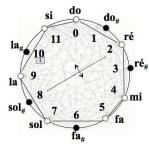
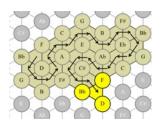
Modèles mathématiques et computationnels dans la chanson

Analyse de la musique et des répertoire III : Musiques actuelles

(partie IV : la représentation circulaire)





Moreno Andreatta
IRMA & ITI CREAA, Université de Strasbourg
Equipe Représentations Musicales
IRCAM / CNRS UMR 9912 / Sorbonne Université











De la musicologie systématique à la musicologie computationnelle

II. Systematisch.

Aufstellung der in den einzelnen Zweigen der Tonkunst zuhöchst stehenden Gesetze.

A. Erforschung und Begründung derselben in der

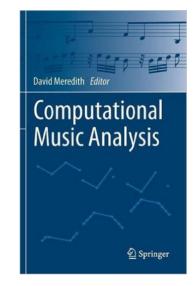
- 1. Harmo- 2. Rhyth- 3. Melik nik (Cohärenz mik (tonal od. (temporär von tonal Relation mit den appertonlich'. oder und temzeitlich). porär).
- B. Aesthetik der Tonkunst. 1. Vergleichung und Werthschätzung der Gesetze und deren cipirenden Subjecten behufs Feststellung der Kriterien des musikalisch Schönen.
 - 2. Complex unmittelbar und mittelbar damit zusammenhängender Fragen.
- C. Musikalische Pädagogik und Didaktik (Zusammenstellung der Gesetze mit Rücksicht auf den Lehrzweck) 1. Tonlehre.
 - 2. Harmonielehre, 3. Kontrapunkt.
- 4. Compositionslehre. 5. Instrumentationslehre, 6. Methoden des Unterrichtes im Gesang und

Instrumentalspiel.

D. Musikologie (Untersuchung und Vergleichung zu ethnographischen Zwecken).



G. Adler (1855-1941)



Hilfswissenschaften: Akustik und Mathematik.

Physiologie (Tonempfindungen).

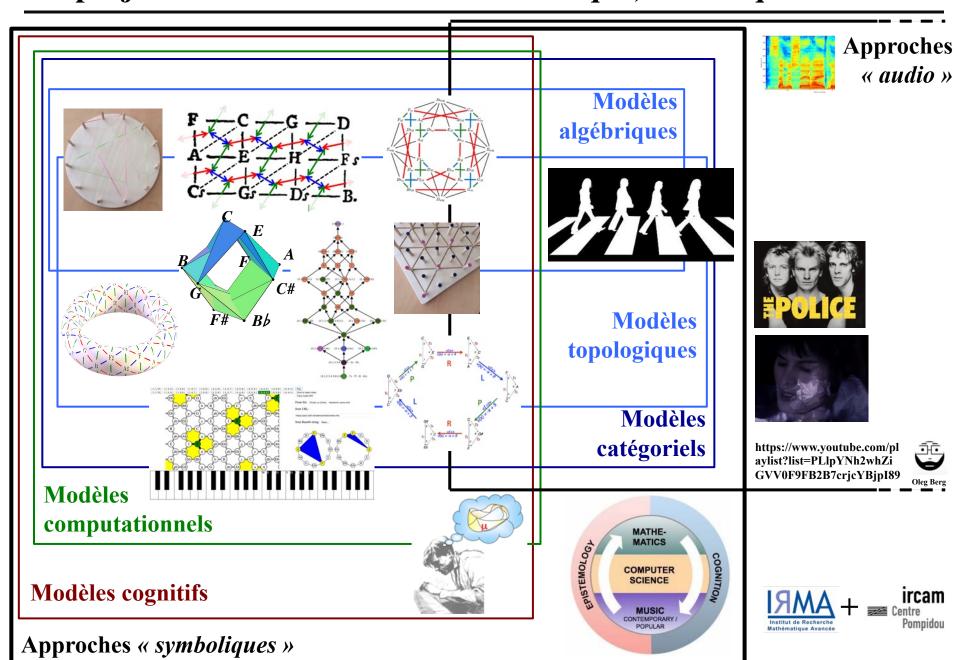
Psychologie (Tonvorstellungen, Tonurtheile und Tongefühle).

Logik (das musikalische Denken). Grammatik, Metrik und Poetik.

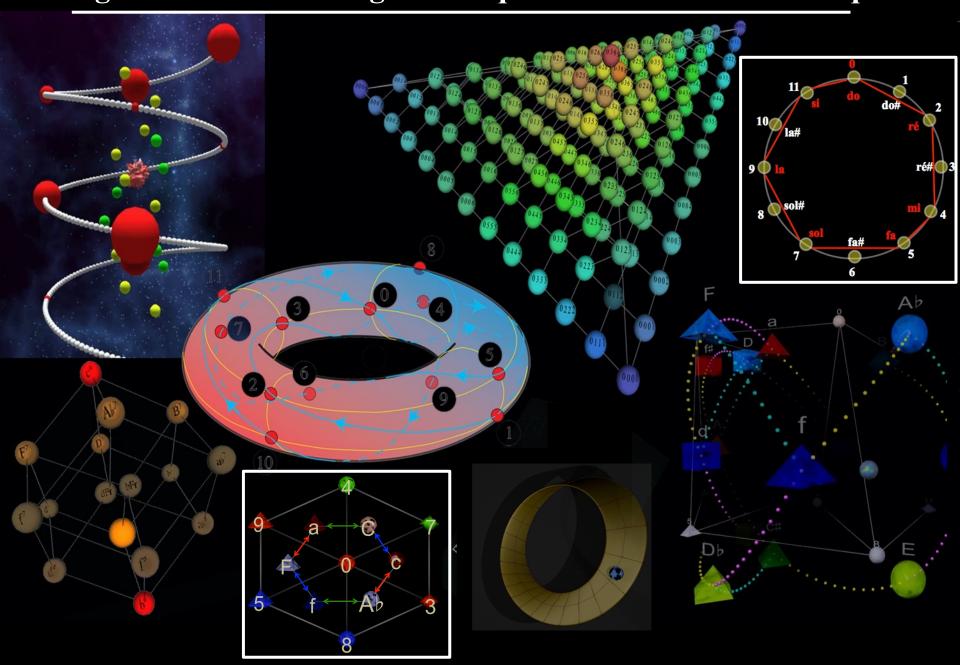
Pädagogik Ästhetik etc.

« La deuxième grande partie de la musicologie est la partie systématique; cette partie se base sur la partie historique. (...) L'accent de l'observation réside dans l'analogie de la méthode musicologique avec la méthode scientifique ».

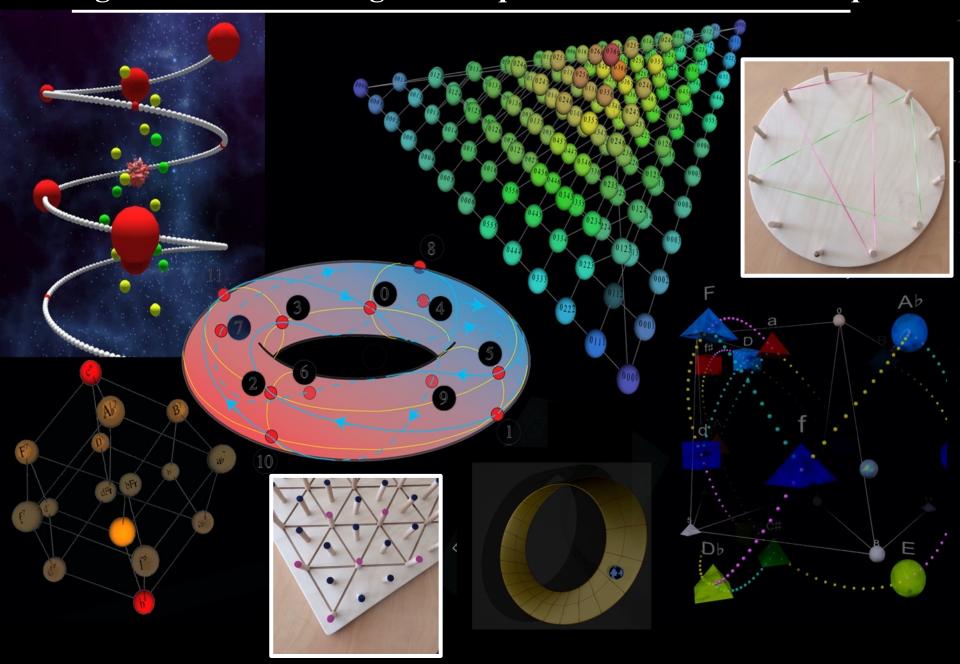
Le projet SMIR : les maths dans la musique, la musique des maths



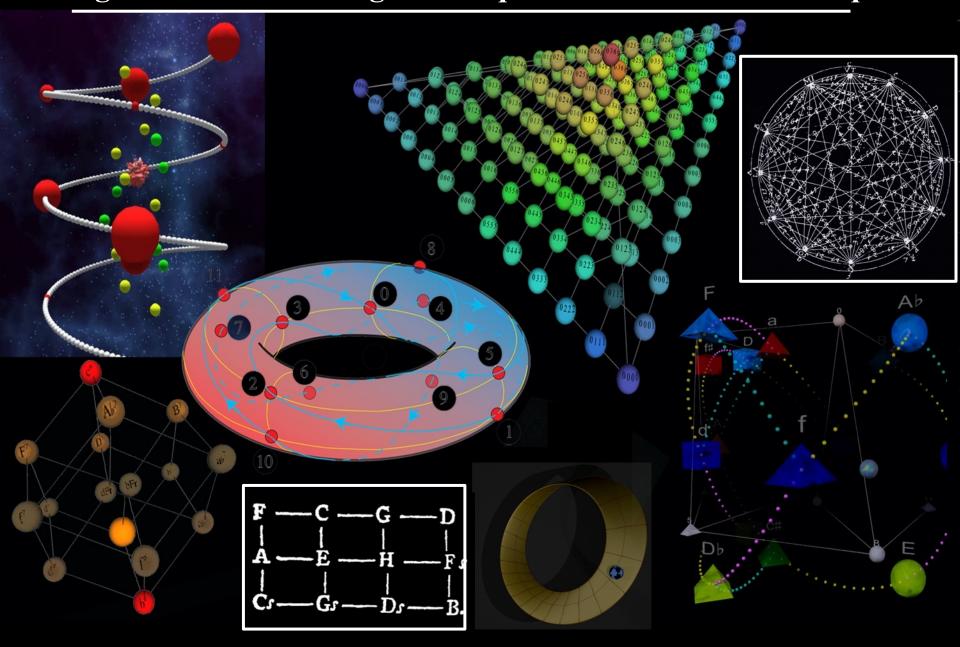
La galaxie des modèles géométriques au service de la musique



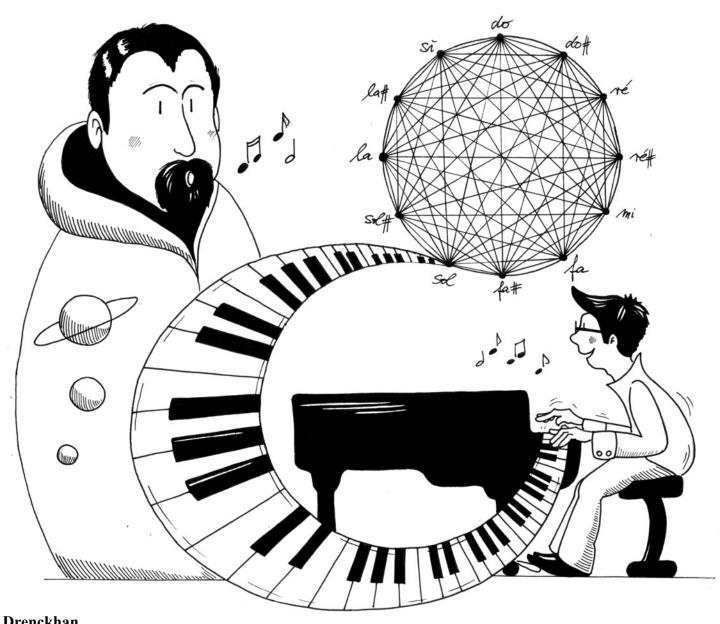
La galaxie des modèles géométriques au service de la musique



