## Long-term effects of non-linear frequency compression on performance of music and speech perception

Subjects

Test devices

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### **Abstract**

Previous studies have already documented improved speech intelligibility and music performance with the use of Nonlinear Frequency Compression (NFC) (Hopkins et al. 2014, Uys at al. 2012) but as it is widely acknowledged that hearing aid users may gain increasing benefit with longer experience it is interesting to look into long-term effects of this technology. Speech perception benefit with extended use of NFC has been reported for children who showed continued speech perception improvement after a year (Glista et al. 2009) and cochlear implantees showed a significant improvement in their ability to recognize familiar melodies when evaluated again after one year (Gfeller et al. 2010). As real-life use and experience of NFC hearing aids is necessary to reveal its true potential, the study described in this poster was performed roughly 3 years after the initial study to address any long-term aspects.

A subgroup of the participants of the study described in Uys 2011 were recruited to check for their music performance and speech intelligibility after 3 years experience with NFC. The results confirm the general observation of increased benefit from the hearing devices when making use of the high-frequency cues provided by NFC. Whereas the majority of parameters describing the subjective perception did not change, those parameters relating to the performance—especially melody identification and speech understanding in noise—did improve over the

longer period. This leads to the conclusion that it is prudent to intensify the evaluation into the long-term effects of NFC technology.

### Introduction

Music is important! This is true as music enhances the quality of a person's life, not only in terms of enjoyment, but also as a medium that models social structures and provides a medium for human interaction (Cross, 2006). High frequency hearing loss is by far the most common audiometric configuration found in individuals fitted with hearing aids and affects speech comprehension but also music perception adversely as music and lyrics can't be detected or identified easily with only limited access to information located in the high frequencies (Glista & McDermott, 2008).

Nonlinear Frequency Compression (NFC) is one successful approach to compensate for the deterioration of speech perception associated with reduced high frequency cues (see a summary in Hopkins et al. 2014) There is also evidence that NFC provides improved music performance (Uys 2011, Uys et al. 2012, Uys et al.

The mentioned studies • Show an improvement of speech perception predominantly in quiet situations and rarely in situations with competing noise

Describe the speech and music performance of hearing impaired subjects only for a relatively short time period (about 6 months) after being fit with hearing devices with NFC. But how about a long-term effect? What happened to speech and music perception of the hearing aid user after getting used to the new information provided by NFC when using the devices regularly in real life?

→ This poster describes a study looking into these interesting aspect.

(1) Is there a long term effect on the perception of music with NFC in adult hearing aid users without any negative effects on sound quality?

(2) How is speech intelligibility in noise changed when using NFC for a longer period of time (> 3

## Participants & Methods

 9 experienced hearing aid user with at least 3 years
NFC experience (subgroup of study in Uys 2011) O No professional musicians Severe to profound hearing loss ○ Age: 26 — 68 years (mean 55,9 years)

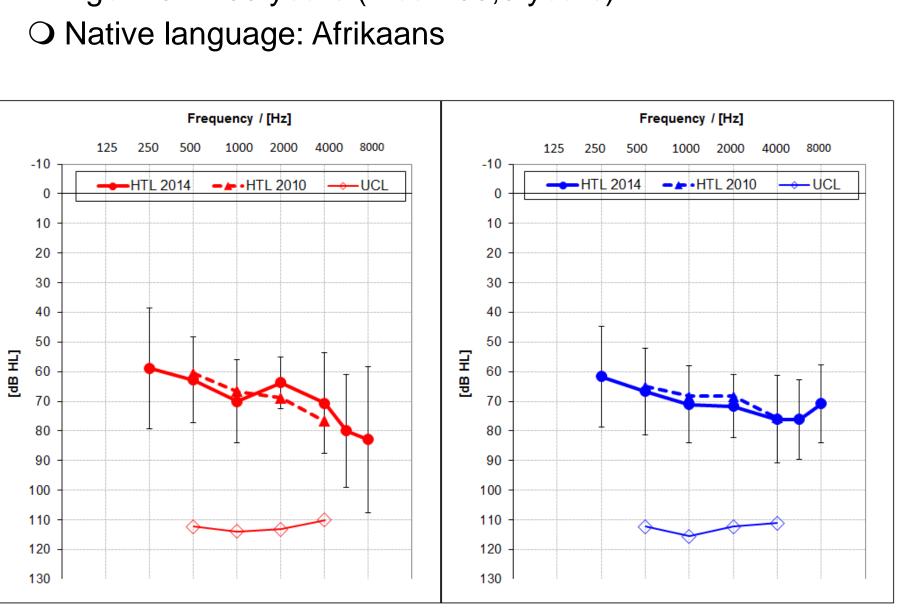


Fig.1: Average hearing loss (and standard deviation)

of the participants measured in 2010 and in 2014

Music perception questionnaire (Uys 2011)

