Consideration of Physical and Perceptual factors in Aided Music Listening

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HAfM 2017, Serman & Arnold

MOTIVATION

NORMAL HEARING SENSITIVITY

Discomfort levels

Intensity [dB re 20 µPa]

Normal hearing sensitivity at thresholds.

IMPAIRED HEARING SENSITIVITY, GAIN and DYNAMIC RANGE (DR)

Discomfort levels

HA PROCESSING: DYNAMIC RANGES

Input Range of HA

Distortion

Internal Noise

Handout 1
HA PROCESSING: GAIN

Simulated insertion gain, pink noise, primax fit.

Target gain curve for soft (50 dB) input signal

Target gain curve for medium (65 dB) input signal

Target gain curve for loud (80 dB) input signal

HA PROCESSING: COMPRESSION

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

Input level
Output level

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

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

Compression = linear amplification

HA PROCESSING: NOISE REDUCTION & DIRECTIONALITY

Fan noise, microphone noise, street noise, speech and speech interferers, transient noises, impulse like noises, fast changes.

Directionality and direction dependent noise reduction:
High sound quality, but short, loud sounds will be overamplified.

HA PROCESSING: NOISE REDUCTION & DIRECTIONALITY

Most interesting range

modulation analysis

desired

undesired

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.

RECORDED MUSIC

Expected:
- Quieter environment
- More compressed music

Hearing Aids (HA):
- Emphasis on linearity (slow compression)
- TruEar (simulated pinna directionality)

LIVE MUSIC

Expected:
- Louder environment,
- More dynamics

Hearing Aids (HA):
- Adaptive compression
- Moderate directionality

MUSICIAN SETTING

Expected:
- Louder environment,
- More dynamics

Hearing Aids (HA):
- Less adaptivity – to preserve the dynamics
- TruEar

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

RECORDED MUSIC

N = 26:
- 15 male, 11 female
- Age = 20-84 (M = 70.8) years
- Bilateral sensorineural hearing loss
- Pure tone audiogram (PTA) PTA (0.5, 1, 2, 4) = 50 dB
- 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
- Active musicians
- Singer
- Trombonist
- One week of usual music practice
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.

**UWO Study: Overall Results**

<table>
<thead>
<tr>
<th>Excellent sound quality</th>
<th>Poor sound quality</th>
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<td>Universal Program: Overall</td>
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**Do Ratings for Music & Universal Program Differ?**

**Styles Rated Better With Music Program**

- Music Program: Classical
- Music Program: Jazz
- Music Program: Folk

**Do Ratings Differ as a Function of Individual Factors?**

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

**The Case of Reference & Favourite Music**

- Simulated Insertion gain, pink noise, primax fit.
- Simulated Insertion gain, pink noise, DSL v5.
- Music Program: Reference and Primax ratings.
DO RATINGS DIFFER AS A FUNCTION OF INDIVIDUAL FACTORS?

**Summary:** Individual Factors Influencing Music Program Ratings

- **Musicianship:** none
- **Tonal working memory:** slow and bad
- **Speech in noise problems:** none
- **Music listening habit:** infrequent

**Music Program Ratings**

- **Universal Program**
  - **Musicianship:** none
  - **Tonal working memory:** ??
  - **Speech in noise problems:** ??
  - **Music listening habit:** ??

- **Music Program**
  - **Musicianship:** none
  - **Tonal working memory:** ??
  - **Speech in noise problems:** ??
  - **Music listening habit:** ??

**Loudness tolerance:** low

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**DO RATINGS DIFFER AS A FUNCTION OF INDIVIDUAL FACTORS?**

**Music listening habit**

- **Nonmusicians:** Universal and Music programs, average of 3 listeners absolute ratings
  - Classical: 12
  - Pop: 15
  - Favourite: 17
  - Jazz: 13
  - Folk: 16
  - Overall: 15

- **Musicians:** Universal and Music programs, average of 3 listeners absolute ratings
  - Classical: 17
  - Pop: 10
  - Favourite: 18
  - Jazz: 15
  - Folk: 14
  - Overall: 16

**Summary:**

There were no significant differences in Age and PTA between the two groups.

There were no sig. differences between the 2 programs in the group of frequent listeners.

There were no significant differences in Age and PTA between the two programs.

There were no sig. differences between the two programs in the group musicians.

There were no significant differences in Age and PTA between the two groups.

There were no sig. differences between the 2 programs in the group that could tolerate loud sounds better.

**MUSIC PERFORMANCE PROGRAM: 2 Case Studies**

- Two active musicians from the study were fitted with Primax HAs, with the Musician Setting Program, and were asked to try the HAs out for one week and compare them to their own instruments.
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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Jonathan Vaisberg

APPENDICES

INDIVIDUAL FACTORS INFLUENCING MUSIC LISTENING WITH HAS

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<thead>
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<th>Musical background</th>
<th>Level working memory</th>
<th>Music listening habit</th>
<th>Speech in noise problems</th>
<th>Loudness sensitivity</th>
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PTA, Age, TWM:

- No sig. differences between both groups
- PTA, Age: no sig. differences between both groups
- PTA, Age, TWM: no sig. differences between both groups
- PTA, Age: sig. differences between both groups
- PTA, Age, TWM: sig. differences between both groups

N: Musicians = 11
Nonmusicians = 15

PTA, Age, TWM: no sig. differences between both groups
- PTA, Age: sig. differences between both groups
- PTA, Age, TWM: sig. differences between both groups

N: Musicians = 9
Nonmusicians = 17

THE FUTURE

- Measure uncomfortable sound levels (and match DR\textsubscript{music} and DR\textsubscript{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