“EMERGENCE”:
A PIECE FOR WIND SYMPHONY
INSPIRED BY THE CHANT OF THE RIO XINANE,
THE ORIGINS OF MUSIC, AND THE GEOMETRY OF HARMONY

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ABSTRACT

In June of 2014, the Rio Xinane (a formerly isolated tribe) emerged from the jungles of Peru onto Brazilian land to meet with Brazil's National Indian Foundation (FUNAI). Their dramatic style of communication includes breaking into song with a reciting tone, as well as body slaps and stylized gestures, and points to the common origins of language, music, and dance in human communication. Summaries of Aniruddh Patel's *Music, Language, and the Brain* and Dmitri Tymoczko's *A Geometry of Music* show how music, language, and movement are intertwined, and how harmony maximizes the spatial dimensions of sound. Matter in the Universe is composed of vibrations, so the vibrations of music can reflect and affect matter. Consequently, music has a pivotal role to play in education and in health. Inspired by this research, *Emergence*, a piece for wind symphony, is a response to the beauty of Rio Xinane communication, composed within the framework of traditional Western harmony.

TO MY PARENTS

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TABLE OF CONTENTS

TABLE OF FIGURES

INTRODUCTION

[W]e are able to bring about an ordering of the unknown ***only by causing it to order itself****.*[1]

Anthropological evidence suggests that music and language were once considered to be the same phenomenon, and furthermore that they were linked to physical movement and dance (so much so that in some cultures, there is no separate word for music and dance).[2] What are now the specialized fields of drama, poetry, dance, and music once comprised, simply, human communication. Before the advent of writing, bards recalled long myths by rhyming and intoning their words: to be a poet or a storyteller was to be a musician, and vice versa. In ancient Greece, drama was musical and featured sung choruses; composers and librettists later joined forces to write operas and musicals and continue to do so to this day.

More profoundly, physicists argue that everything is vibration, in which case music,[3] an ordering of audible vibrations,[4] is a phenomenon that can both reflect and affect matter.[5] If, as physicists suggest, the universe is a symphony of vibrating strings, order and dissonance in music reflect order and dissonance in life. Harmony brings

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[1] Friedrich August von Hayek, *The Fatal Conceit: The Errors of Socialism* (Chicago: University of Chicago Press, 1988), 83. (Bolding represents Hayek's italics.)

[2] Elena Mannes, *The Power of Music: Pioneering Discoveries in the New Science of Song* (New York: Walker Publishing Company, 2011), 107.

[3] Neurologist Daniel Levitin defines music as "organized sound." Elena Mannes, 15.

[4] Music is the "[a]rt of combining sounds with a view to beauty of form & expression of emotion; sounds so produced; pleasant sound, e.g. song of bird, murmur of brook, cry of hounds […]" The Concise Oxford Dictionary (London: Oxford University Press, 1964), 795.

[5] *Michio Kaku: The Universe Is a Symphony of Vibrating Strings*, Big Think, YouTube, https://www.youtube.com/watch?v=fW6JFKgbAF4m, retrieved February 4th, 2015. As Elena Mannes notes, music is "encoded in our bodies and brains." (Mannes, 6) There is "something about music itself, in the physics of sound and in musical structure, that is universal, bridging time and culture. Language development, human emotion, and intelligence are intimately connected to music." (Mannes, Introduction, xvi)

healing, while dissonance brings catharsis and clearer perception of the truth. Moreover, as communication, music represents more intensely the emotions and sensations felt by humans than does language, even if it does so with less specificity. In this respect, it can access depths of the mind that are inaccessible to language.

This thesis presents *Emergence*, a four-movement piece for wind symphony inspired by the emergence of the isolated Rio Xinane tribe from the Peruvian rainforest and their intoning chant, which hints at the common origins of language and music. Intrigued by the links between language, music, and dance, I was also interested in exploring the geometrical aspects and spatial dimensions of harmony in Western art music. Two scholarly works influenced my composition especially: Aniruddh D. Patel's research on music, language, and the brain, which compares music and language processing in the human mind, and Dmitri Tymoczko's work on music and geometry, which shows how the rules of Western harmony evolved naturally by trial and error, exploring ever more complex relations between voice-leading (counterpoint) and chords. The idea of music as primordial and healing also infused the writing of *Emergence* – the cathartic power of music and its expressive and medicinal uses are linked to its evolutionary purpose, as well as to its harmonic characteristics (dissonance and consonance). I have highlighted the ideas that struck me particularly in the case of all the authors quoted in this thesis, so the summaries should by no means be considered definitive.

The summary of Patel's work explores eight themes: bases of sound categories, sound category learning, sound perception, beat perception, melody perception, musical structure/syntax, linguistic and musical meaning, and music and evolution.

The survey of Tymoczko's work covers ten themes: a new approach to musical analysis, the gesture of voice leading, pitch-class circulation and macroharmonies, the richness of triads and fourth progressions, the interplay of voice leading (scales) and harmonic conventions (chords), Tymoczko on Schenker, voice leading tricks and their resulting chords, seeking stability in the scale, dismantling the barriers between musical genres, and broadening the conceptual framework VS concretizing relations in pitch space.

A subsequent overview of the origins, meaning, and healing properties of music presents seven themes: sound and the universe, prehistory and musilanguage, ancient times, the tonic effect of music, music in the service of expression: the twentieth century, music and feeling, and music in the animal world.

Lastly, an analysis of *Emergence* shows how the "musilanguage" of the Rio Xinane inspired a piece for symphonic wind band, and how research on music and language, music and geometry, and the origins, meaning, and healing properties of music influenced my compositional approach.

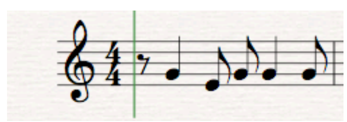
In late June of 2014, the Rio Xinane tribe emerged from the jungles of Peru onto Brazilian land to meet with members of Brazil's National Indian Foundation (FUNAI). A formerly isolated tribe, the Rio Xinane have avoided contact with outside cultures for hundreds of years, and have retained their indigenous methods of communication. In a FUNAI video,[6] members of the Rio Xinane tribe communicate with an interpreter who speaks an indigenous language similar to theirs. They switch easily between speech and

[6] *Funai registra imagens de povo que ainda vive isolado no Acre*, Funai – Fundação do Ìndio (oficial), YouTube, https://www.youtube.com/watch?v=cnJjGmljUmw&list=TLIUNoCKJ6Rd5T81CvIbrTdofj9VeOyuj, retrieved December 15th, 2014.

intoning or singing, and punctuate their speech by slapping their thighs. Their facial expressions are dramatic, emphasized with theatrical gestures. The musical, dramatic nature of Rio Xinane communication stands as evidence that human music and language share the same origin, and that the arts are not superfluous manifestations of human intelligence but are rather intrinsic to communication.

Emergence features the intoning interval of the minor third as chanted by the Rio Xinane.[7] Wind instruments emulate the human voice with a motive representing a simplified version of the original Rio Xinane chant. This motive recurs throughout the first three movements (the fourth movement differs in theme, but still opens with a minor third.)

FIGURE 1: The Rio Xinane Motive



Some neuroscientists agree with history's philosophers and spiritual leaders that the self is not real, and that through introspection, meditation, and contemplation, we can reveal the universal nature of our greater consciousness.[8] If the self is temporary and consciousness is universal, then music hints at this underlying universality by joining many consciousnesses together through a unified experience of performing and listening. The vibrations of music can help to heal the human mind/body in ways that scientists continue to explore, while the use of music in education is one of the keys to unlocking the potential of the human mind.

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[7] Ibid., 0:56 – 1:04.

[8] *Sam Harris: The Self is an Illusion*, Big Think, YouTube, https://www.youtube.com/watch?v=fajfkO_X0l0#t=58, retrieved February 4th, 2015.

CHAPTER 1: ANIRUDDH PATEL'S *LANGUAGE, MUSIC, AND THE BRAIN*

Aren't these the reasons [...] that education in music and poetry is most important? First, because rhythm and harmony permeate the inner part of the soul more than anything else, affecting it most strongly and bringing it grace, so that if someone is properly educated in music and poetry, it makes him graceful, but if not, then the opposite.[9]

In his comparative overview of neuroscience research on music and language processing, Aniruddh Patel calls human beings "unparalleled in their ability to make sense out of sound."[10] Patel presents some of the similarities and differences between music and language that have emerged in recent studies,[11] concluding that "[a]s cognitive and neural systems, music and language are closely related," and that the comparative

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[9] Plato, *The Republic*, Trans. Grube and Reeve, (Indianapolis: Hackett Publishing Company, 1992), 401d. Take heed, Socrates continues: "the person who achieves the finest blend of music and physical training and impresses it on his soul in the most measured way is the one we'd most correctly call completely harmonious and trained in music, much more so than the one who merely harmonizes the strings of his instrument" (ibid., 412a). Socrates recommends heavy censorship in music and poetry to keep the citizens' souls brave and virtuous, and discourages innovation in music, since "the musical modes are never changed without change in the most important of a city's laws" (ibid., 424c).

Mannes repeats a popular citation attributed to Plato: "I would teach children music, physics, and philosophy; but most importantly music, for in the patterns of music and the arts are the keys of learning." (Mannes, introduction, xiii) A search of Plato's works fails to yield the citation, however. In Plato's Republic, children and teenagers are trained in music, poetry, and martial arts/physical education (not physics, as the mystery reference suggests) – the more important subjects of calculation, geometry, astronomy, harmonics, and dialectics are reserved for young adults (philosophy being reserved for mature adults). Socrates points out the limitations of music as a subject: Music (and poetry) "educated the guardians through habits. Its harmonies gave them a certain harmoniousness, not knowledge; its rhythms gave them a certain rhythmical quality; and its stories, whether fictional or nearer the truth cultivated other habits akin to these. But as for [true philosophy], there's nothing like that in music and poetry" (ibid., 522a-b). Perhaps Hellenistic music did not offer the kind of "knowledge" implied, for instance, in Richard Strauss' *Four Last Songs*, although the *Epitaph of Seikilos* suggests that sometimes it did.

[10] Aniruddh Patel, *Music, Language, and the Brain* (New York: Oxford University Press, 2008), 3.

[11] Patel investigates the relationship between purely instrumental music and everyday language, choosing to eschew poetry or vocal music. He seeks the "hidden connections that unify obviously different phenomena" (ibid., 5).

study of music and language is a fruitful way to study how the mind processes sound.[12] Although music and language share many processing mechanisms, music has "much deeper power over our emotions than does ordinary speech."[13] A person's linguistic and musical soundscapes are imprinted on her mind in infancy, thus enabling her to decode her own "sonic milieu," but not necessarily those of other cultures.[14] Unlike physical matter studied in chemistry, for instance, the "'particles' of sound and music" are "psychological entities derived from a mental framework of learned sound categories."[15] Without perception, sound and music are irrelevant.

1.1 BASES OF SOUND CATEGORIES

While the sound categories of many types of music are based on pitch[16] (intervals and chords), the sound categories of speech are often based on timbre (vowels and consonants). While human musical systems are so diverse that universals are few, song based on a "stable system of pitch contrasts" is almost universal, as is octave equivalence.[17] There is a broad avoidance of intervals smaller than a semitone, and a strong preference for asymmetrical scales (these make it easier to detect the relation of any other tone within the scale to the first tone, or tonal centre).[18]

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[12] Ibid., 417.
[13] Ibid., 4.
[14] Ibid., 9.
[15] Ibid., 11.
[16] Patel defines pitch as "that property of a sound that enables it to be ordered on a scale going from low to high (Acoustical Society of America Standard Acoustical Terminology)" (ibid., 86).
[17] Ibid., 13. Equivalence of what is referred to in Western music as the "octave" – this same distance is divided differently from culture to culture.
[18] Ibid., 19-20. Patel notes that Débussy introduced symmetrical scales in Western music after having heard the Javanese gamelan at the Paris Exposition. However, the effect of the "shifting harmonic palette" of Débussy's whole-tone scales depends on familiarity with earlier, asymmetrical scales, against which the whole-tone scales stand out and sound refreshing.

Patel wonders why pitch is favoured as the basis for organized musical sound over other perceptual aspects of sound such as "loudness, length, timbre, and location." Like pitch, timbre is also multidimensional, but noticeable changes in timbre would require an instrument to be struck or blown differently, or would require a change in instrumentation, none of which can occur as rapidly as change in pitch. It is difficult to organize a system out of perceptual differences in timbre, or of "timbre intervals," which are not perceived with enough uniformity to serve as the basis for "a shared category system."[19]

In contrast, the multidimensionality of pitch is easy to organize into a system. Octave equivalency means that we hear notes as similar-sounding not only because of their closeness in pitch height but also because of their similarity in pitch chroma. The two dimensions of pitch (height and chroma) are like a helix in which the octaves line up with each other.[20] Within this framework, one can combine pitches simultaneously to create higher-level entities such as chords and intervals. In Western music, the equal-tempered scale is a compromise between the small, whole-number ratios of Pythagoras and the wish "to move easily between different musical keys."[21]

Since the division of the octave into scales varies so widely between cultures, Patel doubts there is a natural basis for musical pitch intervals themselves.[22] But Patel concedes that the multidimensionality of pitch reflects "the neurophysiology of the

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[19] Ibid., 32-34.
[20] Ibid., 9-13.
[21] Ibid., quoting W. Sethares, *Tuning, Timbre, Spectrum, Scale* (London: Springer, 1999).
[22] Ibid., 21.

auditory system."[23] In related research, Andrew Bell investigates the lattice geometry of the inner hair cells of the human cochlea and reveals an approximation to the 12-tone scale in the middle part of the cochlea "where speech and music perception is strongest." The close resemblance of the spatial cell-firing patterns of the octave and the fifth might explain why they are heard as consonant and similar.[24] The inside of the cochlea is tuned like an "underwater piano," and according to Bell, replicates Pythagorian musical ratios, prompting Bell to note: "Pythagoras was right: music is geometry."[25]

Music can use timbre to echo speech effects: the vocables of North Indian tabla are an example of how timbre in music can reflect the timbre of speech.[26] David Hendy notes that music can also echo the pitches of speech convincingly: in Ghana, the Ashanti people use a "talking drum" to spread news from town to town.[27] Since pitch in speech carries affective signals as well as linguistic ones, Patel suggests it is an adaptive feature of speech that its pitch contrasts are flexible.[28] In the meantime, speech tones vary according to vocal range, which can even change based on the speaker's mood. Pitch in language also affects the perception of pitch in music: absolute pitch is much more common among those who speak tonal languages than among others.[29]

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[23] Patel, 13.
[24] Ibid., 3-4.
[25] Ibid., 1.
[26] Ibid., 67.
[27] *Talking Drum Demonstration*, worldmusicxx, YouTube, https://www.youtube.com/watch?v=CbMMw-88eT4, retrieved August 3rd, 2016. Also see David Hendy, *Noise: A Human History of Sound and Listening*, (New York: Harper Collins, 2013), 12.
[28] Patel, 40-44.
[29] Ibid., 45-48. For instance, in a comparison of students from the Central Conservatory of Music in Beijing to the students at the Eastman School of Music, it is revealed that that 60% of the Chinese students have absolute pitch, in contrast to 14% of the English-speaking students.

1.2 SOUND CATEGORY LEARNING

Underlying the mental processing of both music and language are learned sound categories, which suggests that sound category learning is central to human cognition. Although the final products of language and music are different, their learning processes are shared.[30] The framework for sound perception in language begins forming well before infants can speak their native language fluently, while the ability to discriminate non-native-language speech contrasts disappears by the time an infant is one year old.[31]

In many circumstances, timbre is processed in the left hemisphere of the brain, while pitch is processed in the right. However, the hemispheric asymmetries of language and music-processing in the brain are more subtle than previously believed: when hearing their native language, speakers of tonal languages process pitch in the left hemisphere, which is possible because while pitch contour is always processed in the right hemisphere, pitch interval can be processed on either side. Also, a listener hearing unfamiliar timbre effects (like Zulu tongue clicks) processes them in the right hemisphere instead of the left.[32] In short, the same sound is processed in a different part of the brain depending on whether the listener perceives it as a learned sound category within language, or as music.

Musical abilities predict certain language abilities, and vice versa. For instance, five-year olds who display superior performance on musical tests also have better reading abilities, even when accounting for phonemic awareness and auditory memory. Musical

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[30] Ibid., 72.
[31] Ibid., 61-69. Because the formants of speech "are in almost constant motion," infants often (adorably) have problems segmenting the words: they have trouble hearing where one word ends and the next begins.
[32] Ibid., 74.

ability predicts proficiency in a second language, while musical training sharpens the encoding of pitch patterns in language.[33] The ancient Greeks were not mistaken that musical and poetic training are related, and that they enhance one another.

Patel notes that many artists explored the relation between speech and music in the twentieth century, including Schoenberg in his *Pierrot Lunaire* and Reich in his *Different Trains*. In Patel's view, science is only "beginning to catch up" to art in this area.[34]

1.3 CULTURE AND SOUND PERCEPTION

Sound perception has cultural biases. On the one hand, "the mental framework for sound perception is not a frozen thing in the mind, but is adaptive and is constantly tuning itself."[35] However, certain aspects of sound perception are adjusted to a person's cultural framework and solidify over time: while babies can distinguish "subtle phonetic contrasts" that occur in foreign languages, adults cannot, as they have become accustomed to the phonetic contrasts of their native language. Even so, there may be an "innate processing advantage for the simpler frequency ratios found in the Western versus [for instance] Javanese scales."[36] This advantage is overridden by cultural preferences for other tonality-ratios; for example, in Javanese gamelan, these more complex ratios are interpreted as expressive and meaningful.

Despite their cultural variety, musical systems often highlight the same popular intervals. Patel investigates why in Western music the fifth takes second place only to

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[33] Ibid., 78-79.
[34] Ibid., 86.
[35] Ibid., 85.
[36] Ibid,, 83.

octave, and why it is also a vital interval in many other musical traditions, including those of India and China. [37] While there are cultural and personal reasons to favour consonance or dissonance, humans can agree on whether a sound is rough or smooth, or whether it is dissonant or consonant in the first place. Patel compares dissonance to spiciness in food, and notes that there is a great diversity of tolerance or interest in spiciness across cultures and individuals. Nonetheless there is a hierarchy of intervals, beginning with the octave and followed by the fifth, perhaps because

> the fifth generates a neural pattern that invokes not only the pitches of the lower and upper notes of the interval, but also a pitch one octave below the lower note, and other harmonically related notes. In contrast, the neural pattern to dissonant intervals such as the minor second does not suggest any clear pitches.[38]

This "the 'pitch-relationship theory' of musical intervals"[39] relates to the overtone series, which is heard in every sound that humans encounter, and which features the octave, fifth, and fourth most prominently, in that order. Some theorists argue that the fifth also has special status in human speech, since "the frequency with the strongest energy peak in the speech spectrum is often accompanied by another concentration of energy at an interval of a fifth above this peak."[40] If the fifth is the first overtone detected after the octave, it makes sense that it would appear in speech, as it sounds familiar and yet is easier to produce than the octave.

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[37] Ibid,, 87.
[38] Ibid,, 91, inviting comparison to P. Cariani, "A temporal model for pitch multiplicity and tonal consonance," in S.D. Lipscomb et al. (Eds.), *Proceedings of the 8th International Conference on Music Perception and Cognition, Evanston, IL, 2004* (Adelaide, Australia: Causal Productions) (2004): 310-314.
[39] Patel, 92. Patel invites comparison to R. Parncutt, *Harmony: A Psychoacoustical Approach* (Berlin: Springer-Verlag, 1989).
[40] Patel, 93.

1.4 BEAT PERCEPTION

Rhythm draws the widespread attention of music theorists and linguists alike. Systematic temporal, accentual, and phrasal patterning is more complex in both speech and non-Western music than in most Western music, which relies on "other musical dimensions (such as harmony)" to provide interest. Western music features beat hierarchies, alternating between strong and weak beats, while other kinds of music (that of the Chinese Ch'in, for instance) are more gestural and fluid in rhythm.[41] In most cultures, regular rhythm and phrasing are favoured, prompting Patel to suggest "that these aspects reflect widespread cognitive proclivities of the human mind."[42] In speech, inaccurate rhythm causes a foreign-sounding accent.[43]

Beat perception is sophisticated, anticipatory (rather than reactive), and "involves a mental model of time in which periodic temporal expectancies play a key role. This may be one reason why it is unique to humans," Patel adds.[44] Apart from metrical accents, there are also phenomenal and structural accents that can be used against the prevailing meter for interest. There is evidence that beat perception couples the auditory and motor systems, even when there is no physical movement.[45] This harkens back to the common origins of music, language, and dance.

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[41] Ibid., 97. "[A] seven string fretless zither that has been played in China for over 2,000 years," referring to R. H. van Gulik, *The lore of the Chinese lute: An essay in ch'in ideology* (Tokyo: Sophia University, 1940).
[42] Ibid., 96-99.
[43] Ibid., 98. Referring to D. S. Taylor, "Non-native speakers and the rhythm of English," *International Review of Applied Linguistics* (1981): 19:219-226; D. Faber, "Teaching the rhythms of English: A new theoretical base," *International Review of Applied Linguistics* (1986): 24:205-216; and B. Chela-Flores, "On the acquisition of English rhythm: Theoretical and practical issues," *International Review of Applied Linguistics* (1994): 32:232-242.
[44] Ibid., 102, referring to M. R. Jones, "Time, our lost dimension: Towards a new theory of perception, attention, and memory," *Psychological Review* (1993): 83:323-355.
[45] Ibid., 105-106.

Languages are rhythmically classified as either "stress-timed" (English, Arabic, and Thai, for example) or "syllable-timed" (like French, Hindi, Yoruba, and Singapore English[46]).[47] (Stressed-timed languages have syllables that vary in length, while syllable-timed languages have even syllables.) Other distinctions are tone and lexical pitch accent. These factors intertwine in different ways; for instance, Mandarin is a tone language with stress, Cantonese is a tone language without stress, Swedish is a pitch-accent language with stress, and Japanese is a pitch-accent language without stress.[48] However, the rhythm classification system for languages requires revision since some languages elude the prescribed categories.[49]

Musical rhythm is a psychologically rich phenomenon, involving many perceptual dimensions such as "structure (e.g. meter, simplicity vs complexity), motion (e.g., swinging, graceful), and emotion (e.g., solemnity vs. playfulness)."[50] The very names chosen for these dimensions highlight the relationship between movement, language, and sound.

Comparing rhythm in language to rhythm in music is complicated because the native linguistic soundscape can differ so much. For instance, French speakers are deaf to stress differences in nonsense words while Spanish speakers can hear them because Spanish has "contrastive stress: Two words can have the same phonemes but a different

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[46] Ibid., 128.
[47] Ibid., 118. According to Allen and Hawkins, "the rhythm of English-speaking children is syllable-timed in contrast to the stress-timed rhythm of adult speech." Ibid., 134, referring to G. D. Allen, & S. Hawkins, "The development of phonological rhythm," in A. Bell & J. Hooper (Eds.), *Syllables and Segments* (Amsterdam: North-Holland, 1978), 173-175.
[48] Patel, 119.
[49] Ibid., 135, referring to E. Grabe, & E. L. Low, "Durational variability in speech and the rhythm class hypothesis," in C. Gussenhoven & N. Warner (Eds.), *Laboratory Phonology 7* (Berlin, Germany: Mouton de Gruyter, 2002), 515-546.
[50] Ibid., 116-117.

stress pattern, and this can change the meaning of the word entirely (e.g., *sábana* vs. *sabána*, which mean "sheet" and "savannah" respectively)."[51]

Patel nonetheless finds parallels between linguistic and musical rhythm: phrase boundaries in music and in language are lengthened with similar acoustic cues.[52] Linguistic "accommodation" between speakers of different socio-linguistic backgrounds, (in which speakers unwittingly copy each others' accents) resembles musical "tempo persistence," in which musicians unwittingly replicate a tempo they have just heard. The study of metrical phonology is analogous the study of musical rhythm in that it involves "the patterning of time intervals at several timescales," distinguishing between strong and weak syllables, as well as between different beat levels similar to the tactus and the downbeat in music, for instance.[53]

The key difference between rhythm in speech and music is that musical metre displays much stricter temporal periodicity. Metre in speech is much more variable than in music (33% compared to 5%, in one study),[54] while listeners tolerate more durational variability in speech than they do in music.[55] Patel illustrates: "the prominences of language are not regular enough to allow for anything as abstract as syncopation." Rhythm in language is consequence, whereas in music, it is construct. Lastly, musical

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[51] Patel, 138. Patel invites comparison to S. Soto-Faraco, N. Sebastián Gallés, & A. Cutler, "Segmental and suprasegmental mismatch in lexical access," *Journal of Memory and Language* (2001): 45:412-432.
[52] Ibid., 112.
[53] Ibid., 139-140.
[54] Ibid., 140-141. Patel notes that this represents the coefficient of variation of the interstress interval in speech as compared to the coefficient of variation shown by adults tapping to music, referring to R. M. Dauer, "Stress-timing and syllable-timing reanalyzed," *Journal of Phonetics* (1983): 11:51-62.
[55] Patel, 144.

rhythm conveys a sense of motion, which linguistic rhythm does not.[56] Evidently, these differences only apply to prosaic speech and not to poetry – there are considerably more parallels between poetic speech and music: for instance, rapping certainly allows for syncopation.

One could argue that the iambic pentameter of poetry conveys a sense of motion, as does incantation and recitation. Patel distinguishes, however, between the *temporal* periodicity of music and the *configurational* periodicity of poetry, claiming that the syllables are not isochronous, but that the "repetition of some basic prosodic unit" gives the false impression that the syllables are of equal time duration.[57]

Patel notes with regards to English poetry that iambic feet are more temporally asymmetric than trochaic feet.[58] The more equal trochaic syllables stand out within English speech rhythm, conveying a sense of incantation, explaining why "trochaic meters are often associated with awe and the suspension of reality."[59] In some French and Chinese verse, syllables of equal duration are frowned upon even if each line contains the same number of syllables. However, in English verse, lines are kept within a given duration even if it requires temporal compensation on the part of the speaker.[60]

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[56] Ibid., 150.
[57] Ibid., 154-155.
[58] Ibid., 155. "[I]n iambic feet, the weak syllable is about 50% as long as the following strong syllable, whereas in trochaic feet, the weak syllable is about 80% of the duration of the preceding strong syllable." Patel refers to L. Nord, A. Kruckenberg, & G. Fant, "Some timing studies of prose, poetry and music," *Speech Communication* (1990): 9:477-483.
[59] Patel, 156. Patel refers to S. Adams, *Poetic Designs: An Introduction to Meters, Verse Forms, and Figures of Speech* (Peterborough, Ontario, Canada: Broadview Press, 1997), 55-57.
[60] Patel, 156, referring to I. Lehiste, "Speech research: An overview," in J. Sundberg, L. Nord, & R. Carlson (Eds.), *Music, Language, Speech and Brain* (London: Macmillan, 1991), 98-107. This compensation recalls *rubato* in music.

