



Universiteit
Leiden
The Netherlands

Harmonic duality : from interval ratios and pitch distance to spectra and sensory dissonance

Lach Lau, J.S.

Citation

Lach Lau, J. S. (2012, December 13). *Harmonic duality : from interval ratios and pitch distance to spectra and sensory dissonance*. Retrieved from <https://hdl.handle.net/1887/20291>

Version: Not Applicable (or Unknown)

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/20291>

Note: To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/20291> holds various files of this Leiden University dissertation.

Author: Lach Lau, Juan Sebastián

Title: Harmonic duality : from interval ratios and pitch distance to spectra and sensory dissonance

Issue Date: 2012-12-13

Chapter 4

Practical and speculative harmony

4.1 Some harmonic strategies

4.1.1 Harmonic logics of Tenney, Barlow, Johnston, Novaro and Wilson

Having presented most of the research done so far by visiting harmonic space and the language of proportionality seen under the hypothesis of harmonic duality, we can take a more panoramic view that pushes into compositional territory by reviewing and pursuing some tuning, system and navigation strategies.

When it comes to microtonality, Tenney, like most composers belonging to the tradition of the American Mavericks (Ives, Partch, Harrison, Johnston, Young would be also included here, other experimentalists are not so relevant for harmonic microtonality) accepts, as it were by decree, higher primes as harmonically assimilable. This is partly because of an experimental acceptance of sonic speculations, each departure point suggesting further experimentation and pieces. On the other hand, by pursuing different harmonic approaches throughout his *oeuvre*, we see various tendencies in setting materials into motion, with several extents and perspectives that depend on aesthetic effect. He uses pitch systems based on subsets of harmonic series which could be called ‘spectral’ in that they engage in chains of fundamentals and tend towards timbral outcomes (*Clang*, *Quintext*, *Spectral Canon for Conlon Nancarrow*, the series of *Harmonia*). Combined with his minimalist, anti-narrative, perceptual aesthetic that slowly reveals austere ideas and patterns, it makes a music which quite different from the French spectral movement of those same years. He also works with difference tones as generators of harmony in *Koan for String Quartet*, a harmonization of a long, slow glissando, that weaves proportional (micro) harmonies together with a pitch-distance logic, falling in and out of harmonicity as the different nodes in pitch space are traversed: similar to the rhythmic in and out of phasing of early Steve Reich’s *Piano Phase* but rendered in the harmonic domain. Other logics include the use of harmonic means in *Critical Band*, a long, sustained and slow transition from unison, beatings, roughness and timbral towards proportional harmony made possible through harmonic divisions: as the interval of division grows larger the timbral/proportional borderline is crossed at the critical bandwidth, when the timbral mixtures clarify into proportional stabilities. The last approach is that of different routes for crossing through harmonic spaces (*Bridge*, *Changes: 64 Studies for 6 Harps*, the series of *Spectra*, *Arbor Vitae*), all of these quite complex algorithmic works that bring together his interests in gestalt theory, ergodic form and harmony¹⁹⁴. It is in these last category of works that he takes tolerance more into account.

His harmonic aesthetic can be divided into two strands: that which tends towards consonance, limiting the proliferation of primes (the *Harmonia*, for instance) and that which is highly experimental, privileging inharmonicity and high primes (*Spectra*, *Bridge*, *Changes*, *Arbor Vitae*, or

194 This is not an exhaustive list of works nor an attempt to characterize of all of Tenney’s music. I am leaving much his output aside (such as his percussion, processual or equal tempered pieces), mentioning only the pieces which I think are important for delineating harmonic materials and logics. For more details on his microtonal music I recommend Wannamaker, R. (2008). The Spectral Music of James Tenney. *Contemporary Music Review*, 27(1), 91-130. For details on all his music previous to the early 80’s, see Polansky, L. (1983). *The Early Works of James Tenney*. In *Soundings*, 13, 119 – 297. Last retrieved June 7, 2012, from http://eamusic.dartmouth.edu/~larry/published_articles/tenney_monograph_soundings/index.html

Critical Band which transitions between the two aesthetics). *Changes* is particularly interesting in that he explores the harmonic space of 72-ET parametrically, in a stochastic spirit, following an ergodic logic¹⁹⁵ in harmonic space, a logic which is also taken over to the time scale of texture and sequence, pursuing sound configurations based in terms of temporal, dynamic and vertical densities, all in a state of continuous transition made possible by algorithmic interpolation between discrete states. The constraints and textural guidelines are supplied by an hexagram corresponding to each study, the aim being to achieve a maximum of variety of parametric states within a multi-level 'holarchy' and a multi layer approach (some studies are 'monophonic' some 'polyphonic'). The harmonic logic also has an additional modal compartment that includes various tonics and limits the pitches at a time to scalar subsets of 72-ET¹⁹⁶.

Elsewhere he proposes algorithms to build compact configurations in harmonic space through a growth path incorporating pitches that minimally increase the total harmonic distances of the set. This follows a crystallographic metaphor, some sort of chemical logic of least increase. The approach of *Arbor Vitae* is an organic metaphor of descent (usually he rises) from the high branches of a large tree (as high as harmonic 1300, octave reduced) all the way down to the root. The branchings consist of the harmonic series of each new prime, and they connect between themselves through the coinciding primes which are both roots of their branch and harmonics of some lower branch forming a mesh which, when the angles between primes are accommodated to be less than ninety degrees, looks very much like an arborescent structure. Locally, the branches and their leaves are harmonic amongst themselves though the higher they are in the tree, the more inharmonic they are to the main trunk and lower branches, something very similar to what happens with regards to antitonicity in my applications.

The case of Ben Johnston is quite different as he evolves from a just-intoned atonality passing through different phases of harmonic and stylistic experimentation. The main pieces I refer to are the string quartets, perhaps his main playground for microtonal development. His approaches almost always involve some use of variation technique in which the very tuning or fundamentals of the harmonic materials are varied. The fourth quartet is a series of variations on a folk tune, each variation involving different tunings together with the rhythmic and metric analogies of these ratios. The fifth is also a variation on tunings and a folk melody but this time with a focus on the 13th harmonic, sometimes juxtaposing different tunings against each other and effectively conveying the sonorities of the thirteenth harmonic as stabilities, even if very alien ones. His middle quartets, 6-8, explore further into unknown territory, being the most daring, especially the 7th which has been called the 'Mount Everest' of string quartets¹⁹⁷ (the first recording of it will come out around 2013, so I cannot comment on it yet). The 6th is a sort of expressionist quasi-atonal world in what seems like 11 or 13-limit intonation in a style reminiscent of early modernism, Silvestre Revueltas and Béla Bartók come to my mind. Quartets 9 and 10 on the other hand explore a speculative style that imagines what Classical music might have been had it not taken the 12-ET route, instead exploring extended chromatic harmonies. These spring from his theoretical research into ultra-chromatic spaces in the lattice, in which the small patches that define common tonality are expanded so that modulation can encompass more chords and tonalities than usual. Ultra-chromaticism can be extended in several dimensions, starting with 5-limit, in which classical Western harmony is expanded without introducing sonorities related to alien primes but by building chords on the

195 Ergodic behavior is, according to Tenney, a statistically homogeneous distribution of a sonic parameter over some structural time frame. In this case it means a constrained random movement through harmonic space. See his article on Form: Tenney, J. "Form In 20th century music", <http://www.plainsound.org/pdfs/Form.pdf> Last retrieved May 29th 2012.