O Phoneme Perception Test (PPT) (Winkler et al. 2012)

O Speechtest in quiet and noise: HINT (Nilsson et al. 1994)

O Subset of Music Perception Test (Uys & van Dijk 2012)

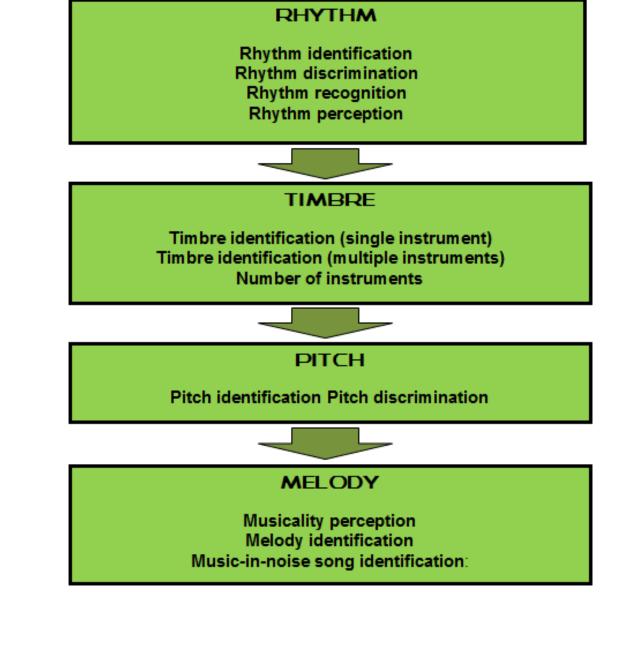
Figure 5 Music Performance Scores of three main subscales

for all three conditions (median, MIN/MAX/25- & 75-quartiles)

\*) statistical significant on a 0.05 level

O Verification measurements using Verifit

O Puretone Audiogram (AC, UCL)



MUSIC PERCEPTION TEST

Fig.2: Block diagram of the Music Perception Test

■ SR ON 2014 ★ 4.1 3.8 3.9 4.2 ★ 4.1 4.3 3.9 ★ 4.1 ■ SR ON 2010 3.4 ★ 4.1 ★ 4.2 ★ 4.2 4.0 4.3 4.0 ★ 4.1 ★

■ SR OFF 2010 ★ 3.7 ★ 3.6 ★ 4.0 ★ 3.7 3.7 3.3 ★ ★ 3.0 ★

Figure 6 Average results (with standard deviation) of rating of

subjective music perception in everyday life. ("0" poor.... "5" best

performance) all three conditions \*) statistical significant on a 0.05 level

O Own devices: Naida UP III O Fitted according DSL v5 formula Audiological Tests

Fig.3: SetUp for speech tests (PPT: only Speech, HINT Speech & Noise)

Figure 7 Detection Threshold measured with the PPT (mean values and standard deviations) \*) statistical significant on a 0.05 level

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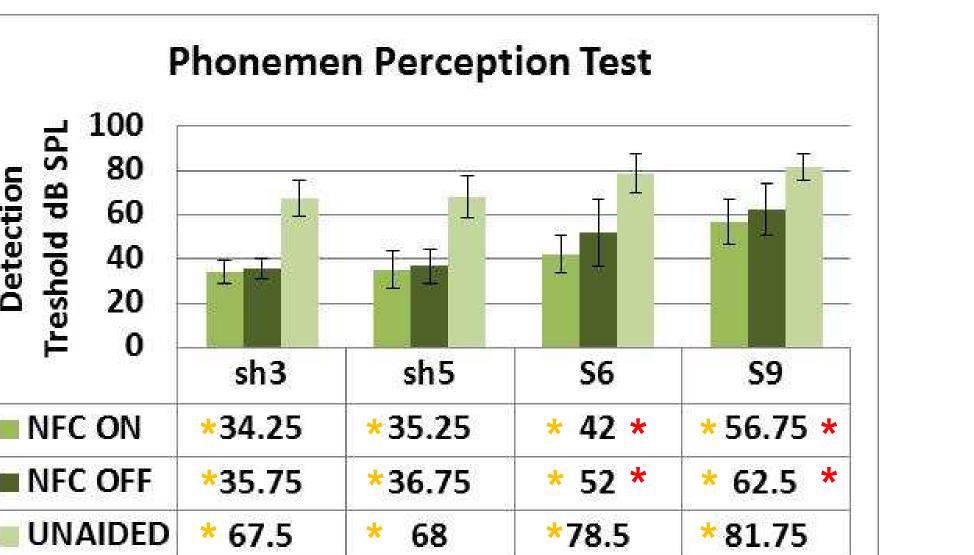
- Audiogram: Participants' audiograms are, on average, the same over 3 years (figure 1)
- Subjective assessment: The perception of music has been improved only in dimension "overall fidelity". Moreover, the music perception in general was not influenced negatively with the use of NFC (figure 5)

