Measuring Hearing Aid Compression Algorithm Preference with the Tympan

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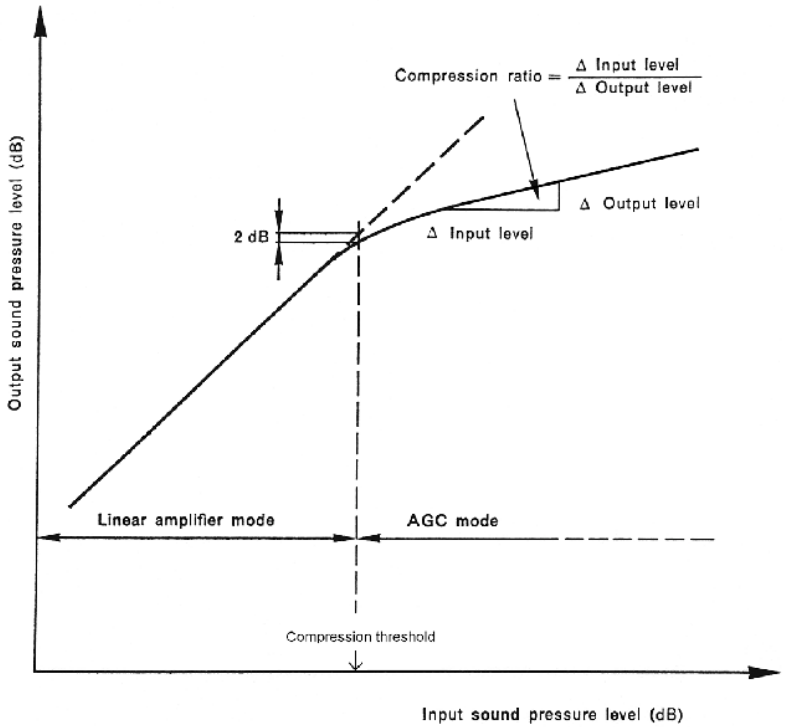
Background: WDRC

- Modern hearing aids use nonlinear algorithms (such as Wide Dynamic Range Compression) to provide audibility to low-level sounds without contributing to added discomfort for high-level sounds (e.g., Souza, 2002).
- These algorithms alter the gain based on stimulus level and are defined by a variety of parameters:
  - attack and release time, compression ratio, compression threshold, etc.



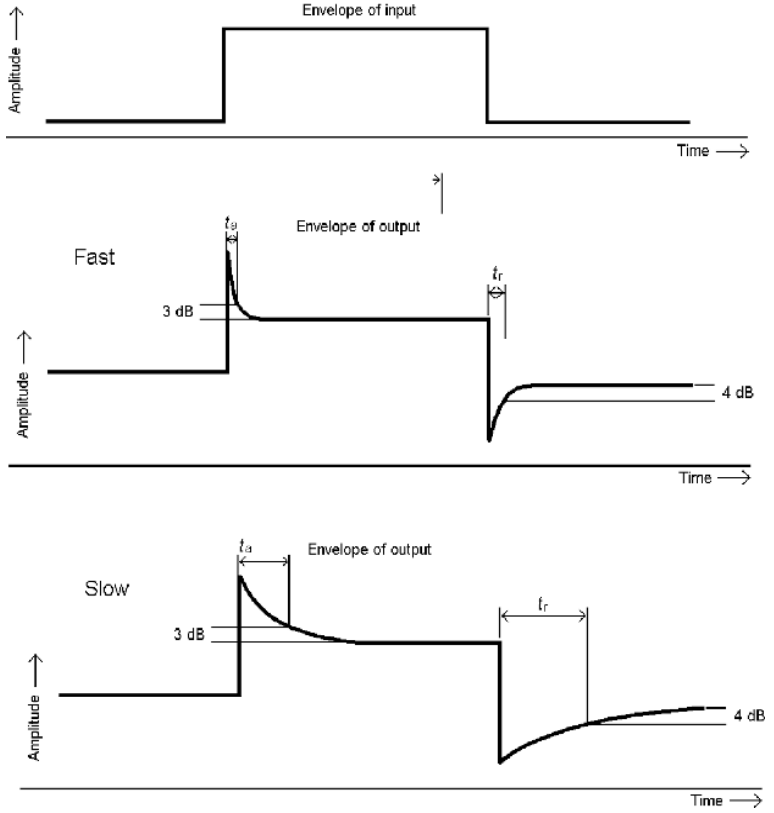
Moore (2008)

Background: WDRC

- The nonlinear nature of the algorithms can distort the envelope of sounds (e.g., Jenstead and Souza, 2005) and alter the signal to noise ratio (SNR) at the output of the hearing aid (e.g., Miller, 2017)
  - Influenced by compression ratio, compression speed, amount of gain applied (usually determined by hearing aid prescriptions), number of channels, etc.
- The environment is also important
  - Type of background noise (e.g., fluctuating or not)
  - Or reverberation (Reinhart at al., 2017)