La galaxie des modèles géométriques au service de la musique



Marin Mersenne, le père de la combinatoire

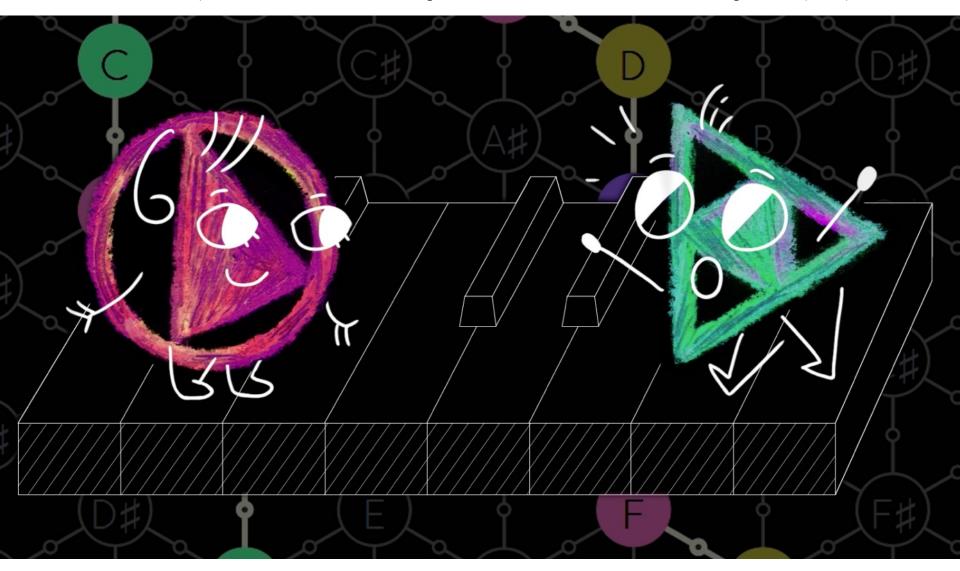


Leonhard Euler, le père de la théorie des graphes



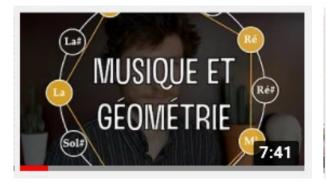
Musique et mathématiques : histoire d'une rencontre

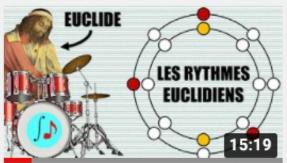
Vidéo pédagogique conçue et réalisée dans le cadre du projet **ProAppMaMu** (**Processus et techniques d'apprentissages des savoirs 'mathémusicaux'**), avec le soutien de la Mission pour les initiatives transverses et interdisciplinaires (MITI) du CNRS.



→ http://repmus.ircam.fr/moreno/proappmamu

Mathémusique : chaîne youtube de Paul Lascabettes

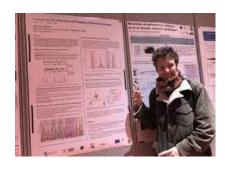












P. Lascabettes (COSMOS Team, Ircam)

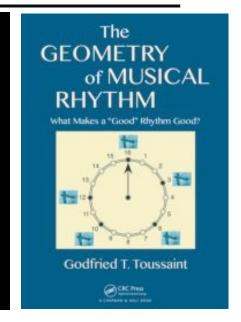
- **Musique et géométrie** : une introduction aux représentations géométriques des structures musicales (rythmes, gammes, accords)
- Rythmes Euclidiens ou les ensembles bien repartis (Maximally Even Sets)
- **Arbres rythmiques** : comment représenter les structures rythmiques complexes dans la pop (et dans les Beatles en particulier)
- Analyse rythmique de la chanson "Here Comes The Sun" des Beatles

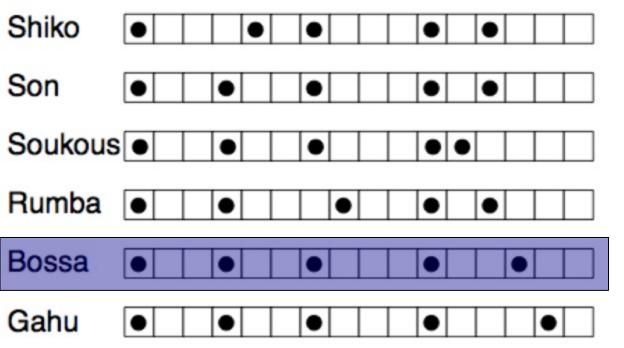
→ http://repmus.ircam.fr/moreno/chanson

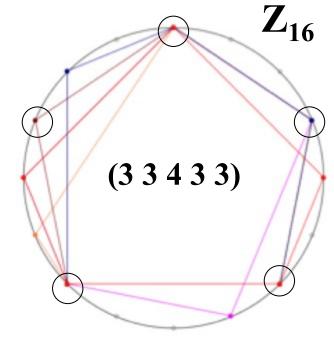
La géométrie des rythmes afro-cubains



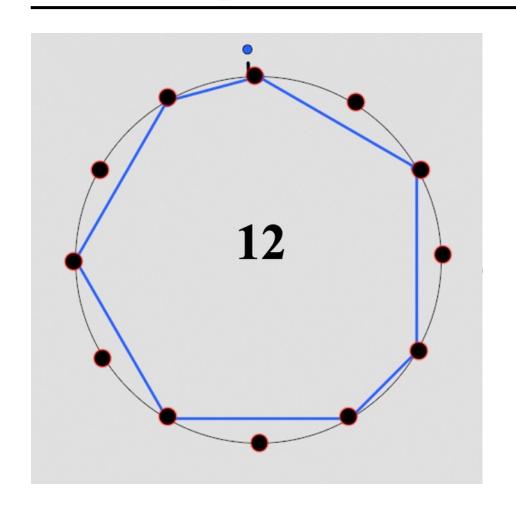




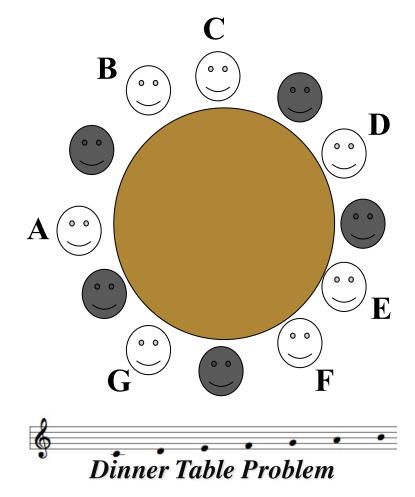


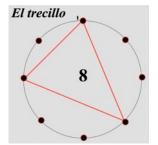


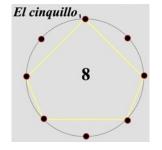
Représentation circulaire des rythmes



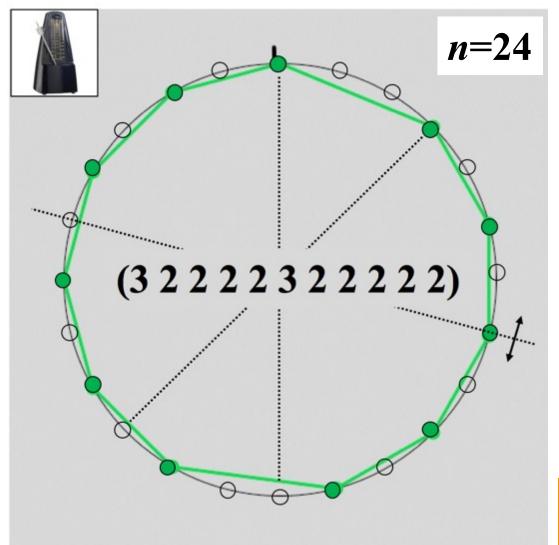








Imparité rythmique et traditions orales

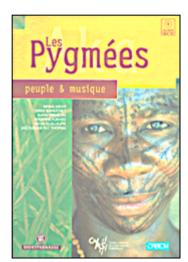


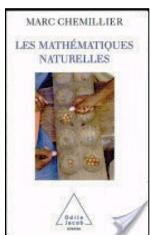






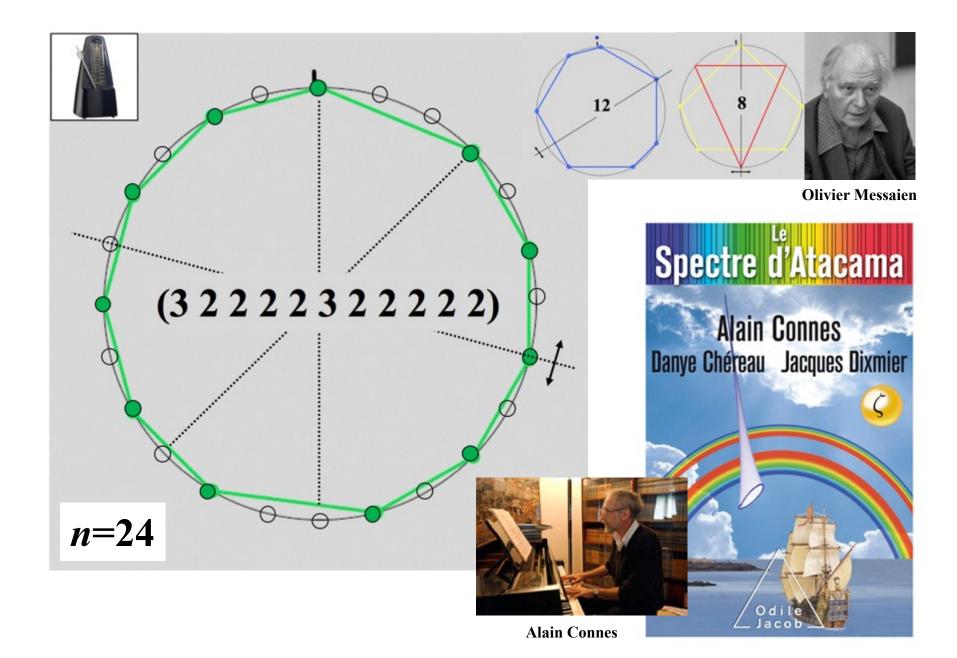
Marc Chemillier





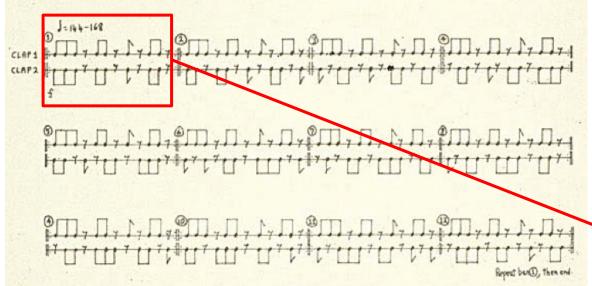


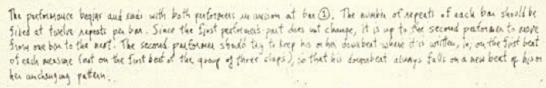
Rythmes non-retrogradables d'Olivier Messiaen



CLAPPING MUSIC

FOR TWO PERFORMERS





The choice of a particular clapping sound, is, with copped or flat hands is left up to the partitudes whichever timbre is chosen, both partitudes, should true to get the same one so that their two parts will blend to produce one oriently parties.

Clapping Music de Steve Reich (1972)

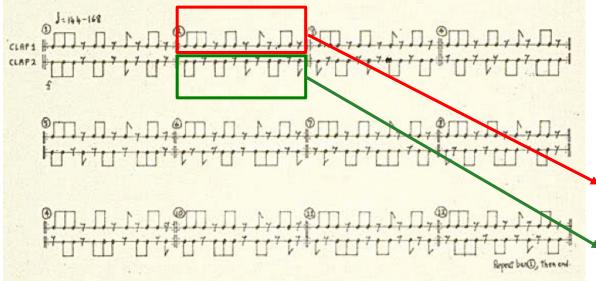
Accepted 178





CLAPPING MUSIC

FOR TWO PERFORMERS





The performance begins and ends with both performers in ancion at bar 3. The number of repeats of each bar should be fixed at toxolor repeats per bar. Since the first performers part does out change, it is up to the second performer to reove from one box to the next. The second performer should tay to keep his or her downbest where it is written, is, on the first best of each measure (not on the first best of the group of three clops), so that his downbest always falls on a new best of his or her anchonging pattern.

The choice of a particular clapping sound, is, with copped or flat hands is left up to the partitudes whicheres timbre is chosen, both partitudes, should true to get the same one so that their two parts will blend to produce one oriently parties.

