

Tonality: Why and How



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Nadia Boulanger and Émile Naoumoff



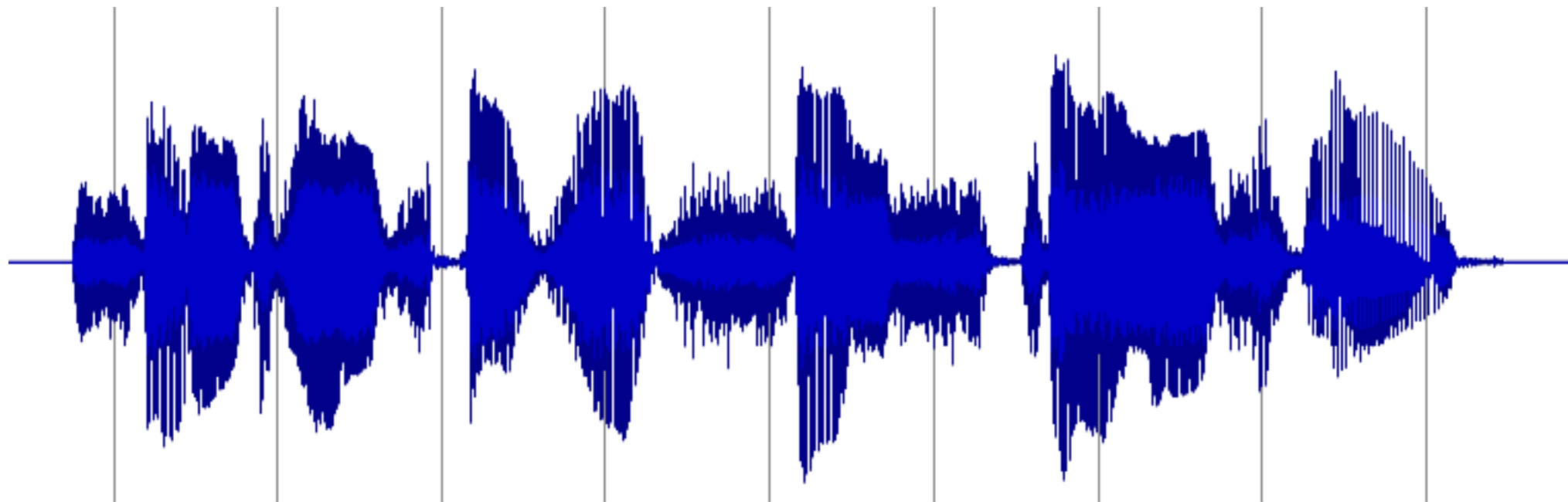
(1977)

Diana Deutsch

Music psychologist
from UC San Diego



*"The sounds as they appear to you
Are not only different
from those that are really present
But they **sometimes behave so strangely**
As to seem quite impossible"*

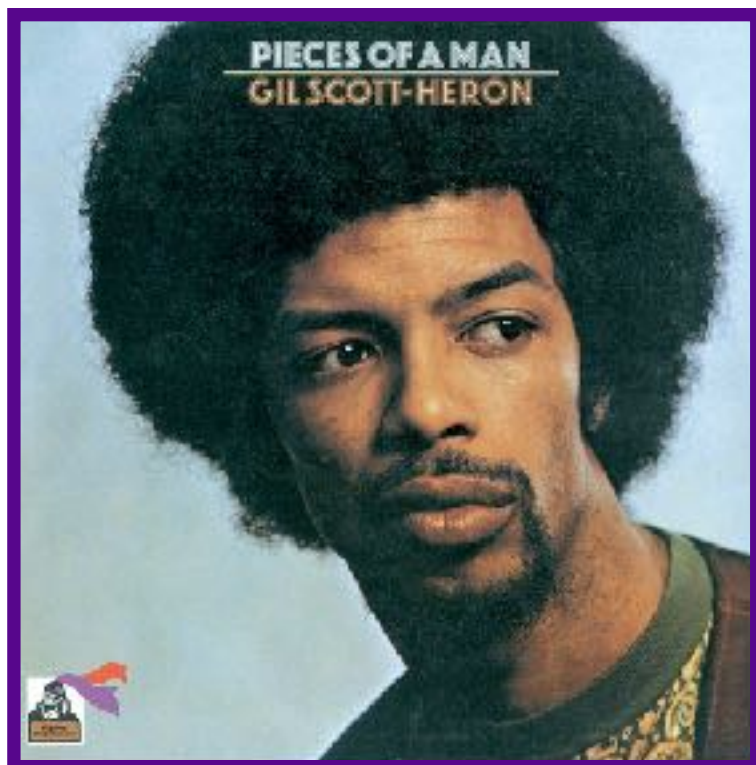
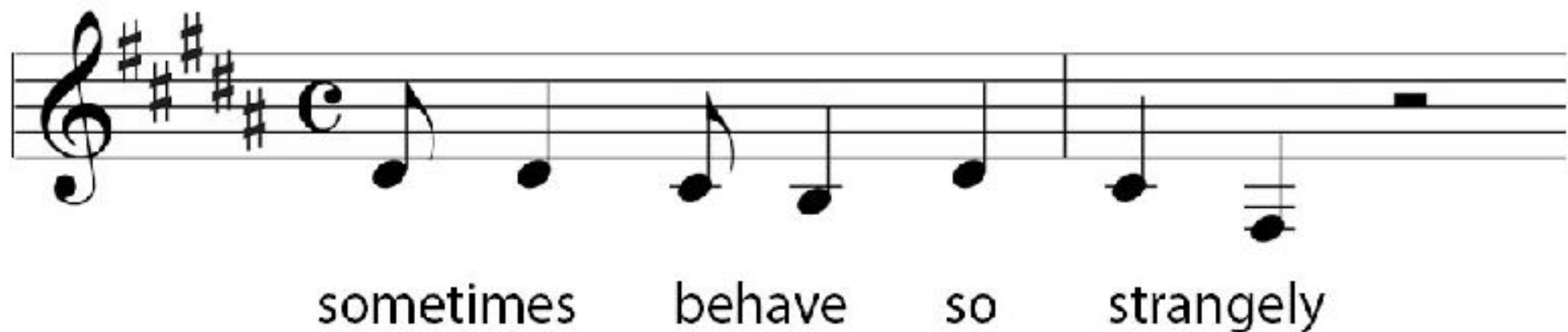


Speech-to-song illusion

Repeating a speech fragment:

“sometimes behave so strangely”

produces a song.

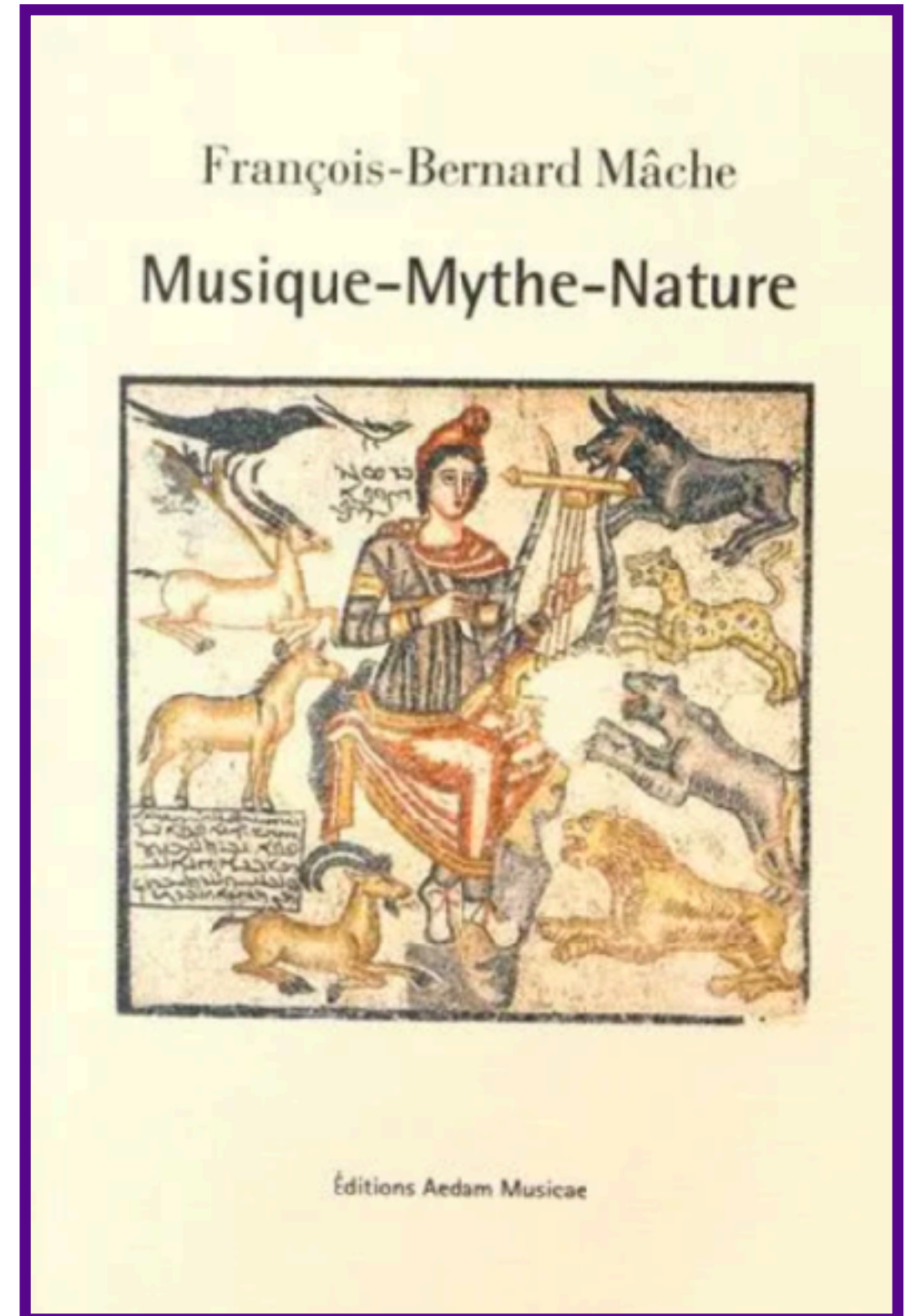
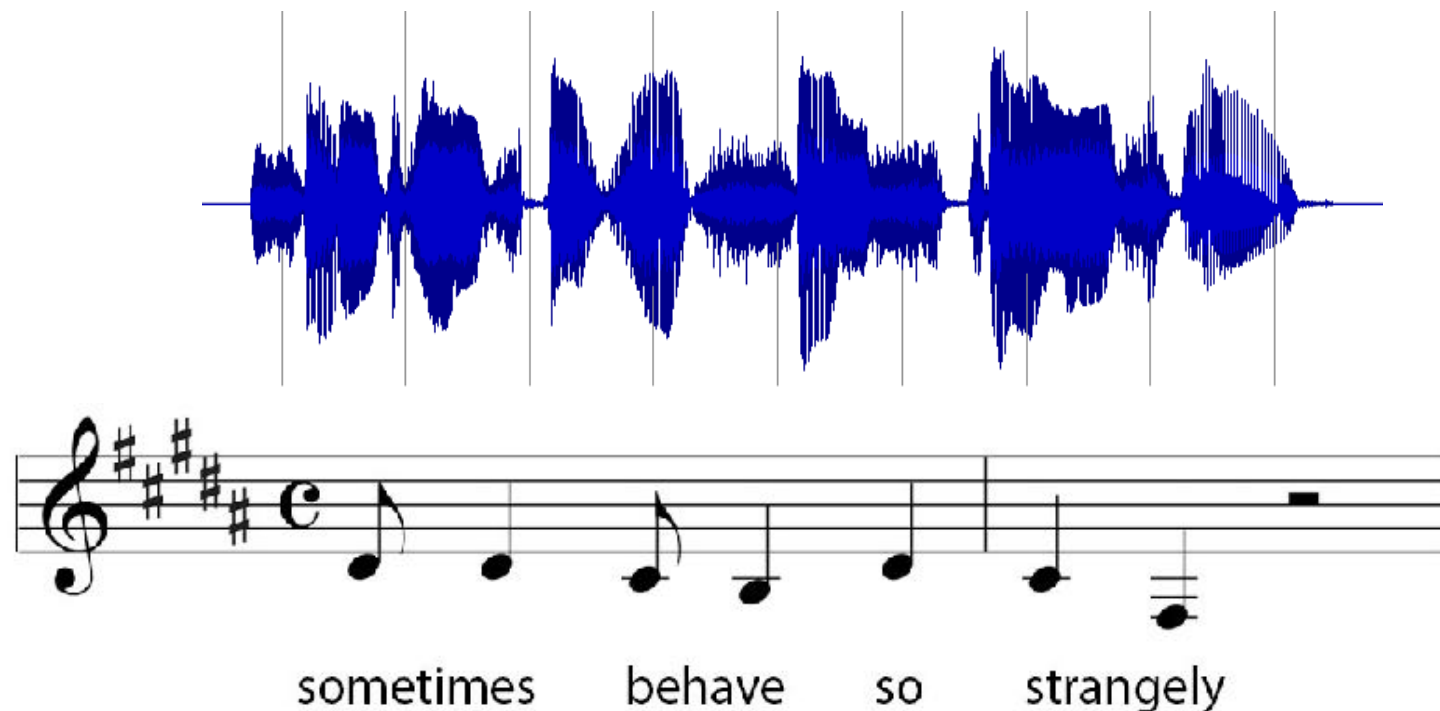


- ➡ Musicality depends on **context**
- ➡ Example: *spoken word* music

Music, Myth, Nature

Ethnomusicologist F.B. Mâche
proposed a list of “universals”:

