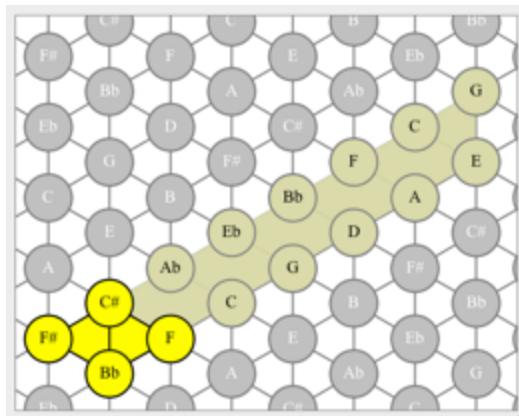




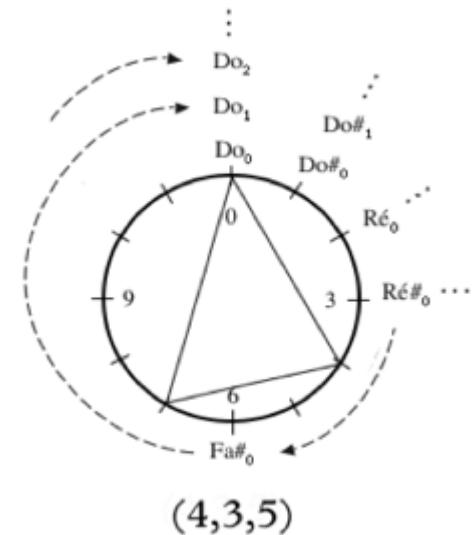
Dalla musica alla matematica: invito al viaggio

terza parte



Moreno Andreatta
Equipe Représentations Musicales
IRCAM / CNRS UMR 9912 / UPMC

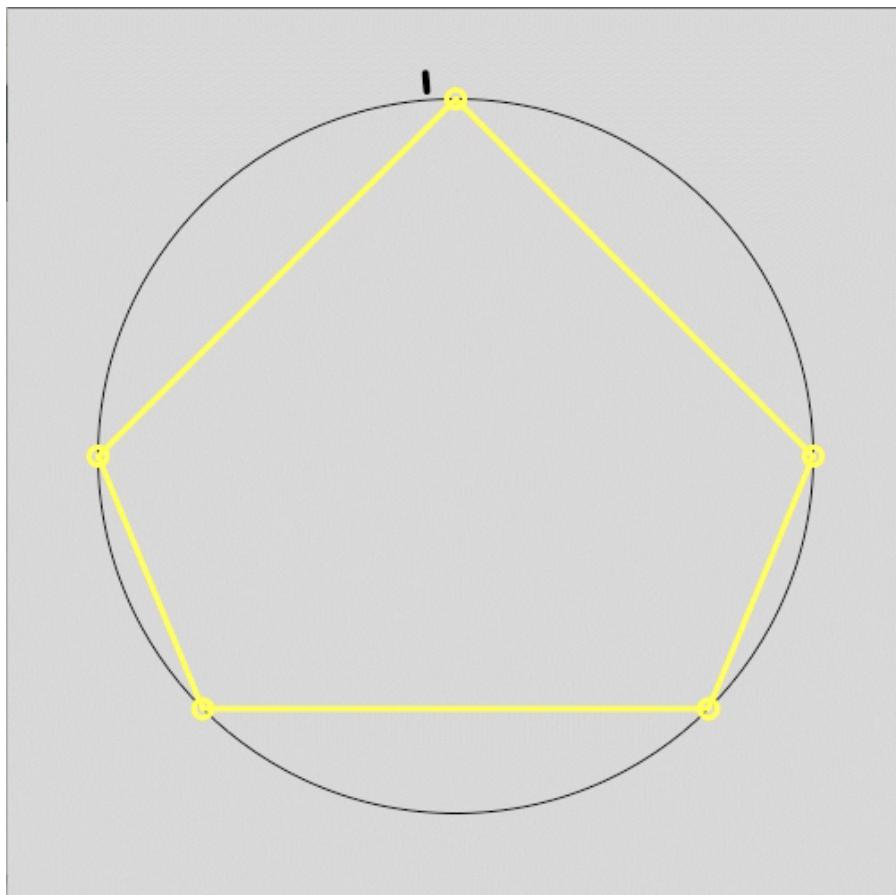
<http://repmus.ircam.fr/moreno/>



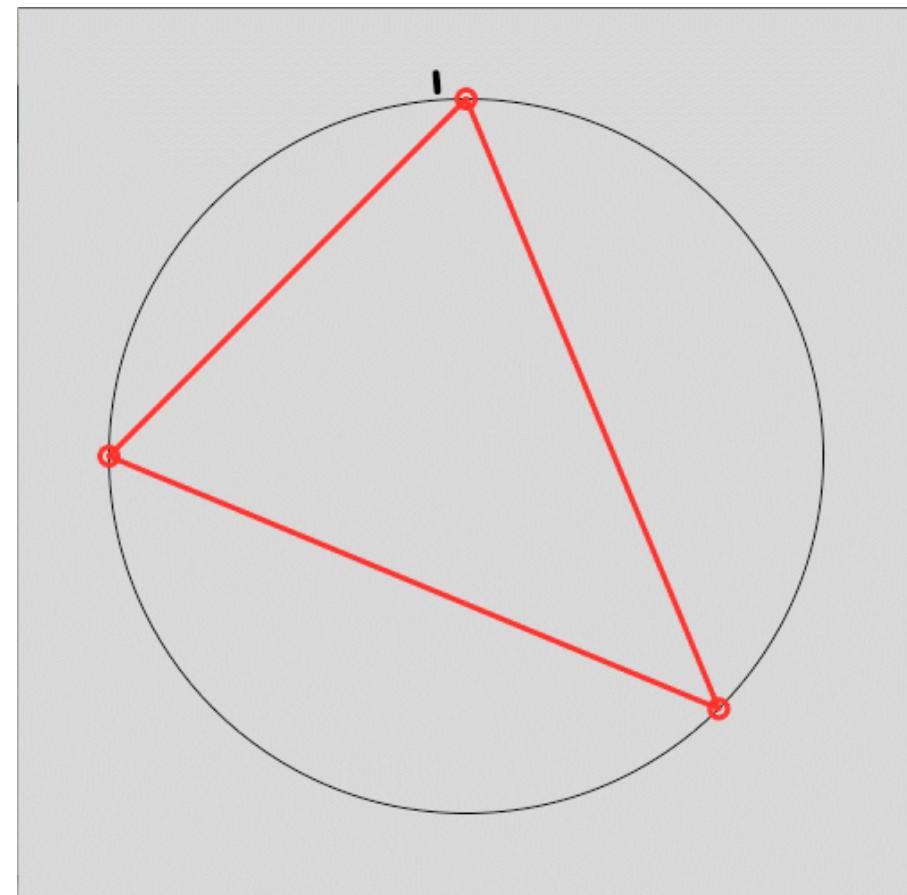
(4,3,5)

Pattern ritmici nella musica afro-cubana

El cinquillo (Fig. 1)

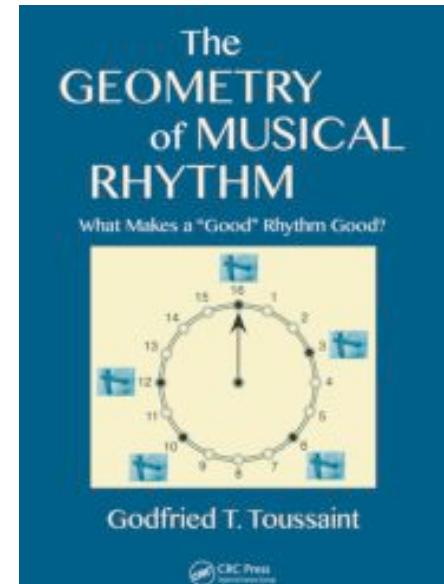


El trecillo (Fig 2)

