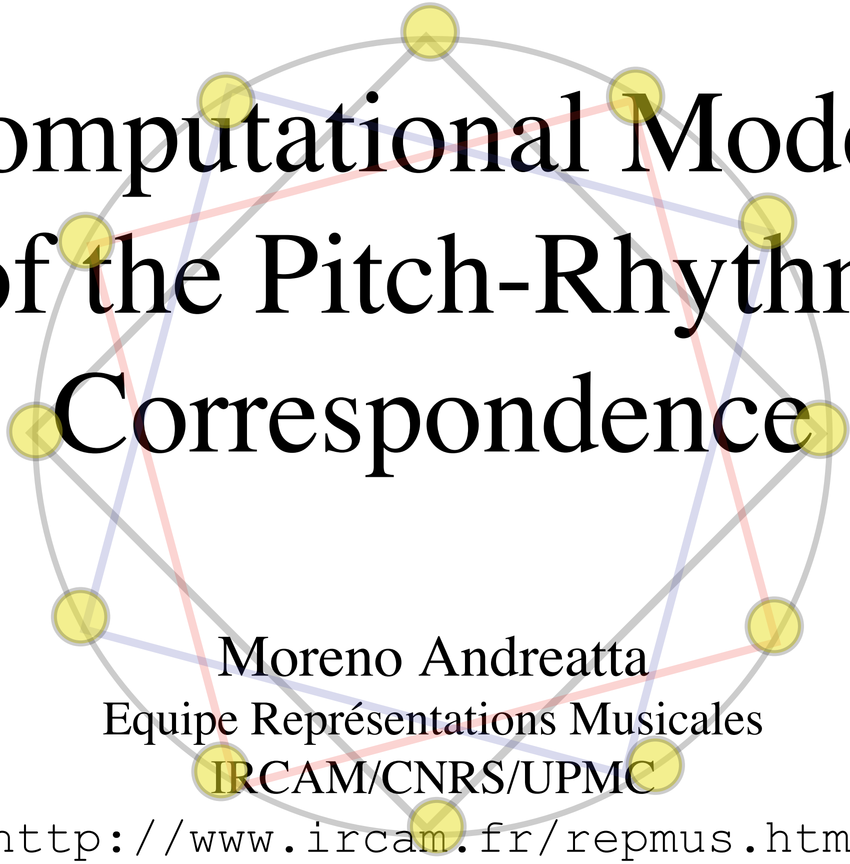
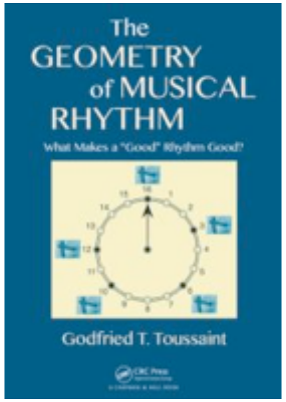


Computational Models of the Pitch-Rhythm Correspondence

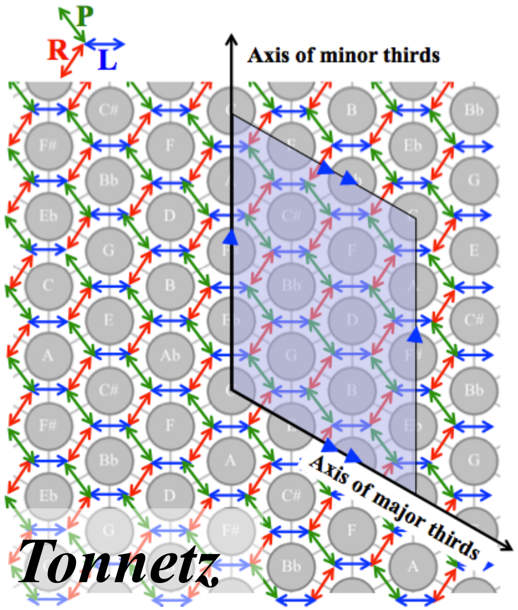
Moreno Andreatta
Equipe Représentations Musicales
IRCAM/CNRS/UPMC
http://www.ircam.fr/repmus.html

The pitch-rhythm isomorphic correspondence



"It is well known that there exists an isomorphic relation between pitch and rhythm, which several authors have pointed out from time to time."

(G. Toussaint, *The geometry of musical rhythm. What makes a "Good" Rhythm Good?* CRC Press, 2013, p. xiii)



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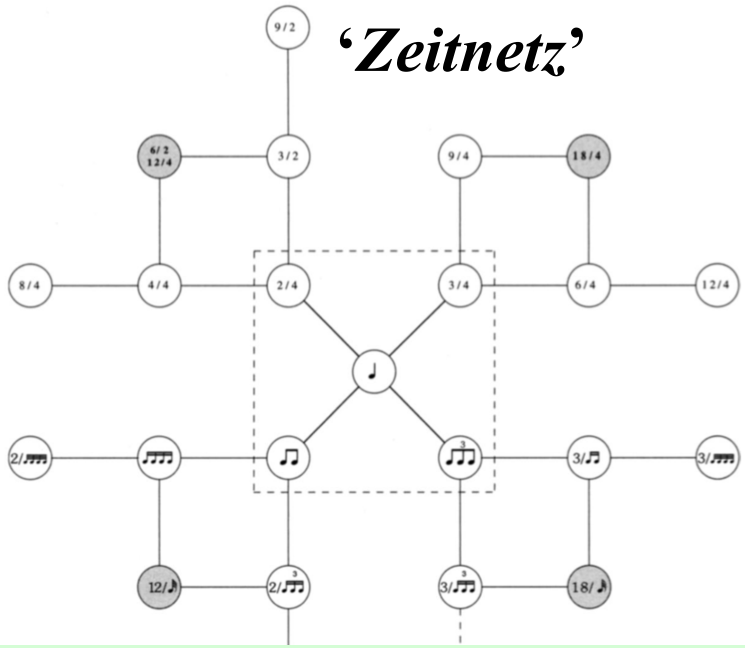
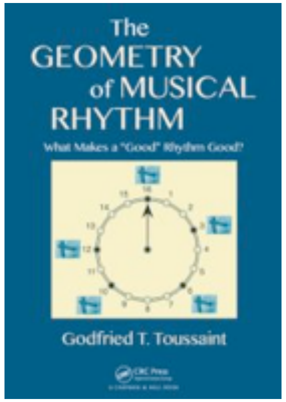


"This non-isomorphism stems from the fact that there are no temporal analogs to octave and enharmonic equivalence and that there are no tonal analogs to various limits on our temporal perception and acuity."

J. London (2002), "Some Non-Isomorphisms between Pitch and Time", *JMT*, 46(1/2), 127-151

The pitch-rhythm isomorphic correspondence



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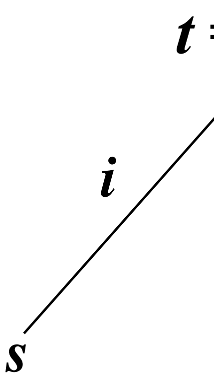
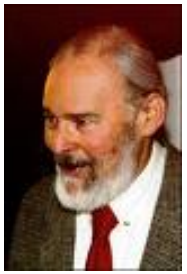
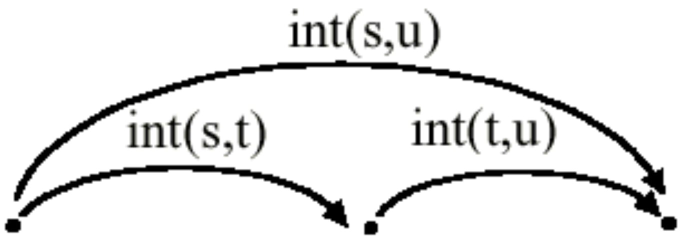




GIS=(*S*, *G*, *int*)

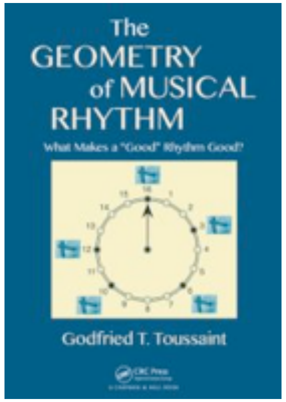
- ***S*** **= a space**
- ***G*** **= a group**
- ***int*** **= interval fonction**



The arrow marked i symbolizes a characteristic directed measurement, distance, or **motion** from ***s*** to ***t***. We intuit such situations in **many musical spaces**, and we are used to calling ***i*** "the interval from ***s*** to ***t***" when the symbolic points are pitches or pitch classes. The **general intuition** at hand is then made formal by a mathematical model which I call a *Generalized Interval System*.

David Lewin (1987), *Generalized Musical Intervals and Transformations*, YUP

The pitch-rhythm isomorphic correspondence



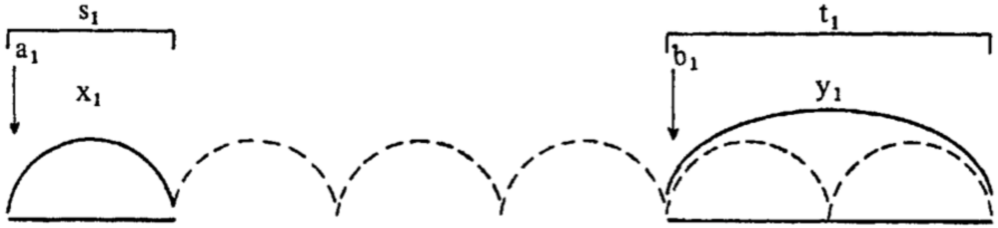
"It is well known that there exists an isomorphic relation between pitch and rhythm, which several authors have pointed out from time to time."

(G. Toussaint, *The geometry of musical rhythm. What makes a "Good" Rhythm Good?* CRC Press, 2013, p. xiii)

$t = \mathrm{T}_i(s)$

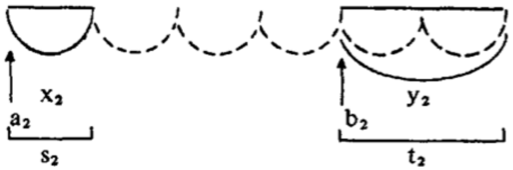
i

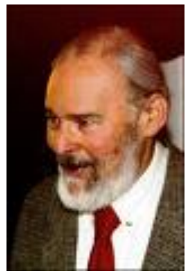
s



GIS=(*S*, *G*, *int*)

$S=\{(a,x) \in \mathbf{R} \times \mathbf{R}^+\}$,
$G=(\mathbf{R}, +) \times (\mathbf{R}^+, \times)$,
$int((s,x), (t,y))=((t-s)/x, y/x)$





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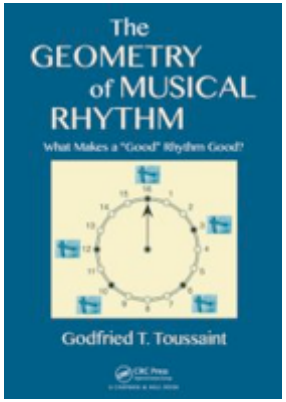
David Lewin (1987), *Generalized Musical Intervals and Transformations*, YUP

