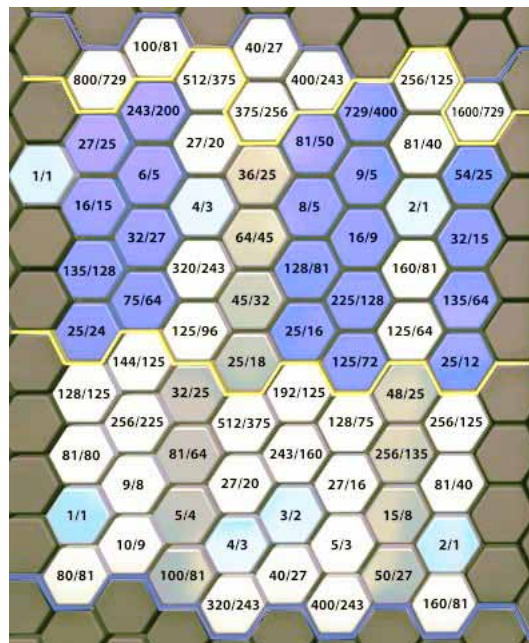


SEMANTIC DANIELOU-53

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English version, Jacques Dudon 2017

Introduction

In 1994, one year before leaving this world, the eminent indianist and writer, Alain Daniélou, shared his desire with Michel Geiss and Christian Braut to produce a digital instrument enabling the experience of his just intonation system inspired from the indian shrutis, the "Semantic".

As a result of that team's efforts, the first Semantic instrument was conceived a few years later. In 2007, it was given to Jacques Dudon, a just intonation composer, who used it in a series of compositions entitled "Semantic Works". That Autumn, to commemorate Alain Daniélou's birth centenary, it was performed in concert by the Thoronet's Microtonal Music Ensemble in the Abbey of Thoronet, as well as in Venise, Rome, and Paris.

The initial 36 notes per octave instrument was then reconceived with the same keyboard by Michel Geiss, while Jacques Dudon and Christian Braut designed the bases of a new software version compatible with any personal computer, allowing each user to discover and experiment with the 53 note tonal system proposed by Alain Daniélou.

Thanks to the constant support of the Alain Daniélou Cultural Center and the Foundation for Indo-european new dialogues (FIND), the "Semantic Daniélou-53" was born. Its aim is to make accessible the just intonation experience for a broader number of people through the means of many pre-programmed modes springing from the global scale of the Semantic : Indian ragas, scales from various musical cultures, demonstration of commas, schismatic, linear, and fractal temperaments related to the Semantic system.

The Semantic Daniélou-53 can make audible microtonalities, which are usually ignored by most of western instruments. And, while allowing to return to the fundamental sources of music, helps us to open our perceptions and develop a finer listening of chords and sounds, as much as in their harmonic spectrality, cultural diversity, or psychoacoustic and musical applications. It enhances, for example, the semantic and emotional quality of intervals naturally generated from the 5th harmonic (pure major third, sixth and seventh) which are physically absent in the Western equal temperament.

Jacques Dudon conceived of this instrument's functionalities for the scientific and pedagogic aspects. The software was realized using the UVI Workstation developed by Univers-Sons, and achieved by Arnaud Sicard, under the coordination of Christian Braut, who is also in charge of the project's communication.

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THE SEMANTIC SYSTEM

An electronic book and different musical pieces are in progress. They will detail the microtonal applications of the system presented by Alain Daniélou, and will guide the Semantic users through the instrument's tunings, as well as several tools and analyses. Just Intonation workshops on the Semantic system are also conducted by Jacques Dudon.

Summed up here are some of this system's characteristics, as well as some basic microtonal notions :

Just intonation is altogether the science and the art of consonances. Instead of tempered intervals, it uses a diversity of consonant intervals, the frequency ratios of which can be expressed in the form of fractions between whole numbers (ex. $3/2$, $5/3$, $64/45$, etc.). It generates, among other acoustical effects, an overtone's "fusion" and an enhancement of differential tones in coherence with the intervals.

The 5th harmonic limit proper to the Semantic system uses, among the whole numbers found in its ratios, only products of prime numbers up to 5. In other words, it only uses primes 2, 3, and 5, in accordance with the hypothesis formulated by Alain Daniélou in his book "Sémantique musicale" concerning our perceptions of musical intervals. Furthermore, thanks to remarkable micro-coincidences, the 7th natural overtone (14 occurrences of this interval in the Semantic-53 scale) and the 17th and 19th overtones, to name a few, are naturally present in several ways, notably among indian shrutis, as well as the Semantic system.

The 22 indian shrutis are the framework of the necessary intervals needed for the expression of all indian modes (or ragas), either from North or South India. Their frequency ratios are commonly expressed in the form of 5-prime limit ratios, that is, only using prime numbers 2, 3 and 5. The intonation system of the Semantic Daniélou achieves an extension of the 22 Indian shrutis, which it contains entirely. You will find the 22 shrutis in the 4th column of the Semantic-53 interval table.

The syntonic comma or **pramana shruti** is the small interval between indian shrutis. Its ratio is $81/80$, and there are 10 of them in the 22 shruti scale. The syntonic comma, which was dissolved in the different western historical temperaments, and the recent 12 tone equal temperament, is particularly essential in indian music as much as in any just intonation, as it expresses for each chromatic degree the subtle emotional polarities of consonances issued from harmonics 3 and 5.

Disjunctions are commas, larger by about one-third of a comma, in the number of twelve, found at the boundaries between the different chromatic notes of the Semantic-53 scale. In 5-limit, their rather complex ratio is either $20\ 000 / 19\ 683$, or $3\ 125 / 3\ 072$. In 7-limit, it comes down to the equivalent of the septimal comma $64/63$.

"Quartertones" are, in common language, tones situated close to the midpoints of semitones, essentially heard in arabian, greek, turkish and persian music, but also in Eastern Europe, Africa, and Asia. They were also used in a tempered way by a few western microtonal composers of the last XXth century. In traditional world music, quartertones originate from more or less equal divisions of the minor thirds, fourths, or fifths, and very rarely of the semitones themselves. Contrary to what has often been written, there are no quartertones among indian shrutis. Extending the 22 shrutis, the Semantic scale, on the other hand, contains numerous quartertones, resulting typically of the product of a comma and a disjunction, that is $3 + 4 = 7$ kleismas. Disjunctions being 12 in number in the Semantic-53, the scale then displays 24 quartertones of this type, whose most frequent ratios are $250/243$ in 5-limit or $36/35$ in 7-limit.

The 5-limit schisma ($32\ 805 / 32\ 768$) is a micro-coincidence of about one eleventh of a comma (1.95372 cent) found, for example, between the two main 5-limit versions of the first shruti (the limma, or chromatic semitone) used in evening and morning indian ragas : it is clear, for example, that in the morning raga, Todi, harmonic paths leading to this minor second point to $256/243$, while in the harmonic context of the sunset raga, Marva, they point to $135/128$. In Todi, it is an extremely minor harmony. In Marva it is, on the contrary, extremely major, and yet the difference of pitch is negligible in common musical practice. Two notes differing by one schisma are considered by Indians as the same shruti and are played by the same key in the Semantic.

Actually, in the 5-limit, many of the Semantic pitches have their ratio indeterminate between two different expressions. In the present S-53 scale, a more thorough analysis of the Semantic system has made it possible to precisely state its least deviations. So for any of its notes, we can select the most coherent ratio within the whole system.

The kleisma, while never found between two successive notes of the Semantic-53 scale, is nevertheless an omnipresent coincidence in the Semantic system, of about one-third of a comma. It is the natural difference between the last note of a series of six minor thirds (6/5) and the 3rd harmonic of the initial note (that is, one pure fifth above the octave); its ratio in 5-limit is then $15\ 625 / 15\ 552$, or 8.10728 cents.

More generally, in the Semantic scale the kleisma is the difference between one disjunction and a comma, that will always be observed between intervals composed of one same total number of commas + disjunctions, but differing according to their position in the scale, by their number of disjunctions.

Because of a perfectly balanced distribution of commas and disjunctions within the octave, for the same sum of commas + disjunctions, any interval of the Semantic-53 scale knows only one possible kleismic variation. The interval table of the Semantic-53 scale (see supporting documents) indicates the kleismic alternatives of each Semantic interval, and their 5-limit and 7-limit ratios.

Ultimately, 41 commas (of 3 kleismas) and 12 disjunctions (of 4 kleismas) separate the 53 notes of the Semantic scale, to generate 105 different intervals, among a global structure of 171 kleismas per octave. Approaching these intervals by a whole number of kleismas is, therefore, the simplest way to express them, making the 171th of an octave a precise and convenient logarithmic unit to measure not only the Semantic's but all 5-limit or 7-limit intervals.

The notes of the Semantic scale being generated by a series of fifths (or inversely by a series of fourths), by multiplying the number of kleismas to a fourth, or inversely a fifth, by the proper number of generations, one will know the kleismas value of all the Semantic intervals. The interval table indicates these values for all the 105 intervals of the Semantic-53 scale.

One perfect fifth (3/2) is made up of 100 kleismas and its octave complement a perfect fourth (4/3), of 71.

