Interim between Pitch and Timbre

COGS 300

Hertz vs. Semitones

http://ptolemy.eecs.berkeley.edu/eecs20/week8/scale.html

The frequencies 440Hz and 880Hz both correspond to the musical note A, but one octave apart. The next higher A in the musical scale would have the frequency 1760Hz, twice 880Hz. In the western musical scale, there are 12 notes in every octave. These notes are evenly distributed (geometrically), so the next note above A, which is B flat, has frequency $440 \times \beta$ where β is the twelfth root of two, or approximately 1.0595. The next note above B flat, which is B, has frequency $440 \times \beta^2$.

A	440
B flat	466
B	494
C	523
C sharp	554
D	587
D sharp	622
E	659
F	698
F sharp	740
G	784
A flat	831
A	880

Left is a table of the complete musical scale between middle A and A-880. Each frequency is β times the frequency above it. The applet on the previous page has a button that you can use to play the musical scale.

The psychoacoustic properties of the musical scale are fascinating. The musical scale is based on our perception of frequency, and harmonic relationships between frequencies. The choice of 12 evenly spaced notes is based on the so-called **circle of fifths**.

Frequencies that are harmonically related tend to sound good together. In the following applet, you can combine any set of frequencies in the scale.

Hertz vs.semitones

- The need for a psychoacoustic measurement of pitch (semitone) vs. a physical measurement (hertz) is clear.
  - If an octave represents a doubling in hertz, then each octave interval is twice as big as the one before.
  - Dividing each octave into 12 chromatic steps will make for larger (in hertz) intervals in each octave.
  - Psychoacoustically, we need the sub-measurement of “cents” (hundredths of a semitone).

Definition of “Diatonic Scale”

- Email conversation with Colleen Muriel: flute player, composer, and teacher; London, England.
- Different experts define “diatonic scale” differently.
  - The major scales
  - The major and minor scales
    - The keys of classical music
    - The only composers who followed the diatonic system religiously were Haydn and Mozart (Classical era), Bach (Baroque era) mixed diatonic and church modes, and Romantic composers shifted away from pure diatonic writing.
  - The major and minor and all the church modes
    - Wikipedia article on “diatonic scale” (source of graphic on next slide) (http://en.wikipedia.org/wiki/Diatonic_scale)
    - Church modes are used in Medieval, Renaissance, and some modern music including jazz.

Church modes

Scales derived from playing only white keys on the piano starting at different notes (plus all their transpositions).

[Variations on the Lydian scales are prominent in Jazz]

Mode	Also known as	Tonic relative to major scale	Interval sequence	Example
Ionian	Major scale	I	T-T-s-T-T-T-s	C-D-E-F-G-A-B-C
Dorian		II	T-s-T-T-T-s-T	D-E-F-G-A-B-C-D
Phrygian		III	s-T-T-T-s-T-T	E-F-G-A-B-C-D-E
Lydian		IV	T-T-T-s-T-T-s	F-G-A-B-C-D-E-F
Mixolydian		V	T-T-s-T-T-s-T	G-A-B-C-D-E-F-G
Aeolian	Natural minor scale	VI	T-s-T-T-s-T-T	A-B-C-D-E-F-G-A
Locrian		VII	s-T-T-s-T-T-T	B-C-D-E-F-G-A-B

Harvard Dictionary of Music 2003, "Mode"

	Mode		Final	Ambitus	Tenor
1.	Protus authentic	Dorian	d	d-d′	a
2.	Protus plagal	Hypodorian	d	A-a	f
3.	Deuterus authentic	Phyrgian	e	e-e′	c′
4.	Deuterus plagal	Hypophrygian	e	B-b	a
5.	Tritus authentic	Lydian	f	f-f′	c′
6.	Tritus plagal	Hypolydian	f	c-c′	a
7.	Tetrardus authentic	Mixolydian	g	g-g′	d′
8.	Tetrardus plagal	Hypomixolydian	g	d-d′	c′
9.		Aeolian	a	a-a′	e′
10.		Hypoaeolian	a	e-e′	c′
11.		Ionian	c	c-c′	g
12.		Hypoionian	c	g-g′	e′

Diatonic

- Harvard Dictionary of Music 2003:
  - A scale with seven different pitches (heptatonic) that are adjacent to one another on the circle of fifths; thus one in which each letter name represents only a single pitch and which is made up of whole tones and semitones arranged in the pattern embodied in the white keys of the piano keyboard; hence, any major or pure minor scale and any church mode, as distinct from the chromatic scale, which employs only semitones.

Circle of Fifths