Digital Sound Capstone
DXARTS 460

Lecture 4:
Sound as music

Spring 2011

Instructor: Stelios Manousakis

What is music?

Sonic codes

• Established sonic codes can be grouped into two basic categories, both considered to be inherent human capacities with universal distribution in human societies: language and music.

Sonic codes

The form of a code depends on:

- Properties of the medium, or how a message travels

- Properties of the users:
  - the capacity of the transmitter to form an intelligible message
  - the capacity of the receiver to perceive and understand the message

- The function of the code

- Cultural group history

If any of the above changes, the code will change as well.

What is music?

- A code used to *organize sound in time*
- A code used to *organize time with sound*
- A code used to *cause human sensations in time through sound in an organized manner*
- A code used to *generate human emotions* through an *organized succession of physio-/psycho-/cognitive sensations*
- ...

Creating musical sound

- What defines a musical culture?
- What defines a musical idiom or language?
- What defines a musical style?

Creating musical sound

• The **semantic field of music**: The multidimensional parameter space of sound perception as decoded by our cognitive processes

• The **musical field** can be described as a parameter space:
duration, *loudness*, *pitch* and *timbre* are its primary dimensions

• **Categorization** is a key for human perception and cognition. A space has to be divided into a functional and economic (meaning easy to perceive and remember) set of meaningful states

• In order to navigate in any kind of space a **strategy** is needed. Because of the social character of musical behavior, such strategies are greatly dependant on history, culture, science and technology.

Creating musical sound

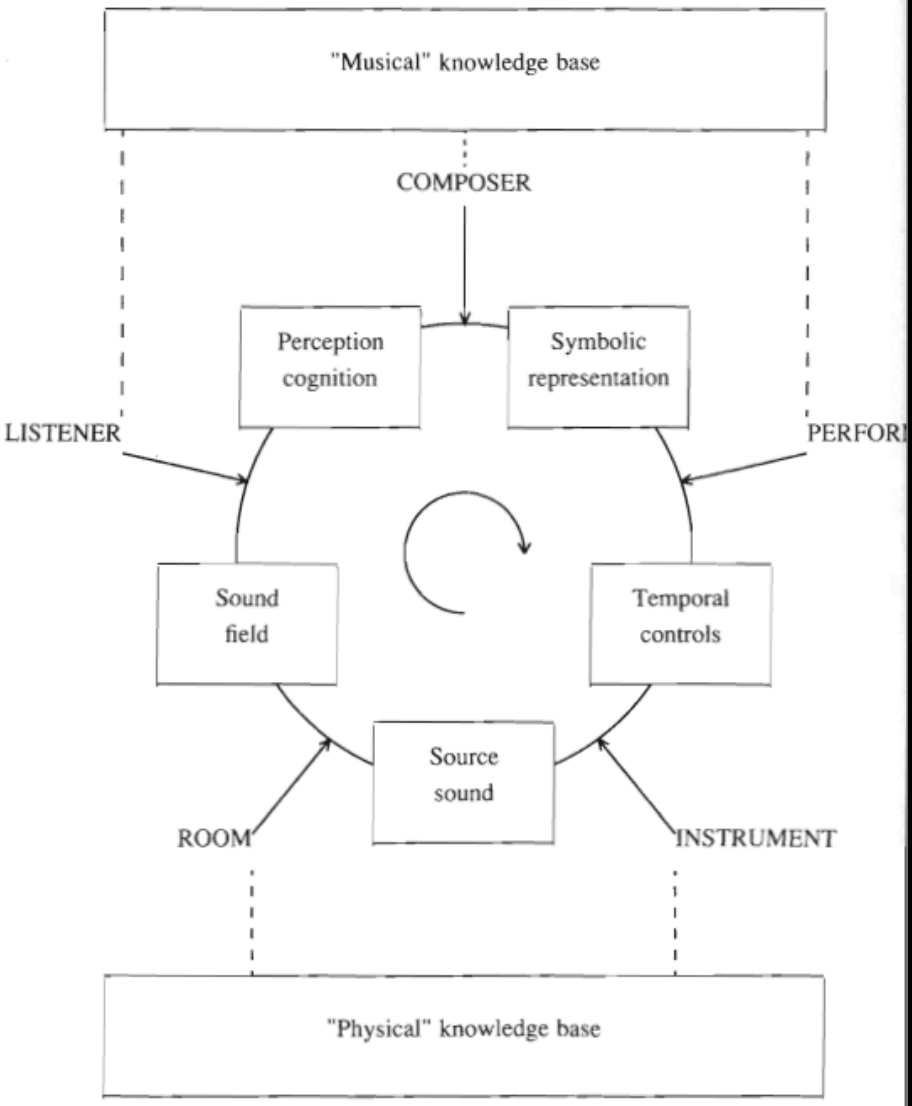


Figure 1-1 Musical data (in boxes) and processors (in capital letters). Data is information that may exist in many forms; processors may be human beings, machines, or a combination of both.