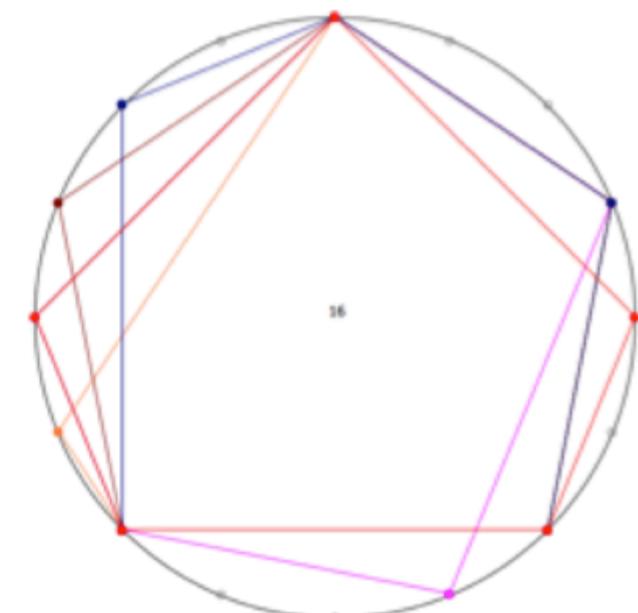


La geometria del ritmo musicale

Godfried T. Toussaint, The Geometry of Musical Rhythm: What Makes a "Good" Rhythm Good?, Chapman and Hall/CRC, 2013



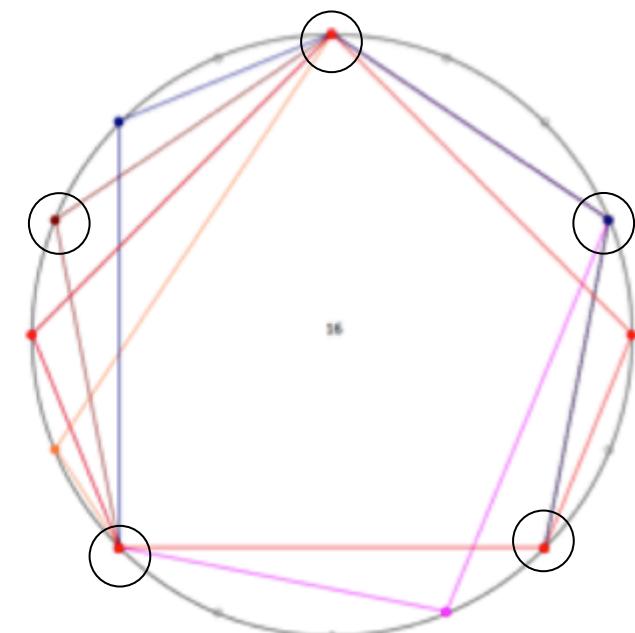
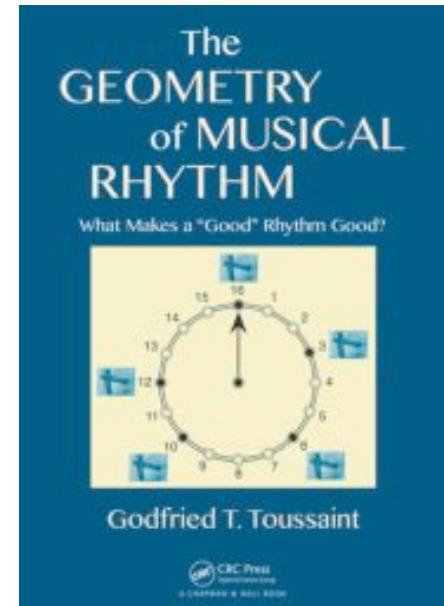
Shiko	● ● ● ● ●
Son	● ● ● ●
Soukous	● ● ● ●
Rumba	● ● ● ●
Bossa	● ● ● ●
Gahu	● ● ● ●



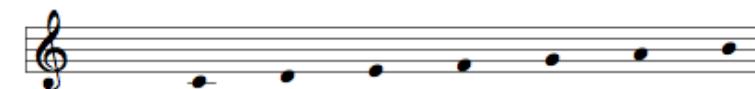
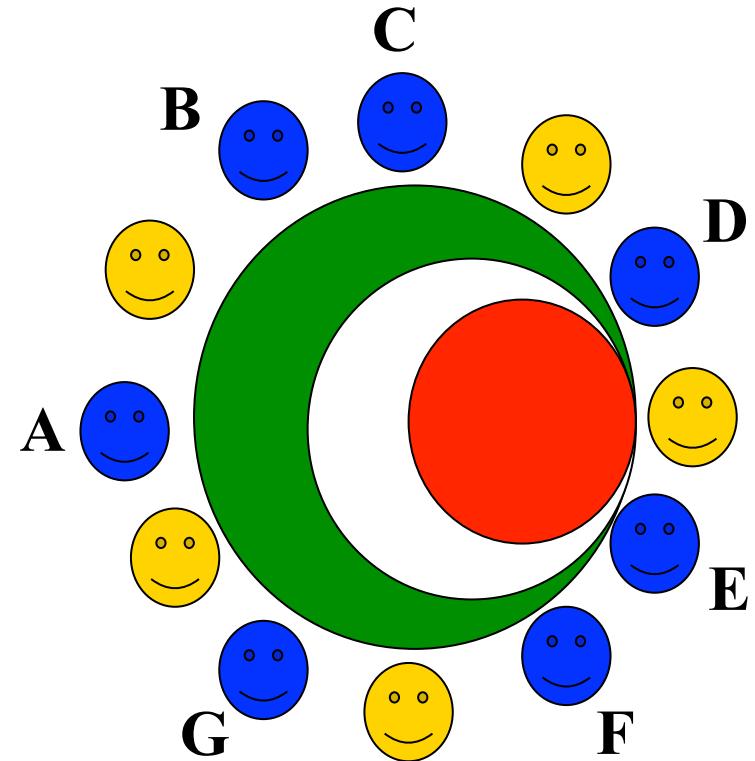
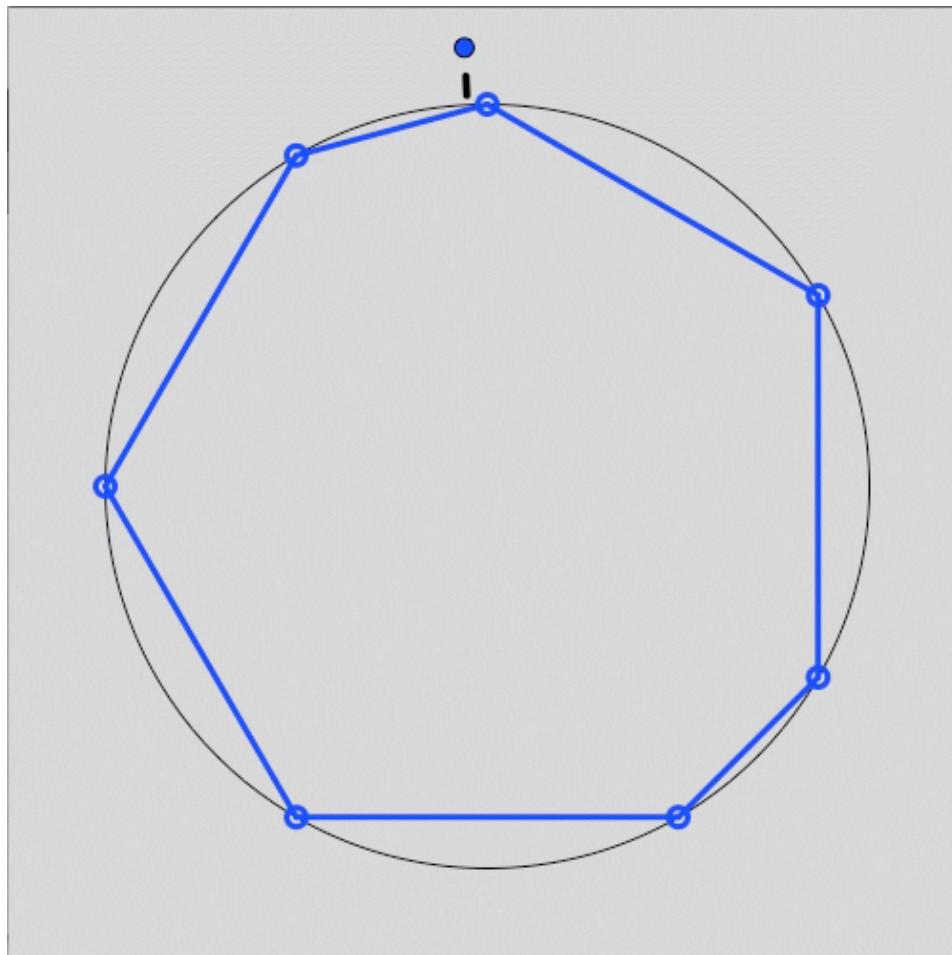
→ Qual è il ritmo più regolare?