Patel also observes that in rock music, verbal stress often anticipates metrical accent "by a fraction of a beat," leading to "a sense of syncopation and rhythmic energy."[61]

The non-periodic aspects of rhythm provide grounds for comparison between speech and music, as the rhythms of a composer's native language are detectable in his or her music. Patel and his colleagues have established the normalized pairwise variability index (nPVI), based on the "greater degree of vowel reduction" in stress-timed languages in comparison to syllable-timed languages, which measures the "durational contrast between successive elements in a sequence." Applying the nPVI to musical tones in British and French instrumental music reveals that just as English has a significantly higher nPVI than French, the nPVI of Elgar's music is higher than that of Débussy's.[62] This difference holds fast in a study of sixteen composers such as Poulenc, Delius, Vaughan Williams, and Saint-Saëns. They found that German music was the only kind not to reflect the high nPVI value of its speech, and interestingly, the nPVI of German music almost doubled between 1650 and 1900. Patel suggests this divergence is due to the "waning influence of Italian music on German music of this period."[63]

1.5 MELODY PERCEPTION

Once again, there are key differences between the phenomenon of melody in speech versus that of melody in music, even if there are demonstrable links. Patel defines melody, in both speech and music, as "an organized sequence of pitches that conveys a

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[61] Patel, 156-157.
[62] Ibid., 161-165. This is true even if the "raw variability of note duration in the Débussy theme is *greater* than that in the Elgar theme (as measured by the coefficient of variation, in other words, the standard deviation divided by the mean)" (ibid., 162-163).
[63] Ibid., 167. Another factor might be the waning use of spoken French in the courts of German princes, where many composers earned their keep.

rich variety of information to a listener." While musical melodies revolve around a "focal pitch that serves as a perceptual centre of gravity for the melody," linguistic melodies lack stable pitch intervals.[64]

Speech melody is determined by physiological factors, (the average vocal range being of one octave, with women usually one octave above men). Speech melody conveys "affective, syntactic, pragmatic, and emphatic" signals. Speech melody that has no bearing on the semantic meaning of words is called *intonation*, while speech melody that alters the meaning of words is found in tone languages (Mandarin and Yoruba) and in pitch-accent languages (Swedish and Japanese).[65] Intonation varies between languages, so that for instance, English spoken with French intoning patterns results in what would be considered a French accent.[66]

A common feature of the speech melody of humans (and of primates in general) is *declination*: "a gradual lowering of the baseline pitch and narrowing of pitch range over the course of an utterance." Declination is suppressed in questions, and is more obvious in prepared speeches than in casual speech. People who are tone-deaf or who make pitch-contour errors in music have no noticeable problems producing or perceiving speech intonation. [67]

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[64] Ibid., 183. Patel quotes Joshua Steele, who wrote that in speech, the voice "moves rapidly up or down by slides, wherein no graduated distinction of tones or semitones can be measured by the ear; nor does the voice… ever dwell distinctly, for any perceptible space of time, on any certain level or uniform tone, except the last tone of which the speaker ends or makes a pause." Ibid., 186-187. J. Steele, *Prosodia Rationalis: Or, An Essay Toward Establishing the Melody and Measure of Speech, to Be Expressed and Perpetuated by Peculiar Symbols* (2nd Ed.) (London: J. Nichols, 1779, reprinted by Georg Olms Verlag, Hildesheim, 1971).
[65] Ibid., 182-186.
[66] Ibid., 192.
[67] Ibid., 184-185.

Both instrumental music and vocal music can be influenced by the pitch contours of language, as in the work of Leos Janácek (1854-1928), who attempted to transcribe the intonation contours of his Czech language.[68] In Cantonese opera, speech melody influences the music directly. Scripts must be memorized very quickly and performed "without music notation or rehearsal." Singers compose on the spot, using linguistic tones as inspiration.[69]

Musical melody is two-dimensional (representing pitch vs. time), but is translated by the human mind "into a rich set of perceived relationships."[70] Melodic contour can affect beat perception, and is one of the first musical phenomena that infants can distinguish.[71] In infant-directed speech (also known as *motherese*) the intonation contours are exaggerated to convey emotional cues, making sensitivity to pitch contours adaptive for infants.[72]

Patel underlines "universal Gestalt principles of auditory processing" that reflect the rules of counterpoint: pitch proximity, pitch reversal, and symmetry of pitch reversal patterns. Listeners expect the following pitch to be close to the last one, they expect a reversal in the direction of the melody following a large interval jump, and they expect a symmetrical reversal pattern. These patterns may be related to speech, since the limited range of the voice imposes directional reversals.[73]

Patel attributes the effectiveness of music to the tension between Gestalt auditory principles such as physical pitch proximity and the varying tonal stability of scale pitches

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[68] Ibid., 183, Footnote 2.
[69] Ibid., 217.
[70] Patel, 190.
[71] Ibid., 195.
[72] Ibid., 195.
[73] Ibid., 196-197.

(psychological proximity).[74] Tones can feel "stable, complete, and pleasant" in one context, and "unstable, incomplete, and irritating" in another.[75] Because music offers patterns of pitch sequences at simultaneous hierarchical levels, "musical melodies engender a much richer set of perceptual relations" than spoken melodies.[76] The emotional purchase of music may spring from the sheer breadth of its perceptual relations.

Patel describes the combination of the interval system of scales and the temporal grid of metre as a "scaffolding" for "an elaborate set of structural relations between tones."[77] Formal harmony is an even more complex scaffolding, with the added vertical dimension. Oliver Sacks relates the experience of composer and performer Rachael Y. who lost her ability to process harmony when she was injured in a car accident. Her physician "described her 'agonizing experience of hearing all music as discrete, contrapuntal lines, being unable to hold on to the harmonic sense of chordal passages. Thus, where listening was linear, vertical and horizontal at the same time, now it was horizontal only.'"[78] This composer's unenviable predicament helps to illustrate the spatial dimension of music perception.

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[74] Ibid.,199.

[75] Ibid., 201. Patel adds: "[s]ome form of a tonal centre or tonic is widespread in musical melodies of different cultures, in both art music and folk music" (ibid., 199, Footnote 8).

[76] Ibid., 203-205.

[77] Ibid., 183.

[78] Oliver Sacks, *Musicophilia* (New York: Vintage Books, 2008), 425.

1.6 MUSICAL STRUCTURE/SYNTAX

Humans are distinguished from animals in the recursive nature of their syntactic structures, both linguistic and musical.[79] Patel points out that there is considerable neural overlap in the syntactic processing of language and music, and that musical structure rivals linguistic syntax in richness. Musical structure contains multiple levels or organization, scale degree relations that are hierarchical rather than simply binary, harmony (which is multi-dimensional and extremely syntactically complex), event hierarchies featuring structural and ornamental levels, and structural relations (such as harmonic functions) that represent high levels of abstraction. Furthermore, the link between structure and meaning is as strong in musical syntax as it is in linguistic syntax.[80] (For example, consider the ubiquitous antecedent-consequent phrase.)

Unlike linguistic syntax, musical syntax uses contrast rather than similarity to gain perceptual coherence. Linguistic syntax is made up of relationships of constituency, while musical syntax represents a contrast between structural and elaborative events, as well as patterns of tension and relaxation.[81] Patel agrees with Joseph Swain that patterns of tension and relaxation as musical pieces unfold in time are the source of interest in tonal music. Smaller patterns of tension and relaxation can be buried in larger ones "of identical geometry but of a longer timescale."[82] Lerdahl and Jackendoff speak of the constant breathing in and out of the music.[83] In language, meaning comes from "the

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[79] Ibid., 241-244. Birdsong is syntactic (swamp sparrow syntax varies by geographical location) but because of its recursive structure, human language is much more complex than birdsong, allowing words to carry abstract grammatical functions, for instance. Ibid., 244.
[80] Ibid., 258.
[81] Patel, 256, referring to J. Swain, *Musical Languages* (New York: Norton, 1997).
[82] Ibid., 263-265.
[83] Patel, 257, referring to F. Lerdahl, & R. Jackendoff, *A Generative Theory of Tonal Music* (Cambridge, MA: MIT Press, 1983).

conceptual structure of reference and predication in sentences," or "who did what to whom," but music is more syntactically ambiguous than language, a feature that is exploited for aesthetic purposes.[84]

Syntactically, pitch is almost universally organized into musical scales of 5 to 7 tones in each octave. This offers the mind psychological reference points and mental categories for the organization of sound.[85] Carol Krumhansl depicts the tension between the physical proximity of tones and the psychological distance between the same tones due to their scale degrees and harmonic purpose.[86]

FIGURE 2: Geometrical Representation of Perceived Similarity Between Pitches[87]

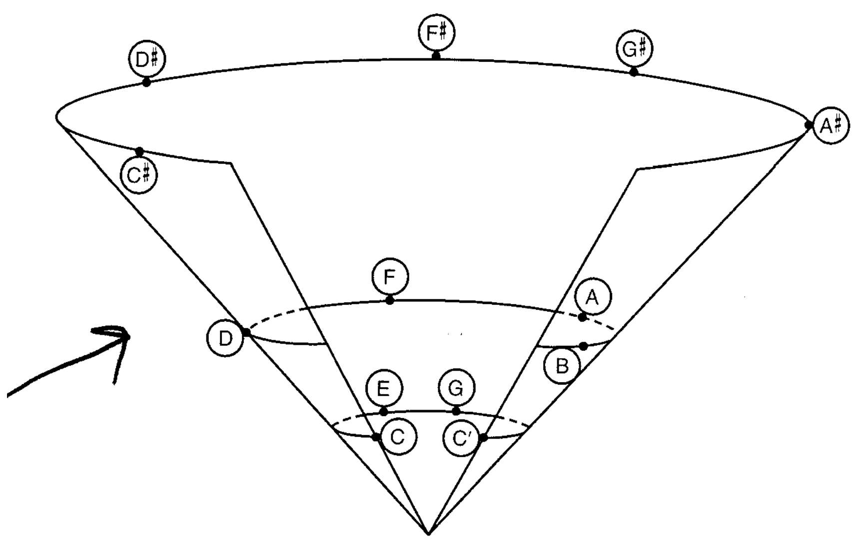

Figure 5.3 Geometrical representation of perceived similarity between musical pitches in a tonal context. The data are oriented toward the C major scale, in which C serves as the tonic. C′ is the pitch one octave above C. From Krumhansl, 1979.

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[84] Ibid., 244-264.
[85] Ibid., 244-245. Infants do not have "implicit knowledge of scale structure," and they only begin to acquire "learned sound categories for language at 10 months […] which may reflect the greater amount of linguistic versus musical input that infants have experienced by that age." Ibid, 247.
[86] Ibid, 246. Referring to C. L. Krumhansl, "The psychological representation of musical pitch in a tonal context," *Cognitive Psychology* (1979): 11:346-374.
[87] Patel, 247. Used with permission (see Appendix A). Figure from Krumhansl (see footnote 131 above).

The vertical (contrapuntal) and horizontal (harmonic) aspects of chord patterning in music provide additional layers of syntactic richness, and the syntactic prototypicality of chord progressions is detectable even by musical novices.[88] Patel also displays the geometrical torus map of Krumhansl and Kessler, which renders the psychological distance between keys spatially.[89]

FIGURE 3: Map of Psychological Distances Between Musical Keys[90]

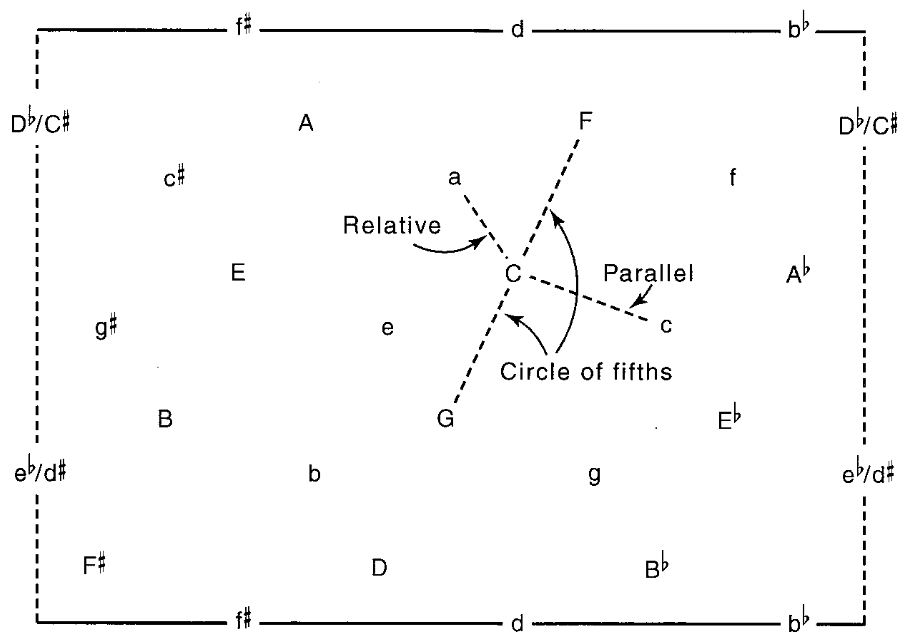

Figure 5.7 A map of psychological distances between musical keys. Major keys are indicated by uppercase letters and minor keys by lowercase letters. Dashed lines extending from the key of C major indicate related keys: two adjacent major keys along the circle of fifths (G and F; cf. Figure 5.6) and two related minor keys (see text for details). Modified from Krumhansl & Kessler, 1982.

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[88] Patel, 249.

[89] Ibid., 252. Referring to C. L. Krumhansl & E. J. Kessler, "Tracing the dynamic changes in perceived tonal organization in a spatial representation of musical keys," *Psychological Review* (1982): 89:334-368.

[90] Patel, 252. Used with permission (see Appendix A). Modified by Patel from Krumhansl and Kessler (see footnote 134 above).

Patel emphasizes Hugo Riemann's claim that musical listening is "a highly developed application of the logical functions of the human mind,"[91] even if hearing has physical dimensions. There are likely deep connections in the brain between linguistic and musical syntax,[92] but the idea of "tonal closure," prevalent in music theory, has been called into question. While listeners expect stories to come to a clear end, studies show that even highly trained musicians cannot hear whether a piece is returning to a "home key" if the length exceeds one minute, reflecting the limitations of human short-term memory.[93] The pleasure derived from hearing a piece end in the same key as it began may be more of an intellectual one than an experiential one.

1.7 LINGUISTIC AND MUSICAL MEANING

Patel observes the permeability of musical meaning across cultural boundaries.[94] It is not possible, however, for music to be "meaningful" in the sense that language is – Patel refers to the philosopher Kivy who claims that discussing whether music is meaningful is a "category error," "like asking whether a rock is dead."[95] While music is logical, has syntactic significance, and expresses emotion, it is not a language of words. Specificity of meaning in music must be pointed out by the composer, or alluded to by

[91] Ibid., 267, referring to Dahlhaus on Riemann, found in C. Dahlhaus, *Studies on the Origin of Harmonic Tonality* (R. O. Gjerdingen, Trans.) (Princeton, NJ: Princeton University Press, 1990). Patel also notes: "the psychoacoustic properties of musical sounds appear to provide a 'necessary but insufficient' basis for tonal syntax." Patel, 260, referring to F. Lerdahl, *Tonal Pitch Space* (New York: Oxford University Press, 2001).

[92] Ibid., 268. It is also worth noting that "implicit knowledge of syntactic conventions in tonal music […] has been repeatedly demonstrated in nonmusician listeners in Western cultures" (ibid., 295).

[93] Ibid., 307.

[94] Ibid., 300.

[95] Ibid., 304, referring to P. Kivy, *Introduction to a Philosophy of Music* (Oxford, UK: Oxford University Press, 2002).

context or lyrics. The freedom of music from specificity of meaning allows it to express the "vast and ever-growing diversity of human aesthetic creativity and interest,"[96] in Patel's words.

Emotion in music is linked to, among other things, the tension and resolution inherent in tonality. When harmonic expectations are violated, a listener experiences emotion. This arousal is not positive or negative, necessarily, but rather transient.[97] Krumhansl has shown in psychological studies that while each listener exhibits emotional peaks and valleys at the same points in a given piece, the type of emotion felt varies widely from listener to listener.[98] This transient arousal is also referred to as the "chills," which people also feel in response to other deeply moving artistic stimuli (literary, visual, and so on).[99] Alongside musical structure, individual memories and cultural associations contribute to shaping a listener's emotions.[100]

However, even children as young as five or six fall into step when asked to judge the expressive qualities of music that has been divided into only two expressive categories (happy vs sad).[101] Tom Fritz of the Max Planck Institute in Leipzig conducted a study among members of the Mafa tribe (who had never been exposed to Western music) in a remote area of northern Cameroon. Fritz asked tribe-members to listen to

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[96] Patel, 243.
[97] Ibid., 308.
[98] Mannes, 64, referring to C. Krumhansl, "An Exploratory Study of Musical Emotions and Psychopyhysiology," *Canadian Journal of Experimental Psychology* (1997): 51:336-52. "Examples of selections were 'Spring' from *The Four Seasons* by Vivaldi (happy), *Adagio for Strings* by Samuel Barber (sad), and *Night on Bald Mountain* by Mussorgsky (fear)." Mannes, 228, in Endnote 11 of Chapter 5.
[99] Ibid., 318, referring to Leonard B. Meyer, *Emotion and Meaning in Music* (Chicago: University of Chicago Press, 1956). Patel notes that chills are "an unusual form of arousal compared to everyday emotions, because they are so transient," but everyday emotions are also much more transient than is widely believed, as meditation helps to reveal.
[100] Mannes, 68.
[101] Ibid., 309.

classical Western pieces through headphones and to attribute an emotion to each piece, represented by happy, sad, and scary faces. Fritz found that the ability of the Mafa tribe-members to recognize musical emotions "was much better than chance for all three emotional states." According to Fritz, this study shows that the emotional expression of music is not culturally bound, but is rather "inherent in the music itself."[102]

Unlike the "transient arousals" that accompany an unexpected harmonic shift and that vary in emotional content from listener to listener, the overarching feeling of a piece is distinct and can usually be agreed on. For instance, music with dancing rhythms, major harmonies, quick tempos, and constant pitch and dynamic ranges sounds "happy," while music with the same constant pitch and dynamic ranges, but minor harmonies and slower tempos sounds "sad." Music with dissonant harmonies, wide variations in pitch and dynamic, and quick tempos sounds "scary."[103]

Affect in music may come partly from speech, since sad speech is also slower and lower in pitch than happy speech.[104] These acoustic cues to emotions in speech are likely cross-cultural.[105] At the most basic level, happiness brings smooth vibrations, while emotional turmoil brings bumpy vibrations. Musical patterns can evoke "the physical bearing or movements of people in different emotional states." Structure can be used metaphorically to represent emotion (complex structure could sound more ponderous and introspective, for instance). Both Indian classical music and Javanese gamelan music contain affective categories for specific types of compositions depending, for instance, on

[102] Ibid., 54.
[103] Ibid., 64.
[104] Ibid., 312.
[105] Ibid., 345. Likewise, cues to vocal affect in instrumental music "are combined in an additive fashion," so that, "reflecting the exigencies of particular instruments. […] [I]f a performer cannot vary timbre to express anger, s/he compensates by varying loudness a bit more […]" (ibid., 346).

their "scale, tonal hierarchy," or "melodic gestures." Emotions can be conveyed through timbre: anger has been depicted through "harder" timbres like those of high stringed instruments.[106] (This may reflect how the voice rises in anger.)

Music can evoke motion, whether through a beat to which listeners synchronize themselves, through imitating the gestures of sound-production, or through causing fictional movement such as "an auditory sense of 'looming,'" or of impending doom. A listener can have a sense of self-motion or a sense of "external objects moving in relation to the self." Some speech theorists underline the gestural basis of sound production, arguing that acoustic events are actually "phonetically structured articulatory gestures that underlie acoustic signals," in which case sound is a "medium for the perception of movement" in the first place.[107]

Musicians are familiar with the concept of tone painting, in which music imitates natural phenomena. Eighteenth-century critics like Hüller complained that "our intermezzi" are full of "clocks striking, ducks jabbering, frogs quacking, and pretty soon one will be able to hear fleas sneezing and grass growing."[108] Subtle, refined tone painting can be found in the religious works of Haydn, Mozart, and Bach, as when, in

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[106] Ibid., 313-314. Trumpets also come to mind. Socrates is leery of emotional affect in music because of its political dangers: "When someone gives music an opportunity to charm his soul with the flute and to pour those sweet, soft, and plaintive tunes we mentioned through his ear, as through a funnel, when he spends his whole life humming them and delighting in them, then, at first, whatever spirit he has is softened, just as iron is tempered, and from being hard and useless, it is made useful. But if he keeps at it unrelentingly and is beguiled by the music, after a time his spirit is melted and dissolved until it vanishes, and the very sinews of his soul are cut out and he becomes 'a feeble warrior.'" Plato, *The Republic*, 411b. (According to Grube and Reeve, "a feeble warrior" refers to Homer's *Iliad*, 17.588.)

[107] Ibid., 320. Further observations on motion and listening can be found in the works of Eric Clarke, who offers an ecological perspective on listening; Marc Leman, who teaches embodied music cognition and explores musical gestures and expression; and Rolf Inge Godoy, who researches phenomenological and cognitive approaches to music theory. (Professor Doug van Nort, comments from the defence, June 28th, 2016.)

[108] Ibid. Hear T. Gureckis, "Grass Growing," *One Winter Is Notenuf*, Spotify, retrieved May 2015.

Bach's cantata *Gottes Zeit ist die allerbeste Zeit*, BWV 106 (also known as *Actus Tragicus*) the soprano's voice rises up to heaven in a meandering melisma as his/her character dies.

Musical topics or characteristic figures such as marches, pastoral melodies, and dance forms such as the minuet point to a parallel between "topical structure in music and language."[109] Tone painting often implies movement or imitation of a shape or sound, where musical topics often pervade a whole movement or section of a piece. Both point to specific, concrete phenomena outside of the music, and in that respect call to mind words, themes, or images to enrich the listener's experience.

The *Leitmotif*, which has referential qualities and is often perceived as a "persona," is another link between language and music.[110] In studies, listeners processed musical leitmotifs in similar regions of the brain as those used to process linguistic contexts, showing that music can elicit specific semantic concepts.[111]

Instrumental music plays the use of topics in sophisticated ways. This might explain, says Patel, "the intuition of certain musically sensitive people that the sound of a string quintet or quartet is somehow reminiscent of a well-wrought 'conversation' between several individuals." Music is also associated to cultures, contexts, and social classes. Customers will buy more expensive wine if there is classical music playing in a

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[109] Patel, 321.
[110] Ibid., 328-329.
[111] Ibid., 344-345. S. Koelsch, "Neural substrates of processing syntax and semantics in music," *Current Opinion in Neurobiology* (2005): 15(2):207-12. Patel also points to D. Cohen, "Palestrina counterpoint: A musical expression of unexcited speech," *Journal of Musical Theory* (1971): 15:85-111. Cohen argues that the rules of Renaissance counterpoint "act to suppress sudden changes in volume, pitch, or rhythm, thus making the music similar to the prosody of 'unexcited speech.'" The "ideal of calm, religious expression" is reflected through the music.

shop than if there is popular music playing, for instance.[112] Music can also arouse narrative thought, as when a piece reflects "the feeling of a heroic struggle triumphantly resolved." It can also transport the listener back in time, or induce a state of trance.[113]

Musical structure can be culturally meaningful, such as the moment of "coincidence" of simultaneously-running geometrical/cyclical patterns in Gamelan music. The word "*Kepbetulan,* 'coincidence' in Indonesian, and *kebeneran* in Javanese both derive from root words meaning 'truth,' *betel/bener*." In Western music, a focus on progress and change may drive the importance of harmonic progression in chord syntax.[114] The Mephistophelean character of Western harmony stands in contrast to musical styles whose beauty comes from their static, elaborative nature.[115]

Patel suggests that scientific study of the emotional response to music is so late in coming because of the difficulty of quantifying emotion, and because music may "elicit emotions that do not fit neatly into the pre-established everyday categories."[116] Like Mannes, Patel mentions the findings of Krumhansl that instrumental music can arouse can arouse common, everyday emotions in listeners, possibly through empathy or

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[112] Ibid., 322-323. Furthermore, in one study, "on 'French music days,' French wines outsold the German wines, and vice versa." Patel refers to A. C. North, D. J. Hargreaves, & J. McKendrick, "The influence of in-store music on wine selections," *Journal of Applied Psychology* (1999): 84:271-276.

[113] Ibid., 323-325. Patel wonders if instrumental music could induce a state of trance as effectively as ritualistic music with words. Elena Mannes quotes ethnomusicologist Kay Kaufman Shelemay who speaks of the gamelan sending "people into a trance" and the trance then protecting the people. Mannes, 204, referring to an interview with Kay Kaufman Shelemay for *The Music Instinct*; Judith Becker, "Music, Trancing and the Absence of Pain," in *Pain and its Transformations*, ed. Sarah Cokley and Kay Kaufman Shelemay (Cambridge, Mass.: Harvard University Press, 2007).

[114] Patel,, 326.

[115] Non-Western styles are sometimes set to Western harmony, as in Aishwarya Nigam's cover of Kailash Kher's *Saiyaan*. *Aishwarya Nigam – Saiyaan*, narical, YouTube, https://www.youtube.com/watch?v=petHoFuzZmI, retrieved August 6th, 2016.

