Introduction

- It is still not understood why only some hearing-impaired listeners perceive tinnitus, despite the strong relationship between tinnitus and hearing impairment.

- One possible reason is that hearing-impaired listeners with tinnitus may have different cochlear defects from hearing-impaired listeners without tinnitus.

- This study aims to explore possible differences in behavioural measures of cochlear function between hearing-impaired listeners with tinnitus and hearing-impaired listeners without tinnitus.

notes

It is unknown why only some hearing-impaired listeners are afflicted with tinnitus. One possibility is that hearing-impaired listeners with tinnitus and hearing-impaired listeners without tinnitus have different inner ear damage. This study aims to explore this possibility by examining the differences in cochlear function in the two hearing-impaired groups.

Participants

- Three groups of participants
  - 19 normal hearing listeners, no tinnitus
  - 27 tinnitus, hearing-impaired
  - 15 no tinnitus, hearing-impaired

- All participants have normal outer and middle ear function.
- Participants with tinnitus were screened for known tinnitus-associated pathologies (eighth nerve lesions, Ménière's Disease, temporomandibular joint disorders)

notes

Three groups of participants were studied. The first group comprised of normally hearing listeners without tinnitus. This group would form the normal ‘baseline’. Two age-matched hearing-impaired groups were also examined. The first group had persistent tinnitus, while the other group did not report any perception of tinnitus. All participants were screened for normal outer and middle ear conditions, and also for other known conditions that are involved with tinnitus, for instance, eighth nerve lesions, Ménière's Disease and temporomandibular joint disorders.

Method

- Initial screening
  - History taking
  - Structured interview
  - Otoscopy
  - Pure-tone air- and bone-conduction audiometry
  - Tympanometry
  - Tinnitus Handicap Inventory
  - Tinnitus Modulation Manoeuvre Checklist

- Cued single-interval up-down paradigm used (Lecluyse and Meddis, 2009)
- Absolute Thresholds
- Frequency selectivity measured using Iso-Forward Masking Contours (IFMCs)
- Compression measured using Temporal Masking Curves (TMCs)
- Distortion Products Otoacoustic Emissions (DPOAEs)

Lecluyse, W., Meddis, R. 2009. A simple single-interval adaptive procedure for estimating thresholds in normal and impaired listeners. J Acoust Soc Am 126, 2570-9.

notes

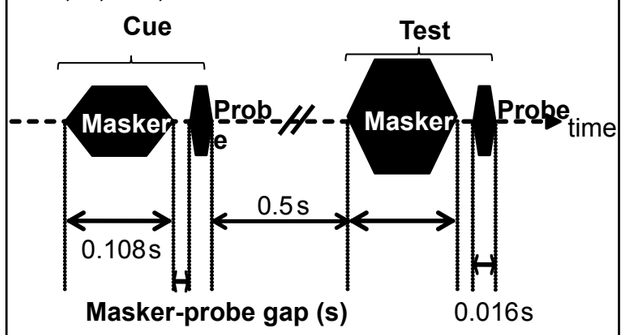
In the first part of the screening session, participants were asked to describe their hearing ability, any known experiences that may have caused their hearing loss, and a description of their tinnitus. The second part of the screening session assess the outer and middle ear functions (otoscopy, audiometry and tympanometry). Two questionnaires were also completed. The first was the Tinnitus Handicap Inventory to determine the amount of distress experienced due to the tinnitus. The Tinnitus Modulation Manoeuvre Checklist was completed to find out if any somatic movements could cause large variations in the perception of tinnitus. None of the hearing-impaired listeners with tinnitus reported large changes in their perception of tinnitus.

The measurement method used was based on the cued single-interval up-down paradigm described by Lecluyse and Meddis (2009). The measurements made included absolute thresholds, frequency selectivity, compression and distortion products otoacoustic emissions. These measurements were then summarised in 'hearing profile'. An example of a hearing profile is shown on the next slide.

