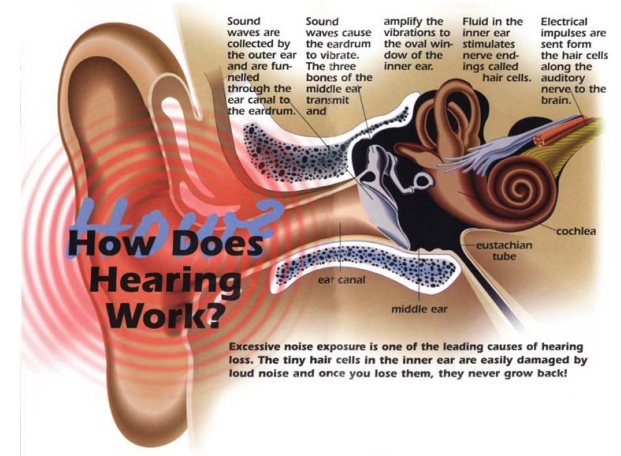




© Can Stock Photo - csp14834491



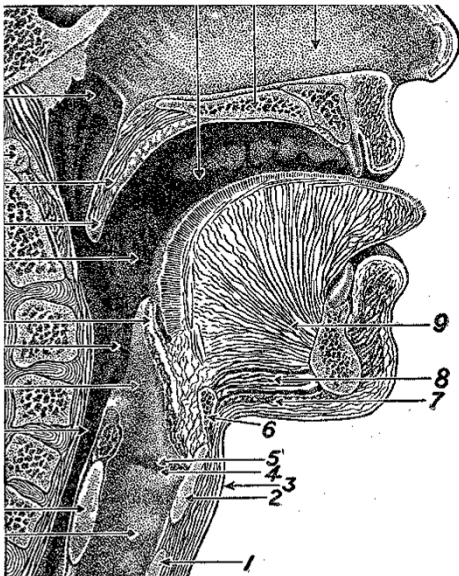
Infocommunication

Sound, hearing and speech

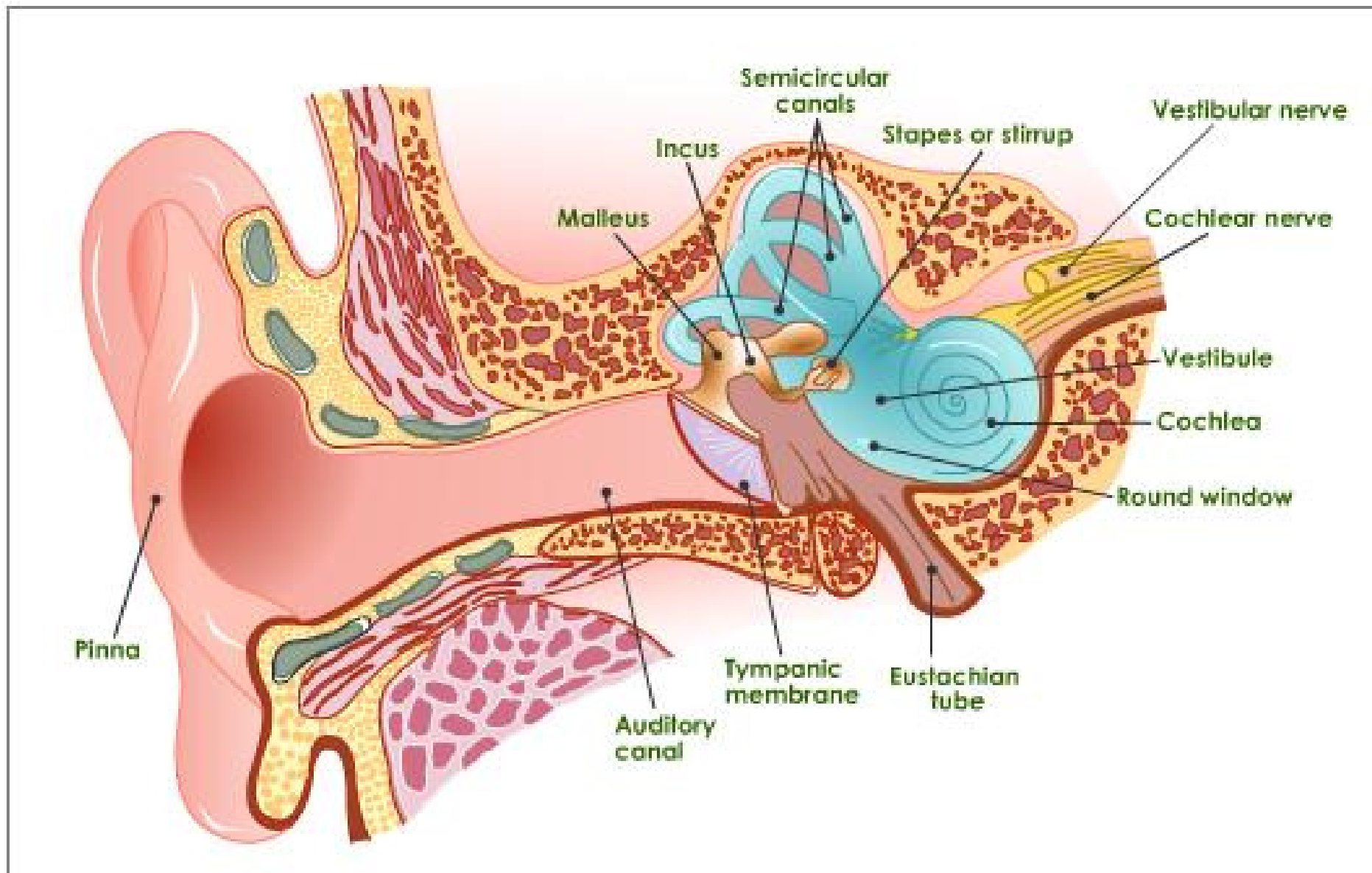