[116] Ibid., 315. Patel establishes as his basic emotional categories "happiness, sadness, anger, and fear." Ibid., 316.

contagion ("the passive spreading of an affective response").[117] Listeners also use music for their own emotional self-construction, basing their attitudes towards certain aspects of life on music.[118]

While listeners experience the emotional mood of a piece, performers may not do so in the same way, according to neuroscientist Lawrence Parsons.[119] When Parsons tested musicians in a brain scanner while they were playing Bach, the brain areas associated with emotion were completely inactive.[120] Although the rigorous demands of performing Bach might make this example less significant, it would be interesting to know how this experiment would turn out with the works of other composers, or for musicians performing different instruments, some of which are melodic, some of which are also harmonic and require that many musical lines be played at once.

Patel quotes the philosopher Susanne Langer who holds that through music, composers articulate "subtle complexes of feeling that language cannot name, let alone set forth.'"[121] Music engages ancient and deep brain structures that are used for the most vital human functions: they govern some of the most primitive cravings – those of food, sex, and addiction.[122]

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[117] Ibid., 316. Patel refers to the study of Krumhansl (1997), also raised by Mannes: see footnote 163.
[118] Patel, 317. This also pertains to the use of music for violent political ends: in Plato's *Republic*, Socrates is concerned that music might weaken warriors, but music can also harden people against their enemies or sweep them into delusions of superiority.
[119] Ibid., 309.
[120] Ibid., 65-66.
[121] Patel, 317, referring to S. Langer, *Philosophy in a New Key: A Study in the Symbolism of Reason, Right, and Art* (Cambridge, MA: Harvard University Press, 1942).
[122] Patel, 318.

1.8 MUSIC AND EVOLUTION

While language "is the sole province of humans," songs among birds and whales exist; however, among animals, "song is not a volitional aesthetic act but a biologically mediated reproductive behaviour." Furthermore, as far as human beings are concerned, selective musical deficits are irrelevant with regards to evolution.[123] This shows that music has an evolutionary use among some animals that it may have outgrown in humans, who use music for a much wider variety of purposes, and whose reproductive habits do not rely on music. Recent research reveals that music may have *preceded* language in the evolution of the human species.[124]

In humans, there are two ways in which music and language can "share developmental mechanisms" in two ways: music can engage a mechanism refined by evolution for language whenever it uses processes similar to language, or both music and language can engage cognitive processes that are more general and are not unique to either phenomenon.[125]

The idea that original human communication involved both music and language is supported by the concepts of "babbling, vocal learning, and the anatomy of the vocal tract."[126] It is remarkable that vocal babbling, which is how babies learn to match oral

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[123] Patel, 356-357.

[124] Kimberly Sena Moore, Ph.D., "Which Came First: Music or Language? A theory that language evolved as a subset of music" *Psychology Today* (posted Sept 20th, 2012). https://www.psychologytoday.com/blog/your-musical-self/201209/which-came-first-music-or-language, retrieved August 6th, 2016. Sena Moore mentions the researchers and authors Daniel Levitin, Michael Thaut, Ian Cross, Silvia Bencivello, and David Huron in particular.

[125] Ibid., 386-387. Mannes lauds the *Musikkindergartens* in the Middle East and in Berlin founded by Daniel Barenboim. In these programs, children are immersed in and learn through music. They learn "discipline, playfulness, affection" while treating "music as play." Children in the *Musikkindergarten* show heightened improvement in "social networking skills" as well as greater "language abilities." (Mannes, 86-87)

[126] Patel, 371.

movements to auditory results, is produced by deaf babies as well as hearing ones. Since the emergence of babbling is spontaneous and therefore babbling is not an imitation of adult speech, it must be that selection has affected language acquisition.[127] Infants quickly learn "to recognize the equivalence of a speech sound […] across differences in speaker, gender, and speech rate, a task that has proven difficult for even very powerful computers." Only humans have a lowered larynx, which has a biological cost because it makes choking on food much more likely. This feature may stem from the evolution of language.[128] In early childhood, humans have "exquisite sensitivity of vocal development to perceptual experience" – this enchanted period is over by puberty.[129]

In contrast to the highly precocious nature of language acquisition, the progress of the acquisition of musical ability is slow. Patel is surprised that "sensitivity to key membership develops rather slowly in children" despite the strongly tonal nature of nursery songs.[130] This is logical, however, as key membership is relational, whereas children are usually exposed to simple melodies that are limited in key. As children have not been exposed to the overarching key structures, they have no way of discerning the greater context of key relations. Therefore, a sense of the limits or boundaries of each key would be missing.

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[127] Ibid., 359. Deaf babies "babble with their hands" upon being "exposed to sign language." Babbling "represents the maturation of a mechanism that maps between motor output and sensory input, and guides humans toward the discovery of the phonological structure of language, whether spoken or signed." Ibid., 360.

[128] Ibid., 360-361.

[129] Ibid., 362-363. This sensitivity to language is just as pronounced in deaf children: in a Nicaraguan school for deaf children in Managua, a new language has been developing because of the absence of adults available to teach a fully developed language. The children have been increasing the complexity of their grammar with each fresh cohort entering the school, and are creating "more systematic patterns" than those generally used among the hearing and among adults. This suggests "learning predispositions that have been shaped by natural selection." Ibid., 365.

[130] Ibid., 372.

The question of whether or not there is "a critical period for the acquisition of musical skills" then arises. A child who cannot speak by the age of 13 will probably never speak at a normal level of ability. However, George Gershwin, who reached highly abnormal levels of musical ability, began playing the piano at age 13. The amount of practice in childhood does affect "the neuroanatomy of the motor system," especially that pertaining to independent finger movement, but it has no noted effect on musical cognitive abilities. Of all cognitive skills in music, only absolute pitch has a critical acquisition period: it is rare in individuals who began studying music after the age of six.[131] The early critical acquisition period for language points to its heightened evolutionary importance vis-à-vis music.

Remarkably, the four percent of the population that exhibit tone-deafness have no related cognitive deficits in non-musical areas, nor do they have trouble with socialization. In contrast, those who fail to develop language may also fail to develop "certain basic cognitive skills," such as "false belief understanding," or the recognition that "one's own thoughts and beliefs can be different from those of others, and/or mistaken." It is also remarkable that autistic individuals (who have profound cognitive deficits in the area of socialization) respond to musical affect.

Human beings in fact derive more pleasure from hearing birdsong than from hearing human music, which some theorists take to mean that "group singing preceded the evolution of language." Infants also derive more pleasure from hearing their mothers sing than from infant-directed speech. It is possible that the extra stimulation of music, which is felt as well as heard, soothes infants to a higher degree, and enables mothers to

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[131] Ibid., 374-375.

forage for food without constantly holding their babies, giving them an evolutionary advantage.[132]

Several bird species have absolute pitch, but very poor relative pitch, so it is thought that the modification by natural selection of the human auditory system towards relative pitch processing may come from the processing of speech intonation. Monkeys show "qualitatively different patterns of neural activity" in response to consonance and dissonance, which suggests that all vertebrates may hear certain intervals as smooth or rough-sounding, perhaps because of the similarity of the auditory system of al vertebrates.[133]

Patel recommends the study of beat-based rhythm processing to explore evidence that human beings have evolved for music. If other animals cannot be taught to acquire it, it is not "latent in animal brains," and therefore could have been a factor of natural selection in human beings. Human beings synchronize because of a link between the motor and auditory systems that allows them to anticipate upcoming beats. Although other animals (rabbits, for instance) can be taught to anticipate "the duration of a short time interval between a warning tone and a puff of air on the eye," they do not seem to have the heightened auditory-motor link that makes auditory beats so much easier to perceive for human beings than visual rhythmic patterns.[134]

It is possible that natural selection "modified the basal ganglia in a way that affords tight coupling between auditory input and motor input." Vocal learning also requires this tight coupling and taxes the nervous system in similar ways. Perhaps the ability to synchronize to a beat is dependent on the "neural circuitry for complex vocal

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[132] Ibid., 369-370.
[133] Ibid., 396-397. Patel notes that monkeys, however, do not necessarily *prefer* consonance.
[134] Ibid., 402-404.

learning"[135] In that case, human music that preceded language might have sounded quite different from post-linguistic music.

Oliver Sacks notes that "rhyme" and "rhythm" are etymologically linked to the Greek, meaning "measure, motion, and stream." He attributes to music the power to enhance repetitive motions such as walking and dancing, and to enhance the ability "to organize, to follow intricate sequences, or to hold great volumes of information in mind." The wife of one of Sacks' patients describes how her husband (who could no longer identify everyday objects) learned to get through his daily tasks if they were stated in song.[136] Sacks agrees that the power of music to help sustain language and action through "an articulate stream, a melody or prosody" points to the common origins of music and language.[137]

In contrast with the obvious usefulness of language, music's "lack of an obvious survival value has puzzled evolutionary thinkers since Darwin," who wrote that "our musical abilities 'must be ranked among the most mysterious with which [humans are] endowed.'"[138] There is no current evidence of natural selection for music in human beings.[139]

Even so, Patel does not draw from this that music is only a frill conceived to "tickle our senses." Patel insists that "the choice between adaptation and frill is a false

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[135] Ibid., 410-411. Patel mentions "anecdotal evidence" of parrots (also capable of vocal learning) who are able to synchronize to a beat. See also p. 70, footnote 514.
[136] Sacks, 257-258. "I put all his usual clothes out, in all the usual places, and he dresses without difficulty, singing to himself. He does everything singing to himself. But if he is interrupted and loses the thread, he comes to a complete stop, doesn't know his clothes – or his own body. He sings all the time – eating songs, dressing songs, bathing songs, everything. He can't do anything unless he makes it a song."
[137] Ibid., 260.
[138] Patel, 367, referring to Charles Darwin *The Descent of Man and Selection in Relation to Sex* (London: John Murray, 1871).
[139] Patel, 377.

dichotomy – music belongs in neither category. The human race is unique in that it regularly invents things "that transform its own existence." Written language, aircraft, and the Internet have changed the fabric of human life. Music is likewise an invention that is transformative and universally and deeply valued, like the use of fire. "Once a culture learns fire making, there is no going back, *even though we might be able to live without this ability*." Archaeology shows that the transformative power of music has been known since the earliest known days of human existence.[140]

Unlike technologies like the Internet or fire making, music "has the power to change the very structure of our brains, enlarging certain areas due to motor or perceptual experience." In this respect, music differs from technology[141] but resembles other kinds of innovation such as the use of written language.[142]

Patel contributes much towards bridging the divide between the sciences and the humanities. He paraphrases John Donne, encouraging thinkers and scientists to "address that subtle knot which makes us human."[143] If music preceded language, then music was crucial for the evolution of language, and its evolutionary purpose is no longer a mystery. In that case, music is not so much an innovation as a basic human need.

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[140] Ibid., 400-401.

[141] For all the practical and mental benefits the internet provides, internet technologies have been found to cause more multi-tasking, which is proven to weaken critical thinking and questioning of the status quo. Michael Landon-Murray and Ian Anderson, "Thinking in 140 Characters: The Internet, Neuroplasticity, and Intelligence Analysis," *Journal of Strategic Security* (2013): 6(3): 73-82, http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1268&context=jss, retrieved August 6th, 2016. Patricia Greenfield "has found the internet disrupts the deep processing that allows 'mindful knowledge acquisition, inductive analysis, critical thinking, imagination, and reflection.'" Referring to Patricia M. Greenfield, "Technology and Informal Education: What is Taught, What is Learned," Science 323 (January 2009): 71.

[142] Ibid., 401.

[143] Ibid., 417. Donne's poem *The Ecstasy* reads "that subtle knot which makes us man." John Donne, *The Ecstasy*, The Poetry Foundation, http://www.poetryfoundation.org/poem/173355, retrieved January 28th 2016.

CHAPTER 2: DMITRI TYMOCZKO'S *A GEOMETRY OF MUSIC*

If architecture is frozen music, then the New York Times Building must be Sister Mary Jane's top, high note.[144]

Dmitri Tymoczko argues in *A Geometry of Music* that "conventional musical notation evolved to satisfy the needs of the performer rather than the musical thinker." He eschews what he refers to as the "redundancies and inefficiencies" of regular notation to conceive novel, spatial representations of voice-leading and counterpoint. Thus, he reveals the "harmonic and contrapuntal relationships that underlie much of Western contrapuntal practice."[145] Through musical set theory, musicologists have tried to categorize all the chords possible, but Tymoczko suggests that the geometry of voice-leading distance and chordal space is too sophisticated to submit to such a simplification.[146]

To account for the richness and variety of harmonic expression, Tymoczko presents "geometrical models of musical structure" in which notes are represented, for instance, on the circle of *pitch-class space*. He continues with "higher-order objects – chord progressions and voice-leadings – that describe motion through time." Tymoczko emphasizes the "importance of symmetry in music theory," seeking the conditions under which "harmonic consistency and conjunct melodic motion can be combined." He considers paramount "the interdependence between acoustic consonance, efficient voice

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[144] Oliver Herford, in *The Book of Musical Thoughts: A Musician's Garden of Verses*, Compiled by Eliza Leypold Good (Chicago: P.F. Volland & Company, 1912), 36.
[145] Dmitri Tymoczko, *A Geometry of Music* (New York: Oxford University Press, 2011), 79.
[146] Ibid., 28. For example, set theory does not account for the rootedness and centricity of a piece, in which "chord tones themselves can be differentiated in terms of their importance."

leading, and harmonic consistency."[147] His goal is "to provide general categories for discussing music that is neither classically tonal nor completely atonal," which includes "some of the most mysterious and alluring music" of the twentieth century.[148]

2.1 A NEW APPROACH TO MUSICAL ANALYSIS

Tymoczko's approach is distinct from those of traditional music theorists: …Because of the complexity of voice leading, theorists have failed to understand "the fundamental logic animating nineteenth-century music." They have

> sometimes depicted chromaticism as involving whimsical aberrations, departures from compositional good sense, rather than as the systematic exploration of a complex but coherent terrain. This has in turn led historians and composers to depict nineteenth-century chromaticism as pushing tonal logic to its breaking point, such that the step to complete atonality became all but inevitable.

In contrast, Tymoczko demonstrates through "new geometrical tools […] that the music of Chopin and Wagner can be just as rigorous as the music that preceded it."[149]

Tymoczko proposes five features that "are present in a wide range of genres, Western and non-Western, past and present" and that they "jointly contribute to a sense of tonality":

> 1. *Conjunct melodic motion*. Melodies tend to move by short distances from note to note.
> 2. *Acoustic consonance*. Consonant harmonies are preferred to dissonant harmonies, and tend to be used at points of musical stability.
> 3. *Harmonic consistency*. The harmonies in a passage of music, whatever they may be, tend to be structurally similar to one another.

[147] Ibid., 28.
[148] Ibid., 3.
[149] Ibid., 21.

> 4. *Limited macroharmony*. I use the term "macroharmony" to refer to the total collection of notes heard over moderate spans of musical time. Tonal music tends to use relatively small macroharmonies, often involving five to eight notes.
> 5. *Centricity*. Over moderate spans of musical time, one note is heard as being more prominent than the others, appearing more frequently and serving as a goal of musical motion.[150]

Tymoczko also makes four overarching claims. Firstly, "composers who wish to combine harmonic consistency and conjunct melodic motion" do not have endless options: "they can either use familiar sonorities in more or less familiar ways, or they can use chromatic chords whose notes are clustered together." Secondly, Tymoczko distinguishes the closely related phenomena of "scale, macroharmony, and centricity," scale being "a musical ruler," macroharmony being "the total collection of notes used over small stretches of musical time," and centricity being "the phenomenon whereby a particular pitch is felt as being more stable or important than the others." Thirdly, Tymoczko claims that "tonal music makes use of the same voice-leading techniques on two different temporal levels: *chord progressions* use efficient voice leading to link structurally similar *scales* (italics added)." Tonal music is "both self-similar and hierarchical": it provides a rich framework in which chords and scales intertwine, their hierarchies playing off one another, "exploiting the same procedures at two different time scales."[151]

Lastly, "geometry provides a powerful tool for modelling musical structure" because "there exists a family of geometrical spaces that depict the voice-leading relationships among virtually any chords we might care to imagine. Some of these (such as the familiar circle of fifths) are relatively simple, but others (such as the Möbius strip

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[150] Ibid., 4.
[151] Ibid., 14-17.

containing two-note chords) are considerably more complex." Tymoczko introduces these "musico-geometrical spaces, explaining how they work, and showing how they allow us to visualize a wealth of musical possibilities at a glance."[152]

2.2 GEOMETRICAL TOOLS

Tymoczko uses the mathematical concept of symmetry to define musical objects as belonging to the same "equivalence class."[153] Drawing on Rousseau, who "articulated the modern notion of a chord,"[154] Tymoczko describes how we use various "symmetry operations" to "transform a musical object." *Transposition* and *inversion* are "distance-preserving operations in chromatic space"[155] that correspond "to the geometrical operations of *translation* and *reflection*." *Octave shifts* change the pitch chroma without changing the pitch class, *permutations* involve reordering the notes within a chord, and *cardinality change* occurs when a new voice is added that doubles one of the notes already present.[156]

Not only chords, but also scales can be analyzed by geometrical means. Tymoczko states: "a musical scale is very similar to what mathematicians call a *metric*, or a method of measuring distance."[157]

> When the scale is *nearly* even, then the two forms of transposition [scalar and chromatic] will be nearly but not exactly the same. In some ways this latter situation is

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[152] Ibid., 19. Tymoczko created video representations of the chord movements in a phrase of Chopin's E minor prelude in "circular pitch-class space" on a two-dimensional Möbius strip, and in four-dimensional space. http://dmitri.mycpanel.princeton.edu/ChordGeometries.html, retrieved March 3rd, 2015.
[153] Tymoczko, *The Geometry of Music*, 35.
[154] Ibid., 36.
[155] Ibid., 119.
[156] Ibid., 33-38.
[157] Ibid., 121.

> preferable: scalar transposition along a perfectly even scale does not introduce any variations into the music and can become boring rather quickly. A bit of unevenness therefore adds musical interest by introducing a degree of variation. Interestingly, we can also make an analogous point about chords. When a chord divides the octave *perfectly* evenly, efficient voice leading typically involves parallel motion in all voices and does not create the effect of independent melodic lines. A little bit of unevenness is preferable here as well, allowing us to escape parallelism by causing the voices to move unequally. We might therefore say that both scales and chords are subject to the *Goldilocks Principle* – not too much evenness, because that would be boring, and not too little, because that would lead to musical disorder.[158]

Tymoczko's preference for unevenness reflects the universal mental processing advantage for uneven scales and for tonal centricity discussed above by Patel.[159] This suggests that the Goldilocks principle might apply to various non-Western musical styles as well.

Tymoczko also points out the useful property of scales "[i]n twelve-tone equal temperament: […] they contain *every* chord that does not itself contain a 'chromatic cluster' such as [C, C#, D]." The scales thus offer "a greatly extended harmonic vocabulary that nevertheless stops short of atonality's extremes."[160]

Just as the composers using voice-leading techniques that reflect geometrical patterns would not have described them as such, the mathematicians of the nineteenth century would not have been able to articulate the fine points of four-dimensional geometry, as "the study of higher dimensional geometry was in its infancy in the 1830s."[161]

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[158] Ibid., 122-123.
[159] See section 1.1, 4.
[160] Ibid., 127.
[161] Ibid., 293.

2.3 THE GESTURE OF VOICE LEADING

For Tymoczko, "[v]oice leadings are like the atomic constituents of musical scores, the basic building blocks of polyphonic music."[162] Traditionally, "Western music involves the simultaneous satisfaction of two independent constraints – a vertical constraint that requires chords to be structurally similar, and a horizontal constraint that dictates that they be connected by efficient voice leadings."[163] Furthermore, "*efficient voice leadings occur when scalar or interscalar transpositions neutralize the effects of chromatic transpositions."*[164] In other words, composers learn to play the vertical and horizontal constraints against each other, and the resulting geometric movements in pitch space constitute the evolving language of Western tonality.

Of the traditional avoidance of voice crossings, Tymoczko notes: "there are both *perceptual* and *conceptual* reasons to expect that voice crossings should be infrequent, since crossings make life difficult for both listener and composer."[165] Tymoczko represents the 'gesture' of "strongly crossing free voice leadings" visually on two adjacent circles, and it somehow resembles the gesture of 'turning out' in classical ballet,[166] or the *repoussoir* used as a framing effect in the visual arts.[167]

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[162] Ibid., 42.
[163] Ibid., 147.
[164] Ibid., 151.
[165] Ibid., 148.
[166] In ballet, 'turnout' refers to the way in which dancers angle their legs and feet outwards so that, for instance, when their heels are together, the toes are pointing outwards in opposite directions.
[167] Wikipedia, "Repoussoir," http://en.wikipedia.org/wiki/Repoussoir, retrieved June 7th, 2015. "In two-dimensional works of art, such as painting, printmaking, photography or bas-relief, *repoussoir* is an object along the right or left foreground that directs the viewer's eye into the composition by bracketing (framing) the edge."

FIGURE 4: Geometrical Representation of Crossing-free Voice Leadings[168]

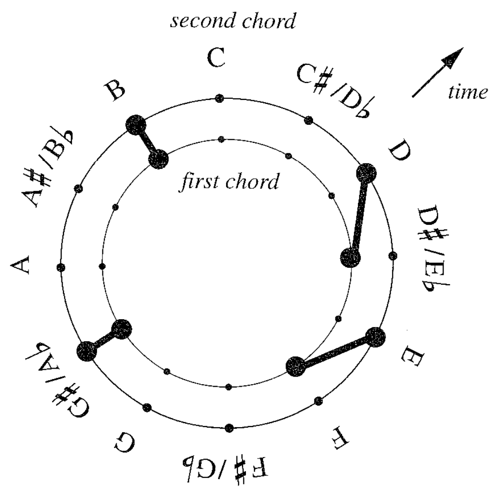

Figure 4.9.5 Strongly crossing-free voice leadings can be represented geometrically by non-intersecting paths connecting two concentric circles. Here the music progresses radially outward, from the inner circle to the outer. The voice leading (F, G♯, B, D♯)→(E, G♯, B, D) holds G♯ and B constant, moving F and D♯ down by semitone.

2.4 PITCH-CLASS CIRCULATION AND MACROHARMONIES

Tymoczko develops "tools for quantifying macroharmony" and for measuring "the rate of pitch-class circulation." He compares the works of Chopin, Débussy, Stravinsky, and Shostakovich, describing a wide range of pitch-class circulation rates, "ranging from Palestrina-like sections that use just a few pitch classes, to highly chromatic sections in which all twelve notes are in play." He observes that the "diversity in the rate of pitch-class circulation [in these composers' works] stands in stark contrast to the homogeneity of much atonal music." This difference in pitch-class circulation explains "why some listeners find atonal music to be somewhat static. In writing music with a consistently fast rate of pitch-class circulation, atonal composers deprived themselves of one important tool for creating large-scale harmonic change."[169]

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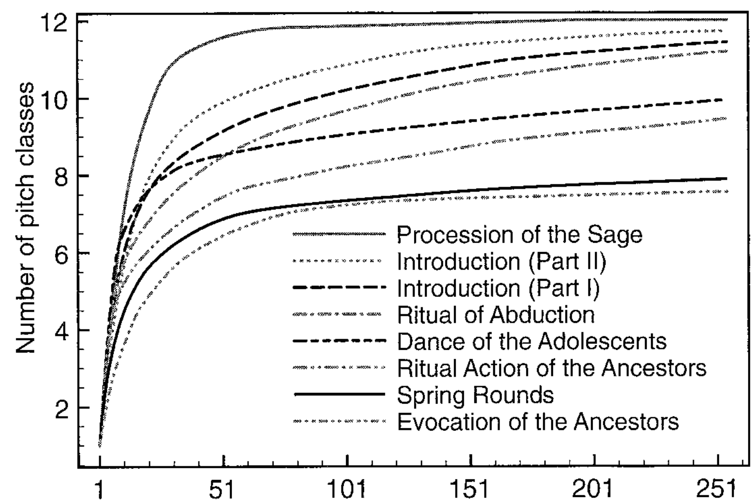
168 Tymoczko, 147, Figure 4.9.5. Used with permission (See Appendix B).
169 Ibid., 161-163.

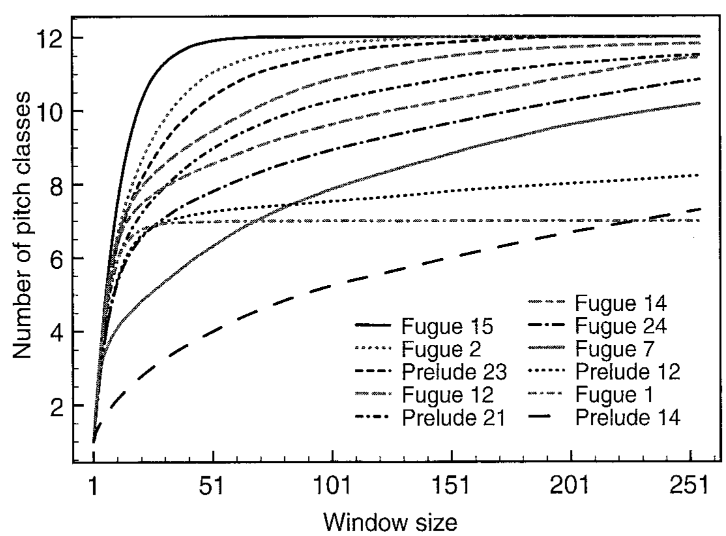
FIGURE 5: Pitch-class Circulation in Stravinsky and Shostakovich[170]

Figure 5.4.1 (Continued) Pitch-class circulation in Stravinsky's *Rite of Spring* (*c*) and Shostakovich's *Preludes and Fugues* (*d*). Again, the pieces cover a large range.