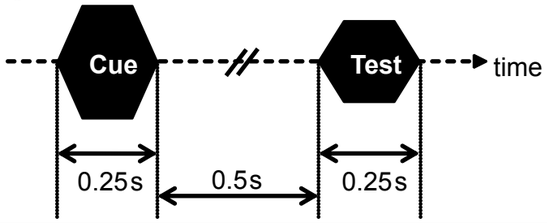
Average Hearing Profile: Normal hearing, no Tinnitus

Temporal Masking Curve
- Probe level: 10 dB SL
- Masker frequency = Probe frequency
- Masker-probe gap of 0.02, 0.04, 0.05, 0.06 and 0.08 s

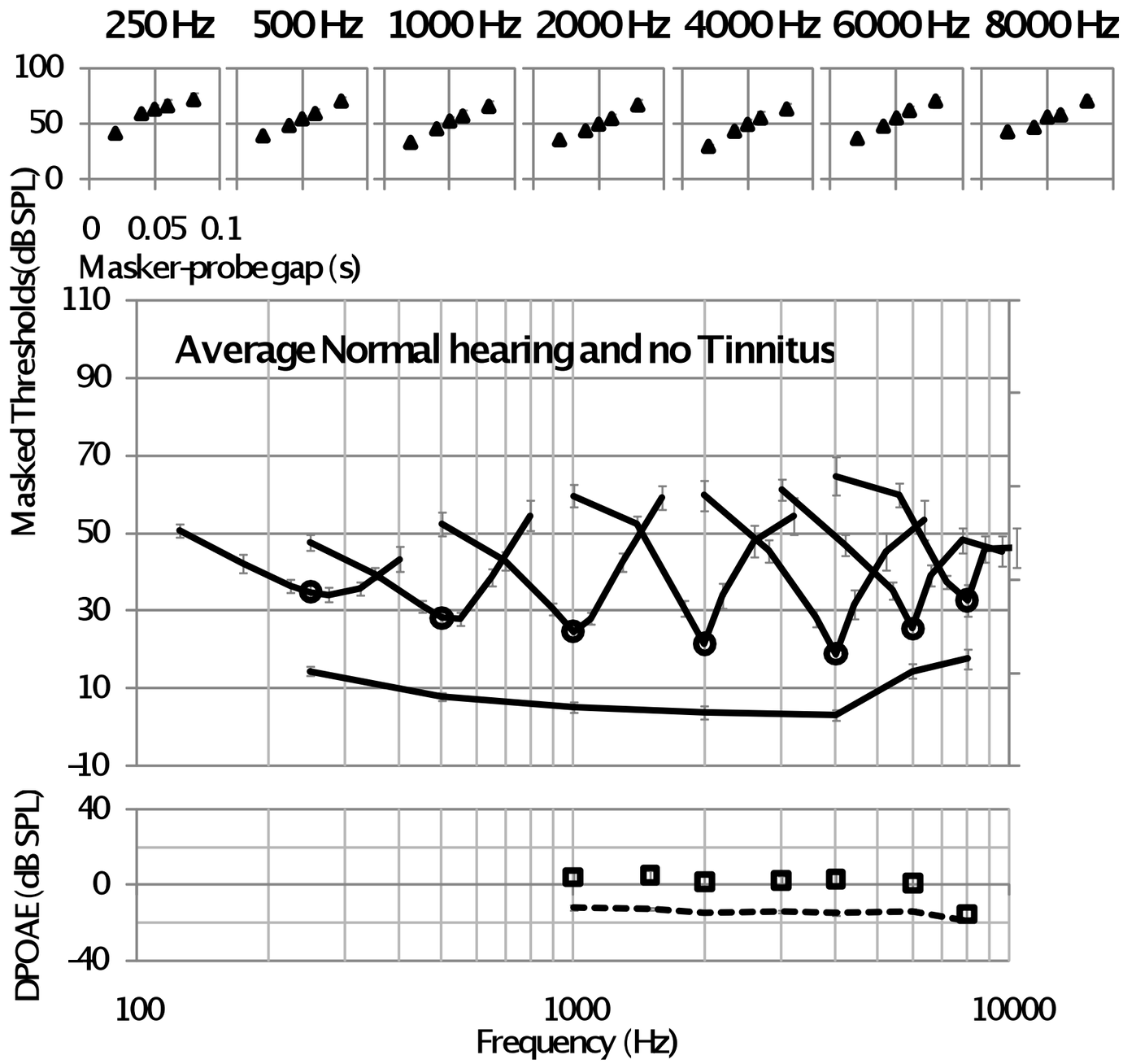
Iso-Forward Masking Contours
- Probe level: 10 dB SL
- Masker/ probe frequency ratio of 0.5, 0.7, 0.9, 1, 1.1, 1.3 and 1.6