Clapping Music (1972)

Asso Pode 12/12

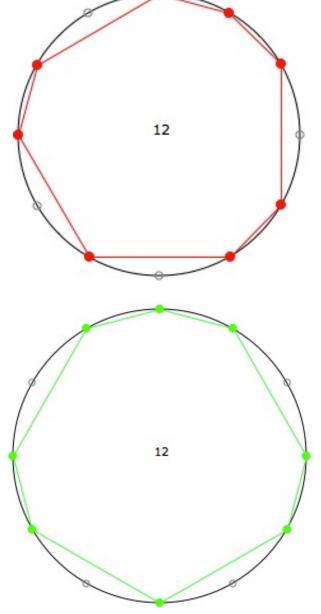
CLAPPING MUSIC

FOR TWO PERFORMERS



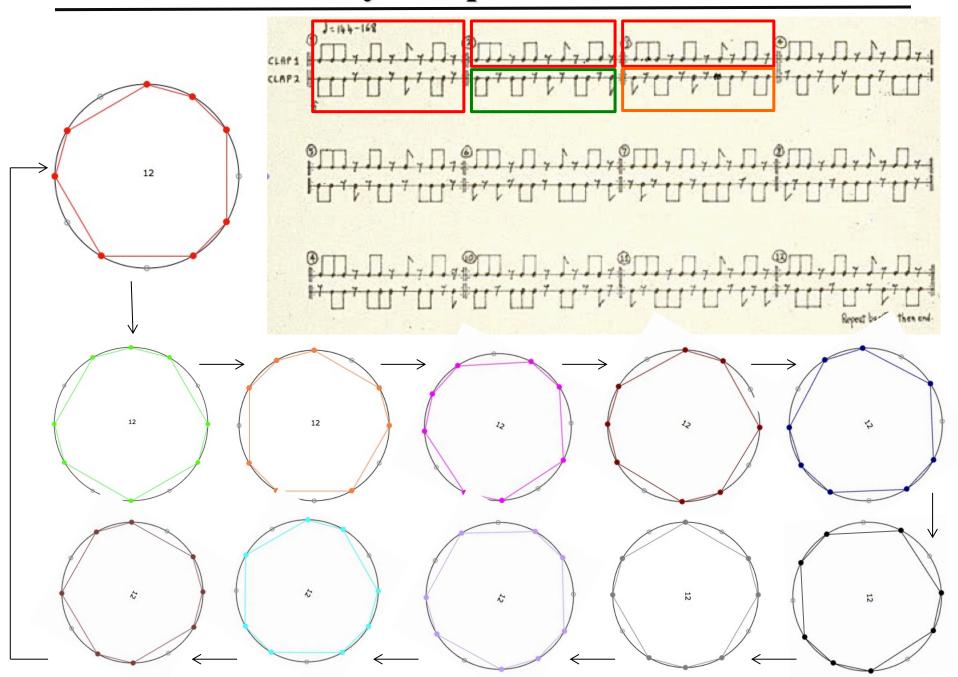
The performance begins and such with both performers in answer at ben 1. The number of repeats of each ban should be sized at toucher repeats per ban. Since the Sixed performers part does not change, it is up to the second performer to revie from one box to the next. The second performer should tay to keep his or her downbeat where it is written, is, 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 best of his or her anchonging pattern.

The choice of a particular clapping sound, is, with copped or flat hands is left up to the partitudes whichers timbre is chosen, both partitudes, should try to get the same one so that their two parts will blend to produce one oriently existing parties.



Clapping Music (1972)

Assor Rock 12/12



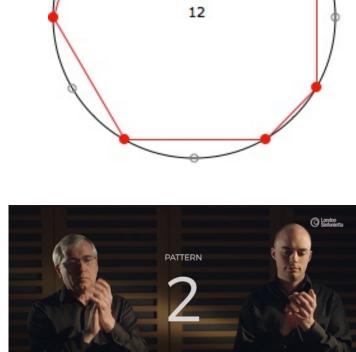
CLAPPING MUSIC

FOR TWO PERFORMERS



The performance begins and such with both performers in autom at bar 1). The number of repeats of each bar should be filed at toxelve repeats per bar. Since the first performers part does out change, it is up to the second partonner to revie from one box to the next. The second partonner should try to keep his or her downbeat where it is written, it on the first beat of each accounter (not on the first beat of the group of three claps), so that his downbeat always falls on a new best of his or her anchoninging pattern.

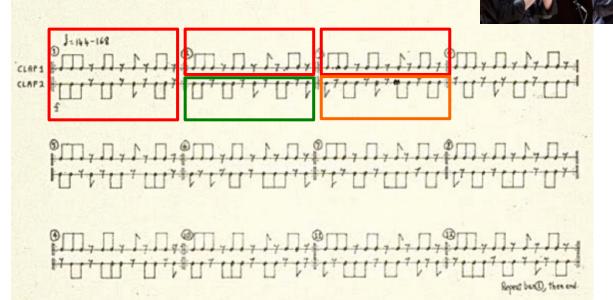
The choice of a particular chapping sound, in, with clipped or flat hands is left up to the parformers. Whichever timbre is chosen, both purformers, should try to get the same one so that their two parts will blend to produce one oranil resulting parties.



https://apps.apple.com/app/id946487211?ls=1

CLAPPING MUSIC

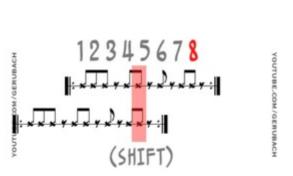
FOR TWO PERFORMERS



The performance begins and rules with both performers in anomal of the 3. The available of repeats of each ban should be filed at topology napests per ban. Since the first performers part does not change, it is up to the second performer to respective one but to the next. The second performer should try to keep his order doublest where it is written, is, on the first best of each measure (not on the first best of the group of three claps), so that his downbest always falls on a new best of his or anchoring my pattern.

The choice of a particular clarging sound, is, with copped or flat hands is left up to the partitudes. Whichers timbre is chosen, both partitudes, should true to get the same one so that their two parts will blend to produce one oriently paters.

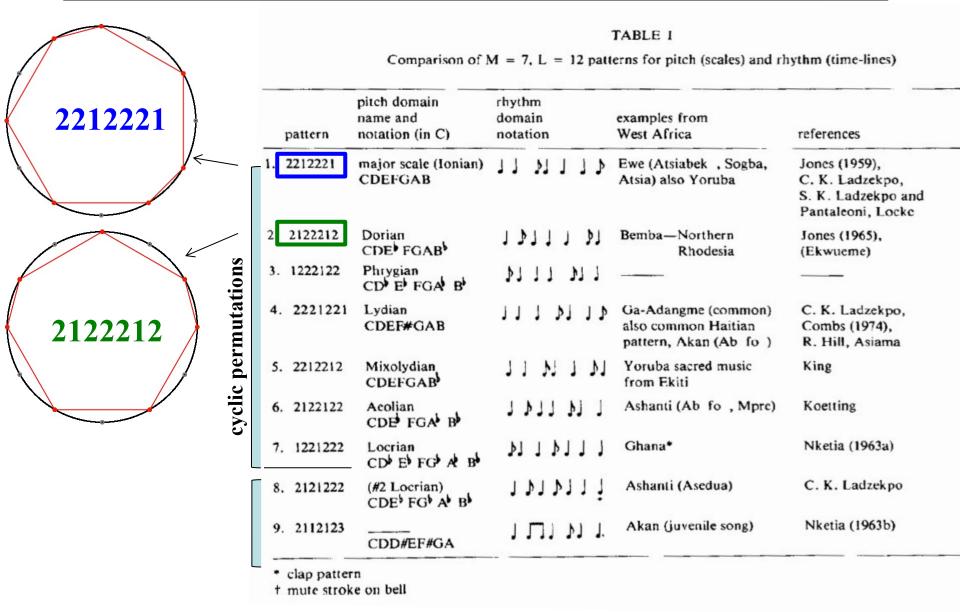
Acos Pede 12/12



12

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

Isomorphisme cognitif entre rythmes et hauteurs



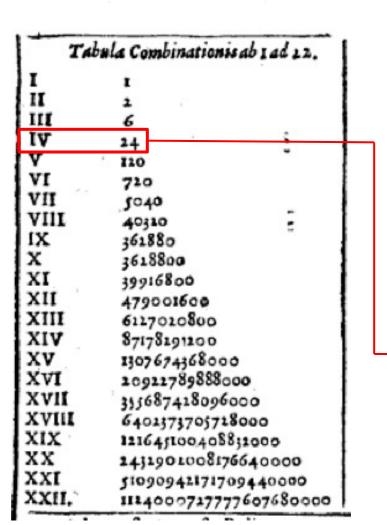
J. Pressing, "Cognitive isomorphisms between pitch and rhythm in world musics: West Africa, the Balkans and Western tonality", Studies in Music, 17, p. 38-61

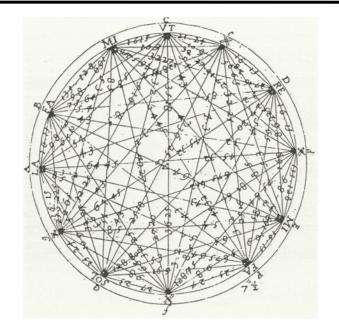
Mersenne et la naissance de la combinatoire

114 Marin Mersenne, Harmonicorum Libri XII, 1648

LIBER SEPTIMUS

DE CANTIBVS, SEV CANTILENIS, EARVMQ; NVMERO, PARTIBVS, ET SPECIEBVS.







Marin Mersenne

Varietas, seu Combinatio quatuor notarum.

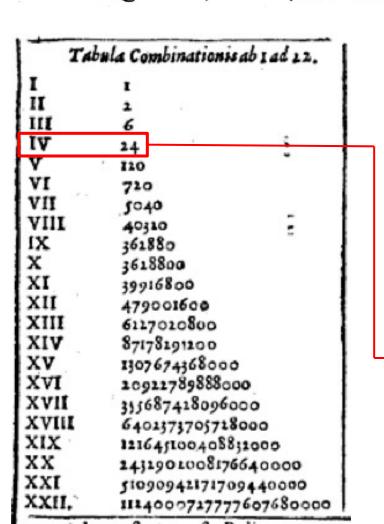


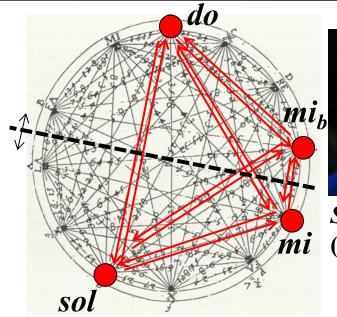
Approches permutationnelles en musique savante

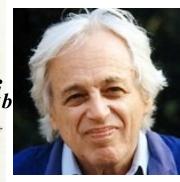
114 Marin Mersenne, Harmonicorum Libri XII, 1648

LIBER SEPTIMUS

DE CANTIBVS, SEV CANTILENIS, EARVMQ; NVMERO, PARTIBVS, ET SPECIEBVS.







Six Bagatelles (G. Ligeti, 1953)

Varietas, seu Combinatio quatuor notarum.