So for example, two perfect fifths being a 9/8 more than an octave, the major tone (9/8) is made up of twice 100 k minus one octave (171 k) = 29 kleismas. Inversely, 16/9, the product of two fourths, is made up of twice 71 k = 142 kleismas.

The perfect major third (5/4), in the schismatic temperament that characterizes the Semantic system, is equivalent to a series of 8 fourths: 8 times 71k minus 3 times 171k (3 octaves) = 55 kleismas.

A perfect major sixth (5/3) can be produced by the sum of a fourth and a major third, that is $71 + 55 = 126$ kleismas, etc.

The values in kleismas of the three intervals between indian shrutis are finally :

- 3 kleismas for the pramana shruti or syntonic comma (81/80) ;

- 10 kleismas for the lagu (25/24) ;

- 13 kleismas for the limma (256/243 or 135/128).

The octave sums up 10 commas + 5 lagus + 7 limmas = $30 + 50 + 91 = 171$ kleismas.

The 53 commas

Why 53 notes in the Semantic system ?

After the first cycle of 12 notes generated by a series of 12 fourths (or symmetrically 12 fifths), a series of 53 fourths (or 53 fifths) is the next cycle that produces an maximally even octave division, that sums up to only two step sizes of intervals, close to each other and balanced in an optimal way : 7 limmas and 5 apotomes with 12 notes, then 41 commas and 12 disjunctions with 53 notes.

As far as the dimensions of commas and disjunctions are close enough, as Alain Daniélou mentioned, these two types of commas cannot be mistaken, so the Semantic system cannot be assimilated to a 53 commas-equal temperament whose thirds and sixths, among others, are much more approximate.

In the hexagonal keyboard of the Semantic Daniélou-53 software, two yellow lines indicate the disjunction's positions among the commas : crossing these yellow lines implies a move of one disjunction (of 4 kleismas) instead of a comma (of 3 kleismas).

DESCRIPTION OF THE INTERFACE

The Semantic Danielou-53 comes in the form of a Mac OS X or Windows application whose command window includes two keyboards played using a mouse, trackpad, or other input device. One keyboard we will call "Hex", with hexagonal keys in a honeycomb layout, limited to a little more than an octave but allowing the display of the whole Semantic scale (53 notes per octave). The second keyboard, below, we will call "Hal", with classical "piano keys" (this form of keyboard having its origin in the town of Halberstadt), having 7 white keys and 5 blacks keys per octave extended to 8 octaves, allowing to slide in continuity on all the keys.

Notice that for all the tunings, the intervals with C (1/1) are indicated in the form of their ratios on the Hex keys.

On the upper part to the right of the Hex keyboard, the "Instrument" menu allows a choice of 28 different timbres specially chosen for each instrument. It is transposable in octaves, along with a master tuning and a fine-tuning with a precision of one cent, while the pitchbend range (modulation wheel) by default is one major tone (9/8) or a perfect fifth (3/2), with the option of being tuned differently, to a precision of one-hundredth of a cent.

A second menu allows immediate access to 72 different tunings, alphabetically listed under 6 families :

- **Semantic sets** (full 53 notes scale, and 12, 22, 36, 45, 48 notes per octave selections)
- **Indian ragas** (shruti-tunings allowing the interpretation of the totality of ragas)
- **World musical cultures** (Europe, Africa, Middle-East, Asia, Indonesia, South and North America)
- **Related temperaments** (compatible temperaments with the Semantic system)
- **Ambient tunings** (microtonal scales for atmospheric music and various soundscapes)
- **Demonstration tunings** (genesis of the main harmonic coincidences of the Semantic).

Most of the tunings have their mappings conceived for a 12 notes / octave interpretation, and for some others 24, 36, 48 or 53 notes / octave as for the Semantic-53 default tuning (see the full version 1.1 list of tunings in the supporting documents).



One essential element to appreciate all the Semantic just intonation, a tunable drone (or "Bourdon") is available via the "Play" button. Its pitch is in C by default, in a three octaves choice, and independent volume control.

A general volume control is situated at the upper right of the window, with a VU-meter graduated in decibels.

In one last section under the preceding ones, three modules with their proper settings allow a sound envelope control as well as two sound effects, reverberation and delay.

COMPATIBLE DEVICES

It is possible to pilot the Semantic from any external ordinary MIDI / USB keyboard.

The instrument has also been designed to be compatible with the "Axis 64" button keyboard of C-Thru, allowing the execution in polyphony of all the tunings and particularly the full 53 notes Semantic scale, in the same geometrical configuration as that of the interface window, but extended to three octaves.

Notice that if you order this Axis 64 keyboard, think to add to your order the additional colored keys necessary for the specific Semantic mapping : 18 white keys and 42 dark blue keys.

The Semantic is also compatible with a Doepfer ribbon pitchbend, making it possible to perform the Semantic scales in a continuous glissando on a range of one octave and a tone, the contact of the finger on the ribbon activating or releasing the action of the pitchbend.

The features of these two devices, added to those of the Semantic Danielou software, turn the interface into a highly performing microtonal instrument.

MINIMAL CONFIGURATION

Mac OS X 10.7 and 10.8 (64-bit | 32-bit), Mac Intel processor (or from Mac OS X 10.5 with UVI Workstation 2.5.1), Windows 7 and Windows 8 (64-bit | 32-bit),

Dual Core processor at least, 2 Go of RAM.

Hard disk 7 200 rpm recommended or SSD (Solid State Drive).

Hosting softwares :

UVI-Workstation (free download).

Or : MOTU MachFive 3 , Digital Performer 7 & 8, Pro Tools 10 & 11, Logic 9 & X, Cubase 7+, Nuendo 6+, Ableton Live 8 & 9, Studio One 2, Garage Band 6, Maschine 1 & 2, Tracktion 4, Vienna Ensemble 5, MPC Renaissance, Reaper 4, Sonar X3, Main Stage 3, MuLab 5.5, Finale 2014, Sibelius 7...

INSTALLATION

The "Semantic Daniélou-53" software is available at these addresses :

<http://www.find.org.in/semanticdanielou-53.ufs.zip>

<http://www.semantic-danielou.com/semanticdanielou-53.ufs.zip>

(more instructions on the FIND website : <http://www.find.org.in/> > "Semantic" link on the upper right)

It is advisable to install the host application intended to run the Semantic, beforehand, such as the UVI Workstation :

<http://www.uvi.net/en/software/uvi-workstation.html> ("Support" menu > tab "Download")

Then proceed as follow :

- decompress the file " SemanticDanielou.zip " (if not automatically done after downloading) :
- it will create a file entitled " SemanticDanielou.ufs " ;
- store this file in the location of your choice ;
- launch the UVI Workstation application ;
- open the preferences menu by clicking on the small jagged wheel in the center at the very top of the window ;
- go to "Sound Banks" ;
- add the access path to the file " SemanticDanielou.ufs " ;
- quit / and relaunch the UVI Workstation application ;
- load the instrument " SemanticDanielou.ufs " from the Workstation browser.

SEMANTIC DANIÉLOU-53 : FIRST STEPS

Preliminaries :

After opening the UVI Workstation, select in the menu "Search" > "Instruments" (or wherever you will have placed it) the instrument "Semantic Danielou-53", by double-click to load the program.

Click on any key of the keyboards "Hex" (at the top) or "Hal" (below) to check the sound output and adjust the volume (knob at the upper right).

Activate the "Play" button of the drone (if this drone seems too low in pitch, select in the menu one of the two upper octaves).

Play on either one or the other keyboards Hex or Hal with timbres and tunings of your choice.

By default, the active tuning is the full scale with 53 notes per octave "Semantic-53".

On the "Hal" keyboard (with piano keys), the default tuning spans the 53 degrees of the Semantic scale starting from C2 and extends them by octaves, in their pitch order.

Alternatively, the tuning "Semantic-45" reiterates the note 1/1 with every C key in order to make it easier for first encounters if you use a external MIDI keyboard, to play 45 of the main intervals of the Semantic scale with 1/1, which will be repeated in the higher octave with the same fingerings.

Refer to the list of tunings (in the supporting documents) to visualize their classification by types of tunings.

Notes forming an heptatonic scale are generally placed on the white keys of the Hal keyboard (below), while all 12 notes of the scale are on the white + black keys (= higher rank of the Hal keyboard).

For example, in the tuning menu, select any of the Indian ragas situated between Ahir Bhairav and Todi, and slide on the keys of the Hal keyboard to feel their special "rasa" (feeling), or follow the suggestions of specific experiences among those suggested in the following pages.

Presentation of the buttons keyboard "Hex" of the Semantic Daniélou-53 :

This mapping of the 53 notes of the Semantic in 7 diatonic columns, changing their color at middle-height, respects the classic "Halberstadt" form with 12 white and black keys par octave borrowed by the original Semantic, while displaying a continuous succession of commas vertically.

The hexagonal keys here have the advantage of making the difference between major tones (9/8) and minor tones (10/9) explicit, being tempered to one unique value in the Western meantone tuning while in the Semantic system (as in Indian music and in every other just intonation system) they differ by a comma.

With this special form of keyboard, not only the vectors of the major or minor tones can be clearly differentiated at a commal level, but also the vectors of any class of interval (such as the minor thirds, fourths, fifths, sixths, and any shrutis), as well as all tetrachordal forms, etc. that use them (see the honeycomb display of the Semantic-53 scale).