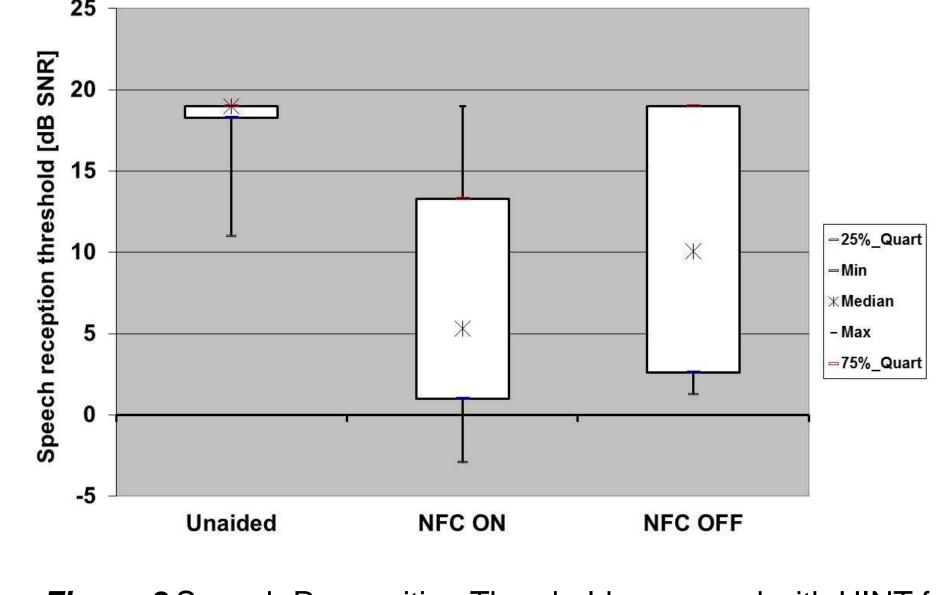
Results

- Music Perception Test (MPT): testing the performance to process/perceive basic components of music, revealed (figure 6)
- Acclimatization to get used to <u>rhythm</u> is finished after 4 weeks
- > Timbre changes slightly but the changes are only significant compared to the performance without NFC. Perception of melody improved significantly as they got acclimatized to the devices and adapted to make use of the new cues which became audible with NFC.
- the MPT and therefore one can conclude that the observed effects are caused by the acclimatization to the NFC technology rather than by repeated exposure to the test material. • Speech Test in quiet: Consistent with a couple of other studies, NFC improves speech understanding in quiet. The HINT means show 8% improvements, but with no statistical significance. The Phoneme Perception Test shows a reduction of the detection threshold (10 dB at 6 kHz and 6 dB at 9 kHz) with statistical significance (figure 7). Additional measurements revealed less confusions comparing NFC activated versus NFC deactivated.

Note: As repetition and learning may improve one's performance on certain tasks or tests, it should be noted that participants never received any feedback during evaluations with

• Speech Test in noise: Speech recognition measured with HINT is improved with NFC by about 5 dB but this is not statistically significance: n=5 improvements, n=1 deterioration, n=3 no result. (figure 8)





MAX/25- & 75-quartiles) \*) not statistical significant

Figure 8 Speech Recognition Threshold measured with HINT for the conditions NFC ON, NFC OFF and unaided (median, MIN/

## **Discussion and Conclusion**

• Given the small sample size, it is interesting to see that some effects of experience with NFC were seen. It seems that the additional cues provided by NFC become helpful after lengthy acclimatization in better understanding speech in noise and identifying melodies. If a larger sample were made available the statistical power could be increased and stronger assumptions about the impact of experience and NFC could be made.

• Until this is possible, it is interesting to note that NFC shows a benefit on two of four sub scales of the MPT even when initially fit. Assumptions that NFC distorts sound and requires a learning phase before it is useful are therefore contradicted. The implementation appears, in severe to profound listeners, to improve information that is useful during the MPT and this information is available immedi-

→ Additional testing of this hypothesis is underway to better understand what is useful, and whether this will generalize to milder hearing losses.

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