MacIntroPsych 1XX3

Audition and Music

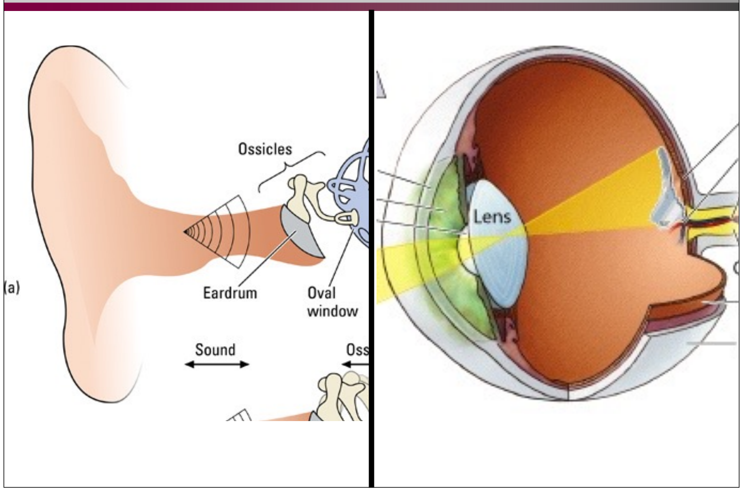
Sound Sensations

McMaster University SCIENCE

Department of Psychology, Neuroscience, and Behaviour

http://www.intropsych.net

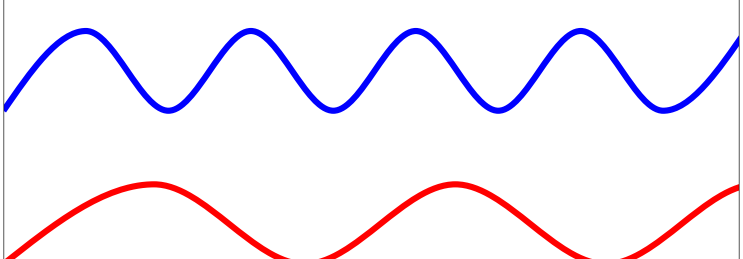
Similarities to Vision



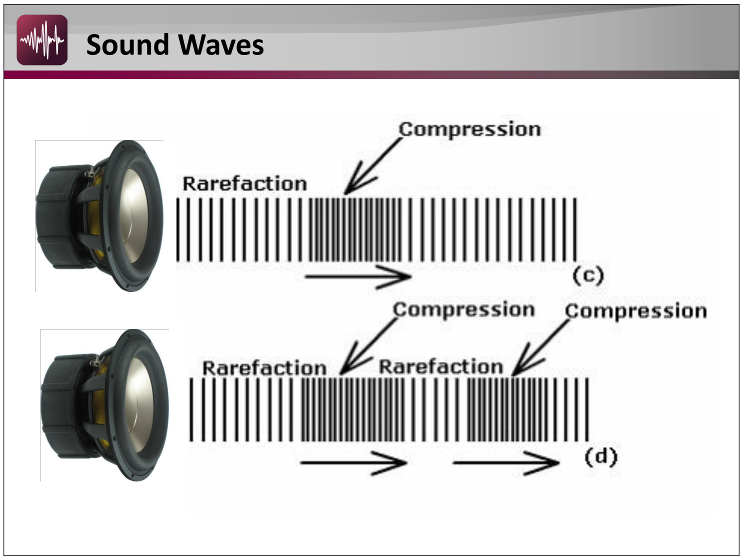
In studying audition, you've likely noticed many similarities to what we have just learned about our visual system. Both have an external apparatus that collects stimuli from the environment and translates it to a neural signal our brain can understand.

