Psychoacoustics lecture notes

-Outer ear:

-pinna helps to capture, focus sound. Also very useful for localization and filtering.

-Resonant frequency of around 3k corresponds to human speech, adding as much as 20dB (30 to 100 fold) of gain between 2.5k -7k. This is a double edged sword, meaning our ears are tuned to human speech, but that hearing loss usually occurs first in this range.

-Middle ear:

-Contains the three smallest bones in the body, Malleus (hammer), Incus(anvil), and Stapes(stirrup). Their function is to transmit the pressure waves reaching the eardrum into fluid-membrane waves in the inner ear.

-Serves to match impedance between the inner and ear makes sure that the sound reaching our eardrum is efficiently transferred to the fluid of the inner ear. It does this by using the tiny ossicles as a lever, concentrating the sound that hits the much larger eardrum down to much smaller area of the stapes that attaches to the inner ear.

-Stapes attaches to the oval window of inner ear

-Acoustic Reflex is the ability of the ossicles to stiffen, which makes it less effective and protects the ear from high SPL, or sudden jerking movements.

However, this only works for slow onset and low frequency sounds(up to 1.2k), not with things like music.

-Inner ear:

-2 systems, one for balance, one for hearing

-The spiral shaped cochlea(35 mm long if stretched out)contains a water-like fluid, and takes the transmission from the Stapes through the oval window and funnels the sound down in twisted length. The spiral shape, long thought to be irrelevant in how sound travels in it, actually creates higher sensitivity by focusing the sound near the outer edge as the turns get tighter. Each spot along the cochlea is most sensitive to a specific frequency(characteristic frequency).

-The sound reaches the Organ of Corti, which contains the hair cells that translate the wave energy into electrical signals.

-Organ of Corti has inner hair cells (IHC's) and outer hair cells (OHC's). The IHC's actually turn the mechanical vibrations into nerve impulses, while the OHC's change their shapes to add or attenuate the signal, making the IHC's much more sharply tuned to their characteristic frequency.

-This movement of the OHC's, along with acoustic reflex, make our ears active devices, as opposed to passive microphones. The OHC's consume a lot of energy and nutrition, and are usually damaged before

the IHC's. When this happens, our hearing not only becomes less sensitive, it becomes less sharp. This is why simply adding gain for hearing loss patients is not sufficient to solve the problem.

-Frequency Selectivity

-at higher SPL, the characteristic frequency selectivity of the IHC's decreases, meaning that one loses the ability to discern between different frequencies. Thus, when listening to music, one should play back at a relatively low level.

-above 60 dB, as level increases, the characteristic frequency decreases. Thus, when one hears a tone at a high level, the IHC's that are normally tuned to a higher characteristic frequency are now best tuned to pick up that tone. Since the brain does not know that the characteristic frequency has decreased, it perceives the pitch to be sharper than it actually is.

*Possible Demo

**********announcements: turn in grading menu and 3 picks for songs by next Wednesday, Friday show, quiz redo

-Masking

-simultaneous masking

-forward masking (masker starts and end before a signal is played). Works up to 100ms after the masker has stopped

-backward masking (masker starts AFTER the signal has been played). Works up to 20ms after the signal has stopped.

-Masking is very useful for audio encoding. By taking advantage of masking effects in recordings, much information can be cut out since people are not going to be able to hear those things anyway. This saves a lot of data space, making mp3's much smaller than full format audio files such as wave or aiff.

*Demo

-Auditory Filters and Critical Bandwidths

-when listening to a noise at constant SPL, increasing the bandwidth of the signal will not change the perceived loudness of the signal until a certain threshold is reached, after which loudness will increase even though the SPL is unchanged.

*Demo

-Phase Locking

-for some time, people thought we could not detect phase differences. Even Ohm thought so. However,

these results have been traced to faulty experimental methods. Actually, it's quite important.

-Auditory Area

-Under the best conditions, a person with good hearing can discriminate about 1400 different pitches, of which 120 are used in the western scale of equal temperament.

-Loudness vs. Level

-Fletcher Munson curves illustrate equal loudness contours for different frequencies.

-This means that subwoofers must be played at high levels to achieve strong bass sound. The consequence of this is masking mid and high frequencies.

-This also explains why playing back recordings at low level will make it appear that very low and very high frequencies are missing.

-Takes into account the frequency response of our ears, and therefore is a better scale than SPL to account for loudness

*Demo

-Pitch Perception

-a subjective quality that depends not only on frequency, but on SPL and the waveform of a signal as well.

-range of pitch is from 20Hz – 5kHz

-Pitch is binaural, an addition of what both of your ears hear put together in your brain

***Demo

-Steven's rule

-equal frequency intervals do not always give the same sense of pitch distance, depending on the RANGE in which the interval is situated. For instance, a FIFTH in a high frequency range may seem to be a smaller pitch distance than a THIRD in a lower range.

-Frequency, for instance, although it is a continuously variable PARAMETER, is not linear with respect to PITCH, since equal changes in frequency do not result in equal pitch changes. Instead, frequency must be doubled to get equal pitch changes, and therefore the relation may be called *logarithmic*

*Demo (above 5k, virtual pitch)

-Timbre

-What is it? The "color" of a sound. It is what makes a trumpet playing 440 Hz sound different from a piano playing 440 Hz.

-How do you say it? Tam-ber

-frequency spectrum, harmonics, envelope (ADSR)

****Demo Logic sounds of instrments

-2 ears as opposed to 1

-beat frequency

*****Demo of virtual beat frequency

-localization

*****Demo Hass effect

-ITD and ILD

-