196 Tenney, J. (1987). About 'Changes: Sixty-four Studies for Six Harps'. *Perspectives of New Music*, 25(1/2), 64-87.

197 See Gann, K. (2010). The Mount Everest of String Quartets. [weblog]. Last retrieved June 6, 2012, from http://www.artsjournal.com/postclassic/2010/03/the_mount_everest_of_string_qu.html

intermediate degrees and exploring tonalities not reachable in 12 ET. The other, more experimental approach includes both this expansion as well as the introduction of new primes. Johnston's strategies are more proportional than timbral, rarely using relations which involve a separation of steps in the lattice, instead following close-knit chains of relationships and without avoiding traditional connotations but pursuing them into unknown territory. Theoretically he makes a distinction between melodic and harmonic uses of harmony in order to produce scalar frameworks that are made simultaneously in harmonic- and distance-space by filling in each diatonic degree with prime-limited mixtures of intervals and doing this symmetrically within intervallic equivalences. He does not distinguish between consonance and harmonicity, his duality being more a horizontal/vertical rather than a timbral/proportional one¹⁹⁸.

Clarence Barlow's approaches are quite varied although not pursued for more than a single piece or groups of pieces normally. His timbral logics have reached into phonetics, with *Im Januar am Nil* (1984) being the one where he follows this path to the fullest extent, making musical patterns out of phonetic spectra. This has been taken further towards what he calls 'synthstrumentation' and 'spectastics'. The former is the use of spectral information used for instrumentation, some kind of electronic synthesis with acoustic instruments – as in the case of *Im Januar am Nil*, but there are quite a few other pieces involved, such as *Septima de Facto* (2007) and sections of his widely embracing orchestra piece *Orchidea Ordinaria* (1986). The latter method is the use of spectra as statistical probabilities for composing granular textural behaviors (used in conjunction with the other method). Other timbral approaches can be appreciated, as in *Approximating π* (2007), an electronic piece made out of a single overtone series in square waves, where the amplitude of each of its ten partials changes according to the 'Newton approximation algorithm' for obtaining the digits of π , creating a static harmony with an extremely fast internal movement that slows down into a stable timbre (taking 76 minutes to come to a standstill). His proportional developments include long, imperceptible transitions within an harmonic field, such as the different versions of *Until* (1975-78), each consisting of a melody against a drone which slowly changes from being consonant to dissonant, with an almost unnoticeable effect, the version for piccolo having an additional behavior of creating psychoacoustic difference tones with the sine wave drone. His most intricate developments include modal stochastic fields (*Cogluotobusisletmesi*), from which his algorithmic generator program *Autobusk* stems and where metric and tonal fields are coupled together, to be varied and traversed in continuous and imperceptible amounts. He also delves into what we could call 'hybrid' harmonies that consist of manipulations of harmonic effects of various cultures and styles (such as the mixture of Clementi, Schumann and Ravel in *1981* (1981), the Western and Indian logics of *Ludus Ragalis* (1974-2006), or a study of septimal blues harmony in *otodeblu* (1997).

Augusto Novaro is one of the pioneers of microtonality, following Julián Carrillo's footsteps but eventually taking a proportional route that precedes and differs quite a lot from that of Harry Partch. As recounted in the introduction to his self-published book *Sistema Natural de la Música*¹⁹⁹ which wraps up into a systematic treatise many years of research, he discovered/invented, after the deception of having unsuccessfully experimented with equal intervallic divisions, a musically fruitful arithmetic method of intervallic division. He names the smaller of the numbers of a co-prime ratio²⁰⁰ the *fundamental*, the larger *co-fundamental* numbers, building from them arithmetic series that divide any interval into any number of ratios, all within whole number arithmetic. He then finds reciprocal series, corresponding to inversion and to harmonic (as opposed to arithmetic) means. Together with transposition of these scalar/chordal structures (called gradual series) a wealth of

198 Johnston, B. (2006 [1976]). Rational Structure in Music, *Maximum Clarity*, 62-76.

199 Novaro, A, *Sistema Natural de la Música*, Mexico City: Author's Edition, 1951.

200 'Co-prime' is just the mathematical jargon meaning that the numerator and denominator of a ratio have no factors in common, they are prime amongst themselves. It is what we have called a reduced ratio, meaning its terms cannot be further factorized.

combinations that produce scales and chords is made available (complex series, which combine the four kinds of series).

The first part of Novaro's book investigates his arithmetic series, turning afterward to geometric series (logarithms) that lead him to investigate tolerance and approximations to just and unequally spaced intervals. His visualizations revolve around logarithmic spirals, from which he developed the resonance chambers for his *novaro clave* microtonal piano. The second part of the book concerns practical music or ways to perform and approximate these discoveries as well as the instruments invented for this purpose, such as the 'acoustic boxes' made to experiment with 15, 19, 22, 31 and 34 divisions per octave. 53 ET has a dedicated section that explores all of its intervals (the fifty third root of two is very close to a 81/80, a bit less so to the 64/63 seventh comma, and a bit more than the Pythagorean comma, showing perhaps why this temperament approximates so well many 3, 5, 7 and even some 11 and 13-limit ratios). This temperament is studied in a diatonic manner, having up to 8 levels of sharps and flats between each degree. Since Archytas' harmonic means there have been no developments in harmonic theory concerning arithmetic ways for generating of intervals. Novaro does not take Archytas as his departure point though. As far as it goes, and as it is common in harmony, he came up through independent *a priori* deductions after years of tribulations which almost led to him abandoning music. The series are implemented in *Dissonance Lib*, providing departure points for some current compositions I am pursuing²⁰¹.

In terms of innovation in the proportional realm and the harmonic lattice, Ervin Wilson holds a prominent place, and I think his ideas will take some years to be assimilated and pursued, as he is not completely a composer, instead balancing between a theorist and an inventor of tuning systems. His logics are arithmetical, exploring patterns and numeric structures lying close to the confines of number theory and diophantine equations ('pairs' and 'triplets'). These arithmetic discoveries include inventions such as 'moments of symmetry', 'combination product sets' and 'co-prime grids'. The latter are interesting because they embrace several kinds of arithmetic series: the 'lambdoma' which is a form of Farey series, as well as the Pierce, Fibonacci and the Novaro series. These grids are made through the combinations of co-prime numbers found through triangular and rhomboid graphical structures out of which musical ratios are derived. Wilson acknowledges his indebtedness to Novaro and Joseph Yasser, concluding his investigation into the grids with a beautifully weird Pythagorean metaphor: 'An Hyperdimensional co-prime pattern fills the paradisaal infinitude'²⁰².

His arithmetic structures are expressed in geometrical ways, forming subsets of the harmonic lattice that represent primes and connections between consonant intervals with different angles, forming projections of hyper cubes, hexagons and other figures, some of which have been used as templates for microtonal keyboards. He names them hexanies, eikosanies, stellate harmonies, diamonds, mandalas, spirals, scale trees, zig-zag patterns and even more²⁰³. He combines both arithmetic and geometric logics and offers an epistemology of pitch in which he talks about three levels of musical

201 His series rapidly grown into high dimensions in harmonic space, not being prime limited, so in terms of the lattice they are a bit complex to follow. Beyond the scope of this thesis I am laying the ground for an article researching how his series relate to the classical Greek means and *katapyknosis* as well as how they comport in harmonic space. As is the case with arithmetics, apparently trivial constructions give rise to complex structures which can be musically fertile.

202 Wilson, E. (2000). Pecan Tree Patterns, in a Nut-Shell. [PDF photocopies of author's research]. Last retrieved June 6, 2012, from <http://www.anaphoria.com/peach.pdf> I will leave to the reader any interpretation or link regarding this phrase that I could not help including even if it does not follow from the argument.

203 Most of his research consists of pencil and paper sketches of his discoveries, as well as letters to prominent microtonalists. His disciples are taught in the way of an oral tradition so he has not published any systematic books. Most of his letters papers and letters reside in <http://www.anaphoria.com/wilson.html> Last retrieved June 8, 2012, but more information (including explanations for lay people) can be obtained at <http://www.thesonicsky.com> Last retrieved April 5, 2012, and the integration of his theories into wider microtonal research is found in the Xenharmonic wiki: <http://xenharmonic.wikispaces.com> Last retrieved June 8, 2012.

abstraction. The first corresponds to musical reality and feeling (most music), the second to the theories, rules and methods behind musical reality, while the third is the ‘master set of ingredients’ in which developments of the infrastructure of music, the amplification of its gene pool, takes place: tuning systems, microtonality. He also mentions a mystical fourth level beyond the whole number grids he develops, a ‘skylight’ level of the creative act, inseparable from perception, where musical systems become dynamic.