The pitch-rhythm isomorphic correspondence



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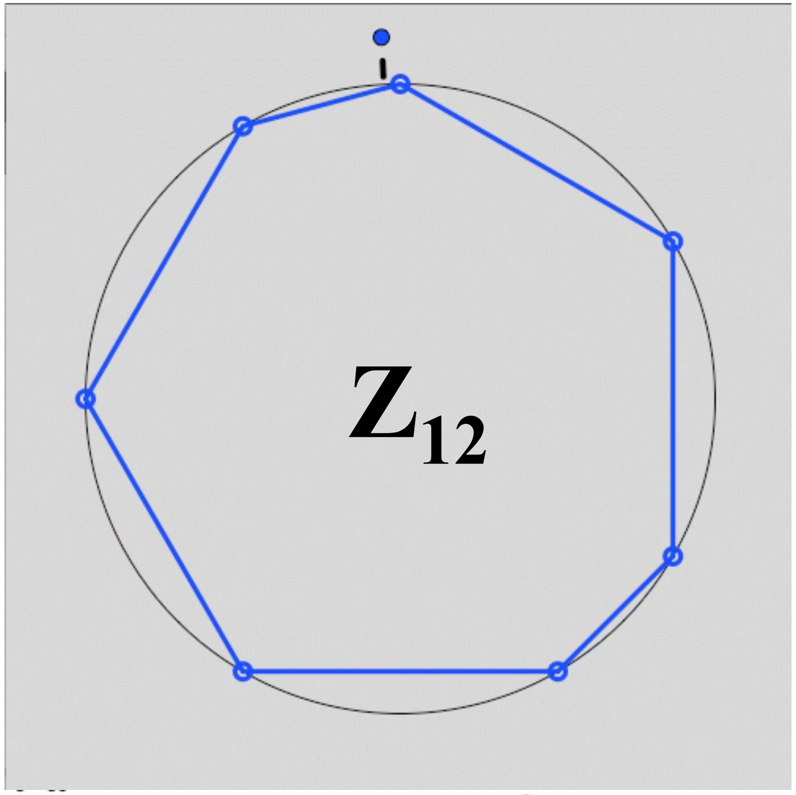
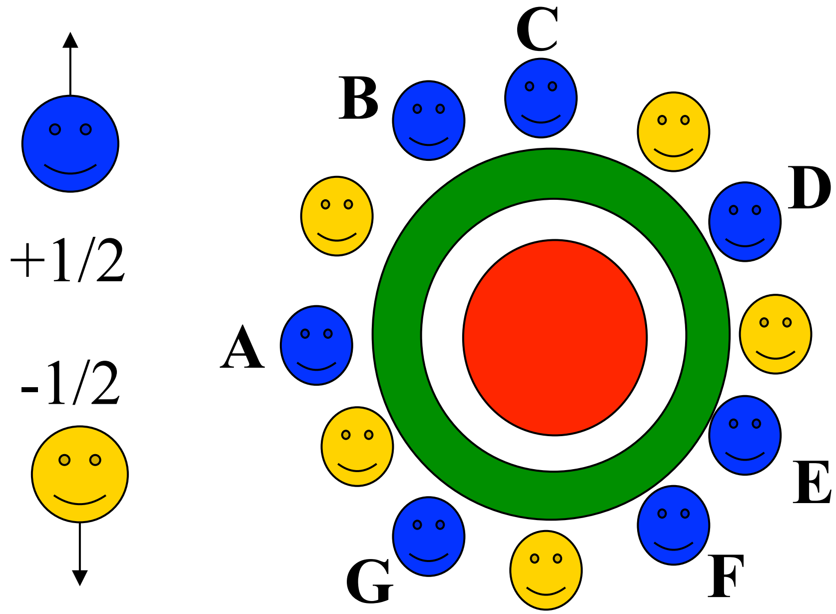
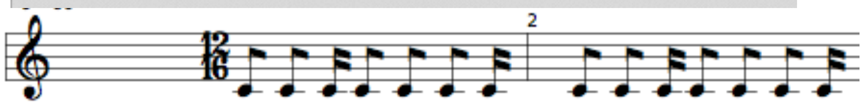
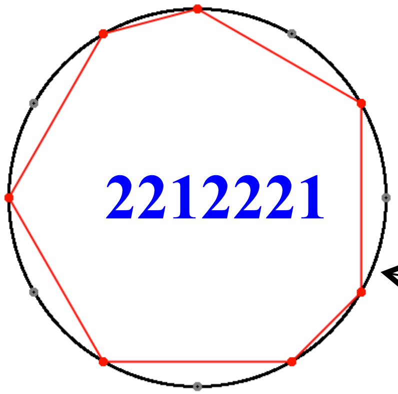


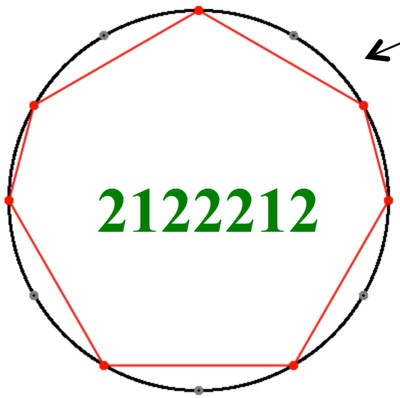




J. Douthett & R. Krantz, "Energy extremes and spin configurations for the one-dimensional antiferromagnetic Ising model with arbitrary-range interaction", *J. Math. Phys.* 37 (7), July 1996

The pitch-rhythm *cognitive* isomorphic correspondence





...

cyclic permutations

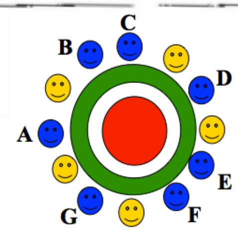
TABLE I

Comparison of M = 7, L = 12 patterns for pitch (scales) and rhythm (time-lines)

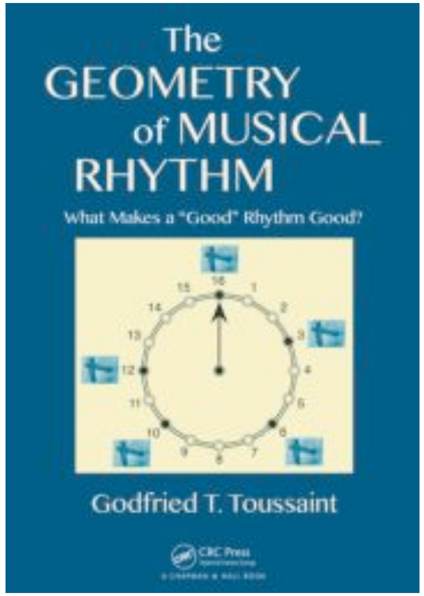
	pattern	pitch domain name and notation (in C)	rhythm domain notation	examples from West Africa	references
1.	2212221	major scale (Ionian) CDEFGAB		Ewe (Atsiabek , Sogba, Atsia) also Yoruba	Jones (1959), C. K. Ladzekpo, S. K. Ladzekpo and Pantaleoni, Locke
2	2122212	Dorian CDE♭ FGAB♭		Bemba—Northern Rhodesia	Jones (1965), (Ekwueme)
3.	1222122	Phrygian CD♭ E♭ FGA♭ B♭		———	———
4.	2221221	Lydian CDEF#GAB		Ga-Adangme (common) also common Haitian pattern, Akan (Ab fo)	C. K. Ladzekpo, Combs (1974), R. Hill, Asiama
5.	2212212	Mixolydian CDEFGAB♭		Yoruba sacred music from Ekiti	King
6.	2122122	Aeolian CDE♭ FGA♭ B♭		Ashanti (Ab fo , Mpre)	Koetting
7.	1221222	Locrian CD♭ E♭ FG♭ A♭ B♭		Ghana*	Nketia (1963a)
8.	2121222	(#2 Locrian) CDE♭ FG♭ A♭ B♭		Ashanti (Asedua)	C. K. Ladzekpo
9.	2112123	——— CDD#EF#GA		Akan (juvenile song)	Nketia (1963b)

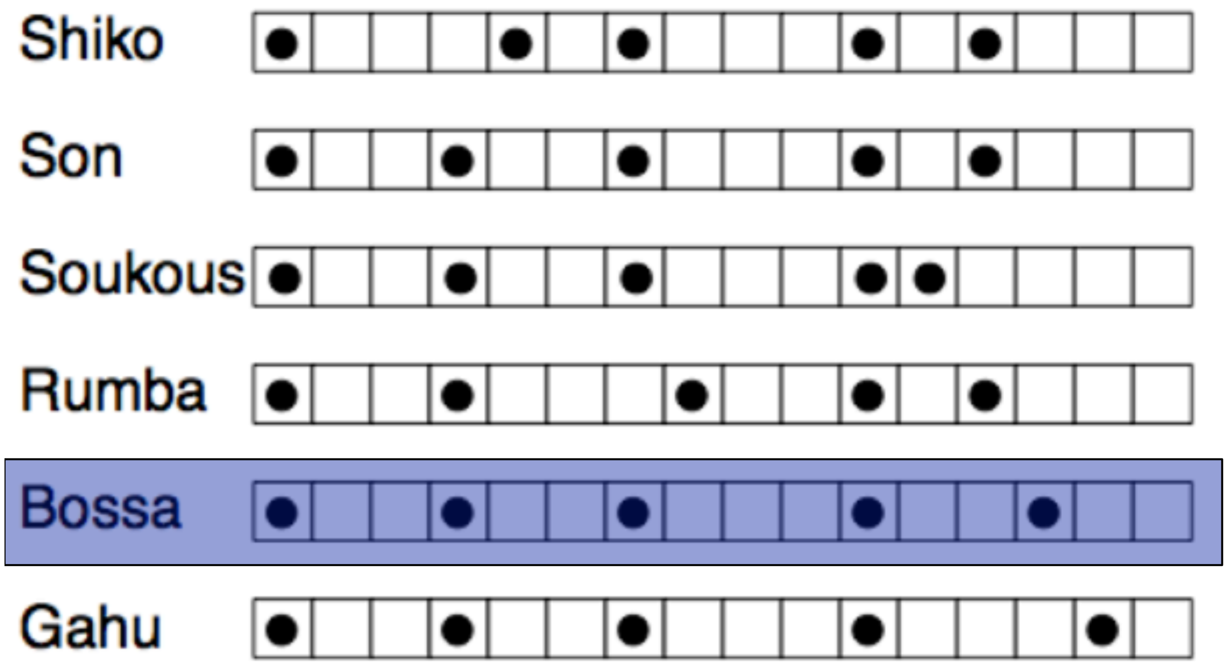
* clap pattern
† mute stroke on bell

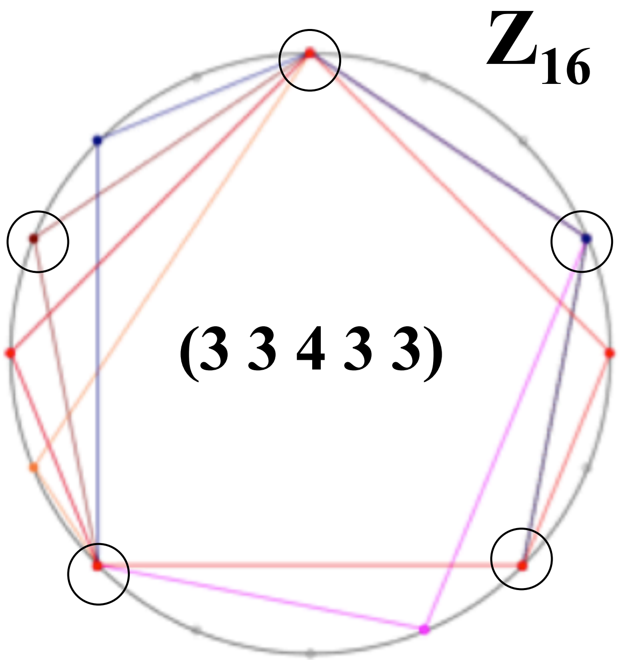
J. Pressing, "Cognitive isomorphisms between pitch and rhythm in world musics: West Africa, the Balkans and Western tonality", *Studies in Music*, 17, p. 38-61



