



GN

Music perception without and with hearing instruments

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GN Hearing EHV Feb 2018

Let's Start with a bit of >>*Audience Participation*<<

How Important is Music for You ?

Trend in audiences
of audio related
talks

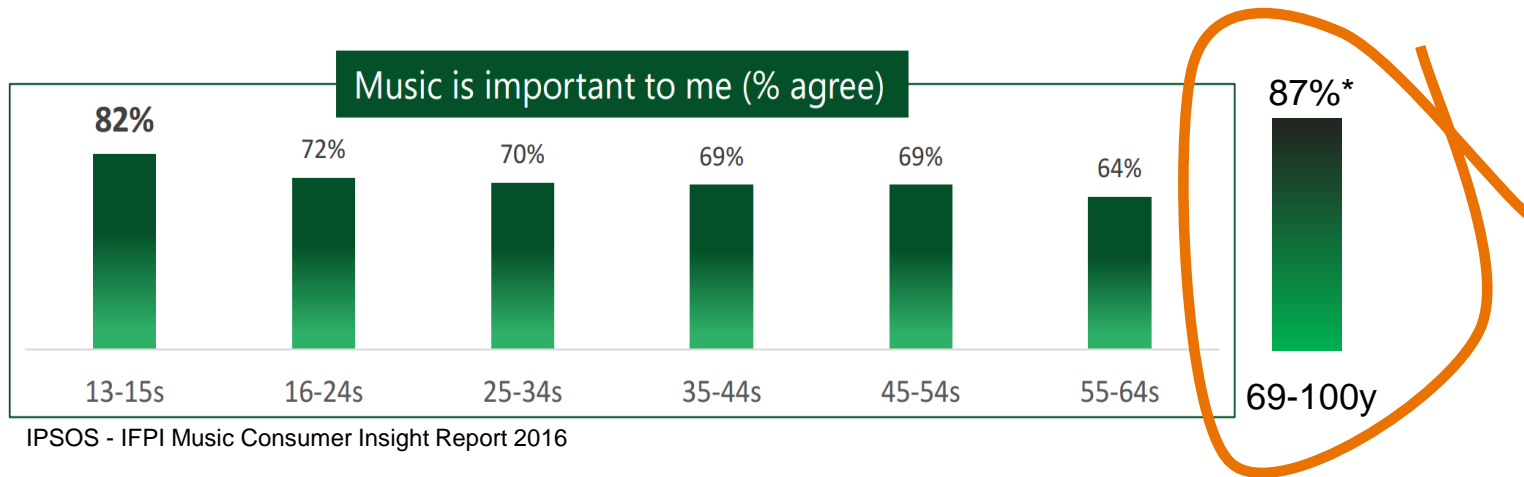
- | | | |
|--|--------|--------|
| A. Music is not very important for me | ≈ 30 % | ≈ 1 % |
| B. I enjoy music, be it mostly as a background sound | ≈ 35 % | ≈ 5 % |
| C. I deeply enjoy music, I often listen to music quite consciously | ≈ 35 % | ≈ 94 % |

How important is music for the general public ?

Nielsen's Music 360 US study 2014

(data for this study was collected in August and September of 2014 among 2,581 representative consumers ages 13+)

- ❑ **93%** of the U.S. population listens to music **more than 25 hours per week**
- ❑ **75%** of Americans say they **actively choose to listen to music** (73% say to actively watch TV)



*The importance of music to (300) seniors; Cohen, A et al; Psychomusicology, Vol 18(1-2), 2002

Where do I come from to arrive at this topic?

- ❑ Music lover since youth (now quite equally divided between classical, jazz and popular music)
- ❑ Masters TUE EE in 1985, Philips Research, Philips HI (1989), GN ReSound (2000)
- ❑ 'Higher Acoustics', course Antwerp, B (1991)
- ❑ Bachelor at Fontys Hogescholen in Audiology & Acoustics (2009)
- ❑ 'Audiophile', designing/building/improving HiFi equipment for myself and interested friends e.g. a new type of dipole loudspeakers (a 10 y process)

- ❑ I noticed that most hearing aid users I know complain about:
 - ❑ first of all - of course - hearing in noise
 - ❑ **immediately followed by music perception/enjoyment**



Disclaimer

- Observations and thoughts in this presentation do not necessarily reflect observations and thoughts of GN Hearing and/or its hearing aid brands.