Any pure fifth, for example, sees its keys aligned horizontally in the same way, which was not possible with a non-hexagonal keyboard. Respecting these isomorphisms, the geometry of a major diatonic scale becomes :

C D
 E G B
 F A C[^] D[^] etc...

It is also exactly the lower keys pattern of the Axis keyboard, which can serve as an additional visual and tactile help.

Around the middle-height of the keyboard, the color change between the "white" and "black" zones of every column operates at the level of the disjunction, shown by a yellow colored line.

(Note that when used with any tuning of 12 notes per octave, the yellow lines of the Hex keyboard indicate the shift to the following note of the scale).

One remark about the mapping of the tuning by default Semantic-53 : the Axis-64 keyboard consists of 64 notes by octave, there are 11 occurrences of the Semantic-53 notes on the Axis-64, and on the interface's Hex keyboard they are repeated the same way at each octave. These are :

100/81, 320/243, 4/3, 27/20, 512/375, 40/27, 400/243, 80/81, 1/1, 81/80, 250/243, which facilitate the ergonomics of some fingerings.

As a purely esthetical difference between the Axis-64 keyboard and the interface's Hex keyboard (besides the extension of the Axis range to 3 full octaves), on the interface, Hex keyboard columns of keys show one slight angle, which allows us to vertically align the upper key of a column with the lowest key of the following one.

EXERCISES :

1st experience : Major diatonic scale (raga Bilaval) from the Hex keyboard.

Play a major diatonic scale in the low part of the Hex keyboard on keys 1/1 - 9/8 - 5/4 - 4/3 - 3/2 - 5/3 - 15/8 - 2/1 (see the pattern above).

Learn to find in this scale the intervals you are familiar with, for example :

2/1 = octave

3/2 = fifth

4/3 = fourth

5/4 = major third

5/3 = major sixth

15/8 = major seventh, etc.

Take time to experience the just intonation sound qualities, perhaps new to your ears, of the thirds, sixths and major sevenths, based on the 5th harmonic.

Notice that the thirds (5/4) and fifths (3/2) are lined up on the same horizontal rows (perfect triads [C : E : G], [F : A : ^C], or [G : B : ^D]), and that the Hex keyboard differentiates the major tones (9/8) found between 1/1 and 9/8, 4/3 and 3/2, 5/3 and 15/8, using an ascending fingering, from minor tones (10/9) found between 9/8 and 5/4 or 3/2 and 5/3, using a downward fingering.

2nd experience : Minor diatonic scale (Eolian mode, raga Darbari, etc.) and comma genesis.

Let us learn at first to tune the programmable drone in another pitch, here in A (5/3) instead of C. Let us look for this pitch in the Intervals table of the S-53 scale : we find it in the 39th comma where its value is given in thousandths of cents, 884.359. The Semantic drone has a precision of a hundredth of a cent, so we shall enter the value 884.36 in the pitch field.

Pla the same notes as in the previous exercisey again and listen carefully to the chords they create with the drone. Notice that the relative tone A (5/3) is perfectly consonant with all the notes of the scale, except one, 9/8 (D) to whom we may prefer 10/9 ("D -" according to Alain Daniélou's writing) presenting now an interval of a perfect fourth with the drone :

	B						
A		C ^		E ^		G ^	B ^ etc...
		D - ^		F ^		A ^	

(Note that this geometry of keys from A is identical to that of the major scale from C)

With two necessary values differing by a comma for the interval of second in the diatonic scale, we have gone back to the sources of the original meantone temperament, which instead of a double note for the major second (D and D-), has chosen an average intermediate tone (or "meantone"). That was the starting point of all baroque temperaments, up to the actual western 12-equal temperament. This double option of the second interval is valid for any note in other keys. To express all the harmonies of the chromatic scale in just intonation, we then need more than 12 notes per octave, such as the 22 indian shrutis (see experience # 22).

You may also try the "Pramana" scale (demonstration tunings) which cumulates the commal variations of a diatonic scale by displaying them by successive perfect fifths from F (4/3), or D - (10/9).

Alternatively, you may play, in a minor mode identical to the Eolian mode, with the tuning "Darbari" (Indian ragas), whose commas positioned on the minor notes allows to modulate them creating expressiveness (such inflection effects are found in some "gamaka" ornaments of indian music).

3rd experience : Minor pentatonic scales with 2 semitones (defective scale of the previous Eolian mode, in another key)

Tune the drone to 498.04 cents to obtain F = 4/3

Play in the higher part of the Hex keyboard the notes :

1/1 - 16/15 - 4/3 - 64/45 - 8/5 - 2/1 - 32/15

Also with two semitones and in the same tonic (4/3), a variant is the pentatonic Gunakri raga :

1/1 - 16/15 - 4/3 - 64/45 - 16/9 - 2/1 - 32/15

Feel how a heptatonic scale (the Eolian mode) and various defective versions of it can arouse different emotions.

4th experience : Chandrakaus raga

Again with a drone of 498.04 cents, in order to have the "Madhyama" (note F = 4/3) as tonic.

Dedicated to Chandra (the Moon), this very popular evening raga, in "Madhyama" tuning (without the fifth "PA") is obtained on the Hex keyboard with notes :

1/1 - (32/27 and 6/5) - 4/3 - 8/5 - 15/8 - 2/1

5th experience : "Harmonic" minor scale, on the Hex keyboard

The so-called "harmonic" minor mode, can be summarized as an Eolian mode with a major 7th in place of the 7th minor, in other words with a major third above the dominant, hence its common western name. Depending on the schools several commal variations of the scale can exist, such as in the Indian ragas themselves Kirvani (North India) or Kiravani (South India) ; it is also an ancient version of the Pilu raga (North India). The scale presents numerous other modes and variations found in Eastern Europe music (gypsy scales) as well as in Indians ragas (Basant Mukhari, Madhuvanti, etc.).

In order to experiment these various options, let us tune at first the drone to 320/243, with a pitch of 476.54 cents. On a horizontal line in the second half of the Hex keyboard, we find a minor triad with notes : 320/243 - 128/81 - 160/81, whereas the major triad of the dominant note (PA) will be found in the bottom row of the keyboard : 80/81 - 100/81 - 40/27 (note that these two last notes are also repeated at the very top of the Hex keyboard). The other major triad of the scale is : 135/128 - 320/243 - 128/81.

The complete scale is thus played on keys :

135/128 - 100/81 - 320/243 - 40/27 - (128/81 - 25/16) - 225/128 - 160/81 - (25/16 - 135/64) - 200/81 - 640/243.

Its commal variations mainly concern the minor notes, which can be lowered of a comma in their own column, that are 25/16 and 25/12, which act as minor thirds of a "19/16" type above SA and MA, which remain unchanged. But the major seventh (the "leading tone") 100/81 could also be raised by a comma, with the note 5/4, to form a pure major third with 25/16. In an optional complement such as in Pilu raga, a 7th minor (of a 16/9 type) in tune with 25/16 and 25/12 will be found in 75/64.

6th experience : Harmonic minor scale, pre-programmed (tuning Kidarvani)

Select this time the tuning " Kidarvani " (contraction of ragas "Kirvani" and "Darbari").

The scale, which contains several of the variations suggested in the previous exercise is the following one :

1/1 - 9/8 - 19/16 - 6/5 - 4/3 - 3/2 - 8/5 - 16/9 - 9/5 - 15/8 - 2/1

It can be experimented as well on the Hex keyboard as on the Hal keyboard, with a drone in C.

7th experience : Mougi raga

In the lineage of the previous modes, this raga with gypsy consonances (composition of Jacques Dudon) takes advantage of the Semantic-53 full scale keyboard to suggest slidings by descending commas between each of the 4 semitones. The main notes of the scale, which uses F# instead of F are the following ones : 1/1 - 9/8 - 19/16 - 45/32 - 3/2 - 16/9 - 15/8 - 2/1

It will be interpreted preferably on the Hex keyboard with a drone tuned in C (zero cents).

The slidings can be played by patterns of 6 descending commas each, starting from notes 2/1, 256/135, 3/2, 6/5.

For a more basic version adapted to the Hal keyboard, select the tuning " Mougi-c ".

8th experience : Five-limit Bhairav raga

Again on the Hex keyboard with a drone in C, this morning raga, considered as the king of ragas and an expression of Shiva is approached in 5-limit by the notes :

1/1 - 16/15 - 5/4 - 4/3 - 3/2 - 8/5 - 15/8 - 2/1

A beautiful defective form of this raga is the very ancient pentatonic Bibhas raga :

1/1 - 16/15 - 5/4 - 3/2 - 8/5 - 2/1

9th experience : Bhairav Raga, in 17-limit

The scale, Bhairav-17, in the tuning menu suggests a pre-tuning of the keyboards in which vadis and samvadis (main notes of the raga) contain optional semitones 17/16 over SA (1/1) and PA (3/2), perfectly coherent with the Bhairav mode and providing a very sweet kleisma beating (256/255) with their alternatives of 16/15. With an attentive listening we can distinguish a subtle difference of feeling between the semitones 17/16 and 16/15, the first ones much more steady, detached, contemplative, the second ones more emotional and passionate.