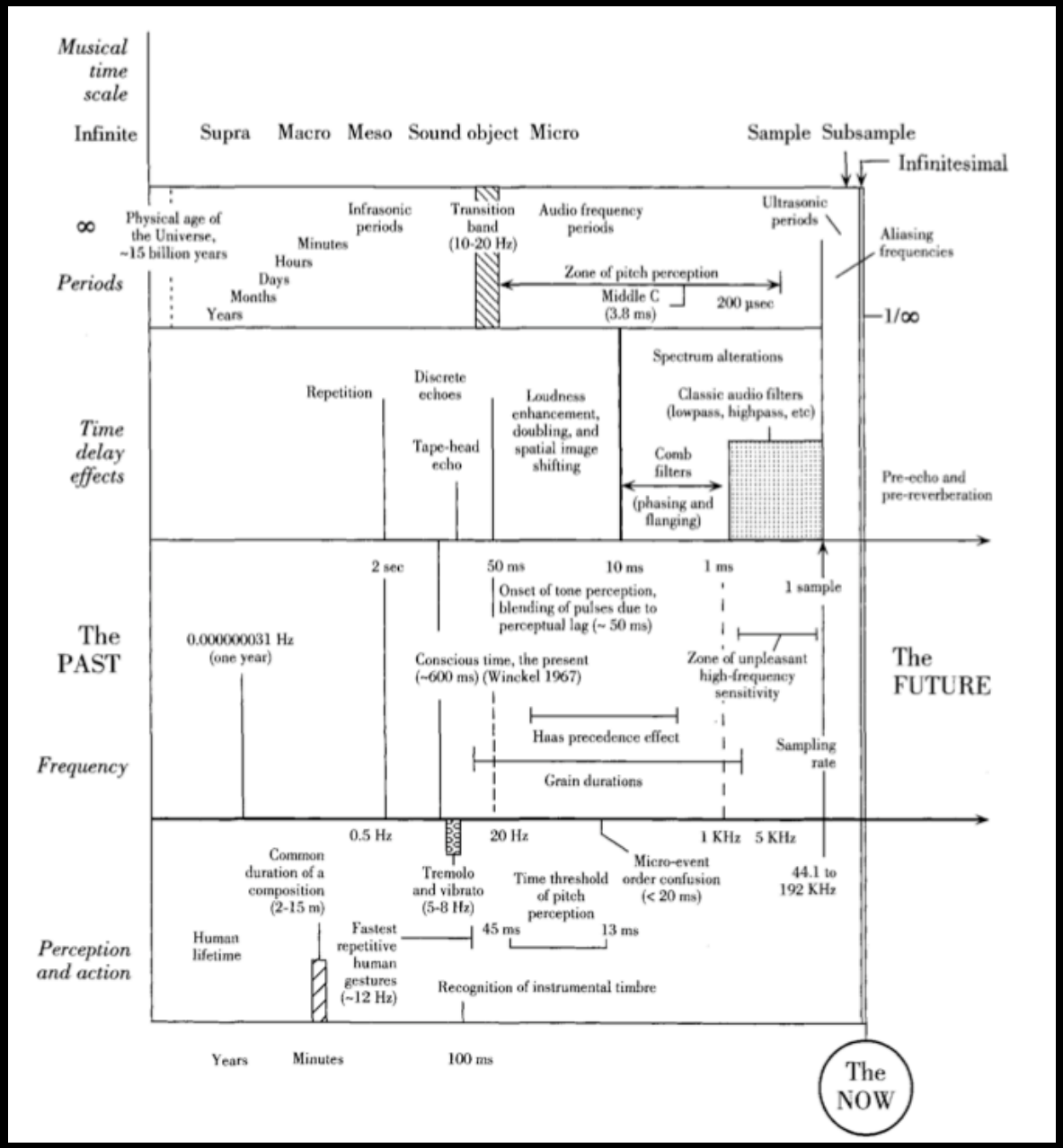
Musical time

- Time scales of music (Curtis Roads, 2001)

1. Infinite
2. Supra
3. Macro
4. Meso
5. Sound object
6. Micro Sound
7. Sample
8. Subsample
9. Infnitesimal

- When sound passes from one time scale to another it crosses perceptual boundaries, thus appearing to the human brain to change qualities. Meaning that quantitative changes, become qualitative ones