4.1.2 Some of my approaches to harmonic space

Furthering the descriptions of approaches to dissonance curves delineated in section 2.1.2, I would like to focus now on harmonic strategies and the pieces composed during this research. Here the topics intermix as the ordering is done with regard to individual pieces and not to the chronology of the research topics. Some span from the theory, some provided a platform for theorizing, some both, but it is difficult to tell because of the intricate nature of the research. The review will not be a full description of the pieces, but will be centered mainly on their harmonic workings. I have already delved into some detail on *Clinamen* in section 2.1.2 and *Circular Limit* and the *Logos sessions* in 3.2.2. In this section I will talk about four more pieces plus a bit of what lies ahead at the moment of writing.

4.1.2.1 *rolita pa modelo* (2007)

Generally I work by inventing a tuning or harmonic *modus operandi*, then devising a logic or navigation scheme in order to either discover what may happen through that logic, or mix it with and be loyal to a drama/affect/concept overriding the work. My first probings into dissonance curves were of the first kind, in the piece *rolita pa modelo* (2007) for chamber ensemble. It is based on a rather static single pitch set derived from a mathematical spectrum (a sawtooth wave)²⁰⁴. This set was traversed through random weighted choices, producing different subsets of the set through the harmonicity windows through which it was filtered. These windows work like ‘tendency masks’ (a term coined by composer Gottfried Michael Koenig) that let through only intervals within a minimum and maximum harmonicity threshold. These thresholds continuously change during the piece. The work adapts to the 8 piece ensemble by approximating to 12ET for most instruments with a few important notes of the set intoned outside ET (relatives of partial 11 played in quarter tones in the flute and 7th harmonic related sonorities obtained by retuning a few of the harp’s strings). Most of the algorithmic generation was used to create the soloist harp part, which was later enhanced, embellished or counterpointed with the other instruments, with various functions assigned to different sections of the ensemble. The guitar, for example, plays the role of commentator to the harp, the other instruments generally support it by extending with resonances and furnishing it with decorations. Throughout the piece there are some interludes that interrupt the process, where the instruments emancipate from their assigned roles and the harmonies become transposed and more complex, resting in crucial chords that are required to be played in exact microtonal tuning. Here instruments other than the flute and harp also play microtones.

The general consistency I was looking for in the piece was to arrive at a polyphony that is a by-product of texture (of notes chosen randomly within the harmonicity limits) and not the usual way,

204 The pitch set comprises 3 octaves upon a fundamental G₃: 1/2, 8/15, 5/9, 3/5, 5/8, 2/3, 31/45, 7/10, 11/15, 3/4, 7/9, 4/5, 5/6, 13/15, 7/8, 8/9, 9/10 (lowest octave), 1/1, 11/10, 10/9, 9/8, 7/6, 6/5, 5/4, 13/10, 4/3, 11/8, 7/5, 13/9, 3/2, 14/9, 8/5, 13/8, 5/3, 7/4, 16/9, 9/5, 11/6, 15/8 (central octave), 2/1, 13/6, 11/5, 9/4, 7/3, 12/5, 5/2, 13/5, 8/3, 11/4, 14/5, 3/1, 16/5, 13/4, 10/3, 7/2, 11/3, 15/4, 4/1 (upper octave). They are more or less common just scales with extended clusterings of intervals around the thirds, tritones, sixths and sevenths.

where texture is a result stemming from fixed polyphonic assignments. In this way the density of voices and their vertical/horizontal relationships change constantly between independent, chordal and timbral (supporting) roles. I like to listen to it as if it were an immersion into a single resonance (with some added intermezzos) from different sonic perspectives.

4.1.2.2 '*strings*' (2007) and *Ahí estése* (2011)

The next project done that same year involved the real time triggering of dissonance curve materials for the piece '*strings*', for guitarist, speakers and live electronics. Most of the technical work involved 'fine tuning' the interactive music system in order to obtain a perceptually clear link between what was played by the guitar (or any other kind of input) and the resulting chords and textures generated by the computer. This meant finding optimal windows for the spectral analysis to be further processed by extracting the highest partials and deciding which of them was to be considered the fundamental. There is also a separate pitch detection running in parallel in order to compare with the spectral fundamental and because having both options is useful as they produce different results. It is from the most prominent partials, usually between 8 and 10 of them, as well as from the overall amplitude and the fundamental, that the curves are calculated. After that, they are rationalized and their harmonicities calculated. The timing aspect is crucial as the curves take a few seconds to calculate and make their effects heard (this was in 2007, now with faster computers this time has gone down by at least a factor of 10).

Once the dissonance curve pitch sets are obtained, several kinds of textures are built upon them, some being simple chords, some with moving layers, others involving scalar canons, random textures as well as several combinations of these. They are made with synthetic timbres, mostly based on derivations of sine waves and filtered noise. A single texture combines several timbres in various layers. The musical interaction is based on a feedback process of '*acousmatic* imitation' between performer and computer, the former deciding the moments of mimesis by triggering the curves and textures with a foot pedal. The reaction to the computer is through a global mode of listening, embracing not only pitch but pertaining also to timbre and texture. The resulting actions consist not only of notes, but also sounds aggregates ('clangs') called for by the sonorous context. The score has instructions which refer the musician to follow or go against the computer, so that the resulting sounds blend and 'concord' with the electronic textures or contrast and stand against them. It is an interaction with the computer through *écoute réduite*, as it could be said that the machine listening implied by dissonance curves is of this kind. The interaction process is improvisatory but not an improvisation: the performer is not supposed to 'jam' but to stay closely connected with the sounding environment and be open to wherever this process might take him/her and the computer. The causal relationships have to follow the timbral setting in connected chains of sonorities where spectra and pitch are the main centers of action. The piece uses timbral harmony almost exclusively.

On top of this feedback process, the structuring of the piece is carried out by means of a graphic score that states the general guidelines for each of the six panels that comprise a performance: articulation, texture, pitch, dynamics and 'style' – such as '*cantus firmus*', '*bailey-esque*' (Derek Bailey type gestures), '*Mississippi delta blues*', and others. The guitar has a microphone in the neck, with which computer controlled feedback is produced when it approaches any of several speakers placed over the performance space. This begins to happen in the last third of the piece. Its overall principle is a change in focus from 'micro' pitch-timbral responses of the beginning, gradually growing towards 'meso' gestural textures, eventually making the guitar player play with his whole torso, moving the guitar neck around the speakers and provoking feedback to be interacted with through movement. In the last two panels the process continues its movement outwards to the 'macro', when

the performer walking around the space, producing feedback with the extra speakers in the room. The piece deals with a gradual change of attention from micro-time and spatial aspects of timbre towards the macro aspects of performance and space, passing through the middle phases of texture and instrumental gesture. It ends with the guitar player walking out of the room or falling still and quietly back in the center of the speaker arrangements. The tuning of the folk guitar (acoustic guitar with steel strings) is based on a dissonance curve of a low D2 string: $1/2$, $1/1$, $14/5$, $13/4$, $7/4$ and $5/2$. Many extended techniques are called for (though suggested by the performers, one of the reasons why the piece is quite different at every performance and with different guitar players), including the use of e-bow and bottleneck.

The interaction includes a role and a score for a computer performer (me), controlling the scope of the behavior of the computer for each panel. It permits some room to modify the textures and the feedback section, so there is an extra layer of direction over what is happening. The piece has been played with several speaker configurations and with three different guitar players: Tom Pauwels, Matthias Koone and Carlos Iturralde.