Frequency

Frequency is the inverse of Wavelength

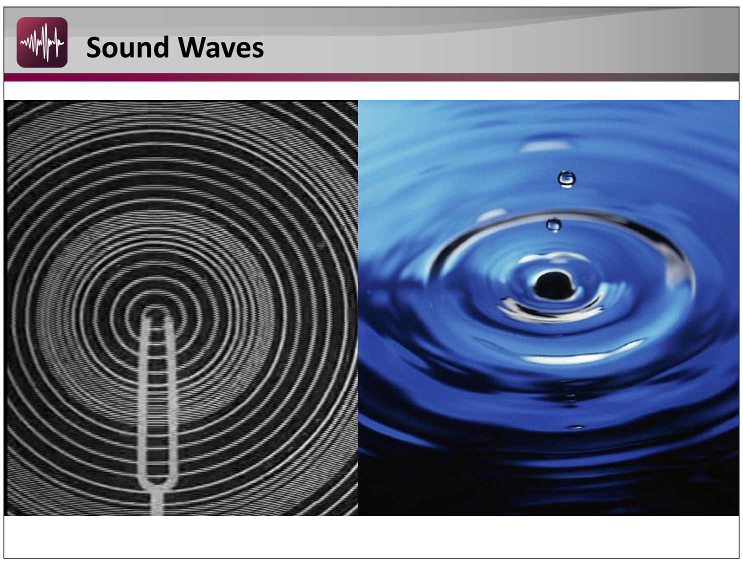


However, there's one difference you might have noted right away---frequency instead of wavelength. In discussing light waves, we talk about wavelength, but for sound waves---which are not electromagnetic, thus need some medium to travel through---we talk about their frequency. Of course, the two terms are very related. If a wave has high frequency or a high number of waves per second, those waves must be very short to fit into the second. Thus, frequency is just the inverse of wavelength!

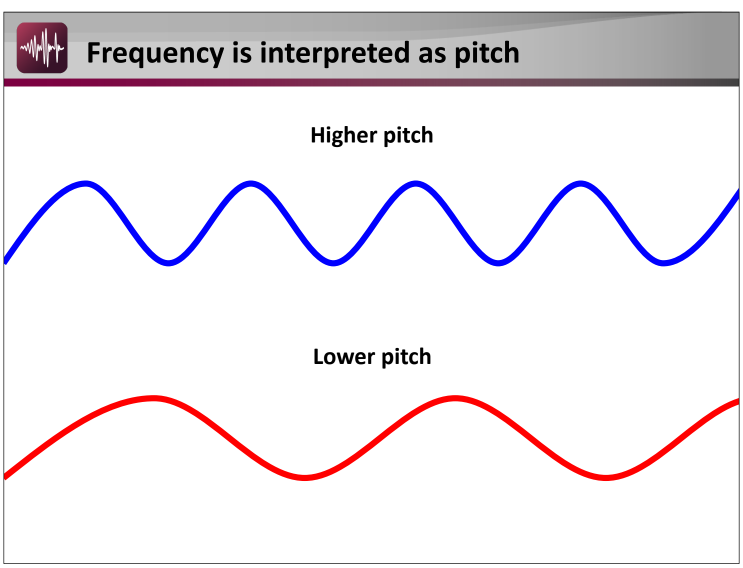


We often picture sound waves as oscillating sine waves like those in the previous slide, however the waveforms produced by sound transmitters are of a different type. When the speaker here moves forward it causes air molecules in front to be pushed closer together causing an area called a compression. When the speaker then moves backward, the air molecules are pulled farther apart causing an area called a rarefaction. It is this pattern of compressions and rarefactions that transmits sound to the tympanic membrane, or eardrum.

Here's another difference between light and sound---with light, there are photons which move sometimes great distances (such as the light from stars traveling to earth) and these can travel through a vacuum. With sound, the actual molecules do not move great distances, they just squeeze together then apart. They also require a medium to be transmitted and therefor cannot travel through the vacuum of space.