Background: Compression speed

- Fast-acting better amplifies low-level sounds
- Slow-acting compression produces less distortion to the stimulus
  - Can sound less “choppy”
  - better preserves SNR



Moore (2008)

Background: Other factors

- Many studies evaluating subject's preference, speech intelligibility, and the acoustic changes imposed by these algorithms have been conducted in a lab environment using pre-processed stimuli (e.g., Souza et al., 2006; Naylor and Johannesson, 2009; Reinhart at al., 2017)

- Whether subjects benefit/prefer more from fast or slow compression (intelligibility and preference) is a complex problem that relates to the environment and characteristics of the hearing aid wearer (Gatehouse 2006; Souza et al., 2019)

- Some studies have used clinically fit hearing aids (Souza and Sirow, 2014; Miller, 2017) and some also conducted measurements outside of the laboratory

Purpose

- We plan to use the Tympan to:
  - Aims: Determine subject preferences for compression speed and compression ratio in real-world environments and relate the subjective results to stimulus acoustics
  - Make real-world acoustic measurements of the environment while subjects are answering questions about their preferences (pre and post processing)
  - Use ecological momentary assessment to get preference data ("**head to head**" comparisons) from participants wearing the Tympan.
  - This study will also:
    - will gather preference data for a variety of environmental sounds
    - will acoustically survey the acoustic environments

Methods

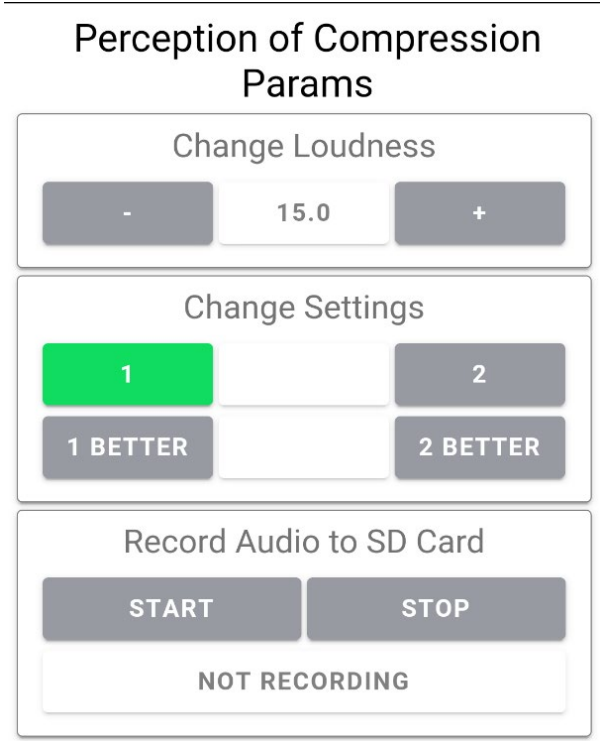
- Tympan will be programmed with gain and compression settings based on NAL-NL2 for an 8-band WDRC algorithm. These will be the baseline hearing aid fit
- Subjects will be asked to wear the Tympan for 1-2 days (8 hours/day)
  - Roughly every hour, subjects will use the Tympan app to listen to different algorithm settings and leave notes
    - Subjects will select between two compression speeds (fast vs. slow) and two compression ratios (high versus low)
    - Fast vs. slow will be 10% above and below baseline settings
    - Compression ratios will be 10% above and 10% below baseline settings
    - Pilot testing will be conducted to ensure that these differences are noticeable
  - During these sessions, the Tympan will record environmental sounds for 1 minute

Analysis

- Sound recordings will be analyzed for envelope distortion, overall level, and maybe(!) SNR using classification algorithms or a power subtraction technique (Sneds, 2015)
    - Also provides a survey of the environments in which these subjects use their tympan (e.g., Wu et al., 2018)
- Preference data and recorded feedback will be related to various acoustic metrics

App sample

- Allows subject to change overall gain and switch between compression settings
- Settings will be fast/slow compression; high/low compression ratio
- Subject can also record notes to SD card
  - Perceptions of environment
  - Type of environment
  - Perceived difficulty in listening
  - Description of the target sound (speech, music, something else?)



Update and current status

- Prelim version of app mostly complete
- Pilot testing of compression settings is our next step
  - Earpieces arrived a few weeks ago
- Subjects likely will need a training session
- In process of getting small grant support to pay subjects

Stuart programming the tympan

Things left to consider

- How will subjects feel about wearing the Tympan and using the app?
- Potential consequences of allowing subjects to control the loudness (overall gain)
- We've programmed the tympan to beep for the EMA, but what if subjects remove their earpieces?
- Can we really get SNR estimates?

Acknowledgements

1. Eric and Chip (Creare) for their help and support
2. Acoustical Society of America for the Tympan Challenge