The geometry of African-Cuban rhythms

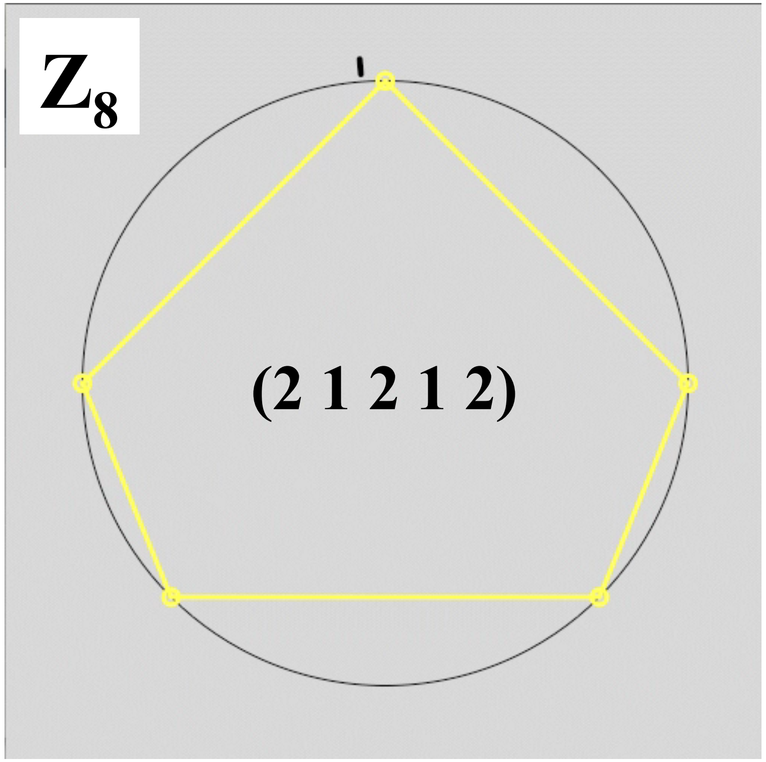


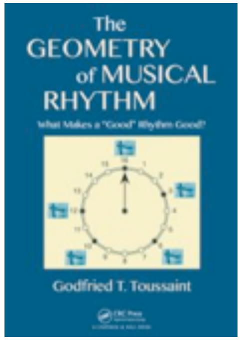




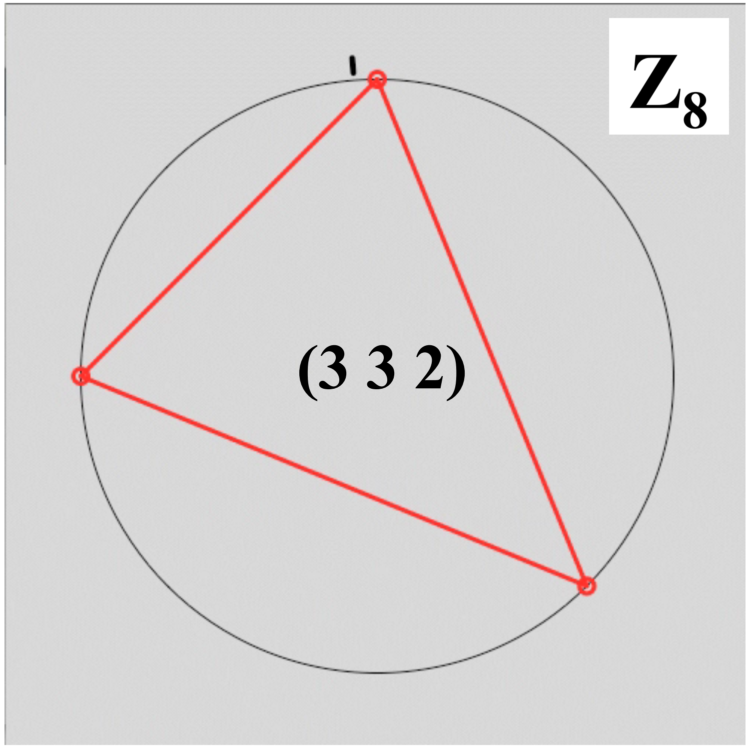
The geometry of African-Cuban rhythms

Cinquillo

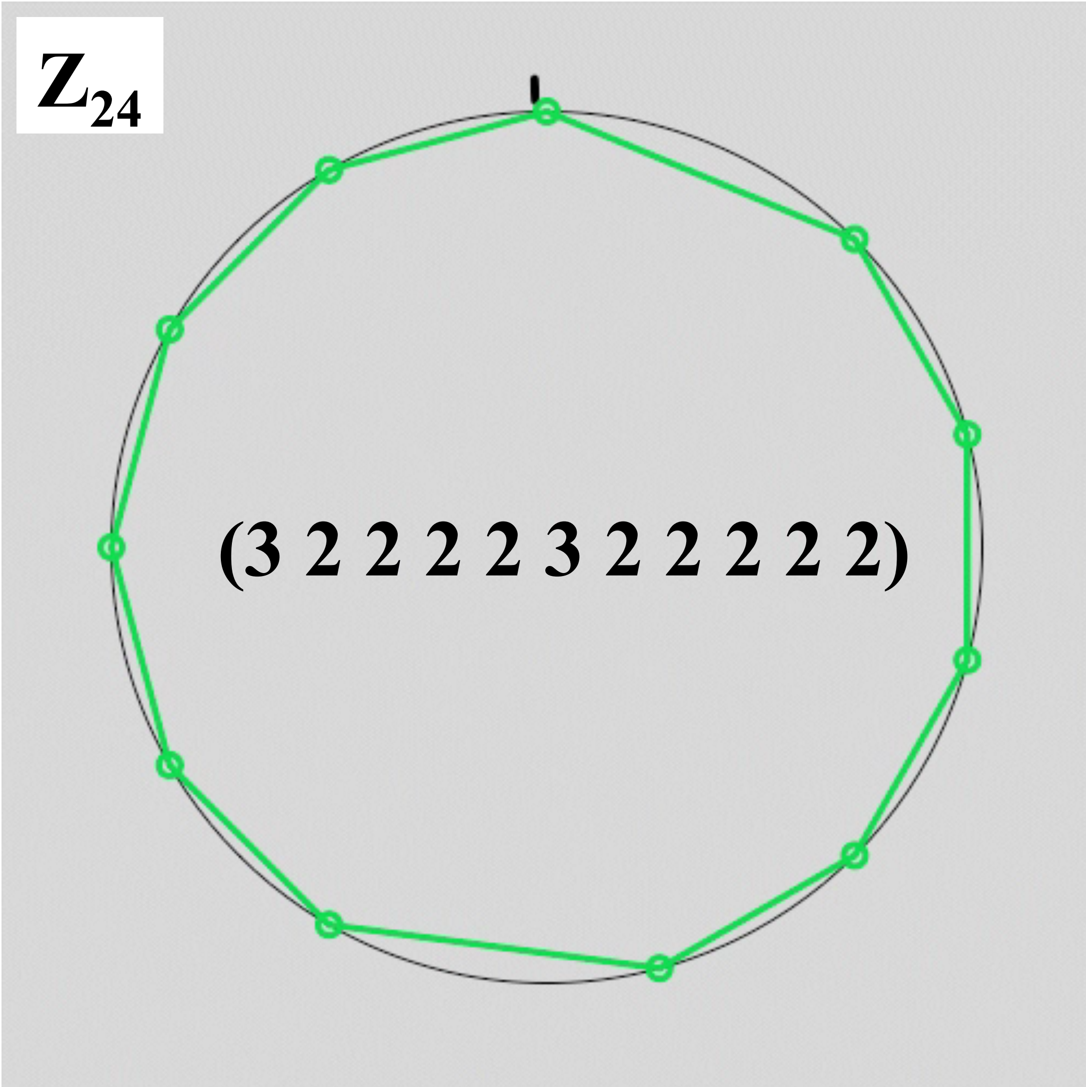




Trecillo

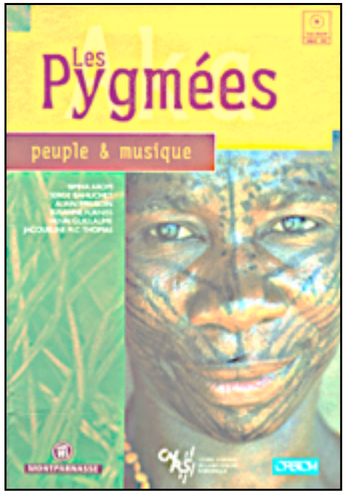


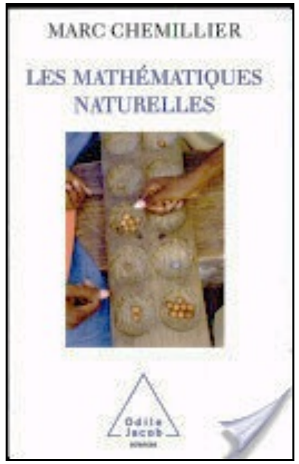
Odditive property of orally-trasmitted practices



Simha Arom

Marc Chemillier





musimédiane

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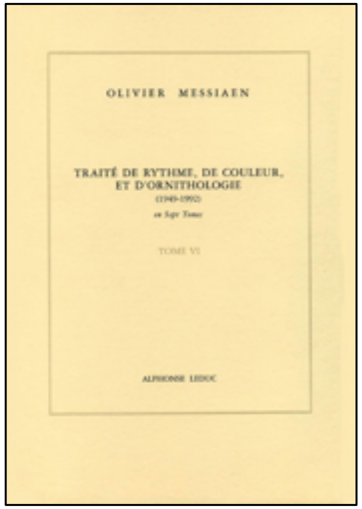
revue audiovisuelle et multimédia d'analyse musicale

➔ **Is maximally eveness a cognitive property?**

The pitch-rhythm *mystic* isomorphic correspondence

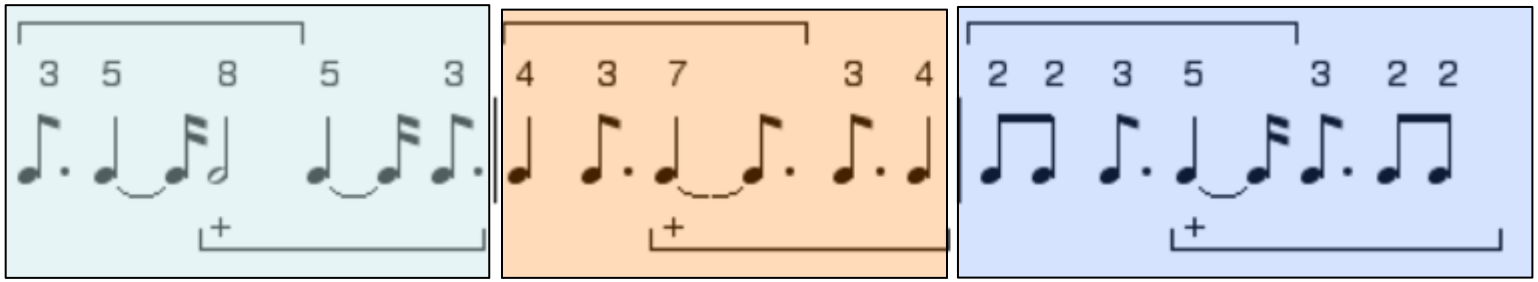


“**These modes** [of Limited Transpositions] **realize in the vertical direction** (transposition) **what non-retrogradable rhythms realize in the horizontal direction** (retrogradation). In fact, these modes *cannot be transposed* beyond a certain number of transpositions without falling again into the same notes, enharmonically speaking; likewise, these rhythms *cannot be read in a retrograde sense* without one’s finding again exactly the same order of values as in the right sense. These modes cannot be transposed because they are —without polytonality—in the modal atmosphere of several keys at once and contain in themselves small transpositions; these rhythms cannot be retrograded because they contain in themselves small retrogradations. These modes are divisible into symmetrical groups; these rhythms, also, with this difference: the symmetry of the rhythmic groups is a retrograde symmetry. Finally, the last note of each group of these modes is always *common* with the first of the following group; and the groups of these rhythms frame a central value *common* to each group. **The analogy is now complete**”.

- **O. Messiaen, *Technique de mon langage musical*, Alphonce Leduc, 1944**
- **O. Messiaen*, Traité de rythme, de couleurs et d’ornithologie*, Alphonce Leduc, 1949-1992**

A ‘Fibonacci’ prime-number-based non-invertible rhythm

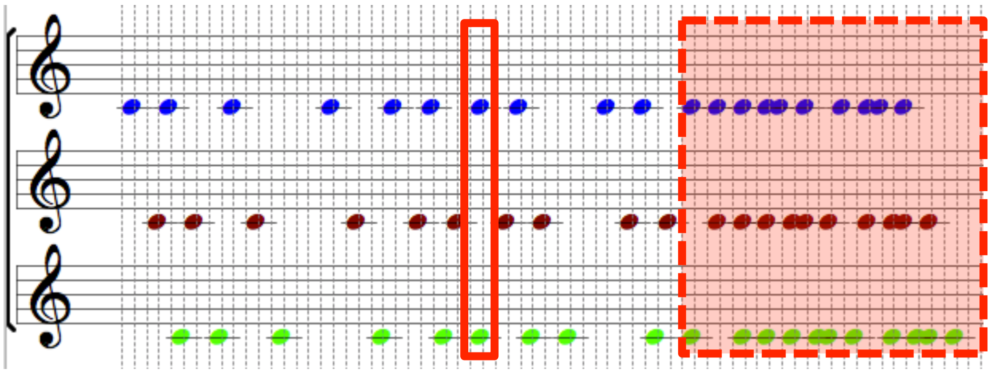
Quatuour pour la fin du temps (1941)



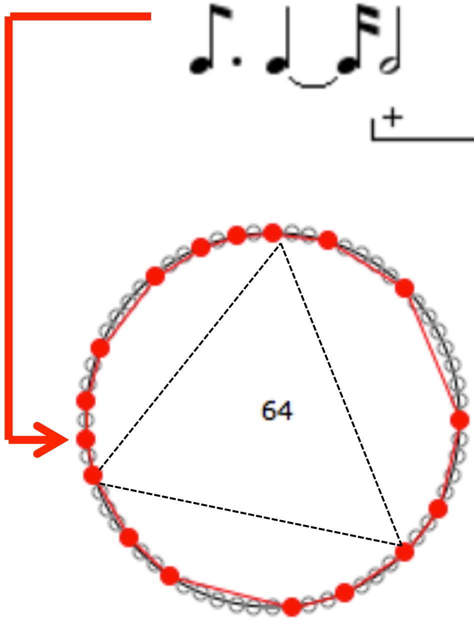
Visions de l’Amen (1943)

Non-invertible rhythms and tiling rhythmic canons

Harawi (1945)