Absolute Thresholds
- Signal duration of 0.25 s



Distortion Products Otoacoustic Emissions
- Screening ratio of 1.22, L_1/ L_2 = 65/ 55 dB



Temporal Masking Curves

Iso-Forward Masking Contours

Absolute Thresholds

DPOAE responses

DPOAE Noise

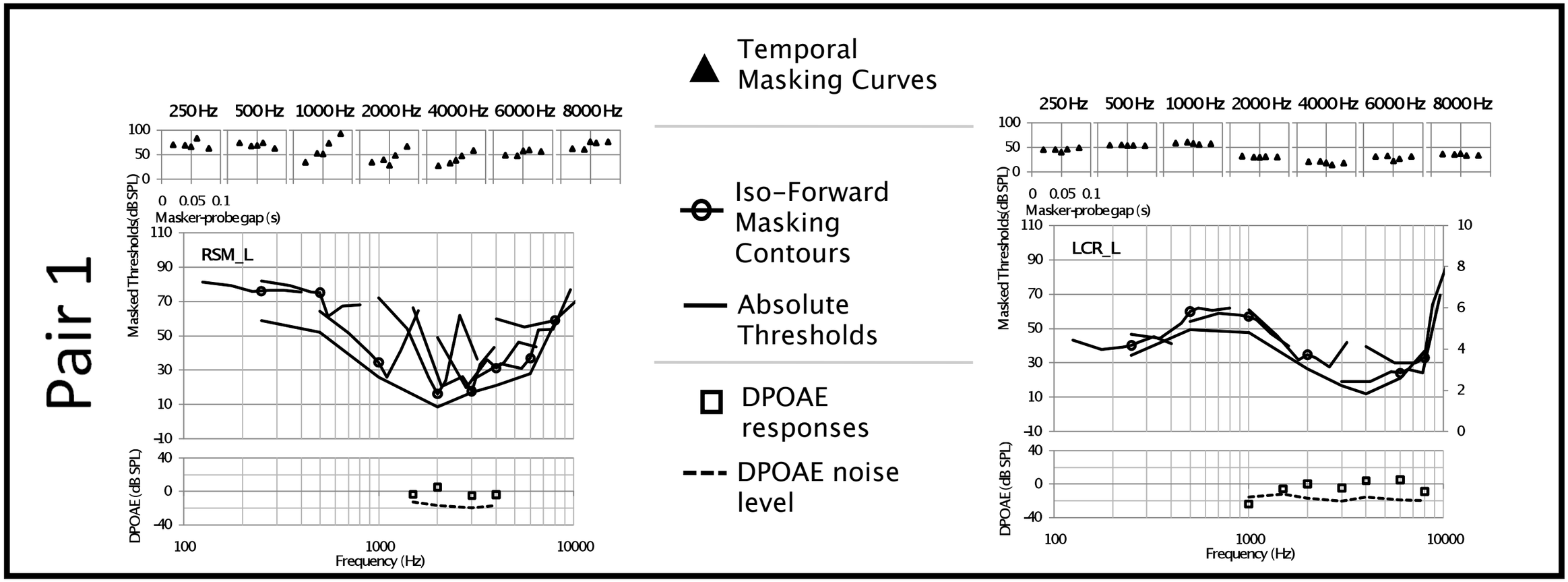
notes

This slide describes the average ‘hearing profile’ of normal hearing listeners who do not have tinnitus. Normal hearing listeners typically have low absolute thresholds, V-shaped frequency selectivity curves and steep compression curves. Also, DPOAEs are normally present across all measured frequencies. The panel on the left describes the psychoacoustical procedures used in the measurement tasks.

Individual Hearing Profiles: Tinnitus No Tinnitus

- Hearing profiles were matched based on average hearing loss, and individual pairs were compared.
- Some examples of matched pairs are shown below and on the following slide.