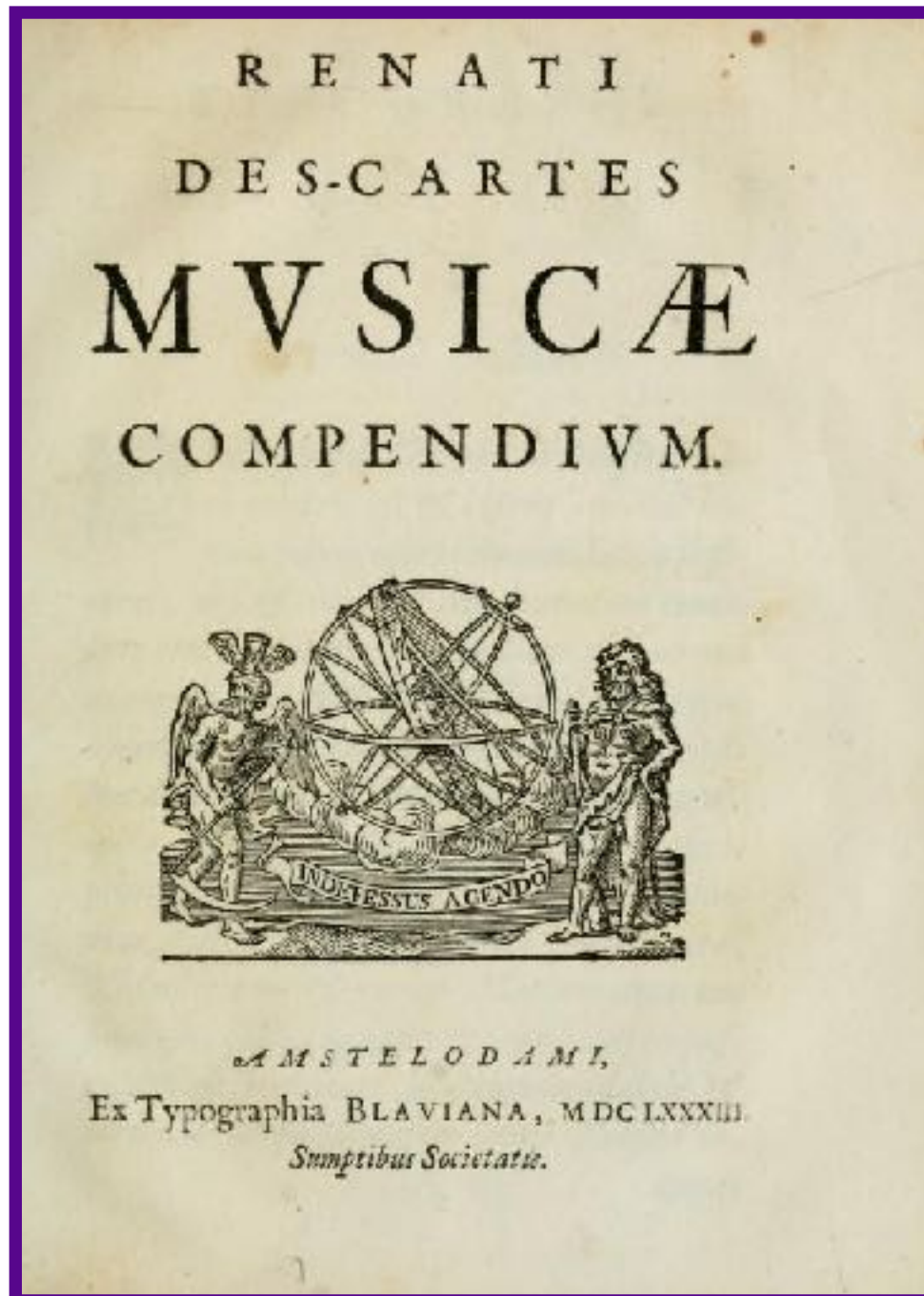
1. Repetition
2. Pitch quantization
3. Question-answer structures



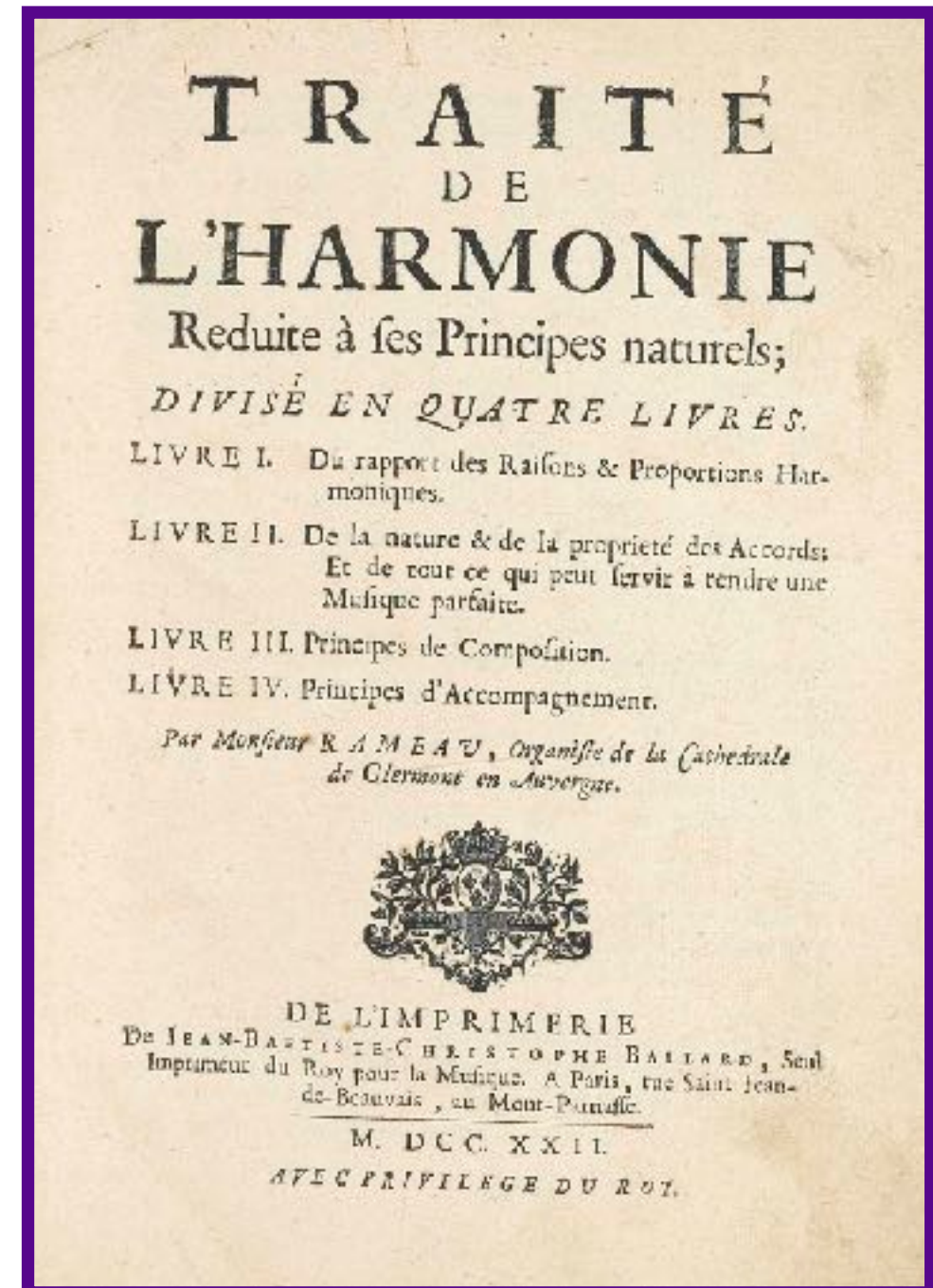
Natural principles?

Treatises have long searched for a “natural” theory of music ...

René Descartes, 1683



Jean-Philippe Rameau, 1722

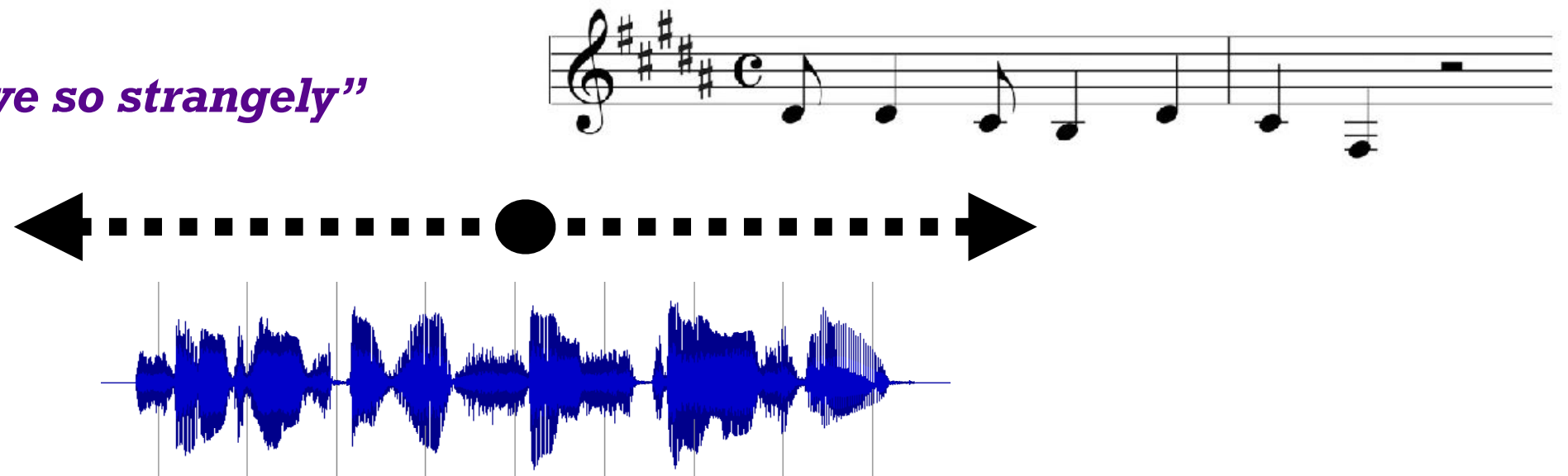


Unity and diversity of musical forms

The current scientific consensus is that:

- music is primarily a socio-historical construct
- **there is no unifying paradigm** for musical expression
- notions such as “consonance” are partly cultural

“sometimes behave so strangely”



Thus, the role of “universals” is not to exclude genres but to understand statistical patterns in subjective responses.

Musical notation

Music is the only form of art which has an **autonomous notation system.**



Musical notation

Music is the only form of art which has an **autonomous notation system**.



Not just the European *sofège*! There are other systems in Korea, India, Russia, China, Indonesia, Middle East, etc.

वसंत-त्रिताल (मध्य लय)

स्थायी

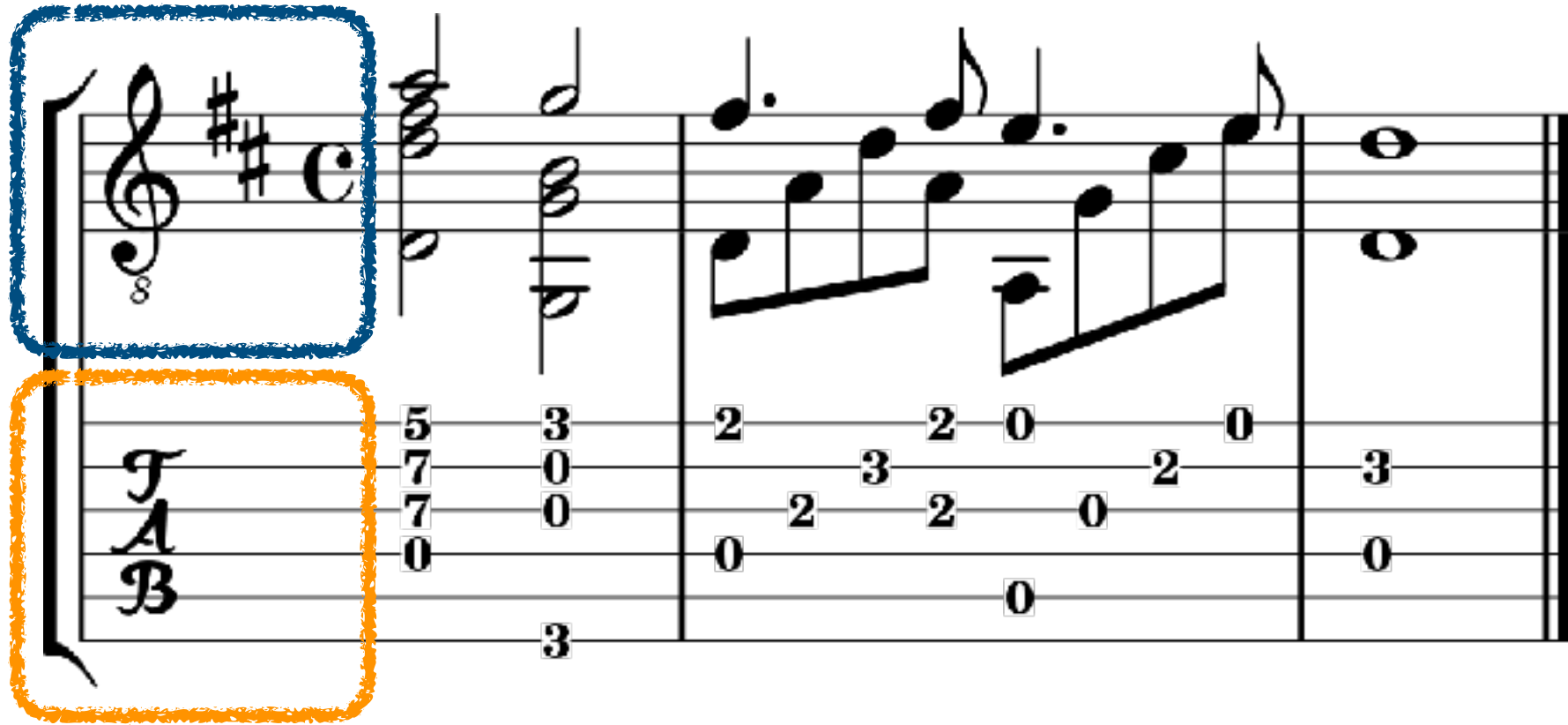
नि	ग	सा	सा	म	म	—	म	नि	ध्रु	नि	सां	नि	ध्रु	प	(प)	मंग	म	ग
८	तु	ब	सं	५	त	ब	न	कू	५	ल	र	ही	५५	५५	०	५	५	५
३				×				२				०						
ग				ग				ग				ग			ग	रु	—	सा
म	—	म	म	म	म	नि	नि	म	ग	—	म	ग	रु	—	सा			
सा	५	द	त	अ	ति	म	न	ह	र	५	कू	ल	बा	५	रि			
३				×				२				०						

for Indian classical music,
cf. YouTube channel
of Anuja Kamat

Notating pitch vs. notating gesture

Globally, there are two types of notation systems:

solmization



tablature

Solmization depends upon a choice of **key**.