La geometria del ritmo musicale

Godfried T. Toussaint, The Geometry of Musical Rhythm: What Makes a "Good" Rhythm Good?, Chapman and Hall/CRC, 2013

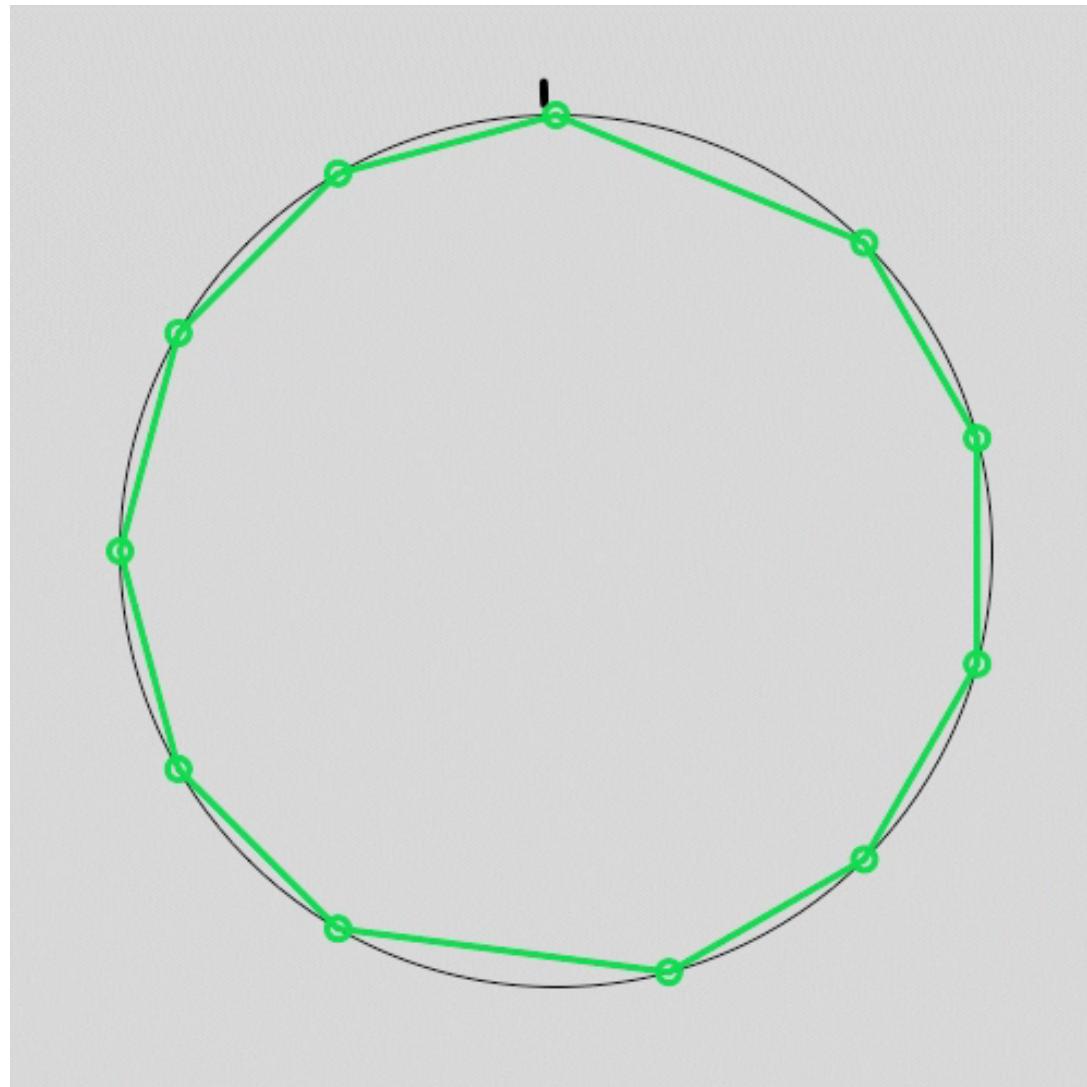


Il Bembé (o Abadja): un pattern ritmico ‘ottimale’ [maximally even]



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

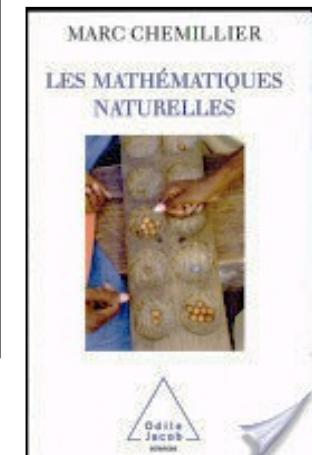
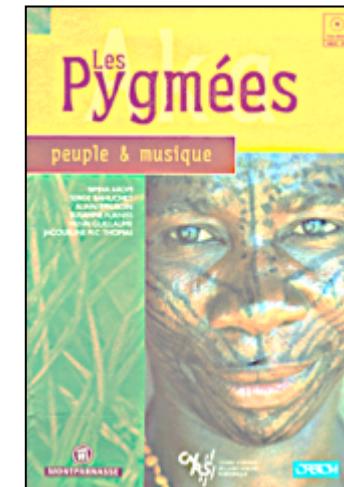
Ritmi asimmetrici nelle tradizioni orali africane: *clap your hands!*



Simha Arom



Marc Chemillier



Dalla musica alla matematica: canoni ritmici a mosaico

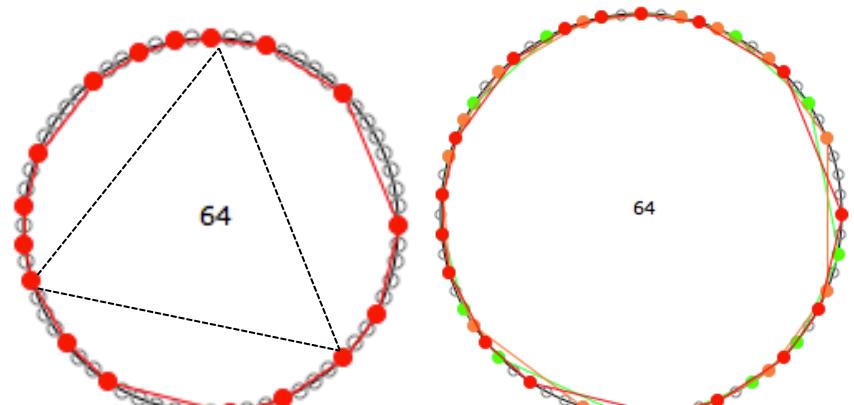
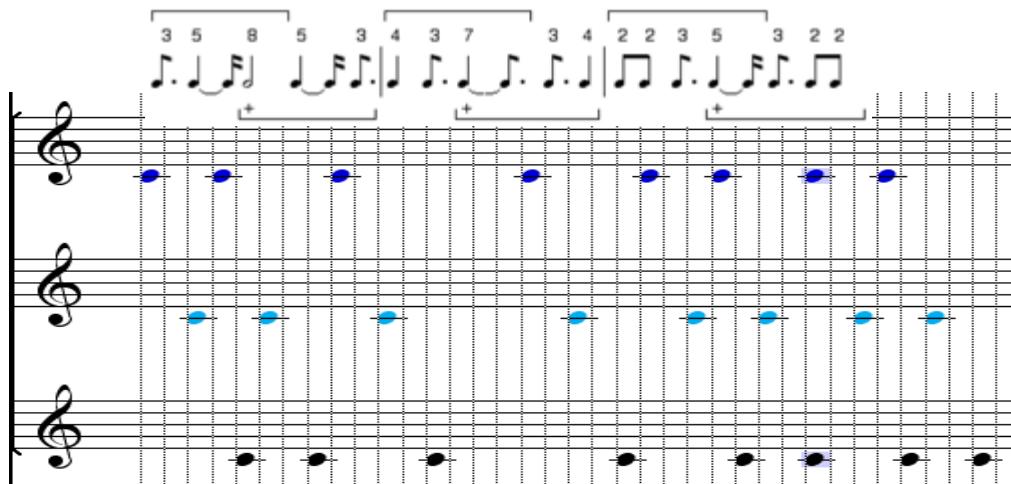


Harawi (1945)



O. Messiaen

Visions de l'Amen (1943)