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*	000	150	16 0	1700	18
19	200	200	22.0	23	24 F

Les contraintes dans l'art : l'OuLiPo (Ouvroir de Littérature Potentielle)



Cent mille milliards de poèmes, 1961



La vie mode d'emploi,



Raymond Queneau



Italo Calvino Le Château des destins croisés, 1969



Georges Perec

De l'OuLiPo à l'OuMuPo (ouvroir de musique potentielle)





M. Andreatta et al., « Music, mathematics and language: chronicles from the Oumupo sandbox », in Kapoula, Z., Volle, E., Renoult, J., Andreatta, M. (Eds.), Exploring Transdisciplinarity in Art and Sciences, Springer, 2018



Mike Solomon



Granger









Joseph Boisseau Martin

Moreno Andreatta

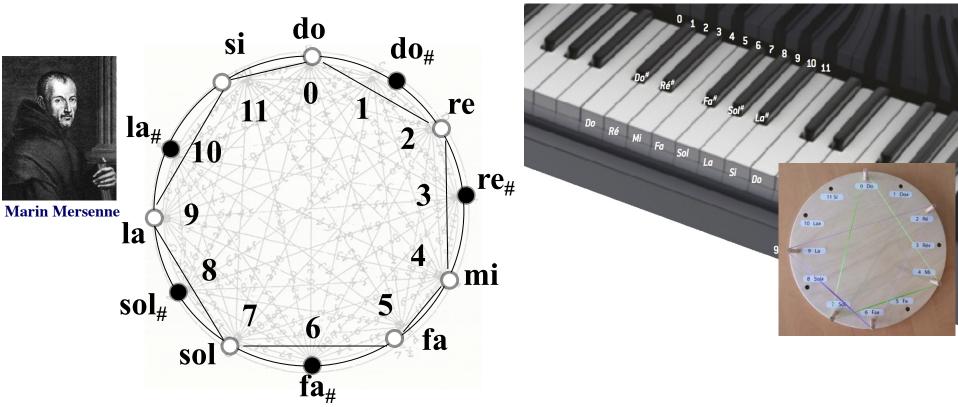
Tom Johnson

http://oumupo.org/

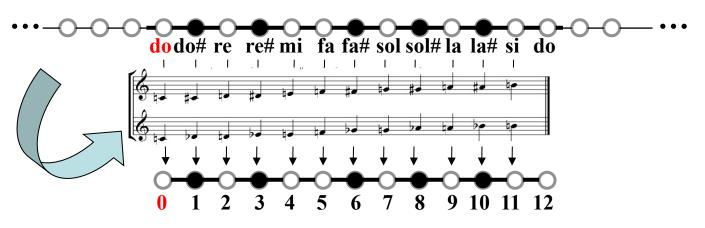
Valentin Villenave

Jean-François **Piette**

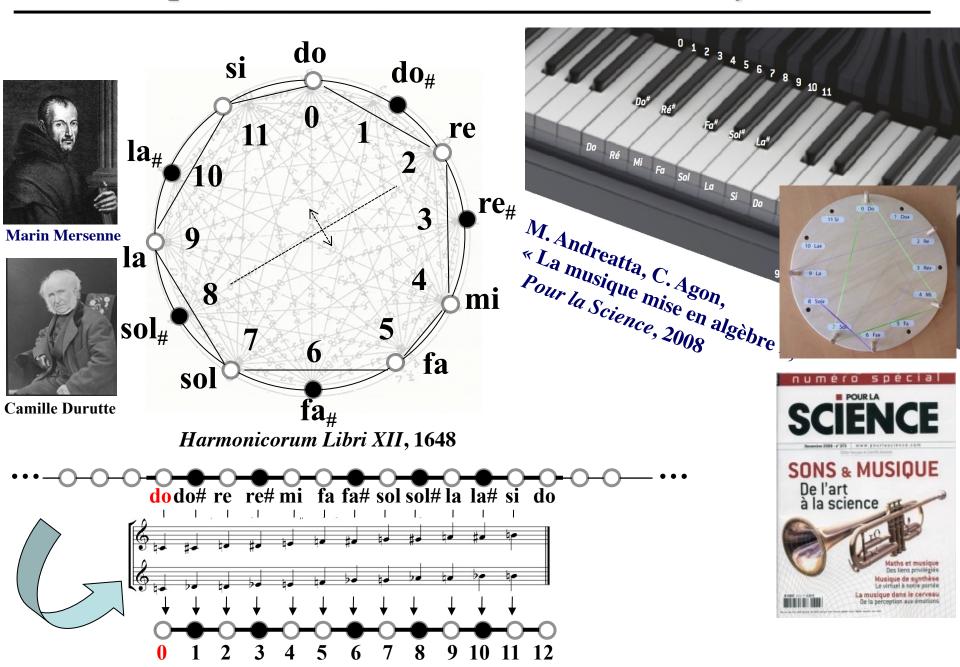
La représentation circulaire de l'espace des hauteurs



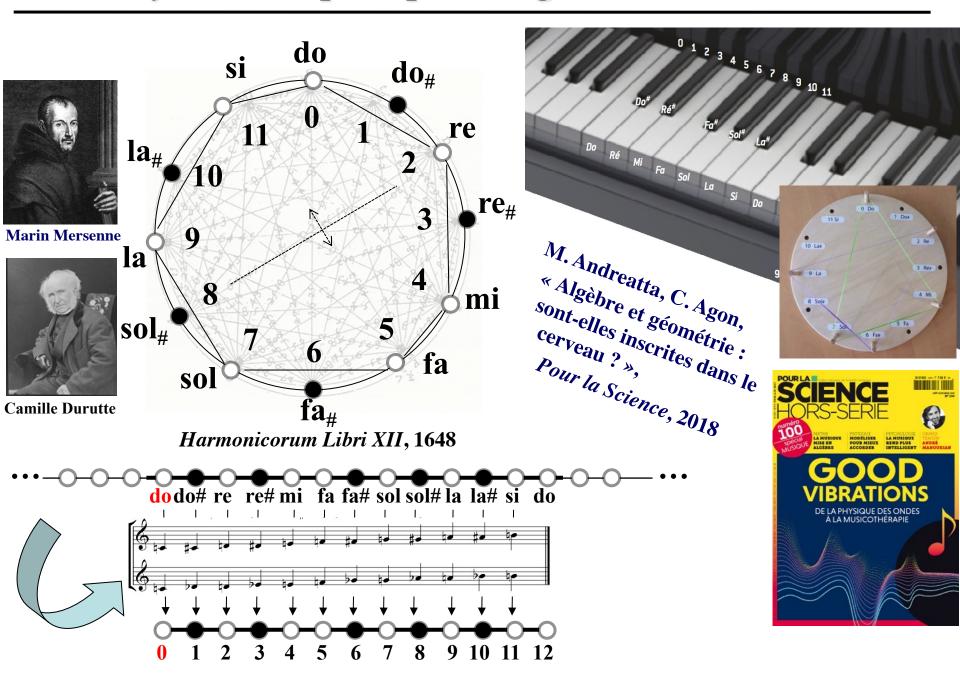
Harmonicorum Libri XII, 1648



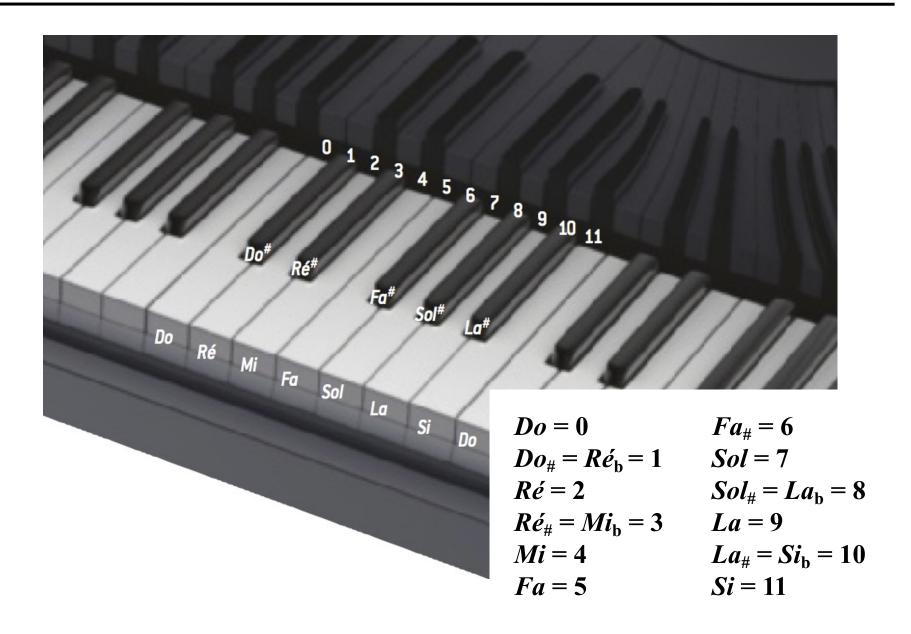
La représentation circulaire et l'idée de symétrie



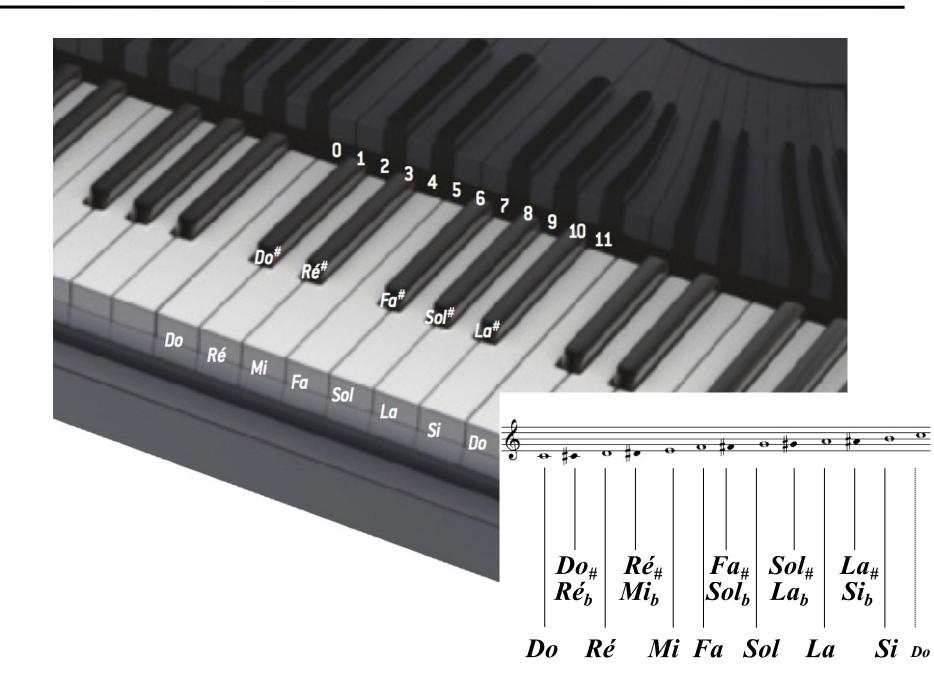
Symétrie et perception/cognition musicales