Text

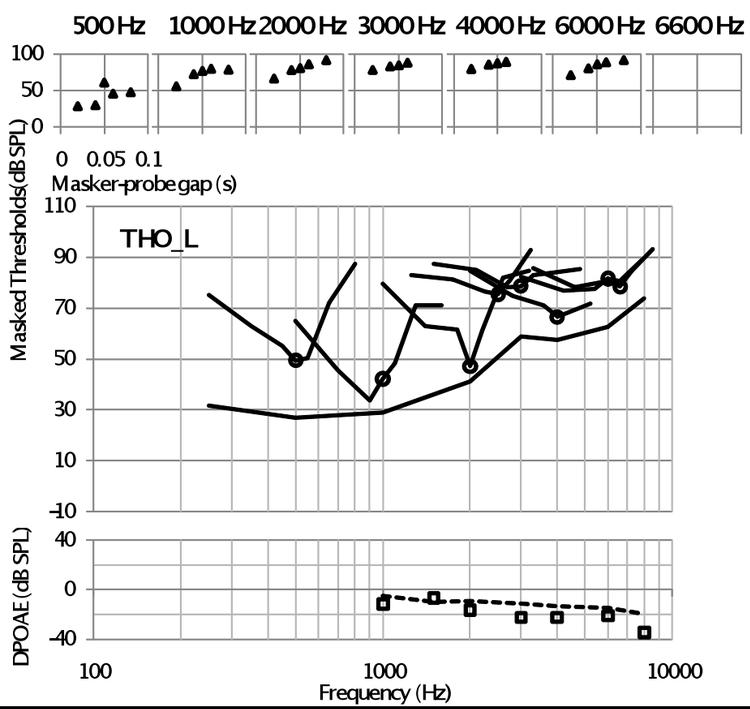


notes

We compared pairs of hearing-impaired listeners with similar absolute thresholds. Hearing-impaired listeners had better frequency selectivity and compression when compared to hearing-impaired listeners who did not have tinnitus.