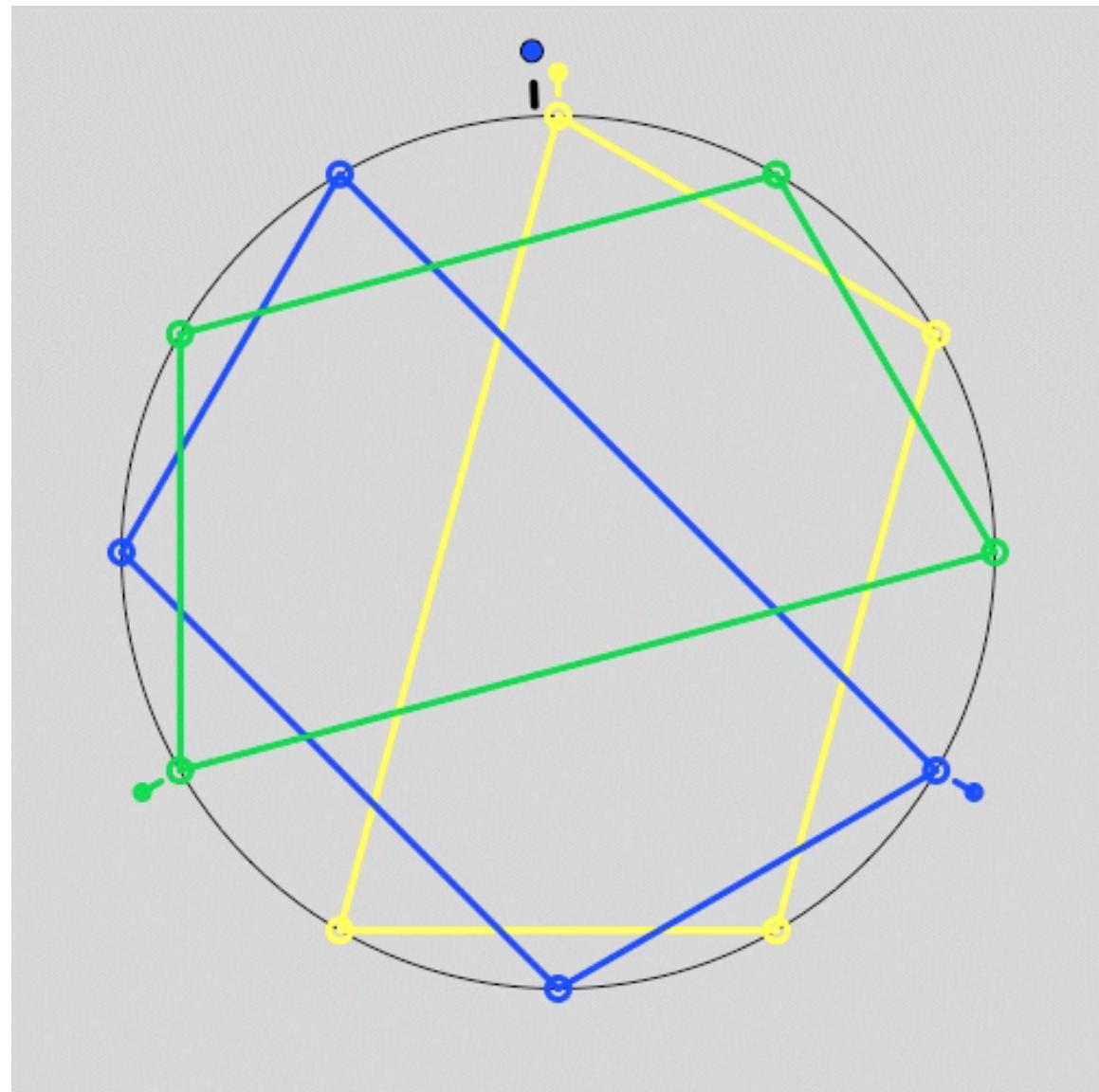
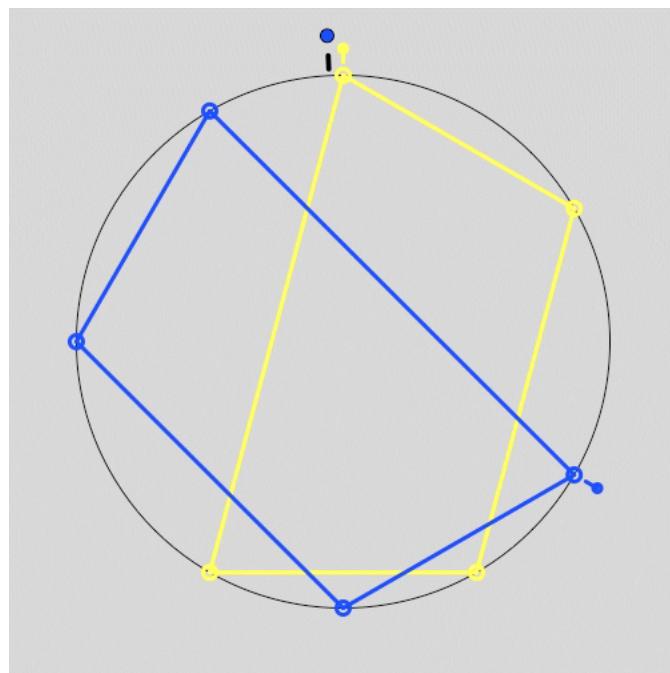
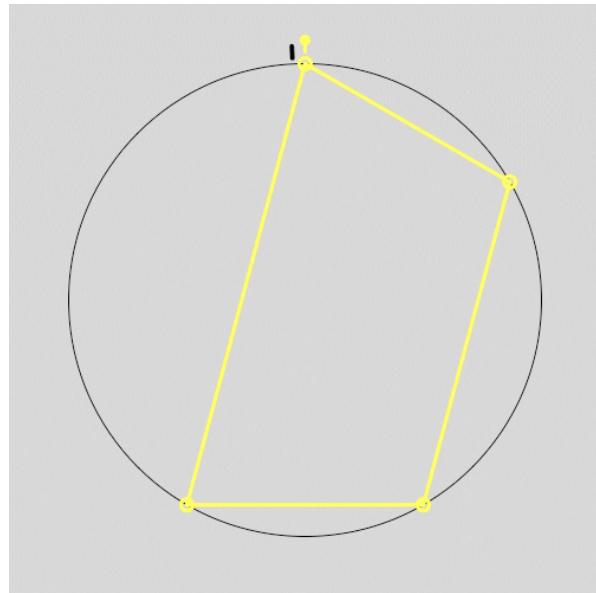


« ...il résulte de tout cela que les différentes sonorités se mêlent ou s'opposent de manières très diverses, jamais au même moment ni au même endroit [...]. C'est du désordre organisé »