Tamás Csapó

<csapot@tmit.bme.hu>

2018 Spring



Structure of the human ear

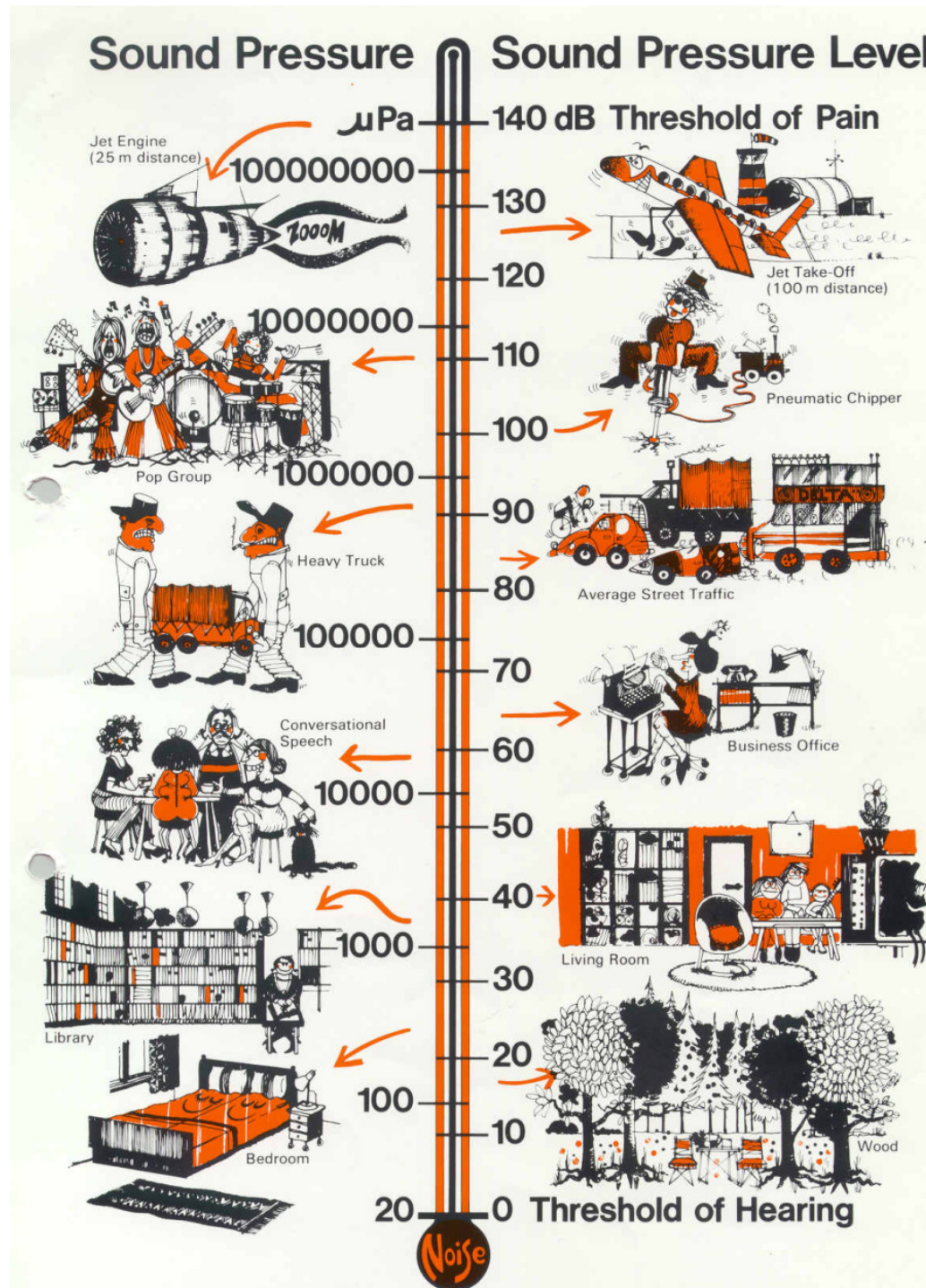


Békésy György / Georg von Békésy

Nobel prize in 1961 (function of the cochlea)



