Backus: Chapter 7 Notes

Frequency and Pitch

The Audible Frequency Range

– According to Backus, the total frequency range of human hearing is 15Hz to 15,000 Hz. Other sources today say the range lies between 20Hz -20,000 Hz.

–*Pitch discrimination* –the ability to distinguish two tines of nearly the same frequency as different in pitch. This caps off at around 7 to 8 kHz (7,000 - 8,000 Hz).

Frequency Range of Musical Sounds

–The working range of fundamental frequencies produced on musical instruments is approximately 27- 4200 Hz.

–Most instruments produce very little sound above 10,000 Hz, and what is produced in this region is associated with noises such as bow scrapings, clicking of keys, and other noise related sounds.

Factors Affecting Pitch

–If the loudness of a pure tone is increased changes in pitch may occur: they will be generally downward at lower frequencies and upward at higher frequencies.

–*Diapauses* – a condition in which a given frequency may produce a certain pitch in one ear and a different pitch in the other.

Pitch Discrimination

–From up to 400 Hz the ear can here a modulation when the frequency range of modulation is 3 Hz or more.

– Above 500 Hz the ear can discriminate a change at 0.03 semitones (this equals 1 Hz at 500Hz).

–The ear is much more accurate in judging changes of pitch that it is in judging changes of intensity.

–*The missing fundamental effect* – The ear hears tones as having a fundamental frequency, even though there is no actual vibration of this frequency present in the sound. Example – a tone that consists of harmonics of frequencies 200 Hz, 300 Hz, 400 Hz, etc. will have a pitch corresponding to the fundamental frequency of 100 Hz.

Absolute Pitch

–*Absolute Pitch*– the ability to name the pitch of a tone without having to compare it to any external standard (also known as perfect pitch).

Backus: Chapter 8 Notes

Intervals, Scales, Tuning, and Temperament

Intervals & Scales

– Scale – an array of chosen frequencies
– Note – an individual frequency in this array

– Consonance – Pythagoras postulated that two sounds will form a consonant combination if their frequencies are in the ratio of 1:1, 2:1, 3:2, or 4:3

– Unison = 1:1 – 2 tones of the same frequency

– Octave = 2:1 – 2 tones, 1 frequency twice the amount of the second
example – 230Hz and 460Hz

– Fifth = 3:2

–Fourth = 4:3

– To find a fifth from a given frequency, multiply that frequency by 3/2
To find a fourth from a given frequency, multiply that frequency by 4/3

– To find the frequency ratio of the inversion of an interval, multiply the smaller figure of the interval ratio by 2. (example– a Fifth = 2:3 ; inversion = (2 x 2): 3 = 4:3 = a Fourth)

Pythagorean Pentatonic Scale

C	D	F	G	A	C
f	(9/8)**f*	(4/3)**f*	(3/2)**f*	(27/16)**f*	2**f*

Pythagorean Diatonic Scale

C	D	E	F	G	A	B	C
f	(9/8)**f*	(81/64)**f*	(4/3)**f*	(3/2)**f*	(27/16)**f*	(243/128)**f*	2**f*

– *Enharmonic Equivalent* – 2 notes are the same sounding pitch, but are spelled differently. examples – C# = Db; Cb = B; F# = Gb, etc.

Pythagorean comma

– If you follow the procedure of creating a circle of fifths using the Pythagorean system, starting from “F” (F – C – G – D – A – E – B – F# – C# – G# – D# – A# – E#),

you return to the enharmonically equivalent note “E#” BUT the E# will be higher in frequency than the original “F.” This difference is call the *Pythagorean comma* and has a ratio of 531441 : 524288.

Cent = 1/100 of a tempered semitone

examples – octave = 1200 cents (12 semitones)
fifth = 700 cents (7 semitones)
semitone or minor second = 100 cents

Other Consonances

– Just intervals – intervals made from ratios of small whole numbers:

Major Third = 5:4

Minor Third = 6:5

Minor Sixth = 8:5

Major Sixth = 5:3

Meantone Tuning

As thirds came into more widespread use, musicians found that Pythagorean major thirds sounded unpleasantly sharp and the minor thirds flat.

