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Consideration of Physical and Perceptual factors in Aided Music Listening





Maja Serman,
Research audiologist

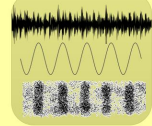


Mirko Arnold,
Sound engineer

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MOTIVATION

Physics of sound



Pressure disturbance propagation

The pressure disturbance can be:

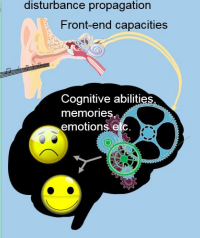
- Strong
- Weak
- Aperiodic
- Periodic

Both physical and individual factors influence music listening.

Sound Experience

Experience of the pressure disturbance propagation

Front-end capacities

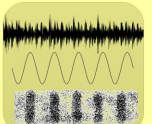


Cognitive abilities, memories, emotions etc.

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MOTIVATION

Physics of sound



Pressure disturbance propagation

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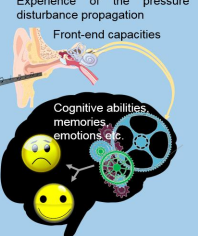
- Strong
- Weak
- Aperiodic
- Periodic

Factors linking the physics and experience of music with HAs:
Gain shaping, Compression, Directionality and Noise reduction.

Sound Experience

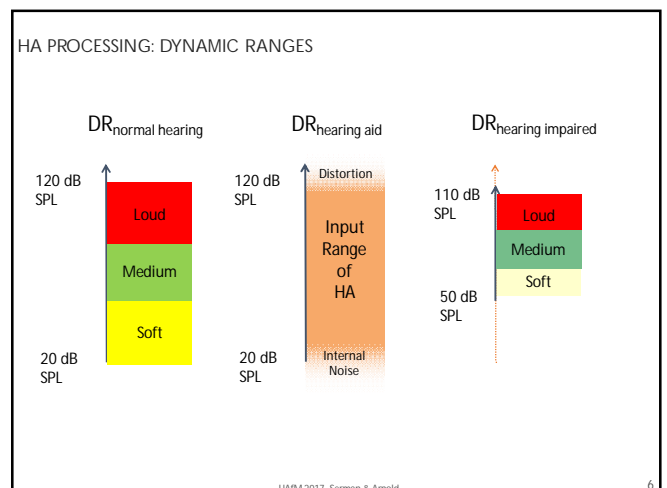
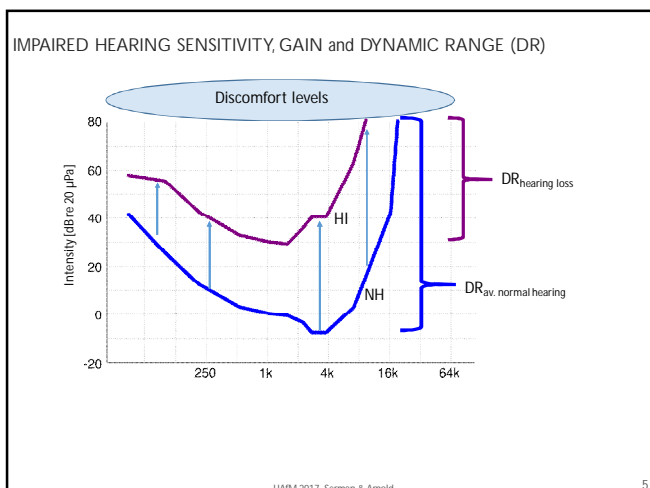
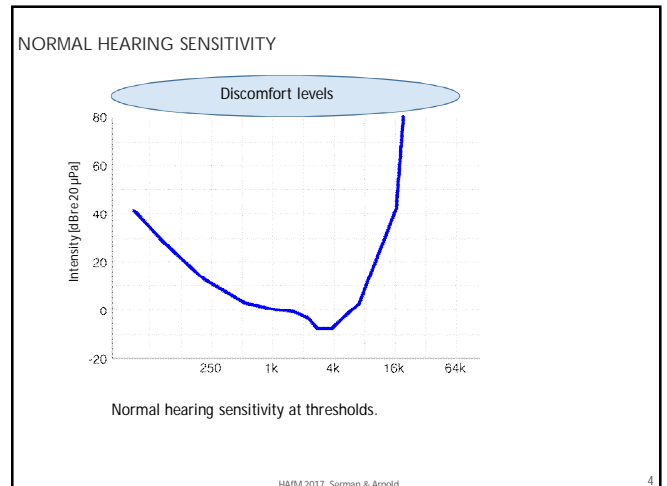
Experience of the pressure disturbance propagation