By sliding at the level of the blacks keys on the Hal keyboard we sweep all the notes of the raga in an effect that recalls the sympathetic strings of the sitar, or those of the "swirmandal", a zither often used in Hindustani vocal art.

10th experience : From Eratosthene's schisma to the Todi raga

The " Eratosthenes " scale (in the "Demonstration tunings" family) shows how a sequence of 5 perfect fifths (3/2) over 5/4 ends in a third minor of 1215/1024, one small schisma (1216/1215) under 19/16.

By disregarding 5/4 (the F key here), this cycle, completed by SA (1/1) and PA (3/2) generates all the notes of the Todi raga.

In a more appropriate mapping, we can experience a completely coherent version of the illustrious Thaat raga Miyan Ki Todi with the tuning "Todi-c" ("Indian ragas" family).

The very popular raga "Gujari Todi" uses the same scale without the note PA (3/2).

11th experience : Chromatic scale "Coherent_shrutis"

This selection of 12 of the 22 shrutis (cycle of fifths from A to D), thanks to the 19th harmonic presents an optimal differential coherence with 1/1, therefore, a better consonant quality. It suggests a special chromatic scale in the minor mode for the interpretation, among others, of numerous ragas (Bhairavi, Mishra ragas, and most ragas from the Ghazal, Qawali, and Thumree styles) :

1/1 - 19/18 - 9/8 - 19/16 - 5/4 - 4/3 - 45/32 - 3/2 - 19/12 - 5/3 - 16/9 - 15/8 - 2/1

12th experience : Marva raga

In a classic modelling in 5-limit, its shrutis would be selected among the 22 shrutis scale (Semantic sets) – the following indicate what could be the notes of this typically Indian raga, played by the setting sun, which omits the note PA (3/2) :

1/1 - 135/128 - 5/4 - 45/32 - 27/16 - 15/8 - 2/1

But it reveals, however, some uncertainties concerning the notes GA, DHA, NI (= E, A, B), in particular, because of a dissonant fourth here between E and A. Taking advantage of some of the intervals of the "Coherent shrutis" scale, obtained notably from a tonic in 19/16, the "Marva-c" tuning optimizes the differential coherence of all intervals, by doubling each of its shrutis :

1/1 - 20/19 - 17/16 - 5/4 - 24/19 - 45/32 - 27/19 - 5/3 - 32/19 - 15/8 - 36/19 - 2/1

We may notice that the Marva mode contains a complete pentatonic scale of a Bhupali type from Dha (32/19).

13rd experience : Bayati

One of the most popular modes of the Arabic music is certainly Bayati, originally a tetrachord of 13-limit which can be approached in a beautiful way by dividing a fourth in 20 - 22 - 29 kleismas found with the Semantic intervals :

1/1 : 625/576 : 32/27 : 4/3

We find them, for example, from the note 256/225 (223.46 c.) which we can tune the drone in.

The keys of the Bayati tetrachord to be used are then :

256/225 : 100/81 : 27/20 : 243/160

which we can extend by a second identical tetrachord :

128/75 : 50/27 : 81/40 : 512/225

Do not hesitate to raise the release level of the envelope as much as you want to enjoy all of the oriental flavor of the small and large neutral seconds (625/576 and 2187/2000, respectively 20 and 22 kleismas) of the scale.

14th experience : Slendro scale of central Java (on the Hex keyboard)

This 5-limit slendro, but of septimal colors, is found with notes :

128/125 - 75/64 - 4/3 and/or 27/20 - 192/125 - 225/128 - 256/125

Optionally, a very soft drone tuned on 75/64 = 274.58 cents may be used.

The syntonic comma between 4/3 and 27/20 here occupies an arbitrator's place, completely reversing the scale in function of the chosen note ; we shall notice that although having the size of a comma, it is virtually perceived in this context as a semitone.

Note also the very strong consonance of the chord 75/64 : 225/128 : 256/125 which will quite naturally be interpreted as a basic 4 : 6 : 7 harmonics triad.

15th experience : Approximation of a Javanese Slendro in 5-limit

Select the "Slendro_cloud" scale of the tuning menu (excerpted from the Semantic-36 scale and without pure septimal tones), to be played with the "Xylo" instrument and on the Hal keyboard :

1/1 - 729/640 - 675/512 - (3/2 and/or 243/160) - 225/128 - 2/1.

Each of the 6 notes is doubled in the higher octave and placed on its next key.

16th experience : Slendro matrix

The "Slendro_sequence" scale, in the tuning menu, suggests this matrix / collection of typically Javanese circular Slendro scales, of triseptime type (= containing 3 septimal tones 8/7 or 5-limit equivalents per octave), the just intonation version of a sequence of 69 kleismas (171ths of octave), such as 250/189 here (C : F) :

1/1 - 81/80 - 8/7 - 125/108 - 75/64 - 250/189 - 75/56 - 189/125 - 49/32 - 3969/2560 - 7/4 - 567/320 - 2/1

Immerse yourself in the specific consonance of the septimal tone (8/7), found in multiple places.

(to be experimented again with the "Xylo" sound...)

17th experience : Harmonics (World musical cultures)

The scale of natural overtones is present in number of instruments such as the Jew's harp, the African mouth bow, the didjeridoo, and of course the voice (vowels singing, overtone singing, polyphonies...).

The tuning " Harmonics " browses on each octave from C to C[^] the natural harmonics from 12 to 24 :

12 - 13 - 14 - 15 - 16 - 17 - 18 - 19 - 20 - 21 - 22 - 23 - 24

Therefore, it allows the experience of intervals of various limits, and in various modes.

With a drone tuned in 4/3 (= E key) we can first simply feel the energy communicated by each of these harmonics in their pure state.

With the default drone C (= harmonic 12 here) then by using alternately every harmonic as a tonic, we can explore which feelings it brings to each of the other harmonics (this experiment is valid for every note of any scale).

If we wish to tune the drone in the Semantic in unison to a given note, it is necessary to enter its value in cents, given by the formula : **Log (ratio) / Log (2) * 1200**. The last number is the number of units by octave, here 1200 cents.

The ratios of the notes with the reference note C = 1/1 are here :

13/12 - 7/6 - 5/4 - 4/3 - 17/12 - 3/2 - 19/12 - 5/3 - 7/4 - 11/6 - 23/12

For example, to tune the drone to the first interval (13/12) with 1/1, we shall enter the value :

$\text{Log}(13/12) / \text{Log}(2) * 1200 = 138.572661 \text{ c.}$

18th experience : Thai scales (World musical cultures)

The very original, and harmonically mysterious traditional scales of the Siamo-Khmer music are often presented by the musicologists as "quasi-equal" heptaphones.

The "Thaï_171-tetrac" tuning, from intervals stemming from the global canvas of 171 kleismas generated from the Semantic-53 scale, achieves a realistic modelling of a Thai heptaphone, designed from two tetrachords a meantone fourth 75/56 wide, divided into 3 quasi-equal intervals, of a 75/68 type or equivalents : 1/1 - 193/175 - 75/68 - 17/14 - 1277/1050 - 75/56 - 11269/8400 - 112/75 - 4607/2800 - 288/175 - 2901/1600 - 136/75 - 2/1

The triad 56 : 68 : 75, with the very strong differential coherence of the Thai tone 75/68 (because 75 - 68 = 7), shows the interest of the kleismic extension of the Semantic scale, applied here to South-Asian music.

So this scale consists of 6 tones of this type and a wider tone of the meantone type in the middle, between F and G, thus containing no "semitone".

The scale "Thai_reversible", in another series, adds three commas, inverting the positions of the 11/10 and 10/9 types of intervals, and also proposing an optional neutral tone of a 12/11 type between E and F.

Compare these previous Thai scales with those of the tuning "Siamese_7-qedo", getting closer to an "almost equal" division of the octave in 7 (generator of 128/105, or 49 kleismas, borrowed from the "Yantra" scale).

Experience diverse pentatonic modes selected among these various scales.

19th experience : Kleisma coincidences

Select the tuning "Kleisma" (in Demonstration tunings).

The scale assembles two sequences of minor thirds (6/5), seven starting from 5/3 and three others starting from 125/72, producing low fifths (23 328 / 15 625) of a 5-limit kleisma (15 625 / 15 552) or 8.107278862 cents.

The four kleismas found in C#, E, G, A# make it possible to recover 3 perfect major thirds (5/4) and a perfect fifth (3/2) :

1/1 - 648/625 - 25/24 - 6/5 - 3888/3125 - 5/4 - 36/25 - 23328/15625 - 3/2 - 5/3 - 216/125 - 125/72 - 2/1

Afterwards, with the full scale of the Semantic-53 (default tuning) on the Hex keyboard, you may exercise your listening to make the difference between intervals situated entirely in one of the zones between the two yellow lines, and their "kleismic variations" of equivalent fingerings but straddling on both sides of a yellow line. These kleismic variations are listed in the "Intervals table" of the Semantic scale.

20th experience : 5-limit Schisma (Demonstration tunings)

Going down 8 perfect fifths (3/2) under D (9/8) we obtain (1024/729, on the F key here) a 3-limit third, while a perfect major third (5/4) above D (45/32, on the F# key) gives a note a schisma higher ($5^3 \cdot 8 / 2^{15} = 32\,805 / 32\,768$).