White Paper by Danish Sound (2014, 66p)

- ❑ Music can be fun, even a great joy in life
- ❑ Music can be very healthy
- ❑ Music can be extremely healthy for elderly and a very great joy in life



Meer aandacht voor muziekbeleving slechthorenden

Audio

Iedereen heeft recht op luistergenot

Ook als het gehoor achteruitgaat, kun je nog genieten van muziek. Dat kan de laatste tijd zelfs steeds beter.

Door **Bard van de Weijer**

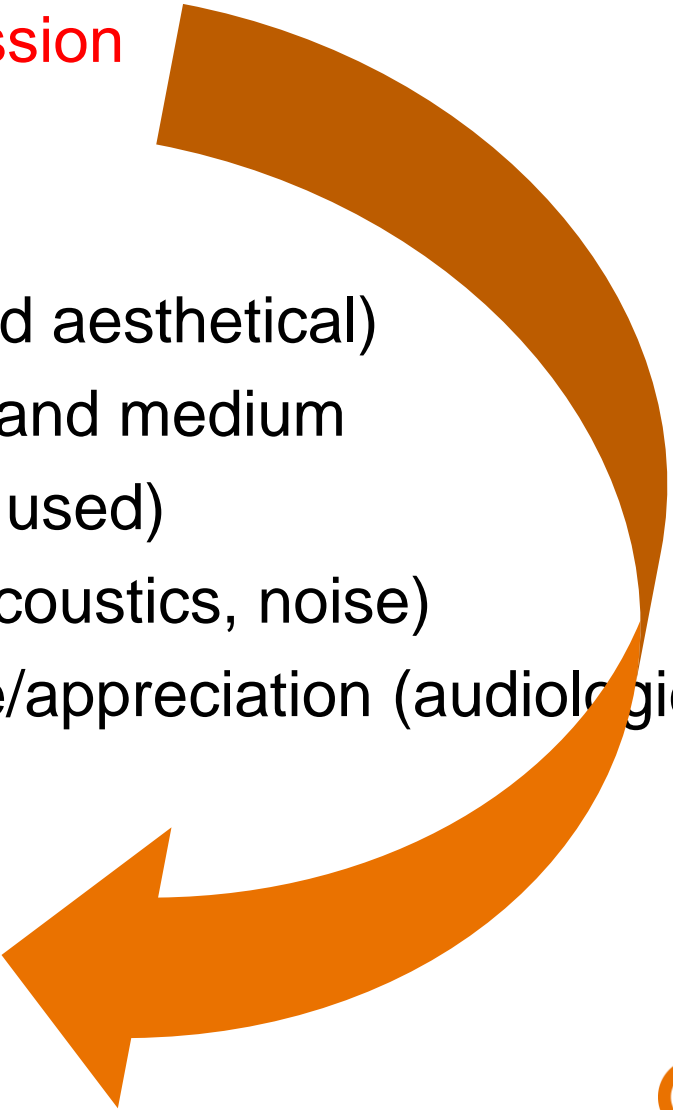
Wie als slechthorende een klassiek concert bijwoont, wordt meestal getrakteerd op een geluidskwaliteit die stamt uit de tijd dat koningin Wilhelmina de overzeese gebieden toesprak. 'Denk Radio Kootwijk', zegt Gerard van der Ploeg. De 75-jarige

dorpskerk: een ringleiding of een draadloos zendersysteem waarbij de ontvanger een lus heeft die om de hals gedragen wordt.