Front-end capacities

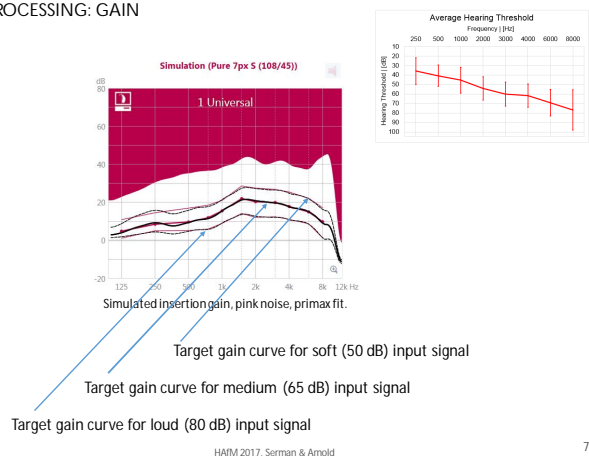


Cognitive abilities, memories, emotions etc.

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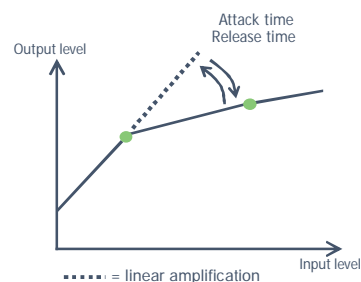
HA PROCESSING: GAIN



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HA PROCESSING: COMPRESSION

Compression



Characteristic gain curve:
More gain for soft than for loud input levels.

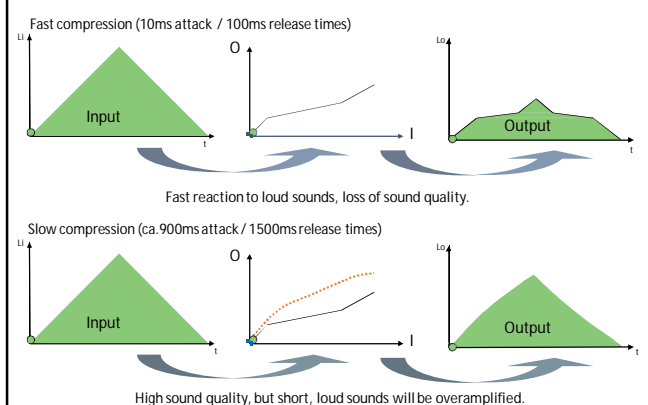
Attack time:
Time needed for the gain for the loud input signal to drop (to the wished for value).

Release time:
Time needed for the gain for the soft input level to come back to its full value.

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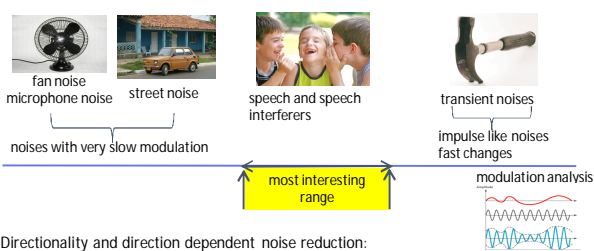
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HA PROCESSING: COMPRESSION

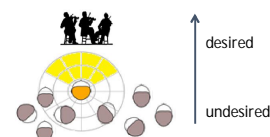


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HA PROCESSING: NOISE REDUCTION & DIRECTIONALITY



Directionality and direction dependent noise reduction:



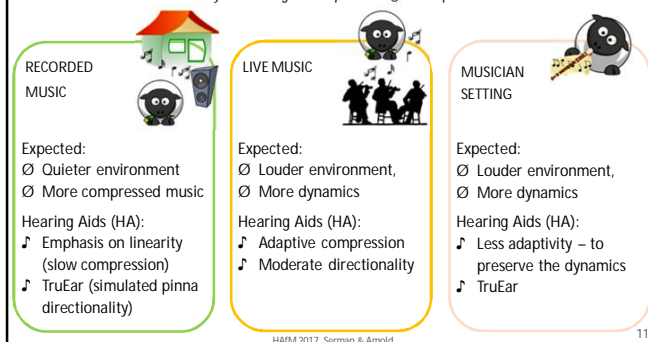
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THREE DIFFERENT MUSIC PROGRAMS

General idea:

- Leave the sound as natural as possible (less processing)
- But! Have "emergency breaks" (fast compression for abrupt level changes)
- Wide dynamic range and optimised gain shape for music.