Tablature depends upon a choice of **tuning**.

What is the shared property of all systems?

در مفصّلات

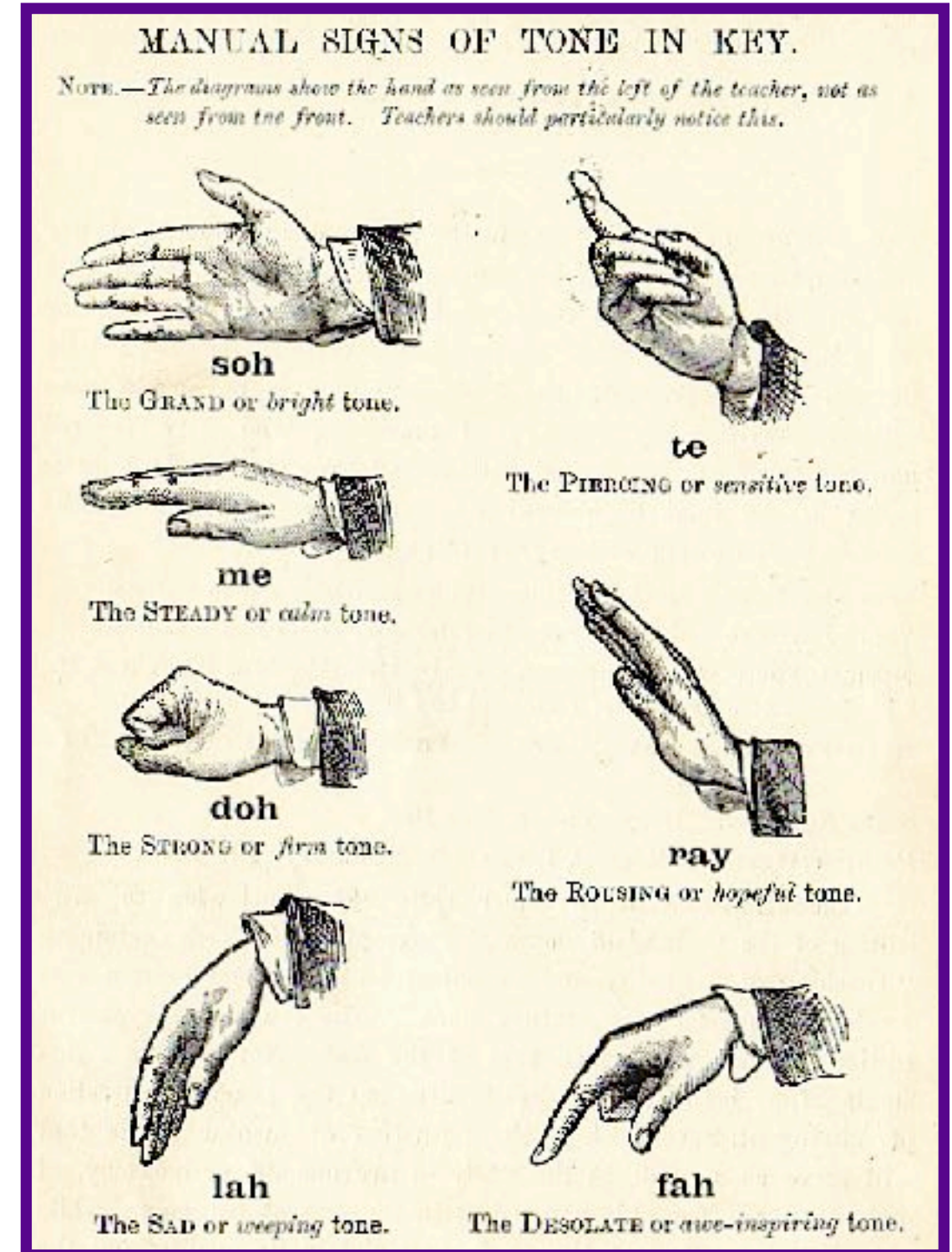
do re mi fa sol la si

ji ro lu pat ma nem pi

i ro ha ni ho he to

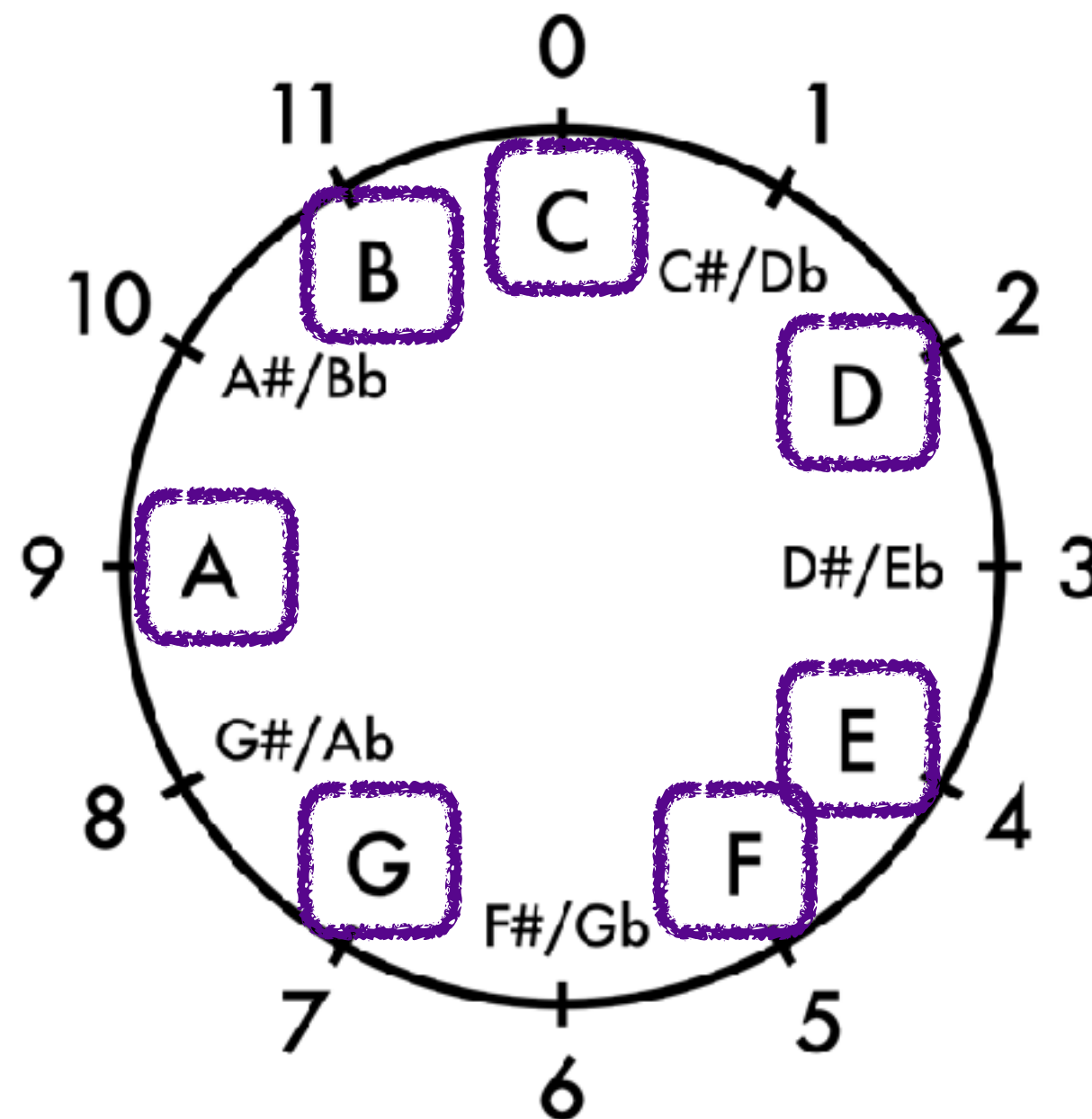
सारे गामपधनि

上
尺
工
凡
六
五
乙



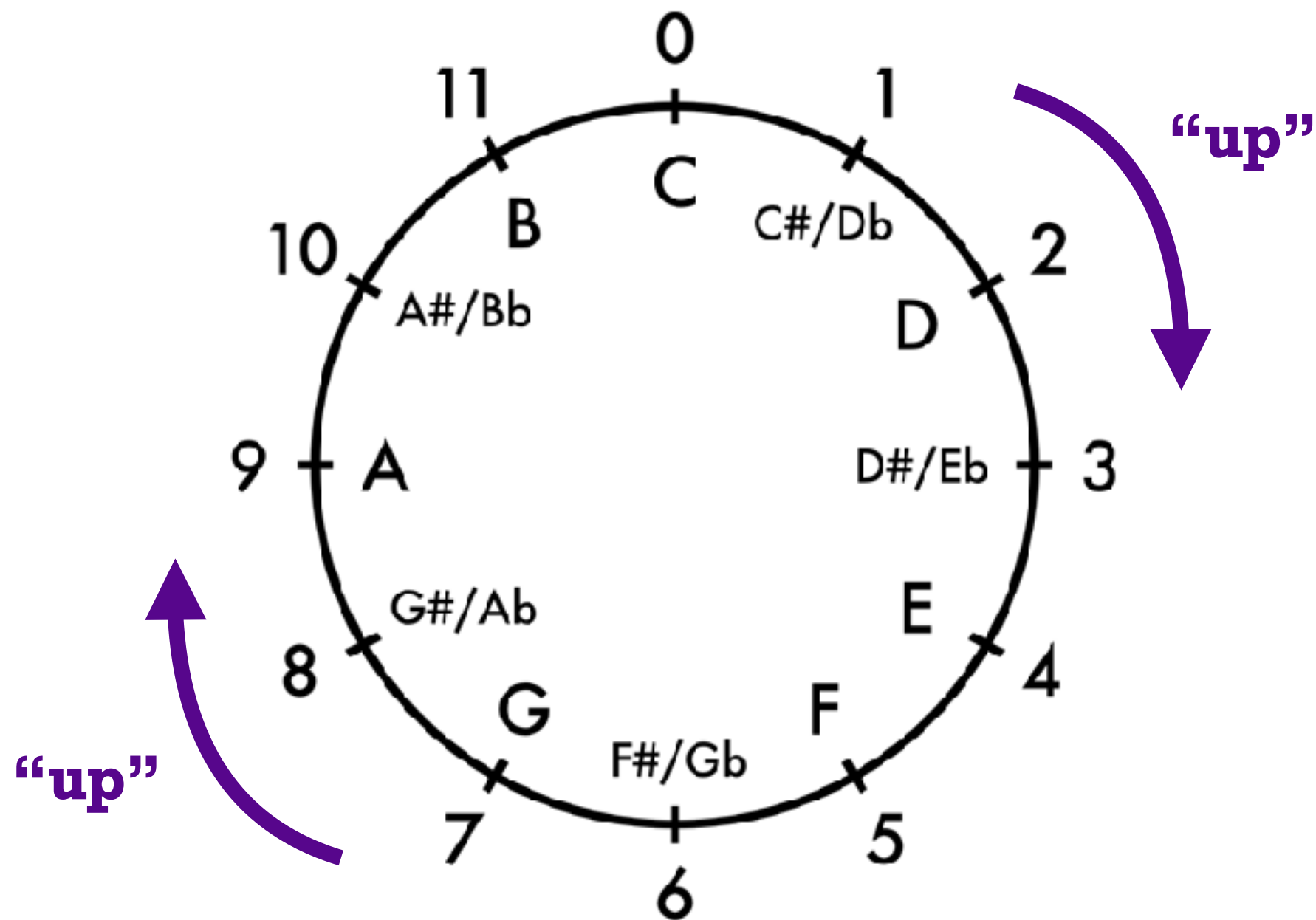
Octave equivalence

The mental representation of musical intervals:
not segments of a line but **angles in a circle!**