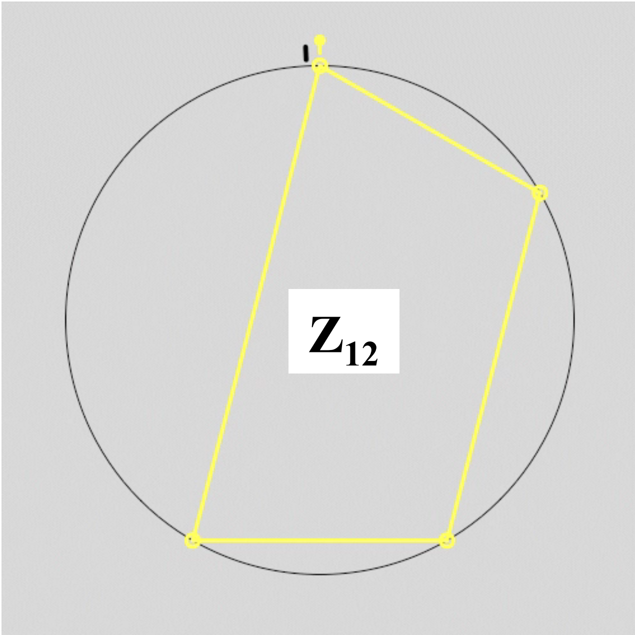
Harawi: rhythmic reduction

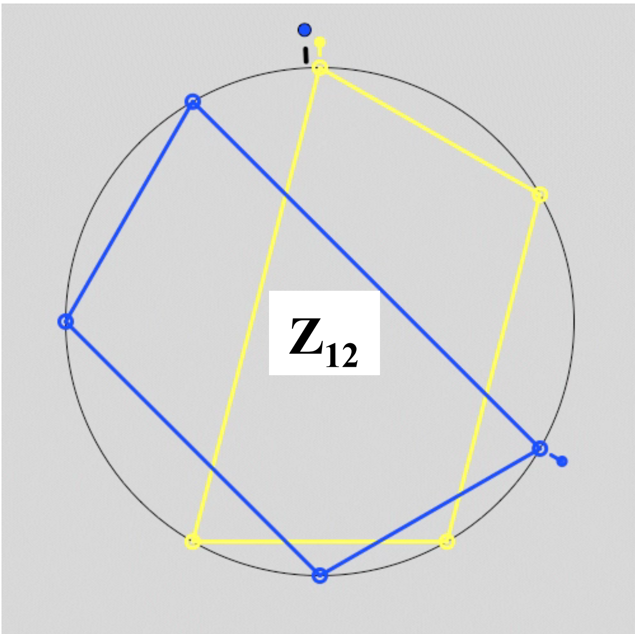


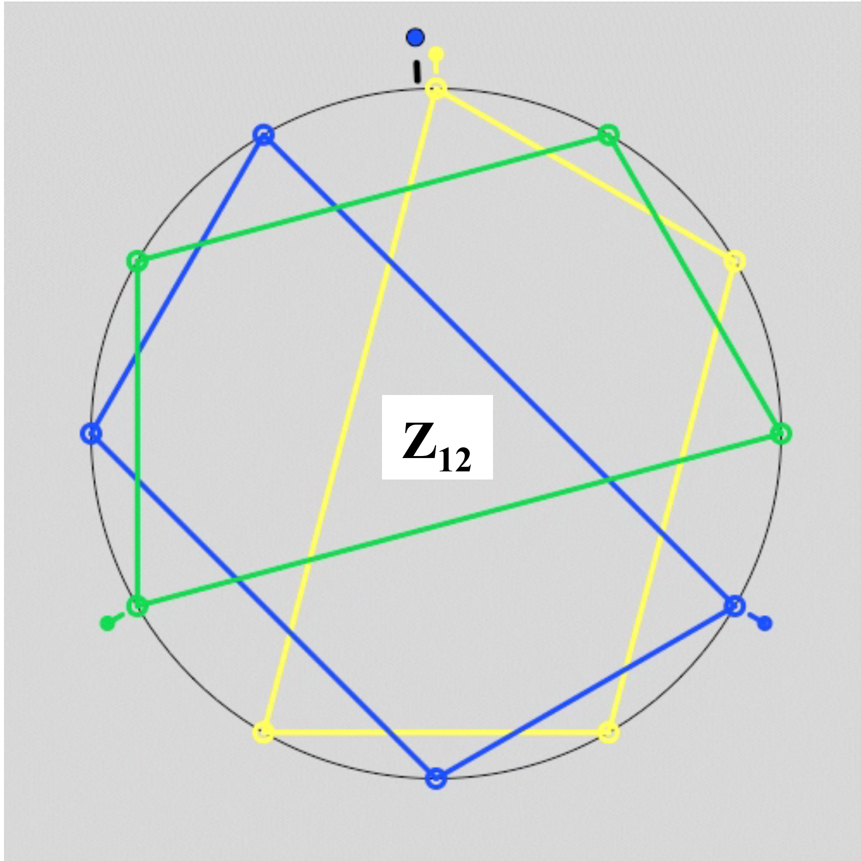
The three non-invertible rhythms divide the durations in 5+5+7 durations, whereas the terms of the three harmonic ostinatos always contain six sonorities for the superior voice, and three sonorities for the two other voices. Consider also that the durations are very unequal. As a result, the different sonorities mix together or contrast to each other in very different ways, <u>never at the same moment nor at the same place</u>. . . . **It is an organized chaos**"

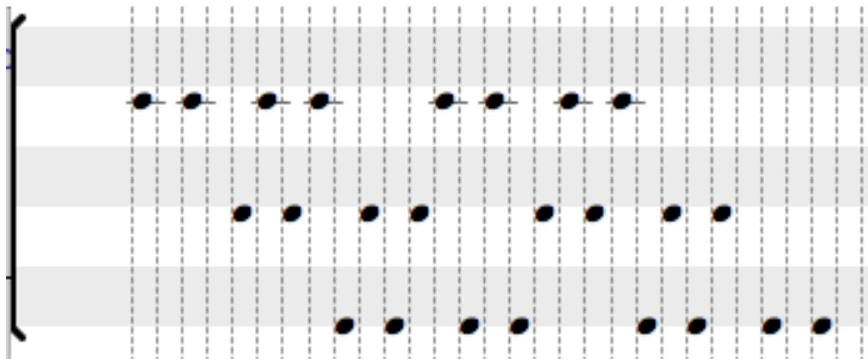
O. Messiaen: ***Traité de Rythme, de Couleur et d'Ornithologie,*** **tome 2, Alphonse Leduc, 1992.**

Tiling the time line with translates of one tile







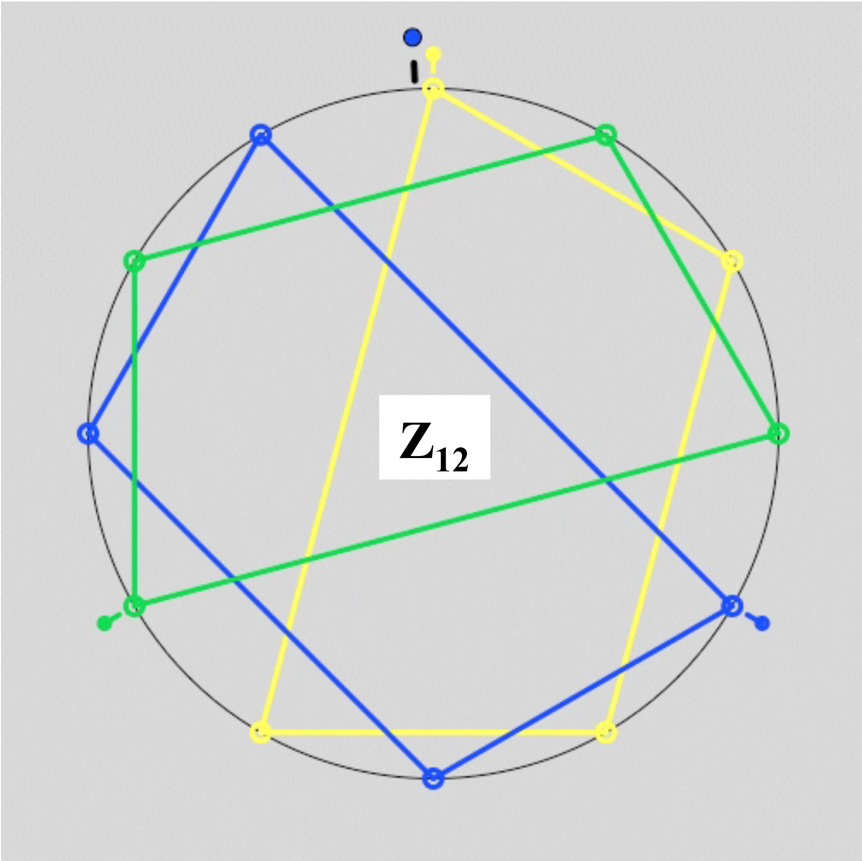


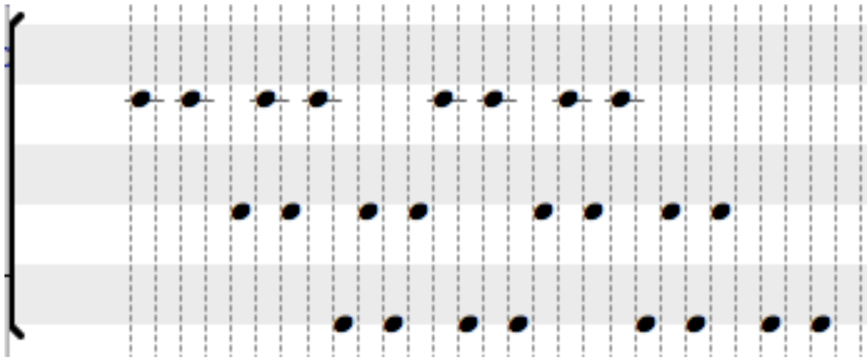
OpenMusic, a Visual Programming Language for computer-aided composition

www.repmus.ircam.fr/openmusic/home

➔ C. Agon, G. Assayag, J. Bresson, *The OM Composer's Book* (2 volumes), 2006-2007

Formalizing the tiling process as a direct sum of subsets





$A_1 = \{0, 2, 5, 7\}$

$\downarrow T_4$

$A_2 = \{4, 6, 9, 11\}$

$\downarrow T_4$

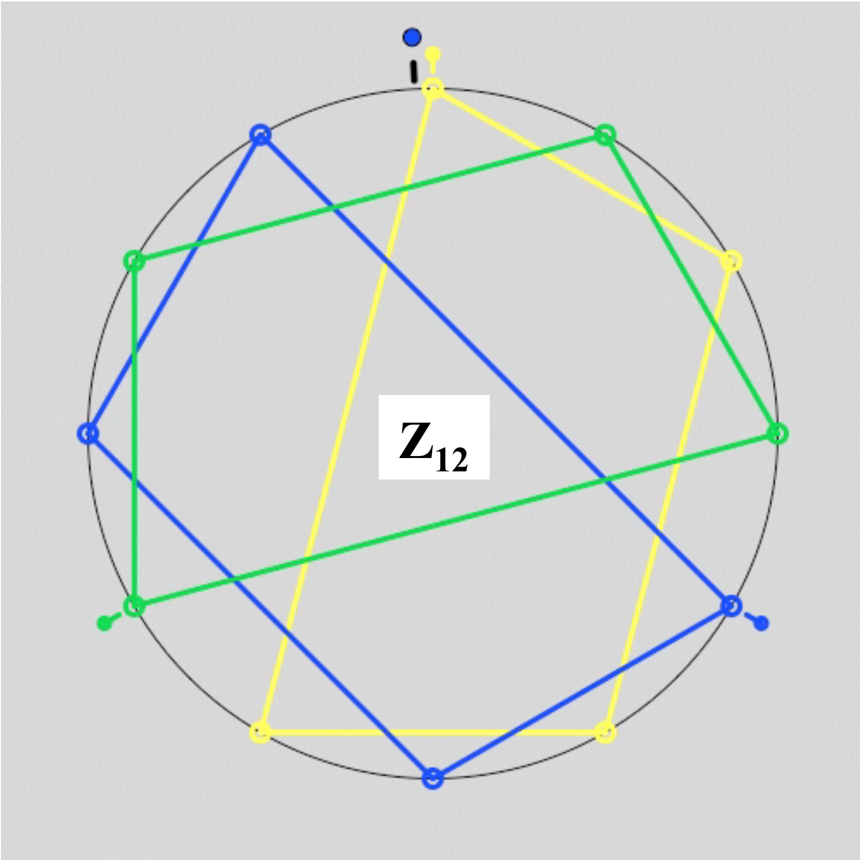
$A_3 = \{8, 10, 1, 3\}$

$Z_{12} = A_1 \cup A_2 \cup A_3$

$Z_{12} = A \oplus B$

$A = \{0,2,5,7\}$
$B = \{0,4,8\}$

Formalizing the tiling process as a chord multiplication

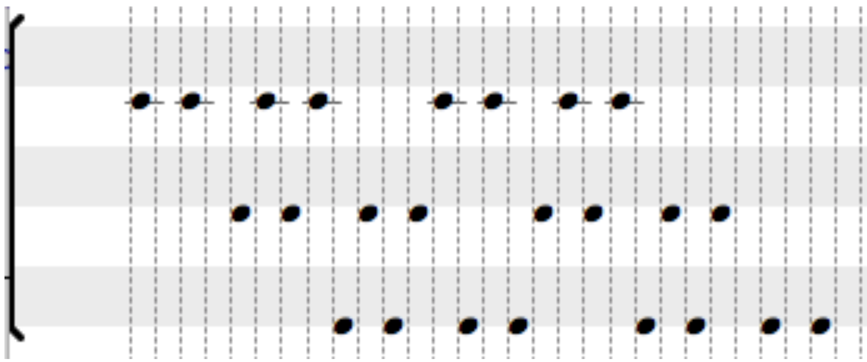


$IS_A = (2\ 3\ 2\ 5)$

$\bullet$

$B = \{0, 4, 8\}$

$$\begin{aligned} A \bullet B = & ((2\ 3\ 2\ 5) \bullet \{0\}) \cup \\ & ((2\ 3\ 2\ 5) \bullet \{4\}) \cup \\ & ((2\ 3\ 2\ 5) \bullet \{8\}) = Z_{12} \end{aligned}$$