The scale, in the ascending order of the keys, progresses by perfect fifths transposed back into the same octave, which produces a surprising melodic effect : 1/1 - 3/2 - 9/8 - 27/16 - 81/64 - 1024/729 - 45/32 - 256/243 - 128/81 - 32/27 - 16/9 - 4/3 - 2/1

21th experience : Ragisma (Demonstration tunings)

The ragisma is simply the archetypal footbridge allowing expression of a 5-limit interval in its 7-limit equivalent, and vice versa. Seven perfect fifths (3/2) and an octave (2/1) above A here end in a note, one ragisma lower than the 7th harmonic of the note found after four perfect major thirds (5/4) above the same initial A. The ratio of this remarkable micro-coincidence is 4375 / 4374, that is $7 * (5^4) / 2 * (3^7)$.

This strange scale here is a "Dudon scale" of this coincidence (= gathering all the divisors of its numerator and denominator) :

1 3 5 (7) 9 25 27 (35) 81 125 (175) 243 625 729 (875) 2187 (4375), then transposed to the same octave.

While this full scale would need 17 notes, in the simplified 12 notes version of this tuning, we can cover all the series of fifths and thirds. We can't listen to both versions of the coincidence, rather difficult to distinguish by ear, of the notes 4374 : 4375, even closer than those of the Yantra schisma 4095 : 4096 (see experience 28).

However, we can appreciate, and in an optimal way with oboe, saxophone or clarinet timbres, the strong consonance of the 5-limit version of the 7/4 interval, that is 2187 / 1250, between keys C and Bb.

22nd experience : The 22 Indian Shrutis

The tuning " 22 shrutis " (Semantic sets) enables a complete experiment of this reference scale of both North and South Indian music, which without transposition provides a correct rendering of all ragas. The intervals between the 22 notes alternate commas and intermediate semitones of two sizes, the lagu (found for example between the minor third $6/5$ and the major third $5/4$) and the limma (for example between the tone $9/8$ and the 3-limit minor third $32/27$).

Two additional notes above and below $1/1$ allow the experiment of the schisma between $256/243$ and $135/128$ (and reversed), quite subtle to differentiate – to play them together will make you appreciate the slowness of their beating.

23rd experience : Syntonic comma pump

With the tuning S-53 on the Hex keyboard, a series of 5 consonant notes, for example, played two by two help to experiment the genesis of the syntonic comma, here between C and + :

C : G : D : A+ : E+

G : D : A+ : E+ : C+

($1/1 : 3/2 : 9/8 : 27/16 : 81/64 : 81/80$ etc.)

It is what is called a "comma pump".

Its continuation can be transposed easily by ascendent degrees on the Hex keyboard (down more or less to the kleisma) to perform this pump in a loop and generate a continuous spiral of commas :

C+ : G+ : D+ : A++ : E++ >

C++ ... etc.

The same path can be performed backward to generate a continuous series of descending commas.

24th experience : Amlak (World musical cultures)

Halfway between Ethiopian music and some night Indians ragas, this fascinating mood scale is the result of the deployment of the fractal algorithm $x^2 = x + 1/3$, performed here by the frequencies 27 - 36 - 45 - 57 - 72 - 91 - 115 ... which trends towards a series of wide major thirds, allowing among other things to link in a coherent way major sevenths and minor thirds (ex : $57 - 45 = 9$, etc.) :

$1/1 - 45/38 - 19/16 - 91/76 - 107/76 - 27/19 - 455/304 - 3/2 - 30/19 - 575/304 - 36/19 - 2/1$

If you enjoy this scale, in quite similar colors but appreciably more Indian you can also experiment the "Nila" raga (Indian tunings) :

$1/1 - 17/16 - 16/15 - 19/15 - 4/3 - 8/5 - 101/60 - 19/10 - 2/1$

Or also the very hieratic "Shri Rag" (Indian tunings), to be interpreted on winter after sunset, here modeled as well according to an Amlak series, to optimize its differential coherence.

25th experience : Semantix-36 (Related temperaments)

The interval of $27/25$, known also under the name of "Zarlino semitone", used as generator, divides the octave almost exactly into 9 intervals of 19 kleismas each, with the property that if we double this interval, or $729/625$, the result is indistinguishable, in practice, from a septimal minor third $7/6$ (the difference again is a ragisma, $4375 / 4374$).

This enneaphone, thus built advantageously by alternating $27/25$ and $175/162$, and transposed by $9/16$, $3/4$, $1/1$, and $4/3$ (a series of perfect fourths) ends in a 36 notes per octave "harmonic temperament" particularly rich in footbridges between the 5 and 7 harmonics :

$1/1 - 49/48 - 25/24 - 200/189 - 27/25 - 54/49 - 9/8 - 8/7 - 7/6 - 25/21 - 243/200 - 100/81 - 63/50 - 9/7 - 21/16 - 4/3 - 49/36 - 25/18 - 567/400 - 36/25 - 72/49 - 3/2 - 49/32 - 14/9 - 100/63 - 81/50 - 81/49 - 42/25 - 12/7 - 7/4 - 25/14 - 49/27 - 50/27 - 189/100 - 27/14 - 96/49 - 2/1$

Its successive notes have between them a pattern of intervals repeated in a loop of [5 - 5 - 4 - 5] kleismas, of an average of a sixth of a tone, that suggests an interesting alternative to the 36 notes per octave equal temperament, which has been used by numerous composers in the last century. The Indonesian Pelog scales being commonly considered for being defective scales of divisions of the octave in 9 intervals, the Semantix-36 scale then contains 36 various versions of Pelog scales.

The 12 notes tuning Semantix-12 proposes some of them in C, G, B, as well as on its white keys a diatonic scale which could very well suit the tuning for an African cora or a Malagasy vali, with two "wide semitones" of the $27/25$ type.

The keys C C# D# (and G G# A#) reproduce the notes $27/25$ and $7/6$ with the almost identical intervals $27/25$ and $175/162$ between them.

The notes C C# E F (or a fifth above G G# A C^[^]) suggests a rather realistic variation in 5-limit of the ancient medieval Persian tetrachord "Buzurg".

As for the tuning "Semantix-Semantic", entirely in 5-limit, but however of very middle-oriental colors, it offers a selection of the intervals common to the scales Semantix-36 and Semantix-36. On the white keys, it is an interesting variation of the previous diatonic scale, $400/243$ in A instead of $42/25$: $1/1 - 27/25 - 9/8 - 243/200 - 100/81 - 4/3 - 25/18 - 3/2 - 81/50 - 400/243 - 729/400 - 50/27 - 2/1$

26th experience : the Tsaharuk scale

Stemming from the scale S-53, a neutral second interval of 20 kleismas (see in interval table : 625/576, 243/224, or 64/59, 13/12, etc.) has the property of being precisely one-fifth of a perfect fifth (3/2, 100 kleismas), as well as one-sixth of a neutral sixth (13/8, 120 kleismas). Nothing surprising thus that when used as a generator it produces numerous familiar intervals used in Arabic music.

In the Semantic system we find this interval in numerous places, for example between one low semifourth (144/125) and a major third (5/4).

Its cyclic properties leads us to suggest a generalization of the qanun tunings systems of the late Arabic music master Julien Jalaeddin Weiss, who used up to 105 notes per octave to interpret, in just intonation, all the subtleties of various Arabic music schools and traditions.

One version with perfect fifths of this harmonic temperament verifies the equal beating of both intervals 13/12 and 16/13 of the triad 12 : 13 : 16, expressed in the algorithm $8x^6 - 13 = 12x - 13$.

From the Tsaharuk-12a twelve notes tuning (World musical cultures),

1/1 - 755/696 - 296/261 - 273/232 - 107/87 - 4/3 - 755/522 - 3/2 - 755/464 - 148/87 - 819/464 - 107/58 - 2/1,
adjust a drone in 217.86 c. to experiment a Bayati mode on white keys from D (296/261).

From the Tsaharuk-12d tuning, reset the drone in C = 0 c. to experiment a Rast mode on white keys from C (1/1).

Alternately, Tsaharuk-17 and Tsaharuk-24 tunings (Related temperaments) show two different aspects of the complete parametrable system, presenting balanced divisions in 17, 77, 94 or 171 notes per octave. One is closer to Persian music for the 17 notes scale, the other one to Arabic music for the 24 notes scale (they are both displayed on 24 notes on the Hal keyboard).