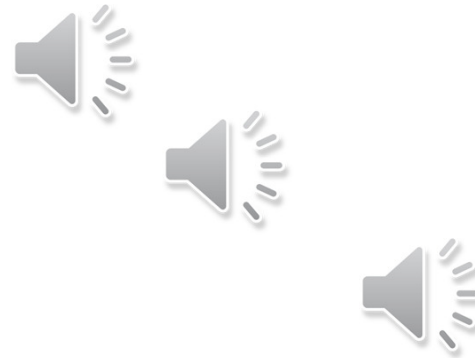
Sound pressure level



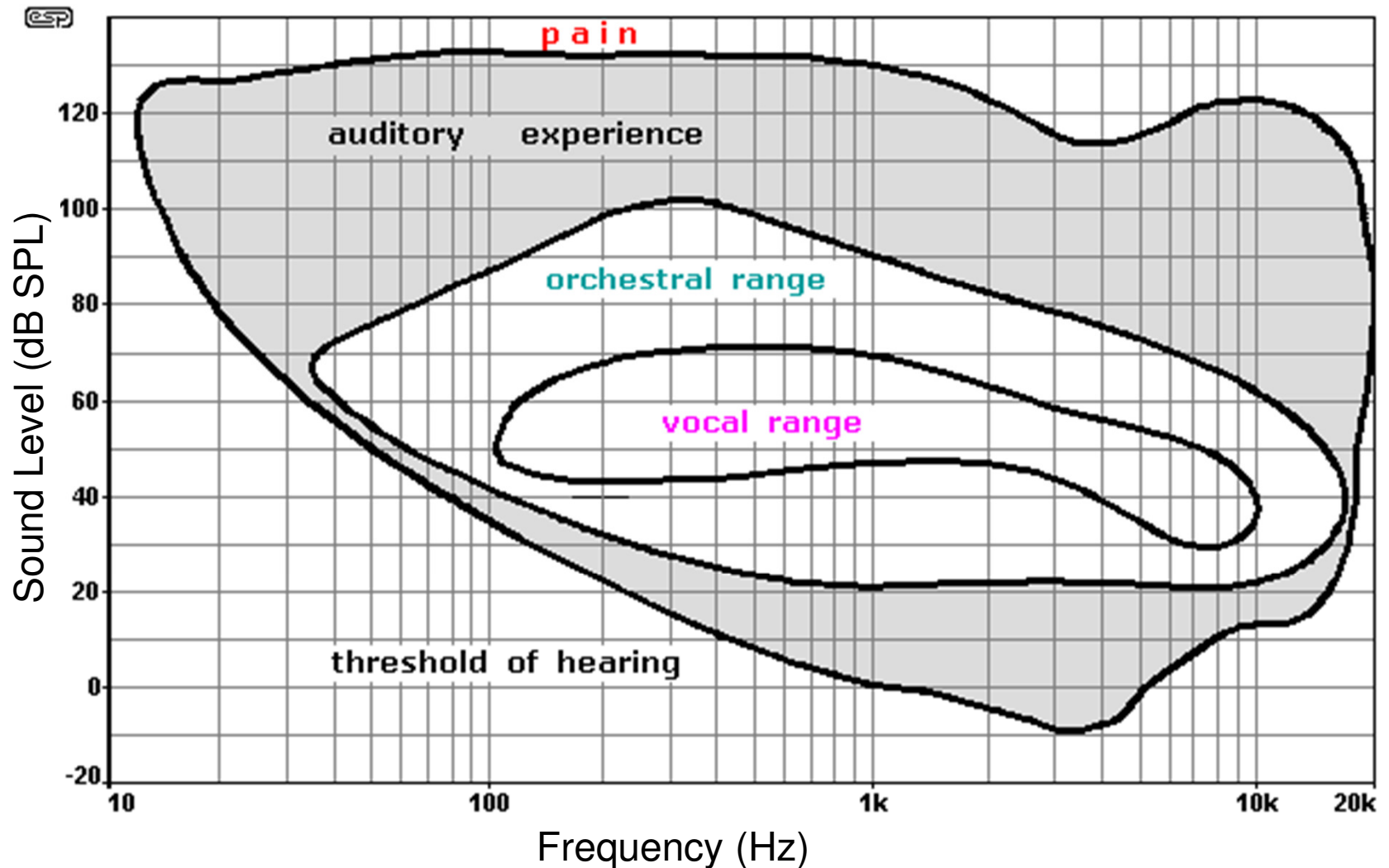
Source:
<http://personal.cityu.edu.hk/~bsapplec/sound.htm>