Zo'n systeem is bedoeld voor spraak en prima geschikt om meneer pastoor goed te kunnen verstaan. Maar het is niet in staat de nuances van Tsjaikovski's

Volkskrant
27 jan 2018

Aspects that influence music perception quality (HI and NH)

1. Musician's performance/expression
 2. Recording environment
 3. Recording equipment
 4. Recording quality (technical and aesthetical)
 5. Storage / Transmission format and medium
 6. Playback equipment (incl HA if used)
 7. Playback environment (room acoustics, noise)
 8. Listener's hearing performance/appreciation (audiological, musical education, taste)
 9. Listeners mood
 10. Listeners emotional reaction
- 

Some highlights in the development of sound reproduction

- **Before 1900** Records (from 1856!) and wax rolls played back purely mechanical, telephony (from 1878)
- **1900-1930** Diode, radio, triode, pentode, feedback principle (stability, low distortion), ...
- **1925** Invention of dynamic loudspeaker (= moving coil LSP) by Kellogg and Rice
- **1930s** Avery Fisher (amateur violist) experimenting with audio design and acoustics 'to make a radio that will sound like you are listening to a live orchestra'. Founded Fisher Radio 1945 and remained a technology leader up to 1969 (when he sold to Sanyo). Stereo was patented by Alan Blumlein at EMI.
- **After World War II** Harry F. Olson conducted experiments where **test subjects listened to a live orchestra through variable acoustic filters (curtains)**. Results proved that listeners preferred highest fidelity reproduction.
- **1950s** Audio manufacturers (most were in US and UK) reached big improvements. They used *high fidelity* or hi-fi as a marketing term to describe records and equipment intended to provide faithful sound reproduction.
- **1950s** Hi-fi became a generic term for (quality) home sound equipment. Many found the difference in quality between "hi-fi" and the then standard AM radios and 78 rpm records readily apparent and bought 33 $\frac{1}{3}$ rpm LPs.
- **Around 1960** Introduction of stereo, FM radio, tape and cassette recorders and of transistors (largely replacing vacuum tubes fast). Transistors marked the start dominance of Japan (and later all of Asia) in the audio industry.
- **1970s** Dome tweeter (widespread type high frequency loudspeaker, having a wider opening angle), Jim Kates was involved in the early development
- **1980s** Widespread introduction of the CD and digital audio
- **1990s** Widespread introduction of large data reduction (MP3 etc), streaming audio and surround sound

In search for the Perfect sound reproduction ... already in 1918 ...

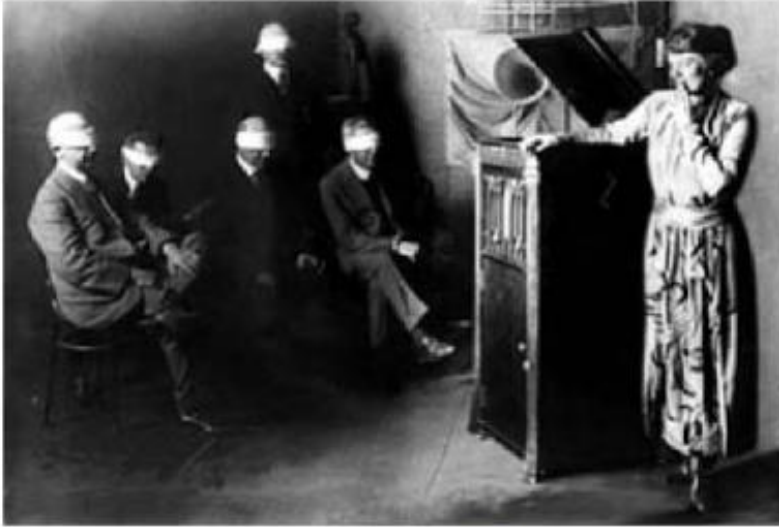


FIGURE 2.1 Singer Frieda Hempel stages a tone test at the Edison studios in New York City, 1918. Care was taken to ensure that the test was “blind,” but it is amusing to see that some of the blindfolds also cover the ears. Courtesy of Edison National Historic Site, National Park Service, U.S. Department of the Interior.

Live versus reproduced comparison demonstrations were also conducted by RCA in 1947 [using a full symphony orchestra (Olson, 1957, p. 606)], Wharfedale in the 1950s (Briggs, 1958, p. 302), Acoustic Research in the 1960s, and probably others. All were successful in persuading audiences that near perfection in sound reproduction had arrived.

