



## Voice Science – Acoustics

Spring 2011

### Some terms you should know before Dr. Sargent's visit

NB - Many of these definitions are off the top of my head, and may not be clear or complete. If they are not enough for you to understand the term, look it up.

**Acoustics** – The science and study of sound

**Intensity** – power passing through an area perpendicular to the direction of a sound wave (can be measured in watts per square meter or decibels.) Related to **sound pressure** (proportional to its square)

**Sound pressure** – in air, the force air molecules exert on each other. Rapid variations in pressure may be perceived as sound.

**Flexibility and Elasticity** - Flexibility is the ability to bend, not stretch. Elasticity is the ability to distort dimensions and return to the original size and shape. A belt is flexible. Air is elastic.

**Amplitude** – measurement of the variation of sound pressure in a sound wave, usually from ambient pressure to its peak

**Volume** – measurement of space; measurement of sound amplitude

**Loudness** – our perception of amplitude

**Pitch** - our perception of frequency

**SPL** - sound pressure level

**0 dB** – a reference level; usually either the quietest sound perceivable by the average person (**Threshold of Hearing**) or the maximum signal level an electronic device can handle without distorting. Actual signal level measurements are stated as positive decibels (above the hearing threshold) or negative decibels (below the saturation level of an electronic sound device). Usually measured at 1 KHz.

**Threshold of pain** – the minimum sound pressure level which is perceived as pain rather than just loudness. Somewhere around 120-140 dB. Hearing damage will result from exposure to much lower sound pressure levels

**Timbre** – Sound quality; dependant on presence and relative strength of overtones in a complex sound

**Spectrum** – frequency spectrum; a graph showing the instantaneous distribution of the energy of a sound over a range of frequencies (timbre); also called **Power Spectrum**.

**Spectrogram** – a display of spectrum over time. Time is the horizontal axis, frequency is the vertical axis and level is represented by the color or grayness of the display lines

**Sine wave** – a smooth waveform. In Cartesian coordinates, the x axis would be degrees of rotation around a circle and the y values of the curve would be proportional to the sine of an angle of x degrees. An audible sine wave has no overtone content, and is the building block of all complex sustainable sounds

**Harmonic series** – the relationship of the sinusoidal components of a harmonic sound. The lowest frequency is what we identify as the pitch of the note, and is called the **fundamental**. The other frequencies present in the tone will be integral multiples of the fundamental frequency and, if perceived individually, would be at set musical intervals above the fundamental *and* from each other (octave, P5<sup>th</sup>, P4<sup>th</sup>, M3<sup>rd</sup>, m3<sup>rd</sup>, etc.)

**Harmonic** – a partial from the harmonic series

**Overtone** – a timbral component higher than the fundamental (doesn't need to be harmonic)

**Partial** – a frequency component of a complex sound

**H1** – the first harmonic, which is also called the **fundamental**. It is the same frequency as FO

**Fo** (also written **FO** and said 'F zero') – The fundamental frequency of a harmonic tone

**F1, F2, F3, F4, F5** – the formants produced by the first five resonant modes of a tube. For a smooth, regular tube the length of the vocal tract and closed at one end, these will be approximately 500, 1500, 2500, 3500, and 4500 Hz (cycles per second). Because the vocal tract is irregular, F1 – F5 will not be spaced evenly.

**F1, F2 (& sometimes F3)** – the vowel determining formants. They can be tuned to frequencies between 200 and 2000 Hz (approximately)

**F3, F4, F5** – two or three of these formants may be clustered around 2500-3200 Hz to produce the singer's formant. In Shakespearean stage speech and musical theatre style singing, the cluster is less tight and F5 may be around 3500 Hz.

**Wavelength** – the distance between equivalent (in phase) points in a repeating (pitched) waveform. Wavelength is inversely proportional to frequency, and their product is the speed of sound.

**Period** – the time required for one wavelength of sound to pass a given point; the inverse of frequency

**Phase** – a specified point in the compression/ rarefaction cycle of a sound wave.

**Fourier analysis** – the breaking of a complex, sustained sound into its sinusoidal components

**Noise** (transient, pink, white) – an imprecise term for sound. Noise might be defined as the non-harmonic portion of a harmonic sound, or random vibration, or transient sounds. White noise is a random collection of sine waves at all frequencies, amplitudes and phases, which results in random motion of air molecules past a reference point and sounds like a hiss. Pink noise is white noise that has been filtered so that its intensity is lower in higher frequency bands

**Vowel synthesis** – the electronic construction of a vowel sound by adding sine waves of different frequency and amplitude together (one method).

**Voice synthesis** – electronic generation of a sound similar to the glottal waveform which is then filtered (electronically/digitally) to represent the effects of vocal tract resonance. Madde is a voice synthesis program available from KTH.

**Formant** - a fixed pitch area of resonance; vocal formants result in vowel sounds and vocal "ring".

**Waterfall plot** – a spectrographic graph that looks like mountain ridges, with the peaks representing the strongest frequency components. Not to be confused with the **Watergate plot (J)** – an illegal attempt to spy on Democrats in the early 1970's

**Wavelength** – the distance between adjacent in-phase points in a repeating waveform.

**Helmholtz resonator** – a spherical resonator with a neck (and sometimes a listening port) which responds to a single frequency. Its resonant frequency is determined by the size of the cavity and the length and diameter of the neck.

**Resonator** – a device which responds to a sound source (excitation) and makes it louder by adding a waveform to its earlier repetitions in phase. A resonator responds to a particular frequency better than others. A response may also be forced, as in the sounding board of a piano.

**Filter** – a device which responds unevenly to sounds of different frequencies. It may attenuate some frequencies while reinforcing others at the same time.

**Vowel** – a sustainable sound produced by a relatively unrestricted vocal tract.

**Consonant** – a sound produced by constriction along the vocal tract

**FFT** – Fast Fourier Transform

Joseph Fourier (1800's, friend of Napoleon) discovered that any repeating waveform can be broken down into sinusoidal components. FFT does this digitally. The results are displayed on a spectrogram

**LTAS** – Long Term Average Spectrum

The average spectrum of a longer (user determined) sound sample. A long sample yields a voice print which cannot be disguised and is distinct from other voices' voice prints. A short LTAS sample provides a more reliable spectrum than a single instantaneous sound sample, which may not be representative of the perceived sound.

**LPC** - Lineal Predictive Coding

A smoother version of an output spectrum than FFT produces. Often corresponds more closely to the resonant characteristics of the vocal tract.

**Coupling** – the amount of influence a resonator has on a vibrator or two resonators have on each other

**Formant** - A FIXED PITCH AREA OF RESONANCE

**Standing wave** – a pattern of sustained vibration in a resonator as described above. It is caused by waves of the same amplitude and frequency moving in opposite directions. The waves reinforce and cancel each other at stationary points along the tube.

**Velocity Node** - a place along a tube where a standing wave (a wave at one of the tube's resonating frequencies) produces minimum air movement. This is also a point where the pressure experiences maximum change during the vibration cycle.

**Antinode** (velocity)- a place along a tube where a standing wave produces maximum air movement. The antinode as also a place of minimum pressure variation

A velocity node is also a pressure antinode.

A velocity antinode is also a pressure node.

**Vocal Tract** - a tube closed at one end (at glottis) with numerous resonant modes

**EGG** – Electroglottogram; measures “resistance” @ RF across the glottis; more contact = more signal (less resistance); used to measure open and closed phase of glottis