Musical time



Acoustic properties of sound (recap)

Some physical properties of sound waves are

- velocity (or speed and direction)

- frequency
- wavelength
- period

- amplitude
- intensity

- spectrum

Psychological dimensions of sound (recap)

- Loudness -> relates to intensity
- Pitch -> relates to frequency
- Duration -> relates to time
- Timbre -> a complex dimension: relates to (steady) spectrum, formant structure, transients and other features
- Localization -> Radiation and other spatial cues

Sound as music

Raw material	Traditional musical interpretation
• Pitch	-> Scale degrees (pitch class and octave height)
• Loudness	-> Dynamics
• Timbre	-> Tone colors (Instrumentation/Orchestration)
• Time	-> Onset & duration

What is a musical note?:

A sonic unit of a certain pitch class and octave height, dynamics and tone color, starting in a given time and lasting for a specified time period

What is a sound object?

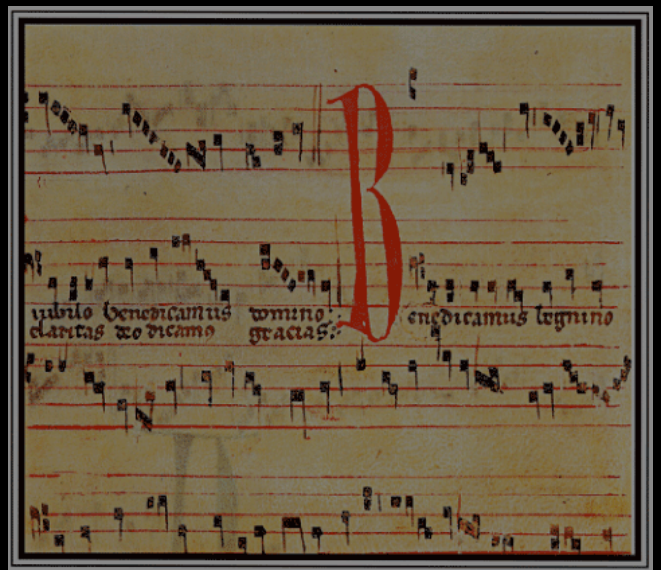
Representing musical sound

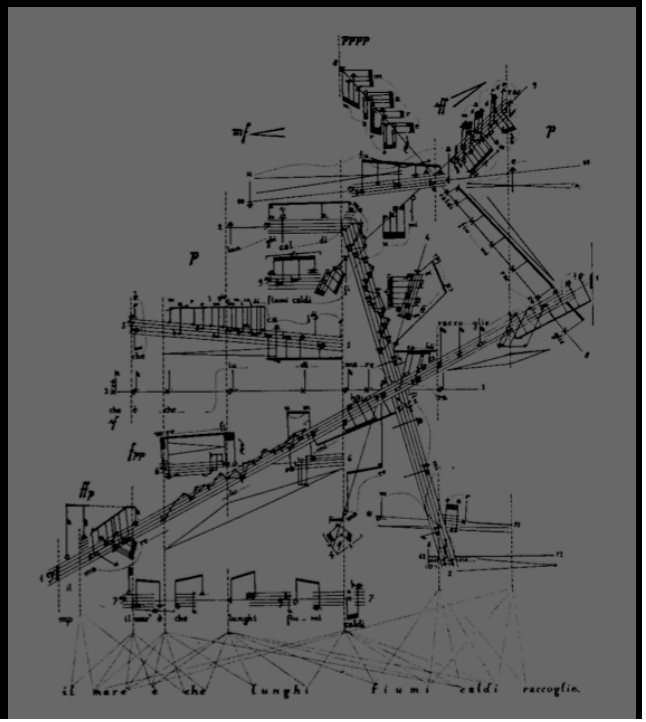
- Instrumental sonic spaces are navigated *physically*

- Compositional sonic spaces are navigated abstractly

- Notation technology enhances compositional abstraction, permitting to explore sound spaces out-of-time and without the intervention of a physical system

- Recording /playback technology does something very similar





Representing musical sound

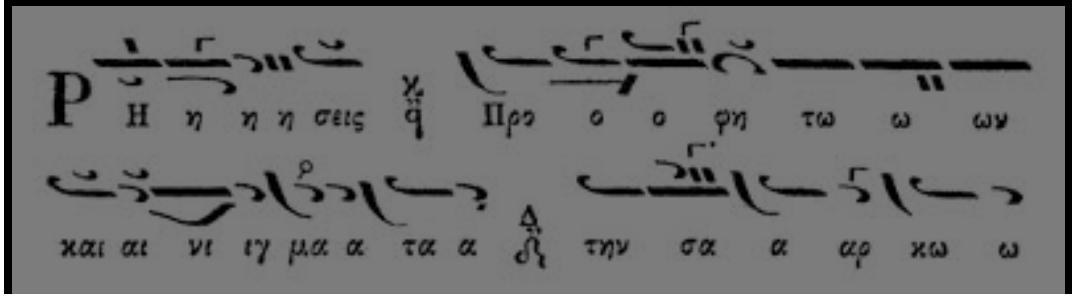
• What are notational systems?:

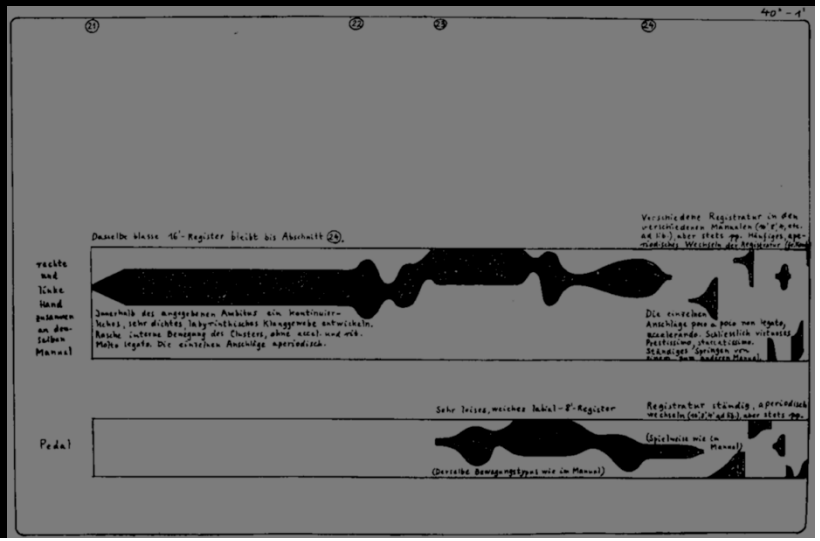
Means for communicating musical experience by representing it in symbolic written and verbal forms

• What are they good for?:

- storing, learning, teaching and performing works
- transcribing and analyzing
- speaking and writing about music
- composing!

• Scores are sonic maps partially describing a work





Organizing musical time

- ***Onset***: when a sound begins in time (dt from a reference point)
- ***Duration***: how long a sound lasts (in seconds / beats)
- ***Rhythm***: A complex phenomenon, relating to the pattern of succession of onsets and durations *of physical sensations* in time – not necessarily of *sound events*!

Organizing temporal space

Music creates a relative time that can speed up and slow down. Therefore, we tend to use relative measurements:

- ***Beat***: a relative metric unit to measure time (pulse in a grid)
- ***Tempo***: how long a beat lasts
- ***Measure***: a collection of beats acting as a unit
- ***Time signature***: how many beats per measure

Organizing temporal space

Discrete categories vs ambivalence vs continuous flow

- Tuplets
- Accelerandi & decelerandi
- Out-of-rhythm playing
- Compound meters
- Polymetes
- Altering beat patterns (strong-weak)
- Senza tempo
- Relative entry times

Organizing pitch space

- Pitch bandwidth is different than psychoacoustical pitch bandwidth in traditional musical codes:
  - Pitches below 25Hz begin to approach rhythm, so are not used much by traditional instruments
  - Pitches above about 4000Hz are difficult to tell apart, so not used much by traditional instruments (pretty much heard as timbre)