(*c*)



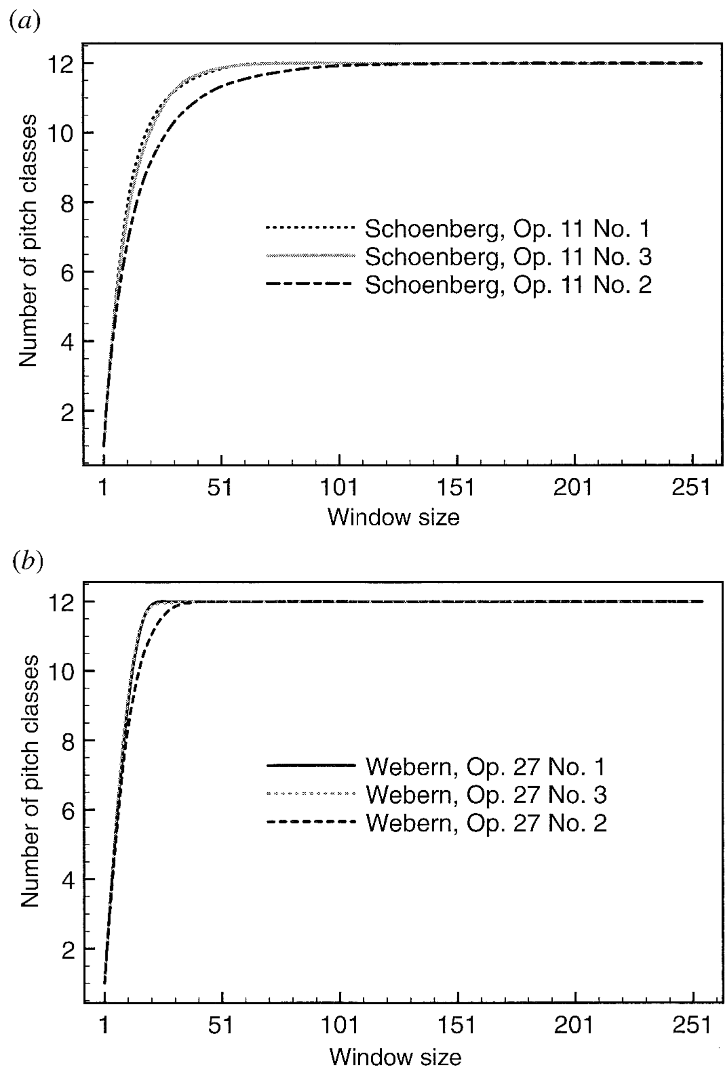
(*d*)



[170] Ibid., 162, Figure 5.4.1. Used with permission (See Appendix B).

FIGURE 6: Pitch-class Circulation in Schoenberg and Webern[171]

Figure 5.4.2 Pitch-class circulation in Schoenberg's Op. 11 and Webern's Op. 27 piano pieces. The individual movements of each piece are much more similar than in Figure 5.4.1.



Tymoczko's study of pitch-class circulation reveals the key difference between diatonic and chromatic music, and uncovers an unexpected similarity between early medieval and atonal music:

> (I suspect that critics [of composers who continued to write diatonic music] have sometimes resorted to stylistic categories in part because we lack precise theoretical terms for talking

[171] Ibid., 163, Figure 5.4.2. Used with permission (See Appendix B).

> about phenomena such as pitch-class circulation.) From this point of view, it is thoroughgoing chromaticism that is conservative, as it abandons macroharmonic change in favor of musical textures that are harmonically uniform in the large. In this respect it recalls the macroharmonic stasis of the earliest Western music.[172]

While early medieval composers had yet to explore the geometric pitch space of the circle of fifths, atonal composers, by choosing to reject acoustically consonant chords, were forced to abandon "harmonic consistency" and "conjunct melodic motion."[173]

Tymoczko observes "that the informal music-theoretical term 'chromatic' involves the interaction of at least two independent variables: rate of pitch-class circulation and the degree of emphasis on particular macroharmonies," which can also be depicted visually. However, pitch-class circulation graphs have a limitation: they "cannot distinguish between quickly modulating diatonic music and nondiatonic music in which all twelve pitch classes are constantly in play." For instance, John Coltrane's tonal solo on 'Giant Steps' and Schoenberg's Op. 11 No. 1 "have almost identical rates of pitch-class circulation, even though Schoenberg's music is intuitively 'more chromatic' than Coltrane's."[174]

Tymoczko's tools offer new ways to explain the particular qualities of various composers' works. Tymoczko discovers, for instance, that "Shostakovich's minor-mode pieces are even more diatonic than Bach's – largely because Shostakovich eschews V-I progressions in favour of diatonic cadences that hearken back to a pre-tonal modality," which gives his music a "distinctive austerity."[175] Ligeti's compositions, for their part, exploit "the mirror boundaries of the higher-dimensional chord spaces, rather than taking

[172] Ibid., 164.
[173] Ibid., 183.
[174] Ibid., 164-166.
[175] Ibid., 168.

advantage of their twists."[176] Ligeti's lines rely less on voice-leading tricks, and more on contrapuntal techniques such as mirror inversion.

Tymoczo insists that "[t]he concept of centricity is complicated, in part because it encompasses two closely related phenomena: *rootedness*, which applies to individual chords, and *tonicity*, which refers to prominence over longer stretches of musical time." In traditional analysis, the conflation of these phenomena raises difficulties: "just as the line between chord and macroharmony is sometimes blurry, so too is the distinction between rootedness and tonicity: […] it can be difficult to say whether the most important tone is a root, a tonic, or something in between." Similarly, "[t]he simplest conception of a chord is binary; notes can be either inside the chord or outside of it, but no further differentiations are made." But Tymoczko notes: "[t]he musical cases we have been considering require finer gradations of prominence."[177]

Tymoczko seeks to "replace the opposition "tonal"/"atonal" with a much more fine-grained set of categories, more appropriate to the richness of contemporary musical practice."[178] He suggests that "twenty-first century scalar composers were the first to systematically combine three fundamental musical operations: change of tonal center, change of scale, and chromatic transposition." In Tymoczko's view, the scalar tradition "encompasses at least six major twentieth-century movements – impressionsism, neoclassicism, jazz, rock, minimalism/postminimalism, and neo-Romanticism," and includes some of the music of Scriabin, Stravinsky, Bartók, and Shostakovich.[179]

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[176] Ibid., 190.
[177] Ibid., 169-170.
[178] Ibid., 190.
[179] Ibid., 186-186.

FIGURE 7: Harmonic Consistency and Macroharmony[180]

Figure 5.8.7 In both the scalar and chromatic traditions, there are genres exhibiting harmonic consistency (top row) as well as genres in which harmonic consistency does not play as an important a role (bottom).

		Limited Macroharmony	
		YES	**NO**
Harmonic Consistency	**YES**	traditional scale-based tonality (Debussy, Jazz)	"triadic atonality" (Gesualdo, Reger)
	NO	pandiatonicism (*Voiles*)	complete atonality (Schoenberg, Babbitt)

2.5 THE RICHNESS OF TRIADS AND FOURTH PROGRESSIONS

Tymoczko proposes that harmonic consistency arises "as the *unbidden byproduct* of more basic musical preferences," namely, the preference for triads (three-note chords) over two-note chords with one note doubled. He asks what would happen if one were "to use three-note chords containing only perfect and imperfect consonances – that is, thirds, fourths, fifths, sixths, and their compounds." As it turns out, "there are only two possibilities: *doubled consonances*, containing multiple copies of some notes, and *triads*, containing no doublings at all." Composers have tended to prefer triads, which are "sonically richer […] simply by virtue of containing three distinct pitch classes." The preference for a "richer note content" seems like a "*weak* notion of harmonic consistency," but it automatically generates "a much stronger kind of consistency" because the chords are all "related by diatonic transposition."[181]

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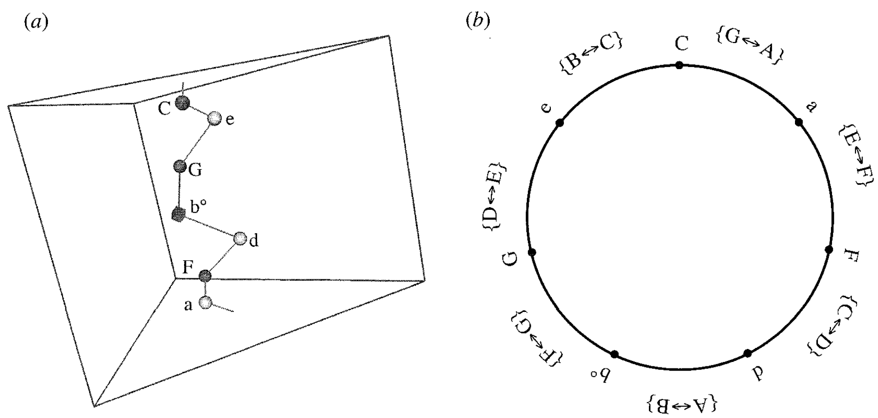
[180] Ibid., 189, Figure 5.8.7. Used with permission (See Appendix B).
[181] Ibid., 202-203.

Tymoczko also illustrates a "circle of thirds" representing the single-step voice leading between adjacent triads in three-note pitch space:

FIGURE 8: Chain of Diatonic Thirds and Circle of Thirds[182]

Figure 6.3.7 The diatonic triads form a chain that runs through the center of three-note chord space, with adjacent triads linked by single-step voice leading. (*b*) This "circle of thirds" is analogous to the familiar circle of fifth-related diatonic scales, and can be used to represent any three-voice, strongly crossing-free voice leading between triads.



Fourth progressions played an important role in the development of harmonic complexity, according to Tymoczko:

> Fourth progressions allow a composer to harmonize a wide range of stepwise melodies in a '3+1' fashion, with the upper voices moving by strongly crossing-free voice leadings and the bass moving from root to root. Root motions by second and third are comparatively less flexible, either because they do not harmonize many stepwise melodies or because they can create forbidden parallels.[183]

[182] Ibid., 205, Figure 6.3.7. Used with permission (See Appendix B).
[183] Ibid., 208.

Furthermore, "[c]ommon tones may also be a factor: step-related triads have no common tones, fourth-related triads have one, and third-related triads have two. The Goldilocks Principle perhaps favours the middle option."[184]

FIGURE 9: Fourth Progressions by Renaissance Composer[185]

Figure 6.3.11 Root progressions by composer, with S = second, T = third, and F = fourth. Over the course of the Renaissance, there is an increasing preference for fourth progressions, a trend that continues into the classical tradition.

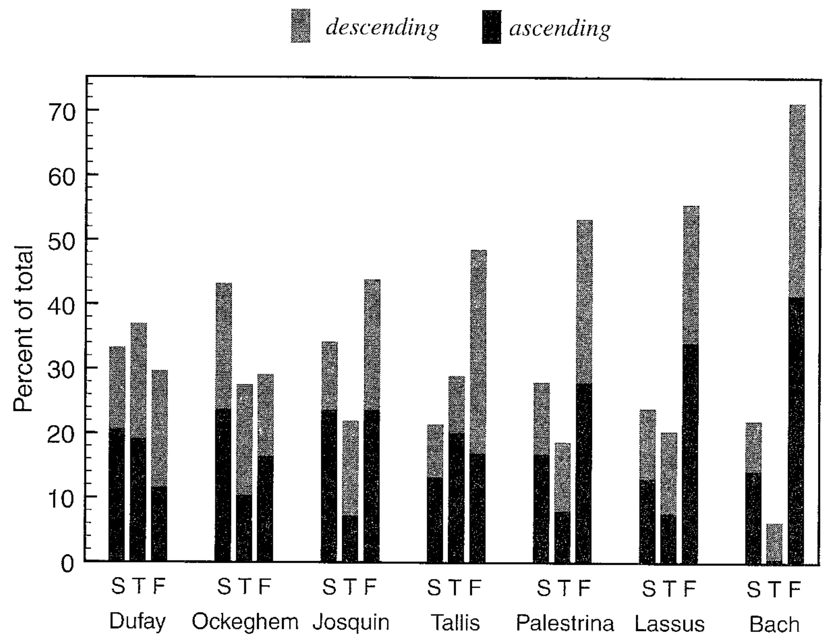


Figure 6.3.12 Fourth progressions allow a composer to harmonize a wide range of stepwise melodies in a "3 + 1" fashion, with the upper voices moving by strongly crossing-free voice leadings and the bass moving from root to root. Root motions by second and third are comparatively less flexible, either because they do not harmonize many stepwise melodies or because they can create forbidden parallels.

Tymoczko also points out how "fourth progressions play a critical role at cadences," mentioning the "'phrygian cadence' common in both Renaissance and classical music."[186] While cadential fourth progressions featured clear patterns of

[184] Ibid., 208, footnote 16.
[185] Ibid., 208, Figure 6.3.12. Used with permission (See Appendix B).
[186] Ibid., 209.

“tension and release,” “within-phrase fourth progressions” did not, and usually involved a 3 + 1 pattern of voice leading. Tymoczko suggests that

> functional tonality arose out of the gradual fusion between these two types of progression – in other words, the within-phrase fourth progressions gradually acquired the tension-release quality of the cadential formulas, articulating the music into a sequence of short “harmonic cycles,” each concluding with its own tension-resolving V-I progression.[187]

Tymoczko argues that scale structure itself reinforces the prohibition on forbidden parallels such as perfect fifths and octaves. Like parallel octaves, “parallel diatonic fifths almost always produce parallel chromatic fifths; by contrast, parallel diatonic thirds do not produce the same degree of chromatic parallelism, since the diatonic scale contains a more even distribution of major and minor thirds.”

Tymoczko compares the development of harmonic practice to the progress of a rock-climber: ”though the climber is in principle free to move in any direction, the structure of the rock will naturally suggest certain routes, offering hand-holds and footholds that will guide any sensible person’s decisions.”

> [S]everal features of renaissance syntax can be seen as relatively obvious solutions to very basic compositional goals – ensuring voice independence, writing consonant music using three-note sonorities, and harmonizing stepwise convergence onto a unison. In hindsight, we can see these developments as exploiting relatively obvious possibilities lying dormant in the diatonic system.[188]

This calls to mind Hayek’s argument concerning the organization of economic matters: rather than try to order things by force from above, it is more efficient to allow them to order themselves (see the heading of the Introduction).

[187] Ibid., 209-210.
[188] Ibid., 211.

Composers have discovered the most exquisite possibilities of melodic and harmonic intercourse simply by experimenting step by step, gradually increasing the level of complexity to meet the gradually more refined ear of the listener. Just as in economics, in music the results are diversification and specialization as many new styles have emerged to suit the audience's wide-ranging tastes. These styles may exploit the possibilities of Western harmony or not, as they can also feature much greater rhythmic and phrasal complexity than Western styles as mentioned by Patel (see p.15). Javanese gamelan for instance, features a texture of stratified heterophony, which is the source of its richness and complexity.

2.6 THE INTERPLAY OF VOICE-LEADING (SCALES) AND HARMONIC CONVENTIONS (CHORDS)

Tymoczko takes issue with theorists influenced by Heinrich Schenker who "seem to deny that functional tonality involves purely harmonic conventions." Tymoczko suggests there are good historical reasons for claiming that functionally tonal music obeys purely harmonic laws. According to Tymoczko, voice-leading conventions drove compositional practice from the Renaissance to the twentieth century, and harmonic conventions overlapped with these throughout the "common practice" period (from 1680 to 1900), eventually taking over and lasting into contemporary times. Tymoczko emphasizes that "[t]heorists who renounce harmonic laws risk effacing these two common practices, and hence obscuring the connections between Renaissance music, classical tonality, and more recent rock and jazz."[189]

[189] Ibid., 213.

While initially, the "chord-by-chord constraints" seemed to Tymoczko "to be the most important and distinctive feature" of tonal harmony, twenty-five years later, he considers "systematic modulation […] at least as important. […] It is interesting, therefore, that modulation continues to feature prominently in twentieth-century music, even in styles that have abandoned the chord-to-chord constraints of the classical era." For Tymoczko, "systematic relations among macroharmonies are the most significant and enduring legacy of the functional tradition."[190]

Tymoczko points out what would later be called a "tritone substitution" in Schumann's *Chopin*: "What makes the chord interesting […] is its twofold status. Contrapuntally, we can think of it as a mere collection of passing tones. Harmonically, however, it has its own individuality and significance."[191] Here, "Schumann temporarily abandons the diatonic world in favour of a direct manipulation of chromatic relationships. This involves replacing a relatively simple diatonic geometry with the much more complex geometry of chromatic possibilities," as in Figure 10.

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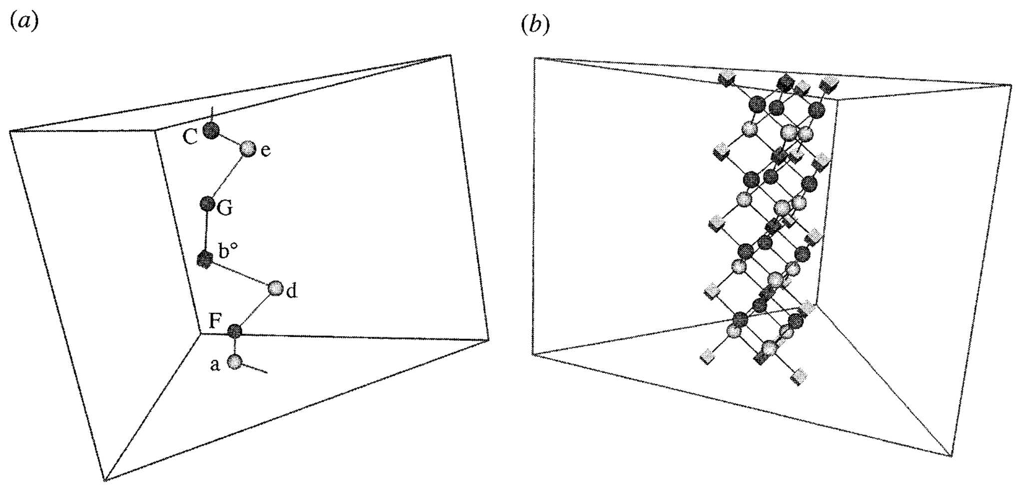
[190] Ibid., 214.
[191] Ibid., 216.

FIGURE 10: Voice Leading Relations of Diatonic Triads and Chromatic Triads[192]

Figure 6.5.3 Voice leading relations among diatonic triads (*a*) are much less complex than those among chromatic triads (*b*).



This phenomenon "could serve as the frontispiece to the entire tradition of nineteenth-century chromaticism, a genre that is characterized by the increasing tendency to conceive of chords as objects in chromatic space."[193]

In an analysis of the Scherzo from Schubert's C major String Quintet, Tymoczko observes: "the majority of the modulations use efficient chromatic voice leading among triads and seventh chords."[194] For Tymoczko, "a deep appreciation of nineteenth-century music requires a systematic grasp of *all* the voice-leading possibilities between familiar sonorities." The music of Chopin and Schubert does not result "from capricious acts of musical fancy, Romantic lawbreaking that obeys no fixed principles;" rather it represents "a small collection of familiar paths through chromatic space."[195]

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[192] Ibid., 216, Figure 6.5.3. Used with permission (See Appendix B).
[193] Ibid., 217.
[194] Ibid., 219.
[195] Ibid., 220.

It is well-known that twentieth-century music "witnessed a tremendous expansion of harmonic options; new chords were permitted and new chromatic voice leadings were used to connect formerly distant chords." However, music's "scalar or modal vocabulary" did not expand, so that composers exploited "the fact that the sonorities of chromatic harmony can all be embedded in a small number of familiar scales." For instance, composers might juxtapose a familiar acoustic scale with an unfamiliar mode, setting acoustic scales in D and Bb, for instance, in a mode treating C as the tonic.[196] Tymoczko suggests that jazz musicians inherited and systematized these techniques, which initially appeared in the music of Ravel and other twentieth-century composers.[197]

However, the inheritance could have gone in the other direction, since Ravel loved hearing jazz performances and is known to have adopted jazz sonorities into his own style. Frederick Delius was another composer influenced by the strains of North American music – as a young man working on a Florida orange plantation, he was struck by the subtle, improvisatory harmonies of spiritual songs he overheard there.[198] In whichever direction the influence went, for Tymoczko, the twentieth-century phenomenon "in which nondiatonic scales are used to accompany functionally harmonic progressions […] represents one of the most interesting recent developments in the thousand-year tradition that is Western tonality – a thread of common practice linking a wide variety of recent tonal styles."[199]

Tymoczko objects to the habit of calling the eighteenth and nineteenth centuries the "common practice period." He disputes the argument that "there is no substantive

[196] Ibid., 221.
[197] Ibid., 223.
[198] Christopher Palmer, "Delius and Folksong," *The Musical Times* 112, No. 1535 (January 1971): 24-25. JSTOR, retrieved April 14th, 2014.
[199] Tymoczko, 223.

sense in which Palestrina or Duke Ellington can be said to participate in the same musical tradition as the musicians of the eighteenth and nineteenth centuries." Instead, "The tension between these two types of relations may be one of the forces that animate musical melodies."[200] Patel speaks of "salient hierarchies of stability" within musical scales: "different scale degrees take on distinct psychological qualia in the fabric of the music." Tones can feel "stable, complete, and pleasant" in one context, and "unstable, incomplete, and irritating" in another.[201] Humans have "a general propensity to organize pitch sequences into patterns at multiple hierarchical levels," and "musical melodies engender a much richer set of perceptual relations" than spoken melodies.[202] The emotional purchase of music may spring from the sheer breadth of its perceptual relations.

Tymoczko analyzes the pieces of Bach, Haydn, Mozart, and Beethoven to determine whether they follow the modulatory practices described by Gottfried Weber, who argues that tonal pieces "often modulate between 'closely related' keys."[203] In fact, Tymoczko finds that "the four most common major-key destinations are V, IV, vi, and ii," while the most common minor-key modulatory destinations are III and VII, "often by a wide margin."[204] Furthermore, there is a "close relation between a major key and the minor key two semitones above it; major keys modulate to their supertonic minor more

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[200] Ibid.,199.
[201] Ibid., 201. Patel adds: "[s]ome form of a tonal centre or tonic is widespread in musical melodies of different cultures, in both art music and folk music" Ibid., 199, Footnote 8.
[202] Ibid., 203-205.
[203] Ibid., 246.
[204] Ibid., 250.

often than to the parallel minor," while minor keys modulate "to their subtonic major more frequently than to any key except the relative major."[205]

Tymoczko attributes these results to a "scalar model" of modulation in which composers modulate to keys that have the most similar scale steps rather than to those that begin on the same tonic note. This underlines the importance of voice-leading relationships between the scales. This becomes pivotal when analyzing the music of "composers such as Debussy, Ravel, Shostakovich, and Reich," which exploit "efficient voice leading between a wide range of scales and modes." Rather than depart from the traditions of harmonic practice, these composers have found new ways to exploit them.[206]

Tymoczko finds that not only is tonal music "hierarchically self-similar" in that it combines "harmonic consistency and efficient voice-leading at both the level of the chord and the level of the scale," but there is a "precise structural similarity between the underlying voice-leading graphs" of "the techniques composers use to relate chords and scales." Chords and scales "can be represented by *essentially the same geometry*." Tymoczko believes "tonal music obeys purely harmonic principles that specify how chords can move, while modulations involve voice-leadings between scales." In contrast, some of the followers of Heinrich Schenker "seem to deny that functional tonality involves harmonic rules, asserting instead that its putative 'harmonic grammar' can be explained contrapuntally."[207]

[205] Ibid., 251.
[206] Ibid., 252.
[207] Ibid., 258.

2.7 TYMOCZKO ON SCHENKER

Tymoczko questions the Schenkerian

> model of musical organization according to which entire pieces were massively recursive structures, analogous to unimaginably complex sentences. The complexity of these hierarchical structures far outstrips those found in natural language, and seems incompatible with what we know about human cognitive limitations. Further, […] the recursive model has an uncertain relationship to the chord-to-chord constraints that play an indisputable role in classical harmony.[208]

Tymoczko also separates the tasks of "characterizing the grammar of elementary tonal harmony" and "the analytical project of *saying interesting things about particular pieces*."[209] He points out that Heinrich Schenker "conceives of musical passages as being *nested* within one another, much like linguistic clauses." Referring to Miller's study of 1956, "which emphasizes the '7 ± 9' limits on human short-term memory," Tymoczko argues: "[g]iven the centrality of language to human survival, it is evolutionarily reasonable to take the limits on hierarchical linguistic cognition as a rough guide to the limits on hierarchical musical cognition."[210] That would place certain limits on Schenker's nesting analogy. But if music preceded language in evolution, and if music engages visual, spatial, and motor dimensions of perception, perhaps there are older, deeper processes of cognition at work.

Tymoczko quotes Rothstein (1992):

> [early] Schenker conceived of tonal music as a kind of battleground on which the forces of harmony, voice leading, rhythm and motivic repetition contest with each other… The notion of semi-independent musical forces, in perpetual conflict

[208] Ibid., 259.
[209] Ibid., 263.
[210] Ibid., 259, Footnote 36.