Individual Hearing Profiles: Tinnitus No Tinnitus

Pair 2



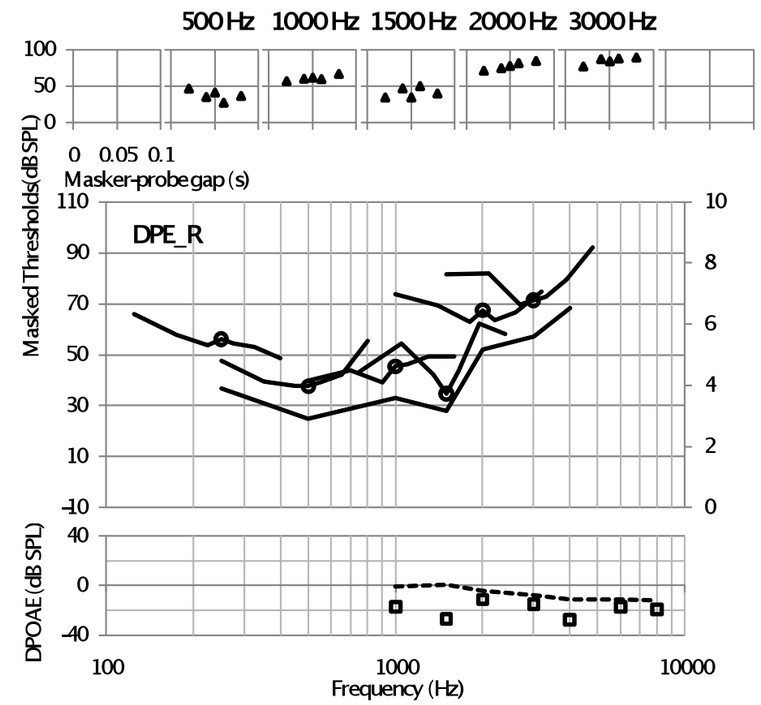
▲ Temporal Masking Curves

Iso-Forward Masking Contours

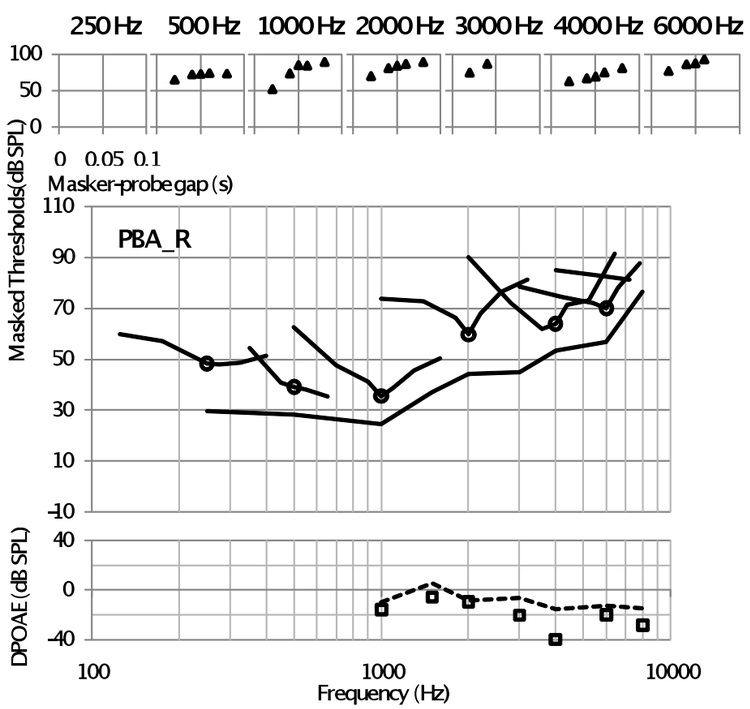
Absolute Thresholds

DPOAE responses

DPOAE noise level



Pair 3



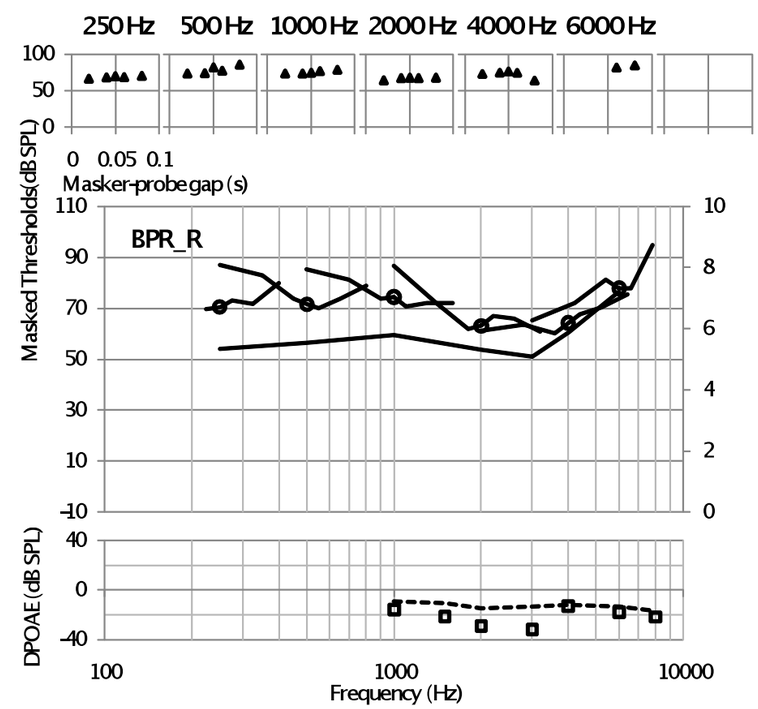
▲ Temporal Masking Curves

Iso-Forward Masking Contours

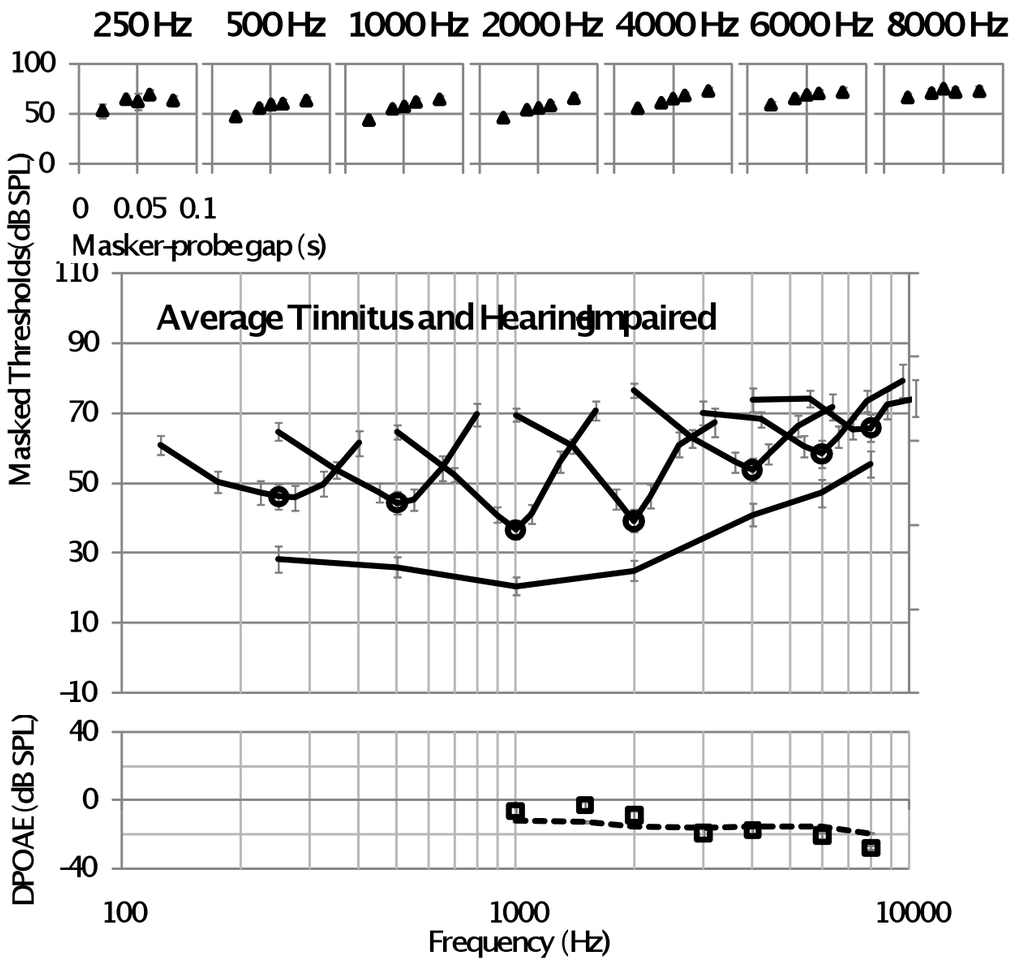
Absolute Thresholds

DPOAE responses

DPOAE noise level



Individual Hearing Profiles: Tinnitus



▲ Temporal Masking Curves

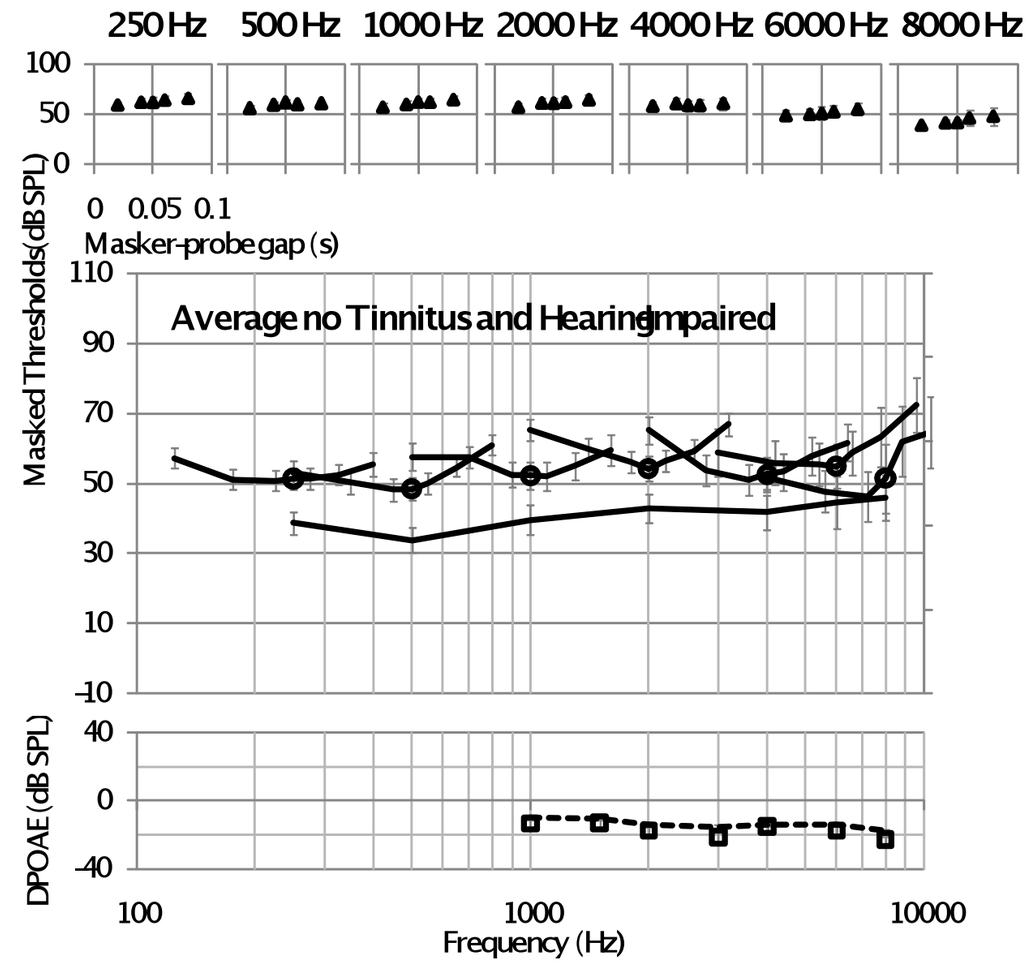
Iso-Forward Masking Contours

Absolute Thresholds

DPOAE amplitudes

DPOAE Noise

No Tinnitus



- On average, the differences between the two hearing-impaired groups, in terms of frequency selectivity ($t(38) = -2.61$, $p = 0.013$, two-tailed) and compression ($t(36) = -2.75$, $p = 0.009$, two-tailed) were statistically significant.

notes