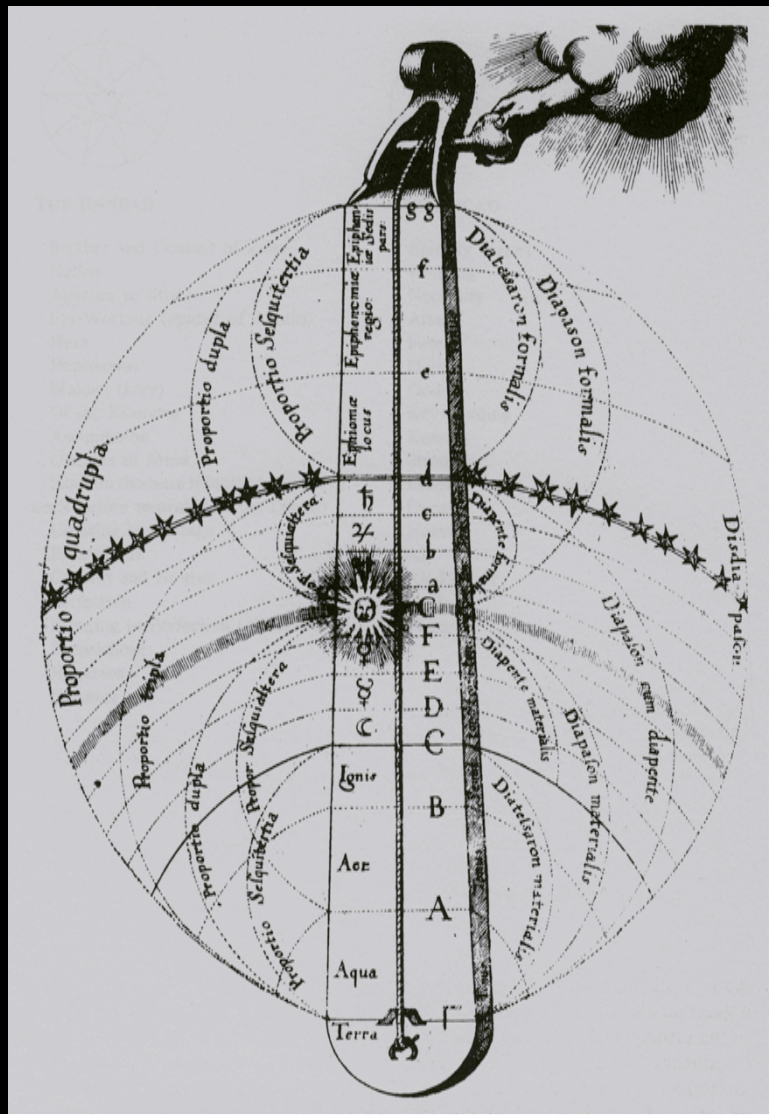
Organizing pitch space: Tuning systems

- The musical pitch space is not continuous in traditional musical codes but gridded:

  - Tuning systems

    Psychoacoustic, cognitive, physical

    mathematical, even philosophical factors.



