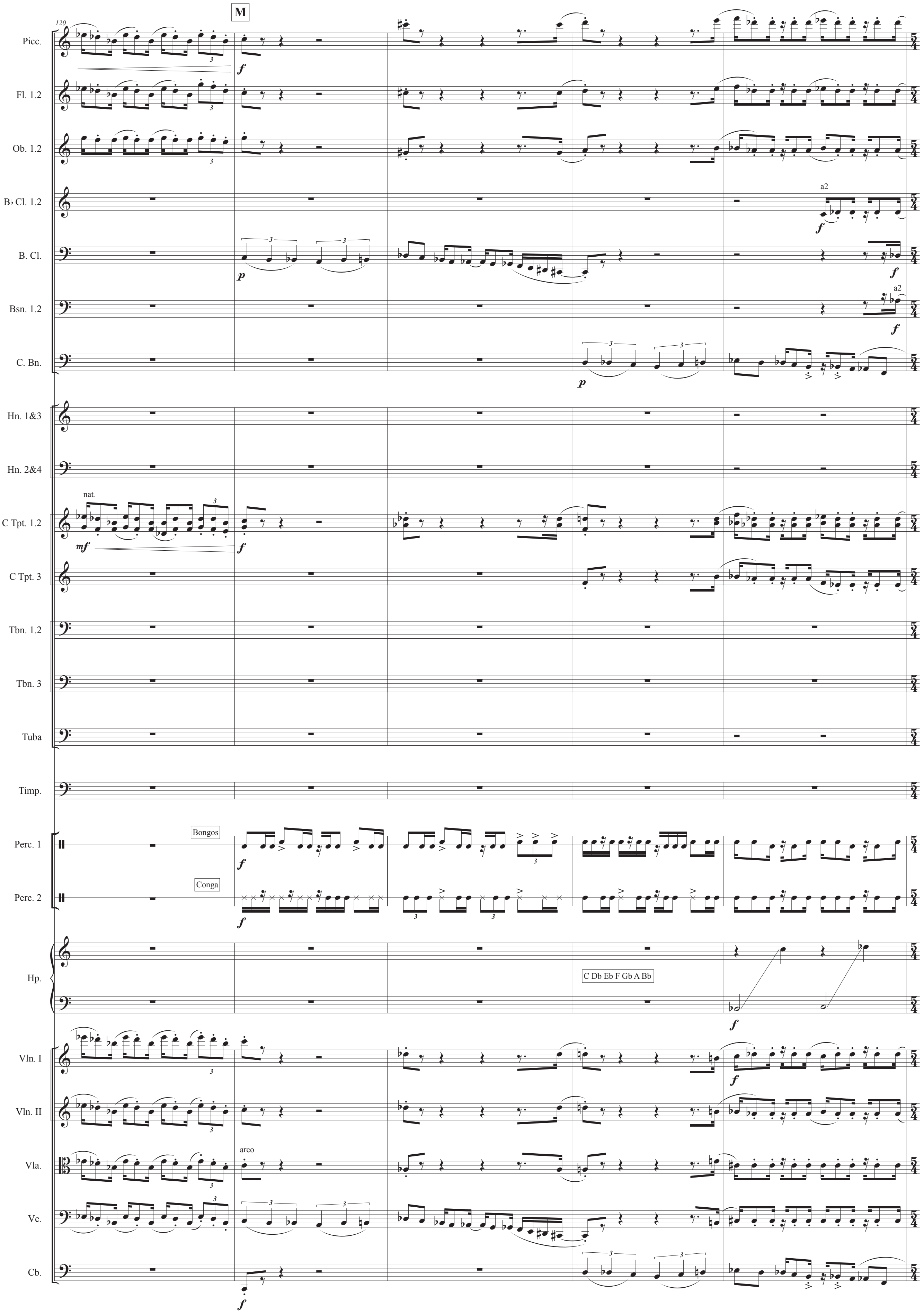
Picc.
B♭ Cl. 1
B♭ Cl. 2
Perc. 1
T.B. 2
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco
pizz.
stagger bowings
C Tpt. 1.2
C Tpt. 3
Con sord.