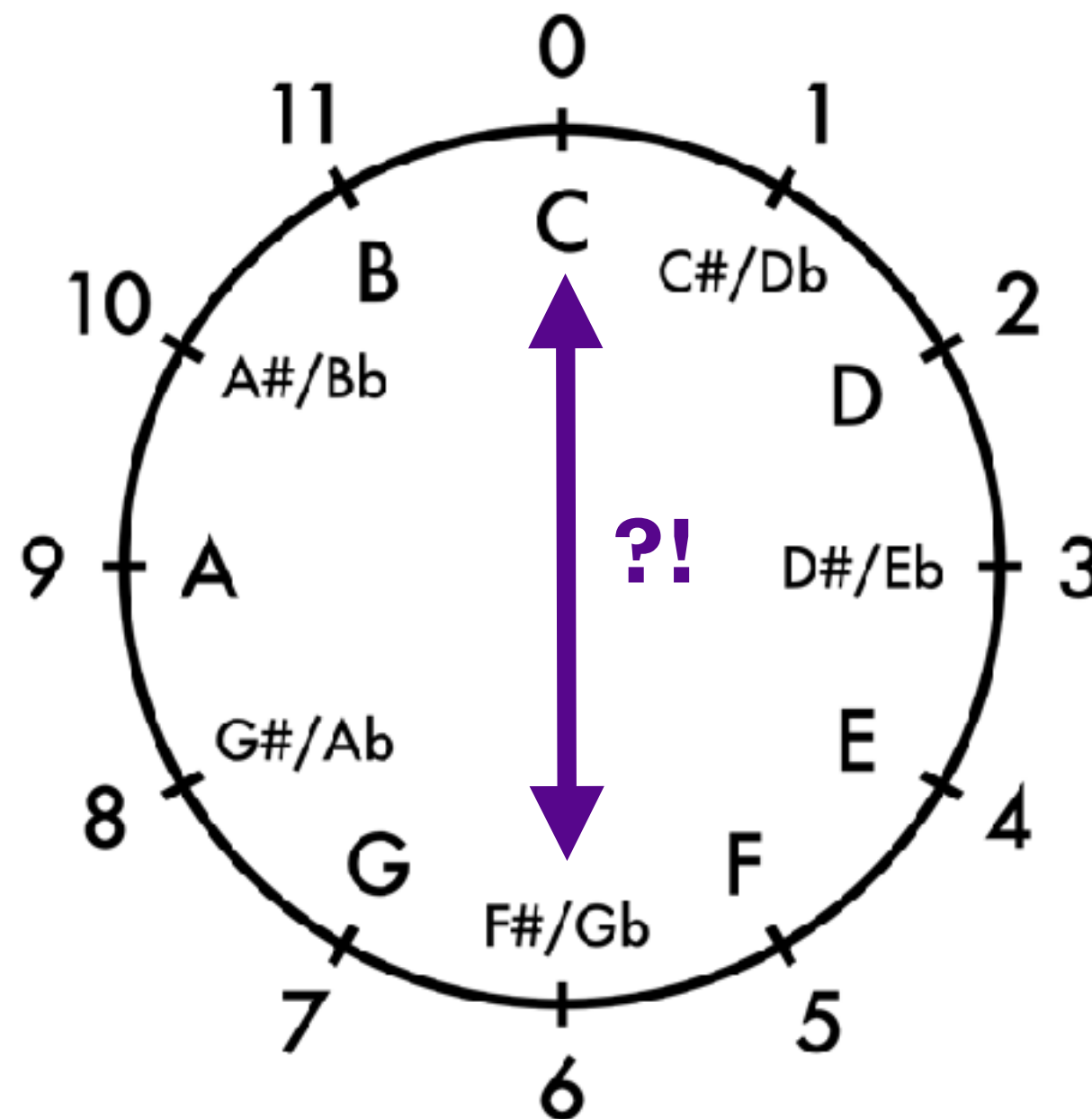
Implications of octave equivalence

Implication #1: we can **revolve endlessly**

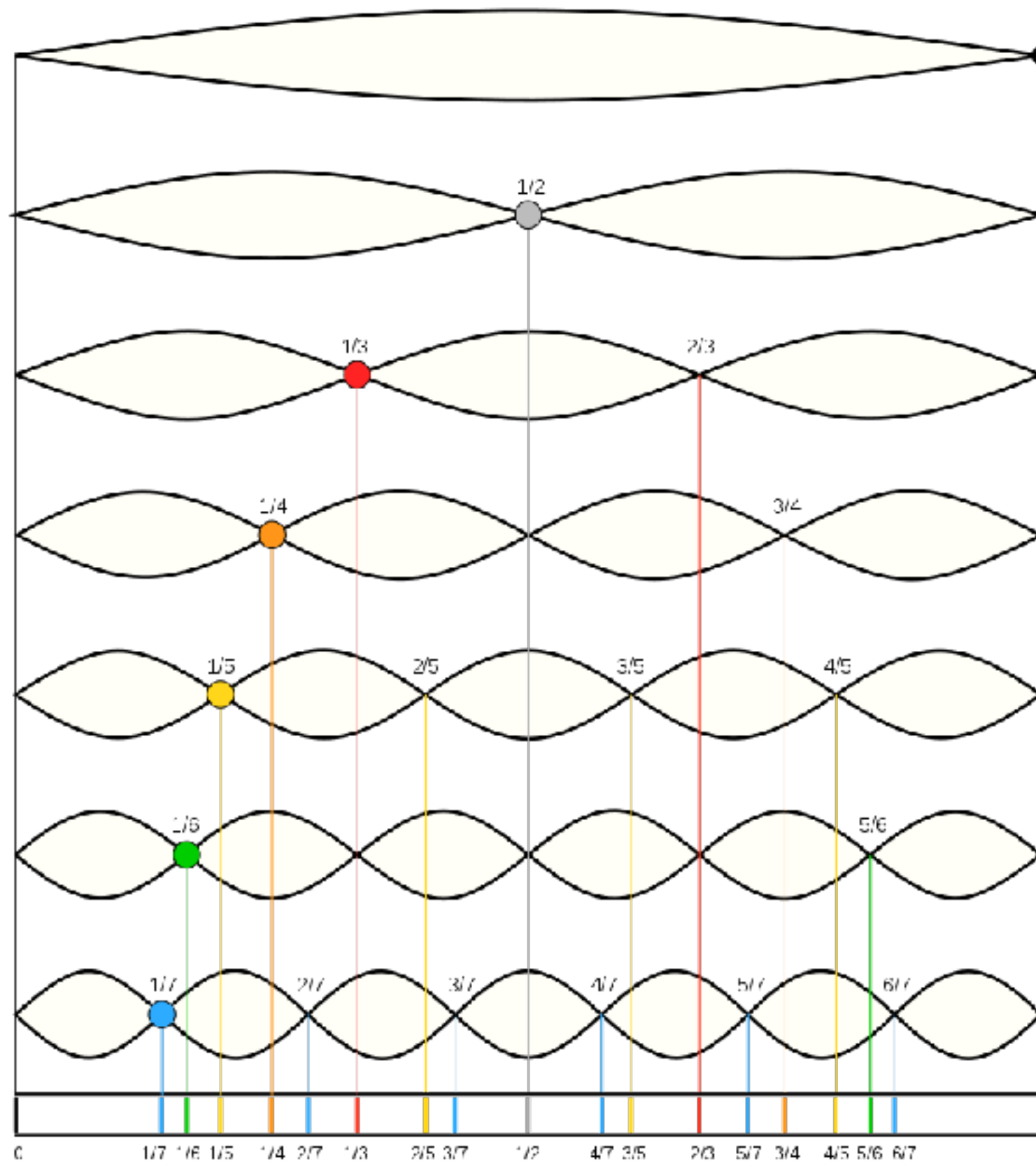


Implications of octave equivalence

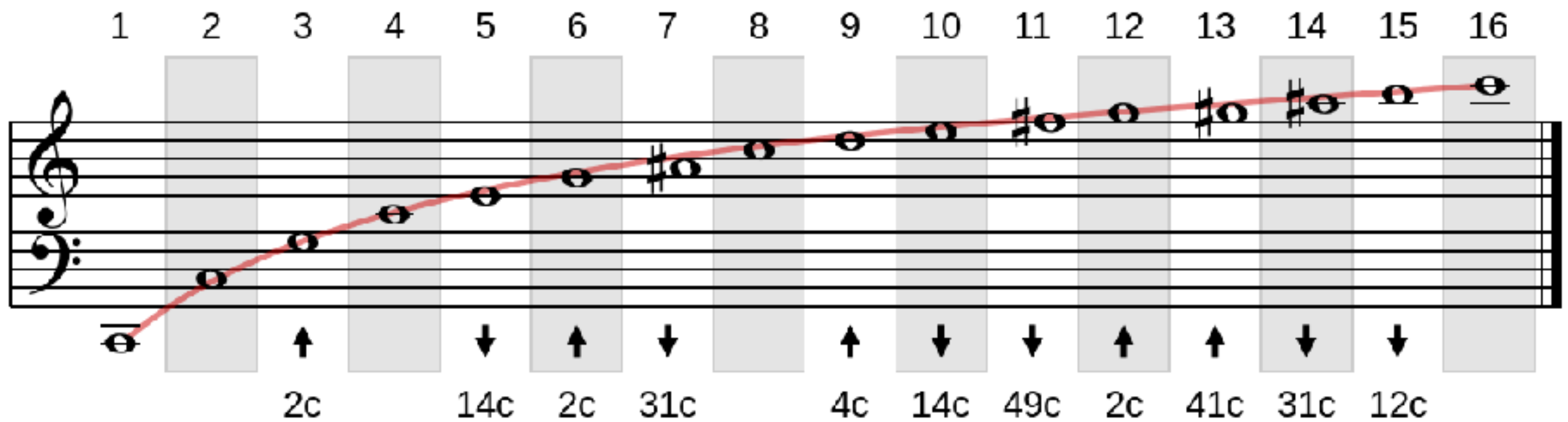
Implication #2: the half-octave (tritone) is a **flat** angle