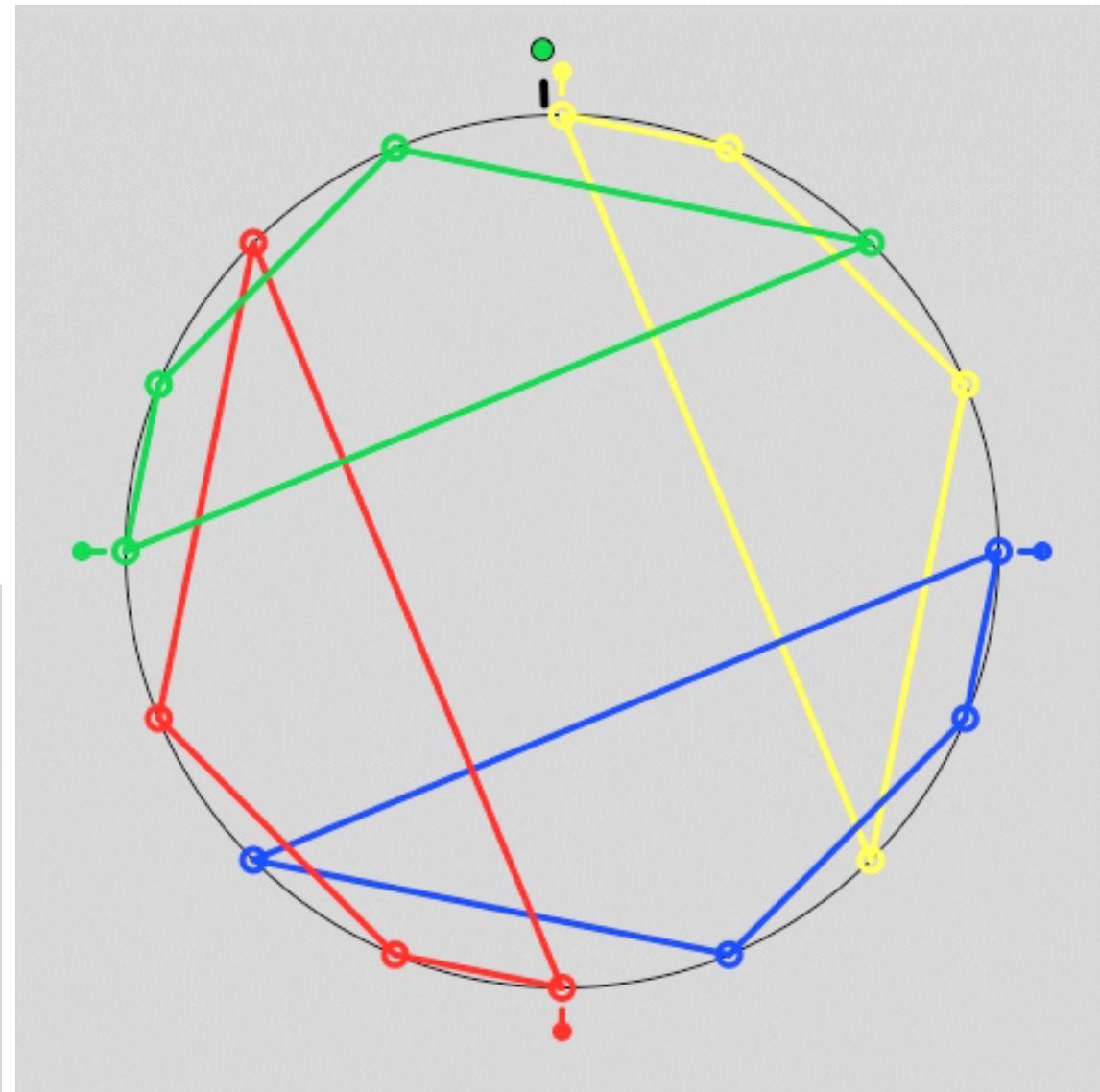
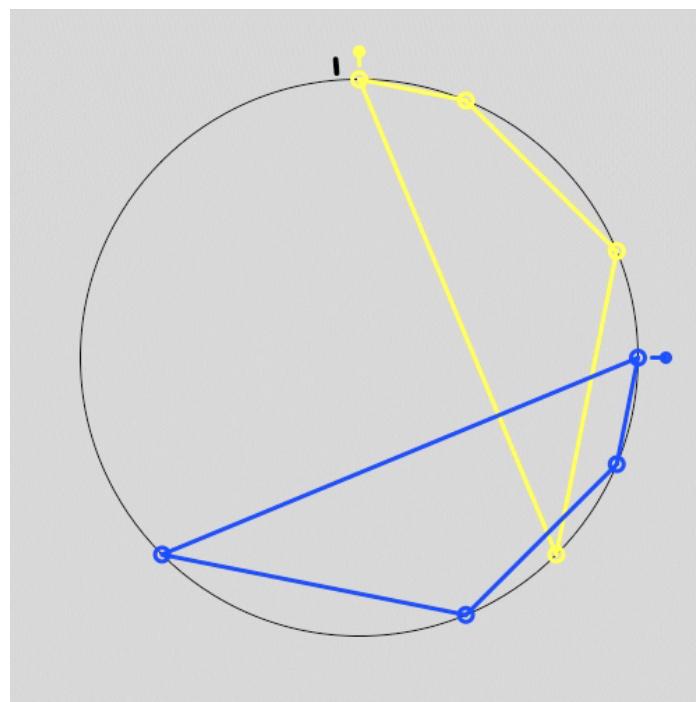
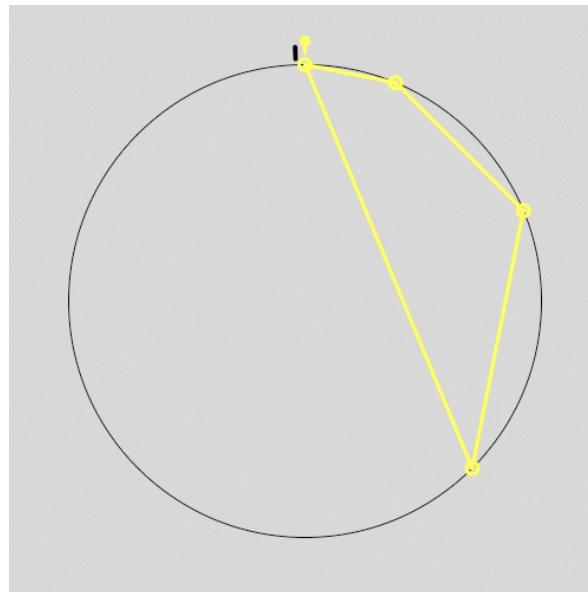
O. Messiaen : *Traité de Rythme, de Couleur et d'Ornithologie*, tome 2, Alphonse Leduc, 1992.



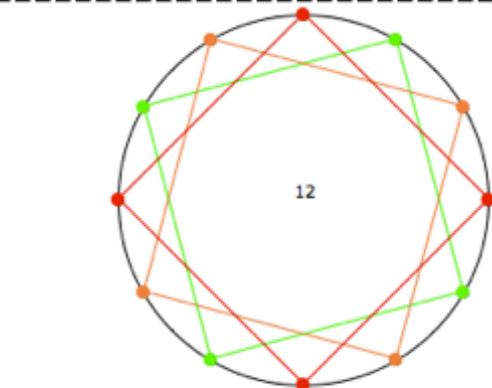
Un canone ritmico a mosaico a tre voci e di periodo 12



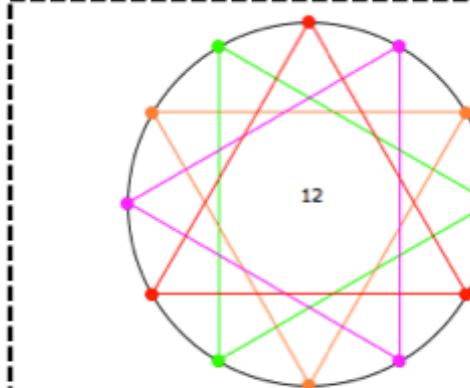
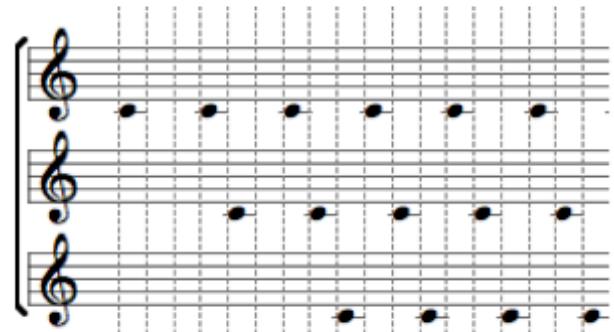
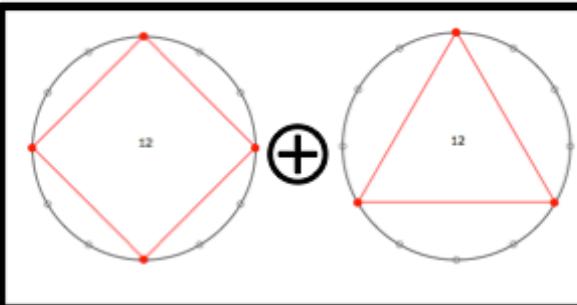
Un canone melodico-ritmico a mosaico a quattro voci e periodo 16



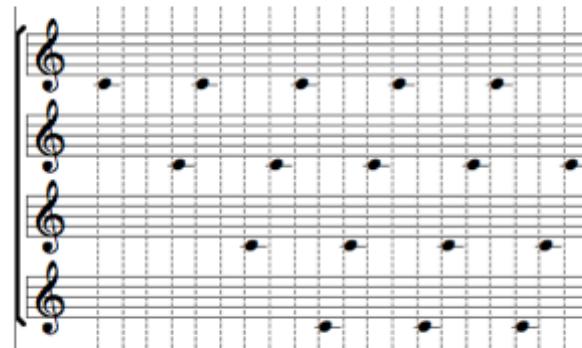
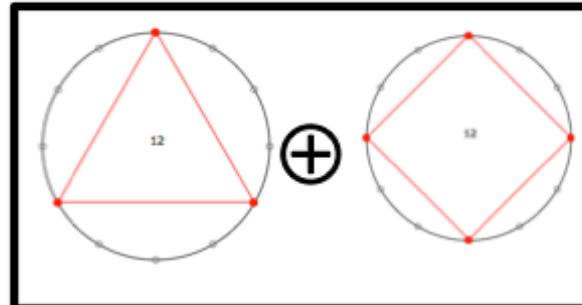
I vari tipi di canoni ritmici a mosaico