Last year, I had the opportunity to present a modified and updated version of this system as an installation. Many improvements were made to the machine listening strategies (beginning with the fact that my laptop now is around 8 times faster) permitting more analysis and less time between triggering and the sounding of the textures. The main change in the system, however, was that it is now triggered automatically by amplitude thresholds. The installation is called *Ahí estése* which is a reference to *aisthesis* with a very Mexican way of saying ‘stay put’. The allusion to *aisthesis* is a metaphor for the ‘sensory ether’ where perception occurs, as the analysis extracts and puts into motion the harmonic qualities inherent in sounds in the same way as intellection (*noesis*) infers abstract forms (*eide*) from sensory data.

The intention is to harmonize an environment with which the audience can interact. The setting is with quadraphonic speakers in the corners of a space and a microphone in the middle. There are several behaviors programmed into the system, akin to the textures in ‘*strings*’ but covering more possibilities and layers. The dissonance curve analysis goes further than before, including harmonic space partitions and virtual pitch, so every texture has 3 strata of ‘orchestrations’, each possibly comprising more than one layer: a timbral one, a harmonic one, and another with a virtual fundamental (usually very low and derived from a virtual pitch algorithm). The thresholds act both in time and amplitude, so that only long enough sounds cause triggers, making the computer screen flash like a camera to notify the users that a ‘sound photograph’ has been taken. The thresholds automatically change their values slightly, so occasionally relatively quiet sounds can trigger the analysis, sometimes only louder and longer ones. It is also designed to be triggered by itself every so often: the sounding textures will provoke a trigger, keeping the sonic results in variable constant change even when no interaction from the audience is happening.

The behaviors/textures also include a wider range of variability than in ‘*strings*’: tempos, timbres, rhythmic arrangements, ‘orchestrations’, along with spatialization. The behaviors are quite contrasted between each other. For example, one of the behaviors produces canons of harmonic intervals in ways inspired from (but not sounding like) Tenney’s *Spectral Canon for Conlon Nancarrow*, the canons making circles around the quadraphonic field and accompanied by fast swirling sparks of high timbral intervals and a slow drone in the virtual pitch stratum. Another behavior is very rhythmical and staccato, providing several layers of tuplets derived from the intervallic proportions. Each layer has its own comportment, usually at a different time scale from the others. In some behaviors the tempos change automatically, in others they are fixed.

The installation contemplates interventions by musicians and sound artists to incite and make tangible the sonic potential of the system. They have been barely tapped upon as the installation

was presented during a limited amount of time. These interventions are planned as controlled improvisation sessions guided by open schemes and using some microtonal and timbral strategies to drive the system. There is also a plan to present it in a larger space which has 21 speakers around and above the room. The idea is to position the intervals in the room according to their coordinates in harmonic space, rendering the proportions spatially.

4.1.2.3 *Blank Space* (2009)

Many topics discussed in this research concur in this piece. It includes dissonance pitch sets chorales, partitions and granular harmony together with the *polyrhythmia* algorithm discussed in Section 2.1.2 regarding *Clinamen*, here used for the first time (still in an old and buggy version, as it was one of its first compositional tryouts). It is for clarinet, piano and soundscape.

Material is derived from a sound recording in order to structure many aspects of the piece, such as the harmonies, rhythms and form. I decided to use sounds relating to war, at first wanting them to relate to Mexico's president's insane and brutal 'war on drugs' – by now, after some 80,000 estimated deaths, he does not call it 'war' but 'struggle', but in late 2008 he still did, – but after not finding sonic examples that could be specific to it, I delved into the by then stereotypical Iraq war – for which I had already done a piece in 2004, – which is why the piece begins with an Iraqi Assyrian funeral chant. By the beginning of 2009 however, when the piece was underway, the bombing of civilians in Gaza overtook everything else and it is from this conflict that the rest of the sound material is taken.

The score was generated algorithmically. The first part is based on the moving canons produced by the accelerations/decelerations in several voices of the *polyrhythmia* algorithm. The beginning section proceeds like regular contemporary music: abstract, 'interesting' gestures and rhythms over a wide *ambitus* in both instruments, accompanied by rhythmic layers of synthetic electronic sounds. The pitches derived from the Assyrian chant which introduces the section follow naturally from it. The *polyrhythmia* steady state rhythm is a 4 to 3 polyrhythm in 4 voices; it begins with vertical chords that begin to diagonalize, producing shifts and melodic fragments that gradually fall into the steady rhythm; afterward the process is inverted, taking about as much time to fall back again into vertical sync (each component process lasts about a 45 seconds). The whole process is repeated twice but because of the changing pitches and the way the different coincidences were transcribed, it turns into a quite different variation. The textures are produced when coupling the rhythmic process with the pitches, which are selected from variable harmonic windows (tendency masks), as in *rolita pa modelo*. The texture was transcribed freely for the two instruments, writing manually in an improvisatory manner over the generated textures, like 'connecting the dots' between the isolated abstract notes generated by the algorithm or as with a star map, looking for melodic and harmonic coincidences or interesting interactions between the instruments, varying the articulations and dynamics at will in the interest of creating a layer of musicality upon the 'dry' algorithmic process.

At a certain stage, after having been a good example of well behaved contemporary music, the music steps out of itself at the same time as the world and reality enter into it. As this reality is related to events that happened at the time of composition, they were not completely chosen. First there is an electronic transition from the last chords of the *polyrhythmia* process that begin with the Assyrian voice but turn into a mixture of chords and voices, finally to emerge as the voice of Israeli Foreign Minister, Tzivi Livni saying 'we are going to change reality'. It is at this point that the piece goes astray and several episodes ensue where the piano and soundtrack harmonize sound recordings of voices and bombs by way of solos separated by electronic chords. The voices are taken from statements by Livni relating to 'reality' and the minimization of civilian casualties. The dissonance

textures are transcribed for the piano and electronics in several different ways and rates simultaneously, going up to granular speeds by the fourth interlude, the harmonization of an explosion turned into an angry piano solo (whose performance in the recording done in 2012 by pianist Gabi Sultana is particularly stunning). The harmonizations include all features of dissonance harmony: partitions, virtual pitch, textures at several times scales and granular harmony. Together, piano and electronics make for multilayered dissonance chorales which follow the contours and inner harmonies of the voice recordings, sometimes even harmonizing the very noise of the recording medium (highly compressed audio downloaded from the internet). In the case of the bomb, the electronics make a chorale out of the piano solo, in a way making for a dissonance chorale of the second order: one made of the piano which itself is a texture derived from the kaboom²⁰⁵.

Afterwards the clarinet makes a solo accompanied by a recording I found of the bombing of a school that took place in those days. Here I used the *polyrhythmia* procedure in a different way, one which still holds promising possibilities. The core rhythm/spectrum which is fed to the algorithm is a transcription of the Assyrian chant fragment, here pitch and rhythm are specified together. It is then deployed melodically, instead of polyphonically: the several layers that comprise the canonic acceleration/deceleration are conflated into a single voice, producing a beautiful ornamented melody which feels like variations on the archetype and hands a middle eastern kind of flavor to it²⁰⁶. It begins with the phrase/cell, wanders around for a while, arrives in the middle at the melody again to vary differently till the end of the process, where it falls again into vertical chords where the piano resumes. During this clarinet solo, the horrible soundscape begins to include a chorale made out of harmonies derived from the bomb of the piano solo, which lead to the ending chorale. It is a somewhat tonal chorale, the analysis having extracted the core periodicities from the noise of the bomb, most of them used by the instruments in equal temperament. The electronics have two layers made out of timbral and harmonic subsets, providing both types of microtonal pitches, making for a harmony that is both tonal and close to the center of harmonic space but also has outer orbiting constellations at various speeds with timbral components. Even the harmonic pitches sound at the same time congruent with the chords and are a bit outside normal tuning, making for a mixture which I find compelling.