Sound pressure level

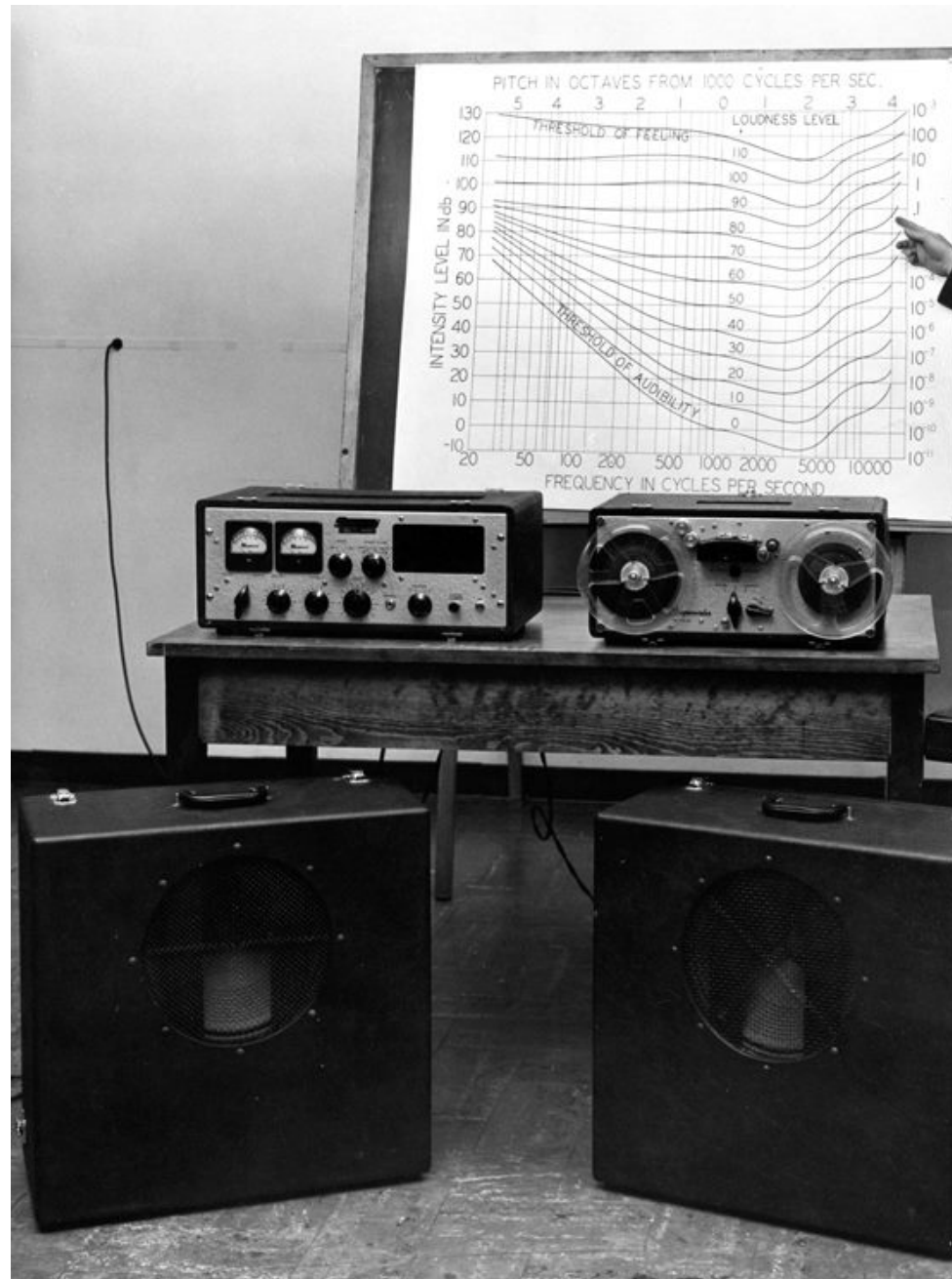
- 440 Hz tone (A4 on musical scale)
 - reduced in 1 dB steps
 - reduced in 3 dB steps
 - reduced in 5 dB steps