... and repeated ever since:

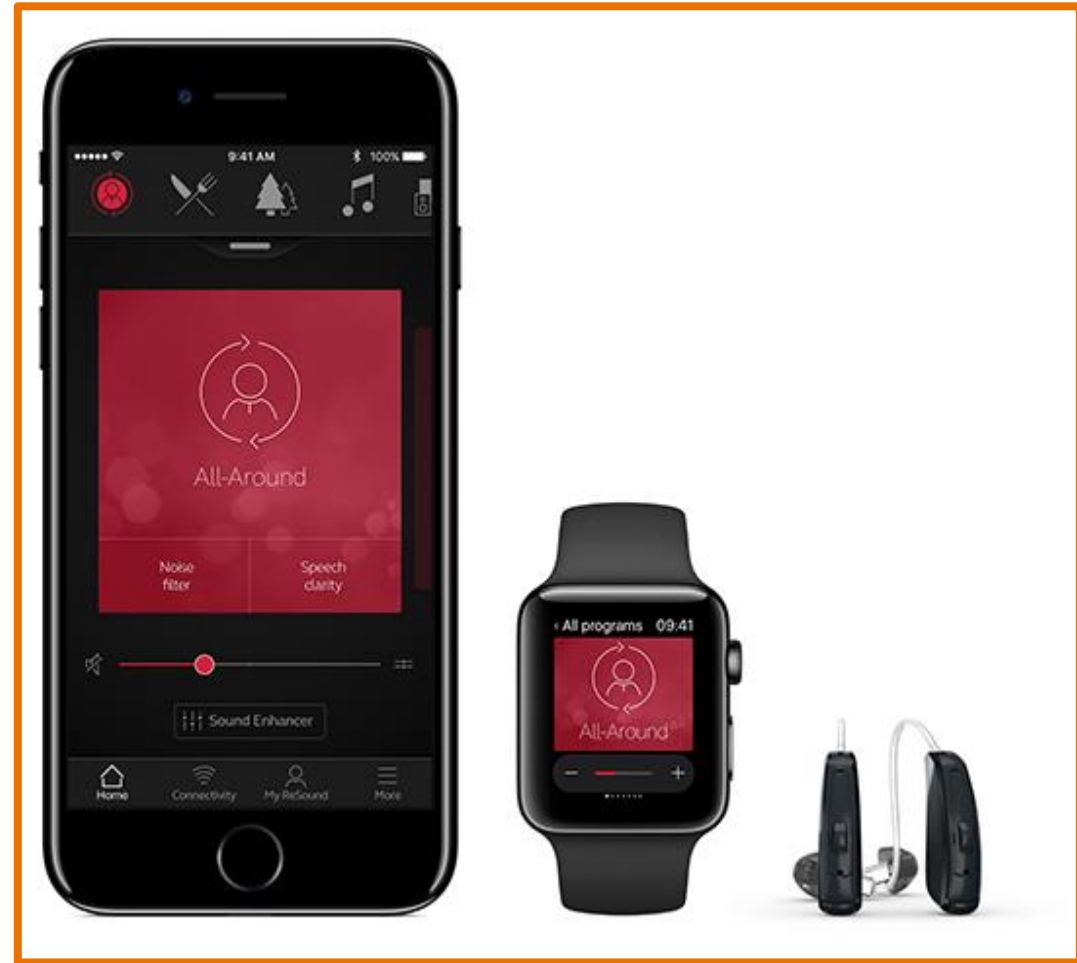
Artists (part): <https://goo.gl/XUUko2>

Loudspeakers (part): <https://goo.gl/goFSqE>

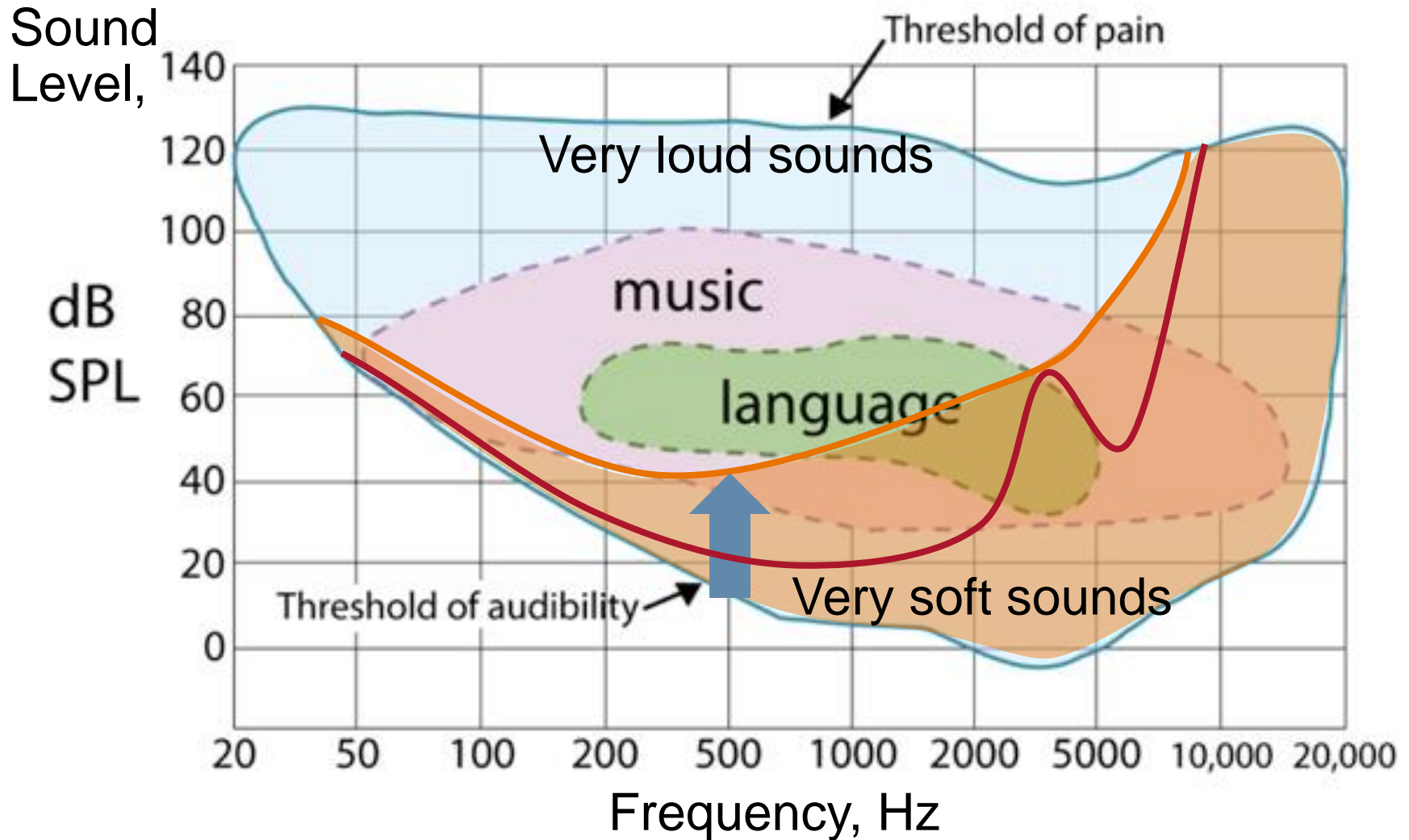
whole piece: https://www.youtube.com/watch?v=_lmXi1y1fzs

Some highlights in the development of HA

- **1898** First **electric** hearing aid (the Akouphone), using the just invented carbon mic.
- **1921** First (very bulky) **electronically** amplified HA (the Vactuphone), using the just invented triode, a glass lens is attached to make the main body look like a box type camera...
- **1930s** First HA **sound processing**: HPF, and AGC
- **After World War II** Application of micro size vacuum tubes (developed for military walkie-talkies), body worn only
- **1950s** Fast application of the **transistor**, first (very bulky) **BTEs**
- **1960s** Very fast introduction of **ICs** (first IC by Philips, the OM200, was for HA), first **ITEs**
- **1960s** Fast application of **electret microphones** (offering a good sound quality from the introduction)
- **1970s** More **sound processing**: dual channel, multichannel + AGC-I, AGC-O, environmental settings
- **1987** First **digital** HA (Nicolette, \$10.000 each), **1995** First commercial digital HA (Widex Senso)
- **1996** First non hard-wired digital HA (Philips D72)
- **Around 2000** All major companies stopped making analog HA
- **2010-16** wireless streaming to a box, streaming to iPhone, remote finetuning, adaptive finetuning, binaural beamforming...



