Comparison of peripheral compression estimates using auditory steady-state responses (ASSR) and distortion product otoacoustic emissions (DPOAE)

Encina Llamas, Gerard; Epp, Bastian; Dau, Torsten

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Gerard Encina Llamas, Bastian Epp and Torsten Dau

Centre for Applied Hearing Research (CAHR), Technical University of Denmark (DTU)

ABSTRACT

The healthy auditory system shows a compressive input/output (IO) function as a result of healthy outer hair cell function. Hearing impairment often leads to a decrease in sensitivity and a reduction of compression, mainly caused by loss of inner and/or outer hair cells. Compression is commonly estimated based on behavioral procedures (Plack et al., 2004), which are time consuming and rely on assumptions regarding the ability to selectively investigate cochlear processing. or objective recordings such as otoacoustic emissions (OAEs) (Neely et al., 2003), which allow to selectively study cochlear processing but the interpretation of results for individual data is challenging.

Auditory steady-state responses (ASSR) are another objective method which allows fast, reliable and frequency-specific measurements of hearing function. It is hypothesized that compressive behavior is observed in normal-hearing (NH) listeners while in hearing-impaired (HI) listeners, sensitivity and compression are reduced. ASSR data are later compared to data from distortion-product otoacoustic emissions (DPOAE) recordings.

RESULTS

Panel A: DPOAE recordings were done in a NH subject, showing growing I/O function with constant compression estimate (NH: F-test = 1 dB). Panel B: ASSR recordings were done in a NH subject, showing growing I/O function with constant compression estimate (NH: F-test = 0 dB).

Multiple and single frequency stimulation elicit similar responses. No interaction among the different SAM tones seems to be present. These results are consistent with psychoacoustical data.

HI subjects show higher variability in the results. Significant responses at input levels of 30 dB SL and above have been obtained for HI subjects.

ASSR I/O functions in HI subjects lack the loss of sensitivity at lower stimulus levels.

REFERENCES


DPOAE recordings show growing I/O function with constant slopes using mid-range stimulus levels.

Compression estimate from DPOAE I/O functions was obtained using the method proposed by Neely et al. (2003).

CONCLUSIONS

• ASSR compression estimates for levels above 30 dB HL are consistent with psychoacoustical data.

• ASSR I/O functions recorded in HI subjects reflect the loss of sensitivity at lower input levels.

• Correlation analysis between ASSR and DPOAE recordings showed more compressive functions in ASSR than in DPOAE.

• Reduced compression at levels close to threshold (<20 dB HL) could not be estimated using ASSR. Longer recording times are required to estimate compression with ASSR near threshold.

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HYPOTHESIS

Peripheral compression can be estimated through ASSR I/O functions in NH subjects. HI subjects show a change in sensitivity and compression estimate.

How do compression estimate correlate when measured using ASSRs versus DPOAEs?

METHODS

ASSR

(20 subjects, 13 NH and 7 HI)

64-channel EEG system with active electrodes (Biosens). ASSR magnitude obtained from the recorded ASSR spectrum, computed from the weighted averaged waveform.

DPOAE

(12 NH subjects)

Fitting curves

• Least-squares-fit (LSF) method used to obtain the magnitude and phase of the 2f1−f2 DPOAE component.

• DPOAE data were obtained using a time windowing technique (Long et al., 2008).

CONCLUSIONS

Fig. 3 Comparison of ASSR I/O function with multi-frequency (●) and single frequency (□) stimulation at a center frequency of 1 kHz.

Fig. 4 The panels show magnitude of the DPOAE generator component I/O functions recorded in a NH subject (left axis). Right axis show compression estimated as the slope of the fitted function (Kelly et al., 2006). Panel A: f2 = 0.5 kHz, Panel B: f2 = 1 kHz, Panel C: f2 = 2 kHz, and Panel D: f2 = 4 kHz. Panel A: C: f2 = 0 kHz @ 93 Hz, and Panel D: C: f2 = 4 kHz @ 89 Hz. The subject has normal-hearing (pure tone audiogram ≤ 20 dB HL), as shown in the inset audiogram (panel C).

Fig. 5 Comparison between slopes from best fitted line in ASSR versus DPOAE I/O functions of 12 HI subjects. Different symbols represent the four center frequencies: 500 Hz, 1 kHz, 2 kHz and 4 kHz.

Fig. 6 Averaged parameters obtained from the best fitted line to ASSR I/O functions from individuals. Panel A: f2 = 0.5 kHz, Panel B: f2 = 1 kHz, Panel C: f2 = 2 kHz, and Panel D: f2 = 4 kHz. On each panel, the left dashed rectangle shows the slope of the linear fit. NH: HI in non-impaired frequencies, and HI in the impaired frequency).

Lin (HI): N = 6
Lin (NH): N = 13
Two−Slopes: N = 6
Panel C
Lin (HI): N = 3
Lin (NH): N = 0
Two−Slopes: N = 0
Panel D