After some performances I decided to include a voice into the ending chorale, feeling that the political nature of the piece was a bit drowned in the musical process. It consists of a computer generated voice speaking quotes from architect and theorist Eyal Weizman, relating to the ‘blanking out’ of civilian populations and the policies of war²⁰⁷. The title of the piece is itself taken from a mention by Joseph Conrad of ‘the blankest of all blank spaces’ when referring to the disastrous colonization of Congo by the Belgian King Leopold II in the late XIX century. The title is also related to philosopher and political theorist Bolívar Echevarría’s concept of ‘whiteness’ (*‘blanquitud’*): ‘Whiteness is a concept than can serve to explain the reasons for selective genocide in the contemporary world: why do we deliver certain populations to sacrifice, why do we condemn them to die.’²⁰⁸

205 Dissonance analyses of several orders are an interesting future avenue for research: generating a texture from dissonance curves and then making an analysis of that texture to produce yet another one, and so on. It would produce always changing but related textures and harmonies within a clearly perceivable process.

206 The uses of *polyrhythmia* where ‘quantized’ to sixteenth notes for this piece. In *Clinamen* (2011), as discussed in section 2.1.2, the process is deployed ‘as is’, with a much more refined formula for the tempo changes and in many more voices (more than twenty as opposed to four at the beginning of this piece and about 7-8 in the melodic rendering we are discussing now).

207 Weizman, E. (2010). Political Plastic (Interview). *Collapse*, VI, Falmouth: Urbanomic, 257-303. The quotes I took are ‘lesser evil’, ‘tolerated sin’, ‘violence itself legislates’, ‘how much will still be tolerable’, ‘not by the victims, of course, but by others who are watching’, ‘moderation of harm’, ‘the magic number was 30’.

208 Echevarría, B. (2010). Occidente, Modernidad y Capitalismo (interview by Carlos Oliva Mendoza, in Spanish). *La*

It is a piece I like a lot, quite unlike anything else I have written and, at the same time, a piece I feel quite uncomfortable with, very exposed and touching delicate matters. It has an aura of prayer or some kind of supplication, something I never noticed during its making, probably due of the solemn subject matter and also because chorales, be them of any speed and kind, tend towards this kind of music.

4.1.2.4 *Chamba de um acorde* (2011)

This piece pursues my interest in the relation between pitch and duration. This time a pitch set is constructed that does not derive from dissonance analysis but from mathematical curiosity. Working in this piece is where I came up with the method to separate a pitch set into its mixtures of fundamental intervals, entailing collecting mixtures for each prime and its combinations with all the lower primes. Hence, octaves will form a set, mixtures of 2s and 3s another one, 5 combined with 3s and 2s, 7s with 5,3,2, and so on. The pitches were generated through arithmetic series from primes up to 11, limiting their size to 36:

2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36
 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36
 5, 10, 15, 20, 25, 30, 35
 7, 14, 21, 28, 35
 11, 22, 33

With duplicates removed and sorted, it looks like this:

2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 18, 20, 21, 22, 24, 25, 26, 27, 28, 30, 32, 33, 34, 35, 36

Converted to ratios:

1/1, 3/2, 2/1, 5/2, 3/1, 7/2, 4/1, 9/2, 5/1, 11/2, 6/1, 7/1, 15/2, 8/1, 9/1, 10/1, 21/2, 11/1, 12/1, 25/2, 13/1, 27/2, 14/1, 15/1, 16/1, 33/2, 17/1, 35/2, 18/1

Octave reduced (useful for showing distinct harmonic hues, with rounded cent values below):

1/1, 33/32, 17/16, 35/32, 9/8, 5/4, 21/16, 11/8, 3/2, 25/16, 13/8, 27/16, 7/4, 15/8
 0, 53, 105, 155, 204, 386, 471, 551, 702, 773, 841, 906, 969, 1088

The unreduced pitch set is then separated into prime mixtures and affixed to a fundamental of A1, 55 Hz, displayed here ordered by their highest prime in the mix (left), note names with cent deviations from equal temperament, and as ratios (below each note):

2:	A2, 0 2/1	A3, 0 4/1	A4, 0 8/1	A5, 0 16/1				
3:	E2, 2 3/2	E3, 2 3/1	B3, 4 9/2	E4, 2 6/1	B4, 4 9/1	E5, 2 12/1	F#5, 6 27/2	B5, 4 18/1
5:	C#3, -14 5/2	C#4, -14 5/1	G#4, -12 15/2	C#5, -14 10/1	F5, -27 25/2	G#5, -12 15/1		
7:	G3, -31 7/2	G4, -31 7/1	D5, -29 21/2	G5, -31 14/1	B5, -45 35/2			
11:	Eb4, -49 11/2	Eb5, -49 11/1	Bb5, -47 33/2					
13:	F5, 41 13/1							
17:	A#5, 5 17/1							

Up to here the material was calculated with the computer in interactive sessions such as the one described in section 3.1.6. Once the premises were decided on, most of the piece was written

Jornada Semanal, 805. Last retrieved August 5, 2012, from <http://www.jornada.unam.mx/2010/08/08/sem-carlos.html>. My translation.

spontaneously, in the way of an improvisation over its materials, in about a week (in contrast, the piano solo and the transition to the end took almost a month). This idea is to distribute the pitches among the instruments, setting them into proportional rhythmic grids, making the piece a set of variations upon these subsets and their instrumental and rhythmic allotments. The duration of each variation was determined in part with the falling in sync of the rhythmic phases, but also having to do with trying to extend each panel as much as I felt was plausible before the setting exhausted itself.

The distribution of pitches allocates 2s and 3s together, the 5s by themselves and the higher ones being packed together in various manners. During most of the piece, the intervals are approximated to equal temperament which means that the more complex ones get conflated into pitches shared by other ratios. There are breaks in the rhythmic process, though, when the instruments play vertical arrangements and the flute and clarinet are asked to play exact pitches. This means the higher, difficult to perceive primes (11, 13, 17) rear out their heads from time to time. I was seeking for a harmony at the same time static (in the sense of non modulating) but also colorful, neither tonal nor atonal. I found that the premises for the writing opened up to fruitful discoveries instead of wearing themselves out quickly.

The rhythmic assumption was to ‘transpose’ the rhythmic analogies so that 2s and 3s are played in rhythmic multiples of twos, 5s are in triplets and higher intervals in quintuplets. This because I think (and argued in section 1.2.7) that rhythm is more sensitive to periodicities than pitch, so it is reasonable to play the intervals in simpler rhythmic relationships than their literal counterparts, one step below, as it were: 3 goes to 2, 5 to 3, and 7 and higher to 5, retaining the rhythmic complexity from getting too complex. The piece is fixed most of the time on 3:4:5 rhythms (together with ‘octave’ transpositions of them) in diverse settings, which meant incorporating metric modulations to diversify the speeds and relationships. The pitch contours result from patterns of permutations together with accents and grouping that produce conflicts between the additive meters and the multiplicative rhythmic grids, as when 7/8 meters collide with 5 against 3 multiplicative relations. Most of these processes tend toward staccato textures, sprinkled with long contrasting tones.

Once it was felt that several possibilities had been used, I wrote a piano cadenza consisting of three variations that incorporate many of the previous configurations within a single instrument. It increases in intensity, leading to the entrance of the trio in a section of 10:3:2 rhythms in the maximum density and difficulty whose culmination leads to the last large section of the piece where repetitions of periodic cells in 3:4:5, deployed against a 4/4 bar, are gradually infected with silence, this leading to the ending section where chordal islands are formed out of the remains of the process. Chords and bits of the rhythms that survive the eruption of silence form isolated and progressively sparser textures. This section was aided by algorithmic calculations for the introduction of silences into a the process, letting the holes suggest the formation of these islands as if by overlays or masks intersecting the inexorable rhythms.

