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

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ABSTRACT

The healthy auditory system shows a compressive input/output (I/O) 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 on 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 show compressive ASSR I/O functions for NH subjects. For HI subjects, ASSR reveals the loss of sensitivity at low stimulus levels. Growth slopes are smaller (more compressive) in ASSR than in DPOAE I/O functions.

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

NORMAL-HEARING:

• NH subjects consistently show compressive functions with slopes between 0.1 and 0.5 dB/db.
• ASSR saturates or even decreases at higher stimulus levels.
• Repeated points (●) recorded in different sessions show small variability in the response.

HEARING-IMPAIRED:

• 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 reflect the loss of sensitivity at lower stimulus levels.

DPOAE in NH:

• DPOAE generator I/O functions in NH show growing I/O function with constant slopes using mid-range stimulus levels.

DPOAE in HI:

• DPOAE generator I/O functions in HI show a change in slope with higher variability in the response.

REFERENCES


REFERENCES

Deouell et al. (2009). Compression estimates could lead to an additional compression mechanism in the peripheral auditory system.

CONCLUSIONS

• ASSR compression estimates for levels above 30 dB HL are consistent with psychoacoustic 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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Fig. 1: Comparison between I/O function slopes for ASSR vs DPOAE

Fig. 2: The panels show ASSR I/O functions recorded in a NH subject using 4 simultaneous SAM tones. Panel A: f2 = 0.5 kHz @ f1 = 83 Hz, Panel B: f2 = 1 kHz @ f1 = 87 Hz, Panel C: f2 = 2 kHz @ f1 = 93 Hz, and Panel D: f2 = 4 kHz @ f1 = 98 Hz. The subject has normal-hearing (pure tone audiogram ≤ 20 dB HL), as shown in the inset audiogram (panel A).

Fig. 3: Comparison of ASSR I/O function with multi-frequency (●) and single frequency (○) stimulation at a central 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 line function (Neesly et al., 2009). Panel A: f2 = 0.5 kHz, Panel B: f2 = 1 kHz, Panel C: f2 = 2 kHz, and Panel D: f2 = 4 kHz.

Fig. 5: Comparison between slopes from best fitted line curve in ASSR vs DPOAE I/O functions of 12 NH subjects. Different symbols represent the four center frequencies (1 kHz = 1 kHz, 2 kHz and 4 kHz).

Fig. 6: Averaged parameters obtained from the best fitted line curve for ASSR vs DPOAE 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 guillotine rectangle shows the slope of the linear fit for NH (●), HI in non-impaired frequencies, and ○ HI in the impaired frequencies); and the right guillotine rectangle shows the average of the compression estimates from the two-slope fitting model. The number of subjects (N) is shown on top of each rectangle.