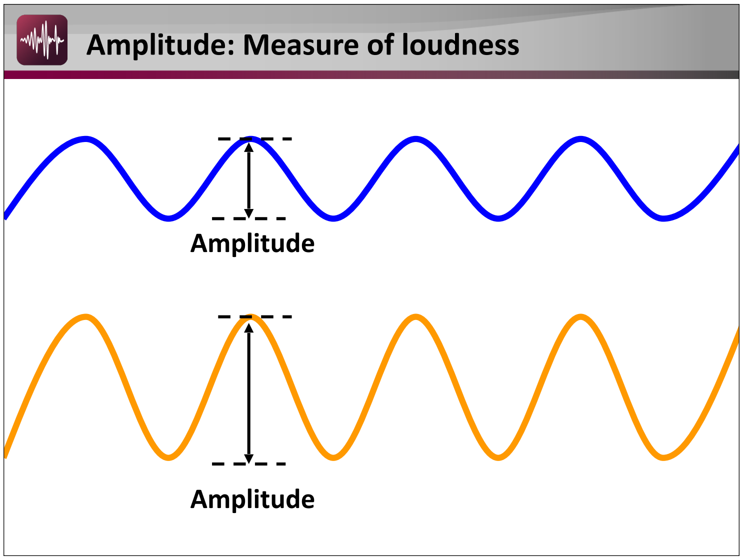


But it's important to remember that, although we often visualize sound transmission as being linear, sound waves radiate outward in all directions, much like the way waves ripple outward on water when you drop a stone in.



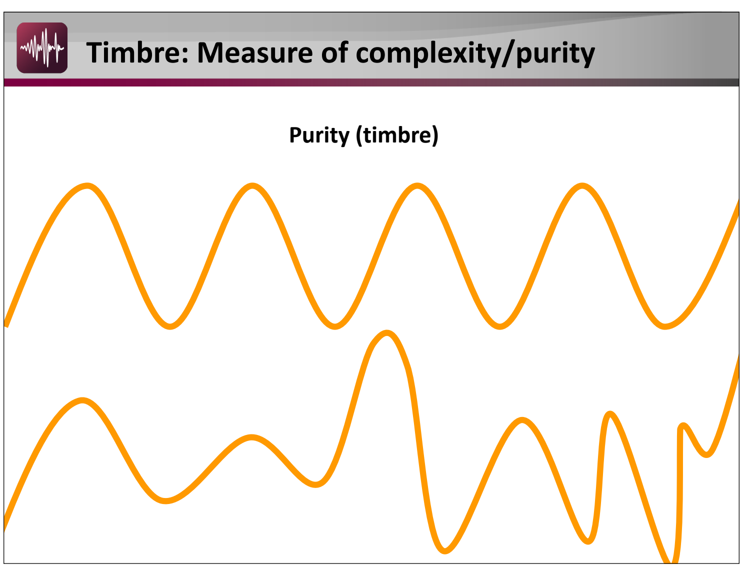
The frequency of these oscillations gives rise to what we call pitch

So a bass guitar is able to create lower frequency sound waves, or lower pitched sounds, than a banjo.



Variations in the **amplitude** or height of a sound wave affect the perception of **loudness**.
Loudness is measured in decibels---a logarithmic scale which means that going from 70 decibels to 80 decibels doesn't increase the loudness by 10, but doubles the loudness.

- Threshold 4db - Mosquito at about 2 meters away
- Whisper 40 db
- Conversation 70 db
- Hockey game 130 db



A **pure tone** (top) is a tone with a sinusoidal waveform. It has a single frequency and wavelength. However this is rarely how we experience sound which is a combination of all the sounds in our environment. In spite of this impurity, our brain sorts things out very well.

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Ear Structure

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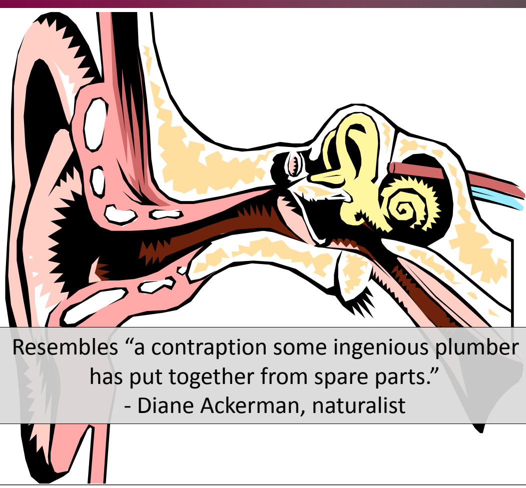
Human Ear