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STUDY AT NATIONAL CENTRE FOR AUDIOLOGY; UNIVERSITY OF WESTERN ONTARIO (UWO)

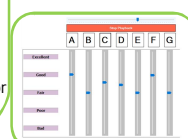
RECORDED MUSIC

- N = 26:
- Ø 15 male, 11 female
- Ø Age = 20-84 (M = 70,8) years
- Ø Bilateral sensorineural hearing loss
- Ø Pure tone audiogram (PTA)
- PTA (0.5, 1, 2, 4) = 50 dB
- Ø Experienced HA user

- Sound quality ratings:
- ♪ 5 music examples
- ♪ Recordings with 5 different HAs, generic formula(reference), anchor
- ♪ Headphones

MUSICIAN SETTING

- N = 2 Case studies
- Ø Active musicians
- ♪ Singer,
- ♪ Trombonist
- One week of usual music practice



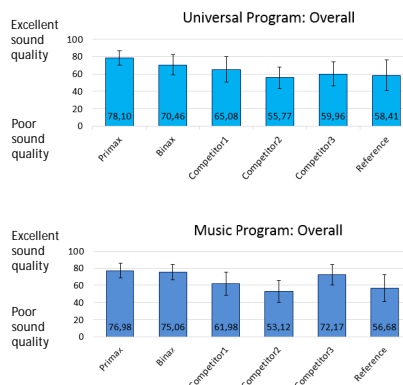
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UWO STUDY: OVERALL RESULTS

The original study, designed by Veronika Littmann and colleagues from UWO.

For more details see Vaisberg *et al.* 2017. "Comparison of music sound quality between hearing aids and music programs." *AudiologyOnline*.



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DO RATINGS FOR MUSIC & UNIVERSAL PROGRAM DIFFER?

Universal Program recordings



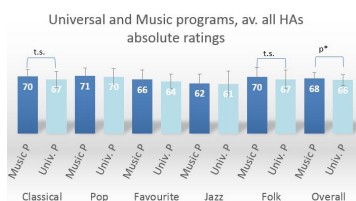
Music Program recordings



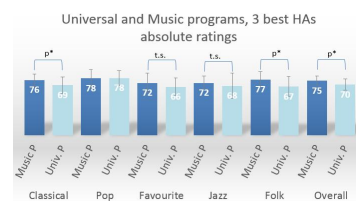
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DO RATINGS FOR MUSIC & UNIVERSAL PROGRAM DIFFER?



Average of 5 different HAs (4 manufacturers).

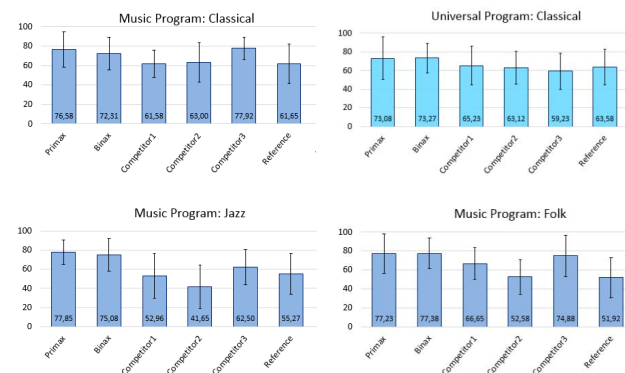


Average of 3 different HAs (2 manufacturers).

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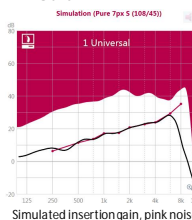
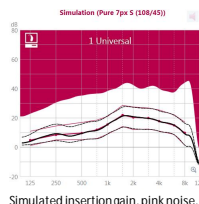
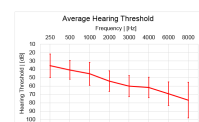
STYLES RATED BETTER WITH MUSIC PROGRAM



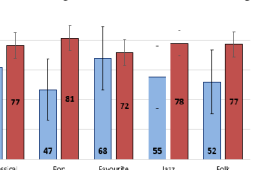
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THE CASE OF REFERENCE & FAVOURITE MUSIC



Music Program: Reference and Primax ratings



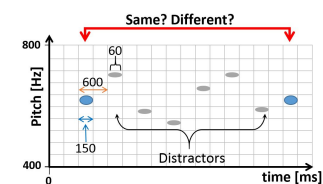
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DO RATINGS DIFFER AS A FUNCTION OF INDIVIDUAL FACTORS?