The Fourier series has a fractal structure

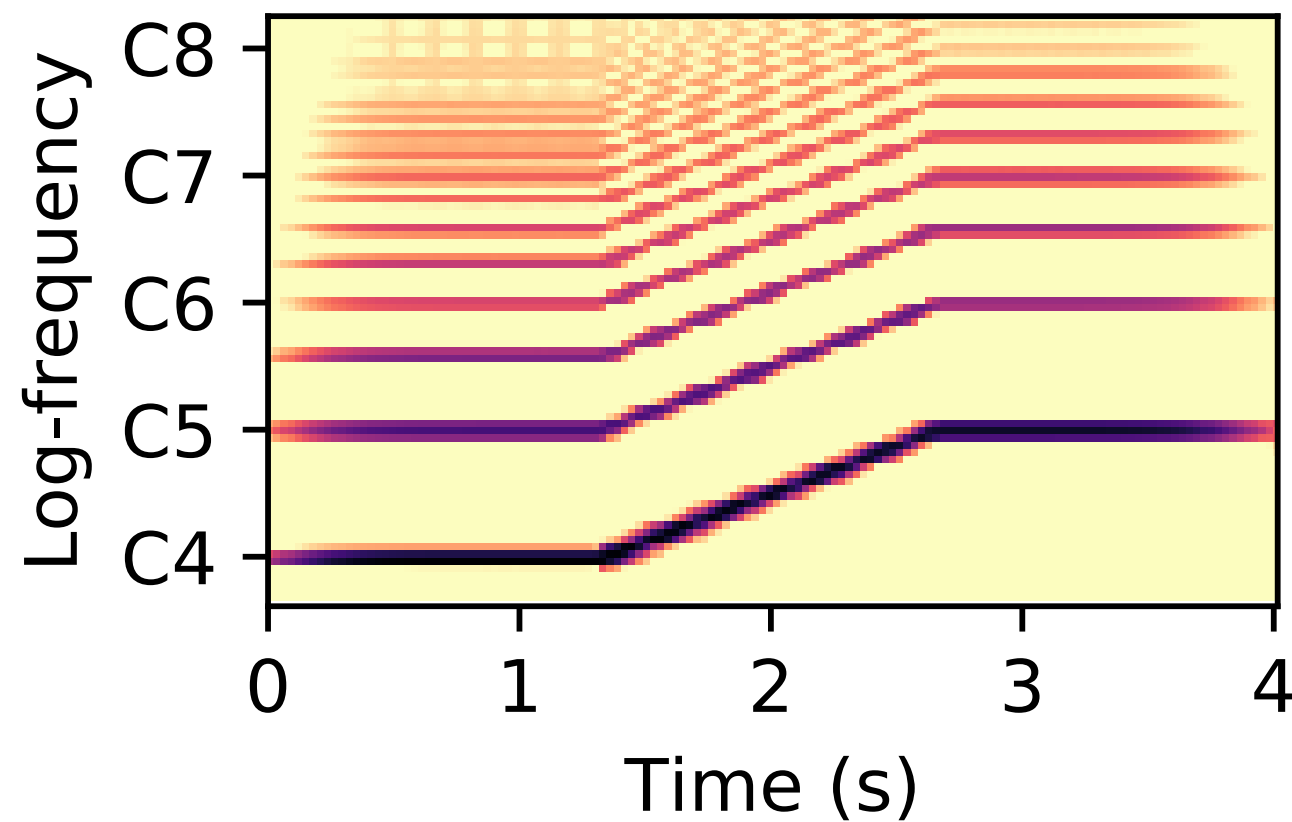


Solmization of Fourier overtones

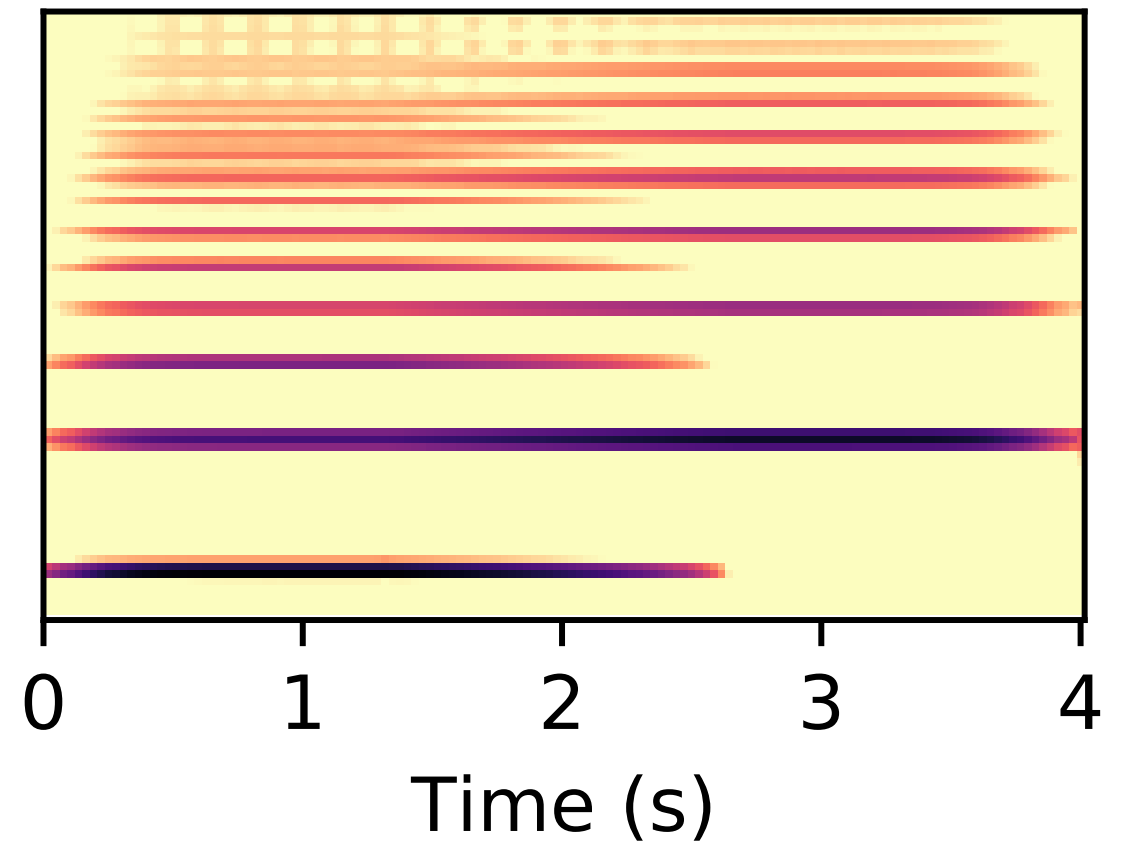


Two continuous paths from C4 to C5

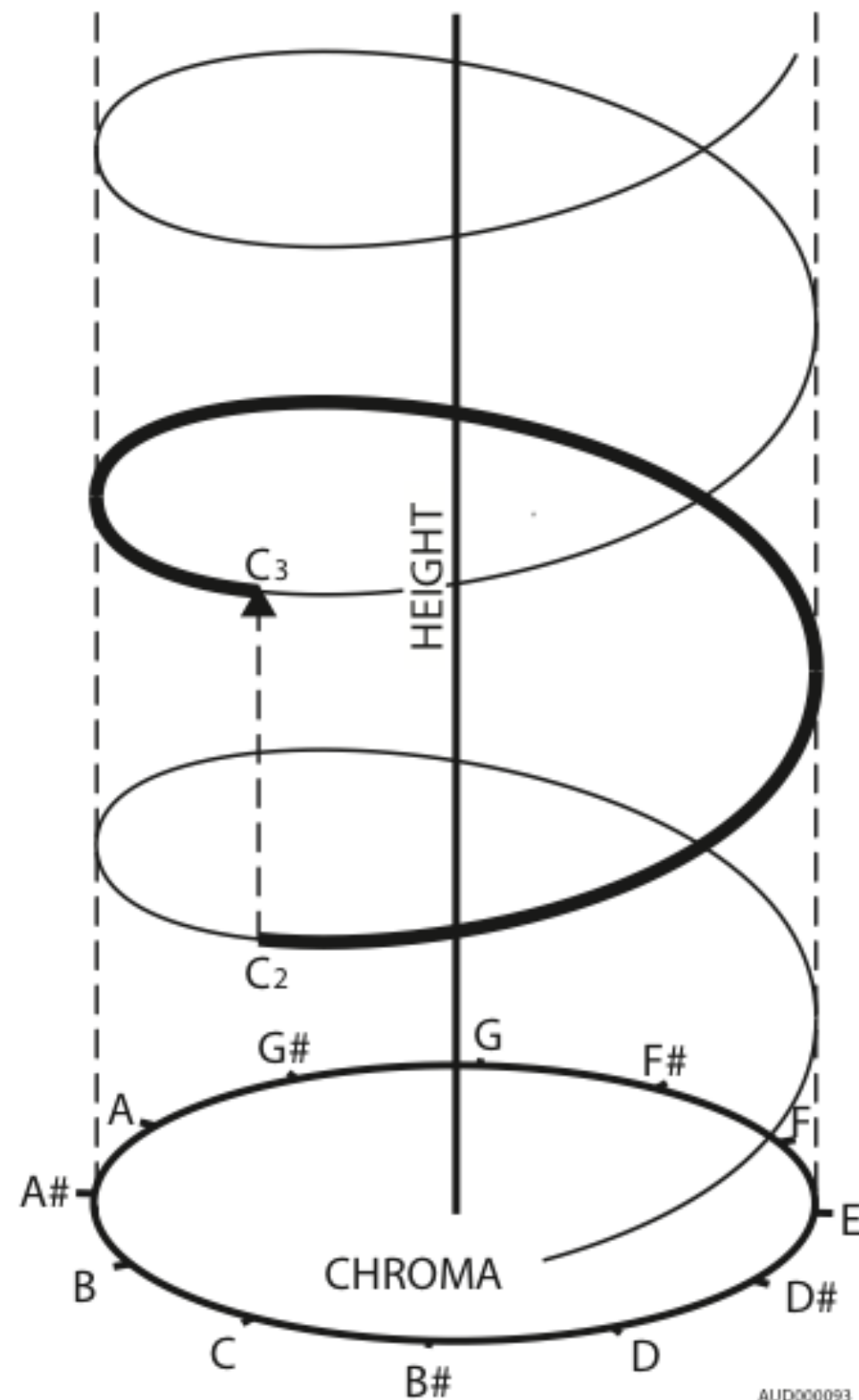
glissando



**cancellation of
odd-numbered partials**



The helix topology of musical pitch

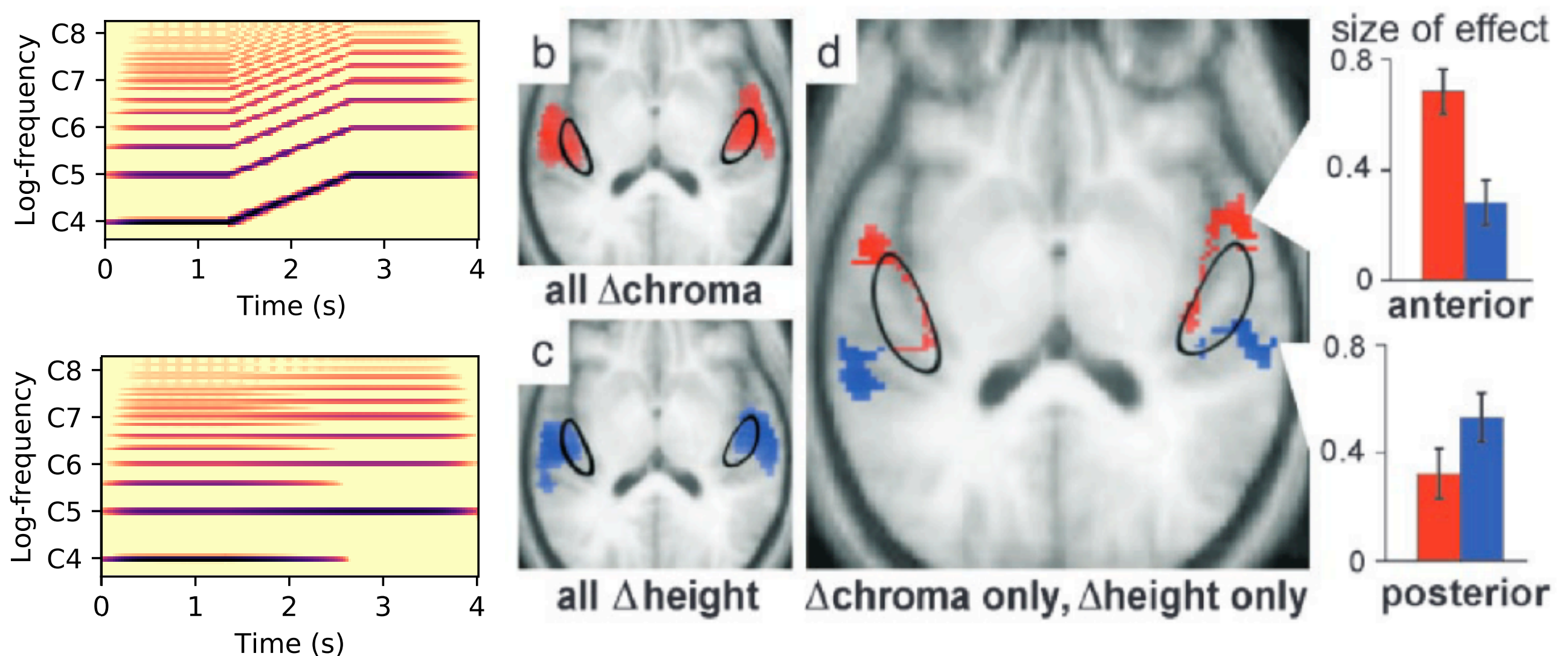


Separating pitch chroma and pitch height in the human brain

J. D. Warren^{*†}, S. Uppenkamp[‡], R. D. Patterson[‡], and T. D. Griffiths^{*††}

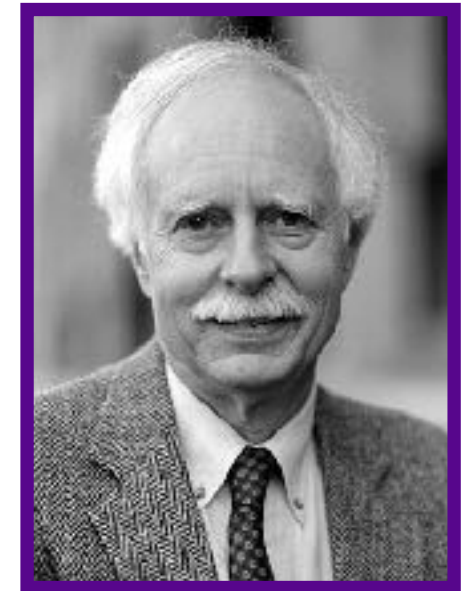
Proceedings of the National Academy of Sciences (2017)

The two stimuli activate different regions of the central auditory cortex.

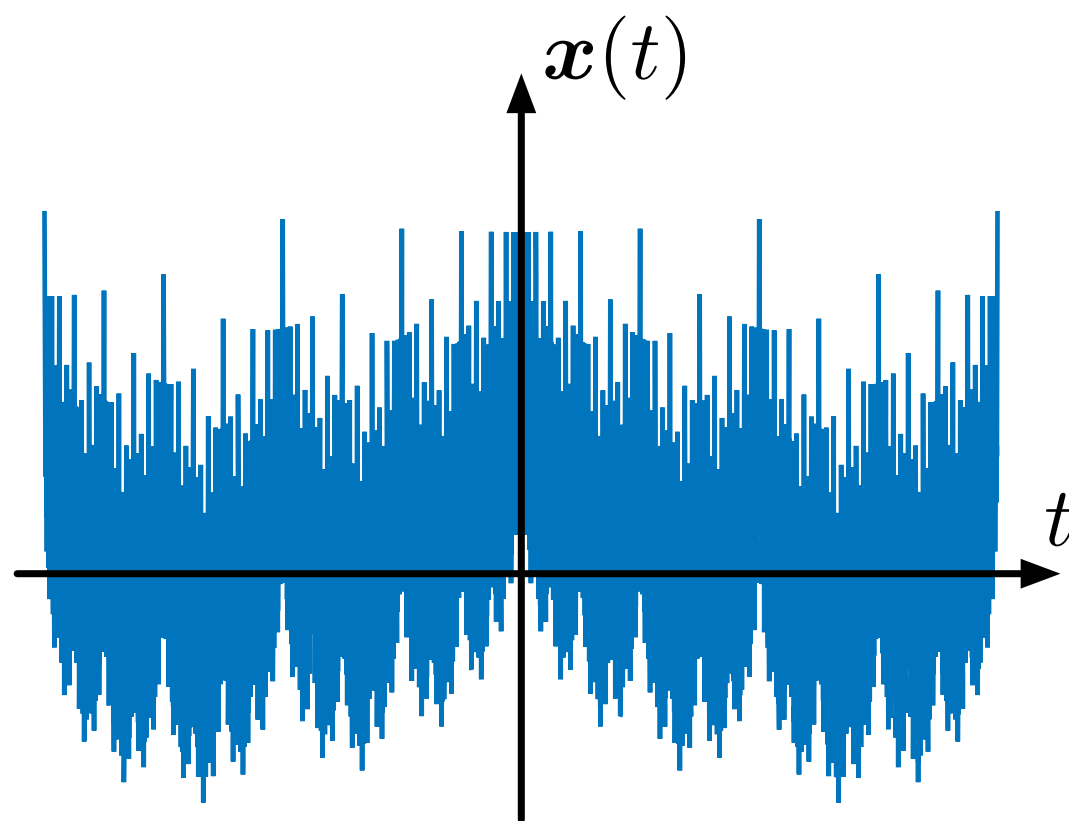


Shepard Tone

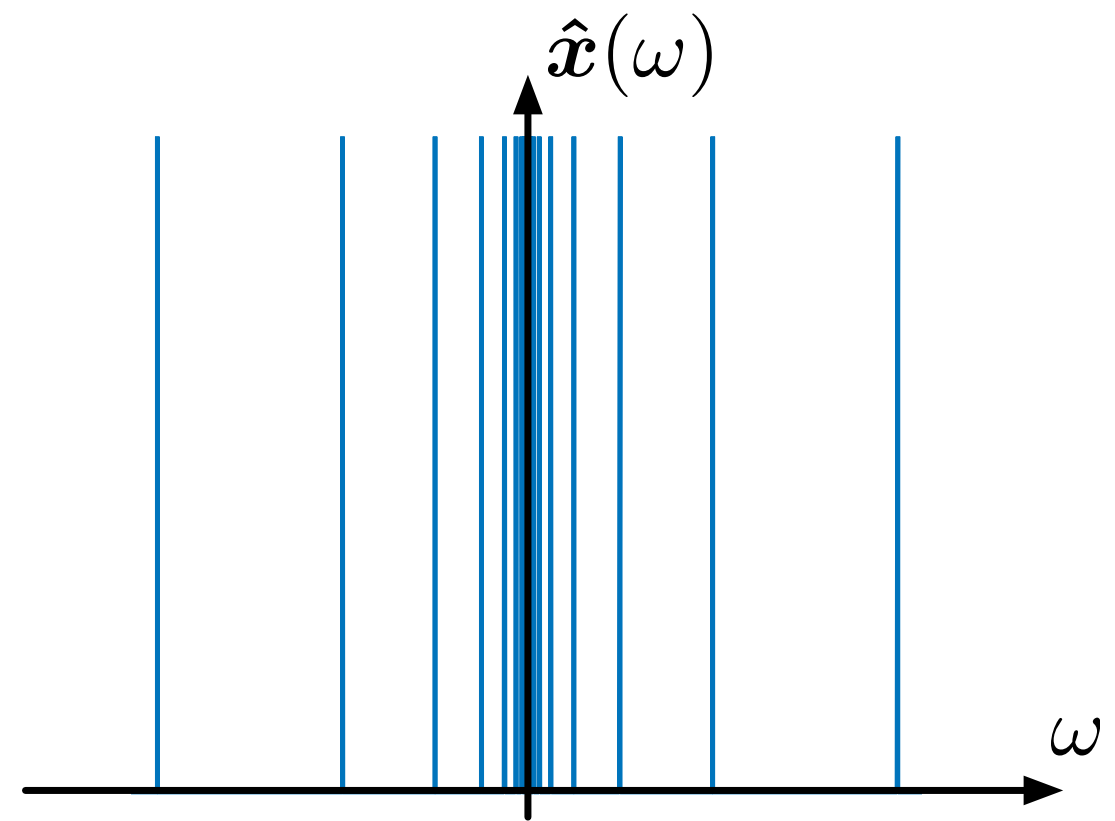
Roger Shepard,
Psychologist
from Stanford