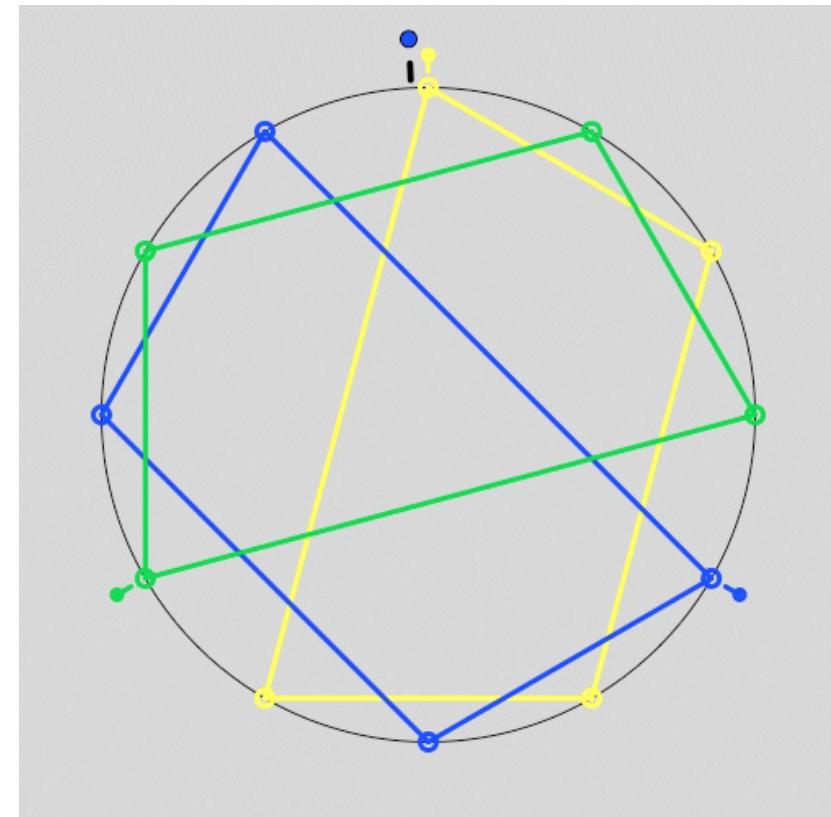
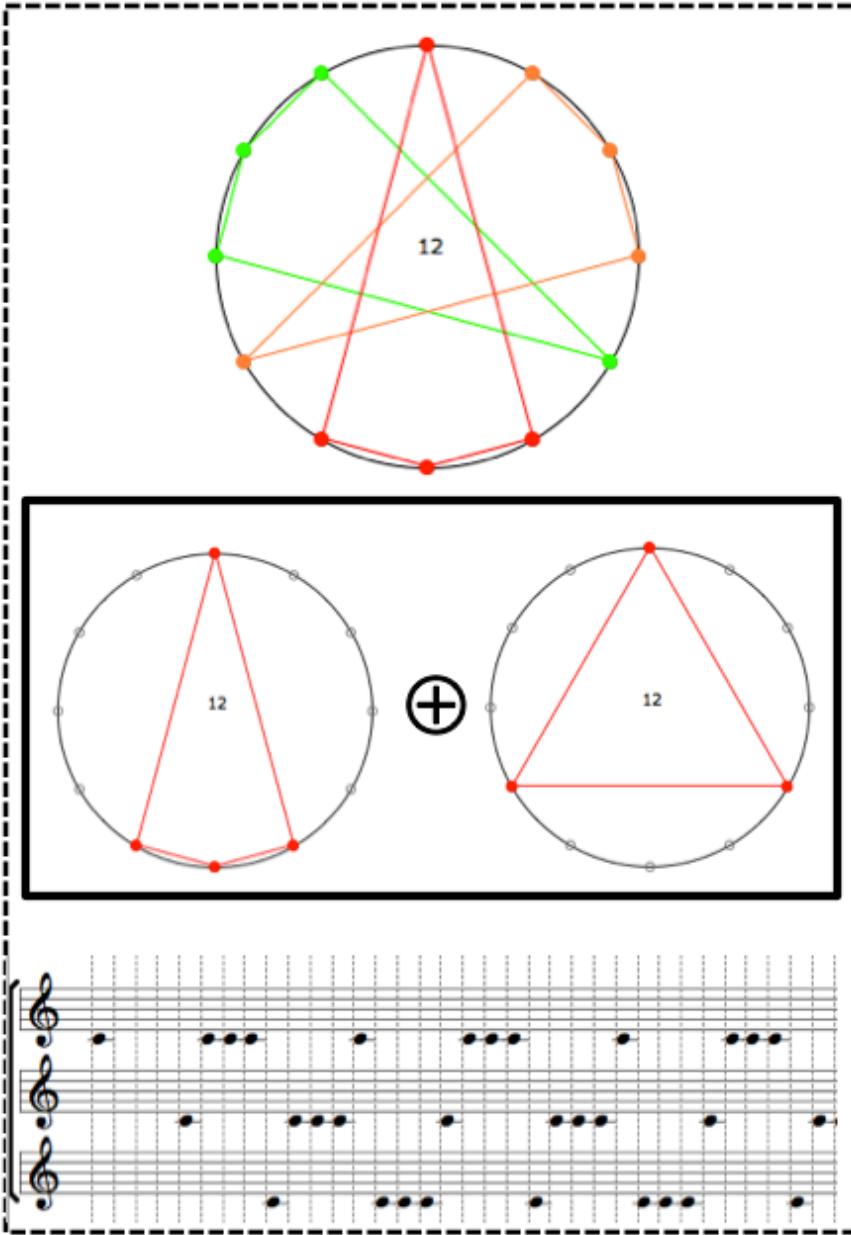
$$Z_{12} = Z_4 \oplus Z_3$$



$$Z_{12} = Z_3 \oplus Z_4$$



I vari tipi di canoni ritmici a mosaico



I vari tipi di canoni ritmici a mosaico

The diagram illustrates various types of rhythmic mosaic canons using circle graphs and musical staves.

Top Left: A large circle graph labeled "12" representing 12 time points. It features several colored lines connecting points, forming a complex web of connections. Colored dots are placed at specific points on the circumference.

Bottom Left: Two smaller circle graphs, each labeled "12", representing 12 time points. They show different connection patterns between points on the circumference.