> with each other, seems to have been largely abandoned by Schenker as he developed his theory. I believe this was a serious mistake.[211]

Tymoczko suggests that theorists of a pluralist Schenkerian bent should "re-examine Schenker's emphasis on musical unity" in light of a "manifest disunity" – that "*disunified* conception of musical structure, in which harmony and counterpoint work against each other, providing very different ways of organizing the same piece." Other "musical parameters – not just harmony and counterpoint, but also form, theme, and motive" can be used to parse a piece.[212]

2.8 VOICE-LEADING TRICKS AND THEIR RESULTING CHORDS

Tymoczko demonstrates how chromatic music of the Romantic era "reuses […] a relatively small number of musical tricks." He demonstrates how "chromatic alterations produce a variety of familiar tonal chords, including the diminished seventh, the dominant seventh with an augmented fifth, and the dominant seventh 'flat five' chord." Added to this list are the familiar augmented sixth chords that first appeared as secondary dominants, but began to be used as "dominant sonorities in their own right" at the beginning of the nineteenth century. "This tendency reaches its apogee in twentieth-century jazz, where these altered dominants – conceived as 'tritone substitutions' for the V7 – become virtually mandatory." A more recent development is the "lowered fourth scale degree" that is available in minor key and that Shostakovich uses in his G minor Piano Quintet. Not all chromatic alterations in nineteenth-century music have standard names, however, and an ability to confront the "harmonic unknown," paired with an

[211] Ibid., 258, Footnote 34.
[212] Ibid., 264, main text and Footnote 41.

understanding of how to think for one-self chromatically "might lead composers to invent sonorities of this kind."[213]

Tymoczko is able to find similar voice-leading progressions in Schoenberg's song 'Erwartung,' Op. 2 No. 1 and in Haydn's Piano Sonata Hob. XVI/49 in Eb major.[214] He describes the "descending voice leading" of Jimi Hendrix's (possibly Billy Robert's) *Hey Joe* (C+ G+ D+ A+ E+) as mirroring "the narrator's descent into murderous depravity."[215] He discovers that Chopin's F Minor Mazurka, Op. 68 No. 4 and his E minor Prelude, Op. 28 No. 4 "use virtually the same voice-leading procedures to embellish very different harmonic sequences." These represent the "fundamental similarity between descending-semitone and descending-fifth progressions – a relationship that lies at the root of the jazz 'tritone substitution.'"[216]

The "liquid, semitonal voice leading" of the climax of Wagner's Tristan prelude "is strongly reminiscent of Chopin's E minor Prelude, and can in fact be modelled using the very same geometry."[217] But where "Chopin moves steadily forward, Wagner moves backward and forward in a stuttering manner" through "the lattice at the centre of four-note chord space."[218] In this way, chromaticism becomes autonomous – it loosens itself "from tonal functionality" and "becomes an independent force with its own distinctive logic."[219] Wagner's "*harmonic* choices are influenced by voice-leading relationships not

[213] Ibid., 268-272.
[214] Ibid., 279-280.
[215] Ibid., 284.
[216] Ibid., 287-289.
[217] Ibid., 299.
[218] Ibid., 301, Figure 8.6.11.
[219] Ibid., 301.

directly manifested by the surface of his music." "Extremely efficient" voice-leadings are "embellished" with voice-crossings for Wagner's signature sound.[220]

The embellishment of "traditional tonal progressions" developed into a chromaticism that sometimes threatened "to eradicate tonal functionality altogether:" "familiar tonal concepts lose their purchase" in pieces such as Strauss' *Salome*, while "an incessant chromatic voice leading produces a highly chromatic macroharmony without any strong sense of tonal centre."[221]

2.9 SEEKING STABILITY IN THE SCALE

Twentieth-century composers developed techniques "to counteract chromaticism's pull:" "*chord-first* composition," "*scale-first* composition," and "the *subset technique*," an "intermediate between the first two." As Tymoczko understands, twentieth-century composers used scales "to ameliorate the destabilizing effects of chromatic motion," renewing and refreshing tonality.[222]

For instance, Grieg's 'Drömmesyn,' Op. 62 No. 5 (1895) establishes "subtle counterpoint between the scale, tonic, and melody, in which the three elements never once move in parallel." In Débussy's work, the chromatic voice leadings "occur at a much slower rate" than in Wagner, giving rise to "additional scales at the musical surface," and endowing a "simple classicist quality that is in marked contrast to the relentless churning of Wagnerian chromaticism."[223] Shostakovich, Tymoczko notes, "is more likely to *lower* the notes of the natural minor scale" than to raise them, as is more

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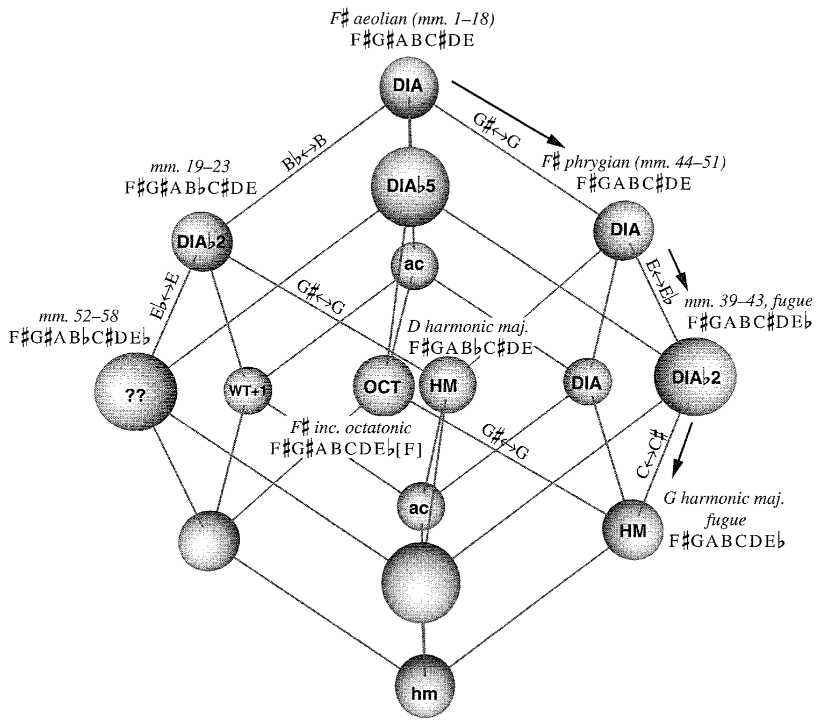
[220] Ibid., 295.
[221] Ibid., 304-306.
[222] Ibid., 307-308.
[223] Ibid., 314-318.

common with other composers, creating "a distinctive sinister character." He describes as a "scale tesseract" the "modulatory space through which Shostakovich moves," which he depicts with a four-dimensional cube.[224]

FIGURE 11: Scales in Shostakovich's F# minor Prelude and Fugue [225]

Figure 9.3.10 The four lowerings can be combined to produce sixteen scales, eight of which appear in Shostakovich's F♯ minor Prelude and Fugue. I have labeled only the scales relevant to Shostakovich's piece.



Both scales in Shostakovich and chords in Chopin can be represented by "similar geometries" (in the case of Chopin, the E minor Prelude descends along a "four-dimensional chord lattice").[226] Furthermore, the "scalar palette" of Steve Reich is similar to that of Shostakovich in that it explores "the darker end of the harmonic spectrum," and

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[224] Ibid., 329-330.
[225] Ibid., 330, Figure 9.3.10. Used with permission (See Appendix B).
[226] Ibid., 332.

in the works of both composers, D dorian "represents a comparatively bright tonality."[227] Tymoczko finds similar patterns not only between the scale modulation techniques of these composers, but also within the "broader tradition of twentieth-century scalar thinking."[228]

In his analysis of Grieg's Lyric Piece 'Klokkeklang,' Op. 54 No.6 ((1891), Tymoczko observes that "the B section begins by contrasting two scales that are close but not adjacent on the lattice (C and D diatonic), with the separation increasing as the music progresses." Tymoczko likens this to a pistol duel in which the participants "walk several paces away from each other," but the swinging motion of bells also comes to mind – especially when they swing in opposite directions at increasing or decreasing intervals. Tymoczko manages to link 'Klokkeklang' to Stravinsky's 'Petits airs' from *Histoire du Soldat* (1918) and to Steve Reich's *City Life* (1995) through their use of "'fixed' scale degrees stacked in fifths, filled out by additional 'mobile' degrees that appear in a variety of forms."[229]

In Miles Davis Group's *Freedom Jazz Dance* (1966), the notion of "being in Bb" encompasses "natural minor, dorian, the acoustic scale, and even the octatonic. In other words, the relevant conception of tonality is not the major-minor system of the eighteenth and nineteenth centuries, but rather the extended scalar system of the twentieth."[230]

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[227] Ibid., 338, Footnote 28.
[228] Ibid., 339.
[229] Ibid., 342-345. Tymoczko notes that "Grieg was an important influence on Ravel, whose music in turn was important to Stravinsky; and both Stravinsky and impressionism influenced the language of jazz, which was in turn important to Reich" (ibid., 345). That said, Tymoczko emphasizes that similiarities are "symptomatic of shared musical concerns crossing stylistic boundaries" (ibid., 346).
[230] Ibid., 349.

Tymoczko acknowledges the diversity of twentieth-century compositional approaches. Aside from the popularity of the octatonic and acoustic scales, Tymoczko mentions Messiaen's "seven symmetrical 'modes of limited transposition,'" the "pervasive" and "occasionally somewhat brittle" diatonicism of neoclassical composers, and polytonality achieved "by superimposing multiple scales at the same time, leading to musical textures poised delicately between tonality and atonality." Nonetheless, he considers the "contrast between nineteenth-century homogeneity and twentieth-century individualism" to be "naïve" and "misleading." He is interested in drawing out the "threads of continuity between Debussy, jazz, and Reich," describing these as "simultaneous convergence on an intrinsically fertile territory."[231]

2.10 DISMANTLING THE BARRIERS BETWEEN MUSICAL GENRES

Tymoczko explores unexpected links: as the bebop pianist Al Tinney calls "dominant seventh chords resolving to predominant sevenths [...] a hallmark of the bebop harmonic style," Tymoczko remarks "[i]t is interesting to find this bebop hallmark in Mozart!"[232] Tymoczko also draws parallels between Stravinsky's 'Dance of the Adolescents' from *The Rite of Spring* (1913) and The Beatles' *Help* (1965), in which "deliberately simple or even primitive" melodic material is exploited and set in sophisticated but "familiar modal contexts."[233]

Tymoczko strongly emphasizes that jazz improvisers are no different from classical composers despite the fact that they play music that is not strictly notated. Jazz

[231] Ibid., 350-351.
[232] Ibid., 291, Footnote 24.
[233] Ibid., 347.

music is the “inheritor of early modernism and progenitor of late twentieth-century post-minimalism,” therefore it cannot be separated from “’legitimate’ concert music.” Furthermore, jazz’s “left hand voicings” are derived from “an elementary voice-leading schema […] in which fifth-related diatonic seventh chords are connected by descending stepwise voice leading.” Because jazz chords are so thick, “jazz pedagogues sometimes describe chord voicings negatively,” speaking of “avoid notes” that one should leave out of given chords. Because jazz makes “heavy use of root position chords,” the identity of the chords remains clear. Tymoczko identifies classical pieces in which jazz voicings are anticipated, such as Ravel’s ‘Forlane’ from *Le tombeau de Couperin*, Grieg’s Lyric Piece ‘Salon,’ Op. 65 No. 4, and Scriabin’s Etude, Op. 65 No. 3.[234] There are also several examples of composers leaving out jazz “avoid notes,” such as Debussy in the *Prélude à l’après-midi d’un faune*.

Post-war jazz musicians began using more quartal harmony and playing more melodic fourths in solos, just as in 1919, Stravinsky used fourths prominently in his *Firebird Suite* (‘Infernal Dance’) and Scriabin stacked them to create his “mystic chord.” Bartok’s *Out of Doors*, movement 2, and Hindemith’s *Ludus Tonalis* also emphasize the fourth.[235] Bill Evans’ version of Miles Davis’ ‘So What’ features a chord of three perfect fourths and one major second, often called the ‘So What’ chord, that is reminiscent of the tuning of the guitar.[236] Tymoczko argues that quartal harmony originated with “the notated avant-garde” and moved into jazz, from whence it then re-infiltrated contemporary composition as writers “borrowed jazz zounds.”[237]

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[234] Ibid., 352-355.
[235] Ibid., 357, Footnote 8.
[236] Ibid., 357.
[237] Ibid., 360.

Tymoczko refers to the "happy convergence between quartal voicings and tritone substitution," which may "have contributed to the increased systematization of what was originally a more ad hoc collection of musical practices." Tymoczko compares tritone substitutions to diatonic third substitution of the eighteenth-century insofar as both substitutions "preserve important notes in the first chord while moving the remaining notes by short distances," a phenomenon that is easily explored geometrically. Tymoczko "reminds us that the standard German sixth chord can be understood as a tritone substitution for the applied dominant chord V7/V," and finds that when he applies a tritone substitution "to the standard viiº4/3-I6 progression," he obtains the very ivº7 to I6 progression "commonly associated with Strauss' *Till Eulenspiegel*." He also derives the Tristan chord "by applying the tritone substitution to the first chord in a standard iiº4/3-V7 progression." This suggests that "jazz simply codifies procedures that are already present, at least in embryo, in notated music."[238]

Another important parallel between jazz and twentieth-century classical music is that these styles display a slower rate of harmonic change embellished with fast-moving scales at the melodic surface (as in jazz improvisation). Tymoczko explains the importance of the octatonic and whole tone scales in jazz, as well as the two modes of the acoustic scale (Lydian dominant and altered) that emerge when the tritones G-C# and C#-G are "filled," stating: "it was jazz theorists […] who first isolated this collection of scales and asserted their importance."[239] That said, Debussy "was extremely fond of the Lydian dominant mode," and often accompanied seventh chords with a sharp eleventh.[240]

[238] Ibid., 363-364.
[239] Ibid., 365-367.
[240] Ibid., 372.

The "sidestepping" of jazz is also anticipated by the sudden modulations of Chopin, as in his second Nocturne, "where a cadence on Bb major immediately leads to a dazzling digression to E major." Although it involves no polytonality, it bears a resemblance to the bold sidestepping of jazz soloists.[241] The polytonality of jazz is one of its most characteristic features, allowing "music of extraordinary subtlety, in which the choice between functional tonality and other modes of pitch organization can be made anew every few seconds." "[U]pper structure" voicings, in which dominant voicings "contain a triad foreign to the tonic key" reinforce the polytonal effect.[242] The end result is "a dazzling process of continuous musical variation, wherein the same basic elements are constantly reconfigured – as if you could never step twice into the same musical river." Tymoczko describes the playing of Bill Evans in 'Oleo' as "not simply a virtuosity of the body but of the mind as well – the spontaneous expression of a deep understanding of the fundamental principles of twentieth-century tonal composition."[243]

Jazz, says Tymoczko,

> is an accretion of musical techniques formed over the ages: at its core, we have a ii-V-I schema dating from the time of Monteverdi; in the upper voices of the piano's right hand, we find an efficient chromatic voice leading between third-related major triads (Eb, G, Bb) →(D, G, B), reminiscent of the progressions that fascinated Schubert, Brahms, and Wagner. On top of this we find scales characteristic of early twentieth-century modernism: an acoustic scale over the V chord, and the Lydian mode over the tonic chord. This routine passage, in other words, is a musical synthesis literally centuries in the making, incorporating and domesticating the ideas of previous revolutionary eras.[244]

[241] Ibid., 375.
[242] Ibid., 378.
[243] Ibid., 386-387.
[244] Ibid., 388-389.

While classical composers "largely work alone," jazz musicians are engaged in "an inherently social form of music making," which provides "more fertile ground for constructing a genuinely shared musical language."[245] Tymoczko makes it clear that it is not possible "to understand the development of notated music without understanding its relation to non-notated styles."[246]

2.11 CONCRETIZING RELATIONS IN PITCH SPACE

Tymoczko's approach is a fitting complement to previous methods of analysis. A case in point is the analytical method James Tenney, who broadens the conceptual framework for analysis to register the differences in aspects such as timbre, dynamic level, and duration.[247] James Tenney generously suggests that "greater importance […] has been given in twentieth-century music to *all* the parameters of musical sound; that whereas in earlier music the responsibility for the articulation of musical ideas was mainly given to the pitch-parameter, the other parameters have begun to carry more and more of this responsibility."[248] For instance, Anton Webern's music contains "relatively simple sounds, which in another music might be only elements," but which in his music function "as musical ideas in their own right."[249] There is a "reduced scale of organization," for which Webern compensates by "demanding a different scale of

[245] Ibid., 389.
[246] Ibid., 394.
[247] Ibid., 32.
[248] James Tenney, *Meta-Hodos and Meta Meta-Hodos*, 2nd ed. (Oakland, CA: Frog Peak Music, 1986), 18. http://monoskop.org/images/1/13/Tenney_James_Meta-Hodos_and_Meta_Meta-Hodos.pdf, retrieved May 5th 2015.
[249] Ibid., 21.

perception."[250] Small musical gestures and shapes acquire much greater meaning based on their exposed, unusual context.

Tenney proposes the term "clang" to denote "any sound or sound-configuration which is perceived as a primary musical unit – a singular aural gestalt." Tenney notes that "clang" is a word "that refers specifically to *auditory* perception, unlike other words that are "borrowed from the visual or other perceptual realms."[251] In contrast, Tymoczko's geometrical analysis explores links between the auditory and spatial realms. (That said, Tenney also resorts to comparing visual patterns of similarity between depictions of "clangs" in the music he analyzes, as when he compares two "clangs" in the first sequence of the first movement (*Thoreau*) of Charles Ives' *Concord* Sonata.)[252]

For his part, Tymoczko returns the focus to pitches and to their relation in space. Instead of discarding the importance of pitch relation, Tymoczko applies geometrical tools to understanding, for instance, how the rate of pitch class circulation plummets dramatically as soon as music loses tonal centricity, and why atonality feels in some ways like an impoverishment. Tymoczko opines that atonality is "neither so abrasive as to die out completely, nor so attractive as to achieve widespread acceptance."[253] Atonal music is "not so much analogous to a language that is hard to understand; instead, […] like the taste for clam chowder ice cream, this is one that people often do not care to cultivate."[254]

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[250] Ibid., 20.
[251] Ibid., 23-24.
[252] Ibid., 69.
[253] Ibid., 392.
[254] Ibid., 185. Socrates takes a dim view of abrasive-sounding music: "That those whom we are rearing should never try to learn anything incomplete, anything that doesn't reach the end that everything should reach – the end we mentioned just now in the case of astronomy. Or don't you know that people do something similar in harmonics? Measuring audible consonances and sounds against one another, they labour in vain, just like present-day astronomers. Yes, by the gods, and pretty ridiculous they are too. They talk about something they call a 'dense interval' or

Tymoczko continues: "the unpleasantness of the musical stimuli may be more important than the perceptibility of underlying structure: pleasant-but-random is perhaps preferred to unpleasant-but-structured."[255]

> [T]onality is not one among an infinitude of habitable planets, all easily accessible by short rocket flight; instead, it is much closer to being the *only* habitable planet that we have discovered so far. And just as we have an interest in conserving the ecology of this, our only habitable planet, so too might we have an interest in protecting the sophisticated tonal languages that manage to survive in today's economic climate.[256]

Additionally, Tymoczko portrays the directions of voice leadings and the relation between the vertical and horizontal movements of melody and harmony in pitch space in ways that account for the multi-dimensionality of sound and the spatial aspect of the human auditory processing system. He manages to compare diverse types of music while also revealing differences between the works of composers of similar genres, illustrating the continuity within music history, attributing clear characteristics to several specific musical styles, and making paradigm-shifting discoveries, such as the extreme drop in pitch-class circulation featured in atonal music.

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quartertone – putting their ears to their instruments like someone trying to overhear what the neighbours are saying. And some say that they hear a tone in between and that it is the shortest interval by which they must measure, while others argue that this tone sounds the same as a quartertone. Both put ears before understanding. [You mean those excellent fellows who torment their strings, torturing them, and stretching them on pegs.] I won't draw out the analogy by speaking of blows with the plectrum or the accusations or denials and boastings on the part of the strings; instead I'll cut it short by saying that these aren't the people I'm talking about. The ones I mean are the ones we just said we were going to question about harmonics, for they do the same as the astronomers. They seek out the numbers that are to be found in these audible harmonies, but they do not make the ascent to problems. They don't investigate, for example, which numbers are in harmony and which aren't or what the explanation is of each. [But that would be a superhuman task.] Yet it's useful in the search for the beautiful and the good. But pursued for any other purpose, it's useless." Plato, The Republic, 530e-531c

[255] Tymoczko, 185.

[256] Ibid., 393.

This represents an innovative, fruitful contribution to musical analysis. Theorists such as Tenney created new analytical concepts and shift the emphasis away from pitch values in order to account for twentieth-century compositional techniques. In contrast, Tymoczko underlines the unyielding value of harmony and connects music to the mathematical realities and geometrical space, illuminating previously unknown features of compositional technique and demonstrating the dependence of notated music on other, non-classical forms.

CHAPTER 3: MUSIC AND HEALING

Music lifts us on high and builds a soft cloud under our cares and sorrows.[257]

3.1 SOUND IN THE UNIVERSE

Representatives of many civilizations have noted the vital role of music in their midst and in the constitution of the universe. Both Pythagoras and Kepler held that "the movements of the planets are modulated according to harmonic proportions." The Hindu sages "believed in *shabda*, or the audible life stream, which is similar to the concept of the music of the spheres." And the Gospel according to John opens: "'In the beginning was the Word' – which some scholars translate as: 'In the beginning was sound.'"[258] Elena Mannes concurs: "As scientists come to understand the origins of the universe, they [have] discovered the foundations of sound and music – vibration and sound waves." While the Big Bang itself was silent, the distribution of matter, which initially entailed the expansion or vibration of gases, involved sound waves, which are waves of pressure moving through these gases. Now, "[s]cientists can use the sound spectrum to measure the properties of the universe." Physicist and astronomer Mark Whittle proposes: "[the sound of the universe] can tell us about its structure and composition … Far into the future, the few decades in which we now live will be recalled as a time when people first began to understand creation's true story."[259]

To reflect the importance of sound waves in the original expansion of the universe, "[t]he first million years of the universe is called the acoustic era." The first

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[257] Johann Wolfgang von Goethe, The Book of Musical Thoughts: A Musician's Garden of Verses, Compiled by Eliza Leypold Good (Chicago: P.F. Volland & Company, 1912), 36.
[258] Mannes, 145.
[259] Ibid., 147.

four hundred thousand years of the universe, also called the cosmic microwave background (CMB), consisted of gases expanding, causing a whole spectrum of sound. This "early sound of the universe […] actually contained its overtones." In the measurement of early sound waves, "time instead of length is the boundary." Time is being created with the very expansion of matter and sound. The sounds of the universe "are too low to be within the frequency range of human hearing," but they can be heard once they are "transposed fifty octaves higher." The universe is a "roaring/hissing sound" that resembles a "descending scream," according to Whittle. "The pitch drops because as the universe expands, […] the areas into which the gas is falling and bouncing out get bigger. […] The bigger the instrument, the deeper the pitch. The sound also gets louder – a cosmic crescendo."[260] It is not known, however, what produced the first ripple in gas density that led to sound waves.[261] Perhaps "[t]he Pythagoreans were wrong about the planets revolving around the earth in spheres that create sound, but the planets *do* make sound waves as they move and their gravitational field pulls." Mannes clarifies: "Even the earth has a hum. Every object has a natural frequency at which to vibrate."[262]

Physicist Brian Greene believes that "at the heart of matter is music. At the heart of matter are vibrating filaments, vibrating through their sound, matter and energy, maybe even space and time into existence."[263] The "equations for 'simple harmonic motion' are what Brian Greene explains in an interview as 'the most ubiquitous equations in all physics. They're the ones that we deal with all the time in a wealth of different systems:

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[260] Ibid., 148-150.
[261] Ibid., 153. Hear a transposition of the sound of the first 400 000 years of the Universe on the webpage of Professor Marc Whittle: http://people.virginia.edu/~dmw8f/, retrieved August 7th, 2016.
[262] Mannes, 157.
[263] Ibid., 160.

in cosmology … in astrophysics … in everyday settings we deal with them. Those equations are the bread and butter of physics.'"[264] How could music be a mere frill when its patterns resemble equations that form the backbone of physics, and when it accompanies the very expansion of space and time? Professor and author David Hendy understands why "the Earth has been described as a 'macrocosmic musical instrument,' the creatures on its surface a 'great animal orchestra,' pulsing with sound and rhythm."[265] Or "as Louis Armstrong once put it, 'What we play is life.'"[266]

3.2 PREHISTORY AND MUSILANGUAGE

In his 2010 documentary, *Cave of Forgotten Dreams*, Werner Herzog enters the inner sanctum of the Chauvet caves to show us our prehistoric ancestors' drawings. While the discovery at Hohle Fels and Geissenklösterle of thirty-five thousand year old flutes (carved from the bones of swans, mammoth tusks, and the radius of a griffin vulture)[267] proves the presence of music in prehistoric times, cave drawings can help provide some insight into what purpose the music served, since "wherever a cave sounds most interesting, you are also likely to find the greatest concentration of prehistoric art."[268]

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[264] Ibid., 14.
[265] Hendy, 17.
[266] Mannes, 164.
[267] Ibid., 100-101. Experts describe these flutes as "more technologically advanced than modern instruments."
[268] Hendy, 4. Compare also Werner Herzog, "Cave of Forgotten Dreams," documentary film, 2010, "Scenes from *Cave of Forgotten Dreams*," humanresonance, YouTube, https://www.youtube.com/watch?v=_xDcdVWnOiE, retrieved July 26th, 2015.

While popular belief holds that cave art depicts scenes of prehistoric daily life and hunting scenes, current theories offer that the artwork depicts the spiritual realm.[269] In the case of the San people of Southern Africa, the cave paintings (some of them only a hundred years old) portray spiritual experiences in which the powers of animal-spirits (such as that of the eland, a savannah antelope) are called upon by shamans. Sometimes the animals in cave paintings are covered in spots and patterns, which are thought to correspond to the patterns humans see when they are in a state of trance. Prehistoric humans, in the words of South African scholar David Lewis-Williams, were not representing outside objects; rather, they were "nailing down visions" on the cave walls.

Shamans, of course, are also skilled "in deploying sound, not just to invoke the spirits, but also to create a richly suggestive atmosphere."[270] David Hendy proposes:

> In the midst of such apparent magic, our ancestors must have wanted to keep making sound, if only to keep the conversation with the spirit world going too. […] In a continuous feed-forward loop, new sounds, tonal effects, notes and rhythms were discovered. They were tried out, they echoed back, they were copied, altered, replayed, thousands of times, over and over again. And, eventually, from chaos emerged order.[271]

In this prehistoric context, humans might have communicated using "something with elements of both language and music, but which was not quite either. It was a kind of sing-song utterance that has been called 'Musilanguage.'"[272] Neuroscientist Larry Parsons has found that "music, language, and dance may all be connected as forms of

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[269] David Lewis-Williams, in the BBC's documentary "How Art Made the World, Part 2: The Day Pictures Were Born," 2005, "Documentary – BBC How Art Made The World 2 – The Day Pictures Were Born," RebitedJazz, YouTube, https://www.youtube.com/watch?v=vO6ay9eueR4, retrieved January 17th, 2016.
[270] Hendy, 39.
[271] Ibid., 9.
[272] Ibid., 15.

communication."[273] Like the Rio Xinane, "the Pygmies in the Congo speak in a way that seems to be a blend of musical expression and singing narrative, imitation and gesture and dance. Parsons calls it 'a complicated mix of all these as well as language. So it's this bandwidth, this immense bandwidth.'"[274] Archaeologist Steven Mithen also argues there was "a 'multimodal' form of communication, involving gesture and body movement as well as sound."[275]

According to Hendy, "the most important feature of early humans' relationship with nature is that they mimicked it."[276] Hendy imagines early humans mimicking animal sounds and gestures to convey information about their prey to each other while hunting, for instance.[277] He envisions "Proto-humans in family-like groups, perhaps humming or cooing as, searching for food, they moved beyond each other's physical reach but still wanted to stay somehow connected."[278]

While some scientists fail to see how musical gifts might give one an evolutionary advantage, Hendy argues that musical skills were of great use in prehistoric times, offering "those who were most skilled in conveying their own feelings to others, and in reading the feelings of others," an advantage. Humans with greater communicative skills would have been better at "predicting the behaviour of others and being able to

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[273] Mannes, 91.
[274] Ibid., 108.
[275] Ibid., 106. This is reminiscent of Kurt Weill's idea of *Gestus*, defined by the literary critic Daniel Albright "as the dramatic turning point 'in which pantomime, speech, and music cooperate toward a pure flash of meaning.'" Alex Ross, *The Rest is Noise: Listening to the Twentieth Century* (New York: Picador, 2007), 205. Ross refers to Daniel Albright, *Untwisting the Serpent: Modernism in Music, Literature, and Other Arts* (Chicago: University of Chicago Press, 2000), 112.
[276] Hendy, 23.
[277] Ibid., 25.
[278] Ibid., 17.

manipulate their behaviour."[279] As human communication evolved, humans also developed "bigger, more complex ideas about what could be done with sound: how it could be shaped and manipulated to create dramatic effects and to help us understand our place in the cosmos; how nature might be not merely copied, but mastered."[280] Since music bridges "the distinction between us and nature, mind and matter,"[281] it conveys power to its originator.