The scale of the Tsaharuk-24 tuning consists of two sequences of 11 schismatic fifths transposed by a triple comma (typ. 28/27) :

1/1 - 28/27 - 59/56 - 35/32 - 9/8 - 7/6 - 32/27 - 59/48 - 5/4 - 35/27 - 4/3 - 112/81 - 59/42 -
35/24 - 3/2 - 14/9 - 128/81 - 59/36 - 27/16 - 7/4 - 16/9 - 59/32 - 15/8 - 35/18 - 2/1

27th experience : Mohajira-to-Slendro (World musical cultures)

Mohajira is at the same time a very ancient tetrachord mentioned by Ibn-Sina, a scalar structure, a very rich family of fractal scales, and a linear temperament having for generator a neutral third, typically close to 11/9. The scale in 12 notes suggested here :

1/1 - 21/20 - 9/8 - 6/5 - 49/40 - 4/3 - 7/5 - 3/2 - 8/5 - 49/30 - 9/5 - 11/6 - 2/1

comes from the harmonic coincidences 540/539 and 441/440, found in the neutral thirds series of the Mohajira sequence :

80 - 98 - 120 - 147 - 180 - 220 - 270

of which the characteristic heptaphonic structure is displayed here on the white keys of the Hal keyboard, beginning with note G ; it contains three Mohajira tetrachords, of simplified quartertones form : [3 - 4 - 3] from G, B and D.

The scale also presents an Eolian mode in C minor, and many Slendros (pentatonic Indonesian scales),

such as a typical slendro from Jogjakarta in E F# G# B C#,

another one between Surakarta and Jogjakarta slendros in C# Eb F# G# B,

another one of a traditional form of central Java in E F# A B C#,

or another one of a simpler form, on the 5 black keys.

Thus, it makes it possible to link musical cultures very distant at first, therefore its name "Mohajira" which means "migrant".

28th experience : Yantra schisma (Demonstration tunings)

This 12 notes scale is again a "Dudon scale" (= collecting all the divisors of the numerator and the denominator of a harmonic coincidence, transposed in the same octave) of the micro-schisma 4095 : 4096, with factor 35 left here undivided :

1 3 9 13 35 39 105 117 315 455 1365 4095

One can experiment the smallness of this schisma by playing simultaneously keys F# and C^ to listen to their beating.

Its name comes from the fact that the logarithmic representation of this scale in an octave circle allows a geometrical construction of the very famous and mysterious "Shri Yantra" mandala, thanks to very strong symmetries which it establishes between its ratios based on the harmonic 13 :

13, 39, 117 and their symmetrical "quasi-complements", multiples of the factor 35 : 315, 105, 35 . . .

Apart from for this singular property, this scale contains a number of modes which can be related to Arabic music and quoted by the ancients, such as a Rast mode in F, a Bayati mode in G, two Mohajira scales in C (tetrachords 1/1 - 35/32 - 39/32 - 1365/1024 and 3/2 - 13/8 - 117/64 - 2/1) and in neutral E (39/32 - 1365/1024 - 3/2 - 13/8, etc.), with two commal options in E and A and two additional symmetrical quartertones in D and Bb.

It can be appropriate to experiment it with a long sustain, to fully enjoy the flavors of its differential consonances, along with an optional drone in G (3/2 = 701,955 c.), or other notes to one's choice.

29th experience : Kleismean (World musical cultures)

The Semantic system, extended to its "ultimate" deployment in 171 kleismas, allows the simulation of various meantone temperaments, irregular temperaments, well-temperaments, etc., from rational intervals. The "Kleismean" harmonic temperament proposed here fulfills, in 7-limit and by a specific irregular alternation of perfect fifths (3/2) and smaller ones (typically 112/75, flat by a kleisma), the imitation of a meantone temperament presenting perfect major thirds (5/4) at the end of a series of 4 fifths, without ever presenting fifths low of a comma, and by leaving on the other hand on the extremities of the fifth chain as in any meantone temperament, a "fifth of the wolf " (of 32/21 here) between G# and Eb^ :

1/1 - 21/20 - 28/25 - 448/375 - 5/4 - 75/56 - 7/5 - 3/2 - 196/125 - 375/224 - 25/14 - 15/8 - 2/1

It will be interesting to compare the global tuning coherence of the white keys of this type of scale, versus the pure consonance of the white keys of a diatonic scale of more classic just intonation (such as those of "Semantic-12" or of "Coherent shrutis") : this accuracy sensation depends obviously on our kind of listening but also on the acoustic, harmonic and musical context of the moment.

30th experience : Semantic_Axis-19 (Demonstration tunings)

A meantone scale, tempered "to a third of a syntonic comma" possesses perfectly pure major sixths (5/3) and minor thirds (6/5), a characteristic that is shared with the Semantic scale.

Extended beyond 12 notes this historic temperament generates a scale of 19 tones, always very popular among microtonal musicians.

A meantone scale has two sizes of semitones (said "chromatic" for the smaller, "diatonic" for the larger) and a single type of a major tone, which will sum up, in a scale of 19 notes per octave, to three degrees. Therefore the origin of our western classical notation with sharps and flats, a C# not being originally equivalent to a Db, before they became identical with the 12-equal temperament.

The difference, of 9 kleismas between the two semitones in a scale of 19-equal, among the largest in the various meantone forms, is part of its particular flavor.

Contrary to a number of notes limited to 12 for a meantone scale, there are no "forbidden chords" in 19-equal, which offers full circular harmonies.

The extension of the Semantic system ending up in 171 thirds of commas (or kleismas) per octave, and this number being a multiple of 19, there are 9 possible manners, from intervals multiples of 9 kleismas, to generate by reiteration harmonic scales in 19 "quasi-equal" tones in this extension.

Five of them already belong to the Semantic-53 scale : 648/625 (9 k), 125/108 (36 k), 6/5 (45 k), 3888/3125 (54 k), and 25/18 (81 k).

Not less interesting, the four others are issued from the precedents, these are 672/625 (18 k), 125/112 (27 k), 4032/3125 (63 k), and 75/56 (72 k).

(In the second half-octave the next generators to be multiples of 9 kleismas will be equivalent to the inverses of the precedents).

To stay as closely as possible to the Semantic scale, the repetitions of perfect major sixths and minor thirds have been favored here, sometimes by simplifying their ratios (ex. 56/45 instead of 3888/3125, etc.) :

1/1 - 28/27 - 672/625 - 125/112 - 125/108 - 6/5 - 56/45 - 4032/3125 - 75/56 - 25/18 - 36/25 - 112/75 - 3125/2016 - 45/28 - 5/3 - 216/125 - 224/125 - 625/336 - 27/14 - 2/1

31th experience : Semifourths

After the division, the most frequent in traditional world music, of a minor third in two "3/4 of tone", another way of generating quartertones is observed in Africa in diverse pentatonic balafon tunings, generally dividing three of its fourths (4/3) into two "semifourths".

The tuning "Bala_sem-sem" (World musical cultures) contains several versions, in G and in A, of traditional tunings of pentatonic balafons from Mali and Burkina Faso used for celebrations, chaining 4 semifourths, translated in 5-limit by alternation of semifourths 108 : 125 (36 k.) and 125 : 144 (35 k.) to generate a series of fourths.

As for the tuning "Bala-ribbon" (Related temperaments), it interleaves two "Bala" fractal sequences :

1/1 - 25/24 - 9/8 - 6/5 - 13/10 - 4/3 - 83/60 - 3/2 - 8/5 - 26/15 - 9/5 - 39/20 - 2/1

The black keys reproduce a pentatonic sequence of semifourths similar to those of Bala_sem-sem :

[108 : 125 : 144 : 166 : 192] (where 108 is here in Bb).

The second Bala sequence, displayed on the white keys :

[117 : 135 : 156 : 180 : 208 : 240 : (277) : 160] is containing two others from 117 in B and from 135 in D.

By coincidence, this "ribbon temperament" also recomposes a full 5-limit Eolian mode from C (1/1) :

1/1 - 9/8 - 6/5 - 4/3 - 3/2 - 8/5 - 9/5 - 2/1

Explore in this Bala-ribbon tuning the possible migrations of the diverse African pentatonic modes between them, and towards this Indo-European mode.

- - - SUPPORTING DOCUMENTS - - -

Table of the intervals and kleismic variations of the Semantic-53 scale

This table contains all the intervals, within an octave, that can be found between two notes of the full Semantic-53 scale.

They are classified in the 1st column by degrees, that is the number of keys of the instrument to cover the whole range between the notes of the interval, in other words the sum of the numbers of commas and disjunctions separating them.

Except for the unison (or the octave), for any interval of a given number of degrees, according to its position two variants are encountered : the most common option, identical to the 53 intervals stemming from 1/1 (C), is written in bold face, and its variation, deriving from other notes of the scale, is written in italics. Thus the scale contains 53 main intervals and 52 variants, totalizing 105 different intervals.

The 2nd column indicates the size of all these intervals, in integers of kleismas (that are 171 per octave).

This measure is the simplest we can find to refer to the notes or intervals of the Semantic scale.

Because of the perfectly-balanced division of the octave performed by the Semantic-53 scale, for a given number of degrees (other than 0 or 53) there exists only two possibilities of intervals, and always differing from one kleisma. Whatever the number of degrees and its position in the scale, an interval indeed can have only two possible numbers of disjunctions, differing from one unit.

For example, the 1st degree (= separating two any consecutive keys of the keyboard) can be only a syntonic comma (Pramana shruti, of 3 kleismas), or one disjunction (comma septimal, of 4 kleismas). Other example, the 5th degree can be only an apotome (16/15) composed of 4 commas + 1 disjunction (that sums up to 16 kleismas), or a septimal semitone of the 15/14 type, composed of 3 commas + 2 disjunctions (that sums up to 17 kleismas). The 11th degree idem can be of two types : 144/125 or 125/108, etc.