P. Boulez

Iannis Xenakis' sieve formalization

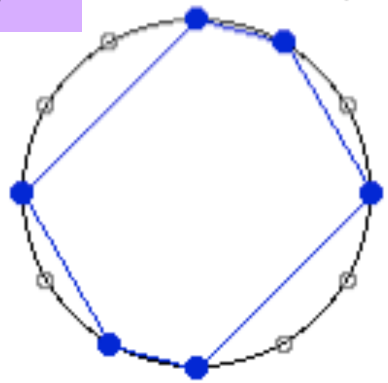
$\{0,\ 1,\ 3,\ 6,\ 7,\ 9\}$

$(6\ 6)\bullet(1\ 2\ 9)=(6\ 6)\bullet\{0,1,3\}$

$=((6\ 6)\bullet\{0\})\cup((6\ 6)\bullet\{1\})\cup((6\ 6)\bullet\{3\})=$

$=\{0,6\}\cup\{1,7\}\cup\{3,9\}=$

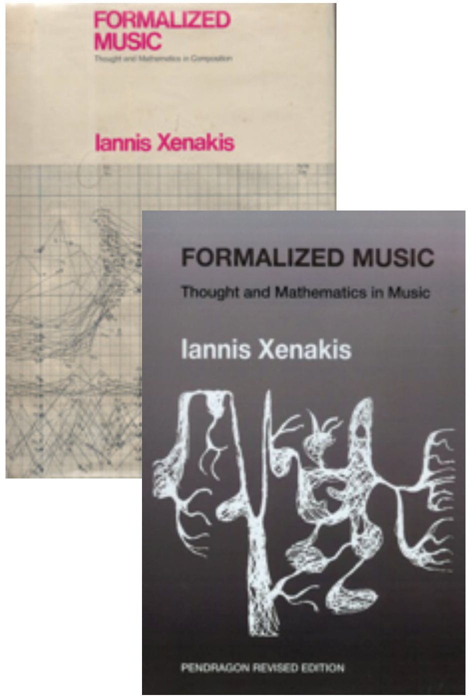
$=\{0,1,3,6,7,9\}.$



$\boxed{6_0 \cup 6_1 \cup 6_3}$ sieve

Anatol Vieru

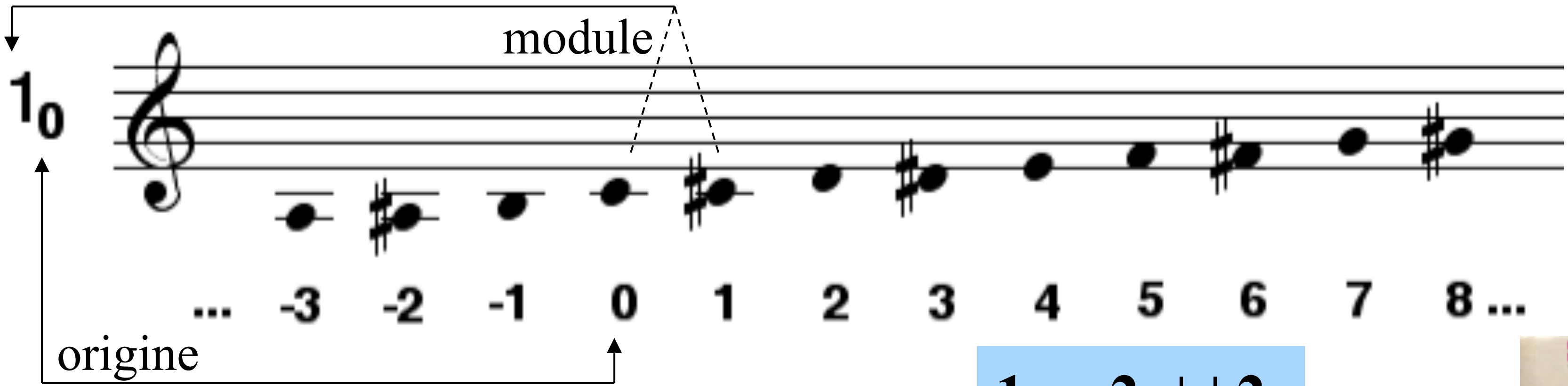
I. Xenakis

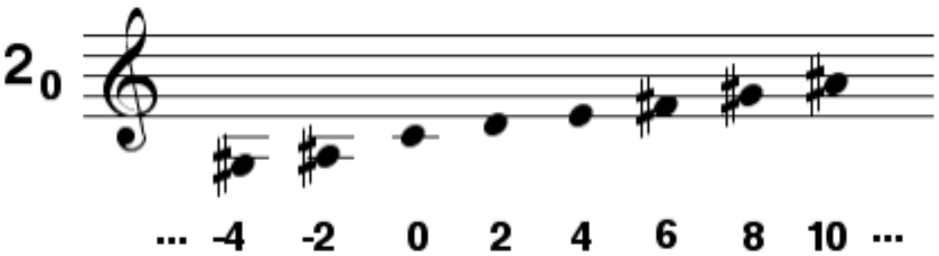


Sieve theorey as a general theory of periodicity

In music, the question of symmetries (spatial identities) or of periodicities (identities in time) plays a fundamental role at all levels, from the sample, in sound synthesis by computer, to the architectures of a piece.[1] It is thus necessary to formulate a theory permitting the construction of symmetries which are as complex as one might want, and inversely, to retrieve from a given series of events or objects in space or time the symmetries that constitute the series. We shall call these series "sieves."

I. Xenakis, "Sieves", *Perspectives of New Music* 28(1), 1992, p. 58–78

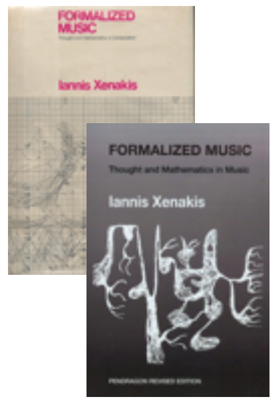




$1_0 = 2_0 \cup 2_1$

$2_0 \cap 2_1 = \varnothing$

$(2_0)^c = 2_1$ $(2_1)^c = 2_0$.



Sieve theorey as a general theory of periodicity

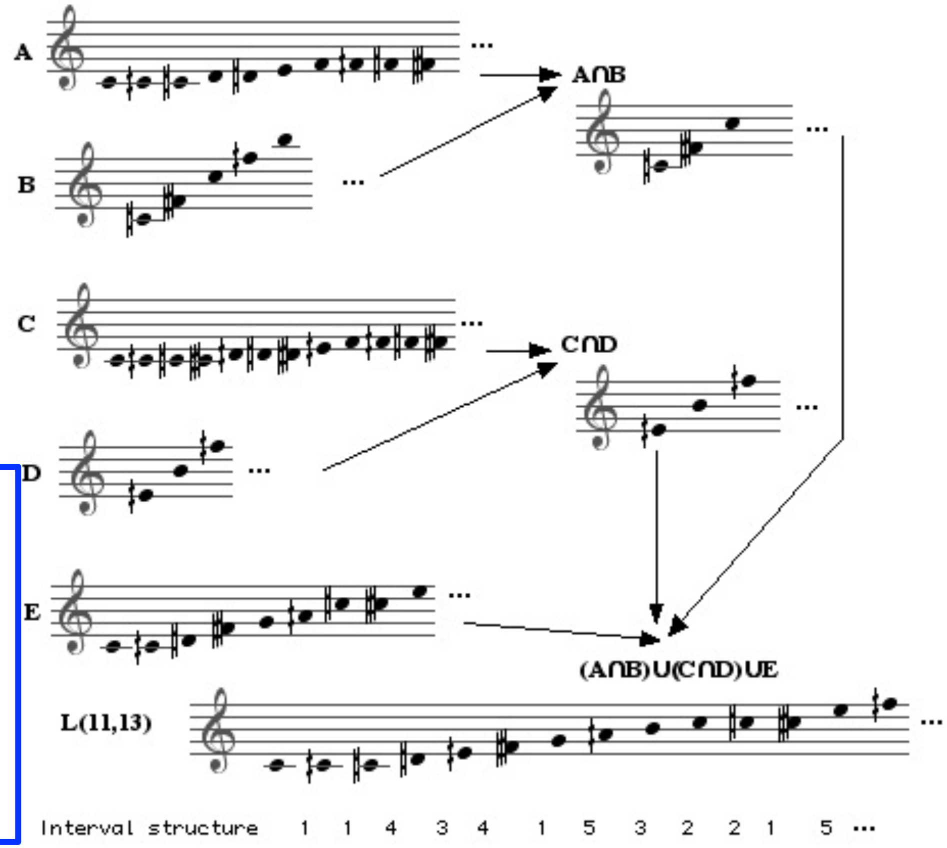
In a similar fashion, a periodic rhythm, for example $(3,2,2) =$ can be notated as $L = 7_0 \cup 7_3 \cup 7_5$. In both of these examples the sign $\cup$ is a logical union (and/or) of the points defined by the moduli and their shifts.

I. Xenakis, “Sieves”, *Perspectives of New Music* 28(1), 1992, p. 58–78

$$L(11,13) = (A \cap B) \cup (C \cap D) \cup E$$

where:

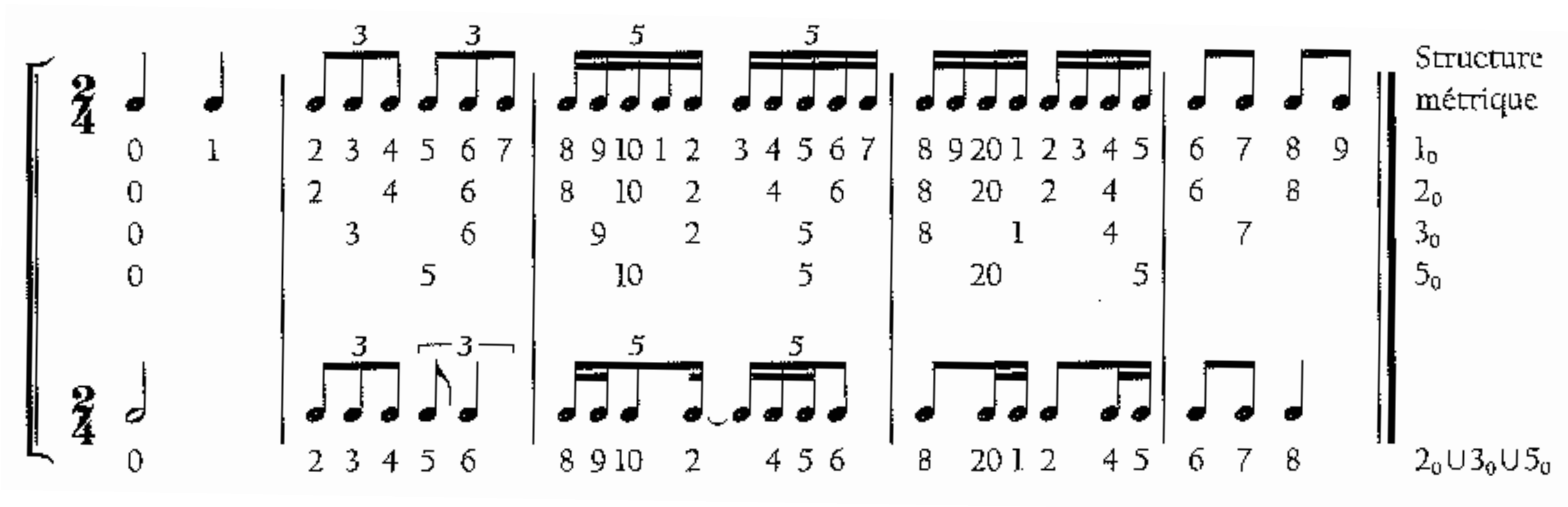
$A = (13_3 \cup 13_5 \cup 13_7 \cup 13_9)^c$
$B = 11_2$
$C = (11_4 \cup 11_8)^c$
$D = 13_9$
$E = 13_0 \cup 13_1 \cup 13_6.$



“One may build rhythmic architectures which are so complex that they are perceived as pseudo-aleatoric distributions of time-points on the time axis if the period is long enough”.

I. Xenakis, « Redécouvrir le temps », éditions de l’Université de Bruxelles, 1988

The extension of sieve theory within algorithmic composition

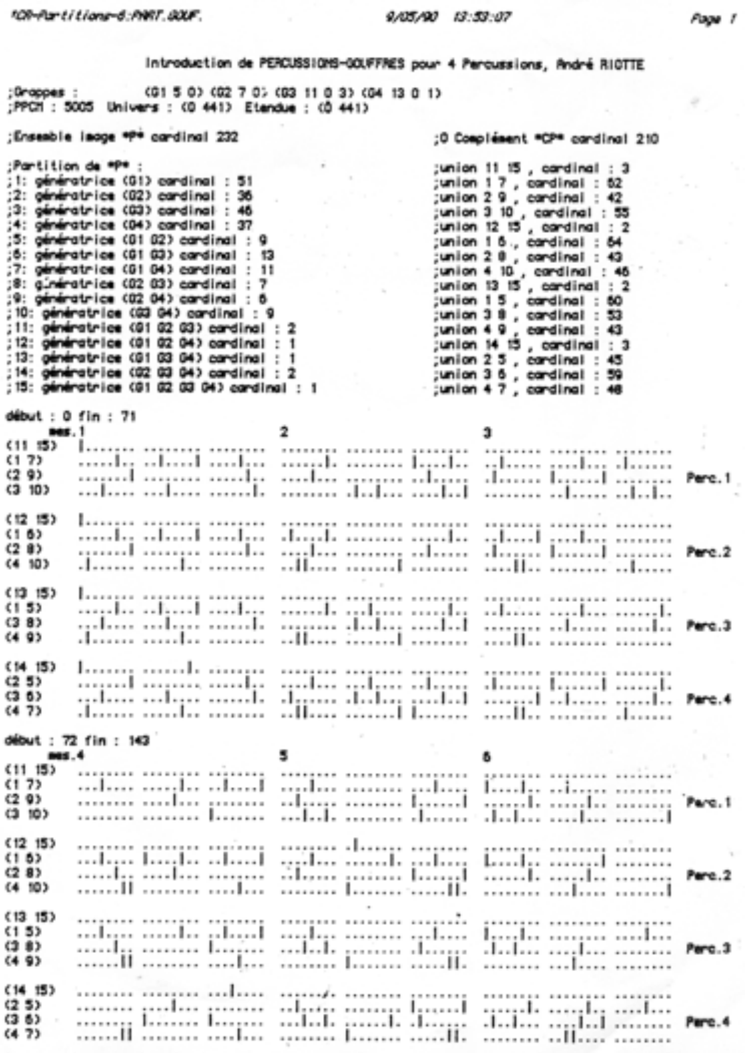


- **A. Riotte & M. Mesnage, *Formalismes et modèles musicaux*, collection "Musique/Sciences", Ircam Delatour France, 2006**

- **M. Andreatta, « Musique algorithmique », in N. Donin et L. Feneyrou (dir.), *Théorie de la composition musicale au XXe siècle*, Symétrie, 2013**

➔ Towards a new approach to non-isochronous meter?