Throughout known history, humans with "control over sound" have been marked "as special. Spirits and gods were widely conceived as invisible but audible things – as sound, wind, vibration." One had to be gifted with sound in order to "detect, let alone interpret, these subtle markers of presence."[282]

Human mastery over sound became apparent in Neolithic society and infrastructure. Humans in various parts of the earth "were putting up stone buildings of their own design – megaliths which turned out to have their own completely new acoustic identity and which demonstrated a new human mastery over the natural soundscape."[283] Over time,

> [a]s societies became more complex, so music and performance became more complex, more specialised. The distinction between those who could make impressive sounds of all kinds and those who couldn't widened. Music, like talking, was once a shared, socially bonding activity. Now, increasingly, such sounds would divide us in two: there would be performers and

[279] Ibid., 17.
[280] Ibid., 27.
[281] Jennifer Dutra, editorial notes.
[282] Hendy, 46. Even in the Middle Ages, "religious writing often [referred] to God's voice as sweet, or perhaps like a wind bringing the Holy Spirit, and touching – indeed, *changing* - whoever heard it." Ibid., 118.
[283] Ibid., 29. Göbekli Tepe in Turkey is one of the earliest sites that has been discovered so far – how sound was used in the temple structures is yet unknown. Hendy discusses the prehistoric sites of the Orkney islands, and the special use of sound at sites like Stonehenge has long been a matter of conjecture.

> audiences, and these two groups often rubbed up against each other in an uneasy alliance.[284]

In the prehistoric caves, music and visual art reinforced each other. Likewise, in the stone buildings of the Neolithic era, sound was used in tandem with architecture. As architecture became more refined, so did music, its auditory counterpart.[285]

3.3 ANCIENT TIMES

Ironically, as religions became more complex and cerebral, the phenomenon of music was called into question. Stoic philosophers such as Seneca tried to take no notice of sound: "to be distracted by noise [Seneca] reckoned, was to succumb to one's own inner disquiet." For their part, "Hindus insisted that a mantra had to be voiced correctly, because the sacred was made manifest through sound."[286] Others, such as the Christians and the Muslims, sometimes considered listening to music dangerous, since "the sounds of music appealed directly to the listener at an emotional level." If music "aroused unruly passions and distracted the listener from thoughts of God," was it impure? "Or was it – as the Sufi tradition within Islam believed – a means of moving the heart closer to God and to greater piety?"[287] Christian church leaders of the sixteenth century wondered whether polyphonic imitation was obscuring the words of the mass.[288] There is no negotiating, however, with St Anselm, according to whom "[d]elight coming from the

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[284] Ibid., 47.
[285] The link between architecture and music represents a rich area of study that is outside the scope of this thesis.
[286] Ibid., 57.
[287] Ibid., 101.
[288] Wikipedia, "Missa Papae Marcelli," https://en.wikipedia.org/wiki/Missa_Papae_Marcelli, retrieved Nov. 7th, 2015.

sense is rarely good, more often it is truly bad."[289] The power of music remains mysterious and beyond complete control. While in ancient Greece, the prince and the poet/musician were considered the most powerful people in society, in the Middle Ages, religious leaders hoped to tame music and use it for the ends of the church.

Sound and music were being used in new ways to impress believers and to help frame their lives "in religious terms."[290] At Wells Cathedral in England, for instance, hidden chambers containing occuli (holes that increase in diameter from the outer chambers into the inner cathedral walls like megaphones) allowed choristers to project their voices from behind all the angel statues to give the impression of a real heavenly choir.[291] Bells became increasingly popular, and ensured that "a parish church, temple or monastery could project its power, define its territory and regulate behaviour across a whole neighbourhood. It served, for instance, as an official timekeeper to the community at large." Bells also held an ancient, pagan appeal, as people "were in awe of their sacred power to dispel evil."[292] Inscriptions found on medieval bells might read: "I disperse the winds; I put the cloud to flight; I break the thunder; I torment the demons; I put the plague to flight; My voice is the slayer of demons; Through the sign of the Cross let all

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[289] Hendy, 117. St. Anselm unwittingly echoes the Buddhist call to detachment from tyrannical sensations: "If he feels a pleasant feeling, he feels it attached. If he feels a painful feeling, he feels it attached. If he feels a neither-painful-nor-pleasant feeling, he feels it attached. This, monks, is called an uninstructed worldling who is attached to birth, aging, and death; who is attached to sorrow, lamentation, pain, dejection, and despair; who is attached to suffering, I say." *In the Buddha's Words: An Anthology of Discourses from the Pãli Canon*, Edited and introduced by Bikkhu Bodhi (Boston: Wisdom Publications, 2005), 31.
[290] Hendy, 111.
[291] Ibid., 43-44.
[292] Ibid., 110-111.

evil flee."[293] Movingly, "[w]hen plague struck a community, the ringing would sometimes continue until the bells cracked."[294]

Boethius described the existence of three kinds of music:

> 'music of the spheres,' made by the cosmos itself as the planets moved through the heavens. It was real and loud and never-ending, but it existed beyond the normal range of human hearing. Then there was 'instrumental' music, the kind that came from, say, trumpets or bells or indeed from voices singing. Finally there was 'human music,' the sound generated within each human organism. This bound together body and soul, but like the music of the spheres it was inaudible to our own ears.

Science has proven Boethius right, in that it is no longer a stretch to consider that "[t]he music binding together body and soul, for instance, [needs] to be in tune with cosmic harmony. Indeed, a person could be thought of as being like a musical instrument that occasionally [needs] retuning."[295] Music, it seems, is capable of retuning us, which can sometimes mean healing the body in astonishing ways.

3.4 THE TONIC EFFECT OF MUSIC

In St. Augustine's Abbey in Canterbury, music was permitted on rare occasions when healing was required for gravely ill people:

> as when it happens that any brother be so weak and ill that he greatly needs the sound and harmony of a musical instrument to raise his spirits – that person may be led into the chapel … so that, the door being closed, a stringed instrument may be sweetly played before him by any brother, or by any reliable or discreet servant, without blame…

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[293] Ibid., 111-112. Quoting Percival Price, *Bells and Man* (Oxford: Oxford University Press, 1983), 82-83.
[294] Ibid., 114.
[295] Ibid., 120-121.

Music was thought to alleviate "mania, melancholia [depression], fever, pain, insomnia, plague, lethargy, apoplexy, catalepsy, consumption and epilepsy."[296]

Oliver Sacks notes how music has "the power to pierce through" melancholia or depression, as noted in Robert Burton's *The Anatomy of Melancholy*, and in countless reports from people in a state of grief or depression. However, "[t]he Arts are not drugs," in the words of E. M. Forster; - "They are not guaranteed to act when taken. Something as mysterious and capricious as the creative impulse has to be released before they can act."[297] The listener must be receptive to what is being expressed for music to take effect. For instance, depression sometimes involves an overall "flattening or withdrawal of emotion" that causes music, among other things, to "'go dead' on one."[298] Sacks describes the strangeness of hearing music while grieving for his mother after she had passed away. Even a live performance of Schubert's *Winterreise* performed by the legendary baritone Dietrich Fischer-Dieskau at his peak "seemed utterly flat, horribly and completely devoid of life."[299] Music can pierce through depression, but only when the listener is ready.

Likewise, Friedrich Nietzche "spoke of [music's] 'tonic' effect – its power of arousing the nervous system in a general way, especially during states of physiological and psychological depression," and of its "'dynamic' or propulsive powers – its ability to elicit, to drive, and to regulate movement." Nietzsche referred to his own philosophising as 'dancing in chains' and drew parallels between his work and "the strongly rhythmic

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[296] Ibid., 121.
[297] Sacks, 324-328.
[298] Ibid., 314.
[299] Ibid., 328.

music of Bizet." Bizet, Nietzsche said, "makes me a better philosopher."[300] Nietzsche's *The Will to Power*, in turn, reminds Sacks of how "the metrical structure of rhythm and the free movement of melody – its contours and trajectories, its ups and downs, its tensions and relaxations" (and also "the 'will' and intentionality of music") allows people who are ill "to regain the freedom of [their] own kinetic melodi[es]." Music, he claims, is "auditory dopamine."[301]

Music historian Alex Ross suggests that Arvo Pärt, Henryk Gòrecki and John Tavener "provided oases of repose in a technologically oversaturated culture. For some, Pärt's strange spiritual purity filled a more desperate need; a nurse in a hospital ward in New York regularly played *Tabula Rasa* for young men who were dying of AIDS, and in their last days they asked to hear it again and again."[302]

Scientists are discovering many new ways in which music can be used not only to soothe the mind, but also to heal the body. Mannes argues that music often "echoes the natural rhythms of the body," for instance, the "normal resting human heartbeat," which "ranges from 60 to 80 beats per minute for adults."[303] Inversely, "[m]usic's connection with the heart rate, breath, and movement of course means that it can *affect* these bodily functions."[304] "Music not only echoes our bodies' responses; we echo music. Humans actually *entrain* to a rhythmic beat," to the degree that music therapists in neonatal

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[300] Ibid., 282.
[301] Sacks, 283. Nietzsche complained in his essay *Nietzsche contra Wagner* that Wagner's late music exemplified "'the pathological in music,' marked by 'a degeneration of the sense of rhythm' and a tendency to 'endless melody … the polypus in music.'" Indeed, Sacks notes, "[t]he lack of rhythmic organization in late Wagner makes it almost useless for parkinsonians; this is also true of plainsong and various forms of chant which, as Jackendorff and Lerdahl remark 'have pitch organization and grouping but no metrical organization of any consequence.'" Ibid., 282, Footnote 9.
[302] Ross, 579.
[303] Mannes 16-17.
[304] Ibid., 20.

intensive care units have begun using the beat of a wooden gato drum to steady and slow the heartbeats of their infant patients.[305]

Music therapy as a discipline originated officially in the 1940s with the return of war veterans.[306] Since then, several new branches of music therapy have evolved, including neurologic music therapy, which is used "to treat stroke patients," and can enable them to speak after having lost that ability.[307] Melodic intonation therapy is used "to stimulate the brain to compensate for damaged areas" – it is especially effective in engaging "more the right side of the brain." The treatment of Parkinson's disease is called "rhythmic auditory stimulation," a technique that takes advantage of the overlapping music and speech pathways in the brain.[308] Dr. Alfred Tomatis has developed "a method of auditory training to target disorders including auditory-processing problems, learning disorders, and autism."[309] Promisingly, there are programs being developed to use music to treat post-traumatic stress disorder.[310] Furthermore, since music "may well be able to activate memory processes," it may have future uses in treating Alzheimer's and dementia.[311]

Psychoneuroimmunology, "a fledgling discipline that has emerged in just the last thirty years, studies the interaction between thoughts, feelings, and beliefs and our

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[305] Ibid., 21-22.
[306] Dr. Barbara Reuer, in *Music and the Mind - Health Matters*, University of California Television (UCTV), https://www.youtube.com/watch?v=wdyHuWv3fsc, retrieved November 8th, 2015.
[307] Mannes, 177-178.
[308] Ibid., 179-182.
[309] Ibid., 189. Autistic people have an overactive "fight-or-flight response of the sympathetic nervous system," which affects their "listening/communication skills and social behaviour." When autistic patients are exposed to speech and music with the low-frequency sounds (which are interpreted as signalling danger) removed, and with "exaggerated vocal intonations," most of them will begin to make eye contact, and this effect will last for at least a week. Ibid., 191.
[310] Ibid., 190.
[311] Ibid., 187.

nervous, immune, and endocrine systems." This new discipline "is producing results that [will greatly affect] the medical and therapeutic uses of music."[312] Each thought that passes through the mind creates physical sensations: pleasant, unpleasant, or neutral. This explains how stress and mental suffering can cause physical illness: "[t]he immune system and the nervous system are wired together and interact in creating biological changes."[313]

Music can counteract this, releasing "neurochemicals such as dopamine, the so-called feel-good hormone; prolactin, the comforting hormone related to mothers breastfeeding their infants; and oxytocin, the 'trust hormone' associated with sex and bonding with other people."[314] In related research, Dr. Claudius Conrad (a classically trained pianist as well as a surgical resident at Harvard Medical School) has shown that music "significantly" reduces "the amount of sedative drugs necessary to reach comparable levels of sedation" in critically ill patients.[315] As well as decreasing levels of stress hormones, "music increases levels of growth hormone."[316]

There is also evidence that "playing a musical instrument can reduce the human stress response at the genomic level."[317] Test subjects who engaged in "group music making" had "three times as many genomic markers for stress" reversed as compared to those involved in a group whose members spent time reading and relaxing.[318] Studies have also shown that "the vibrations of stringed instruments are able to 'mesh' with the

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[312] Ibid., 25.
[313] Ibid., 175.
[314] Ibid., 35.
[315] Ibid., 169. This effect was achieved when patients "listened to a one-hour session of slow movements from Mozart's piano sonatas."
[316] Ibid., 170.
[317] Ibid., 25.
[318] Ibid., 176. Mannes adds: "It [is] not known how much of the response was due to the music per se and how much to participation in a group activity."

energy of the heart, small intestine, pericardium, and thyroid and adrenal glands." The harp, which is especially popular in music therapy, "has lots of strings."[319] Melodic music decreases "the frequency of neuronal firing:" its effect calms and settles the mind. The heart rate variability (measuring "how the heart rate changes") is "high when we [are] stressed, lower when we listen to peaceful music. […] the brain waves also change to ones associated with relaxation states. The magnetic field of the heart seems to be affecting the brain."[320] If one considers that the universe is composed of vibrating strings, it is no surprise that the expression of harmony and dissonance via vibrating strings could heal, and perhaps even bring catharsis and greater depth of understanding.

Neurologist Barry Bittman calls for specificity in the music-science field. Not all music is relaxing – music medicine should "be accurate and individualized when necessary."[321] Music therapists are not only familiar with the scientific literature, but also with each patient's musical experience and history. Music can be cathartic, and can evoke powerful memories, whether pleasant or unpleasant. Notably, "the most effective music prescriptions will involve not just listening but making music – experiencing it directly by singing or playing an instrument."[322] Although the tonic effect of listening to music has long been known, the tonic effect of playing music is a more recent revelation.

It is worth considering that there are many aspects of sound and music that may be calming, healing, or cathartic besides harmony, such as resonance, or emulation of natural phenomena, or even sounds inspired by machines and technology, such as white noise. What constitutes harmony may even change as the human brain and perceptual

[319] Ibid.,171.
[320] Ibid., 174.
[321] Ibid., 175.
[322] Ibid., 193.

mechanisms continue to evolve. And while many find music healing, there are a few who experience synaesthesia in ways that cause music to give them discomfort or pain.

3.5 MUSIC IN THE SERVICE OF EXPRESSION: THE TWENTIETH CENTURY

Music also allows humans to express and reflect some of the troubling facets of our existence.[323] Oliver Sacks is moved by Sigmund Freud's assertion that he was "almost incapable of obtaining any pleasure" from music. Freud continues: "[s]ome rationalistic, or perhaps analytic, turn of mind in me rebels against being moved by a thing without knowing why I am thus affected and what it is that affects me."[324] Freud's contemporary Theodore Reik considered that "[s]uch an avoidance of the emotional effect of melodies can sometimes be seen in people who feel endangered by the intensity of their feelings."[325] Sacks goes on to describe Leo Tolstoy's *The Kreutzer Sonata*, in which a wife commits unfaithfulness while playing the sonata with a violinist. The husband then murders his wife – "though the real enemy, he feels, the enemy he cannot kill, is the music."[326] In the interpretations of Freud and Tolstoy, music evokes the bewitching Sirens of the Odyssey.

The Romantics envisioned liberation, or enlightenment in the same way that Hegel, in his *Phenomenology of Spirit*,[327] envisioned an *aufhebung*, or a synthesis of all that came before. Scriabin's "unfinished magnum opus *Mysterium*, slated for a premiere

[323] Music has often been enlisted for malevolent purposes – Alex Ross quotes Richard Strauss's naïve response to Hitler's rise to power: "'Thank God, finally a Reich Chancellor who is interested in art!'" Ross, 334. See also footnote 184.
[324] Sacks, 321.
[325] Ibid., 322, referring to Theodor Reik, *The Haunting Melody: Psychoanalytic Experiences in Life and Music*, (New York: Farrar, Straus and Young), 1953.
[326] Ibid., 323.
[327] G. W. F. Hegel, *Phenomenology of Spirit*, Oxford: Oxford University Press, 1977.

at the foot of the Himalayas, was to have brought about nothing less than the annihilation of the universe, whence men and women would reemerge as astral souls…"[328] Instead, the world got total war, which was at once anticipated by the music that preceded it and echoed by the music that followed it. Ravel's *La Valse*, written in 1920, represents "a society spinning out of control, reeling from the horrors of the recent past toward those of the near future."[329]

The expression of terror and discomfort through music may also be healing in a therapeutic sense. There is value in expressing reality – it brings greater awareness and shatters the illusions that encourage apathy. Beautiful sounds have a powerful draw, but they do not represent the whole picture. Ross writes:

> For much of the nineteenth century, music had been a theatre of the mind; now composers would create a music of the body. Melodies would follow the patterns of speech; rhythms would match the energy of dance; musical forms would be more concise and clear; sonorities would have the hardness of life as it is really lived.[330]

Far from considering music as a distraction or a balm, many composers of the twentieth century used music to express the unpleasant.

The revolutionary twentieth-century composer Arnold Schoenberg "cast himself in a quasi-political role, speaking of the 'emancipation of the dissonance,' as if his chords were peoples who had been enslaved for centuries."[331] Alex Ross plays down the historical significance of atonality: "There was no 'necessity' driving atonality; no irreversible current of history made it happen." Ross claims: "It was one man's

[328] Ross, 63.
[329] Ibid., 121.
[330] Ibid., 83.
[331] Ibid., 62.

[Schoenberg's] leap into the unknown. It became a movement when two equally gifted composers [Webern and Berg] jumped in behind him."[332] Even so, atonality expressed a profound discontent with the existing state of affairs.

From the primal energies released by Stravinsky to the violent pounding of Pierre Boulez' early works, the music of the twentieth-century resounds with brute force. Stravinky's *Rite of Spring* throws off regularity of rhythm and harmonic logic like a young radical bucking the patterns of society, appealing to wilder, baser instincts. In its second section 'The Augurs of Spring,' "the strings and horns play a crunching discord … A steady pulse propels the chord, but accents land every which way, on and off the beat:"

> one two three four five six seven eight
> one *two* three *four* five six seven eight
> one *two* three four *five* six seven eight
> *one* two three four five *six* seven eight

Ross notes that "[e]ven Diaghilev quivered a little when he first heard the music. 'Will it last a very long time this way?' he asked. Stravinsky replied, 'Till the end, my dear.'"[333]

Stravinsky's work released great artistic energy into the world, but was found wanting in other respects. "There are works that overflow with accusations, hopes, encouragements,'" wrote the French thinker and writer Jacques Rivière. "'You suffer, regret, take confidence with them; they contain all the beautiful perturbations of the spirit; you give yourself to them as to the counsel of a friend; they have a moral quality and always partake of pity.' The *Rite*, he admitted, was not among them."[334] A pitiless age requires pitiless music.

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[332] Ibid., 66.
[333] Ibid., 81.
[334] Ibid., 100-101.

Alban Berg's *Three Pieces for Orchestra*, whose final movement (a "phantasmorgic March") was completed on Sunday, Aug. 23, 2014, the day

> French armies began a humiliating withdrawal to the Marne, and the British expeditionary Force fell back after the Battle of Mons. Hundreds of thousands were already dead. German soldiers were carrying out reprisals against civilians who resisted. That same Sunday night, German troops gathered the citizens of the town of Dinant and began firing into their midst, killing almost seven hundred people, including a three-week-old baby. […] Notes blacken the page; instruments become an angry mob, spilling from the sidewalks into the streets. Right at the end comes a brief mirage of peace: phrases curl upward in the orchestra like wisps of cloud, and a solo violin plays a keening phrase. All the while, the harp and the celesta strike monotonous notes, which sound like the ticking of a bomb. It explodes in the last measures, with a booming trombone-and-tuba tone, a flailing, upward-spiraling movement of the brass, and a final percussive hammerblow in the bass.[335]

The mood in the air was palpable to composers, and their music reveals it plainly. The final section of Strauss' *Metamorphosen* [completed in 1945] "is like the sunrise fanfare of *Thus Spake Zarathustra* moving in retrograde, the harmonic series rewinding to the fundamental. There is no 'light in the night,' only night."[336]

The composer Wolfgang-Andreas Schultz conducted "an absorbing study of war's effect on twentieth-century music," and observed "that feelings of 'hyperalertness, distance, and emotional coldness' often overcome the survivors of horrifying events.'"[337] Romantic composers like Sibelius "took a perverse pleasure in surrendering to melancholy, finding joy Sibelius reaches in darkness. '*Freudvoll und leidvoll*,' [Sibelius] wrote in his diary – 'Joyful and sorrowful.'"[338] But Schoenberg and his followers (and

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[335] Ibid., 71-72.
[336] Ibid., 369.
[337] Ibid., 105-106.
[338] Ibid., 181. "The British composer Julian Anderson has highlighted a passage in *Tapiola* in which a whole-tone interval in multiple registers generates 'deep acoustic throbbing'; this is

later composers like Milton Babbitt) cut the link to cultural and emotional cues, returning to the purity of notes as mathematical ratios just as Mondrian painted blocks of pure, primary colours. Dissonance and blocks of yellow and red may not cause soothing vibrations, but they embody a truth that needs expressing.

Now that the continuity was broken, composers were free to find inspiration anywhere, and many 'returned to the garden,' following a similar path to that of the revellers of Woodstock. In Samuel Barber's Adagio, the atmosphere is suspended in time, an effect that "derives from a metrical trick that Barber might have picked up from Sibelius: although the music streams by in a steady flow, the ear has trouble detecting where the bar lines fall." This effect resembles "a modern form of Gregorian chant."[339] John Cage also plumbed spiritual sources during his work with choreographer Merce Cunningham: he "browsed through the literature of Zen Buddhism, which supplied him with an all-accepting, 'whatever happens will happen' approach to the creative process."[340] His 4'33 is a presentation of silence, and of the incidental noise that comes from the audience throughout a performance. It is the "music" of the now.[341]

The mundane "now" of coughing American audiences contrasts with the "now" of some of the most harrowing moments of the twentieth century, which composers like Krzysztof Penderecki (*Threnody*) and George Crumb (*Black Angels*) managed to invoke. Penderecki and Crumb require extended techniques of their performers, but some of the century's electronic compositions, for instance, cannot even be re-created: they must be

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dissonance of a deeper order, the kind that alters your consciousness without assaulting your ears." Ibid, 184, referring to Julian Anderson, 'Sibelius and Contemporary Music,' in Grimly, *Cambridge Companion to Sibelius* (Cambridge: Cambridge University Press, 2004), 196.

[339] Ross, 311.

[340] Ibid., 399.

[341] In the spirit of the "now," there is a free prepared piano app on the John Cage website: http://johncage.org/cagePiano.html, retrieved November 8th, 2015.

heard in their original form. Ross calls Karlheinz Stockhausen's *Gesang der Jünglinge*, or *Song of the Youths* (created in 1955-56) "perhaps the most influential electronic piece ever composed." In the book of Daniel, Nebuchadezznar has three youths thrown into a furnace "for refusing to worship a golden idol."[342] Stockhausen's piece "is built up in layers from the recorded voice of a choirboy singing 'Praise the Lord! […] The boy's song is broken down into phonetic fragments and remixed in the style of musique concrète. All around is a flickering mass of electronic sound…"[343] This auditory Holocaust must be performed in its original format, via speakers placed on the stage. It is an important expression of human brutality, manifested in the fierceness of the electronic effects and the supernatural voices of the boys, which yank the listener to and fro, growing and shrinking in volume in unnatural, sickening swoops. It is a masterpiece of musical horror.

Twentieth-century music expresses more than violence and suffering, as Ross suggests when he offers that "[t]he difference between Schoenberg and Messiaen is ultimately theological." For Schoenberg, "God was unrepresentable," which means "His presence could be indicated only by placing a taboo on the familiar." For Messiaen, "God was present everywhere and in all sound. Therefore, there was no need for the new to supersede the old: God's creation gathered magnificence as it opened up in space and time."[344] In *The Transfiguration of Our Lord Jesus Christ* (1950), Messiaen's "consonances are sometimes more terrifying than the dissonances that surround them. They are tonality transfigured, rising from the dead."[345] His opera *Saint François*

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[342] The three youths are Shadrach, Meshach, and Abednego. Ross, 430.
[343] Ibid., 430.
[344] Ibid., 488.
[345] Ibid., 494.

d'Assise[346] "ends in twelve bars of hyperbright C major, replete with rapidly gesticulating brass, trilling and groaning ondes Martenot, madly glissandoing mallet instruments, and a shimmering cascade of bells and gongs. It is the negation of the negation, the death of death."[347]

3.6 MUSIC AND FEELING

Pianist and conductor Daniel Barenboim points out that "[t]he ear has a head start over the eye, which doesn't see anything until it comes [of the womb]."[348] Furthermore, "the auditory system is a very fast sensory-processing system – faster […] than the visual system."[349] Hearing is a sensory experience, intensified by the feeling of touch that sound-waves can also stimulate. Music can convey feelings of all kinds, and philosophers have been known to discuss what kinds of feelings music should ideally arouse.