Questions:

- Self-reported difficulties in speech in noise (SIN)
- Outcome expectancy
- Loudness sensitivity
- Music listening habit
- Age, PTA, HA Experience
- Music education/current musical activities

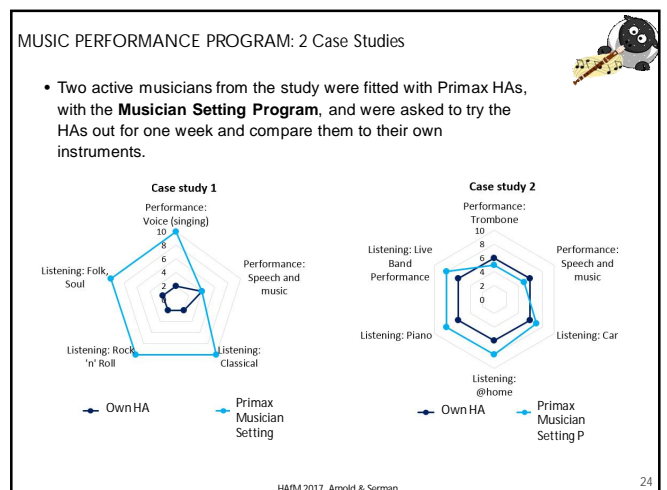
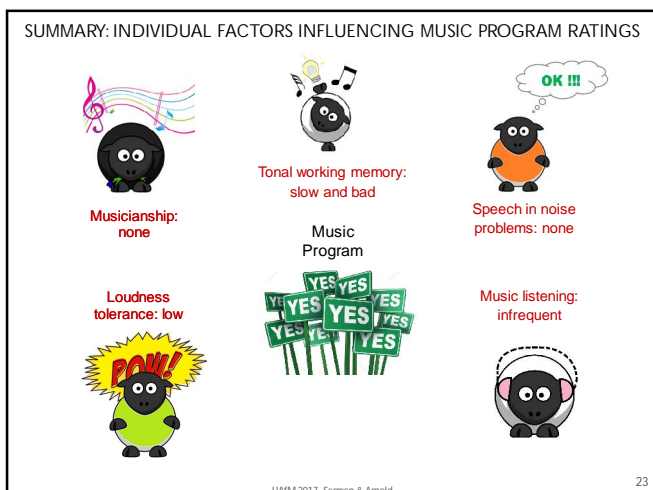
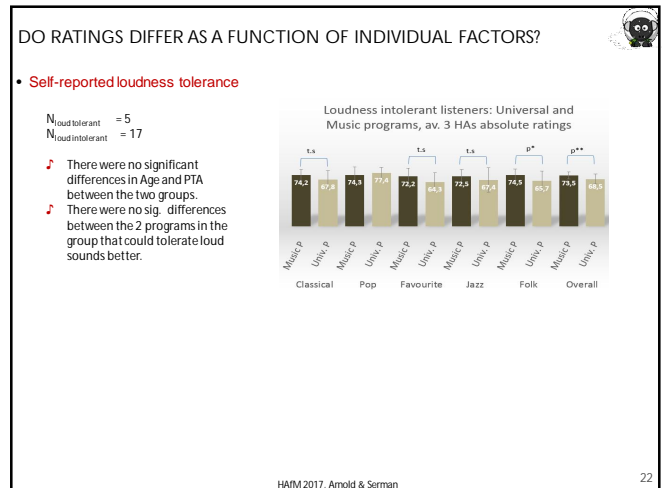
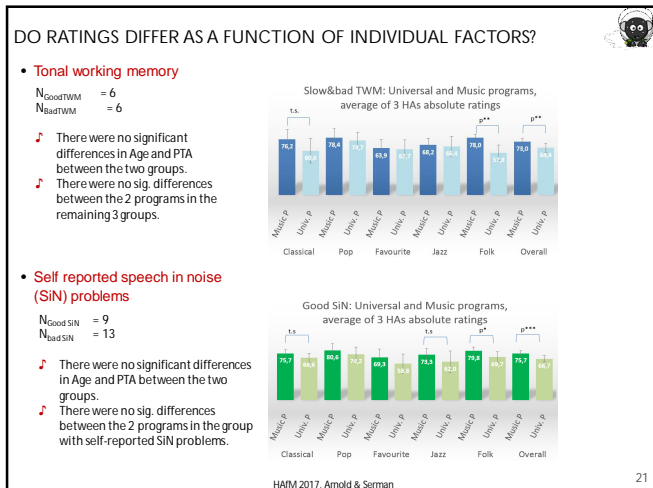
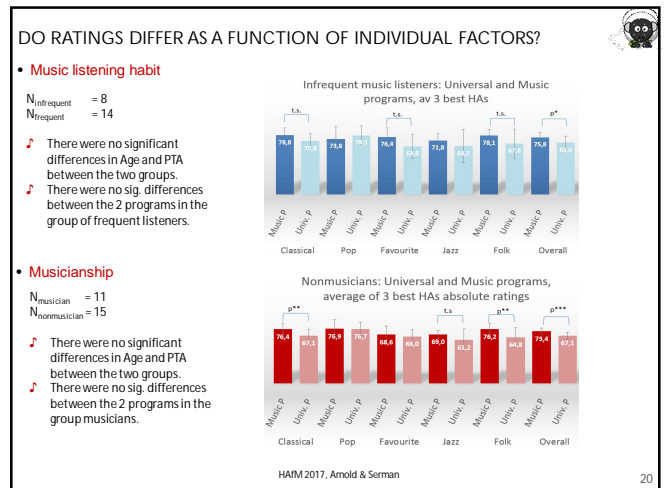
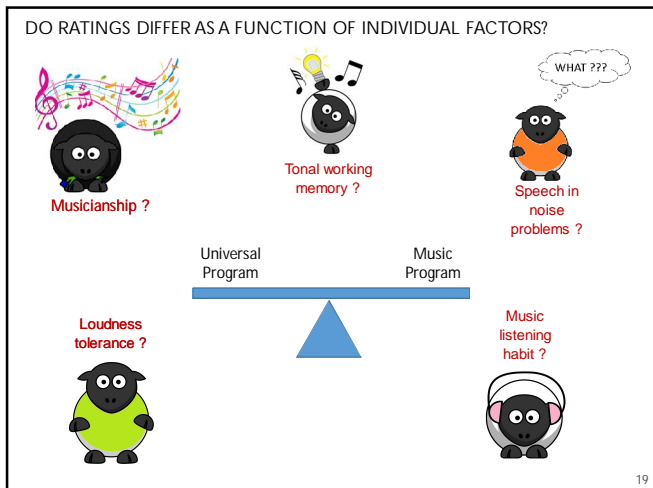