A sound with a chroma but no height



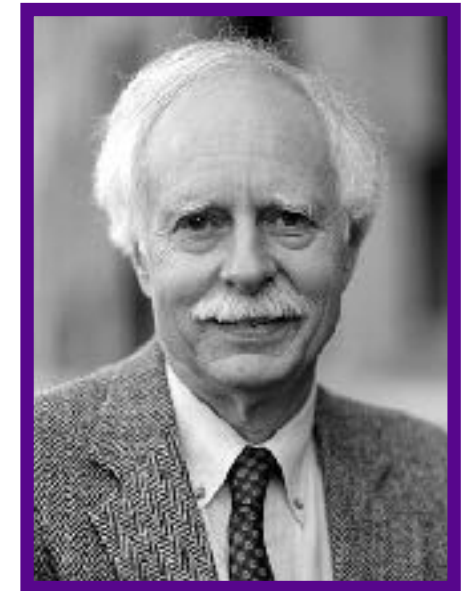
time domain



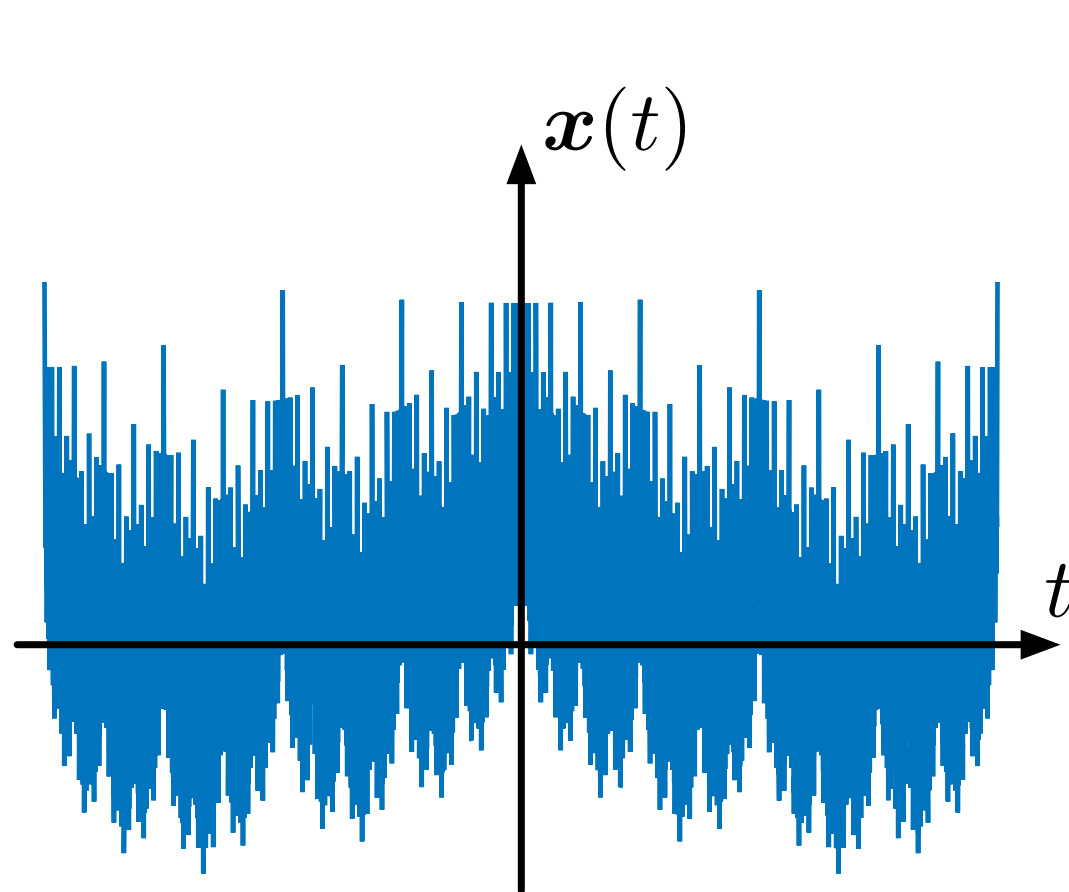
Fourier domain

Shepard Tone

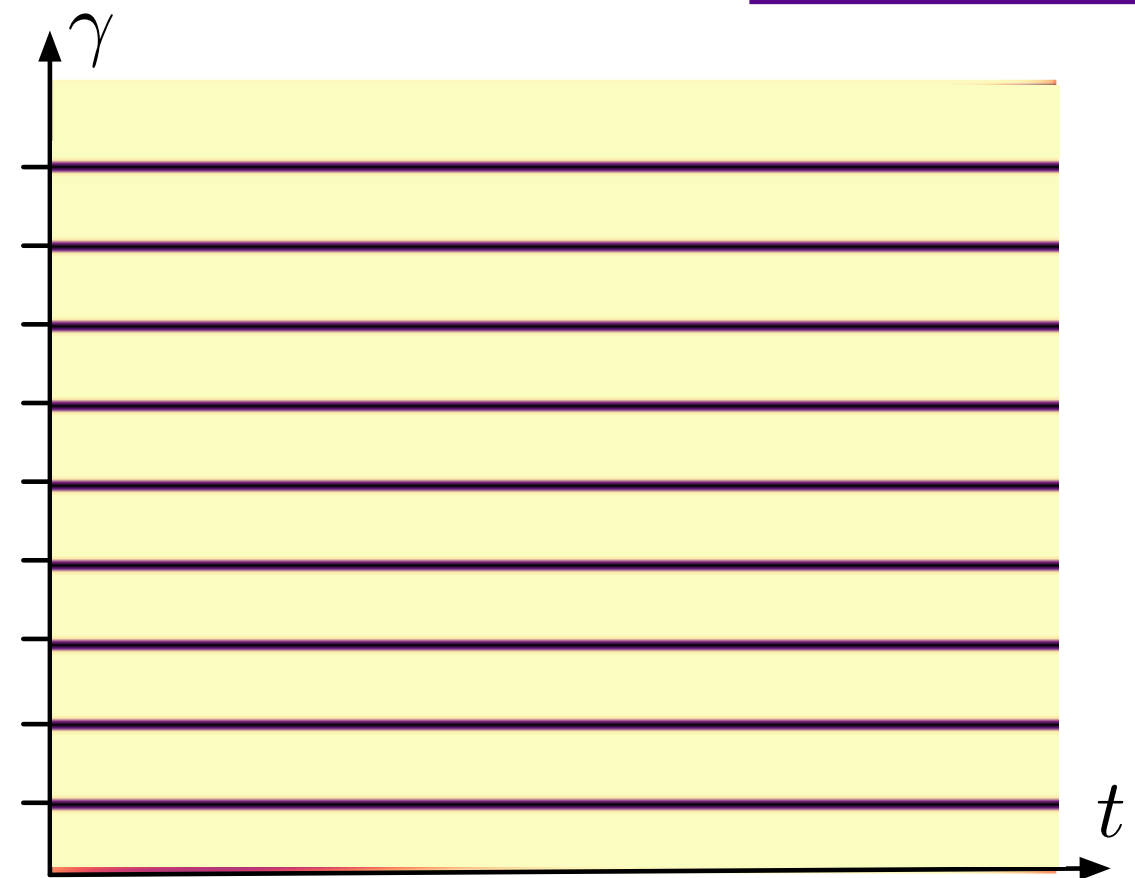
Roger Shepard,
Psychologist
from Stanford



A sound with a chroma but no height



time domain



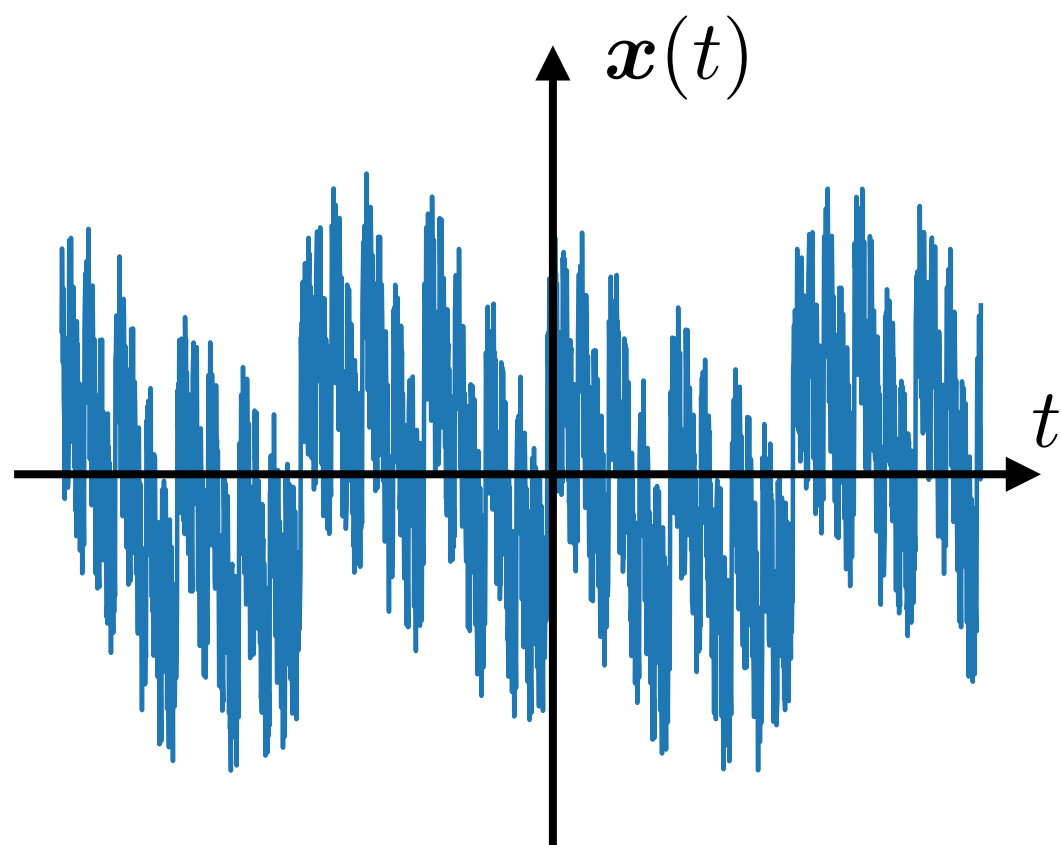
constant-Q transform

Shepard-Risset Glissando

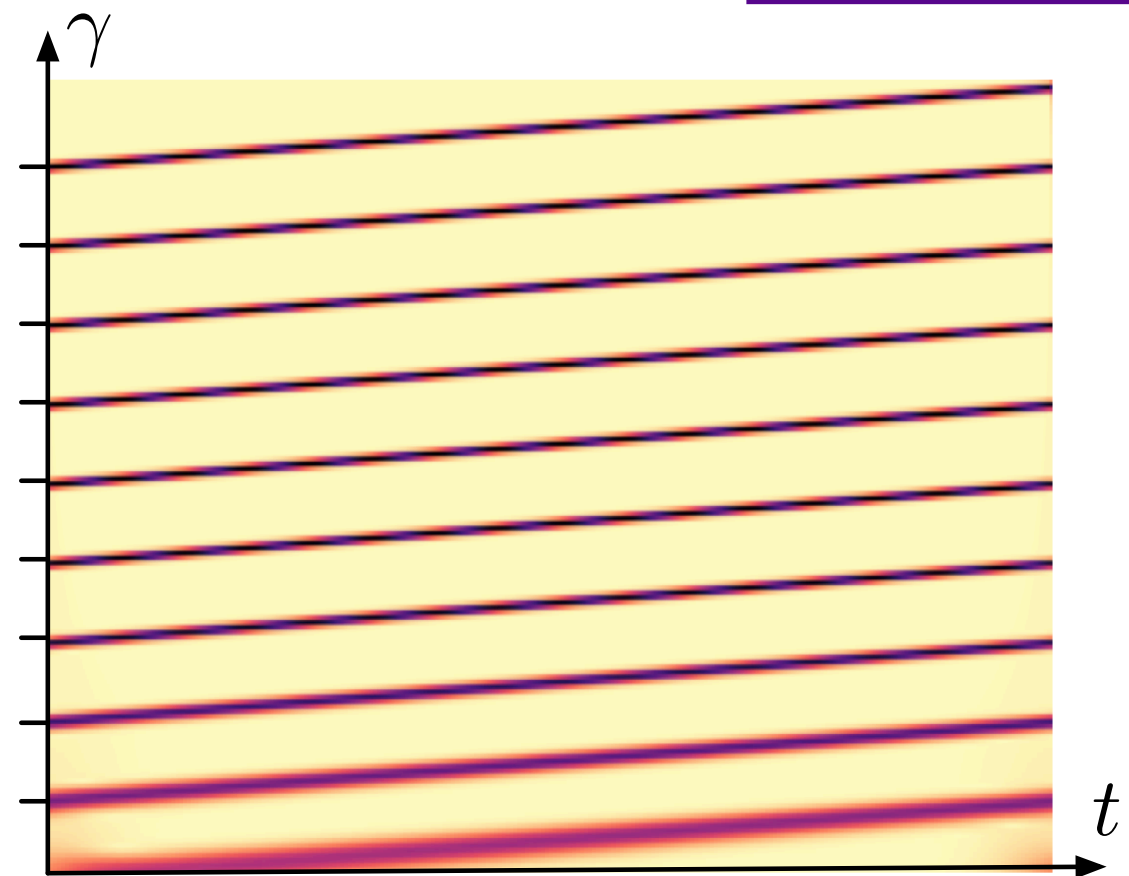
Jean-Claude Risset,
composer
and CNRS scientist



A sound whose pitch ascends endlessly!