Generalized sieve theory: *Partitions-gouffres* (1986) by A. Riotte



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*CR-Partitions-6:PART.GOUF.          9/05/90  13:53:07          Page 1

        Introduction de PERCUSSIONS-GOUFFRES pour 4 Percussions, André RIOTTE

;Groupes :        (01 5 0) (02 7 0) (03 11 0 3) (04 13 0 1)
;PPCM : 5005  Univers : (0 441)  Etendue : (0 441)

;Ensemble image *P* cardinal 232                 ;0 Complément *CP* cardinal 210

;Partition de *P* :                              ;union 11 15 , cardinal : 3
;1: génératrice (01) cardinal : 51               ;union 1 7 , cardinal : 62
;2: génératrice (02) cardinal : 36               ;union 2 9 , cardinal : 42
;3: génératrice (03) cardinal : 46               ;union 3 10 , cardinal : 55
;4: génératrice (04) cardinal : 37               ;union 12 15 , cardinal : 2
;5: génératrice (01 02) cardinal : 9             ;union 1 6 , cardinal : 64
;6: génératrice (01 03) cardinal : 13            ;union 2 8 , cardinal : 43
;7: génératrice (01 04) cardinal : 11            ;union 4 10 , cardinal : 46
;8: génératrice (02 03) cardinal : 7             ;union 13 15 , cardinal : 2
;9: génératrice (02 04) cardinal : 6             ;union 1 5 , cardinal : 60
;10: génératrice (03 04) cardinal : 9            ;union 3 8 , cardinal : 53
;11: génératrice (01 02 03) cardinal : 2         ;union 4 9 , cardinal : 43
;12: génératrice (01 02 04) cardinal : 1         ;union 14 15 , cardinal : 3
;13: génératrice (01 03 04) cardinal : 1         ;union 2 5 , cardinal : 45
;14: génératrice (02 03 04) cardinal : 2         ;union 3 6 , cardinal : 59
;15: génératrice (01 02 03 04) cardinal : 1      ;union 4 7 , cardinal : 48

début : 0 fin : 71
     mes.1                    2                    3
(11 15)
(1 7)
(2 9)                                                           Perc.1
(3 10)

(12 15)
(1 6)
(2 8)                                                           Perc.2
(4 10)

(13 15)
(1 5)
(3 8)                                                           Perc.3
(4 9)

(14 15)
(2 5)
(3 6)                                                           Perc.4
(4 7)

début : 72 fin : 143
     mes.4                    5                    6
(11 15)
(1 7)
(2 9)                                                           Perc.1
(3 10)

(12 15)
(1 5)
(2 8)                                                           Perc.2
(4 10)

(13 15)
(1 5)
(3 8)                                                           Perc.3
(4 9)

(14 15)
(2 5)
(3 6)                                                           Perc.4
(4 7)
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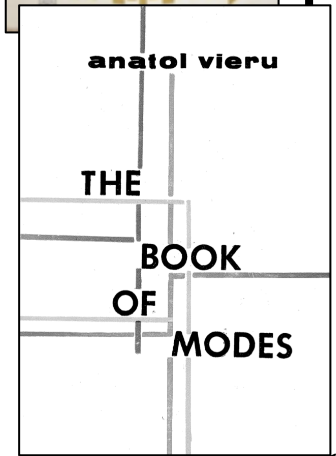
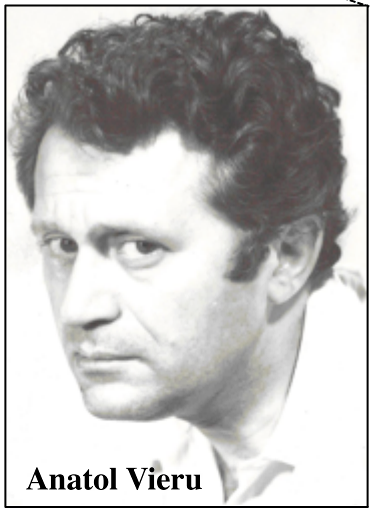
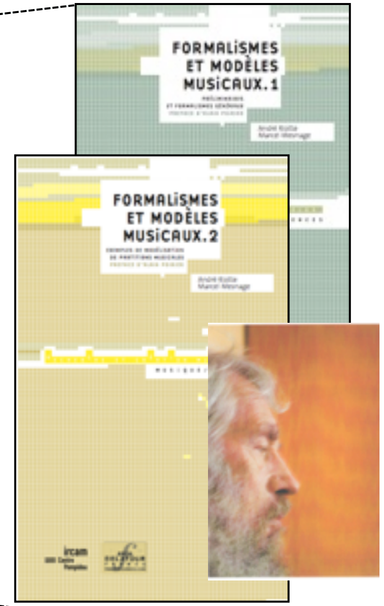
Three algebraic perspectives on the pitch/rhythm relation

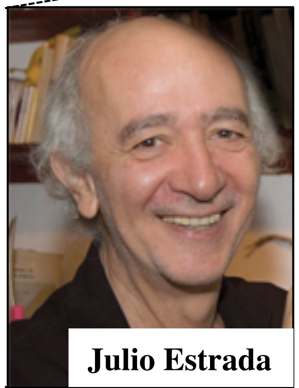




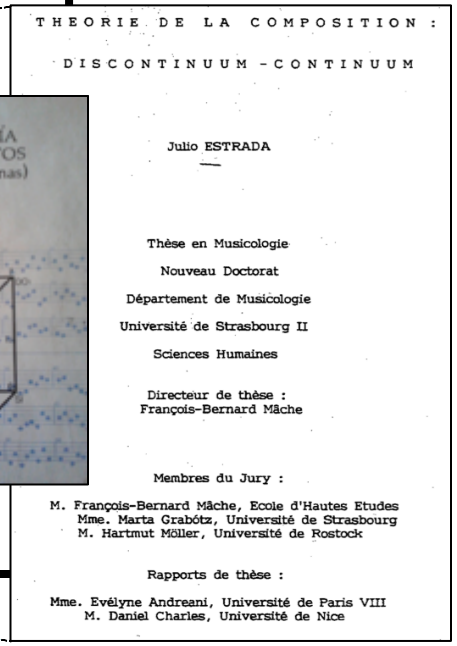
Anatol Vieru

André Riotte





Julio Estrada



THEORIE DE LA COMPOSITION :

DISCONTINUUM - CONTINUUM

Julio ESTRADA

Thèse en Musicologie

Nouveau Doctorat

Département de Musicologie

Université de Strasbourg II

Sciences Humaines

Directeur de thèse :
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M. Hartmut Möller, Université de Rostock

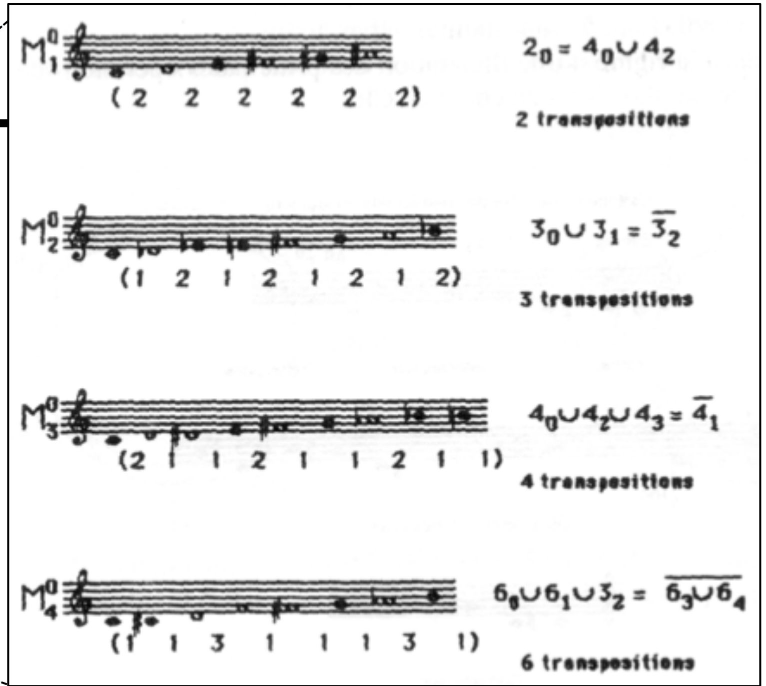
Rapports de thèse :

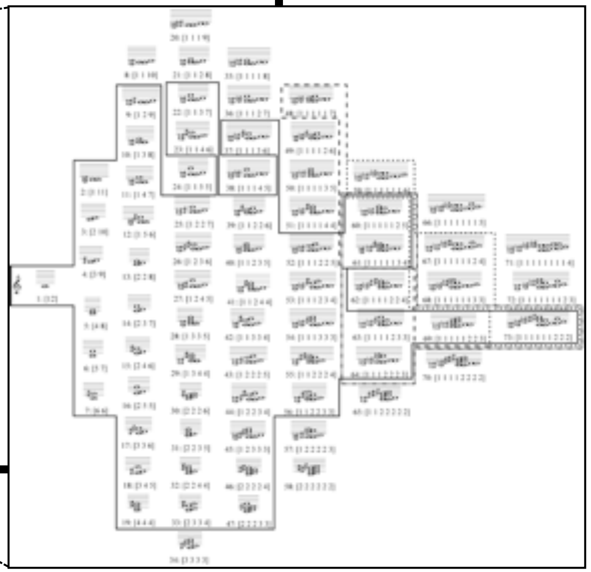
Mme. Evélyne Andreani, Université de Paris VIII
M. Daniel Charles, Université de Nice

Three algebraic perspectives on the pitch/rhythm relation

3.43. *The catalogue of modal structures*
(in the tempered system modulo 12)