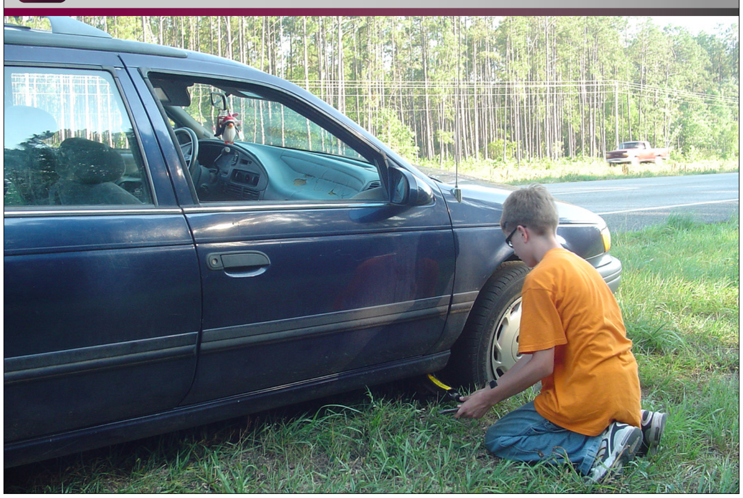


Resembles "a contraption some ingenious plumber has put together from spare parts."
- Diane Ackerman, naturalist

Remember that mosquito we heard at 2 meters? Our eardrum, which picked up the vibration to pass on to the tiniest bones in the human body, actually moved much less than the size of a hydrogen molecule!

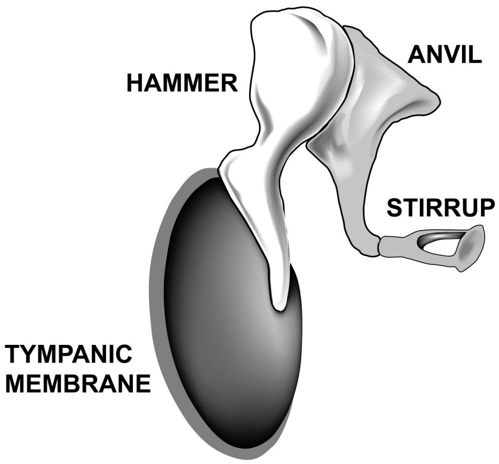
The ear offers a number of challenges… first some signals arriving at the ear drum are very small. Additionally, the inner ear is fluid filled and sound waves, like most things, travel even more poorly through water than they do through air. Thus a system was needed to help amplify the signal arriving at the ear – this is accomplished using levers similar to those which allow a human being to lift a car.

Human Ear



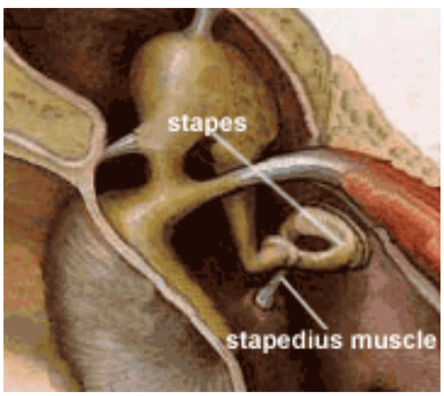
The same way a jack helps amplify human strength to lift a car, our ossicles help to amplify sound.

Amplification



This lever system is comprised of three small bones, the smallest in the body in fact, that resemble a hammer, anvil and stirrup. They're really SMALL as you can see by the human stirrup bone lying on a normal sized penny.