Tonal Working Memory Test (TWM)

- Stimuli: sinus tones
- No of trials: 8
- No of distractors: 6
- Task: same or different
- Pitch change: 0 & 1.9 semitone
- Outcome: % correct and reaction time

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SUMMARY

- ♫ We found evidence for better sound quality ratings of the music program over the universal program.
- ♫ These are style specific: Sound quality of classical, jazz and folk music was rated significantly higher when listened with music program across 3 different HAs.
- ♫ Individual factors musicianship, music listening habit, loudness sensitivity and tonal working memory influence sound quality ratings for music and universal program.
- ♫ Music performance program was rated as highly successful in 2 case studies, the only critical point being listening to speech and music signal at the same time.

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THE FUTURE



- ♫ Measure uncomfortable sound levels (and match DR_{music} and $DR_{\text{individual}}$)
- ♫ Musical style, musical taste and other individual factors of the subject should be intelligently recognized by the music program
- ♫ Do not use only musicians as subjects
- ♫ Investigate individual tastes



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Paula Folkeard



Susan Scollie

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APPENDICES

INDIVIDUAL FACTORS INFLUENCING MUSIC LISTENING WITH HAS

	Musical background	Tonal working memory	Music listening habit	Speech in noise problems	Loudness sensitivity
Definition	actively creating music • currently plays instrument • sings in a choir at least twice a week	Outcome measures TWM test: Mean split % correct Mean split Reaction time: Good TWM: Good & fast Bad TW: Bad & slow	How often do you listen to music? Rarely = (never), few times/month, few times/week Often = every day	When I sit together with a group of people in a busy environment, I can follow the conversation. Bad SIN = strongly disagree, slightly disagree Good SIN = slightly agree, strongly agree	I feel uncomfortable in loud environments. Robust = strongly disagree, slightly disagree Sensitive = slightly agree, strongly agree
PTA, Age, TWM	PTA, Age: no sig. differences between both groups	PTA, Age: no sig. differences between both groups	PTA low: group "often" has a sig. higher HL below 1 kHz ($t = -2.195$, $p < .05$) PTA, Age, TWM: no sig. differences between both groups	PTA, Age: no sig. differences between both groups	PTA, Age: no sig. differences between both groups TWM: group robust has a higher % correct ($z = -1.803$, $p = .101$)
N	$N_{\text{musician}} = 11$ $N_{\text{nonmusician}} = 15$	$N_{\text{good&fast}} = 6$ $N_{\text{bad&slow}} = 6$	$N_{\text{rarely}} = 8$ $N_{\text{often}} = 14$	$N_{\text{Good SIN}} = 9$ $N_{\text{Bad SIN}} = 13$	$N_{\text{robust}} = 5$ $N_{\text{sensitive}} = 17$

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