The 3rd column names each one of the 105 intervals, these more or less common names arising depending on the circumstances from several sources : names generally used by microtonalists (for example borrowed from the Scala software, in which these tunings were written), Indian names, size of the intervals or relevant combinations of other intervals from the scale, names of linear temperaments, or even fractal algorithms and other remarkable generators of the semantic system being part of these Semantic Daniélou-53 tunings, etc.

The 4th column indicates the intervals belonging to the 22 shrutis, in the traditional numbering used in Indian music.

The 5th column refers to the chromatic writing of notes, increased or diminished by syntonic commas used by Alain Daniélou in his book "Semantique musicale".

The 6th column gives the ratios of all intervals in 5-harmonic limit, in their least deviant schismatic variant with the whole system. If the ratios remain the most precise way to define an interval in just intonation, it is necessary not to loose sight of the fact that any interval of the Semantic scale is potentially double and therefore also shows, at least, one relevant schismatic variation. For example a limma, given for a ratio of 135/128 in this table can, according to its position in the scale, be found somewhere else with a value of 256/243, etc. In practice, two notes differing from a schisma are considered as equivalent to the Semantic system.

Expressed alternately in 7-harmonic limit in the 7th column, are reported the ratios of the kleismic variations of the most complex intervals in limit 5, the difference with these later ones being generally of a ragisma (4375 / 4374), approximately one-fifth of a schisma.

We observe that for all the kleismic variants of the main intervals, exists a simpler ratio in 7-limit than in 5-limit, and it is also the case for six of the main intervals.

The 8th column gives the values in cents of the 5-limit versions for all the bold intervals, and of the 7-limit versions for all the intervals in italics. These values in cents are necessary to tune the drones, mastertunings, or pitchbends of the instrument.

To tune a drone to one of the 53 notes of the Semantic-53 default scale, it is necessary to use the bold values exclusively. However, it is appropriate to use the italic values whenever their ratios belong to other Semantic Daniélou-53 tunings.

The last column indicates the numbers of ascending fifths necessary to generate every interval.

When negative, their absolute value corresponds to the number of downward fifths (= or of ascending fourths).

We observe that the sum of the absolute values of the number of fifths of an interval and of its kleismic variation is always equal to 53.

The absolute value of the number of fifths necessary for the generation of an interval is also always the number of occurrences of its kleismic variation within the scale. Therefore, from this 9th column we know that the Semantic-53 scale contains 52 fourths or fifths, 51 major tones (9/8), 46 diatonic semitones (16/15), 45 major thirds (5/4), 44 minor thirds (6/5), 34 semitones of Zarlino (27/25), 22 neutral seconds (35/32), 21 Thai thirds (close to 128/105), 20 neutral thirds (close to 16/13), 16 supermajor thirds (9/7), 15 minor septimal thirds (7/6), 14 septimal sevenths (7/4), 8 Turkish major thirds (56/45), etc. The scale being symmetrical, an interval and its complement (ex. 7/5 and 10/7) always have the same number of occurrences.

To browse in this table a series of notes formed by the repetition of the same interval, it is necessary to add in a continuous way the value in kleismas of the generative interval, and to deduct 171 kleismas every time the sum exceeds 171, as to bring back the interval in the initial octave. So to browse a series of fifths it is necessary to constantly add 100 kleismas to the initial note ; or to browse a series of fourths (or downward fifths) it is necessary to add constantly 71 kleismas.

Ex : series of fifths from C back in the initial octave : 0 ; 100 ; 29 (= 200 - 171) ; 129 ; 58 (= 229 - 171) ; 158 ; 87 (= 258 - 171), etc.

Semantic-53 interval table

n°	Kleismas	Interval	Shruti	Note	L5 ratio	L7 ratio	Cents	Fifths
0	0	Unison	0	C	1/1	1/1	0	0
1	3 4	Pramana shruti, syntonic c. <i>Septimal comma</i>		C+ <i>Db ---</i>	81/80 <i>20000/19683</i>	<i>875/864</i> <i>64/63</i>	21,506 <i>27,264</i>	12 <i>-41</i>
2	6 7	Diesis <i>Septimal diesis / quartertone</i>		C++ <i>Db --</i>	128/125 <i>250/243</i>	<i>36/35</i>	41,059 <i>48,770</i>	24 <i>-29</i>
3	9 10	<i>Archytas' 1/3 tone, septim. lagu</i> Lagu (5th limit)		C+++ Db -	<i>648/625</i> 25/24	<i>28/27</i> <i>729/700</i>	<i>62,961</i> 70,672	<i>36</i> -17
4	12 13	<i>Minor semitone, Damlas</i> Major limma, first shruti	1	C++++ Db	<i>6561/6250</i> 135/128	<i>21/20</i>	<i>84,467</i> 92,179	<i>48</i> -5
5	16 17	Apotome, diatonic semitone <i>Reverse Zira'at, 1/10 octave</i>	2	Db+ <i>D ----</i>	16/15 <i>3125/2916</i>	<i>15/14</i>	111,731 <i>119,443</i>	7 <i>-46</i>
6	19 20	Zarlino semitone, 1/9 octave <i>Tsaharuk, 1/5 fifth, "13/12"</i>		Db++ <i>D ---</i>	27/25 <i>625/576</i>	<i>175/162</i> <i>243/224</i>	133,238 <i>140,949</i>	19 <i>-34</i>
7	22 23	<i>Neutral second, Totem</i> Dotkot		Db+++ D --	<i>2187/2000</i> 800/729	<i>35/32</i> <i>192/175</i>	<i>155,140</i> 160,897	<i>31</i> -22
8	25 26	<i>Olzal, quarter fifth</i> Minor whole tone	3	Db++++ D -	<i>3456/3125</i> 10/9	<i>448/405</i>	<i>174,692</i> 182,404	<i>43</i> -10
9	29 30	Major whole tone <i>Double 17th harmonic, 96/85</i>	4	D <i>Eb ----</i>	9/8 <i>15625/13824</i>	<i>2025/1792</i>	203,910 <i>211,622</i>	2 <i>-51</i>
10	32 33	Double apotome <i>Septimal whole tone</i>		D+ <i>Eb ---</i>	256/225 <i>2500/2187</i>	<i>8/7</i>	223,463 <i>231,174</i>	14 <i>-39</i>
11	35 36	Low semifourth, Semka <i>High semifourth, 37/32</i>		D++ <i>Eb --</i>	144/125 <i>125/108</i>	<i>280/243</i> <i>81/70</i>	244,969 <i>252,680</i>	26 <i>-27</i>
12	38 39	<i>Septimal minor third</i> Augmented second		D+++ Eb -	<i>729/625</i> 75/64	<i>7/6</i>	<i>266,871</i> 274,582	<i>38</i> -15
13	41 42	<i>Basepbis, 85/72</i> 3rd limit minor third	5	D+++ Eb	<i>18432/15625</i> 32/27	<i>189/160</i>	<i>288,377</i> 294,135	<i>50</i> -3
14	45 46	5th limit minor third <i>Superkleismic, double Dotkot</i>	6	Eb+ <i>E ---</i>	6/5 <i>3125/2592</i>	<i>135/112</i>	315,641 <i>323,353</i>	9 <i>-44</i>
15	48 49	Double Zalzal (54/49)^2 <i>Thai third, "39/32"</i>		Eb++ <i>E --</i>	243/200 <i>625/512</i>	<i>175/144</i> <i>128/105</i>	337,148 <i>342,905</i>	21 <i>-32</i>
16	51 52	<i>Rast third, Mogar, "16/13"</i> Dble minor tone, 79/64		Eb+++ E -	<i>19683/16000</i> 100/81	<i>315/256</i> <i>216/175</i>	<i>359,050</i> 364,807	<i>33</i> -20
17	54 55	<i>Turkish major third</i> 5th limit major third	7	Eb++++ E	<i>3888/3125</i> 5/4	<i>56/45</i>	<i>378,602</i> 386,314	<i>45</i> -8
18	58 59	3rd limit major third <i>Riham, 10 steps of 29-edo</i>	8	E+ <i>F ----</i>	81/64 <i>25000/19683</i>	<i>80/63</i>	407,820 <i>413,578</i>	4 <i>-49</i>
19	61 62	Daghboc, dim. 4th, 41/32 <i>Supermajor septimal third</i>		E++ <i>F ---</i>	32/25 <i>625/486</i>	<i>9/7</i>	427,373 <i>435,084</i>	16 <i>-37</i>
20	64 65	<i>Augm. 3rd, quadruple apotome</i> High augmented third		E+++ F --	<i>162/125</i> 125/96	<i>35/27</i> <i>729/560</i>	<i>449,275</i> 456,986	<i>28</i> -25
21	67 68	<i>Septimal fourth</i> Biseptimal Slendro fourth		E++++ F -	<i>6561/5000</i> 320/243	<i>21/16</i> <i>1152/875</i>	<i>470,781</i> 476,539	<i>40</i> -13