Hearing your own voice



While we may want to amplify the sound of the mosquito we would not want to amplify the sound of the hockey game. Attached to each of the three tiny little bones in our middle ear are tiny little muscles that prevent the bones from moving very much---with no lever to increase the wave energy, there is much less volume. It gives us a tiny bit of protection from loud noises---more so in young people.

Since our ears are pretty close to our mouth, why is it that our own voice doesn't seem much louder to us? In addition to sound energy radiating from our mouths to our ears, it is also transmitted through the bones of our skull. It is this bone conduction that alters the way our voice sounds and explains why we are often surprised by how we sounds when recorded.

Noise induced Hearing Loss

We've all heard of rock musicians who have some or total hearing loss (Ozzie Osbourne), but it is not just those in the "hard rock" world. Opera singers also report hearing loss and violinist show more loss of hearing in the ear closest to their violin.

Noise induced Hearing Loss

The more noise you hear today, the less noise you'll hear tomorrow

There are things your can do to prevent hearing lost:

1) MP3 volume adjusted so that you can hear someone speak to you in a normal voice 1 metre away
2) 5 minute/hour rest from music players
3) Earplugs for: Rock concerts, sporting events…

Like walking on grass, a little bit, the grass recovers; too much—mud

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Music Perception

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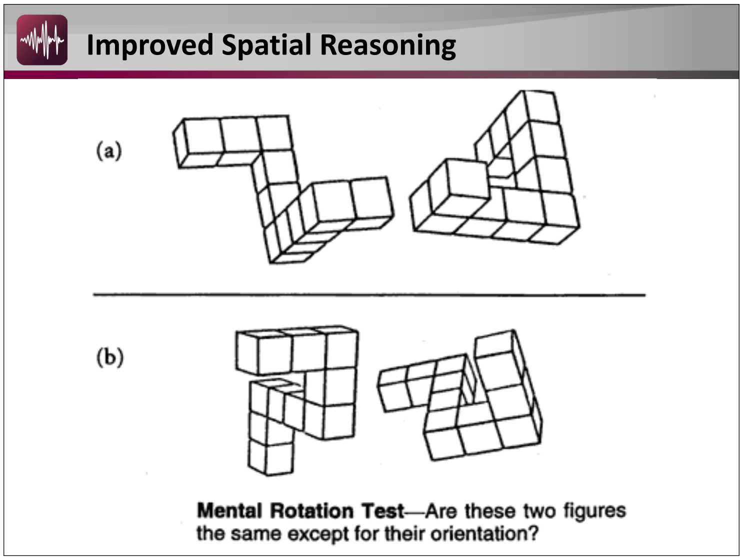
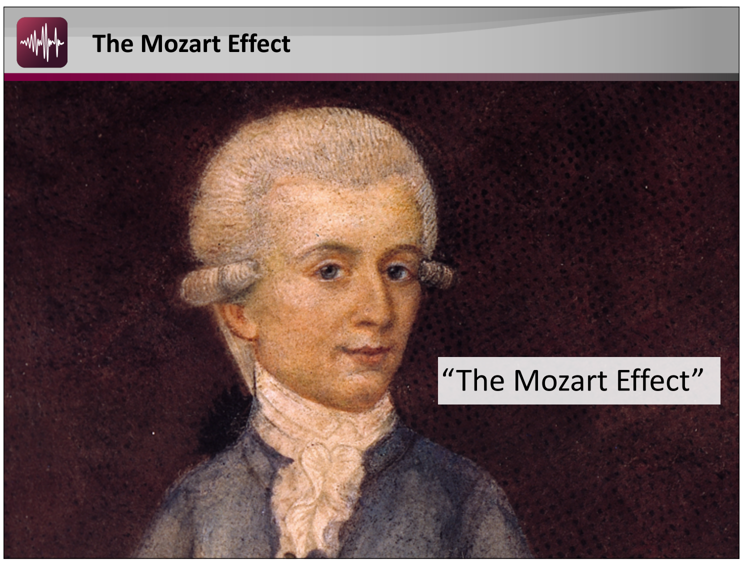
Musician abilities


PHOTO © PETER VISONTAY

Studies of musicians show larger cortical area devoted to music. One study at McMaster showed that this is developed through training rather than being genetic.