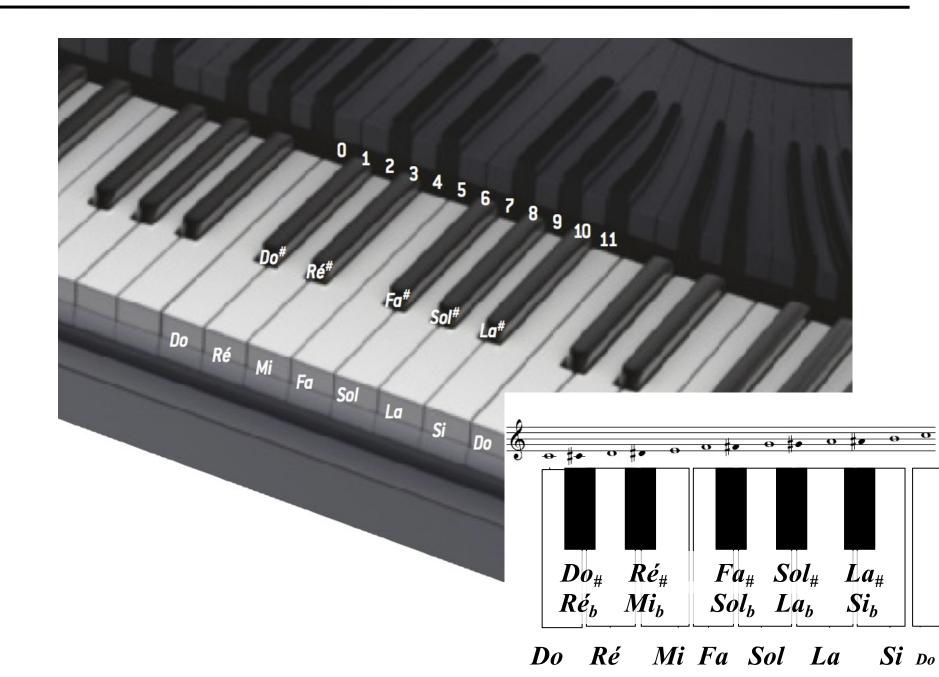
Le piano : douze notes = douze nombres



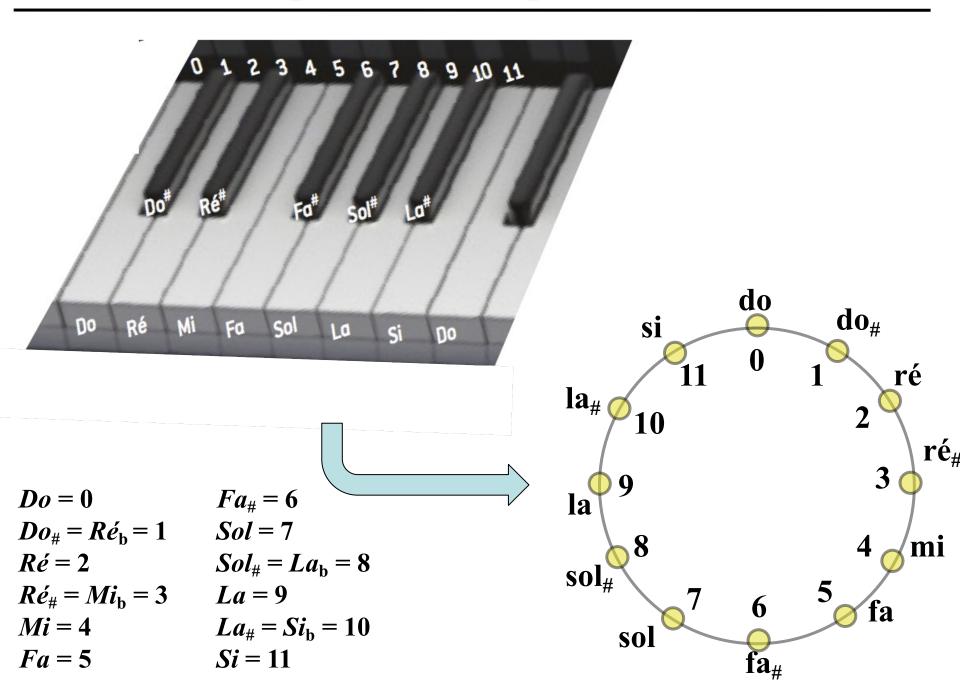
Le piano : douze notes = douze nombres

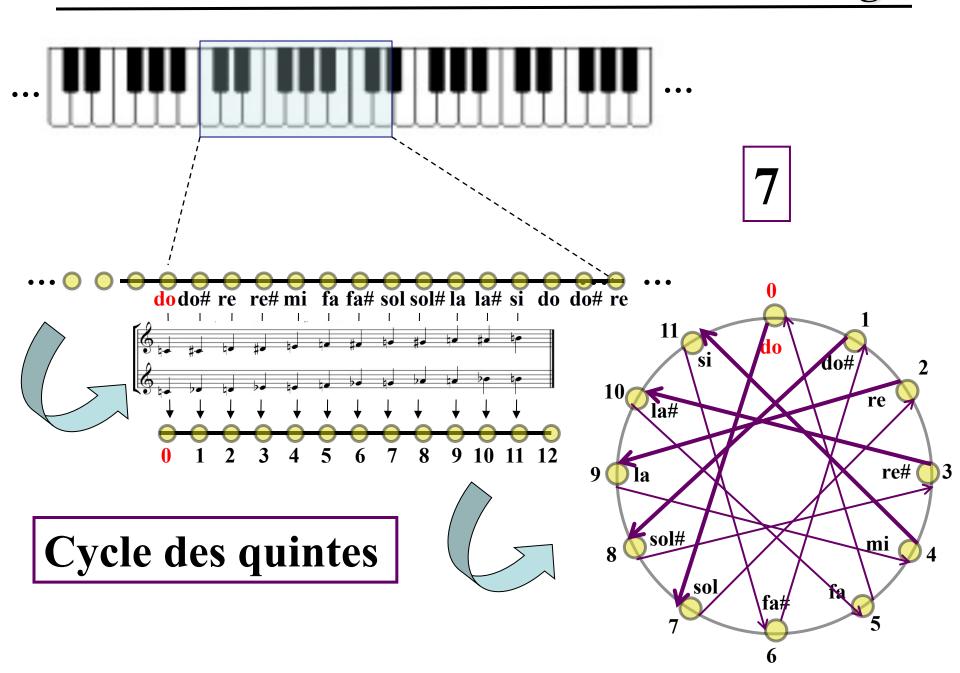


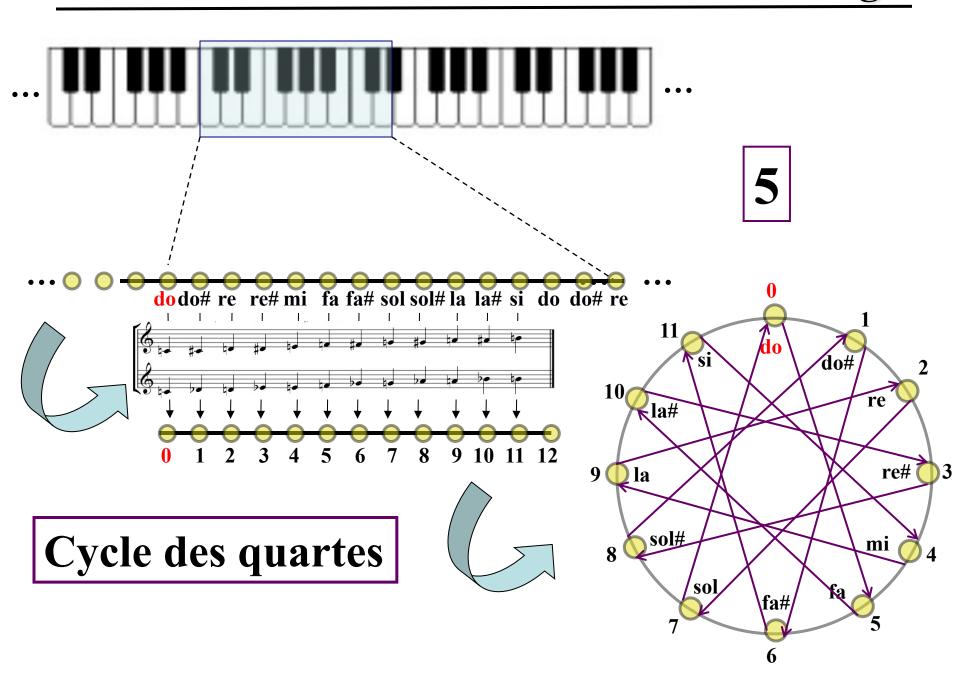
Le piano : douze notes = douze nombres

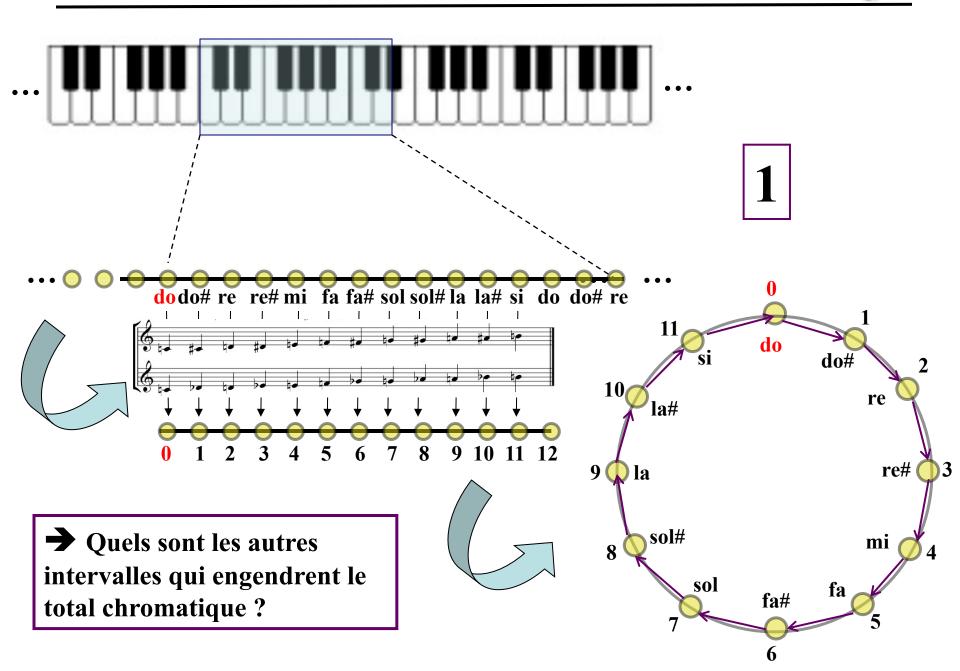


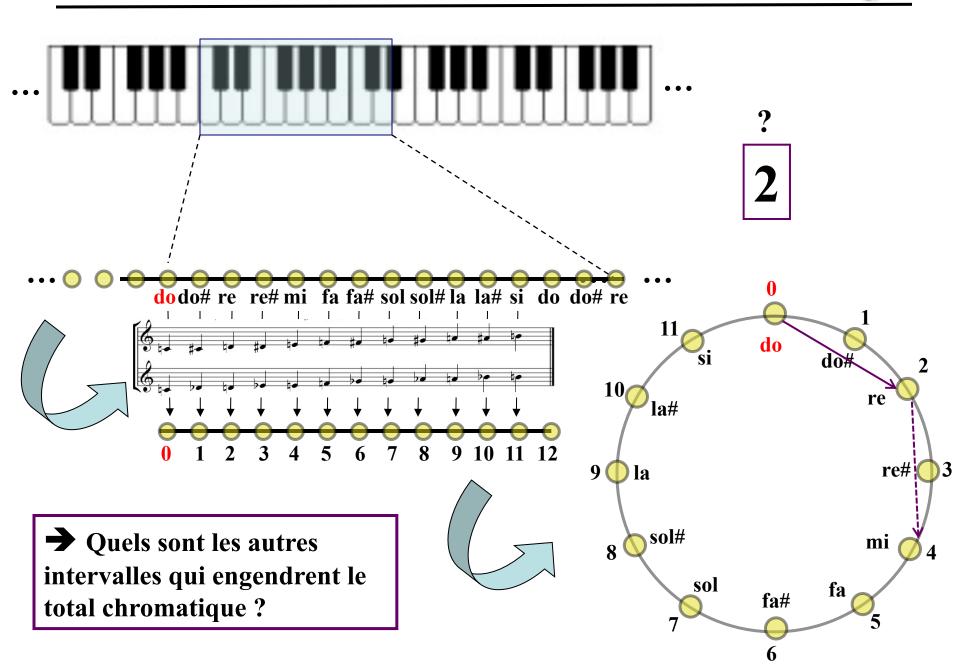
Du piano à l'horloge musicale



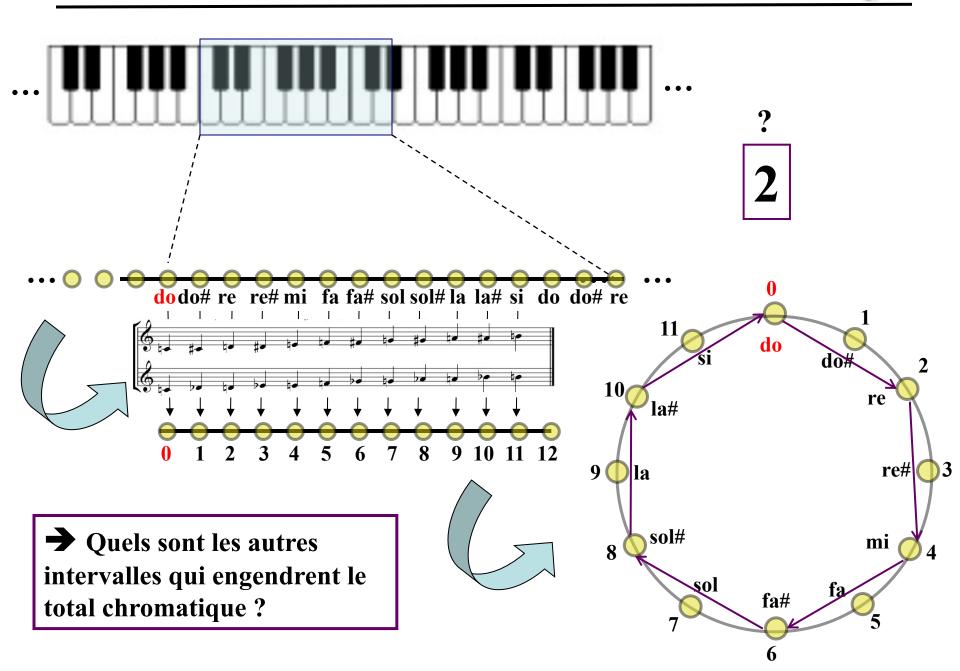




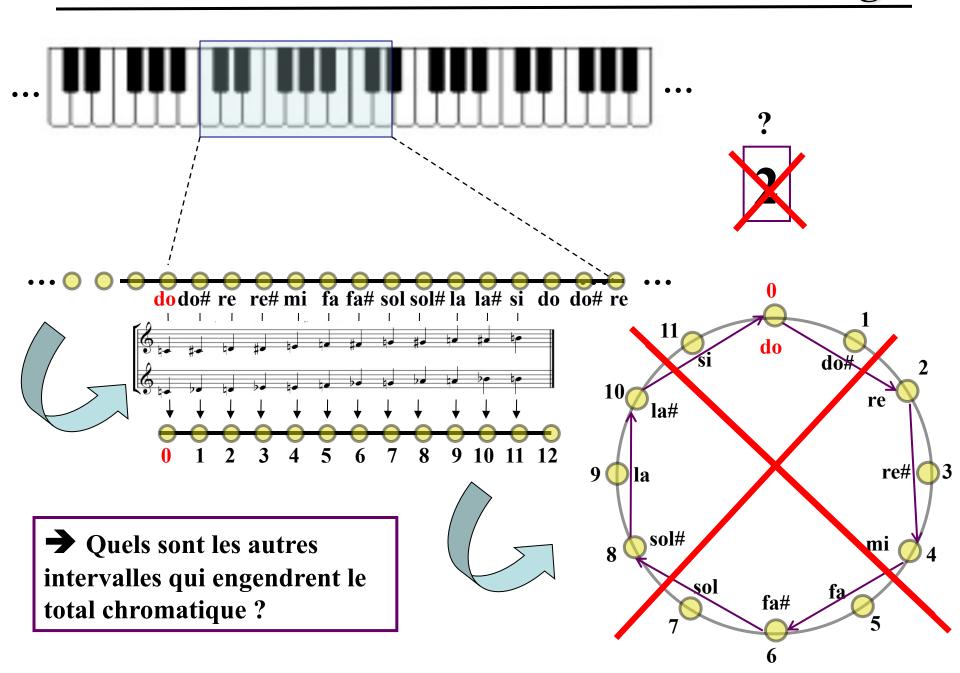




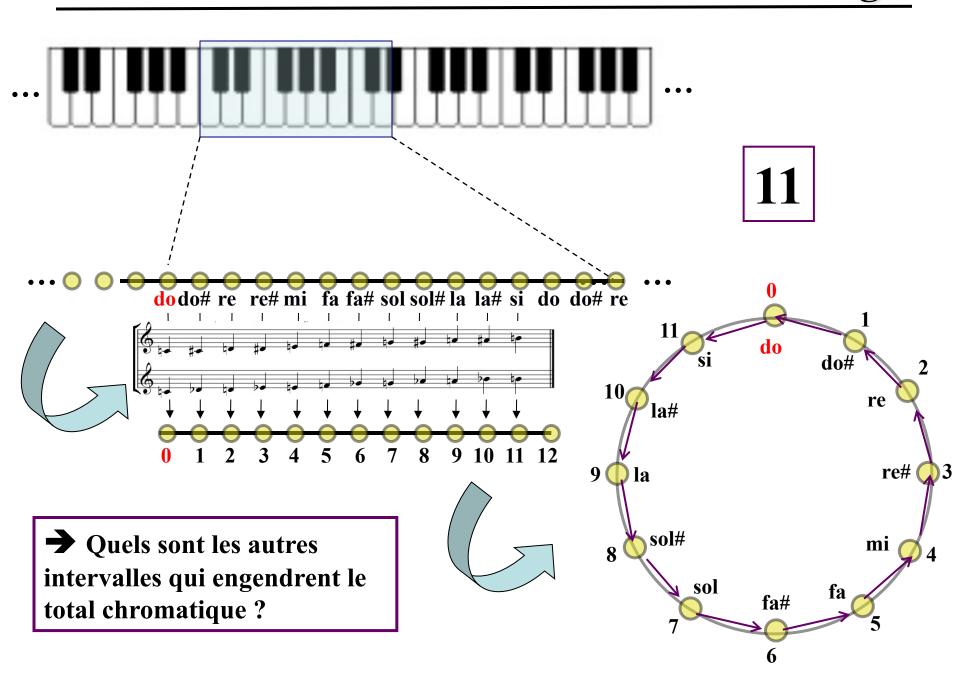
La réduction à l'octave et le cadran d'horloge



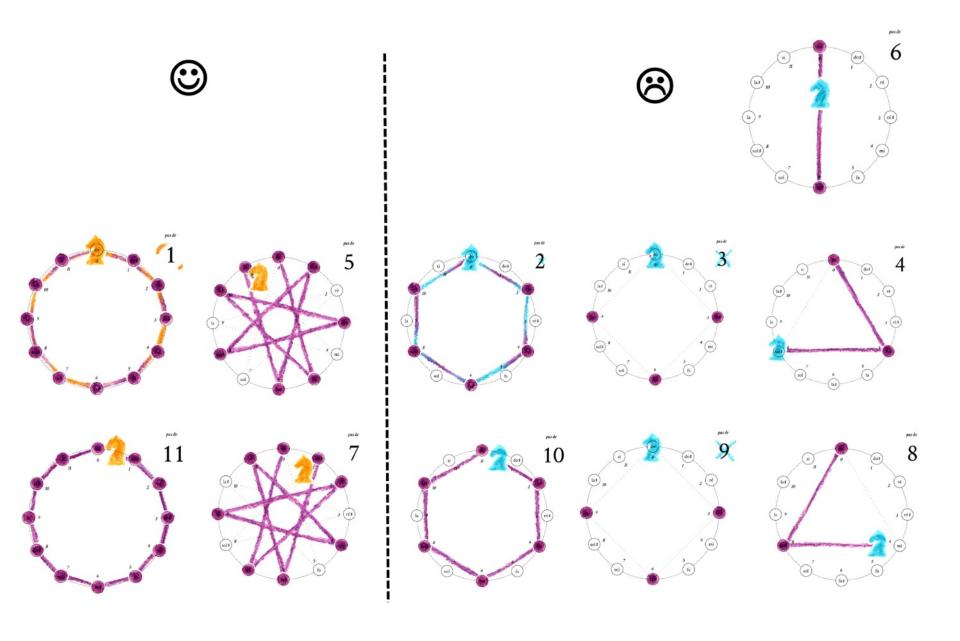