n°	Kleismas	Interval	Shruti	Note	L.5 ratio	L.7 ratio	Cents	Fifths
22	70 71	<i>Persian fourth, 85/64</i> 3rd limit fourth	9	E+++++ F	20736/15625 4/3	896/675	490,333 498,045	52 -1
23	74 75	Fourth plus pramana s. <i>Fourth + septimal comma</i>	10	F+ F# ---	27/20 80000/59049	256/189	519,551 525,309	11 -42
24	77 78	Fourth +diesis, Zinith <i>Septimal neutral fourth</i>		F++ F# --	512/375 1000/729	175/128 48/35	539,104 546,815	23 -30
25	80 81	<i>7th + 3rd limit minor thirds</i> Major third + minor tone		F+++ Db -	864/625 25/18	112/81 243/175	561,006 568,717	35 -18
26	83 84	<i>Septimal tritone</i> Diatonic tritone	11	F++++ F#	4374/3125 45/32	7/5	582,512 590,224	47 -6
27	87 88	Reverse tritone <i>Euler's septimal tritone</i>	12	F#+ G ----	64/45 3125/2187	10/7	609,776 617,488	6 -47
28	90 91	Double minor third <i>9/7 + 9/8, "13/9"</i>		F+++ G ---	36/25 625/432	350/243 81/56	631,283 638,994	18 -35
29	93 94	<i>Double Aksaka</i> Narayana, rev. Zinith		Gb+++ G --	729/500 375/256	35/24 256/175	653,185 660,896	30 -23
30	96 97	<i>Fifth minus septimal com.</i> Fifth minus pramana		Gb++++ G -	3456/3125 40/27	189/128	674,691 680,449	42 -11
31	100 101	3rd limit perfect fifth <i>Persian fifth, 128/85</i>	13	G Ab ----	3/2 15625/10368	675/448	701,955 709,667	1 -52
32	103 104	Fifth plus pramana s. <i>Septimal extended fifth</i>		G+ Ab ---	243/160 10000/6561	875/576 32/21	723,461 729,219	13 -40
33	106 107	Low trisemifourth <i>High trisemifourth</i>		G++ Ab --	192/125 125/81	54/35	743,014 750,725	25 -28
34	109 110	<i>Septimal minor sixth</i> Low minor 6th, dble 5/4		G+++ Ab -	972/625 25/16	14/9	764,916 772,627	37 -16
35	112 113	<i>Mahir, 19 steps of 29-edo</i> 3rd limit minor sixth	14	G++++ Ab	24576/15625 128/81	63/40	786,422 792,180	49 -4
36	116 117	5th limit minor sixth <i>Turkish minor sixth</i>	15	Ab+ A ---	8/5 3125/1944	45/28	813,686 821,398	8 -45
37	119 120	Double Zalzal <i>Bayati sixth, "13/8"</i>		Ab++ A --	81/50 625/384	175/108 512/315	835,193 840,950	20 -33
38	122 123	<i>Thaï sixth, "64/39"</i> Double Daghoc		Ab+++ A -	1024/625 400/243	105/64 288/175	857,095 862,852	32 -21
39	125 126	<i>Turkish 6th, rev. Superkleismic</i> Major sixth	16	Ab++++ A	5184/3125 5/3	224/135	876,647 884,359	44 -9
40	129 130	3rd limit major sixth <i>Sybis, reverse Basepbis</i>	17	A+ Bb ----	27/16 15625/9216	320/189	905,865 911,623	3 -50
41	132 133	Diminished seventh <i>Supermajor septimal sixth</i>		A++ Bb ---	128/75 1250/729	12/7	925,418 933,129	15 -38
42	135 136	<i>Triple minor third</i> Rev. semifourth, 111/64		A+++ Bb --	216/125 125/72	140/81 243/140	947,320 955,031	27 -26
43	138 139	<i>Harmonic seventh</i> Rev. double apotome		A++++ Bb -	2187/1250 225/128	7/4	968,826 976,537	39 -14

n°	Kleismas	Interval	Shruti	Note	L.5 ratio	L.7 ratio	Cents	Fifths
44	141 142	<i>Persian minor 7th, 85/48</i> Minor 7th, dble fourth	18	A+++++ Bb	27648/15625 16/9	567/320	990,332 996,090	51 -2
45	145 146	High minor seventh <i>Reverse Olzal</i>	19	Bb+ B ---	9/5 3125/1728	405/224	1017,596 1025,308	10 -43
46	148 149	Reverse Dlotkot <i>Neutral seventh, "117/64"</i>		Bb++ B --	729/400 4000/2187	175/96 64/35	1039,103 1044,860	22 -31
47	151 152	<i>Reverse Tsaharuk, 59/32</i> Rev. Zarlino semitone		<i>Bb+++</i> B -	1152/625 50/27	448/243	1059,051 1066,762	34 -19
48	154 155	<i>Zira'at</i> Major seventh - 15th h.	20	<i>Bb++++</i> B	5832/3125 15/8	28/15	1080,557 1088,269	46 -7
49	158 159	Reverse limma <i>Major 6th + septimal tone</i>	21	B+ C ----	256/135 12500/ 6561	40/21	1107,821 1115,533	5 -48
50	161 162	Reverse lagu, 123/64 <i>Supermajor septimal 7th</i>		B++ C ---	48/25 625/324	27/14	1129,328 1137,039	17 -36
51	164 165	<i>Rev. septimal quartertone</i> Triple major third		B+++ C --	243/125 125/64	35/18	1151,230 160,897	29 -24
52	167 168	<i>Octave - septimal comma</i> Octave minus pramana		<i>B++++</i> C -	19683/10000 160/81	63/32	1172,736 1178,494	41 -12
53	171	Octave	22	C	2/1	2/1	1200	0

Tunings menu of the Semantic Danielou-53 - version 1.1

Semantic sets :

- 1_semantic-12.scl (= tuning par défaut pour clavier Halberstadt)
- 2_22 shrutis.scl (24 notes)
- 3_semantic-36.scl (36 notes)
- 4_semantic-45.scl (48 notes)
- 5_semantic-48.scl (48 notes)
- 6_semantic-53-sym.scl (= tuning par défaut pour l'Axis-64)

Indian ragas :

- 7_ahir_bhairav-c.scl
- 8_bhairav-5.scl
- 9_bhairav-17.scl
- 10_bhairavi-19.scl
- 11_bhatiyar-5.scl
- 12_bhavani-5.scl
- 13_bhavapriya.scl
- 14_chandrakaus-5.scl
- 15_coherent_shrutis.scl
- 16_darbari-5.scl
- 17_gayakapriya.scl
- 18_jog.scl
- 19_kalyana-c.scl
- 20_kanakangi.scl
- 21_kidarvani.scl
- 22_kirvanti-c.scl
- 23_lalit-c.scl
- 24_madhuvanti-c.scl
- 25_marva-c.scl
- 26_nila-c.scl
- 27_purvi-c.scl
- 28_satara.scl
- 29_shri_rag-c.scl
- 30_todi-c.scl

World musical cultures :

- 31_amlak.scl
- 32_bala_sem-sem.scl
- 33_byzantine-5.scl
- 34_didymus-5.scl
- 35_harmonics.scl
- 36_indian_quarters.scl
- 37_kleismean.scl
- 38_mohajira-to-slendro.scl
- 39_mougi-c.scl
- 40_napolitan_5-l.scl
- 41_romios.scl
- 42_semantix-12.scl
- 43_semantix-semantic.scl
- 44_siamese_7-qedo.scl
- 45_slendro_cloud.scl
- 46_slendro_sequence.scl
- 47_thai_reversible
- 48_thai_17l-tetrac
- 49_tsaharuk-12a.scl
- 50_tsaharuk-12d.scl
- 51_Aslan

Related temperaments :

- 52_bala-ribbon.scl
- 53_Daghboc
- 54_hemififth-schismatic.scl
- 55_Lagunaga
- 56_Secor-septimal
- 57_semantix-36.scl (36 notes)
- 58_sixth_of_sixth.scl
- 59_tsaharuk-17.scl (24 notes)
- 60_tsaharuk-24.scl (24 notes)

Ambient tunings :

- 61_krems_5.scl
- 62_mougi_gliss.scl
- 63_passage_secret.scl
- 64_ragismatic.scl
- 65_whole_tones.scl

Demonstration tunings :

- 66_eratosthenes.scl
- 67_kleisma.scl
- 68_pramana_shruti
- 69_ragisma.scl
- 70_schisma.scl
- 71_semantic_axis-19.scl (24 notes)
- 72_yantra.scl

Instruments menu of the Semantic Danielou-53 - version 1.1

- 1_Twelve Strings guitar
- 2_Bassoon
- 3_Flute
- 4_Sax alto
- 5_Trompette organ
- 6_Xylo
- 7_Cello
- 8_Celtic Harp
- 9_Choir female
- 10_Clar ordinario
- 11_Contrabass
- 12_Grand Piano
- 13_Harmonica
- 14_Harp koto
- 15_Justiciable (distorted guitar)
- 16_Mantra Voice
- 17_Martin wide (acoustic guitar)
- 18_Oboe Ordinario (Damien)
- 19_Ocarina
- 20_Organ pipes
- 21_Oud
- 22_Pan flute
- 23_Saturn (Xtreme FX/)
- 24_Strat with distortion
- 25_Strings Ensemble
- 26_Sweep Moon (synthetic choir)
- 27_Trumpet
- 28_Xpand Sine