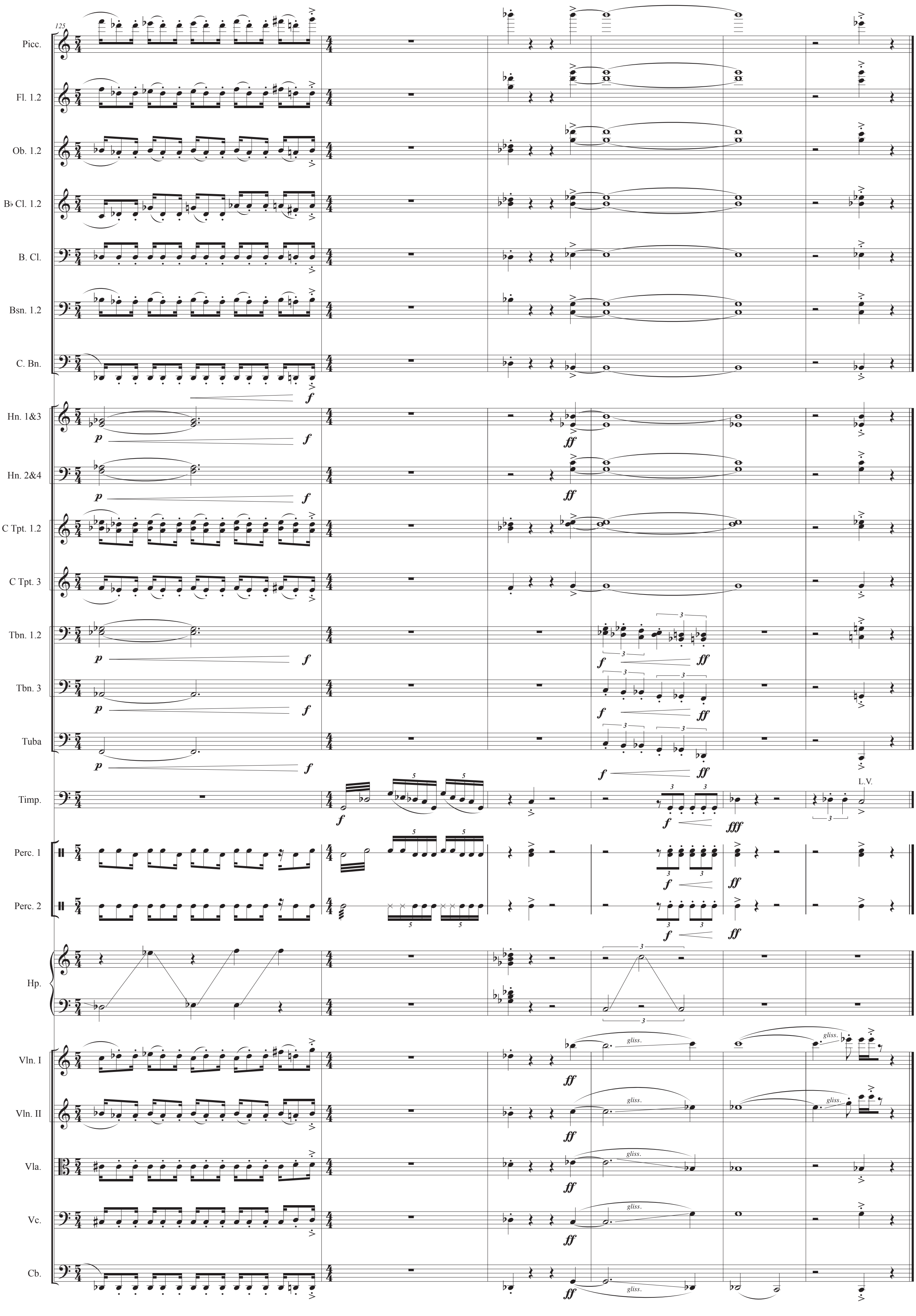
84
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
T.B. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
mp
f
let ring and move to Bongos
let ring and move to Conga
arco
p


J
Picc.
Fl. 1.2
Ob. 1.2
Perc. 1
Bongos
f
Perc. 2
Conga
f
x = slap
Vln. I
mf
f
Vln. II
arco
Vla.
arco
Vc.
Cb.
Solo section (bars 93-108)
Play solos as written. You may also improvise or prepare your own (either as a section or as individuals), repeating the section if necessary. In that case, the written solos should be played last.
K
Picc.
Fl. 1.2
Ob. 1.2
C Tpt. 1.2
soli
f
C Tpt. 3
soli
mf
Tuba
solo
f
Perc. 1
Perc. 2
Vln. I
Vln. II
Vla.
mf
Vc.
Cb.


97
Picc.
soli
mf
Fl. 1.2
soli
f
Perc. 1
Perc. 2
Vln. I
soli
f
Vln. II
soli
mf
f
Vla.
Vc.
Cb.
101
Tbn. 1.2
soli
gliss.
mf
Tbn. 3
soli
gliss.
mf
Perc. 1
mf
f
Perc. 2
f
Hp.
solo
f
Vln. I
Vln. II
Vla.
Vc.
mf
Cb.


105
Ob. 1.2
soli
a2
B♭ Cl. 1.2
soli
a2
Hn. 1&3
a1
soli
gliss.
gliss.
Hn. 2&4
soli
Tbn. 1.2
Tbn. 3
Perc. 1
Perc. 2
Vln. I
Vln. II
Vla.
Vc.
Cb.
L
B. Cl.
Bsn. 1.2
a2
C. Bn.
Timp.
solo
Vln. I
Vln. II
Vla.
Vc.
Cb.


115
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
T.B. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
mf
f
ff
mp
let ring and move to Conga


120
M
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
a2
nat.
Bongos
Conga
C Db Eb F Gb A Bb
arco


125
Picc.
Fl. 1.2
Ob. 1.2
B♭ Cl. 1.2
B. Cl.
Bsn. 1.2
C. Bn.
Hn. 1&3
Hn. 2&4
C Tpt. 1.2
C Tpt. 3
Tbn. 1.2
Tbn. 3
Tuba
Timp.
Perc. 1
Perc. 2
Hp.
Vln. I
Vln. II
Vla.
Vc.
Cb.
f
p
ff
fff
L.V.
gliss.