Ross recounts a telling anecdote: while listening to live music has long been a communal event, the concert-going experience was not codified until the time of Mahler, "who hated all extraneous noise, threw out singers' fan clubs, cut short applause between numbers, glared icily at talkative concert-goers, and forced latecomers to wait in the lobby," prompting the Austro-Hungarian Emperor Franz Joseph to say: "Is music such a serious business? I always thought it was meant to make people happy."[350]

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[346] Composed at the command of French President Georges Pompidou between 1975 and 1983. Wikipedia, "Saint François d'Assise," https://en.wikipedia.org/wiki/Saint_Fran%C3%A7ois_d%27Assise, retrieved January 26th, 2016.
[347] Ross, 514.
[348] Mannes, 11.
[349] Ibid., 186.
[350] Ross, 21.

There is room for every kind of music, from the soothing strains of Vivaldi and the high-minded, sustaining chords of Bach to the disturbing electronic collages of Stockhausen and the wild space-journeys of Messiaen. Music reflects the human experience, and the primal, nourishing music of spiritual gatherings (chanting, drumming, bell-striking) has its place alongside music representing the increasingly elaborate and varied range of human expression. Attempts to create nineteen-tone harmony are laudable, and may produce exciting new music that will test the known human auditory boundaries,[351] but such music will not be used to soothe infants in the NICU. For the purposes of healing, the power of a regular beat (or entrainment) and the resonance of harmony prevail (harmony, of course, being so powerful because it amplifies resonance).

In Italian, "[t]he verb *sentire* means 'to hear,' and the same verb in the reflexive form, *sentirse*, means 'to feel.'"[352] Elena Mannes reminds us that, music "is a vibration [with] incredible physical power. A singer's voice, for example, can shatter glass, and sound waves produce patterns in matter. The study of this wave phenomenon is called cymatics, a term based on the Greek word for wave and coined by Swiss scientist Hans Jenny."[353] Mannes quotes the violinist Daniel Bernard Roumain:

> You know when someone says that a piece of music 'touched me' or 'moved me,' it's very literal. The sound of my voice enters your ear canal and it's moving your eardrum. That's a very intimate act. I am very literally touching you, and when you speak to me, you are literally touching me. And then we extend that principle to the sound of a violin.[354]

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[351] Composer Matthew Barber has developed complex harmony in a nineteen-tone system: *Severall Figur'd Atomes (2006)*, Matt Barber, http://www.youtube.com/watch?v=Rb-NzmSW7Ec, YouTube, retrieved June 28, 2015.
[352] Mannes, 10.
[353] Ibid., 7.
[354] Ibid., 10.

Columbia University physicist Brian Greene was asked "if our very bones and other parts of our bodies can respond to vibration, functioning 'like a large ear when we're listening to music.'" Greene "confirmed that since every object on earth vibrates, our bones do too," and "that the experience of music is something deeply related to our physiology."[355] The solo percussionist Evelyn Glennie, who graduated with honours from the Royal Academy of Music in London, has been deaf since the age of twelve and plays percussion by feeling "the sound – different rhythms, even different pitches – through her feet and through different parts of her body." Glennie "feels the low sounds – like that of a bass drum – in the lower part of her body. And a high sound, like a cowbell, she can sense in the upper part of her body."[356] Glennie's refined, powerful playing attests to the physiological effects of music.[357]

In Mannes' words, "[m]usic is central to our physiology, our psychology, and our very identity and sense of self. It makes us forget our fear and stress. It awakens our oldest memories."[358] Studies show that the human brain is "at its peak demand when two musicians or singers are working together to create music." This suggests that "music is intrinsically social."[359] Music affects the amygdala and other limbic areas, which "evolved very early in human development" and which "are associated with emotional responses and memories." The amygdala responds "differently depending on whether the

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[355] Ibid., 14.
[356] Ibid., 9.
[357] Evelyn Glennie, "How to Truly Listen," TEDX (filmed February 2003), https://www.ted.com/talks/evelyn_glennie_shows_how_to_listen?language=en, retrieved Nov. 8th, 2015.
[358] Mannes, 71.
[359] Ibid., 38. Neuroscientist Petr Janata has shown in brain images "how music moves in tonal space." Janata concludes that "the experience of memory – and emotion – is 'embedded within how our brains work.'" For instance, when a friend is performing, a listener's brain shows "widespread activity" in contrast to the more localized activity it displays when an unfamiliar person performs. Ibid., 69-70.

stimulus is positive or negative," and "plays a key role when the fight-or-flight response is triggered in [the] nervous system." According to recent data, newer brain areas "such as the frontal cortex are also triggered by emotional stimulation." This area is also "activated by the temporal dynamic of music that creates experiences of expectation and surprise, tension and release."[360] The release of dopamine that music causes in the brain comes from that very pattern of tension and resolution. This "expectation/surprise factor" is what creates pleasure.[361] As Patel mentioned, tension and release provide the emotional fuel in music, while violation of expectation can cause strong sensations such as chills – this ties into Tymoczko's description of the evolution of harmony and counterpoint: the complexity of the relations between counterpoint and harmony continues to grow in order to allow for new violations of expectation.

According to scientists, "the peak of neural activity" in fact occurs "during the *silence* of the transition." This finding "suggests that silence is what helps the brain to decode musical structure, making sense of what might otherwise be 'a continuous stream of undifferentiated information.'" In listening to or performing the works of great composers, one discovers that these composers "were masters at setting up silence and using expectation violation."[362] This is partly what makes their music great, although of course the performers must be equal to the task.

According to Jamshed Bharucha, "musical sound is a way to put a group of people into the same brain state."[363] Mannes goes even further, quoting the

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[360] Ibid., 65.
[361] Ibid., 64.
[362] Ibid., 61, quoting neuroscientist Vinod Menon from D. Sridharan et al., "Neural Dynamics of Event Segmentation in Music: Converging Evidence for Dissociable Ventral and Dorsal Networks," *Neuron* 55 (August 2007): 521-32.
[363] Mannes, 113. See also Ibid., 219.

singer/pianist/conductor Bobby McFerrin: "music *is* fundamentally spiritual."[364] Petr Janata is trying to find out "what is going [on] in the brain when people are 'in the groove,' so caught up in either listening to or performing music that they've lost that 'sense of 'I-ness.'''"[365] Janata considers the "element of social engagement" pivotal: "Playing music together is really powerful," although one can also "be in the groove by oneself, too, listening to music" alone.[366] To perform music is "addictive," says Mickey Hart, percussionist of the band Grateful Dead. "It feeds those parts of the brain and psyche that create consciousness and awareness. When we hit a good rhythm, our consciousness is transformed; you're dancing with the vibratory world." [367] As far as addictions go, to be addicted to performing music is not so bad.

It is tempting to envision an idealised past in which music was more magical and powerful. Neuroscientist and saxophone-player Daniel Levitin says "It's almost ironic that today technology and culture have taken us to where we all have our little ear-buds and we listen to music in private, given that for tens of thousands of years the only way music was experienced by humanity was communally."[368] Similarly, Mannes observes "how scientists and musicians alike keep coming back to the thought that our ancestors somehow knew something about music that we have lost. They knew it wasn't just for

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[364] Ibid., 220.
[365] Ibid., 205, referring to Petr Janata, interview with Elena Mannes for *The Music Instinct*.
[366] Ibid., 206.
[367] Ibid., 208, referring to Mickey Hart, interview with Elena Mannes, October 14th, 2010.
[368] Ibid., 213, referring to David Byrne and Daniel Levitin, "The Singer/Songwriter and the Neuroscientist Meet Up to Discuss Music," *Seed*, April 30th, 2007, http://seedmagazine.com/content/article/david_byrne_daniel_levitin/, retrieved January 29th, 2016.

professionals up on a stage performing for the rest of us to pay money to hear. Music is for everyone."[369]

While such populist thoughts are comforting, the richness of possible musical experience in the twenty-first century should not be underestimated. It is certain that music used to play a more primal role in human communication. It seems unlikely, however, that music was only experienced communally, as human beings might have enjoyed singing and playing music on their own, even in prehistoric times. Furthermore, ear-buds do not only contribute to isolation – they also allow listeners from all over the world to hear the same music regardless of place and time, which in a way represents a greater shared experience.[370] In the twenty-first century, it is possible to experience music communally with much larger numbers of people than it used to be, in much greater performance spaces, much more frequently, and performed with a higher level of skill. It is also easier to access musical training than it ever was before, and there are more people doing exactly that than there ever have been in known history.

In any case, the ideal musical past harkens back even further than human prehistory: human instincts regarding music are so primal that humans show "*more* emotion" when hearing birdsong than they do when "listening to beautiful songs sung by a human voice."[371] There is a "wider range of response listening to birdsong, with more activity in the emotion areas, executive planning areas, and auditory areas of the brain."[372] This response suggests the primacy of our musical nature, as it comes from

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[369] Ibid., 212.
[370] "When I'm alone, in my phones, I feel love in digital stereo"… Saint Etienne, "I've Got Your Music," from the album *Words and Music by Saint Etienne*, released May 18th, 2012.
[371] Mannes, 70. Olivier Messiaen's fascination with birdsong comes to mind in this context.
[372] Ibid., 70-71.

long before we evolved into human beings. In other words, musical experience preceded human experience.

3.7 MUSIC IN THE ANIMAL WORLD

What is the difference between animal and human music? Musician and author David Rothenberg claims that birdsong "is not exactly language." There is a contrast between the "simple calls birds use to convey specific ideas such as 'I'm hungry' or 'Danger.'" "Birds know these calls from birth," Rothenberg points out, "but they *learn* their songs as they mature – even though they're wired to learn their species' own songs." A baby-bird call "looks like chaos – just a collection of unorganized sounds," but as the bird grows, the "cloud of unstructured sounds develop[s] structure like a crystal emerging." Furthermore, dopamine "is released in the brains of songbirds when they sing." Primarily, birds sing "to attract a mate and they feel good in the process."[373]

Erich Jarvis, however, found that the pathways for birdsong "are comparable to the human brain pathways for language." Furthermore, he produced evidence "that humans and vocal-learning mammals as well as songbirds share a set of mutations in genes involved in brain connectivity that link vocal learning to motor control – thereby enabling song production."[374] Cockatoos can entrain to music, which is an unusual skill among animals other than humans. When the famous dancing cockatoo Snowball dances

[373] Ibid., 127-130.
[374] Ibid., 141.

to music, he expects eye contact. He cares that you are dancing with him and looking at him, suggesting there is a social dimension to entrainment.[375]

Mannes explains: "The recent research in the field of biomusicology is letting us hear a whole new world of music-like sounds produced by other species. It turns out even mice 'sing.' Perhaps thankfully, we can't [normally] hear it because the frequency is too high."[376] Although male humpbacks are thought to sing to attract a female, "to date there [has] been no evidence, on film or in any other way, that a female has been drawn by the singing!"[377] Like human songs, "whale songs have structure, rhythmic variations, harmony, and pitch relationships. Musician/composer Paul Winter has even arranged whale songs for human instruments."[378] (A more obvious example of whale songs set to human music is Alan Hovhaness' *And God Created Great Whales*.)[379]

Furthermore, "[o]ther species besides songbirds and cetaceans sing together," such as gibbons, who show "signs of *synchronized* vocalization." For instance, "gibbons sing in pairs with a melodious call," which acts as "a bonding device" between pairs.[380] Furthermore, rhesus monkeys can "transpose melodies by octaves" when they contain "strong melodies."[381] Tests at Harvard have shown that carp can "tell the difference

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[375] Ibid., 122, referring to Aniruddh Patel. See *Snowball ™ and Stevie Nicks*, BirdLoversOnly, YouTube, https://www.youtube.com/watch?v=GYMBIGTteWA, retrieved June 28th, 2015.
[376] Mannes, 136.
[377] Ibid., 134.
[378] Ibid., 132. Paul Winter's pieces feature whale songs accompanied by, not arranged for, human instruments.
[379] Alan Hovhaness's "And God Created Great Whales," Op. 229, No. 1,1970, is "a symphonic poem for orchestra and recorded whale sounds." Wikipedia, "And God Created Great Whales," https://en.wikipedia.org/wiki/And_God_Created_Great_Whales, retrieved January 26th, 2016. Listen here: *...And God Created Great Whales*, inspiredbymusicart, YouTube, https://www.youtube.com/watch?v=2LVm5nd-KFA, retrieved January 26th, 2016. The whale songs begin at around 2:40, and the strings and woodwinds can be heard imitating whale song at 7:06 until 7:48 – the vibrato spoils the effect a little, as whales don't have vibrato.
[380] Mannes, 136-137.
[381] Ibid., 138.

between baroque music and John Lee Hooker" (they indicated their recognition by pushing a button with their snouts). Also, java sparrows "can distinguish between Bach and Schoenberg," and at Keio University in Tokyo, proved that they "could distinguish between Vivaldi and Elliott Carter." When given a choice of silence, the birds "still chose the [Vivaldi]."[382]

David Rothenberg proposes "there is in some sense a pattern rhythm and form in the music of the animal world that is common at different levels of organization. I would say that just as people have identified different visual patterns in the visual world, the way plants have developed a certain sense of order and symmetry, that the same thing is going on in sound." Scott McVay states: "The point is when you get a master like Bach or Shakespeare or Goethe, or the humpback whale, it seems like there's the impetus within life to communicate." For Mannes, this viewpoint "takes us out from our planet into the universe – an expansion of the resonant world."[383]

The common origin of music and language points to that underlying impetus within life to express itself. The geometrical and vibrational patterns that form matter in the universe also inform music and the arts. Our understanding of the ways in which the human body responds to the vibrations of music is growing, and it is becoming increasingly clear that music has a pivotal role to play in medicine, as well as in education.

[382] Ibid., 139.
[383] Ibid., 142-143.

CHAPTER 4: ANALYSIS OF *EMERGENCE*

The trumpet (we, intoxicate with pride,
Arm at its blast for deadly wars)
To archangelic lips applied,
The grave shall open, quench the stars.[384]

Why would a composer inspired by the common origins of music and language write a piece for wind symphony instead of a choral piece? In this case, the answer is pragmatic: to learn more about the wind instruments, as I am a string player. Beyond that, the goal was to compose a piece capturing the sense of wonder felt upon hearing members of the Rio Xinane tribe break into song in mid-speech, recalling an ancient time when the word, movement, and music served human communication, and the mundane and the spiritual were one.

Intoning, throughout many cultures, can vary from a minor third up to a fourth – here it is given as a minor third to resemble the intoning of some of the Rio Xinane men in the FUNAI video. The minor third also has deep significance in human perception. Kathleen Wermke of the University of Würzberg has found that babies often cry in minor thirds. Their cries also reflect the intoning patterns of their native language, so that French baby cries rise, while German baby cries fall, for instance.[385] Elena Mannes points out that children also chant rhymes at that interval (nyah nyah n' nyah nyah) and call their parents the same way ("Maaah-Mee"). It is a common interval in lullabies, which according to Mannes are usually quiet, repetitive, and have "narrow pitch range"

[384] William Wordsworth, "On the Power of Sound," *Complete Poetical Works*, Great Books Online, http://www.bartleby.com/145/ww746.html, retrieved February 16th, 2016.
[385] Birgit Mampe, Angela D. Friederici, Anne Christophe, and Kathleen Wermke, "Newborn's Cry Melody Is Shaped by Their Native Language" *Current Biology* (2009): 19(23):1994-1997.

and "falling pitch contours."[386] Jamsched Bharucha has found that humans use the minor third in speech when feeling sad – this is echoed in the use of the minor third in sad-sounding music.[387]

Emergence features limited macroharmonies and harmonic consistency, as it remains within the traditional diatonic, scale-based system (see p.59). It also flows with a regular metre throughout, recalling Sacks' observation that "rhyme" and "rhythm" come from the same Greek word, meaning "measure, motion, stream," and that this feature of music and language points to their common origins (see p.45). This piece also conforms to Patel's observation that richness in Western music rarely comes from rhythmic or phrasal complexity, but rather from harmony (see p.15).

Emergence features an unusual progression of keys:

- movement I: F minor, G minor
- movement II: E minor, B minor, G# minor, E minor
- movement III: E minor, Bb, B, Bb, Gb, Eb, Db, E minor, A minor
- movement IV: B minor, F# minor, E minor, E major, D minor, E minor, G minor, A major, B minor, Bb Major, F major, E minor, and B minor

It also displays parallelism in the motion down to flat 7 and flat 2, representing an overall tug downwards vis-à-vis the tonic. Almost entirely in minor keys, *Emergence* sounds gothic, exhibiting odd angles and distortions. This piece shares some of the tendencies shown in Shostakovich's minor-key pieces: avoidance of the major V chord, and a lowering instead of a raising of minor scale degrees (see p.47).

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[386] Mannes, 46-49.

[387] "Minor third," Wikipedia, https://en.wikipedia.org/wiki/Minor_third, retrieved February 21st, 2016, referring to Meagan E. Curtis and Jamsched J. Bharucha, "The minor third communicates sadness in speech, mirroring its use in music," *Emotion*, Vol 10(3) (June 2010): 335-348.

The Rio Xinane motive (see figure 1, p. 2) is woven into the first three movements of the piece, which follow the traditional format of Allegro, Adagio, and (modified) Minuet. The last movement (Chaconne) diverges from these, replacing the traditional Rondo with a chaotic, dissonant round in 5/4. While the Rio Xinane motive does not appear, the initial melodic figure features a prominent minor third. The third movement Minuet and the fourth-movement Chaconne are modified versions of these traditional forms. The Minuet is in 6/8 and slips well out of binary form, also featuring a Gigue instead of a Trio. It is in fact a Scherzo, which becomes clear in the rambling middle section. The Chaconne is in 5/4 and features stubborn themes that return in a loose round-form, but not at the right times, stepping on each other's toes. There is no real ground bass… only a pattern of whole note chords entering on the second beat of each bar, traditionally the most important beat in the Chaconne. There is a feeling of a recurring rhythm in the harmony, but no real recurring underlying harmonic pattern. Also, there is a harmonic, homophonic interlude in the middle of the movement.

Besides popular music and my own heritage (French-Canadian, Irish, and Algonquin), other possible compositional influences include being a violinist, having danced ballet and flamenco, and having played the bonang barung in a Javanese gamelan ensemble. The frequent cymbal rolls might be Toronto's nearby subway, or the cicadas, which are extremely loud during the summer.[388] As preparation, I listened to several wind symphony pieces, including works of Ralph Vaughan Williams, Gustav Holst, Alan

[388] The American composer George Crumb feels intuitively that composers are influenced by their native "soundscape" and replicate some of its elements in their compositions, which relates to Patel's nPVI studies (see p.20), as well as to Patel's observation that our native sound system "leaves an imprint on our minds" (see p.6). George Crumb, interviewed by Anna Sales, "A Conversation with George Crumb," *West Virginia Public Broadcasting*, YouTube, https://www.youtube.com/watch?v=5xo8SHjTxpc, 4:07- 5:35, retrieved February 16th, 2016.

Hovhaness, Michael Colgrass, Michael Daugherty, Frank Ticheli, John Mackey, Eric Whitacre, and Luis Serrano Alarcón.[389]

The first movement opens with the sounds of the jungle – here, a bowed vibraphone, a rain stick, crickets, and bongos. Four notes played on the crotales come from Stockhausen's *Gesang der Jünglinge*, representing the tension hanging in the air as the Rio Xinane emerge, as well as the weird juxtaposition of modernity with the ancient ways of the Rio Xinane. Once the brass play an opening fanfare (m.8-15), a suspenseful introductory segment highlights the Rio Xinane motive called in succession by three overlapping voices, first in the clarinets, then in the oboes and alto saxophones, (m.16-30). This leads to a Bach-style chorale, embellished with stately arpeggiated patterns and with the Rio Xinane motive at the phrase peaks. The first chorale ends (m.80), and the trombones slide into a dance groove (m.92), which ends up sandwiched between two Bach chorales, identical in harmonic structure.

The second Bach chorale (m.125-174), however, picks up the faster arpeggiated staccato of the dance groove, merging the sacred with the profane. In the second chorale section, the arpeggio is passed between the instruments, running up and down the instrument ranges. The first movement hovers mainly around F minor and G minor, visiting a few other keys in passing.

The second movement is an Adagio inspired by the spirit of the folk-music themes of Dvorak and Tchaikovsky. Beginning in E minor, the flutes set a breath-y triplet pattern under the muted trumpet and clarinet melody, which introduces a sextuplet figure. The bassoons and bass clarinets take over, embellishing a short brass chorale until

[389] I met Luis Serrano Alarçon when he was conducting the Philharmonic Winds in a concert of his own works in Singapore in 2010 (we also presented to him a concert of our student works at the Nanyang Academy of Fine Arts).

the Rio Xinane motive enters with a slow, processional swing in the bassoons, the trombones, and the euphonium (m.181). The trumpets introduce a new theme that begins with a punctuating triplet (m.191) leading into B minor.

The new theme is picked up by the trombones, and eventually by most of the brass and the saxophones. The flutes elaborate with a driving scale pattern until most of the voices back out and a woodwind/tuba solo begins in G# minor. The Rio Xinane motive appears again (m.221-224), and the climax of the movement begins in Bb minor (m.225-240). The sextuplet figure of the original trumpet and clarinet melody is passed between the instruments and crosses all the ranges while the percussion keeps a steady momentum underneath. The recapitulation returns to E minor, leading straight into a dramatic chord progression that drops into Eb minor (the flat seventh) before returning to E minor and offering i7, vo9, and a shiny Picardy third.

The third movement, also in E minor and beginning with a “Minuet” is really a jaunty Scherzo. It delves into extended techniques with key slaps and valve clicks, also featuring trombone bravado, horn calls, and playful bells (crotales, in this case). It begins, however, with a mischievous eighth-note motive in 6/8 time, which travels throughout the instruments and a few keys (Bb, B, Bb, Gb, Eb, and Db), interwoven with the Rio Xinane motive. In this movement, the motive sounds like a call to hunt or to travel; it gives the impression of movement and of energy.

The trombones and the flutes strike up an E minor Gigue (m.291). It is taken over by the woodwinds and horns (who are joined by the brass for a bells up fanfare in m.307), and later by the saxophones, returning to E minor and travelling to A minor until a rambling progression in the woodwinds (m.315-320) leads to a silly dance of the flutes, piccolo, and crotales, followed by the near-silence of key slaps and valve clicks playing the dance rhythm. Suddenly, all the instruments join in to end the Gigue with a loud medieval *branle* (337-344), after which sobriety returns in the form of the recapitulation.

In the last movement, which begins in B minor, the voices are superimposed in a round to emulate the simultaneous intoning of several people at once, as the Rio Xinane demonstrate in the FUNAI video. The crunchy tonalities recall the clash of intonations as the speakers/chanters intone on slightly different "tonic" notes, with slightly wider or narrower intervals. The round is also inspired by the vocal experimentation of Meredith Monk, who uses rounds and patterns to create a fabric of sound.[390] The Rio Xinane motive has disappeared in this movement to make way for a simple, independent melody, which resembles the motive only insofar as it opens with a minor third.

The chaos of the round is dispersed by a cymbal roll (m.418-419), at which point the voices gather into harmony, rich in sevenths so as not to stray too far from the previous dissonances. The harmonic section travels through B minor, F# minor, E minor, E major, D minor, E minor, G minor, A major, B minor, Bb Major, F major, E minor, and finally returns to B minor for the recapitulation (m.475), which crescendos to a climax as it does in all the previous movements.

As Patel mentions, rhythm in music offers a wealth of perceptual dimensions. I attempted to juxtapose rhythmic patterns (as well as to vary them) as in the first movement, where the first chorale beginning at letter D is superimposed with the dance-like rhythms from letter I section when the two are joined together at letter M. The gesture of the continuing sixteenth-note rhythms sweeping up and down around the

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[390] Meredith Monk, *Turtle Dreams*, ECM New Series, 1983, and Meredith Monk, *Book of Days*, ECM New Series, 1990.

homophonic chorale is one of grandeur and motion. In the second movement, a rhythmic motive from the second measure (m.176) returns at letter W as a gesture of strength and resolution, and is finally passed around from voice to voice as an encouragement.

Emergence exhibits something like solemnity at letters D, H, M, S, and W, for instance. It displays playfulness at letter I, at the Gigue in the third movement (m.291) all the way to the recapitulation at letter HH, and at the travelling sequences at letter TT. Frustration can be sensed in the fourth movement Chaconne (m.387) as the motives clash with unrelenting repetition. Victory and epiphany lasts from W in the second movement until the recapitulation at Y. The feeling at letter OO in the fourth movement is of release from torment, and of liberating, graceful movement after the static and repetitive opening of the Chaconne.

Emergence also alludes to Renaissance and Baroque styles, as in the aforementioned chorales of the first movement, and at letter RR in the Chaconne. The Gigue in the third movement refers to popular music of the Renaissance, while OO to VV in the Chaconne evokes jazz. The opening fanfare of the first movement echoes the fanfares of the late nineteenth and early twentieth centuries, such as those of Richard Strauss. The piece loosely illustrates various points along the trajectory of the development of Western harmony and voice-leading as described by Tymoczko. An analysis of some of the chords of *Emergence* according to Tymoczko's diagrams would be pertinent, but I am not versed enough in technology and mathematics to attempt it. Furthermore, it is certain that all these voice-leading possibilities have already been expressed in nineteenth and twentieth-century music, inviting further study of those works instead.

CONCLUSION

This thesis proposes that music is primordial and that it fulfils a deep-seated human need to communicate emotions and states that are not communicable any other way; that the human mind is formed partly by and for music so that education in music is a basic human requirement; that music, language, and dance have the same origins; that the Universe is composed of vibrations, so that music reflects and affects matter; that music, harmony, and rhythm have healing properties; that music has spatial dimensions that correspond to harmony and counterpoint; and that Western harmony (and all of its manifestations, including Jazz) represents a powerful articulation of the these spatial dimensions.