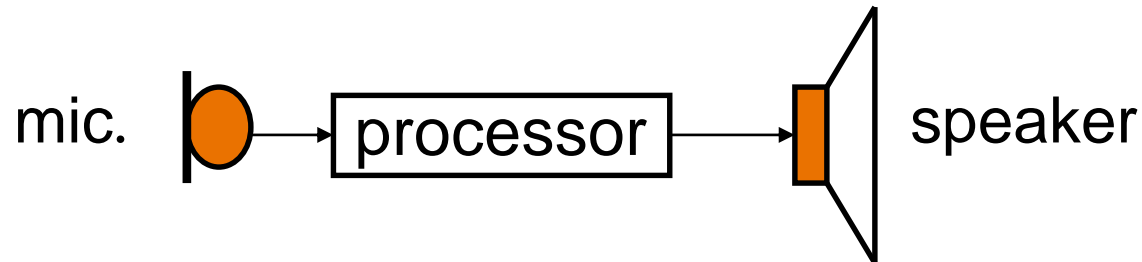
Sound diagram of frequency and level



Typical curves for elderly / hearing damage at younger age

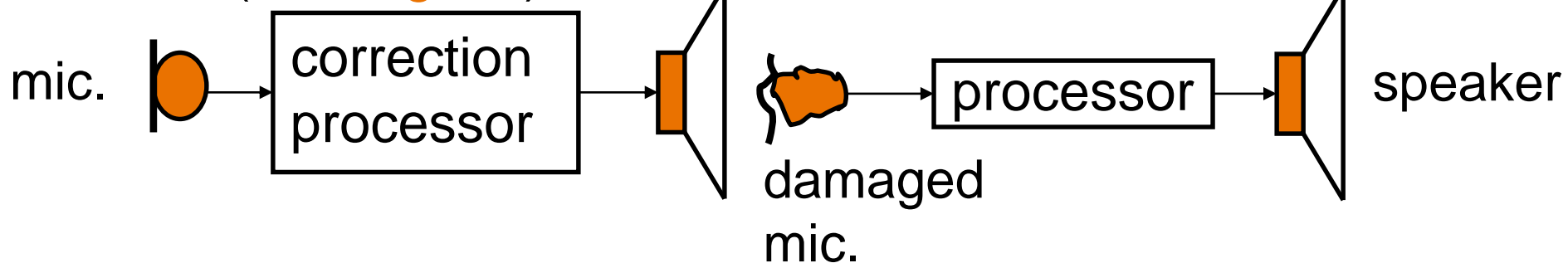
Fundamental Limitations of Hearing Aids

Normal Ear seen as Sound System (nerdish analogy 😊)



Correcting System
(hearing aid)

Impaired Ear seen as
'Impaired' System



In general perfect correction of hearing is not possible !

Feldmann and Kumpf, 1988 Germany

- 79% of respondents reported their **hearing loss hindered enjoyment of music**
- Difficulty understanding the **words of songs**
- **Distortions** of pitch and melody (often in sensorineural hearing loss)
- Most found **hearing aids either improved or caused no change** in their enjoyment of music
- Reported to **continually needed to change the volume settings** while listening to music

Issues with music in hearing aids

- ❑ Input overload (especially with live music)
- ❑ Too less bass output level (bass enhances very much the involvement with music)
- ❑ Too loud output peaks (more dynamic range in music as in speech)
- ❑ Unwanted interactions (feedback cancelation, noise reduction, directivity processing, ...)
- ❑ AGC-I implementation
- ❑ ...
- ❑ ...
- ❑ Some are already worked on and used in commercial hearing aids (music mode)
- ❑ The growing importance of music asks for more research on music performance