We then compared the averaged results of the two hearing-impaired groups. There are clear differences between the pattern of loss between the tinnitus and no tinnitus groups. The tinnitus group had generally high-frequency loss beyond 2000 Hz, but better frequency selectivity and compression than the groups without tinnitus. This was evident at all the frequencies tested. There were only small differences in the DPOAE responses, and these differences were not statistically significant.

Discussion

- This study suggests that the presence (or absence) of tinnitus may be used as a marker to classify the pattern of hearing-impairment present.

- Poorer frequency selectivity and reduced compression in the **no tinnitus group** suggest that outer hair cell function is greatly reduced in this group.

- The pattern of hearing loss in the tinnitus group suggests inner hair cell dysfunction or neural impairment.

- The results of this study are consistent with Bauer et al.'s (2007) observations of negligible outer hair cell damage, but substantial neural impairment in their animal models of tinnitus.

Bauer, C.A., Brozoski, T.J., Myers, K. 2007. Primary afferent dendrite degeneration as a cause of tinnitus. J Neurosci Res 85, 1489-98.

notes

To conclude, the study suggests that the presence (or absence) of tinnitus can be used as a marker to identity the pattern of hearing-impairment present. The observation that hearing-impaired listeners with tinnitus have better frequency selectivity and compression than hearing-impaired listeners without compression will have a great impact on how aural rehabilitation is carried out. Hearing-impaired listeners who have poorer outer hair cell function may require more sophisticated hearing-aid strategies to help them cope with various acoustic environments, while hearing-impaired listeners with tinnitus may just require a simple gain-increase strategy. This study also supports the results of Bauer et al.'s (2007) study that reported that reduced outer hair cell function may not be the main trigger of tinnitus. Rather, the results are consistent with suggestions of inner hair cell defects in hearing-impaired listeners with tinnitus.