In this temperament the major thirds are perfectly in tune and the fourths and fifths slightly compromised — except for one hideously catastrophic fifth, usually between G# and Eb, the famous 'wolf.' However, this is now a 'regular' temperament, for in keys with less than four accidentals the notes of the major scale are in the same relative positions, the thirds all pure. This, for the first time, allows the composer freedom to include harmonic modulation in one direction or another. This is also known as “quarter comma meantone tuning” for the adjustments made to the Pythagorean tuning.

–In meantone tuning the intervals C–D and D–E are both Pythagorean whole tones flattened by half a comma. This puts D halfway between C and E, hence the reason for the name *meantone.*

– Pythagorean Scale vs. Meantone Scale

Number in parentheses denotes the amount sharpened (+) or flattened (-) of *syntonic comma (syntonic comma* = 81/80, or 22 cents ; + 1/4 = about 5 cents)

Pythagorean							
C(0)	D(0)	E(0)	F(0)	G(0)	A(0)	B(0)	C(0)

Meantone							
C0	D(-1/2)	E(-1)	F(+1/4)	G(-1/4)	A(-3/4)	B(-5/4)	C(0)

The Just Scale:

–The use of major and minor thirds resulted in the development of a very important three-note combination – the triad

Major Triad = 1 : (5/4) : (3/2) or 4 : 5 : 6

–Building a just scale

F	A	C				
		C	E	G		
				G	B	D
2/3	5/6	1	5/4	3/2	15/8	9/4

-The diatonic just scale

C	D	E	F	G	A	B	C
1	9/8	5/4	4/3	3/2	5/3	15/8	2

(minor triad = 10 : 12 : 15)

Tempered Scale:

With the further development of music in the direction of more free modulations into more remote keys, the meantone scale became too restrictive, so it became necessary to develop a more practical scale. Thus, the equal division of the octave into 12 parts give us the math of a semitone being a = $(2)^{1/12}$ = 1.05946. Since the semitones are all the same size in the tempered scale, it follows that all intervals will be the same, regardless of their position in the scale.

Intonation in Performance:

From time to time further suggestions are advance regarding possible new tunings and keyboard construction. These are based on the assumption that it is desirable to use just intonation if at all possible. In addition to arguing the superiority of this intonation, Helmholtz declared that string players, when unfettered by the necessity of playing with a keyboard instrument, actually used just intonation, and cited tests made on the playing of famous violinists to support this statement. His authority prevailed for some time; even today, many musicians believe that good string players performing by themselves without the piano, play the just intervals rather than the tempered. With modern acoustical equipment it is possible to measure the intervals actually played – it has been found in both in solo and ensemble performance that musicians tend toward the Pythagorean intervals rather than the just intervals (pp. 149-150).

Standard of Pitch:

By the middle of the 18th century, a frequency of A had settled down to somewhere in the range of 415 to 428; Handel's fork, for example was 422.5 Hz. Over the years the frequency of standard A had gone up... toward the end of the 19th century the standard A had gone as high as 455 Hz in England and even up to 461 Hz in the United States. In 1953 the International Standards Organization recommended the adoption of A-440 as the standard frequency throughout the world. Even this is ignored by major orchestras throughout the world, which is problematic for instrument builders. Additionally, singers should be aware that they are singing the arias in the operas of Mozart and Beethoven about a semitone higher than the pitch for which there were written (pp. 150-151).

Intonation:

The tempered scale serves as the standard for tuning pianos and organs and for the building of wind and brass instruments. What the musician calls the intonation of one of these instruments is the degree to which its playing frequencies conform to those of the tempered scale (p. 155).

example – an oboe's A can vary as much as 20 cents above or below A-440.

Theories of Consonance:

Feelings of what constitutes consonance are a matter of musical training.

There is no acoustic or psychological reason why the key of Eb major should sound "serious and solemn" and the key of E major should sound "expressive of joy." (p. 158)