Organizing pitch space: Temperaments

- Temperaments (tempering):
  compromises, a gain and a loss

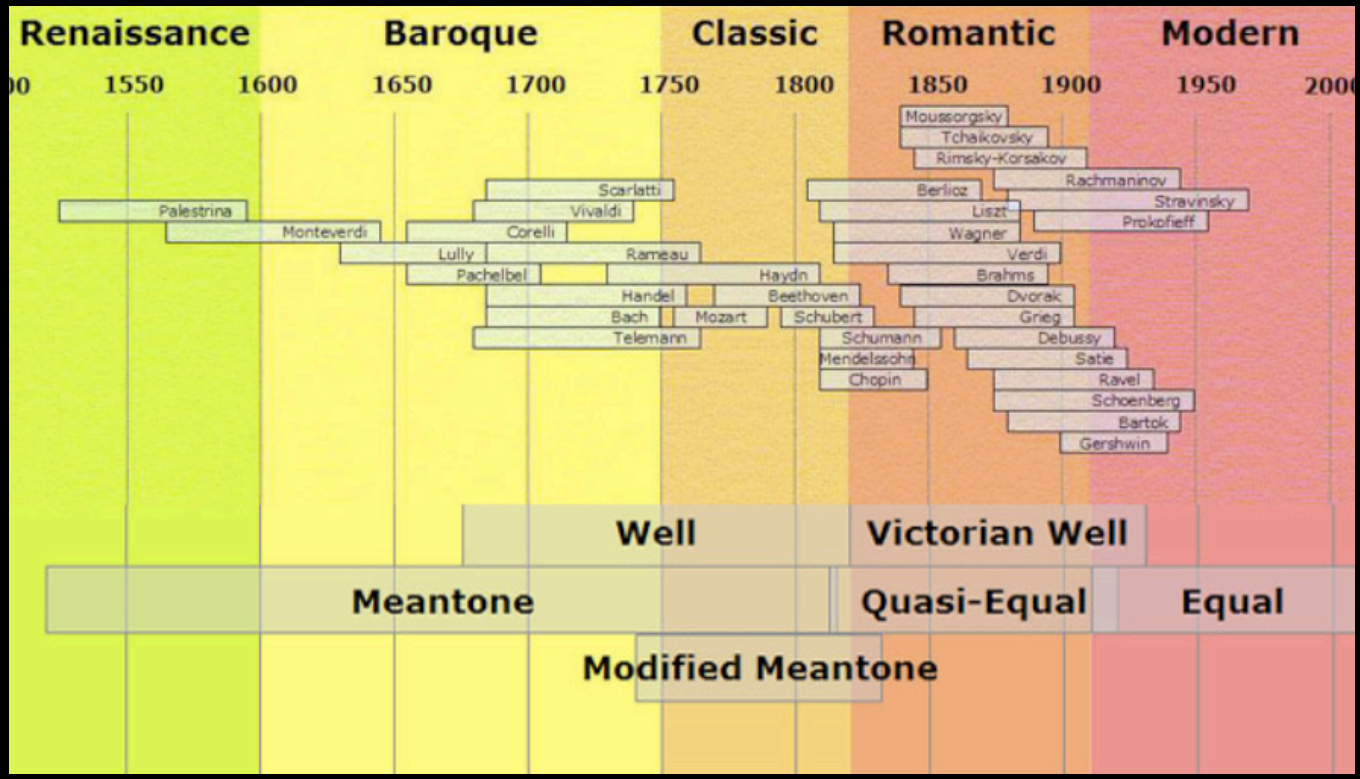
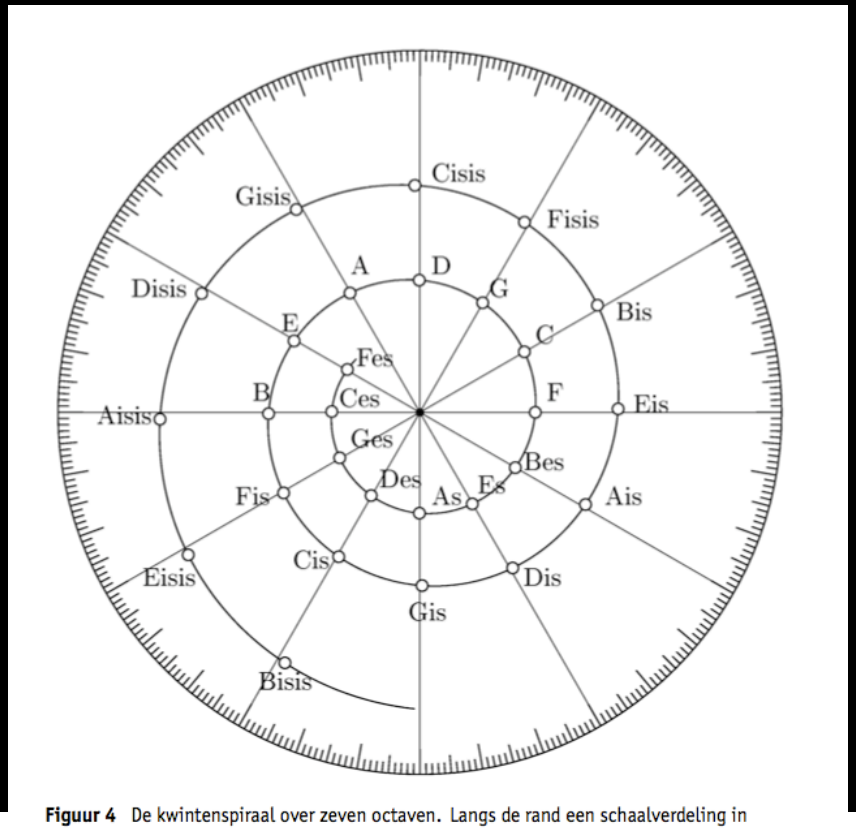


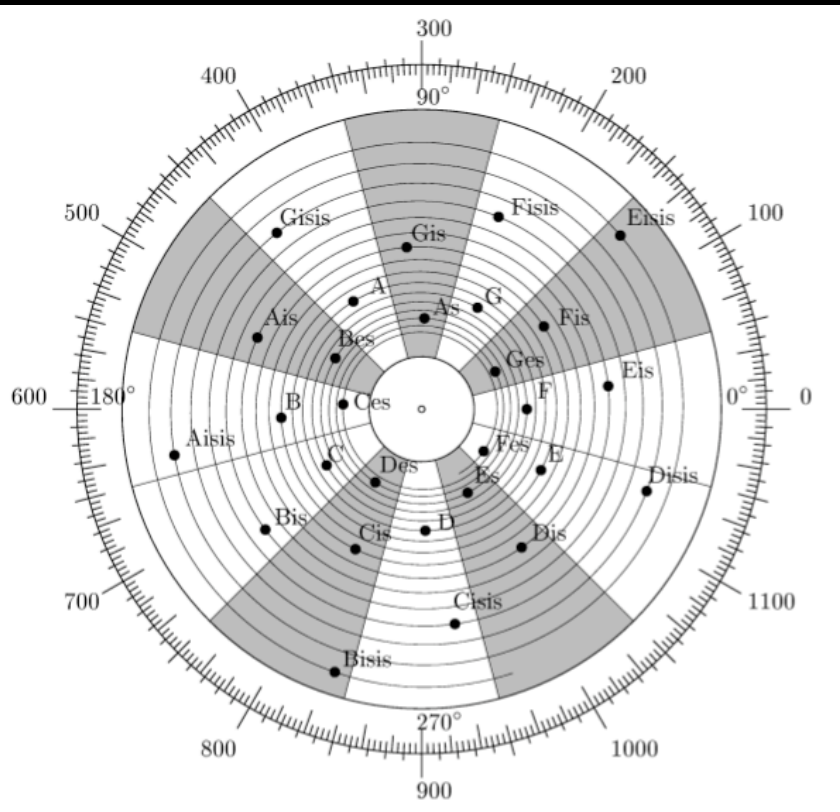
Chart from: http://www.rollingball.com/TemperamentsFrames.htm