Chamba is a polyphony of cycles and combinations of periodicities, producing an effect analogous to various bicycle wheels spinning at different speeds and interfering with each other, a sort of auditory equivalent of a visual *moiré* pattern, a bit like the way Galileo explains commensurability as the conjunction of different but related cycles. The writing of this piece broke a spell of almost a year in which I lost many of my reasons to write music. The title alludes to Antonio Carlos Jobim’s *Samba de uma nota*, but in Mexican Spanish ‘chamba’ means ‘work’ or ‘labor’ and its about a chord instead of a note.

4.1.2.5 Future directions

I am sure this research will bear most of its compositional fruit after the period in which it was

realized. Now that I am about to conclude this thesis I would like to mention some of the ideas I have for a piece that will sum up and pursue further some of these findings, intended to be performed as part of the graduation.

The planned piece is for ensemble *Modelo 62* and is intended as a piece in multiple parts, each exploring a different but related idea or a similar idea in a different form. I have been pondering on how to set up a different relation between the score and the performance, to include more open settings that can produce multiple results within a single specified material, logic and form instead of fixed notations. I want to specify pitch sets and temporalities that are subject to decisions in performance that can unfold the harmonic aggregates, with a view on providing multiple ways of interaction within the ensemble. The tunings must be quite different and subject to idiomatic adaptations, pursuing, for example, *scordaturas* and extended techniques but also involving equal temperament and mixtures of approaches. The various kinds of rules will determine the character of the music, which can change according to different options for the rules, so that they can together make series of pieces or sections. For example, the relation between duration and harmonicity, as in Tenney's notion of 'activation of nodes' in harmonic space, can be established so that far away intervals have long durations and low loudnesses while harmonic intervals become short and loud; inverting this relation (producing relations which are more 'conventional') can produce interesting variations/contrasts within a piece or between pieces. There are other possible variations on this single idea.

During a recent course I was involved in which Michael Pisaro gave a lecture on his music, I was stimulated by an idea present in some of his pieces in which sound field recordings are 'framed' with sine waves of random frequencies. The effect is that they always tend to coincide with some components in the sound field, or that there is at least a tendency to make the relation in the listener. This made me think that the connection between random, fortuitous pitches and specific harmonies can be established in an effective way, opening prospects for approaching harmony simultaneously in timbral and proportional ways. This can be coupled with a tendency towards sparse textures, where there is not so much activity but a space where there is enough information to bring the listener in, contrasting the usual tendency of composers (like me!) to anxiously fill every moment in the music with 'exciting' events. The inclination is to have few but requisite sounds in order to pursue a different approach to the deployment of pitches, seeking the subtle complexity that Ben Johnston talks about not only in the intervals themselves but also between them and in relation to their background, a kind of harmony that summons the listener instead of emitting a great deal of sound waves and information. Complexity as seduction or allurement instead of pouncing and oversupply. The ending section of *Chamba de um acorde* already moved toward this situation, which I want to pursue further: rarefied textures, rhythmic structures framed through overlays that result in textural islands surrounded by silence or other types of framings. I want to take this further both in terms of diaphanous configurations as well as divergent processes either towards densification/sparseness or without going anywhere, simply retaining aloof states of affairs (ergodicity, in Tenney's terms).

The rules and procedures that govern these processes can be inspired by some methods of Cage's school for setting materials into motion, but in a way that does not seem forced, but that arises, one may say, 'organically' from out of my musical approach and style of composing. For this, I think Christian Wolff and Earl Brown's notations and strategies can be of more aid than Cage himself. Only time will tell what will come of this, and this is an example where the thesis will leave off into new musical territory, one which will be still included in the doctoral research but which, in all probability, will bear fruits further along the way, jointly with newer approaches to pitch, harmony, texture and form.

The harmonic strategies that are glimpsed are:

- Vectorial (i.e, based on the coordinates of the harmonic lattice), functional, approaches for generating and moving within harmonic space, by using, for example, chains and combinations of functions: chords with tonic, dominant, mediant, seventh, elevenths, each of which can move its coordinate forward or backward in harmonic space, thus producing varieties of chords, all of which are close to each other, closely connected, and at the same time being complex and with a consistent sonority. The ensemble setting can be done by giving musician or sections a single harmonic function in which to concentrate their performance, each moving in a single axis of harmonic space instead of embracing many complex intervals at a time.
- A Novarian approach using his series of divisions to densify harmonic intervals, from large to small ones (or the other way around), abstractly generated and probably in combination with computer interaction, for example, by putting musicians ‘inside’ a varied version of my sound installation *Ahí estése*, with different behaviors customized for the purpose, where the intervals played by the musicians serve as *provocateurs* that direct the process. Any interval can be divided into any number of parts, with and without reciprocal intervals, producing varied chords and pitch sets from which to choose relationships. The crux of the matter is to devise a logic to the way the divisions are realized: which intervals are divided, into how many parts, and in which order, something which has to be determined by experimenting with them.
- 53ET investigations such as the one shown in Appendix III, from which large partitioned pitch sets will be the starting point for setting up processes from which the ensemble will perform over rule based open structures. This temperament has many seven based intervals, together with a few interesting eleven based ones plus many of the usual known ones in five limit. They will be organized proportionally around fundamental intervals as well as in pitch distance space. There is the idea of specifying the open pitch gamuts to be played depending on specific rules that take into account the microtonal possibilities of each instrument. I want to also add rhythmic gamuts to the pitch partitions, giving each pitch region a corresponding temporal grid and letting the instrumentalists handle the connections. A conductor could give a common pulse but that is not completely necessary because the clouds and textures that may ensue need not be synced to a common pulse, and this may function even more flexibly and musically than in a completely specified written out form. A bit like the way the coincidences between sine waves and sound fields happen but in the domain of note aggregates.
- Partitions: musicians will play gamuts taken from many kinds of subsets obtained by partitioning the previously mentioned pitch generation schemes. I can also think of ‘meteor clouds’ of timbral, distant intervals, generated by the computer and set against the ensemble’s textures.
- Twofold harmony: the two aspects of harmonic duality being composed against each other. A melody with a pitch distance space logic (say thirds or quarter tones in equal temperament) against proportional configurations, opposing two instrumental groups and producing a hybrid result which is thought as complementary in the sense that many unforeseen connections will happen between both harmonic worlds, leaving that aspect partially open so that interesting connection can take place.

Furthermore, I will compose a dissonance soundscape to be played in a concert in a few months from now, in which sound field recordings will be accompanied by electronic materials derived from dissonance analysis. I will try to make the resulting textures quite different in timbre and texture from the dissonance chorales I have been pursuing until now.

4.2 Loose ends, speculative harmony

To conclude, this section will define and discuss a contemporary meaning of harmony. It is after having traversed the more practical and compositional research that it is pertinent to speculate in a panoramic manner, both to conclude and produce insights, opening up to other perspectives and future involvements while connecting some of the ideas about harmony that have been discussed in the previous chapters.

4.2.1 What is harmony? Metaphysics, Noise

'The world is not respectable; it is mortal, tormented, confused, deluded forever, but is shot through with beauty, with love, with glints of courage and laughter: and in these, the spirit blooms timidly and struggles to the light among the thorns.' (George Santayana²⁰⁹)

Harmony is not an originally musical and technical term, stemming instead from philosophy. It is interesting to contrast and confront the practical, auditory and musical ideas regarding harmony with those pertaining to conceptual issues that reach beyond music. The above quote could refer to harmony as the extraction of beauty from chaos, as the attention paid to exceptional things in a world filled with difficulties and sufferings. Having an ethical character, it could be translated metaphorically into sonic terms and related to the quote by Luigi Russolo which opens Chapter 2, which I interpret as referring to the harmony associated with dissonance curves that 'attunes' to the most prominent vibrations in noise²¹⁰. This attuning is not a detraction from 'the irregular movements and vibrations in time and intensity', but a process of revealing its 'gradation(s) and tone(s)'. It is not turning away from the mortal, tormented world, but accepting and including it through selection. Attention not only to its more prominent 'glints of beauty', but also a concern for the relation between confusion and laughter, delusion and courage. Beauty as the contrast between elements of the world and not as a necessary or preexisting model. The 'light among the thorns' is not predefined and could be defined very differently depending on the perspective. The way harmony has been examined throughout this work, with dissonance curves, spectra and rationalization, implies that noise is not its opposite. Their difference is not of kind but of degree: of ranges of gradations and inclusions. In fact, noise is a too general and problematic term that I prefer to replace by (sonic) 'complexity', connecting more easily to a harmony that comprises simplicity and complexity. This is already from the outset one of the main premises behind this study.