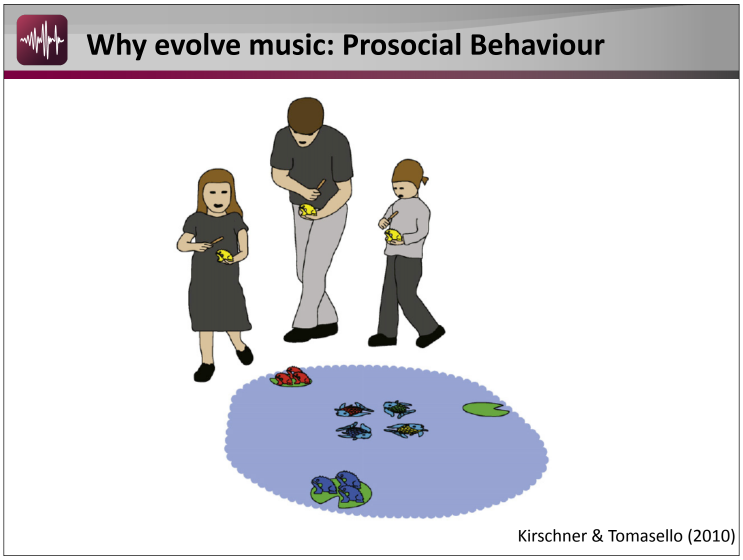


This plasticity is not the only difference found. Musicians test higher on spatial tasks, such as this mental rotation task.



While the Mozart Effect study has been used to promote the erroneous idea that classical music increases intelligence in children it does show a temporary enhancing effect of the music on spatial intelligence scores in adults.

Humans are the only primates that make music. But the evolutionary origins and functions of music are unclear. However there are some compelling arguments.



FROG POND STUDY
Children are place in one of two groups
Group 1: Children created a song and music together about frogs in a pond
Group 2: Children created a story together about frogs in a pond. No musical component.

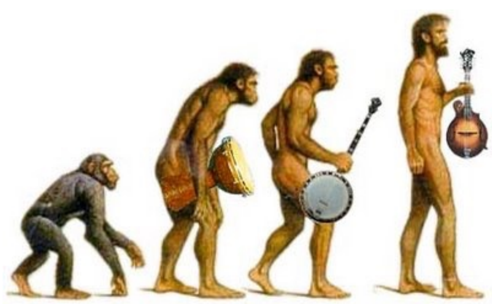
In the second part of the study, children were told to collect some balls which would be used for the next game. One child (a confederate for the study) would purposely drop hers. Experimenters then watch to see if the other children in her group would help pick them up. Children in the Music groups were much more likely to help than those in the story group. Music promoted pro-social cooperative behaviour.

Music can also be used as an intimidation tool. Armies used music as a way to announce their presence and strike fear in the hearts of their opponents. It makes them sound bigger and scarier than they really are.

Why evolve music?

Similar to birdsong? Music has been used in courting rituals for hundreds of years and can make the performing individual more appealing and thus more likely to mate.

How might music evolve?



Are the afore-mentioned factors enough to have driven the evolution of music? Some would argue yes.

Others suggest that music evolved to take advantage of the basis laid down by the evolution of language. There are many parallels between spoken language and music, and the systems which process them. Could our fascination with music merely be an accidental by-product of our brain's fascination with sound and pattern?

What about development?

Babies are born pre-wired with some preferences for music. In fact, research suggests that infants prefer the same musical stimuli and intervals as adult listeners. In fact, infants may be even better at processing musical stimuli than adults!

You may have heard that when we're born, we can differentiate the phonemes from any language, but with experience listening to our native language, we are eventually limited to differentiating only native sounds. This occurs at around 1 year of age. The same is true of music.

Research suggests that infants can process musical scales and beat patterns from any culture, but as we age and experience the native music of our culture, we lose the ability to process foreign musical structures through a process known as **perceptual narrowing**.