Organizing pitch space: Scales, or dividing the octave

- **Scales**
  - **Scalemes** (like phonemes): A pitch unit with a distinguished identity
  - How many scalemes (degrees in a scale)?:
  - Psychoacoustic and cognitive factors at play.
  - Remember: Critical bands, and Just Noticeable Difference



Figuur 4 De kwintenspiraal over zeven octaven. Langs de rand een schaalverdeling in graden. Eén rondgang langs de spiraal (360 graden) correspondeert met een stijging over zeven octaven. Een stijging over een kwint meet 30.083786 graden. De spaken zijn om de 30 graden getekend.



Figuur 5 De kwintenspiraal, maar nu veel 'strakker opgewonden'. Eén volledige rondgang correspondeert nu met één octaaf, en niet met zeven octaven zoals in figuur 4. Langs de cirkelrand is een schaalverdeling getekend in graden (binnenkant) en cents (buitenkant) met 10 cent per schaaldeel. Een stijging over een kwint correspondeert nu met een hoektoe-

Organizing pitch space: between the grid

- Many times, expression lies in–between:
  - *Vibrato*
  - *Trills* and *tremolos*
  - *Pitch bends*
  - *Glissandi* (slide gliss., contour gliss., portamento)
  - *Microtones* (several non-western systems use them traditionally, western art music does too)

Organizing pitch space vertically

- Monody vs polyphony (harmony/counterpoint)
- Strategies for different pitches to co-exist in time
- Consonance and dissonance:

  A cultural concept that changes with place and time

Organizing loudness space

- The sound intensity of many (not all) musical instruments can be adjusted over a certain range, depending upon their construction.

- The range from the softest to loudest sound for an instrument is its *dynamic range*. E.g The harpsichord has a fixed range, whereas the piano(forte) not.

- Static musical dynamics:
  - ppp – fff, up to ASAP (as soft as possible) – ALAP (as loud as possible)
  - vertical dynamics

- Changing dynamics:
  - Crescendo / decrescendo
  - Complex envelopes (e.g. ADSR-type)

Organizing loudness space

- Micro-dynamics / Articulation:

- Acoustic sounds (instruments, objects, orchestra):
  Related to manner of playing an instrument

- Electronics sounds:
  Programmable
- Attacks:
  accents
  legato/staccato
  sforzando
  bowing pressure, breath pressure, striking force, etc

- Releases:
  smooth, detached, short, harsh, punctuated, etc

- Sustains
  Changing dynamics

Organizing loudness space: musical silence

- Very important element in music!
- Real silence: Does it exist?

Musical timbre

- Musical timbre from an acoustic point of view: exciter and resonator model

- Musical timbre and psychoacoustic timbre:
  relates to spectrum, formant structure, transients and other features

- *Static* vs *dynamic spectra*
  Dynamic specrtum: partials with individually moving amplitude envelopes

- Bandwidth of sound

- Resonance

- Acoustic sounds (instruments, objects, orchestra):
  Related to manner of playing an instrument
- Electronics sounds:
  Programmable

- Additive timbre / orchestration: Related to how different sounds are mixed together to compliment each other

Describing musical timbre

- What are some words you would use to describe musical timbre?