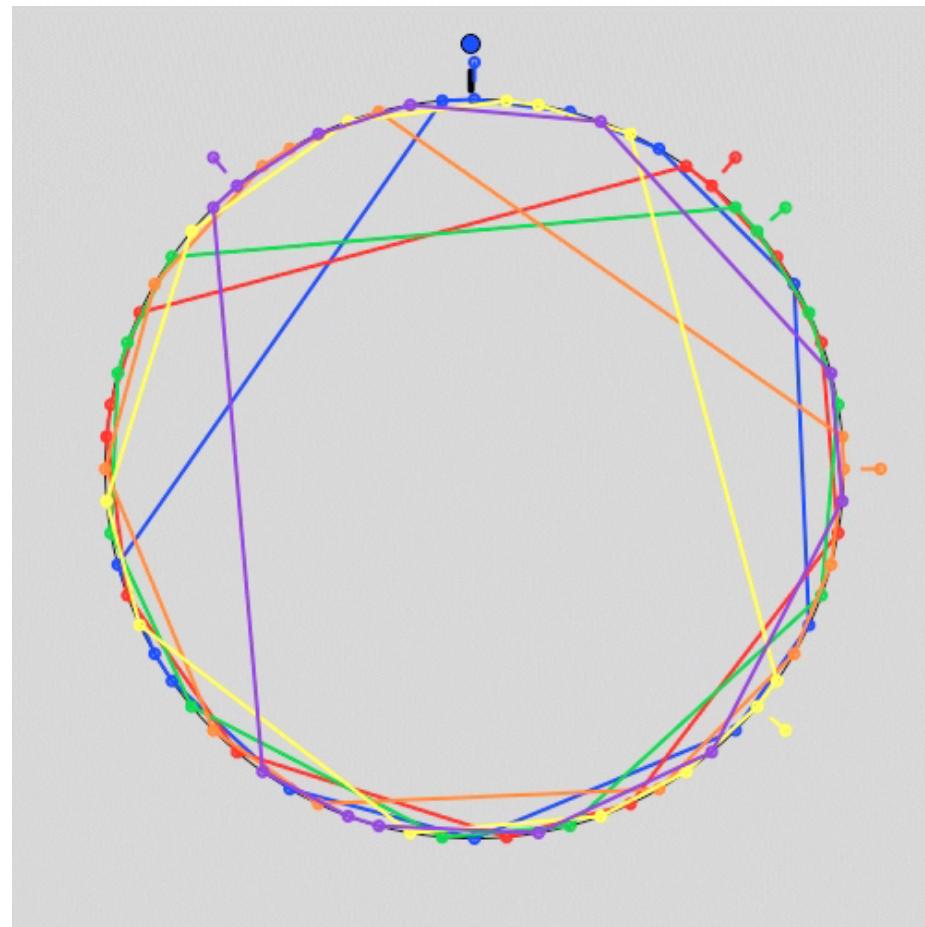
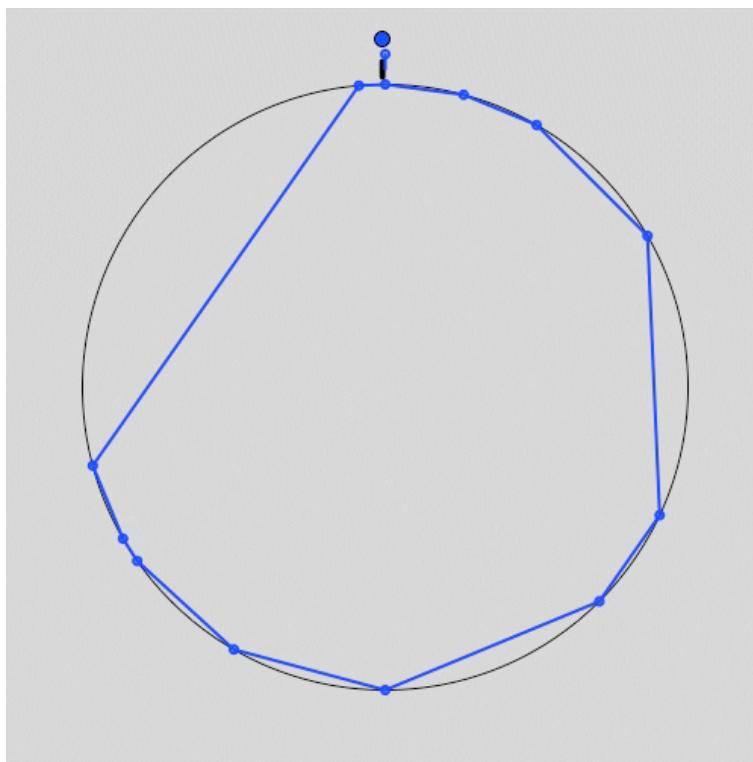
Right Side: A series of four musical staves, each with a treble clef. The staves show rhythmic patterns corresponding to the connections in the circle graphs. The patterns involve vertical stems and horizontal dashes, with colors (red, green, orange, pink) matching the lines in the top graph. An arrow points from the bottom-left circle graphs towards the staves.

Canoni senza periodicità interna (o canoni di Vuza)

The diagram illustrates Vuza canons, which are canons without internal periodicity. It consists of two parts:

- Top Left:** A circular diagram showing multiple colored arcs connecting points on a circle, representing the paths of voices in a canon. The number "72" is centered in the circle.
- Top Right:** Two circular diagrams showing the paths of voices in a canon. The left circle shows a single red path, and the right circle shows a more complex path. Between them is a black circle with a white plus sign (+), indicating the combination of two canons.
- Bottom:** A musical staff with five staves, each starting with a treble clef. The notes are represented by vertical dashes. The notes in each staff are staggered in time, creating a canon effect. The staff lines are dotted, and there are vertical dashed grid lines between the staves.
- Bottom Right:** A small icon of a speaker with a volume dial, enclosed in a bracket, indicating that the musical example can be played.

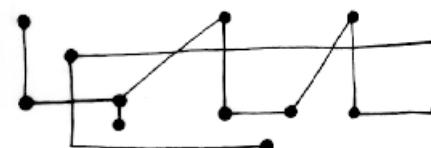
Canone melodico-ritmico di Vuza



Dan Tudor Vuza



Anatol Vieru



*Perspectives of
New Music*

Clapping Music: esercizio minimalista sulle permutazioni cicliche

CLAPPING MUSIC

FOR TWO PERFORMERS

J = 144-168

CLAP1 CLAP2

①

②

③

④

⑤

⑥

⑦

⑧

⑨

⑩

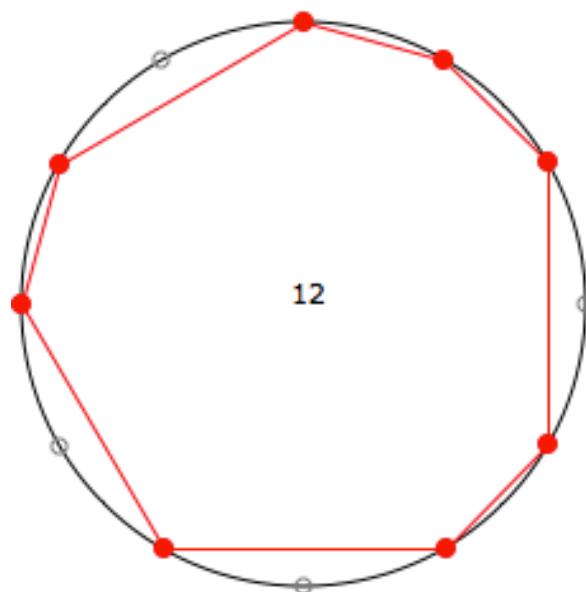
⑪

⑫

⑬ Repeat bar ①, then end.

*Steve Reich 1/72
re-copied 1/78*

Clapping Music (1972)



Clapping Music: esercizio minimalista sulle permutazioni cicliche

CLAPPING MUSIC
FOR TWO PERFORMERS

J = 144-168

CLAP1 CLAP2

①

①

②

③

④

⑤

⑥

⑦

⑧

⑨

⑩

⑪

⑫

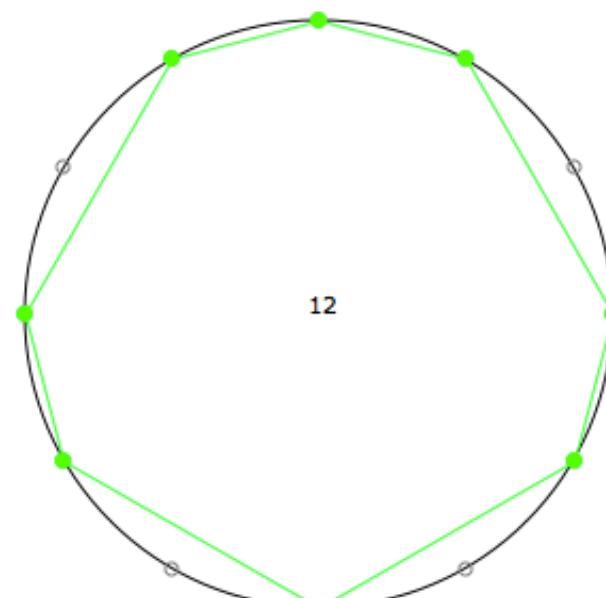
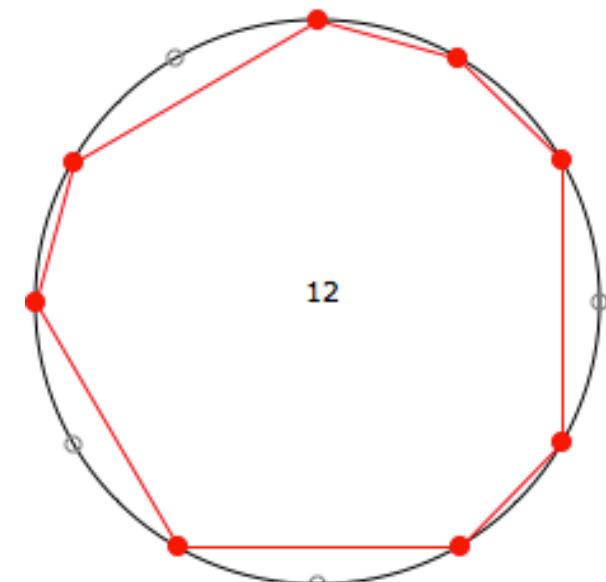
⑬

The performance begins and ends with both performers in unison at bar ①. The number of repeats of each bar should be fixed at twelve repeats per bar. Since the first performer's part does not change, it is up to the second performer to move from one bar to the next. The second performer should try to keep his or her downbeat where it is written, i.e. on the first beat of each measure (not on the first beat of the group of three claps), so that his downbeat always falls on a new beat of his anchoring pattern.

The choice of a particular clapping sound, i.e., with cupped or flat hands, is left up to the performers. Whichever tablet is chosen, both performers should try to get the same one so that their two parts will blend to produce one overall resulting pattern.