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Audition and Music

Music-Related Disorders

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Amusia

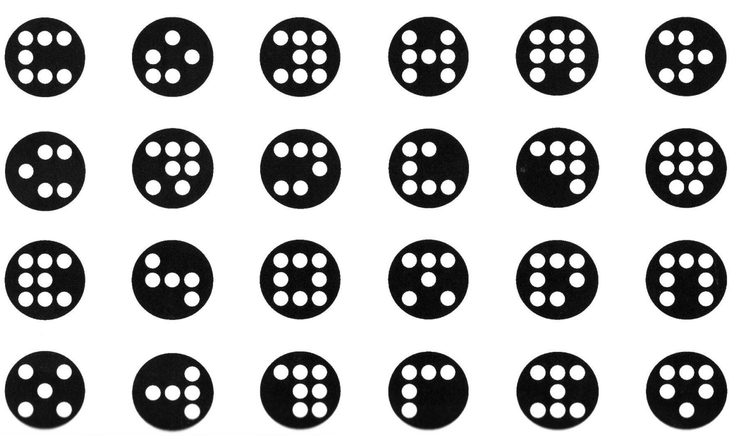
Amusia

- An inability to discriminate pitch
- Also known as tone deafness

On the opposite end of the spectrum from trained musicians are people who have amusia---also know as tone-deafness. Amusia occurs in about 4% of the population and is diagnosed after ruling out deafness, lack of training and low IQ.

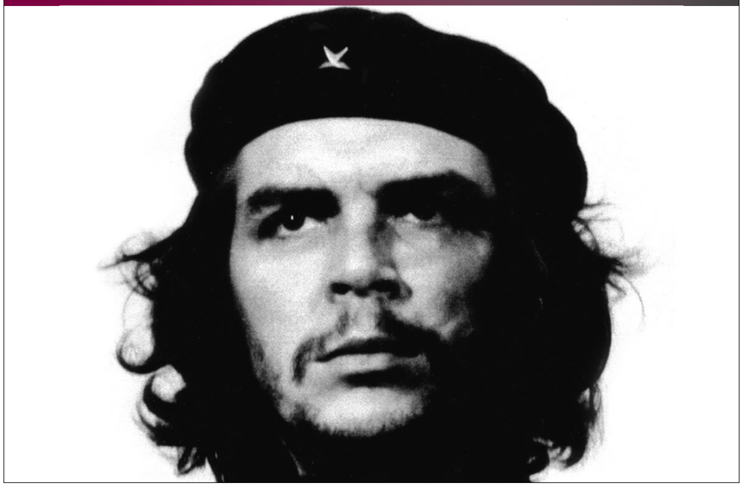
As well as not being able to recognize tones or melodies, people with amusia cannot produce melodies or tones, i.e, they can neither sing nor recognize songs.

Amusia



Research suggests that patients with amusia also have difficulty when it comes to spatial processing tasks. Once again showing a link between music and spatial processing.

Famous Amusic: Che Guevara



Che Guevara was widely recognized as a man of many talents. Yet one talent the 1960s revolutionary lacked was the ability to hear music, a shortcoming he was acutely aware of. According to one account, Guevara was at a party one evening when he spotted a nurse he wanted to dance with. He asked a friend to give him a nudge when the orchestra struck up a tango. But the friend got the signal mixed up, sending Guevara out on the dance floor to dip and swirl his partner absurdly to the tune of a soft Brazilian samba.