Limits of human hearing

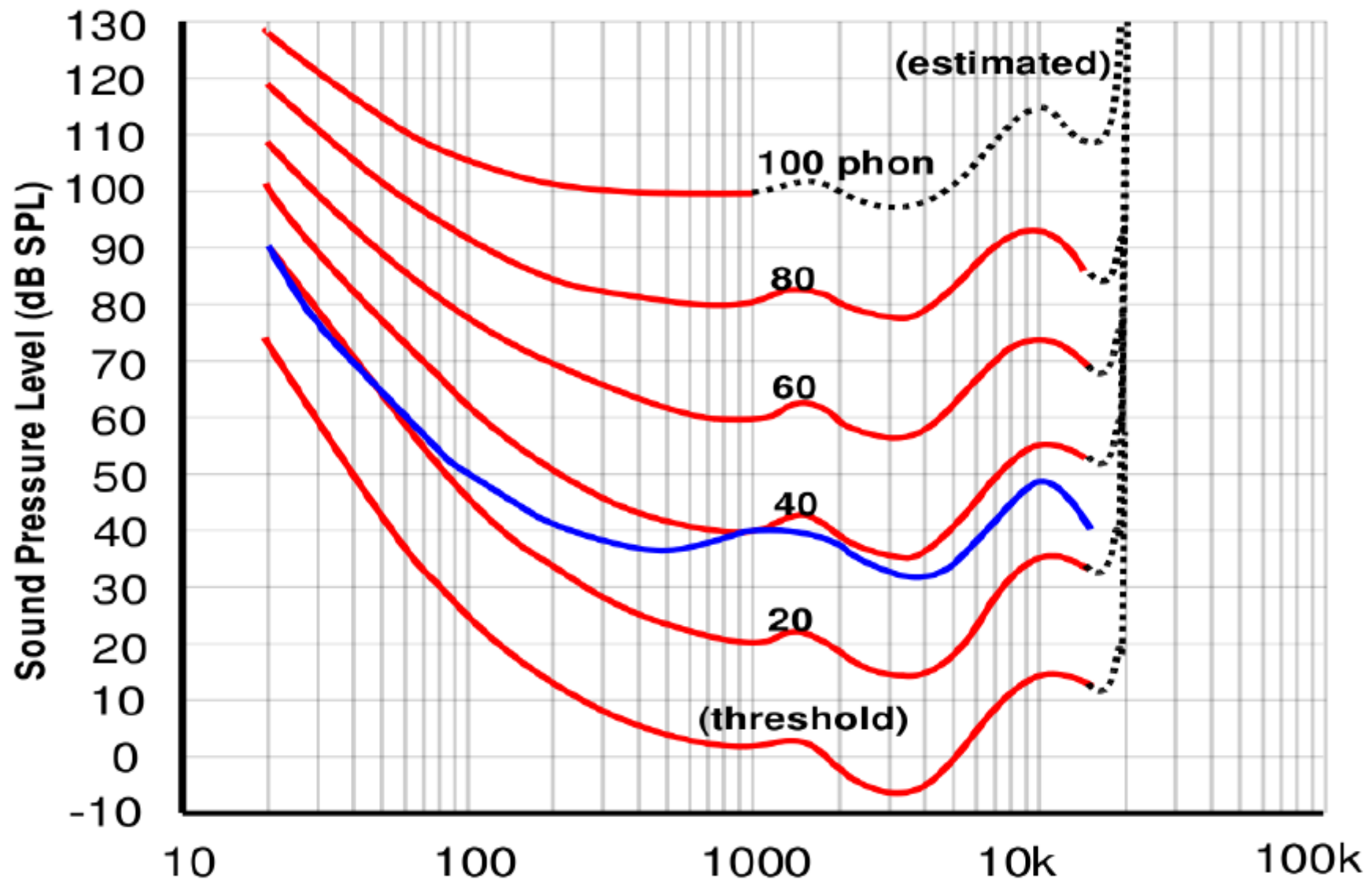


Fletcher &
Munson
1933
experiment



Source: http://www.effectrode.com/wp-content/uploads/fletcher_munson_chart.jpg

Equal loudness contours



Equal-loudness contours (red) (from ISO 226:2003 revision)
Original ISO standard shown (blue) for 40-phon