Clapping Music (1972)

*Philip Glass 1972
re-copied 1978*



Clapping Music: esercizio minimalista sulle permutazioni cicliche

CLAPPING MUSIC
FOR TWO PERFORMERS

J = 144-168

CLAP1 CLAP2

① ② ③

④ ⑤ ⑥

⑦ ⑧ ⑨

⑩ ⑪ ⑫

⑬ ⑭ ⑮

⑯ ⑰ ⑱

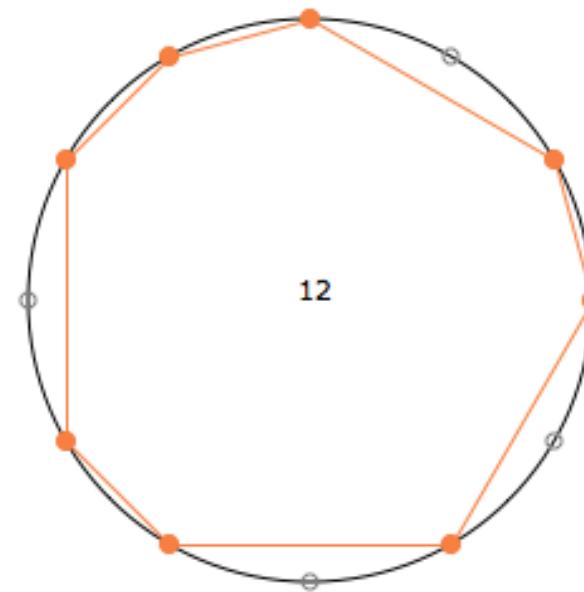
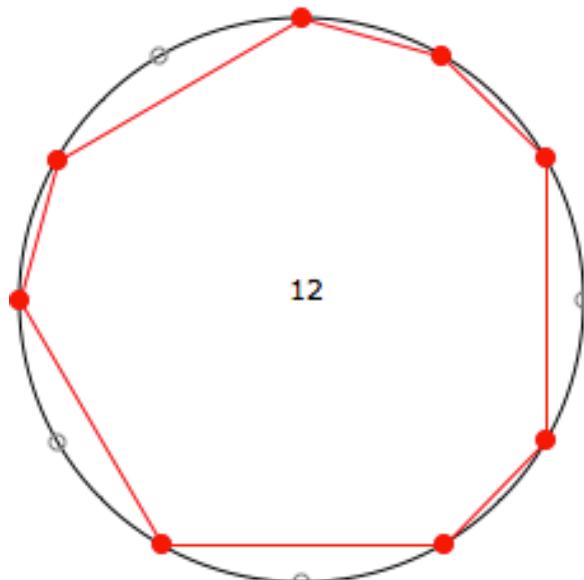
⑲ ⑳ ⑳

Repeat beat ①, then end.

The performance begins and ends with both performers in unison at bar ①. The number of repeats of each bar should be fixed at twelve repeats per bar. Since the first performer's part does not change, it is up to the second performer to move from one bar to the next. The second performer should try to keep his or her downbeat where it is written, i.e. on the first beat of each measure (not on the first beat of the group of three claps), so that his downbeat always falls on a new beat of his own unchanging pattern.

The choice of a particular clapping sound, i.e., with cupped or flat hands, is left up to the performers. Whichever tablet is chosen, both performers should try to get the same one so that their two parts will blend to produce one overall resulting pattern.

*Steve Reich 1972
re-copied 1978*



Clapping Music: esercizio minimalista sulle permutazioni cicliche

CLAPPING MUSIC
FOR TWO PERFORMERS

J = 144-168

CLAP1 CLAP2

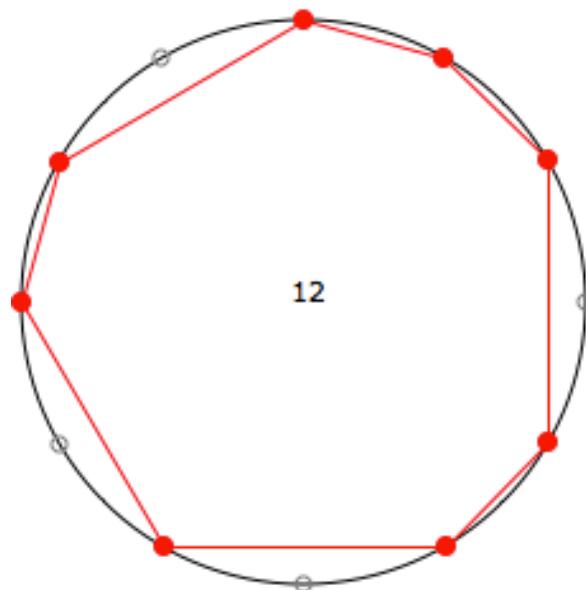
①

② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬

Repeat beat ①, then end.

*Steve Reich 1/72
re-copied 1/78*

Clapping Music (1972)



Clapping Music: esercizio minimalista sulle permutazioni cicliche

The diagram illustrates a minimalist exercise on cyclic permutations of 12 points, corresponding to the musical score for two clappers.

Top Left: A circle with 12 points. Red arrows show a clockwise cycle of 3 points. An arrow points down to the next circle.

Top Right: A musical score for two clappers (CLAP1 and CLAP2) at tempo $j = 144 - 168$. The score consists of 12 measures. Measures 1-3 are highlighted with a red box. Measures 4-6 are highlighted with a green box. Measures 7-9 are highlighted with an orange box. Measures 10-12 are shown below. The score ends with "Repeat bar then end."

Middle Row: Five circles showing different 3-point cycles. Arrows indicate the progression from left to right: (green, orange, magenta, red, blue).

Bottom Row: Five circles showing different 2-point cycles. Arrows indicate the progression from left to right: (dark red, cyan, purple, dark grey, black).

***Clapping Music*: esercizio minimalista sulle permutazioni cicliche**

CLAPPING MUSIC
FOR TWO PERFORMERS

J=144-168

CLAPS CLAP2

① ② ③

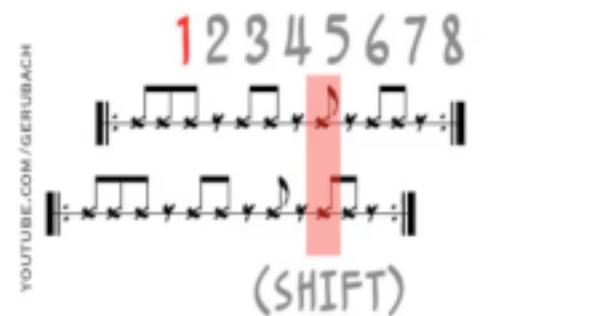
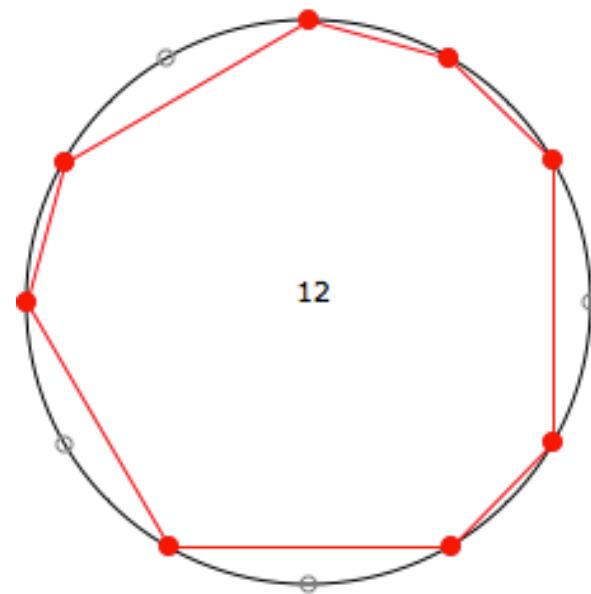
f

④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯

Repeat bar ⑬, then end

The performance begins and ends with both performers in unison at bar ①. The number of repeats of each bar should be fixed at twelve repeats per bar. Since the first performer's part does not change, it is up to the second performer to move from one bar to the next. The second performer should try to keep his or her downbeat where it is written, i.e. on the first beat of each measure (not on the first beat of the group of three claps), so that his downbeat always falls on a new beat of his own anchoring pattern.

The choice of a particular clapping sound, i.e., with cupped or flat hands, is left up to the performers. Whichever pattern is chosen, both performers should try to get the same one so that their two parts will blend to produce one overall rhythmic pattern.



Gerubach's Scrolling Score Project
<http://www.gerubach.com>

Hexachord (by Louis Bigo, 2013)

Grazie dell'attenzione!