Williams Syndrome

Gloria Lenhoff

"This is a gruelling difficult work, with unusual rhythms, awkward melodic intervals, and a text that would push the memory of any soprano at any professional level"

- Maestro Amos

Gloria Lenhoff suffers from Williams Syndrome. She has an IQ of 55, can't make change for a dollar, tell left from right, or cross the street unassisted. However she can sing! Many individuals with Williams Syndrome are drawn to music and display amazing aptitude. In one of her more famous performances, she tackled "Knoxville, Summer of 1915" about which the conductor of the orchestra that accompanied her said the following:

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Music & Emotion

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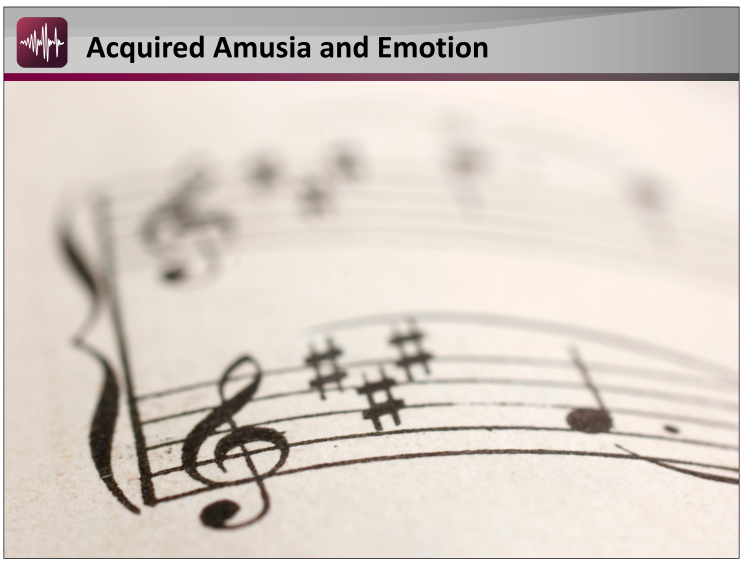
One defining feature of music is emotionality. Music can elicit deep feelings both positive and negative. One reason we like to listen to music is to either enhance or change our mood---we don’t always listen to happy tunes!

See if we can get a consensus in class about whether this tune is happy or sad.

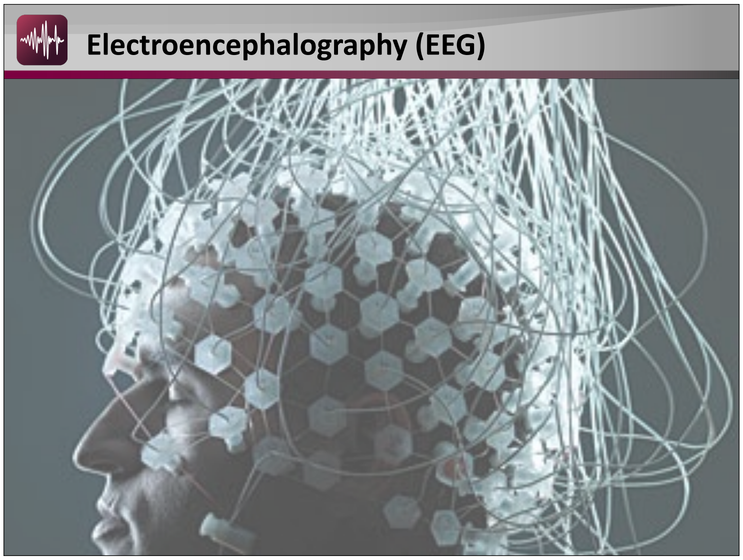


One fascinating case study from the University of Montreal showed some unexpected results. The subject, I.R., had suffered brain aneurisms. The surgery to repair the bilateral damage created lesions in her temporal cortex which had some scientifically interesting results.

On tests, IR measured as having normal intelligence, good recognition and recall. However, she could no longer recognize nor sing songs that she had previously known well. Since her mother was a musician, this deficit could not be attributed to lack of exposure.

Scientists became intrigued when IR reported that she still enjoyed listening to music. They did a series of tests comparing IR to subjects matched for age, education and intelligence and found that, compared to the controls, IR performed very poorly on a series of music tests, including being able to identify if two pieces of where the same or different. However, when the researchers selected several pieces of music that could be categorized as either sad or happy IR was as likely as controls to correctly categorize the

PNB and our music in the mind program



The LIVE lab in PNB and our ability to take EEG recordings from both the performers and the audience.