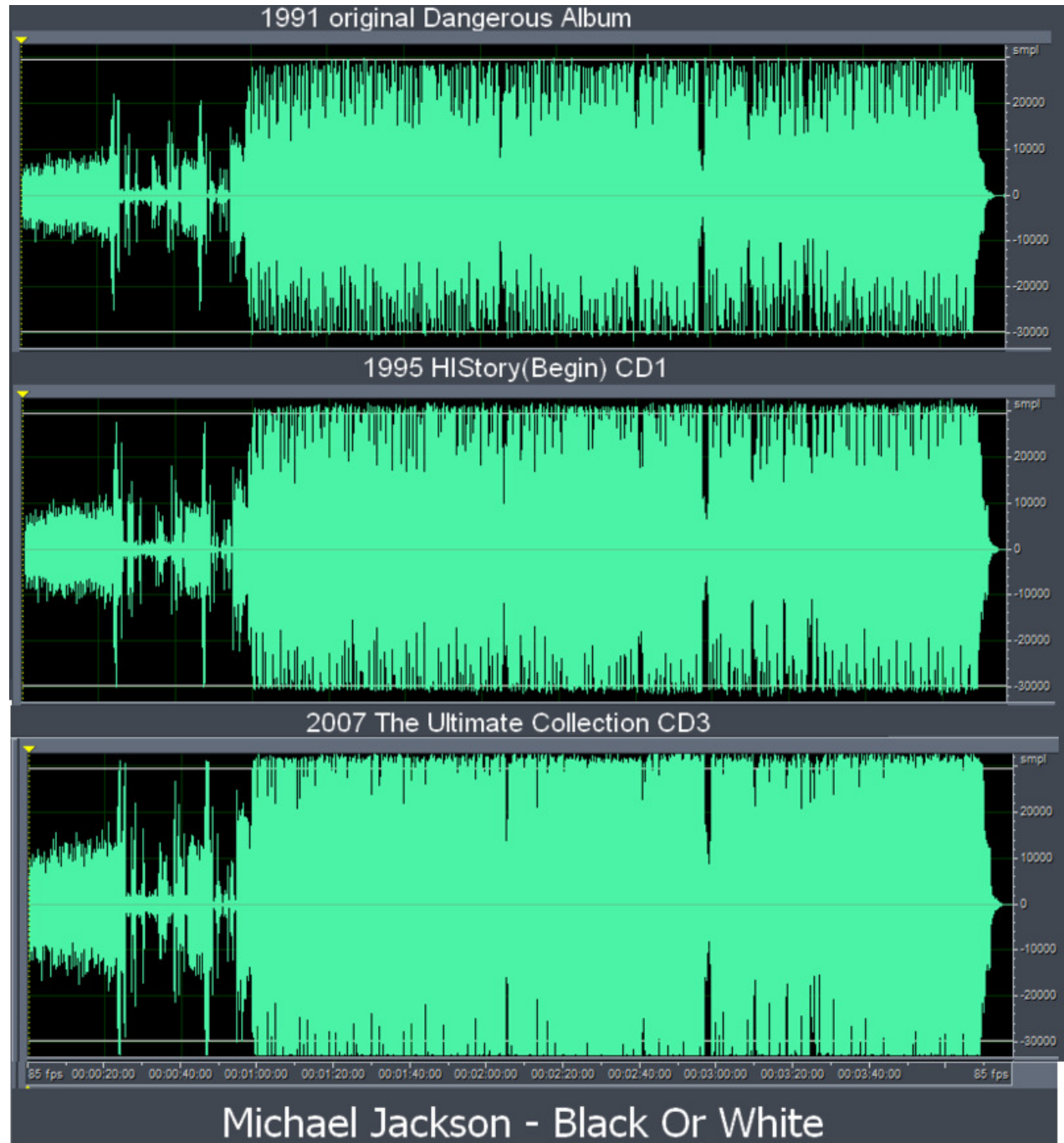
Loudness

- various frequencies at a constant SPL
(the perceived loudness of tones varies at equal sound intensity)
- which tone sounds twice as loud as the reference tone?
 - reference tone + same tone 5 dB higher
 - reference tone + same tone 8 dB higher
 - reference tone + same tone 10 dB higher