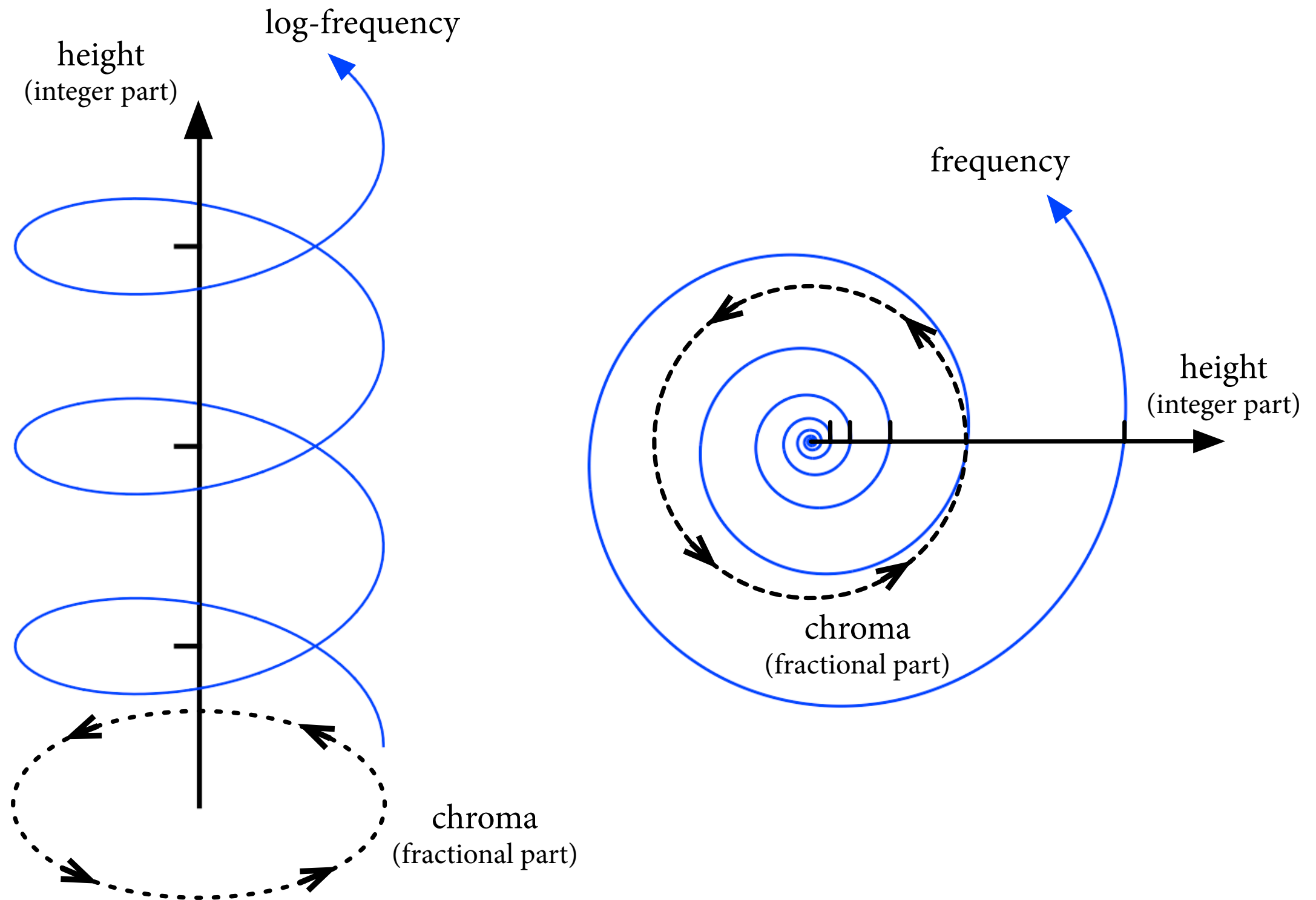


time domain



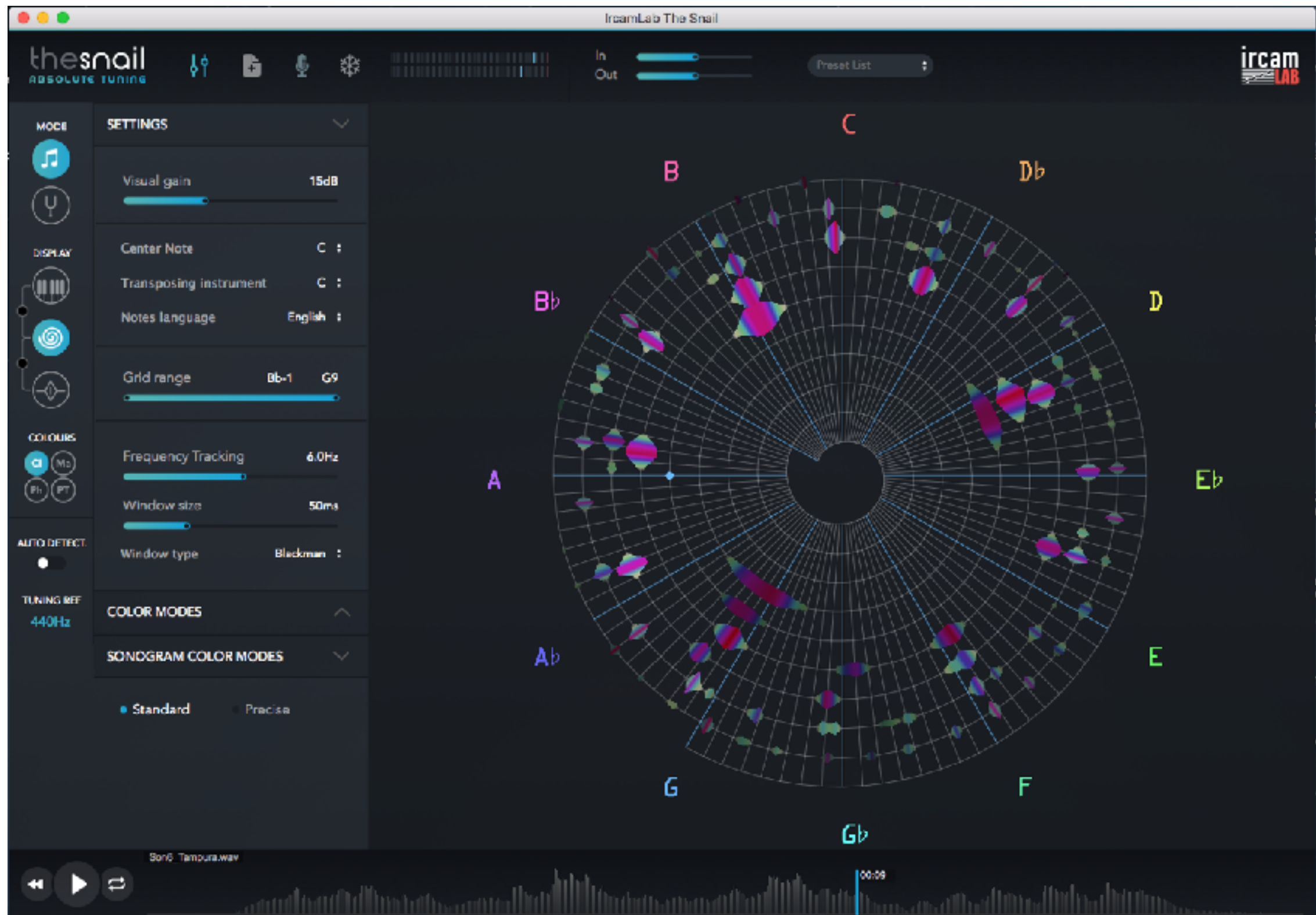
constant-Q transform

3-D helix vs. 2-D spiral



“The Snail” visualization software

by Thomas Hélie, CNRS scientist at Ircam

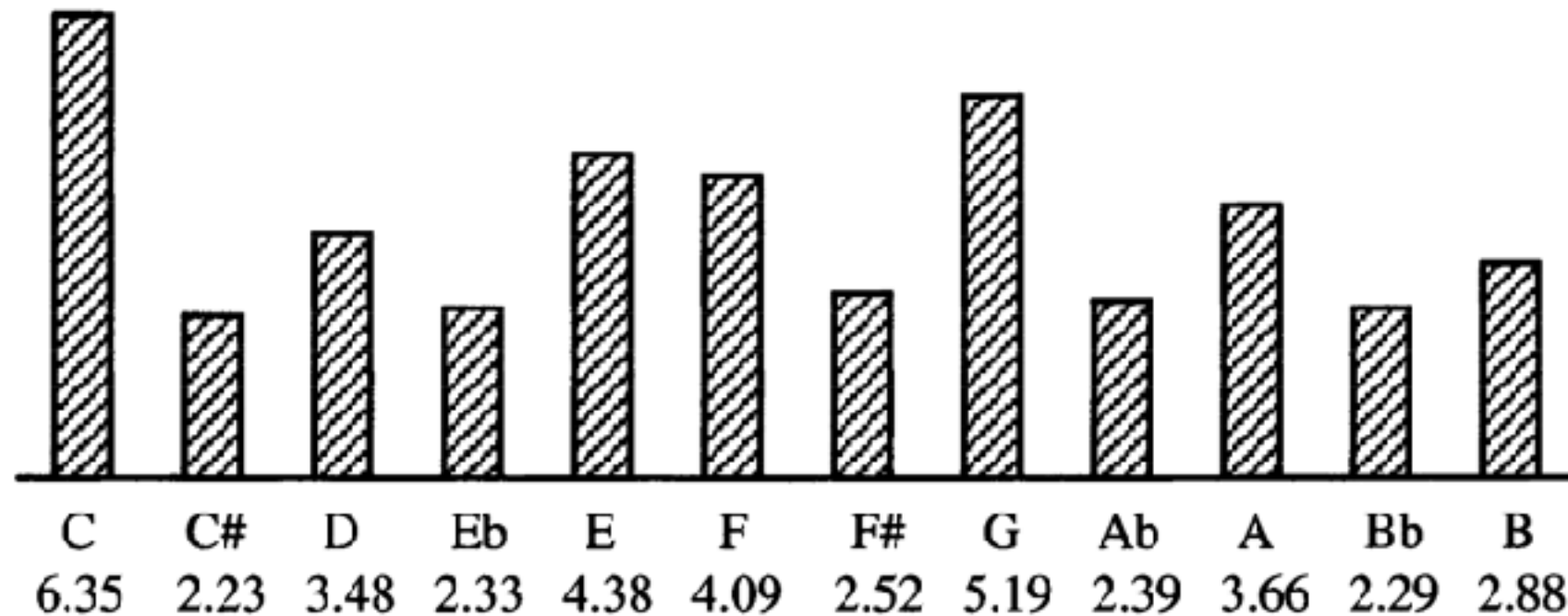


Krumhansl's key profiles

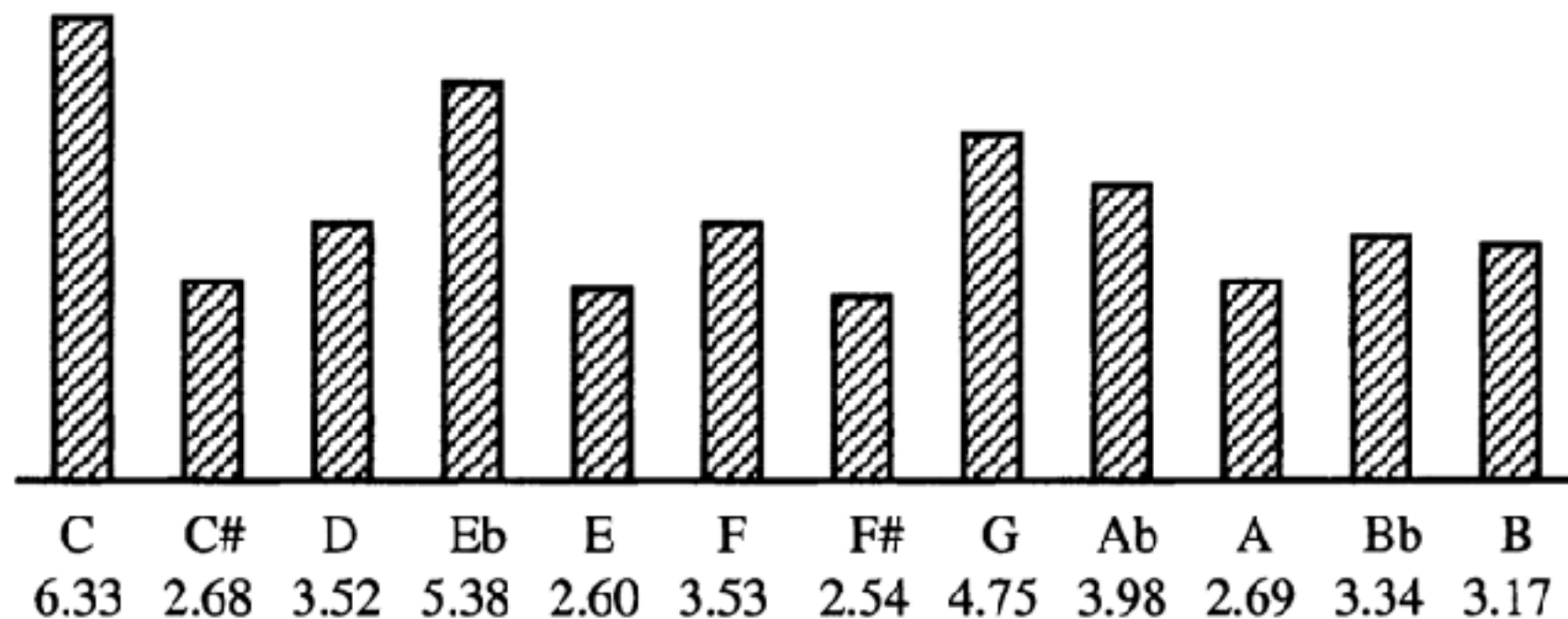
Music psychologist
from Cornell



C major

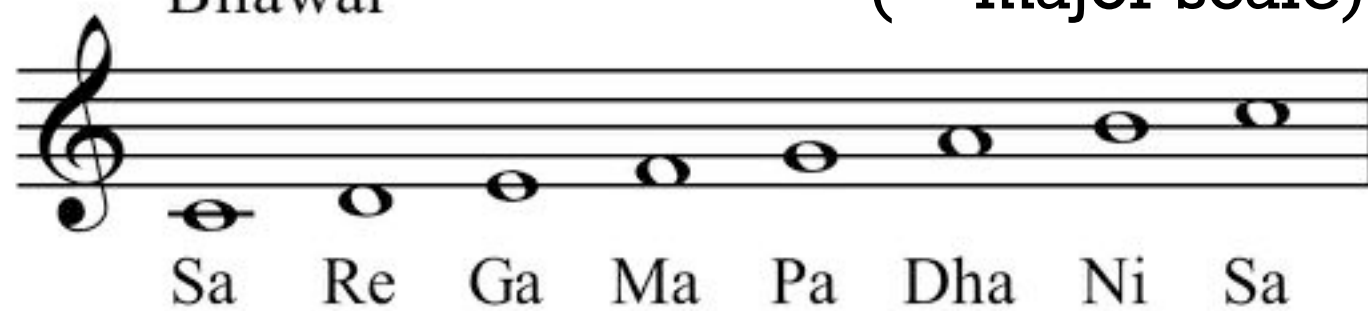


C minor



A different perspective: Carnatic ragas

Bilāwal (~ major scale)