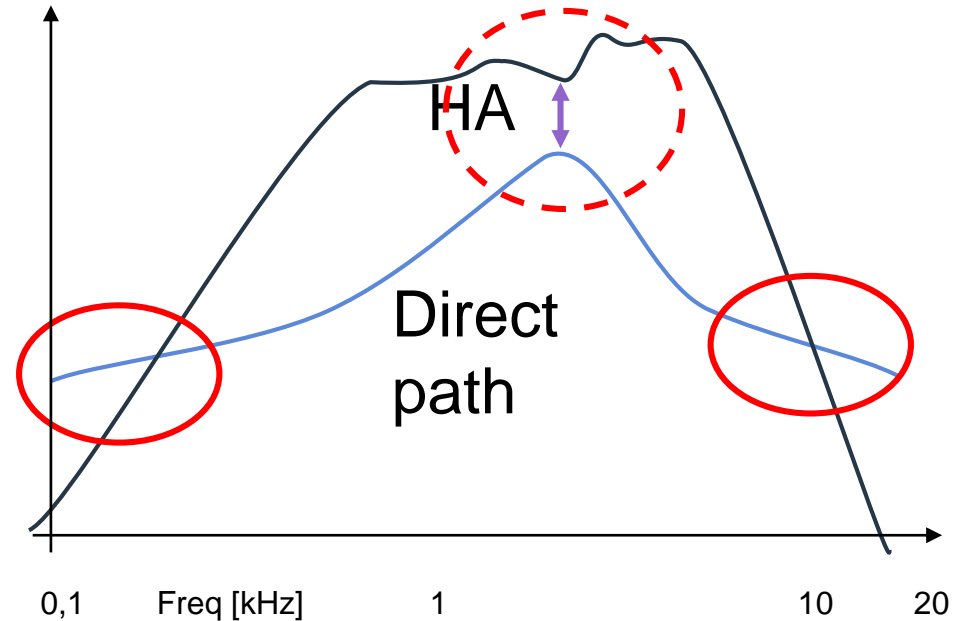
Improvement areas for (music-) sound quality with HA

User related

- Expectations by the user
- Hearing loss level
- 'Hearing distortion' level
- Reduced dynamic range
- Tinnitus
- ...

HA related

- Bandwidth
- Max input
- Distortion/
non-naturalness of sound
- AGC-I implementation
- Beamforming
- Occlusion
- Noise
- Noise reduction
- Feedback suppression
- ...



It's not only about the known audio numbers ...

- *"We should no more let numbers define audio quality than we should let chemical analysis be the arbiter of fine wines."*

Nelson Pass, famous amplifier designer

Some findings at Leeds conference Sept 2017

- Listeners that preferred the music mode on average:
 - Were non-musician
 - Could tolerate loud sounds better
 - Had a slow and/or bad tonal working memory
 - Had less speech in noise problems
 - Were not frequently listening to music
- Advantage was **significantly dependent on music style** (highest advantage for classical, jazz and folk music)
- Influence of many factors (musical abilities, listening habits, loudness sensitivity, tonal working memory)
- Future ideas
 - Include UCL stronger in the fitting of the music mode
 - Recognize listening habits/preferences automatically and adapt music mode e.g. **learning music mode**



What is the aim of using hearing aids?

- To hear sounds
- To stay connected to the sound-world around you
- To understand speech
- To enjoy speech
- To listen to music
- **New aim: to more enjoy music**

Takeaways

1. Muziek is belangrijk voor ongeveer **70 %** van alle mensen, ook voor slechthorenden!
2. **Betere afspeelkwaliteit** kan het luistergenot van muziek aanmerkelijk verhogen
3. **30-50 %** van de hoortoestelgebruikers ervaren een inadequate muziekperceptie, zodanig dat hun luistergenot aanmerkelijk verlaagd is
4. **Toe nu toe werd er in hoortoestel R&D minder aandacht** aan muziekperceptie gegeven dan aan spraakperceptie
5. **Moderne digitale technologie** biedt vele nieuwe mogelijkheden voor verbetering van muziekperceptie
6. **Het managen van de verwachtingen** van muziekperceptie bij mensen met een gemiddeld tot ernstig hoorverlies zal heel belangrijk blijven

Takeaways

1. Music is important for some **70 %** of all people, also for hearing impaired !
2. **Better music playback quality** can considerably raise enjoyment of music
3. **30-50 %** of hearing aid users experience inadequate music perception, decreasing joy of listening
4. **Up to now less priority in HA R&D and in Marketing was given** to music perception compared to speech perception with HA
5. **Modern digital technologies** offer unprecedented possibilities for music perception improvements
6. **Managing expectations** in music perception for people with moderate to substantial hearing loss will stay very important

Thank you !