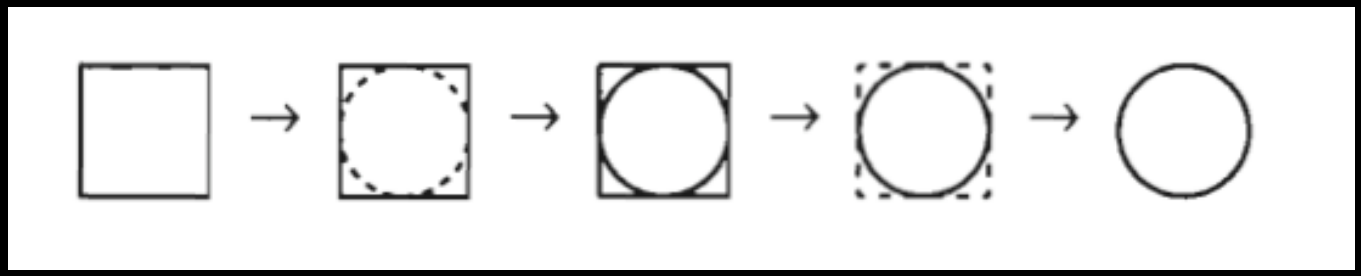
Describing musical timbre

Some examples

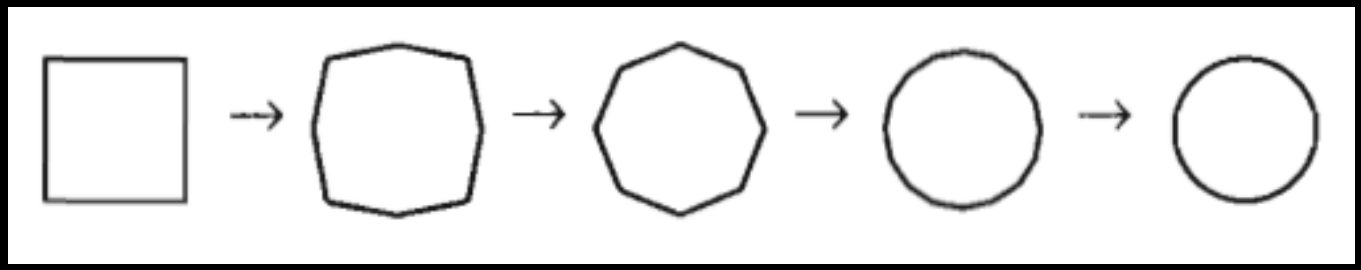
Color	*Muddy/Clear* *Bright/Opaque*
Material Quality	*Woody/Metallic* *Hollow/Full/Dense*
Surface Quality/Grain	*Rough/Smooth* *Airy/Abrasive*
Spatial Quality	*Wet/Dry*
Spectral Quality	*Harmonic/Inharmonic/Noisy* *Dynamic*
Spectral Density	*Consonant/Dissonant* *Thick/Thin* *Delicate/Harsh* *Soft/Hard* *Dolce*

Timbral modulation examples

- Timbral crossfade



- Timbral transformation



Organizing musical synchronicities

Traditional organizational principles and textures:
All musical parameters of sound are at play

- Monophonic structures
- Homophonic structures (harmony):
  - Melody with accompaniment
  - Chordal structures
- Contrapuntal structures (relatively independent lines)
  - Imitative
  - Free
- Compound

Organizing musical synchronicities

Some 20th century vertical structures and textures

- Pointilism: dots (rests, wide leaps) rather than lines
- Stratification: various layers coexisting
- Collageing: 'block juxtaposition'
- Sound-masses: clusters of sound

Bibliography

- COLE, H. (1974). *Sounds and signs; aspects of musical notation*. London, Oxford University Press.
- COPE, D. (1976). *New music notation*. Dubuque, Iowa, Kendall/Hunt Pub. Co.
- DEUTCH, D. (ed.) (1999) *The Psychology of Music* (2nd ed). San Diego, CA: Academic Press
- DOWLING, W. J. and Harwood D. L. (1986). *Music Cognition.* San Diego, CA: Academic Press
- KARKOSCHKA, E. (1972). *Notation in new music; a critical guide to interpretation and realisation*. New York, Praeger.
- KOSTKA, S. M. (2006). *Materials and techniques of twentieth-century music*. Upper Saddle River, NJ, Prentice Hall.
- LOY, G. (2007). *Musimathics, Volumes 1 and 2.* Cambridge, MA: MIT Press
- MANOUSAKIS, S. (2006). *Musical L-Systems.* The Hague, Institute of Sonology
- MOORE, F. R. (1990). *Elements of Computer Music*. Englewood Cliffs, NJ: Prentice Hall
- ROADS, C. (2001). *Microsound*. Cambridge, Mass, MIT Press.
- STONE, K. (1980). *Music notation in the twentieth century: a practical guidebook*. New York, W.W. Norton.
- WISHART, T. (1996). *On sonic art*. Amsterdam, Harwood Academic Publishers.
- XENAKIS, I. (1992). *Formalized music: thought and mathematics in composition*. Hillsdale, NY, Pendragon Press.

NOTE: All images were taken from these books, unless otherwise noted