Sa Re Ga Ma Pa Dha Ni Sa

Kalyan (~ lydian scale)



Sa Re Ga Ma: # Pa Dha Ni Sa

Bhairav (~ phrygian scale)



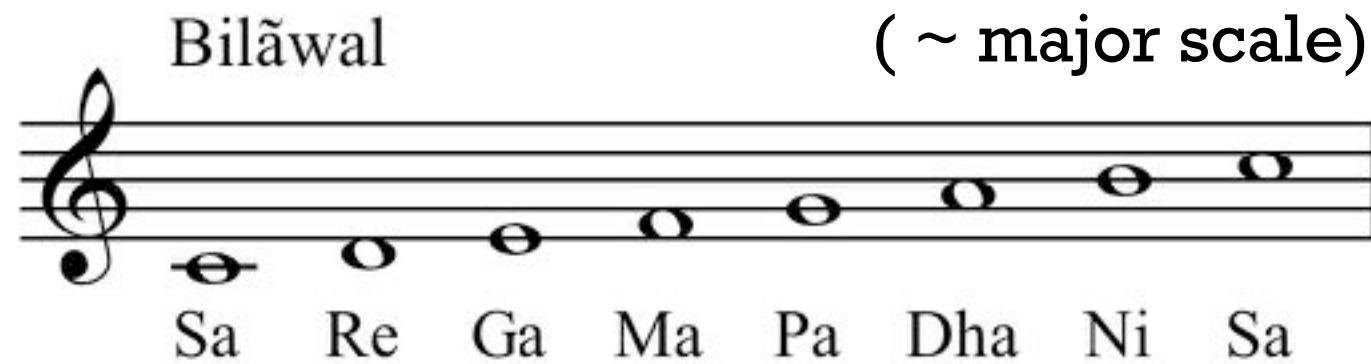
Sa Re: b Ga: b Ma Pa Dha: b Ni: b Sa

Purvi (no European equivalent)



Sa Re: b Ga Ma: # Pa Dha: b Ni Sa

A different perspective: Carnatic ragas



CAUTION

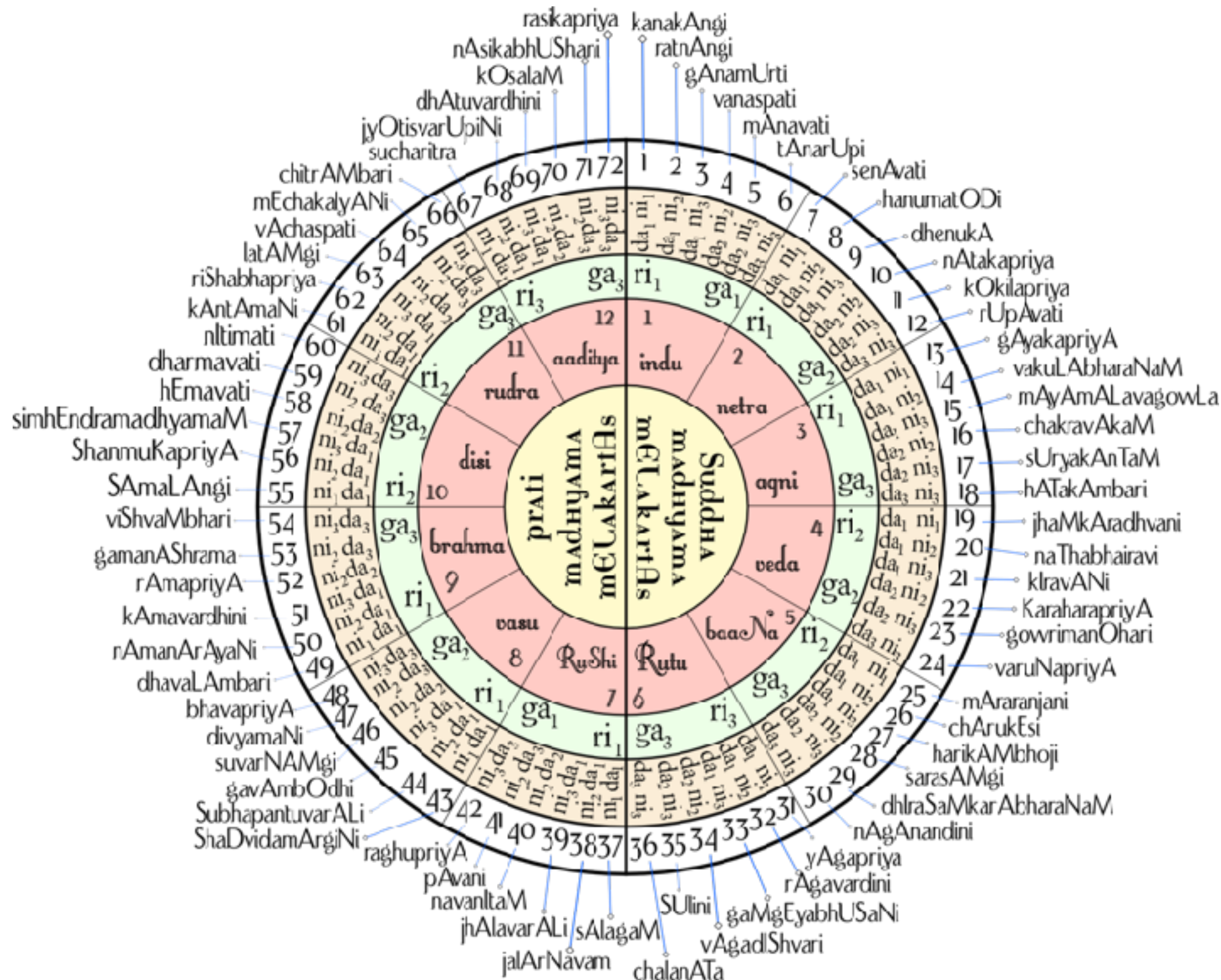
Ragas are more than just scales!

They come with rules of movement and typical melodic progressions.

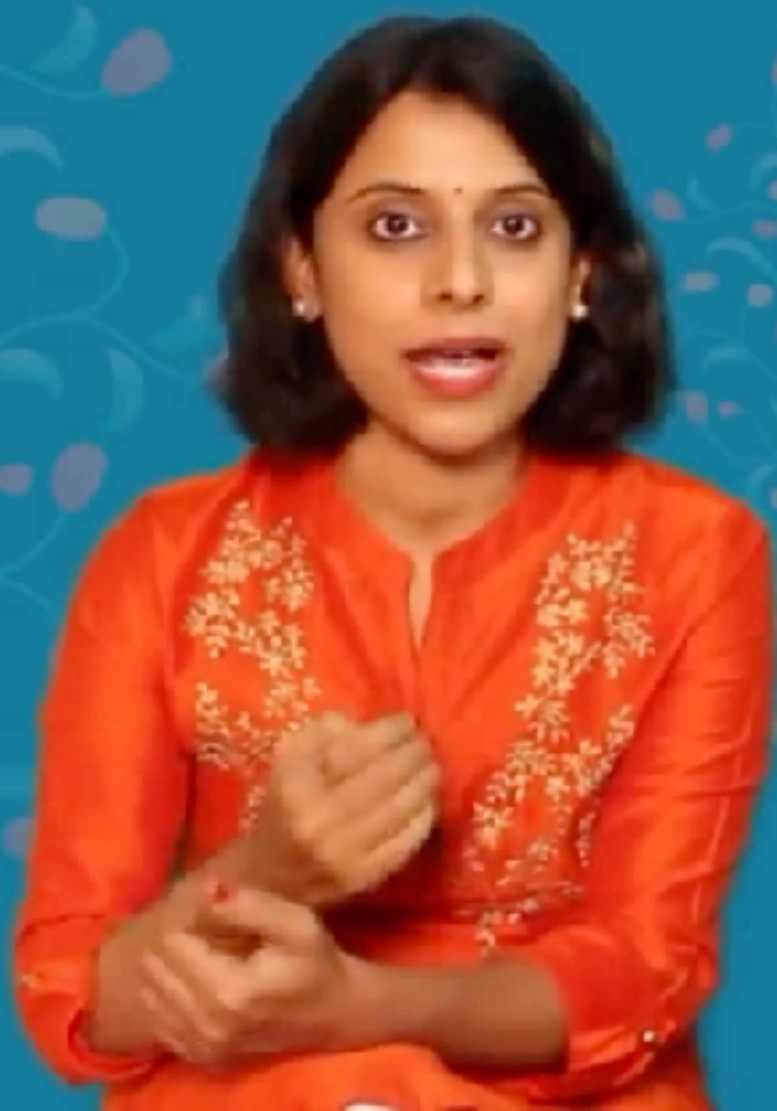
The melakarta:

a collection of 72 “parent raags”

Katapayadi: a systematic organization based on modular arithmetic



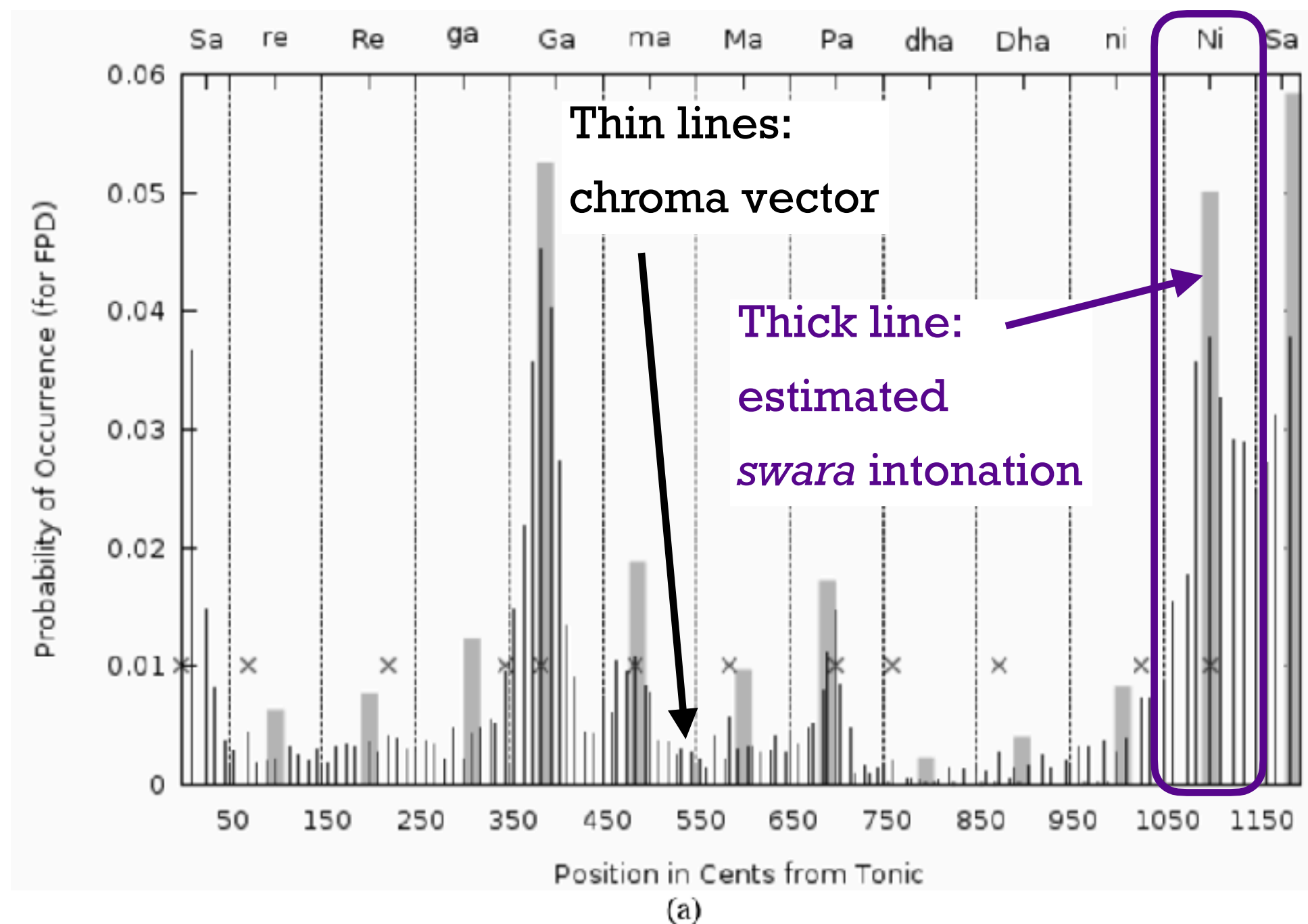
Khamas



Microtonal raga analysis

Fine spectral analysis allows to disambiguate ragas even when they have the same swaras.

Preeti Rao,
scientist
at IIT Bombay



Recap: What did we learn today?