La réduction à l'octave et le cadran d'horloge



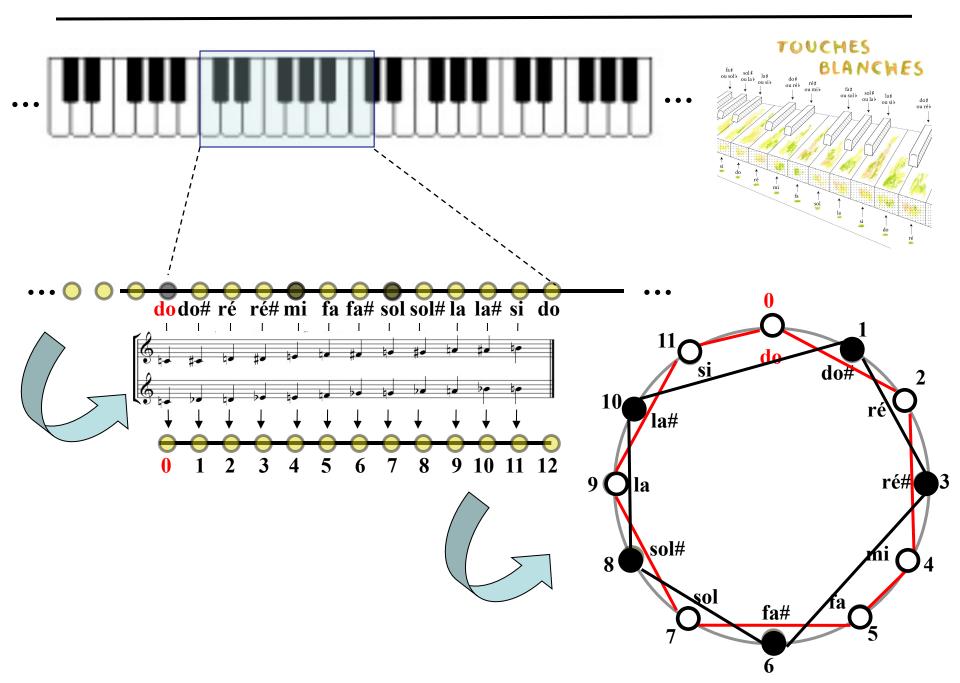
La réduction à l'octave et le cadran d'horloge



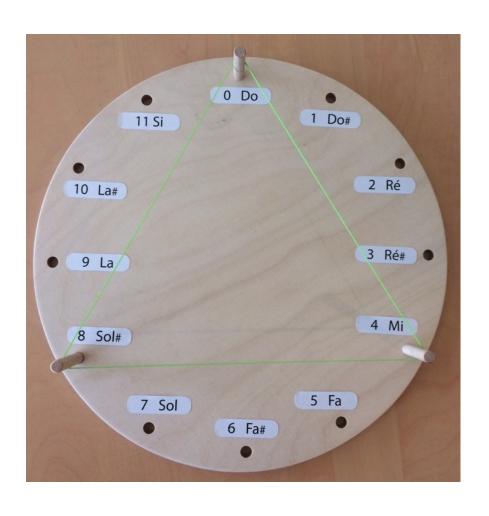
Intervalles générateurs du tempérament égal

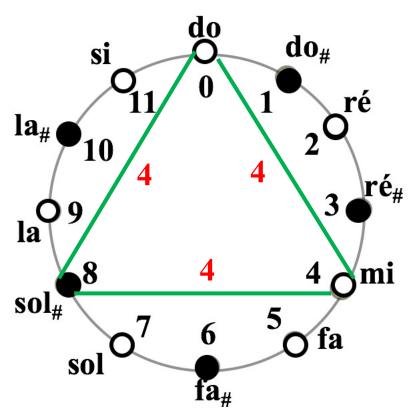


Les touches blanches et les touches noires...

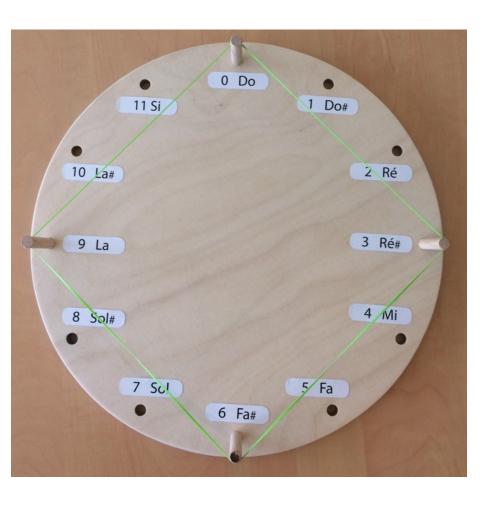


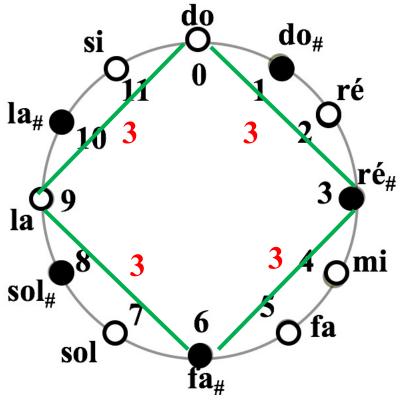
Le triangle équilatéral = l'accord augmenté ou (4, 4, 4)



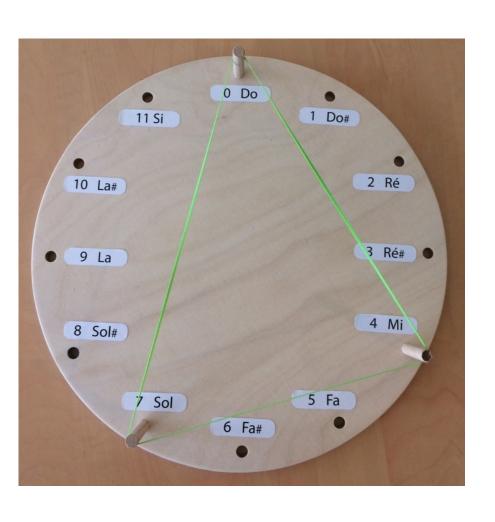


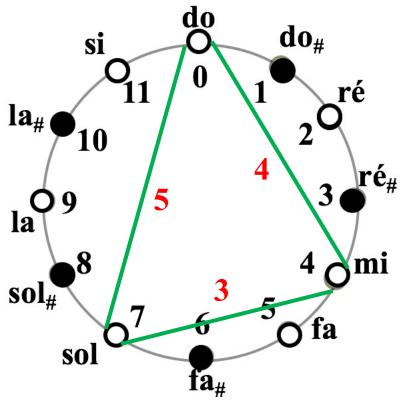
Le carré = l'accord diminué ou (3, 3, 3, 3)