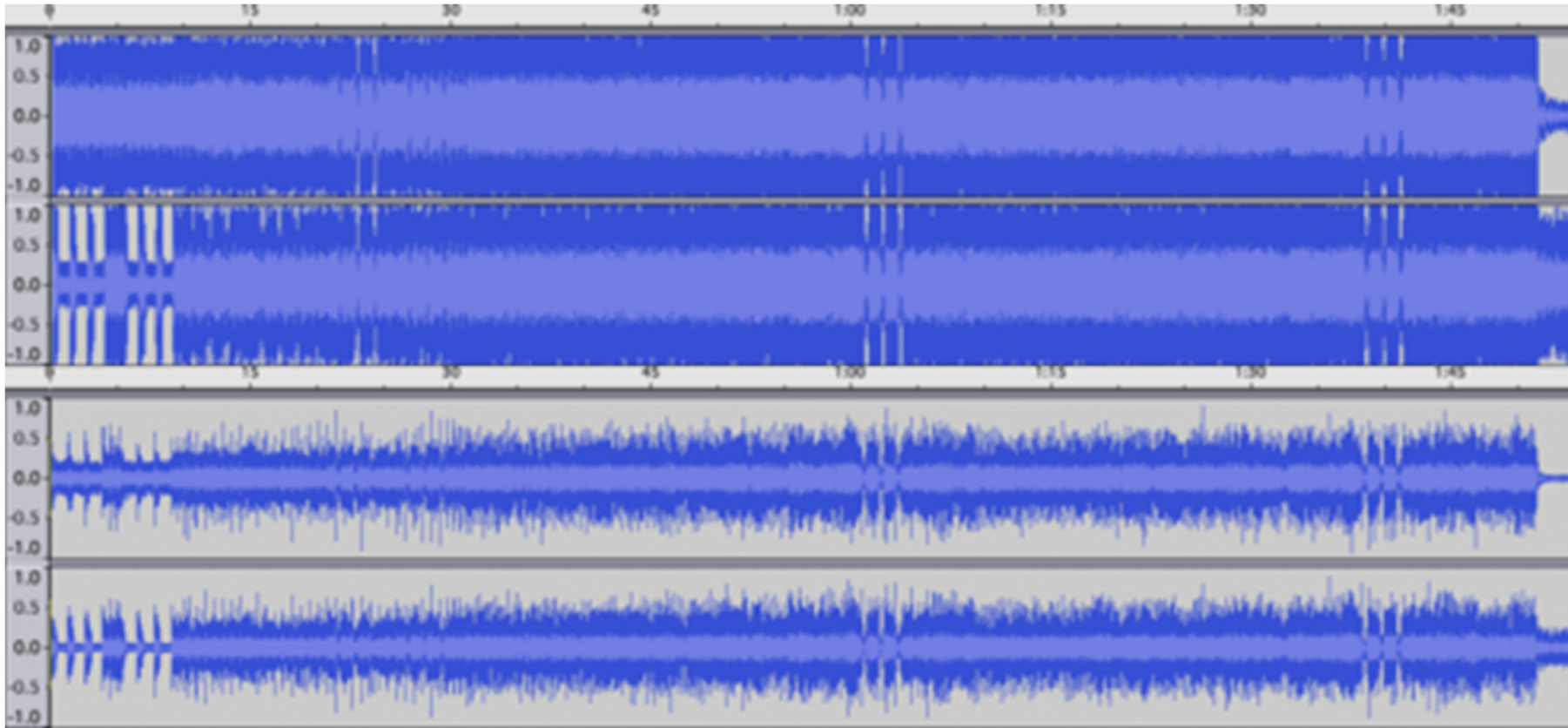
Loudness war

Source:
https://en.wikipedia.org/wiki/Loudness_war



Loudness war

Metallica: Death Magnetic



Source:

https://en.wikipedia.org/wiki/Loudness_war

Loudness war



Source: https://www.youtube.com/watch?v=3Gmex_4hreQ

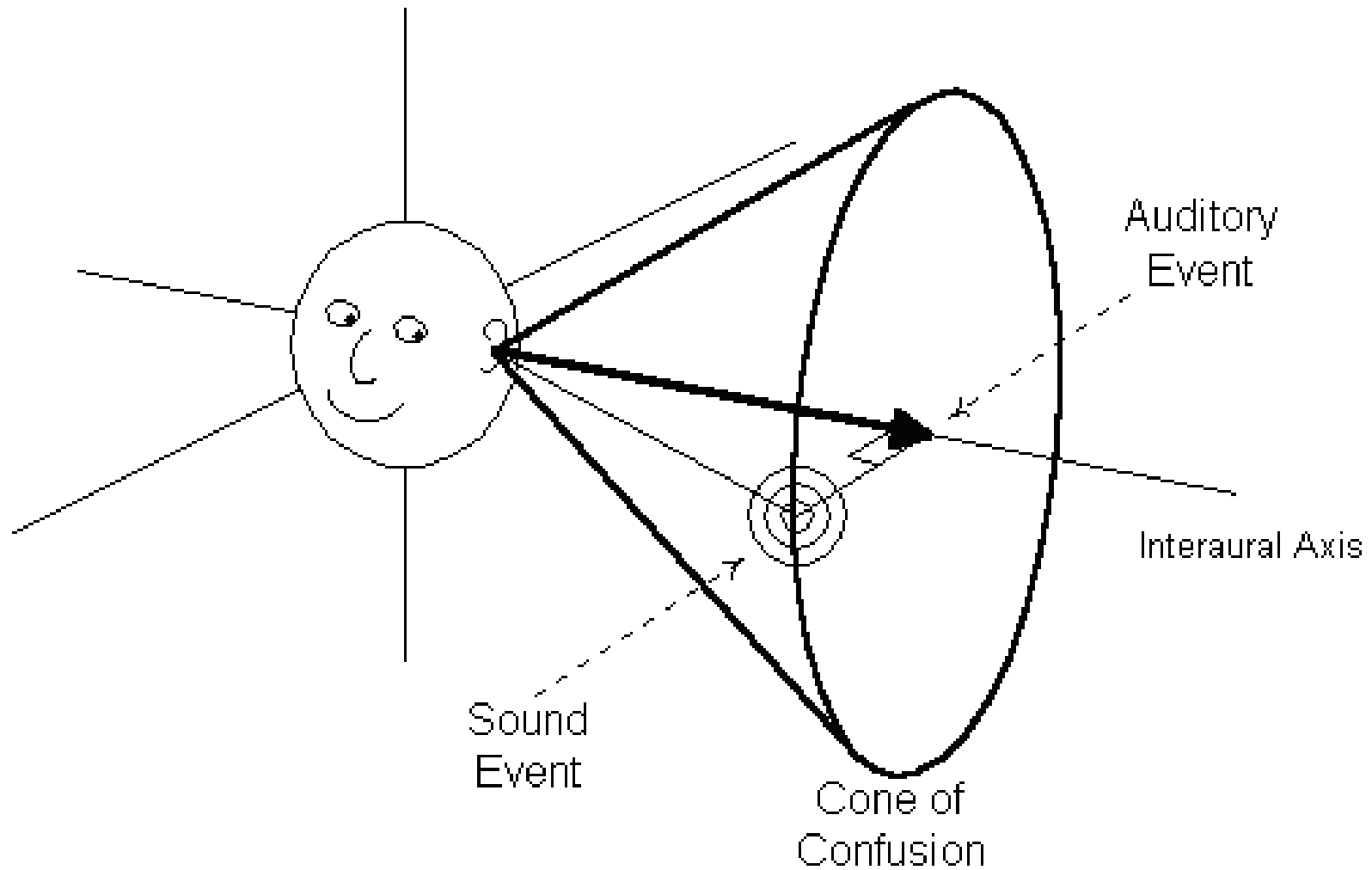
Loudness war

Some of the albums that have been criticized for their sound quality include the following:

Artist	Album
Arctic Monkeys	<i>Whatever People Say I Am, That's What I'm Not</i> ^[6]
Black Sabbath	<i>13</i> ^[57]
Bob Dylan	<i>Modern Times</i> ^[40]
	<i>Together Through Life</i> ^[40]
Christina Aguilera	<i>Back to Basics</i> ^[3]
The Cure	<i>4:13 Dream</i> ^[58]
Depeche Mode	<i>Playing the Angels</i> ^[59]
The Flaming Lips	<i>At War with the Mystics</i> ^{[6][note 3]}
Led Zeppelin	<i>Mothership</i> ^[60]
Lily Allen	<i>Alright, Still</i> ^[61]
Los Lonely Boys	<i>Sacred</i> ^[3]
Nine Inch Nails	<i>Pretty Hate Machine (2010 Remaster)</i> ^[62]
Metallica	<i>Death Magnetic</i> ^{[63][note 4]}
Miranda Lambert	<i>Revolution</i> ^[64]
Oasis	<i>(What's the Story) Morning Glory?</i> ^[6]
Paul McCartney	<i>Memory Almost Full</i> ^[65]
Paul Simon	<i>Surprise</i> ^[66]
Pearl Jam	<i>Ten (2009 remaster)</i> ^{[67][68][69]}
Queens of the Stone Age	<i>Songs for the Deaf</i> ^[6]
Red Hot Chili Peppers	<i>Californication</i> ^{[3][6]}
Ghost	<i>Infestissumam</i> ^[70]
Rush	<i>Vapor Trails</i> ^[71]
The Stooges	<i>Raw Power (1997 remaster)</i> ^[66]

Source:
https://en.wikipedia.org/wiki/Loudness_war

Cone of confusion



Spatial hearing „hearing throne”



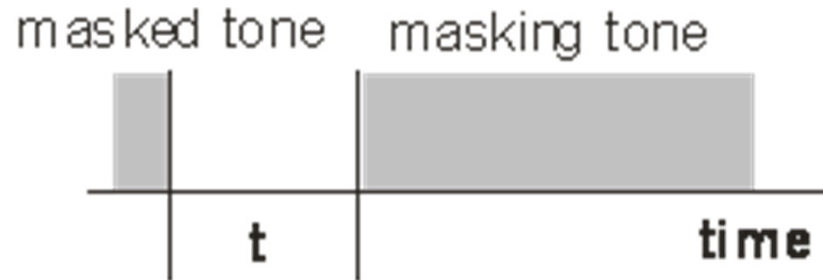
Time domain masking - Forward



- masking tone + tone that is semitone down
 - with a 100 ms delay in between
 - with a 10 ms delay in between



Time domain masking - Backward



- initial tone is going to be masked by the tone that follows
 - delay: 100 ms
 - delay: above 10 ms
 - delay: below 10 ms



Frequency domain masking

- Pure tones mask higher frequencies better than lower frequencies
 - Mask high freqs
 - Mask low freqs