209 This quote was taken from a posting by a close friend of mine. I have not found the original book in which it was published, but it can be found here: <http://thinkexist.com/quotation/the-world-is-not-respectable-it-is-mortal/347861.html> Last retrieved August 17th 2012.

210 Russolo, *The Art of Noise*. Here is it again, for reference: '[T]o attune noises does not mean to detract from all their irregular movements and vibrations in time and intensity, but rather to give gradation and tone to the most strongly predominant of these vibrations.'

Harmony not as an retraction from chaos but as the concern for seeking forms within and through complexity, the separation and dissection of its qualities, as in the case of the timbral *sonances* we have encountered. Furthermore, harmony embraces the opposites of dissonance and consonance, it is not the subordination of order to disorder or of dissonance to consonance. Moreover, taking harmonic duality into account, with each of its two aspects possessing its own polarities (consonance/dissonance; harmonicity/inharmonicity), reveals a field that encompasses atonality, high dissonance and antitonicity as harmonic *regions* not exterior or contrary to consonant and harmonic zones.

If harmony touches on aspects of beauty, order and chaos (*logos-alogos*), continuity and discreteness, relationality and the connection between the micro to the macro, it is because since its Pythagorean inception it has always had a metaphysical dimension. *Harmos* means joining, harmonious denotes interlocking, concerning the relationality of the elements involved more than the elements themselves. Another Pythagorean sort of figure is Leibniz, defining universal harmony both as ‘diversity compensated by identity’ and as ‘identity compensated by diversity’²¹¹, emphasizing that both variety and unity must be operative: ‘there is greater harmony when there is greater diversity, which nonetheless is reduced to identity. (For there cannot be grades in identity, but in variety)’²¹². This is the metaphysical question of whole/part, or unity/multiplicity, very close to the way harmonic duality has been elucidated, unity corresponding to proportional pitch (*logos*) and multiplicity (variety) to linear continuous pitch-timbre (*alogos*). On the musical/auditory side of our research this leads to the question raised by Tenney regarding Cage: ‘Under what conditions will a multiplicity of elementary acoustic signals be perceived as a “single sound”?’²¹³

Late in his life Cage became sympathetic to the idea of harmony, albeit one of an anarchic type, embracing both ‘legal’ and ‘non-legal’ harmony. He states that ‘the simple *togetherness* of art – I mean of sounds – produces harmony. That harmony *means* that there are several sounds ... being noticed at the same time, hmm? It’s quite impossible not to have harmony, hmm?’²¹⁴, also to add a few paragraphs later (in relation to Giacinto Scelsi, but still referring to harmony) that it is ‘sameness and difference as being together’. This is close to Leibniz’s definition above, although I believe that the two aspects Cage mentions (coexistence of diversity of elements and the relation between sameness and difference) should be managed separately as two different characteristics. Harmony includes but is not exhausted by coexistence. The relation between sameness and difference (identity and diversity) can imply relations that are not necessarily vertical nor adjacent in time. Some of the consequences that have been extracted from this study, especially those concerning proportionality, suggest that vertical coexistence is not enough, that there also exists an overall (even if local) measure or reference, an interlocking, that puts the elements into relation, into ‘being together’: a unity that makes a whole more than the sum of its parts.

Cage’s idea of an anarchic harmony arising as the coexistence, through chance encounters, between diverse elements, focuses on the workings and relations of collectives (of sounds, but also of persons), resonating with Cage’s approach of optimistically affirming aesthetic forms as models for collective life. That in this kind of anarchic harmony it would be ‘quite impossible not to have harmony’ should be understood, in my opinion, not as an ‘anything goes’ stance (quite the opposite to the Caguan approach), but as the idea of an inclusive harmony we have just considered, one embracing the entire field of sound and which cannot be opposed to a ‘non harmony’. The problem with accepting any possible combination of sounds as well as means of producing and giving them

211 Stated in his *Elements of Natural Law*. I have taken the quote from Mercer, C. (2004). *Leibniz’s Metaphysics: Its Origins and Developments*. Cambridge: Cambridge University Press, 214.

212 Ibid.

213 Tenney, John Cage and the Theory of Harmony, 15.

214 Cage, J., Retallack, J. (1996). *Musicage: Cage Muses on Words, Art, Music*. Hanover: Wesleyan University Press, 108-109.

continuity resides not the possibilities it opens up but the fact that it obliterates any distinctions, erasing the harmonic regions. It could insinuate, for example, that any collective undertaking could be equally valid, and I don't feel Cage meant this by saying that it is impossible not to have harmony. For Cage there was a right spirit for doing things, with careful disciplined actions and against 'improvisation', 'intention', 'mind', 'ego', etc, giving preference instead to very specific types of sounds and their combinations throughout his work. These constraints delineate a field and an aesthetic posture, a style with which it is so easy to identify Cage's music despite its diversity and indeterminacy. What is significant to my position is to consider a harmony which, within this all-embracing situation (which, of course, includes silence), does not ignore the properties of sounds and therefore makes possible the distinction and inquiry of its various zones, placing them in relief against each other.

This directly leads to Tenney's definition of harmony, one motivated by Cage but developed perceptually, a definition which has been a basic premise throughout this study:

'We can now define harmony as that aspect of musical perception which depends on harmonic relations between pitches — i.e. relations other than "higher" or "lower". Thus defined, "harmony" will still include all of those things it now includes — the "vertical aspect of music," chord-structure, etc. — but it is no longer limited to these, and it is certainly not limited to the "materials and procedures of the diatonic/triadic tonal system . . ." It would, for example, also include pitch-relations manifested in a purely melodic or monophonic situation, and — by this definition — nearly all music will be found to involve harmony in some way (not just Western "part-music"). In addition, the model of harmonic space outlined here suggests an important "first principle" for a new theory of harmony — that *there is some (set of) specifically harmonic relation(s) between any two salient and relatively stable pitches.*'²¹⁵

These 'specifically harmonic relations between pitches' give rise to the examination of harmonic space and also extend harmony from vertical into horizontal correspondences not requiring simultaneity, an aspect that Cage's conception does not explicitly tackle. A melody can be regarded both outside of time, as structure, as well as inside time, as a flow and distribution of this structure. Simultaneity and horizontality have an intimate relationship, the vertical induces the horizontal and vice versa. Harmony has the capacity to go beyond the single sonority and is able to produce systems of relations, comprising multiple sonorities beyond the actual sounding present. These connections correspond to the traditional term of *tonality* (antitonalities being not their opposite or negation but the far side of harmonic tonalities). In terms of harmonic duality, we could name the horizontal aspect, as in Chapter 1, the DC (direct current) feature of harmony in that it consists of pulses, on-off switches ('unity') inside of which vertical AC components (bipolar waves, chords, timbres) happen ('diversity').

For Barlow, 'harmony is the study of that which is intervallically intended or at least understood'²¹⁶, a definition which accommodates anarchic harmony as long as it is listened to as a relationship of intervallic characters, thus pertaining more to harmonicity than to consonance. Both of these previous definitions pertain to compositional and musical characteristics of harmony, and it is from these premises that the formal, structural and metaphysical aspects have been examined. I have arrived at a Pythagorean account of harmony, namely that there is a connection, in hearing, between whole numbers and intervallic characters, from musical questions which eventually lead to abstract ideas that go beyond music, the perspective of musician/composer being always the site from which other external notions are connected. Because it does not evade the lines of reasoning behind the models of the universe that have been put forward by this long standing tradition, this route avoids many of the caricatured and superstitious accounts which surround us to this day and which have given such a bad reputation to the serious efforts of so many proportionalists throughout

215 Tenney, John Cage and the Theory of Harmony, 34-35. Emphasis in the original.

216 Barlow, *Musiquantics*, 20.

history.