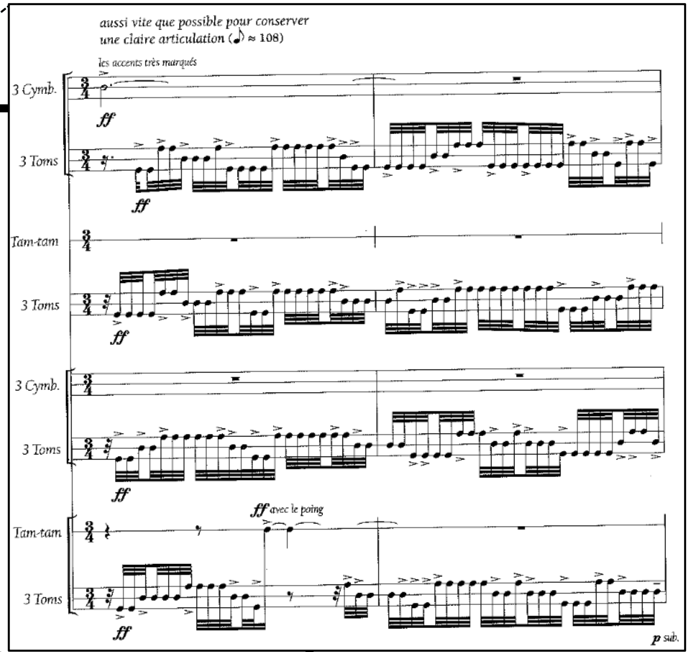
⟨1⟩(∅)	–(1,1,1,1,1,1,1,1,1,1,1,1)	Void structure — total structure	
⟨2⟩(0)	–(2,1,1,1,1,1,1,1,1,1,1)	zero structure	
⟨3⟩(11,1)	–(1,1,1,1,1,1,1,1,1,3)	Perfect chromatic modes	
⟨4⟩(10,2)	–(1,1,1,1,1,1,1,1,2,2)	Major second	
⟨5⟩(9,3)	–(1,1,1,1,1,1,1,2,1,2)	Minor third	
⟨6⟩(8,4)	–(1,1,1,1,1,1,3,1,1,2)	Major third	
⟨7⟩(7,5)	(1,1,1,1,1,2,1,1,1,2)	Perfect diatonic modes	
⟨8⟩(6,6)	(1,1,1,1,2,1,1,1,1,2)	Tritone	— Messiaen VII
⟨9⟩(10,1,1)	(1,1,1,1,1,1,1,1,4)	Perfect chromatic modes	
⟨10⟩(9,2,1)	(1,1,1,1,1,1,1,2,3)		
⟨11⟩(1,2,9)	–(3,2,1,1,1,1,1,1,1)		
⟨12⟩(8,3,1)	–(1,1,1,1,1,1,2,1,3)		
⟨13⟩(1,3,8)	–(3,1,2,1,1,1,1,1,1)		
⟨14⟩(8,2,2)	–(1,1,1,1,1,1,2,2,2)		
⟨15⟩(7,4,1)	–(1,1,1,1,1,2,1,1,3)		
⟨16⟩(1,4,7)	–(3,1,1,2,1,1,1,1,1)		
⟨17⟩(7,3,2)	–(1,1,1,1,1,2,1,2,2)		
⟨18⟩(2,3,7)	(2,2,1,2,1,1,1,1,1)		
⟨19⟩(6,5,1)	–(1,1,1,1,2,1,1,1,3)		
⟨20⟩(1,5,6)	–(3,1,1,1,2,1,1,1,1)		
⟨21⟩(6,4,2)	–(1,1,1,1,2,1,1,2,2)		
⟨22⟩(2,4,6)	–(2,2,1,1,2,1,1,1,1)		
⟨23⟩(6,3,3)	–(1,1,1,1,2,1,2,1,2)	diminished chord,	
⟨24⟩(5,5,2)	(1,1,1,2,1,1,1,2,2)	Perfect diatonic modes	
⟨25⟩(5,4,3)	–(1,1,1,2,1,1,2,1,2)	Major chord	
⟨26⟩(3,4,5)	(2,1,2,1,1,2,1,1,1)	Minor chord	
⟨27⟩(4,4,4)	–(1,1,2,1,1,2,1,1,2)	Augmented chord	Messiaen III
⟨28⟩(9,1,1,1)	–(1,1,1,1,1,1,1,5)	(BACH)	— Perfect chromatic tetrachord
⟨29⟩(8,2,1,1)	–(1,1,1,1,1,1,2,4)		
⟨30⟩(1,1,2,8)	–(4,2,1,1,1,1,1,1)		
⟨31⟩(8,1,2,1)	–(1,1,1,1,1,1,3,3)		
⟨32⟩(7,3,1,1)	–(1,1,1,1,1,2,1,4)		
⟨33⟩(1,1,3,7)	–(4,1,2,1,1,1,1,1)		
⟨34⟩(7,1,3,1)	(1,1,1,1,1,3,1,3)		
⟨35⟩(7,2,2,1)	(1,1,1,1,1,2,2,3)		
⟨36⟩(1,2,2,7)	–(3,2,2,1,1,1,1,1)		
⟨37⟩(7,2,1,2)	(1,1,1,1,1,2,3,2)		
⟨38⟩(6,4,1,1)	(1,1,1,1,2,1,1,4)		
⟨39⟩(1,1,4,6)	–(4,1,1,2,1,1,1,1)		
⟨40⟩(6,1,4,1)	–(1,1,1,1,3,1,1,3)		
⟨41⟩(6,3,2,1)	–(1,1,1,1,2,1,2,3)		
⟨42⟩(1,2,3,6)	–(3,2,1,2,1,1,1,1)		
⟨43⟩(6,3,1,2)	(1,1,1,1,2,1,3,2)		
⟨44⟩(2,1,3,6)	–(2,3,1,2,1,1,1,1)		
⟨45⟩(6,2,3,1)	(1,1,1,1,2,2,1,3)		
⟨46⟩(1,3,2,6)	–(3,1,2,2,1,1,1,1)		
⟨47⟩(6,2,2,2)	–(1,1,1,1,2,2,2,2)		

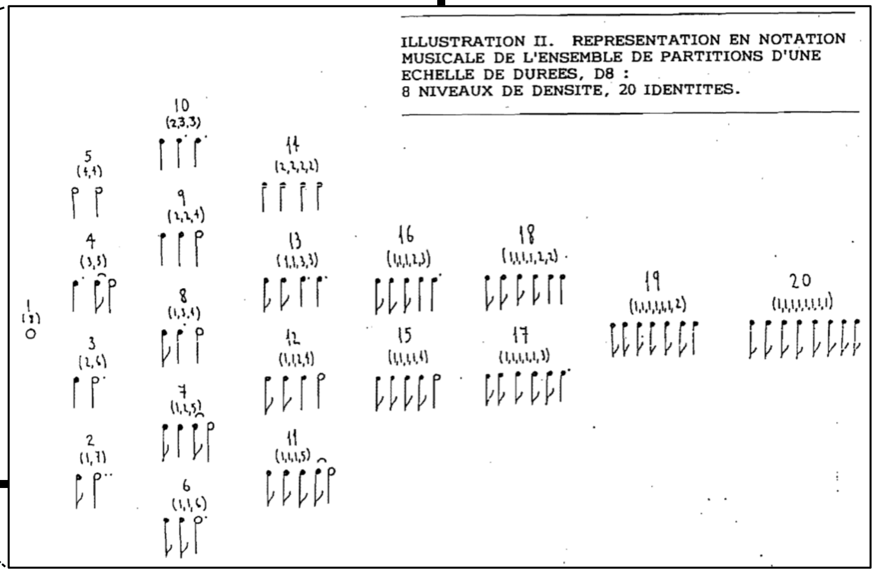




Three algebraic perspectives on the pitch/rhythm relation

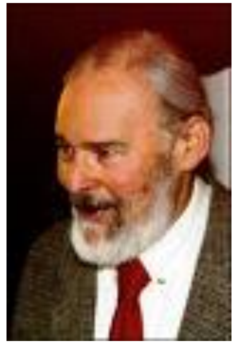
V	0	3	8	7	11	0	11	10
VIII	0	0	0	0	3	3	7	2
IV	3	3	4	4	1	11	11	8
IX	0	0	0	0	0	3	6	[1]
IV	0	10	3	9	10	0	9	7

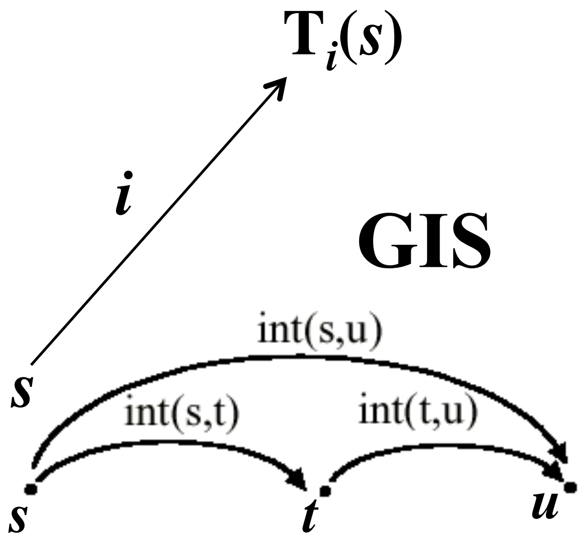




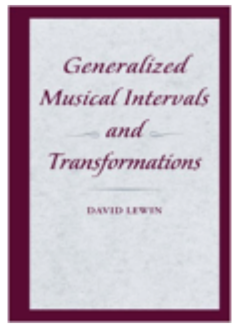
Lewin on Husserl's bidimensional model of time perception

The article [Lewin 1981] builds a numerical model that counts, at each "now"-time *t*, the number of time-spans I recall from the pertinent recent past that have (had) duration *d*. In this way I construct a function W(*d*,*t*) that gives me an "unfolding durational-interval vector" as the "now"-cursor *t* advances. The concept underlying my construction engages a Husserlian two-dimensional model of perceptual time, a model that allows both for Husserl's "primal impressions," impressions that follow the now-cursor *t*, and also for Husserl's "retentions," projections of remembered past times (and past durations) into my present consciousness. [...] I have found the idea of an "unfolding rhythmic interval vector" highly suggestive in connection with a great variety of other rhythmic formalisms (Lewin, 1986)

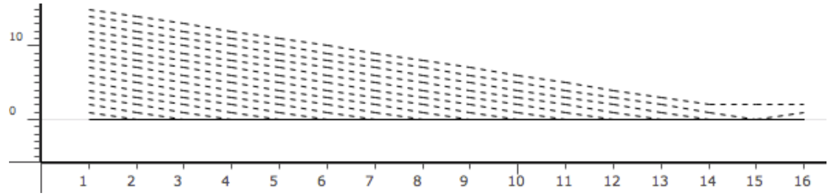




- **David Lewin (1981), "Some Investigations into Foreground Rhythmic and Metric Patterning,"** ***Music Theory: Special Topics*****, ed. Richmond Browne (New York: Academic Press), 101–136.**
- **David Lewin (1986), « Music Theory, Phenomenology, and Modes of Perception »,** ***Music Perception*****, 3, 327-382.**
- **David Lewin (1987),** ***Generalized Musical Intervals and Transformations*****, YUP**



Grasping the unfolding durational content of a rhythmic pattern



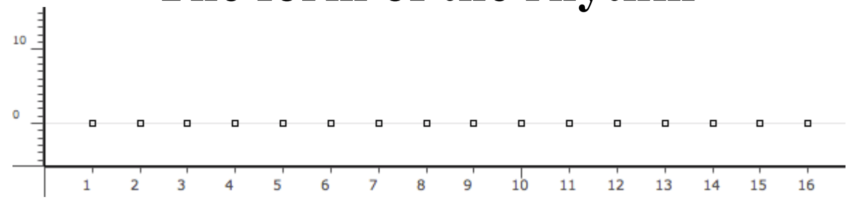
The form of the rhythm

Durations

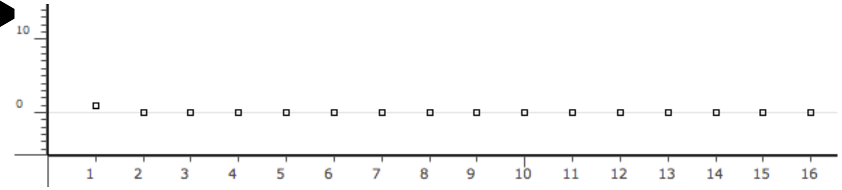
Logical time

```
(0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)
(1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)
(2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)
(3 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0)
(4 3 2 1 0 0 0 0 0 0 0 0 0 0 0 0)
(5 4 3 2 1 0 0 0 0 0 0 0 0 0 0 0)
(6 5 4 3 2 1 0 0 0 0 0 0 0 0 0 0)
(7 6 5 4 3 2 1 0 0 0 0 0 0 0 0 0)
(8 7 6 5 4 3 2 1 0 0 0 0 0 0 0 0)
(9 8 7 6 5 4 3 2 1 0 0 0 0 0 0 0)
(10 9 8 7 6 5 4 3 2 1 0 0 0 0 0 0)
(11 10 9 8 7 6 5 4 3 2 1 0 0 0 0 0)
(12 11 10 9 8 7 6 5 4 3 2 1 0 0 0 0)
(13 12 11 10 9 8 7 6 5 4 3 2 1 0 0 0)
(14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 1)
(15 14 13 12 11 10 9 8 7 6 5 4 3 2 2 2)
```