The thesis provides summaries of Aniruddh Patel's research in *Music, Laguage, and the Brain*, and of Dmitri Tymoczko's work in *A Geometry of Music* to demonstrate these principles, also referring to the works of many others including Elena Mannes, David Hendy, Oliver Sacks, and Alex Ross to illustrate the healing and expressive powers of music. It presents the piece *Emergence* for wind symphony, which offers a motive based on the intoning chant of the Rio Xinane, who alternate between speech and song in their daily communications, demonstrating how language and music are linked. *Emergence* explores some of the features of music as described by Patel and Tymoczko and as a wordless piece reminds the listener that music may well have preceded language.

Environmental philosopher and conservationist John Muir once described the soundscape of Yosemite National Park in California; the "birdsong, the 'wind-music' of the trees, the 'joyous hum' of insects, the 'glad streams singing their way to the sea.'"[391] In the Amazon, one might add to that the human voice intoning its words below the forest canopy, leading to an important coda: What were the Rio Xinane people communicating to the FUNAI representatives?

After an initial encounter, FUNAI members brought with them two interpreters from the Panoan language group who were able to communicate with the Rio Xinane. The Rio Xinane were seeking weapons and allies. They had been driven off their Peruvian land and over the Brazilian border by violent loggers or by drug traffickers. They communicated that they were hungry, and that after they had been attacked and driven away many of them had fallen ill with the flu and diphtheria. As seen in the video, FUNAI members offered them bananas, and allowed the Rio Xinane to swipe some of their shirts, as well as an axe. They later sent medics to treat some of the Rio Xinane for the flu, but must try to limit their contact with all isolated tribes, as the indigenous people have no immunity to common diseases (which most other people carry unwittingly).[392] The testimony of FUNAI is not only politically valuable, but has also opened a window into the origins of human expression. *Emergence* is an artistic response to that miraculous insight.

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[391] Hendy, 233. Referring to John Muir, *My First Summer in the Sierra* (London: Constable, 1911), 255-256.

[392] Ludovica Iaccino, "Brazil: Isolated Tribe First Contact with Outside World Caught on Camera," International Business Times, http://www.ibtimes.co.uk/brazil-rio-xinane-tribe-first-contact-outside-world-caught-camera-1459149, retrieved February 16th, 2016.

Emergence

Transposed Score

for Trishul

C. Pellerin

f-:i9 VI


A
5
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Cric.
Crot.
Bongos
R.S.
Vib.
mf dolce
Timpani Eb F G Ab C
Crotales Cym
Cymbals
accel. roll
Cricket
f:i
Db:IV
bVI
F:IV


13
B
A tempo ♩=96
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Crot.
Vib.
ii7
bII9
I7
(f-):bII7
I
bII7
I
bII7
I


19
C
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
mf
f
mp
bII9
vii
e-:iv7
i
iv7
i
iv7
vii
g-:VI7


24
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
mf
f
ff
pp
VI
vii7

30
D
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
i
iv
II
iv7
v7
III
VI


41
E
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
dolce
f:III
VI
i
VI
III
bVII
i
v


52
F
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
i
V\V
v
IV
i
i
III


64
G
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
V
i
viio
i
bVII
v
i
V\V


76
rit.
H
Meno mosso, ♩=76
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
dolce
V
C:I
g-:i
i
IV
III


I
85
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
dolce
dolce
Cricket
bVII IV i bVII7 I
bVII I


94
J
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
mf leggiero
bVII
I
bV
bV(11)
i
i9


103
K
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
leggiero
bVII
i
bV
VI


111
L
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
leggiero
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
pp
mp
Cym.
pp
mf
Bongos
Cric.
Vib.
i
bVII
bII
Bb-:bVII
VI


118
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
i
bII
V


125
M
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
mf dolce
G:i
iv
III
iv7
v7
III

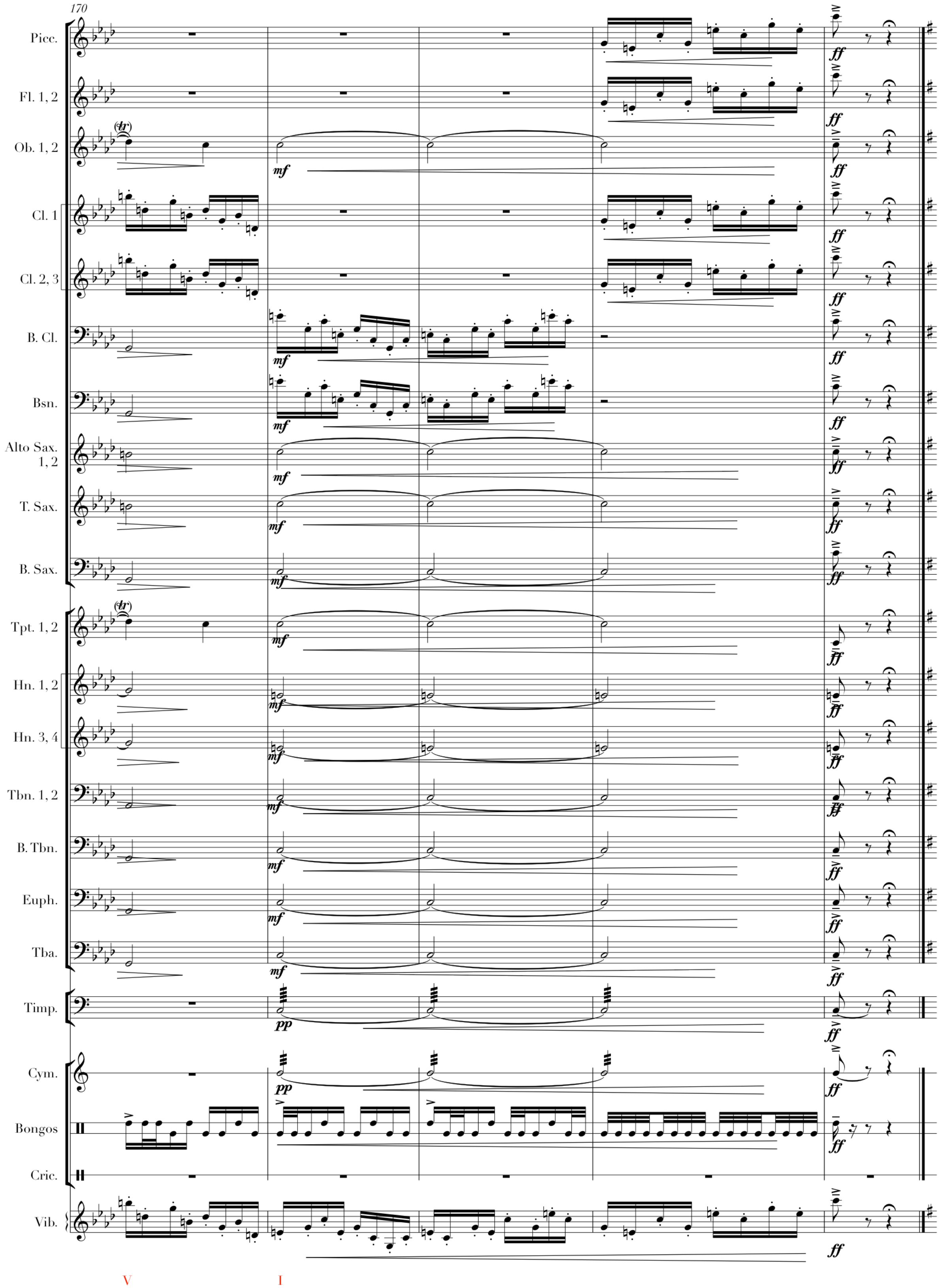

N
134
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
f dolce
pp
mf
VI
f-:III
VI7
i
iv7
III
bVII


142
O
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
dolce
i
v
i
V\v
v


150
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
(tenor sax)
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
IV
i
III


P
158
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
V
i
viio
i


165
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
bVII
v
i
V\V


170
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Vib.
(tr)
mf
ff
pp
V
I


175
II. Adagio ♩=64
Picc.
Fl. 1, 2
mp dolce
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
solo
mute
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timpani E F Bb B
Timp.
Cym.
Crot.
Vib.
mp dolce
e-:i
iv
VII9
v4\2
I
VII6
III9

Q
180
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
IV
V4/3
V
i
VII
III


R
184
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
mf dolce
V\V
V
i
i
VI
III


189
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
VI
eb-:IV
vi
III
g-:i
VII6/4
i
II
g-:iio
I


194
S
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
v
iii/b-
VII
(b-):i
iv
VII
iv


199
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
I
iv
VII
IV


203
T
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
i
iv
F:I


206
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
ff
f
d-:VI
bII
V


209
U
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
solo
f dolce
solo
f dolce
mf
mf
p
p
solo
mp dolce
mf
mp
g#-:i
VI7
V
III
V
i
VI7
V7


V
216
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
tutti
solo
dolce
solo mute
IV
i
III
VII
VI
III

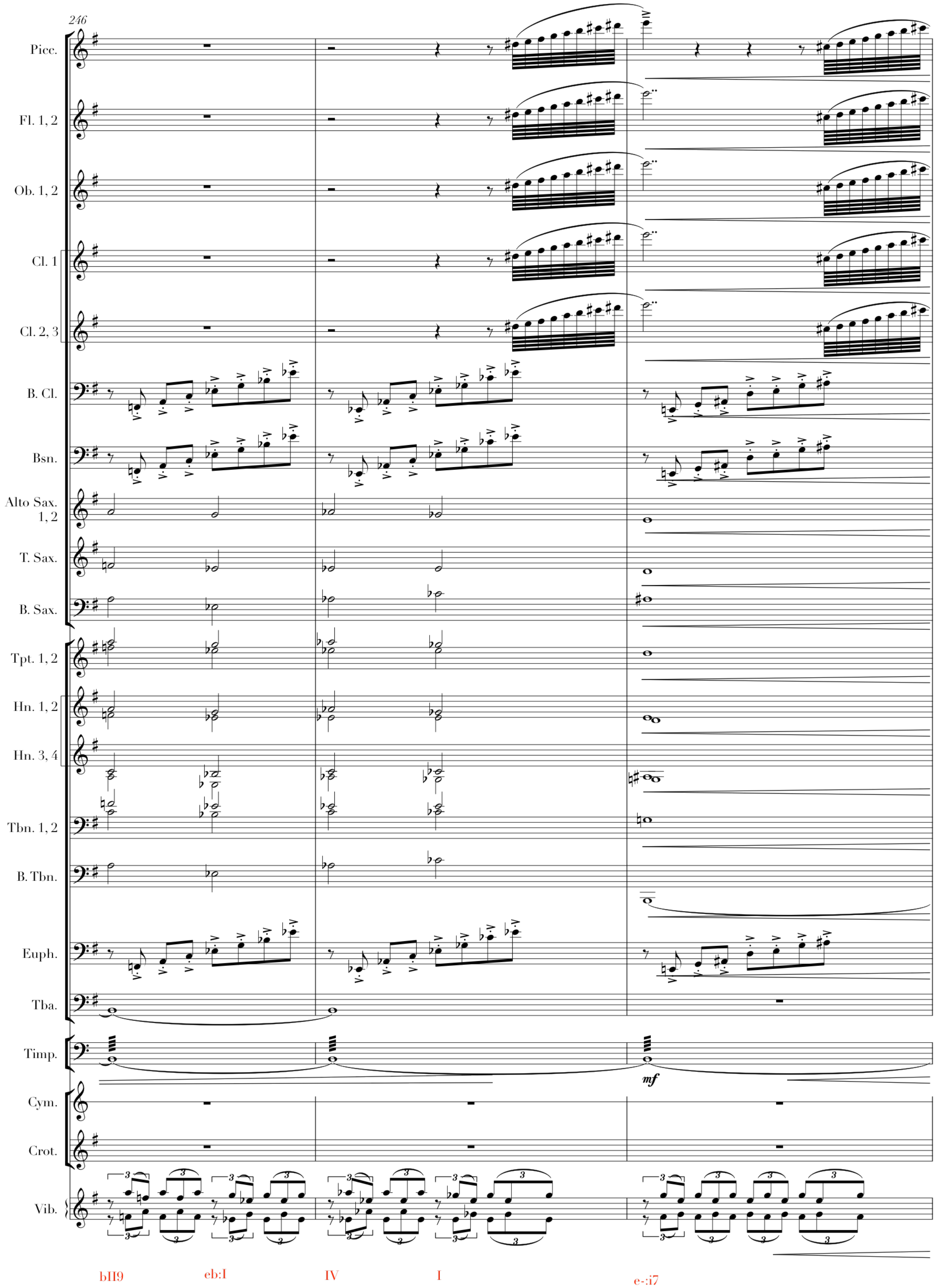

W
222
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
nat.
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
A+:IV I I V
b-:IV bVI V
Bb+:I II iii V vi

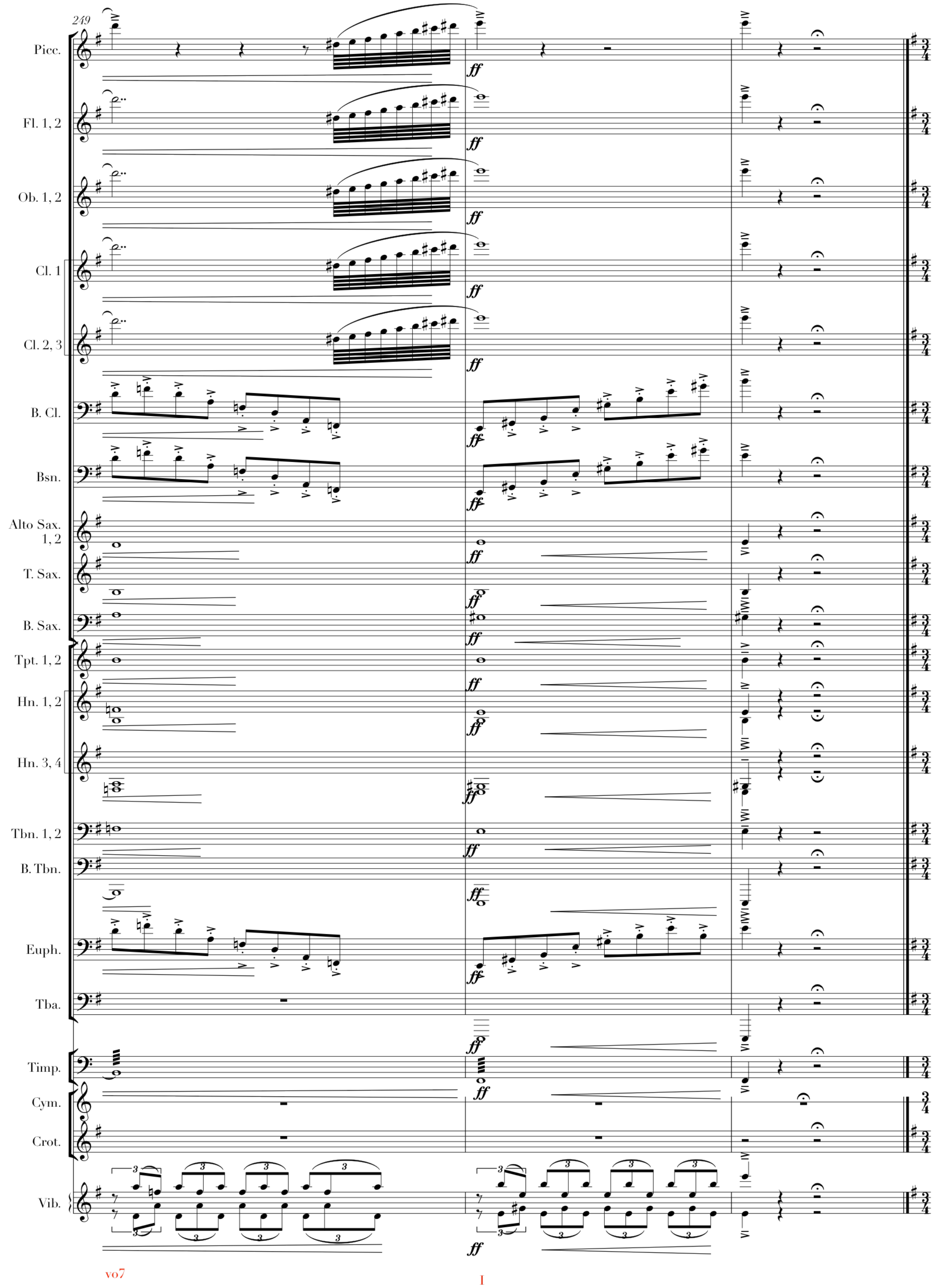

228
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
ff
Cym.
pp
f
pp
Crot.
Vib.
IV
IV7
i
II
V
II
iv
vi7
VII
VI7


X
233
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
V
II
I
vi
V\VI


237
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
VI
VII


Y
241
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
tutti
cresc.
i
iv
VII9
V7
I
bVII
III
IV


246
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
mf
Cym.
Crot.
Vib.
bII9
eb:I
IV
I
e-:i7


249
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
ff
vo7
I


III. Minuet ♩=108
252
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timpani E A B
Timp.
Cym.
Crot.
Vib.
e-:i
iio
III
IV
Eb+:I
VI
e-:bII


Z
260
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
solo
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
VI
bII7
III
Bb+:I
IV


268
AA
Picc.
Fl. 1, 2
dolce
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
soli
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
V
B+:I
b-:i
Bb+:I
IV
III
vi


276
BB
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
V
I
IV
I
vii
Gb:I


284
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
tutti
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
II
Eb:IV
V
Db:I
ii
e:bII
V7


291
Gigue ♪=♪
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
brassy
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Gigue ♪=♪
Vib.
E+:I vi v i III v vi e-:III iv bVI bVII vi IV


CC
299
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
bells up
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
i v vi III bVII a-:VI bIV+ iv i v7 i

DD
308
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
bVII iii6 VI i VI i bII bIV ii7 V iv


316
EE
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
mp
pp
iv
iii6

324
FF
Key slaps
Valve clicks (any valves)
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
vii iii vii iv i vii v i


333
GG
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
ff
i
iv
iii6
vii
iii
vii

342
HH
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
mp
mf
p
iv i vii v i ii7 III IV Eb:I


II
350
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
solo
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
IV
II
e-:VI
bII7
III


JJ
358
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
Bb:I
IV
V
B:I
b-:i
Bb:I
IV


366
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
soli
III
vi
Bb:V
I
IV
I
vii


KK
374
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
tutti
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
Gb:I
II
Eb:IV
V
Db:I
ii


381
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Crot.
Vib.
e-:bII
V7
B7
B
Em


387
IV. Chaconne ♩=132
Picc.
Fl. 1, 2
Ob. 1, 2
sempre
Cl. 1
sempre
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timpani E D F# B
Timp.
Cym.
Bongos
Crot.
Vib.
b-:i
VII
VI
i
VII

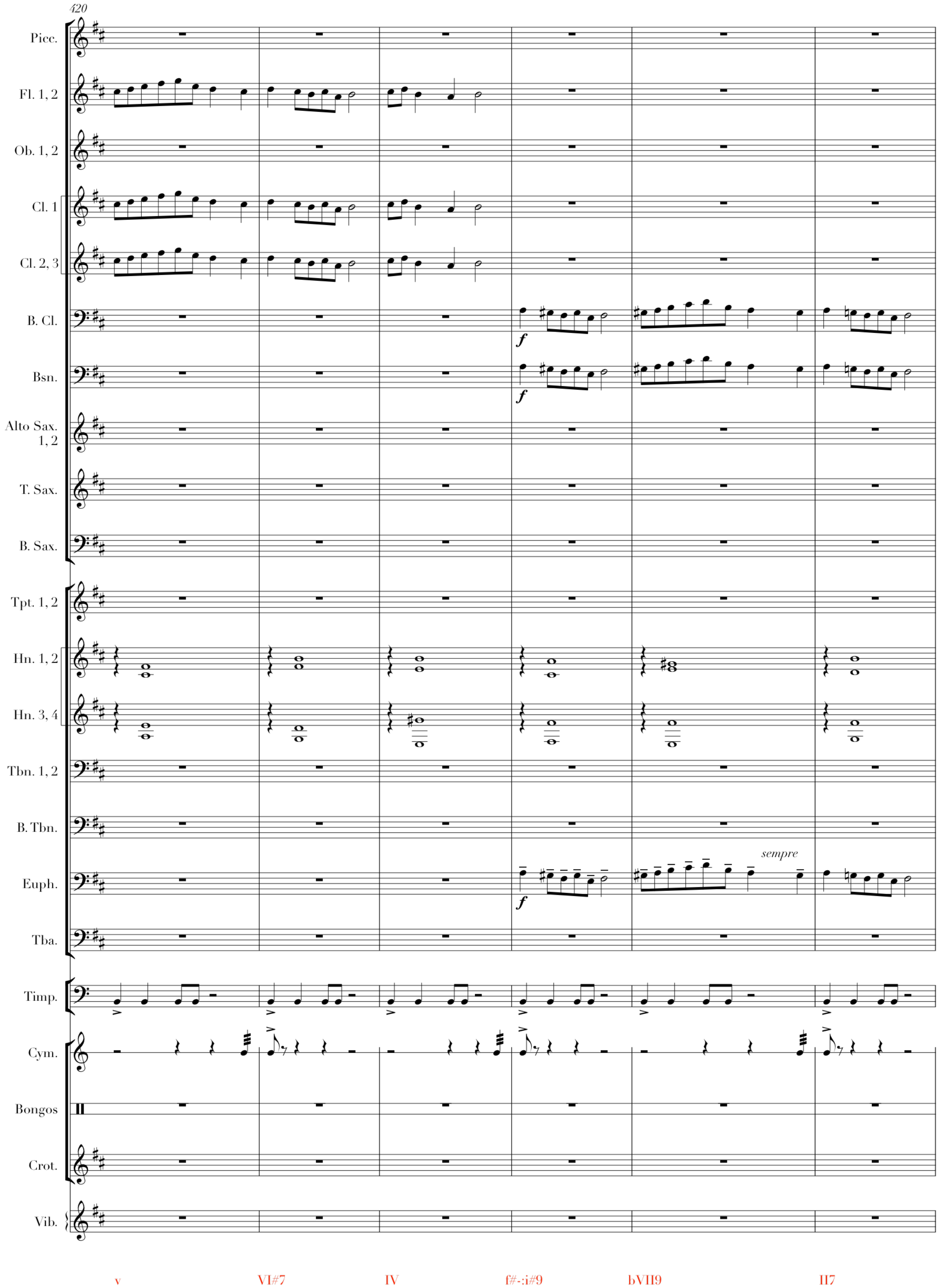

LL
393
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
sempre
f
sempre
sempre
VI
iv
I
VII
VI


398
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
sempre
sempre
sempre
iv
i
VII(11)


MM
403
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
sempre
sempre
i
VII
VI
iv
io
VII(11)


NN
409
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
VIb7
iv#9
i
VIIb7
VI


414
OO
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
sempre
f
ff
mf
iv
io
VII
VI
iv
i


420
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
f
sempre
v
VI#7
IV
f#-:i#9
bVII9
II7

426
PP
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
f
sempre
iv
b-:i7
v7
VI7
IV7
f#-:i9

QQ
432
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
sempre
sempre
sempre
sempre
IV9
II7
VI
b-:bVII
iv
VI7


438
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
i
I
iv
vi
IV9


RR
444
SS
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Crot.
Vib.
p
mp
mf
e-: iv
II
I
III
IV
V
i
d-: III


TT
452
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Crot.
Vib.
IV I bII III iv9 V i (I)


459
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Crot.
Vib.


465
UU
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Crot.
Vib.
bII6
bVII/b-:bVI
i
Bb:I6
vi6/4


471
VV
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Cric.
Crot.
Vib.
V/F: I
iii/e-:iv
VI
V7/V (b-:V)
b-:i


476
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
f
mf
VI
VI7
iVI7
bvii
VI9


WW
481
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
ii7
bII7
i
bvii9
VI9


molto rit.
486
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1
Cl. 2, 3
B. Cl.
Bsn.
Alto Sax. 1, 2
T. Sax.
B. Sax.
Tpt. 1, 2
Hn. 1, 2
Hn. 3, 4
Tbn. 1, 2
B. Tbn.
Euph.
Tba.
Timp.
Cym.
Bongos
Crot.
Vib.
ii7
io
bvii9
VI9
ii7
I

APPENDIX A: PERMISSION TO USE - DR. ANIRUDDH PATEL

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to a.patel

Hello Professor Patel,

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Thank you for your time, and for your inspiring work!

Sincerely,

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Patel, Aniruddh D. <a.patel@tufts.edu> 01/06/2015

to me

June 1, 2015

Dear Clare,

Glad my book was useful to you. You have my permission to use those figures in your thesis, as long as you provide a full citation to my book.

Regards,

Ani Patel

Aniruddh D. Patel
Professor
Dept. of Psychology
Tufts University
490 Boston Ave.
Medford, MA 02155

a.patel@tufts.edu
http://ase.tufts.edu/psychology/People/patel/

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to dmitri

Hello Professor Tymoczco,

I am a Master's student in composition at York University in Toronto. Please find attached my letter requesting permission to use some of the figures from your book *A Geometry of Music* in my thesis.

Thank you for your time, and for your impressive work - it always seemed to me that music was geometrical, but I could never have found a way to explain it as you do!

Sincerely,

Clare Pellerin

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Dmitri Tymoczko <dmitri@princeton.edu> 31/05/2015

to me

Permission granted!

DT

> On May 31, 2015, at 3:00 PM, Clare Pellerin <clare.pellerin@gmail.com> wrote:
>
> <Copyright Permission Dmitri Tymoczco.pdf>

...

Dmitri Tymoczko
Professor of Music
310 Woolworth Center
Princeton, NJ 08544-1007
(609) 258-4255 (ph), (609) 258-6793 (fax)
http://dmitri.tymoczko.com

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II. "Reigen," 5:31, https://www.youtube.com/watch?v=196B-qbuyN8,
III. "Marsch," 9:29, https://www.youtube.com/watch?v=JQYNIfxLqw8, all retrieved June 15, 2015.

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