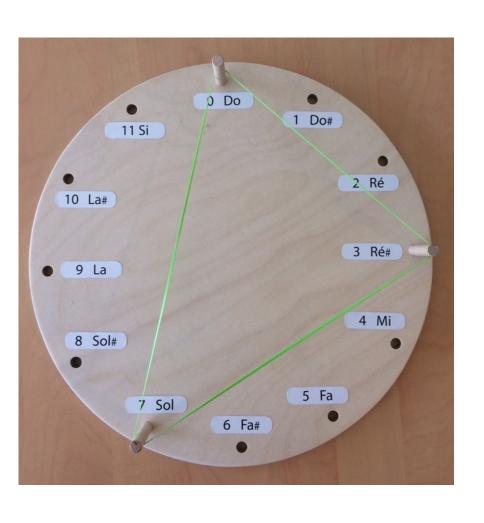


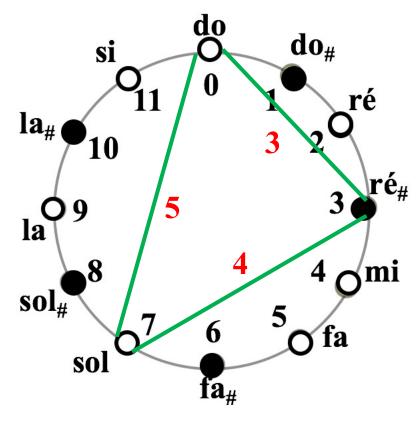
Dessine-moi l'accord majeur ou (4, 3, 5)





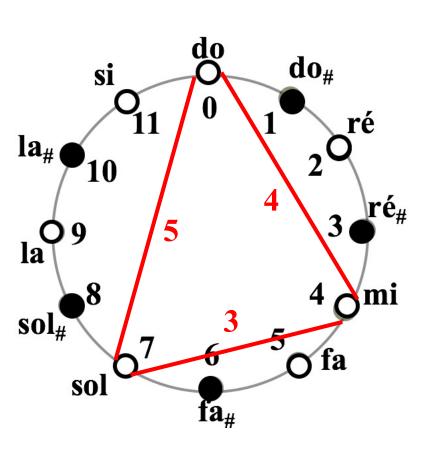
Dessine-moi l'accord mineur ou (3, 4, 5)





Dessine-moi deux accords majeurs



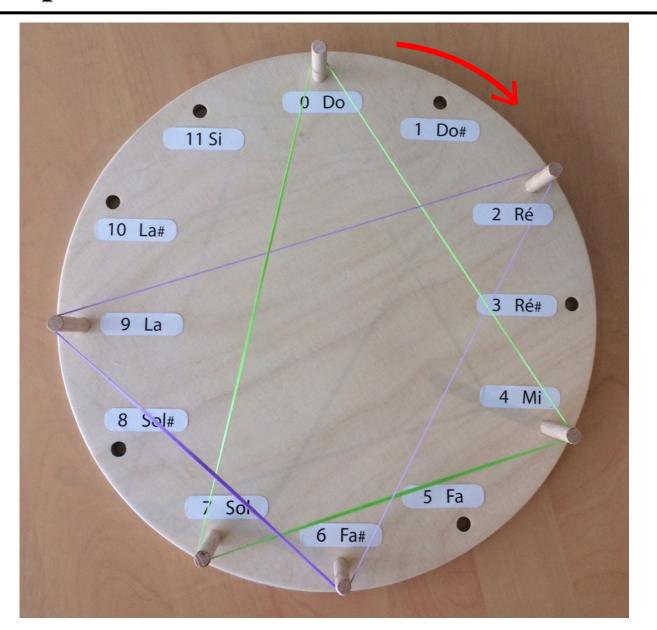


do do# si 0 ré la_# 10 ∖ré# la √mi sol# 6 sol fa#

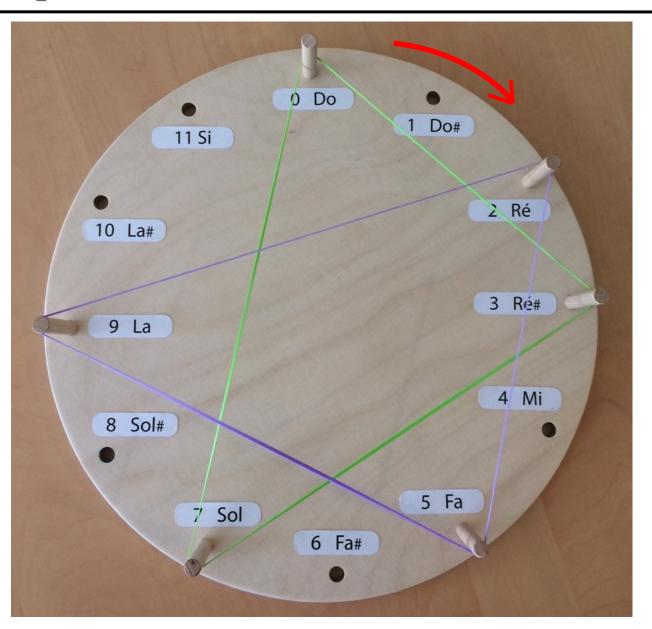
Do majeur

Ré majeur

Quel est le rapport entre deux accords <u>majeurs</u>? On passe de l'un à l'autre via une ROTATION



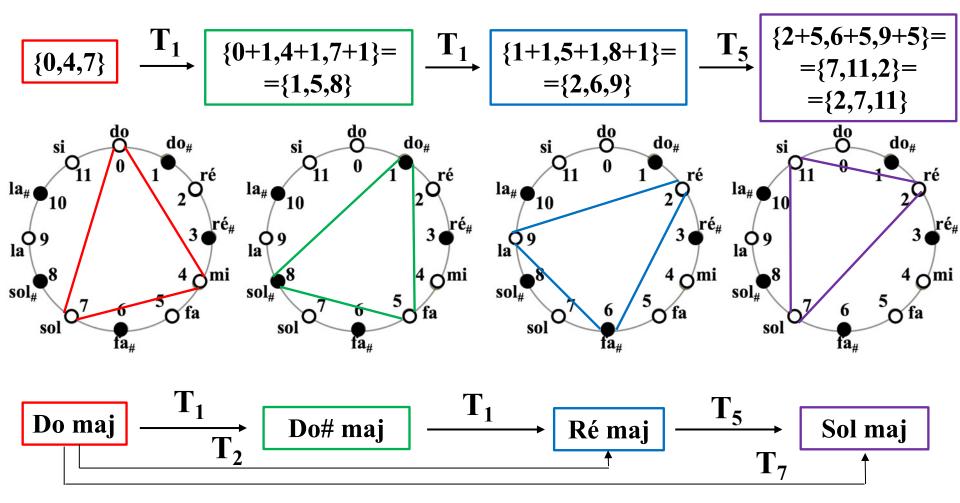
Quel est le rapport entre deux accords <u>mineurs</u>? On passe de l'un à l'autre via une ROTATION



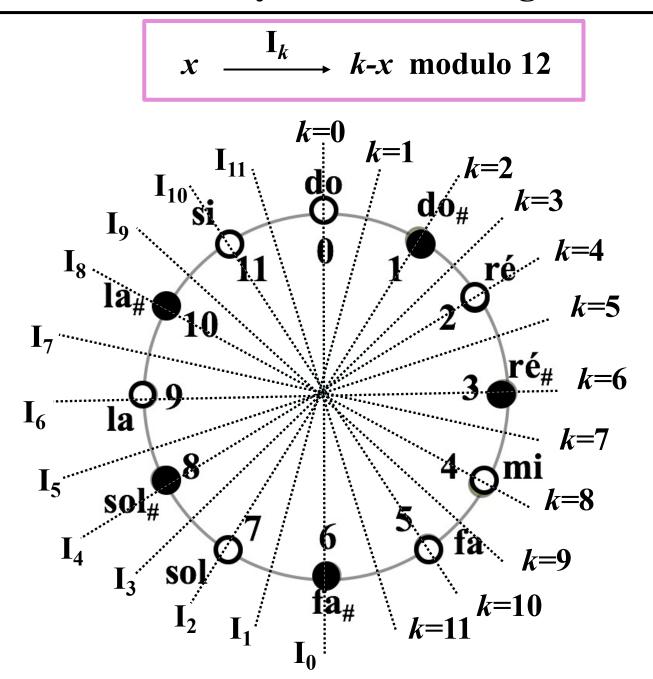
Focus sur les transpositions et les inversions

Les transpositions

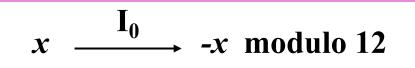
 $T_k: x \longrightarrow x+k \text{ modulo } 12$

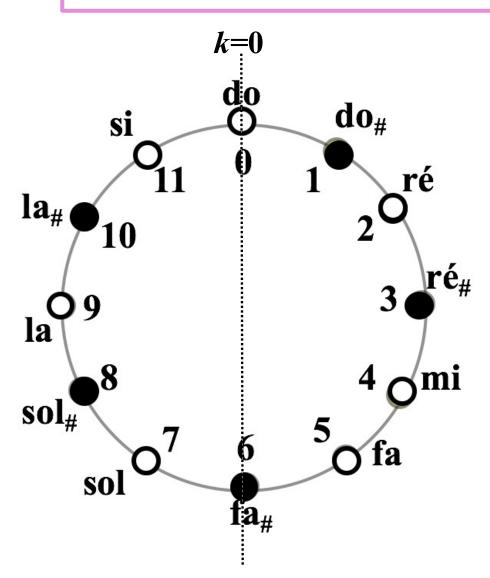


Les inversions sont des symétries axiales généralisées

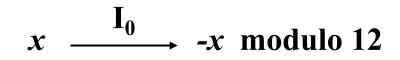


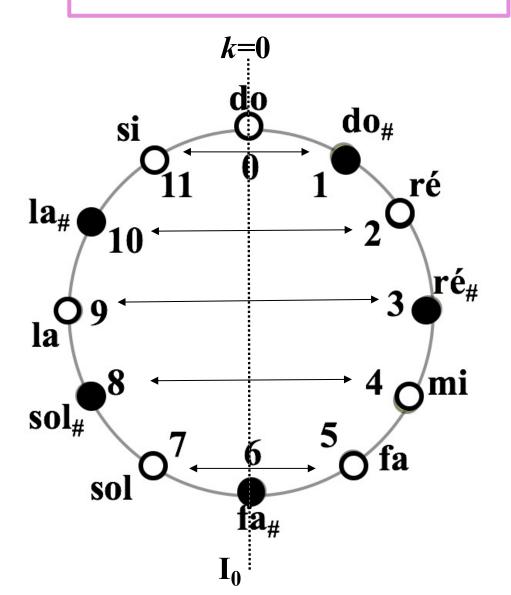
Quelques exemples





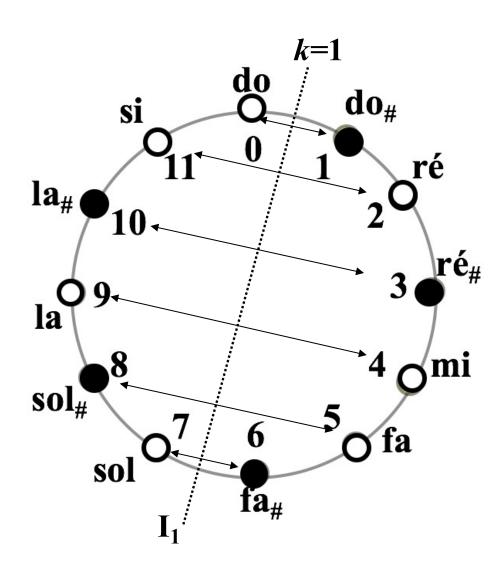
Quelques exemples





Les inversions sont des symétries axiales généralisées

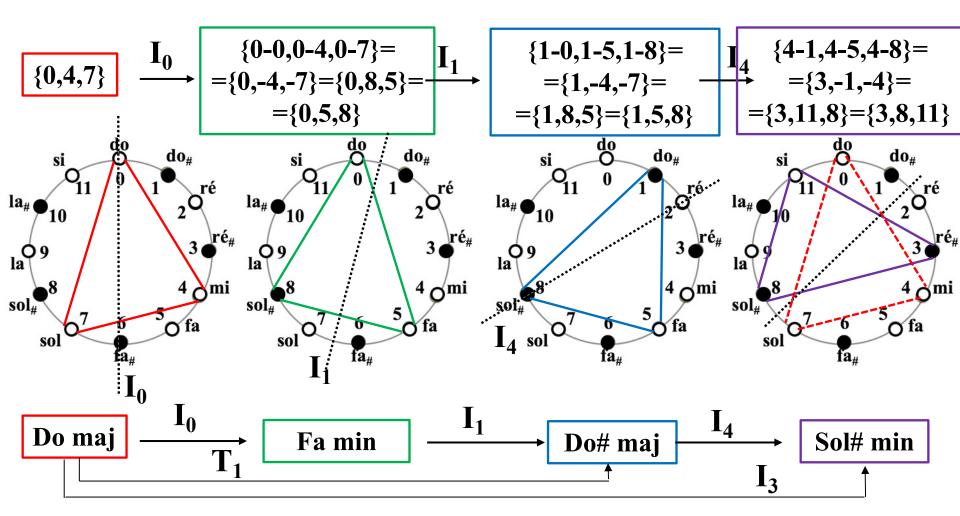
 $x \longrightarrow I_1 \longrightarrow 1-x \mod 12$