t=0



t=1



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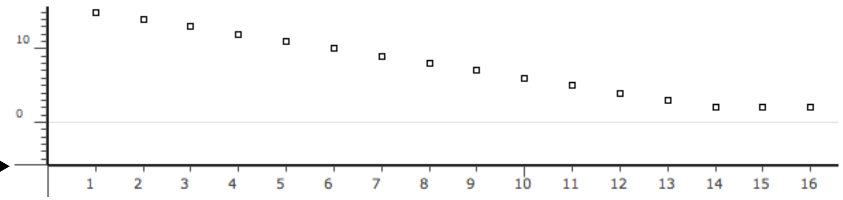
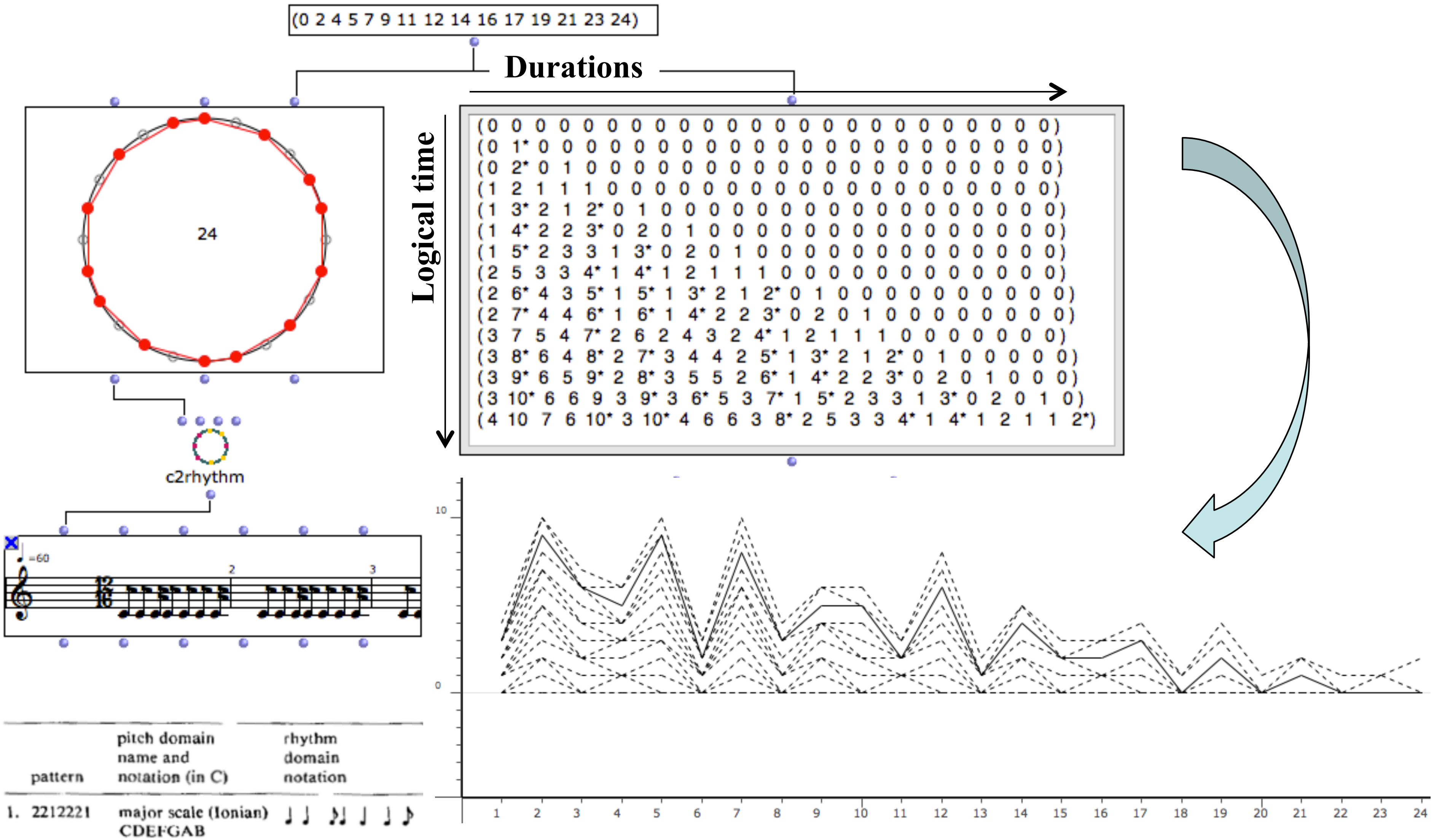


t=15

Unfolding Rhythmic Interval Vector* W(*d*,*t*) = number of time duration *d* has been heard within the rhythmic series up to time *t

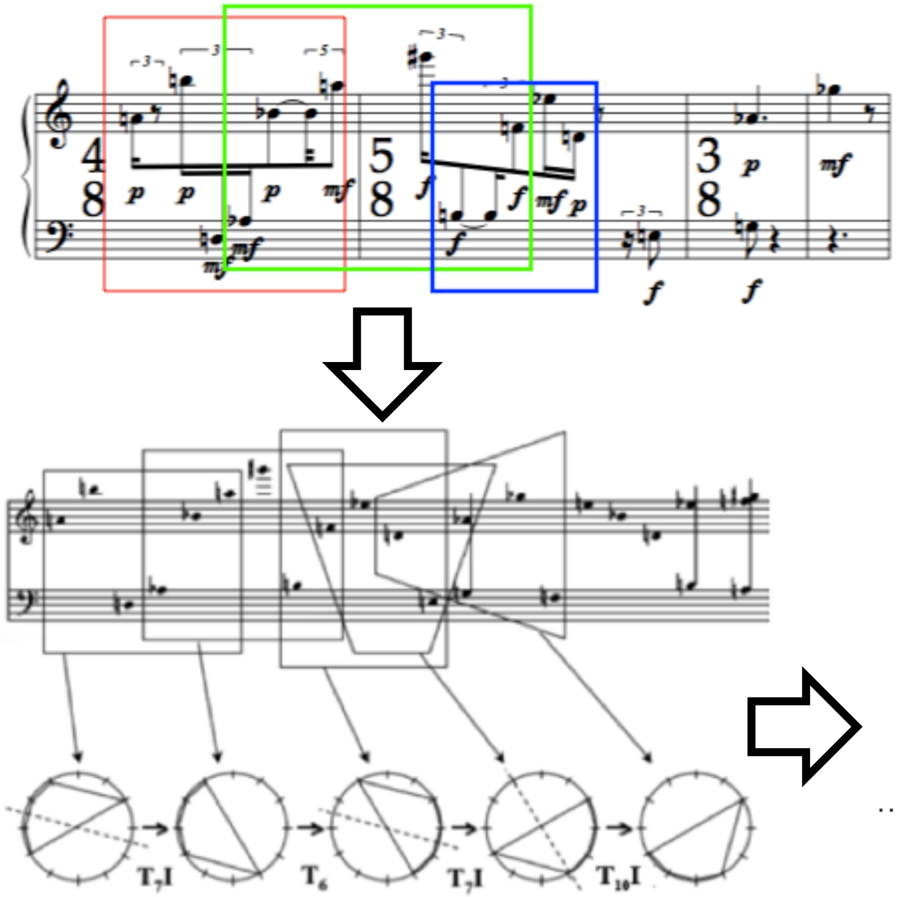
The form of rhythm as a journey to the mountain...



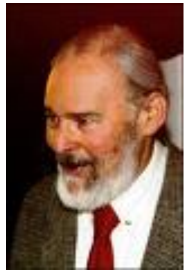
Unfolding Rhythmic Interval Vector

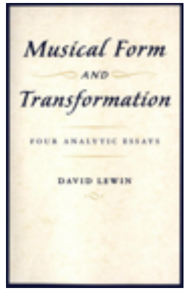
OpenMusic

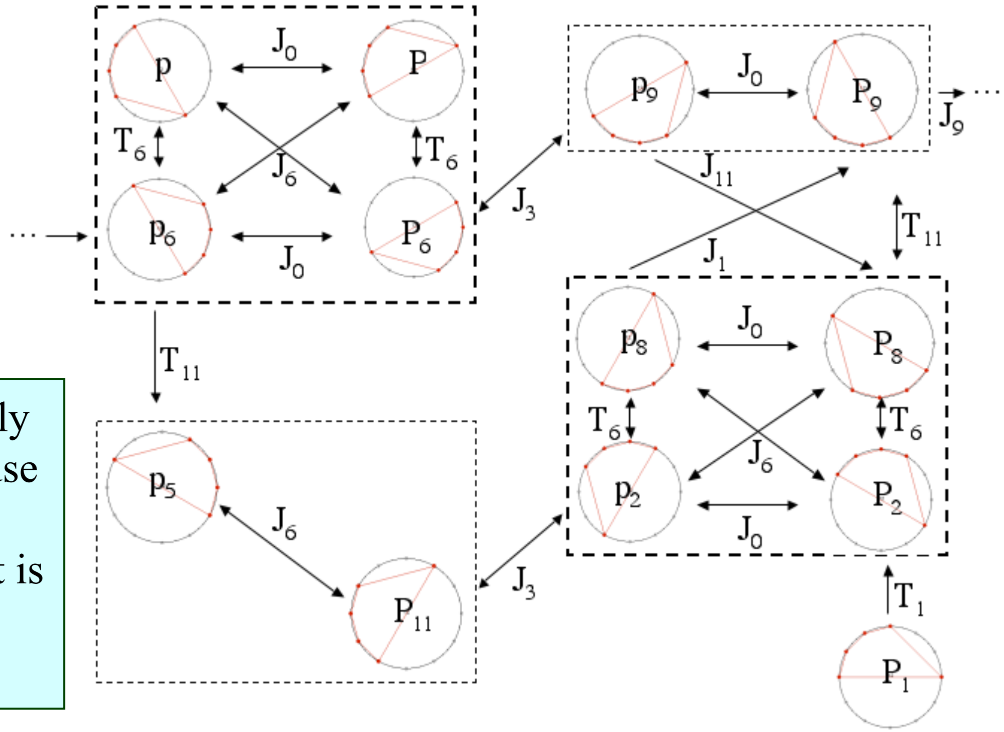
Transformational progressions *versus* transformational networks



"Rather than asserting a network that follows pentachord relations one at a time, according to the chronology of the piece, I shall assert instead a network that displays all the pentachord forms used and all their **potentially functional interrelationships**, in a very compactly organized little **spatial configuration**".

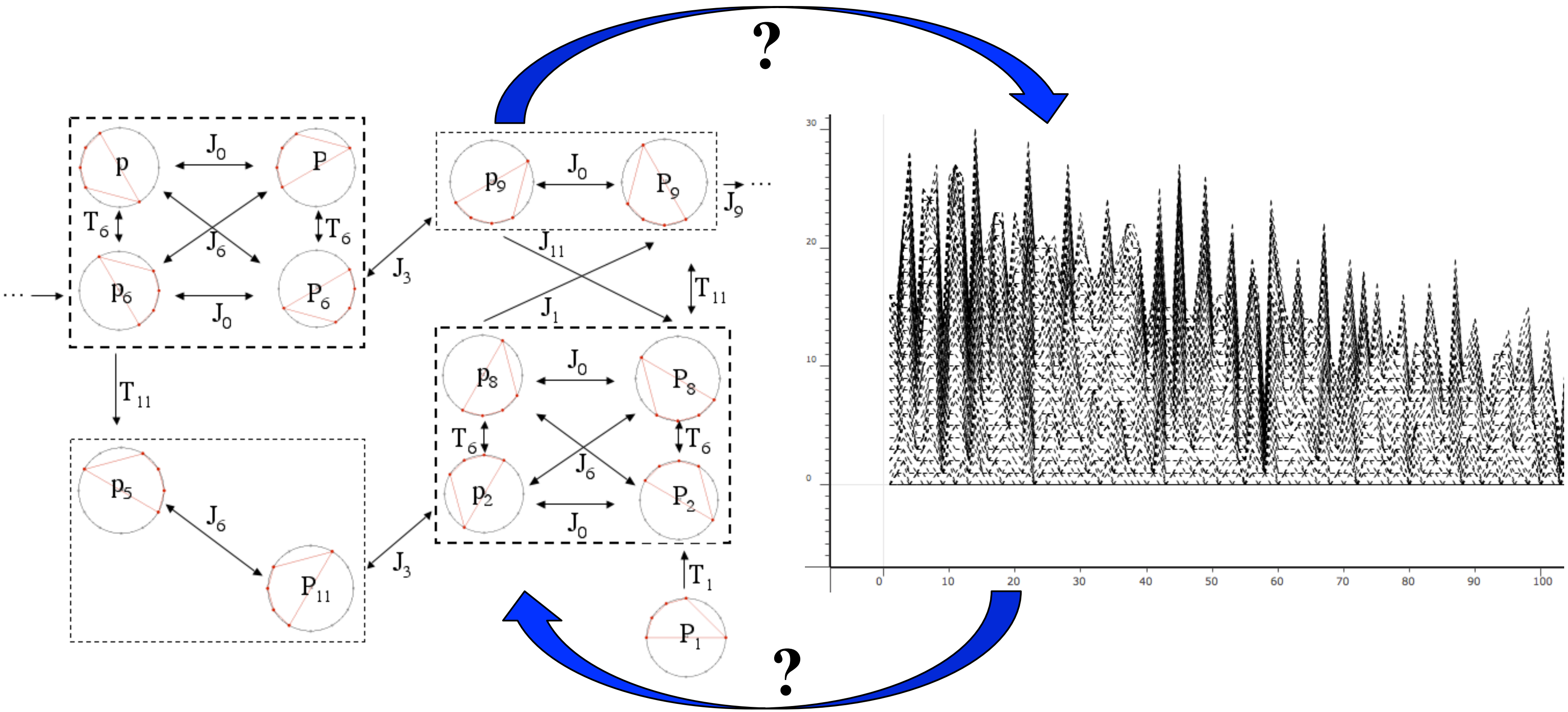






"[…] the sequence of events moves within a clearly defined world of possible relationships, and because - in so moving - **it makes the abstract space of such a world accessible to our sensibilities**. That is to say that the story projects what one would traditionally call *form*".

Towards a pitch/rhythm-based *formal* transformational analysis?



"The idea of **Form** is not adequately conceived as something 'spatial,' something that can be dissociated from the ways in which our impressions build and change during the passage of time for a listener or a performer. The matter can be studied effectively in connection with intensions and perceptions of specifically ***rhythmic* form**, where the passage of time is built into the formal medium itself. [...] It is not necessary to use **t-moments** as our temporal objects. We could use **time-spans**, for example [...]*"*. "We could also extend the "t-and-*d* table" by adding **more dimensions**, in which we may track such things as pitch intervals heard up to time *t*. [...]"

David Lewin (2003), "The Form of Rhythm, the Rhythm of Form", in *The Philosophical Horizon od Composition in the Twentieth Century* (edited by G. Borio), Il Mulino

Thank you for your attention!