There is a metaphor for harmony we could call ‘chemical’ or ‘synthetic’: putting together of elements into something which is qualitatively different from their mere gathering. Chemically this corresponds to a solution rather than a physical suspension. The latter pertains more to textures and aggregates which do not coalesce into a new substance, while the former is a mixture different from the aggregation of its parts, as is the case with timbre, which is more than the breakup into its partial components. This synthetic, as opposed to analytic, feature relates to harmonic duality by showing how both of its facets share the unifying and splitting forces that make possible the various kinds of musical objects at various levels of scale.

From the above considerations, I venture a definition of harmony of my own:

Harmony is an sonic assemblage mixing concrete and abstract elements that produces a result which is greater than the sum of its parts and which produces (and requires) time while also giving the illusion of space.

Harmony must be *assembled*, it is not pre-given: ‘harmony is a result, not a guiding principle’²¹⁷. The arithmetic correlations of harmony do not exhaust it and cannot make of it sets of *a priori* rules that legalize or prohibit certain configurations over others. Harmony must be discovered. As we saw, it cannot be purely deduced, but needs to have an empirical axiom to get started. Secondly, this produces something which is qualitatively different from the mere aggregation of its components and this is what produces a specific temporality and a spatiality. It is not necessary to have multichannel arrays of speakers and sophisticated spatialization (all so unassumingly prevalent in electroacoustic circles) to give the illusion of movement and spatiality: this can already be done with pitch alone, a property that is usually not considered in thinking the spatiality of sound. Temporality is also intimately linked to harmony: not only does pitch and pitch relations require time but they also produce an experiential sense of it at various levels, including sometimes an ‘out of time’ sensation that directs the listener outside the situation where the music is happening.

Harmony is not a happy-ending complacency that resolves conflicts by pointing us to a higher sense of agreement or peace (as in the German name for harmony which is *Eintracht*). It is the joining (*harmos*) as well the splitting and tearing apart, keeping in touch with the emancipation of noise brought forward by atonality and modernism. It implies beauty, but not necessarily past beauty, instead inviting us to extend the notion of beauty. Neither nostalgia (origin) nor ultimate purpose (eschatology). By not positing any entity as a explanation or ground for all else closure is avoided, so origin and ultimate fate are not relevant. The harmony I seek is a coexistence between the real and the ideal. Both cannot be purely *a priori* realms but imperatives to discover the novelty in sonic (and other kinds of) objects. There is no higher goal or meaning: harmony is not global, but local, not a harmony of the whole disseminating into its parts, but the relation of parts with wholes in an indefinite interlocking of embeddedness with no end in sight (therefore it is not holistic), including in the system all its ‘symptoms’, antagonisms, and inconsistencies, as integral parts of it.

We should then maybe talk about a ‘post-established harmony’²¹⁸, the pre-established harmony of Leibniz being an axiomatic (or divine) agreement between sense and thought, world and experience, real and ideal, the condition that permits this world to be ‘the best of all possible worlds’. Instead of taking the lead from a postulated agreement, the sought harmony must be invented *and* discovered in a concern for patterns and relations at all levels. Speculative harmony: in a mirror (*speculum*). To find harmony in randomness as well as building ergodic harmonies thorough an exploration of the space of possibilities of its materials: harmony characterized by complexity.

217 Harman, G. (2009). *Prince of Networks: Bruno Latour and Metaphysics*. Melbourne: re.press, 21.

218 Ibid., 21.

To recognize that there is a specific musical relation between relatively stable pitches and whole numbers ('harmonic relations', or the Pythagorean focal point of our research), implies that there are specific features to musical perception; that music possesses its own autonomous rules (*auto-nomos*: having its own law). This goes against postmodern musicology which states that music is made up entirely of (social/cultural) conventions, as I discussed briefly in the introduction, but it does not imply that music is 'absolute' (that it is the only art that transcends this world) in the sense of Schopenhauer/Wagner. Music is always in communication with other arts as well as the sciences, feeding from both of them. However, it should also acknowledge, greet and respond to its own properties. Music reaches into art and science, but should also remain aloof from them, its functions and context far exceeding those of art and science (for example ritual, dance, trance, resonance – different from the mimesis of art –, healing, forgetting, accompanying, etc). Its distance from language is also one of its main sources of its individuality. In some occasions it has become too close to art, in others, to science. It should not forget its own traits and back and forth communication and transmission of information with the other disciplines. Harmony is a specifically musical phenomenon. Even though it has a connection to science (mainly arithmetics, as we have seen) and art (to broader aesthetic principles), its roots lie in musical and sonic principles. This should be acknowledged and maybe shared with other sonic practices which lack a concern for pitch relations, more frequently out of unawareness and because of the traditional connotations of harmony, than for a lack of interest in the possibilities that can be opened up.

To conclude by going back to the beginning of this section, a few words about harmony and contemporary chaos and numbers. According to the philosophy of Quentin Meillassoux, which is complex and in which I cannot (and do not need to) delve into here, randomness is subject to the same (meta) law as everything else. It is not noise and randomness (as with many theorists of noise who think noise music takes us to the uncanny realms) which convey a glimpse of the contingent, but rather proportionality. Randomness is not the opposite of order. It is not different in kind, but in degree. According to his posture on randomness and probability, what is important is not what is likely but what is *interesting*. Harmonic analogies (proportions) become a Symbol amidst chaos of what is worthy of grabbing on to, the 'light among the thorns' that Santayana refers to in the quote above. He argues that Being is contingent, that everything could change at any moment for no reason whatsoever, so that the laws of nature fall into the same contingency as everything else, randomness being as much a law as any deterministic law²¹⁹. It is in the way he questions the way that mathematics can capture something absolute about being, independent of human thought (a Pythagorean question), that he arrives at these considerations. What I'm relating to harmony is the way it implies the precariousness of whole numbers and proportions, which become small islands in the midst of an extended field of chaos.

The philosophical implications of harmony considered in relation to the psychoacoustically and

219 Meillassoux, Q. (2008). *After Finitude. An Essay on the Necessity of Contingency*. R. Brassier, Trans. London: Continuum. The topic is developed closer to art and music in the dialogue Meillassoux, Q., Hecker, F., Mackay, R. (2010). Chez Meillassoux, Paris, 22.7.2010. Falmouth: Urbanomic Documents. Last retrieved August 18, 2012, from <http://www.urbanomic.com/archives/Documents-1.pdf>. He says: "Randomness means laws. There are laws of randomness, calculations of randomness. It's a way of calculating, that's all. And so it's just a particular mode of the existence of physical laws. It's a way of anticipating, it's absolutely regular, in fact. So, the problem is, if you break laws which are structurally random, you can't find yourself again in randomness, it is not the same phenomenon. But it's very difficult to show this. The problem is that maybe, by examining the way that artists try to show randomness, to make it felt, what did they do exactly? We have something that is 'random', how can we break this? How can I break into this lawful randomness in a way that is other than random? The difficulty is there." Elsewhere, he adds: "[D]etermination and randomness, they are the same. So, at the beginning, for example, you could show it as an opposition, but progressively you see that it is just 'quoted' inside something else. The challenge would be to surprise a musician or an artist of randomness: he thought he was exploring the world of the random, but now he sees that random is just a quotation".

arithmetically informed approach that has been studied can serve to expand and give it a wider compositional assessment. The various perspectives make sense of what has been previously explored, pointing towards new lines of thought that reach beyond the purely technical, sonic and musical, pointing abstractly and aesthetically to ideas to be pursued later both compositionally and theoretically.