Focus sur les transpositions et les inversions

Les inversions (ou symétries axiales)

 $I_k: x \longrightarrow k-x \text{ modulo } 12$



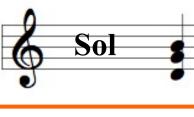




Fa



Fa-



Ré

 $\perp a$

MAGIC IN THE AIR

Feel the magic in the air. Allez, allez, allez

Levez les mains en rair Allez, allez, allez (x2)

(x4 avec toutes les voix)

Ré

Comme d'habitude on est calés

La Si-

Comme toujours ça va aller

Sol Ré

On sème l'ambiance à gogo

La Si-Tous ensemble on fait le show

Sol Ré

On t'invite à la magie Y'a pas de raccourci

La Si-

Oublie tes soucis Viens faire la folie

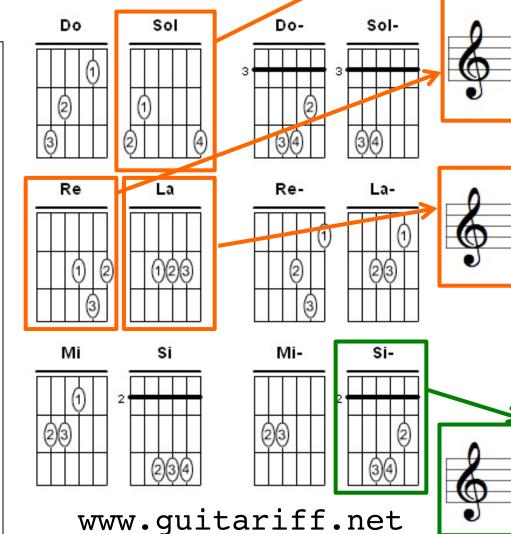
Sol

On t'invite à la magie Y'a pas de raccourci

a S

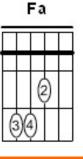
Oublie tes soucis Oh oh oh oh oh oh

Sol





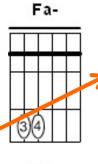
Dο



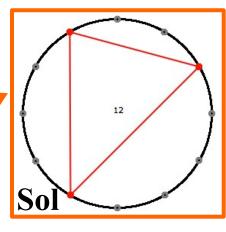
Sol

ACCORDS MINEURS

Do-



Sol-



MAGIC IN THE AIR

Sol Feel the magic in the air, Allez, allez, allez

Si-

Ré

Si-

Levez les mains en l'air Allez, allez, allez (x2)

(x4 avec toutes les voix)

Ré

Comme d'habitude on est calés

La Comme toujours ça va aller

Sol

On sème l'ambiance à gogo

La

Tous ensemble on fait le show

Sol Ré

On t'invite à la magie Y'a pas de raccourci

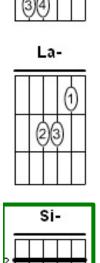
Oublie tes soucis Viens faire la folie

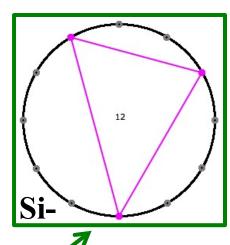
On t'invite à la magie Y'a pas de raccourci

Oublie tes soucis Oh oh oh oh oh oh

Sol

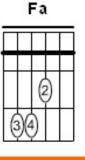








Dο



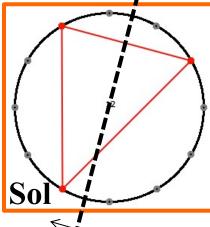
Sol

ACCORDS MINEURS

Do-



Sol-



MAGIC IN THE AIR

Feel the magic in the air, Allez, allez, allez

La Si
Levez les mains en l'air Allez, allez, allez

(x4 avec toutes les voix)

Ré

(x2)

Comme d'habitude on est calés

La

Si-

Comme toujours ça va aller **Sol Ré**

On sème l'ambiance à gogo

La

Tous ensemble on fait le show

Sol Ré

On t'invite à la magie Y'a pas de raccourci

La Si-

Oublie tes soucis Viens faire la folie

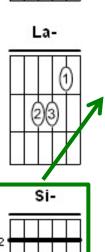
On t'invite à la magie Y'a pas de raccourci

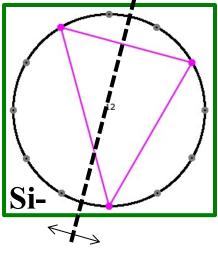
a S

Oublie tes soucis Oh oh oh oh oh oh

Sol

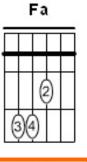








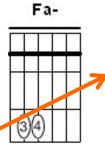
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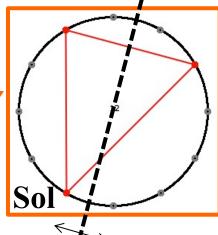
Sol

ACCORDS MINEURS

Do-



Sol-



MAGIC IN THE AIR

Sol Ré Feel the magic in the air, Allez, allez, allez La Levez les mains en l'air Allez, allez, allez

(x2)

(x4 avec toutes les voix)

Ré

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Sol

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Tous ensemble on fait le show

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Oublie tes soucis Viens faire la folie

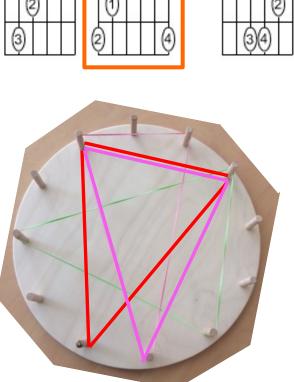
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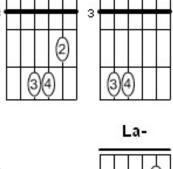
On t'invite à la magie Y'a pas de raccourci

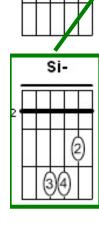
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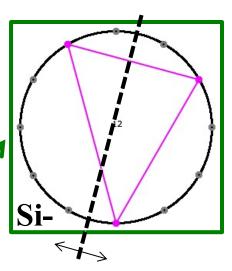
Oublie tes soucis Oh oh oh oh oh oh

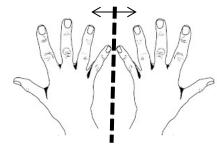
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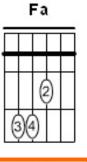








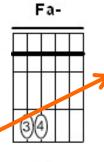
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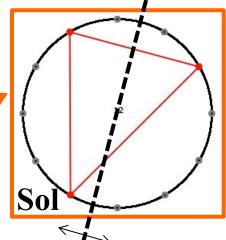
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ACCORDS MINEURS

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Sol-



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(x4 avec toutes les voix)

Ré

(x2)

Comme d'habitude on est calés

La

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Comme toujours ça va aller Sol

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Sol

Ré On t'invite à la magie Y'a pas de raccourci

Oublie tes soucis Viens faire la folie

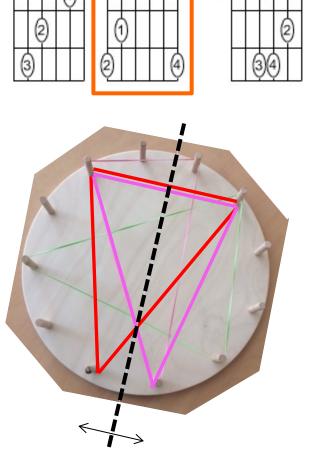
Sol

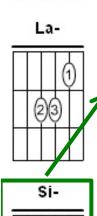
On t'invite à la magie Y'a pas de raccourci

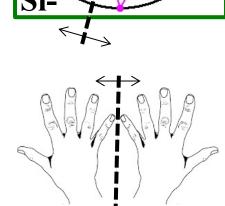
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Oublie tes soucis Oh oh oh oh oh oh

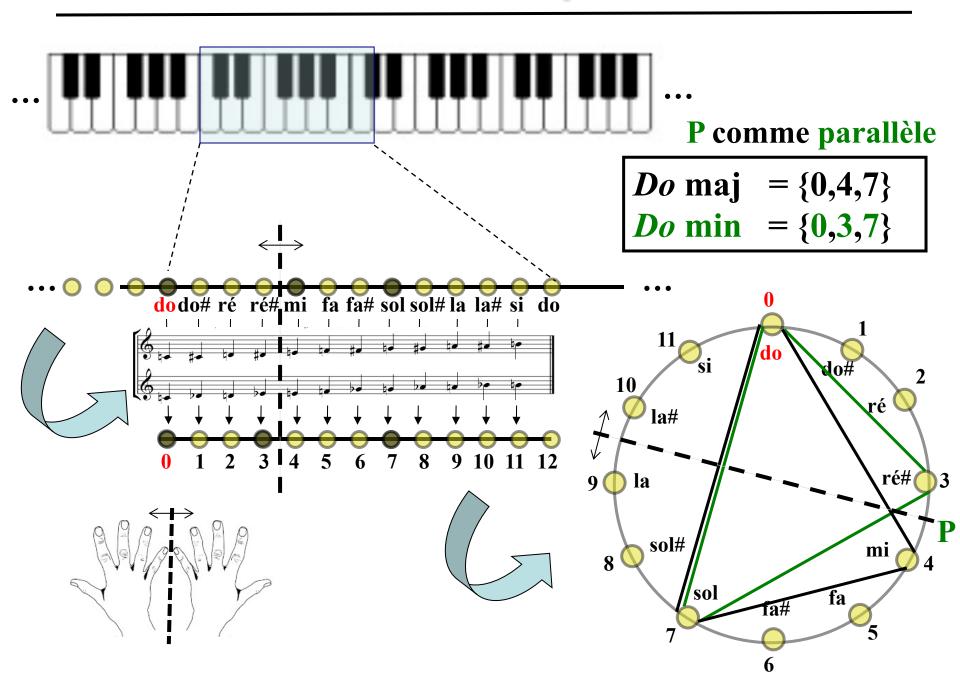
Sol



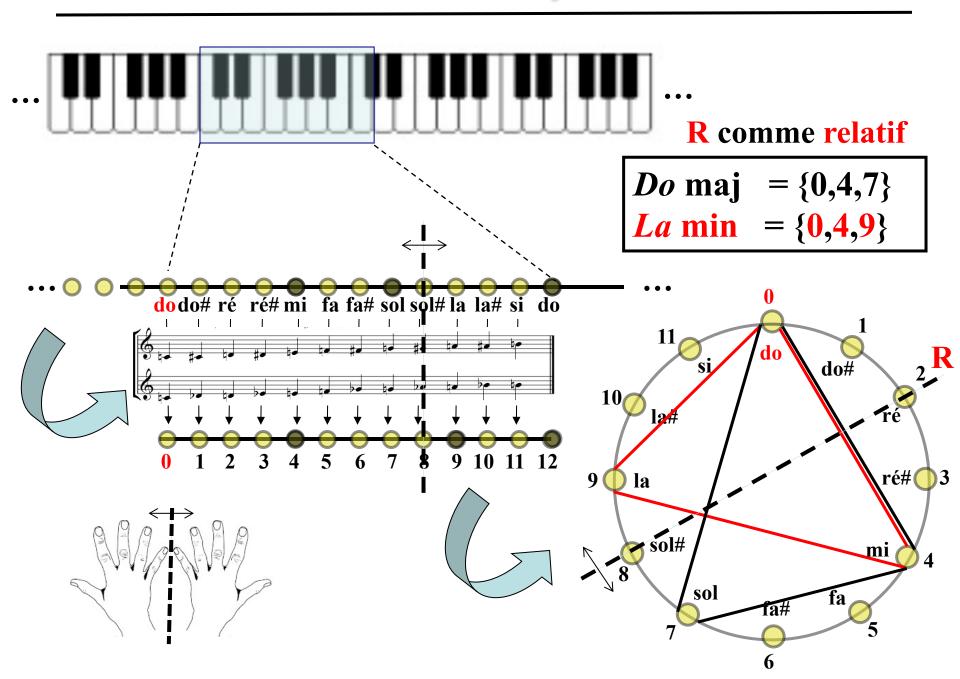




Les inversions sont des symétries axiales



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