What's New in Distortion Product Otoacoustic Emissions in Infants?

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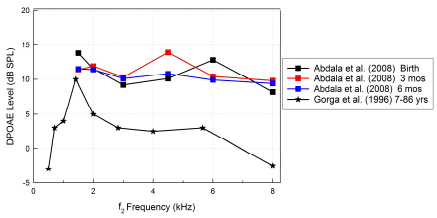
Learner Outcomes

1. Explain differences in infant and adult DPOAEs and identify underlying causes.
2. Interpret DPOAE level and SNR using newly defined cut-off values.
3. Explain how middle ear measures can be used in conjunction with DPOAEs to aid in the prediction of hearing loss.

Introduction to DPAOEs in Infants

- Advantages
  - Doesn't rely on behavioral response
  - Ear-specific
  - Frequency specific
- Disadvantages
  - Lack of infant normative data
  - Limited data on prediction of hearing loss
  - May miss mild hearing loss
  - Cannot tell type of loss (conductive, sensory)

Development of DPOAEs – Cross Sectional Studies



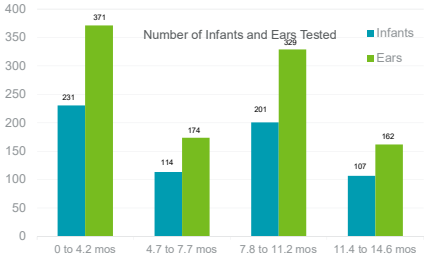
Abdala et al. (2008) Ear & Hearing
Gorga et al. (1996) Journal of the Acoustical Society of America

Test Protocol

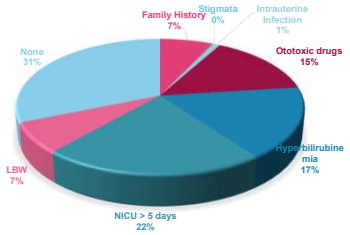
- Otoscopy
- Wideband Absorbance Tympanometry and Reflexes
- DPOAE: 65/55 dB SPL, 1-8 kHz, 7 frequencies
- Threshold ABR: 500-4000 Hz air and bone*
- VRA: 500-4000 Hz air and bone*, SAT

* Minimum protocol AC/BC 1000 and 4000 Hz

Normal Development of DPOAEs



Risk Factors

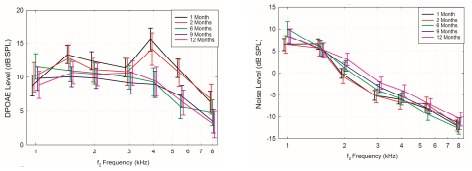


32.4% of Infants had more than one risk factor present

Normal and Hearing Loss Groups

- Infants with Normal Hearing
  - 420 infants (843 ears)
- Infants with Hearing Loss
  - 68 infants (85 ears) were diagnosed with hearing loss:
    - CHL: 63 ears
    - SNHL:10 ears
    - MHL: 8 ears

Normal Longitudinal Development of DPOAEs
(Birth to 15 months)



Model estimated mean DPOAE signal level (left) and noise level (right) in normal hearing infants at 1, 2, 6, 9, and 12 months of age as a function of DPOAE f_2 frequency. Error bars represent the 95% confidence intervals and were offset for visualization purposes.

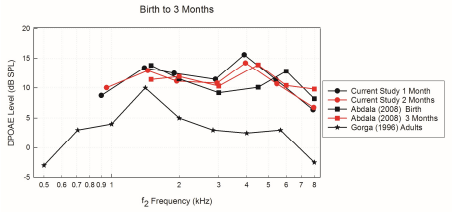
Why are DPOAE signal levels larger in younger infants?

- Ambient absorbance increases from 1 mo to age 12 months
- Largest change occurs between 1 and 6 months
- **Ear canal size**: cross sectional area and length decrease from birth to age 12 months
- **Ear canal and middle ear development:** (mechanics) correlates with DPOAE signal decreases

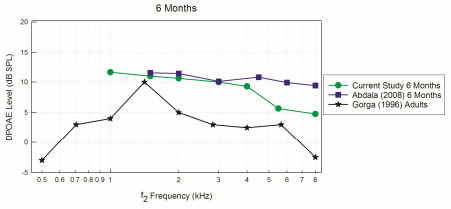
Why are noise levels higher in infants?

- Noise is mainly due to blood flow and breathing.
- Noise increases likely due to infant noise eg., movement and breathing increases with age.
- Eustachian tube is open at rest in infants, so nasopharyngeal noise is higher.

DPOAEs in Infants (Birth to 3 mos.) and Adults

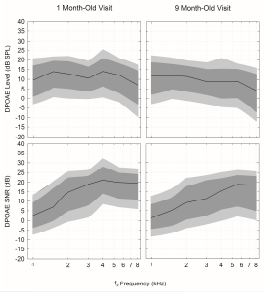


DPOAEs in Infants (6 mos.) and Adults



Normal Hearing Normative Percentiles

(Birth – 15 months)



DPOAE signal level and SNR distributions based on percentile rankings from normal hearing infants at 1 and 9 months of age.

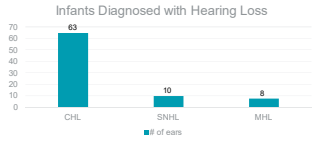
= 10^{th} to 90^{th} percentile
= 20^{th} to 80^{th} percentile
= Median of 50^{th} percentile

Summary: Longitudinal Development

- Developmental differences are seen in absorbance across the frequencies tested with DPOAE, ABR and VRA
- Development of DPOAE signal level is most rapid between 1-6 months of age, and is stable between 6-15 months.
- Development of DPOAE signal level is consistent with decreases in middle ear absorbance and increases in ear canal length
- Noise levels increase only slightly between 1-12 months but are higher in infants then in adults

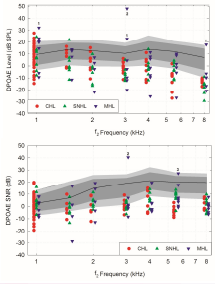
Results

- Section 2: Prediction of Hearing Loss
  - Defined as conductive (SHL), sensorineural (SNHL), or mixed hearing loss (MHL).
  - Hearing loss defined as >25 dB at any frequency
  - Conductive loss = ABG >10 dB at any frequency



Individual DPOAE Data

(Birth to 4 months)

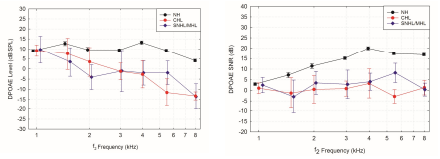


Individual DPOAE signal level and SNR values for infants with hearing loss plotted over the 1 month normative data.

= 10^{th} to 90^{th} percentile
= 20^{th} to 80^{th} percentile
= Median of 50^{th} percentile

DPOAE by Hearing Loss Type

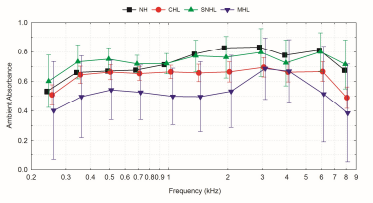
(Birth to 4 months)



Mean DPOAE signal level and SNR values plotted as a function of f_2 frequency. Brackets represent the 95% confidence intervals.

Absorbance by Hearing Loss Type

(Birth to 4 months)

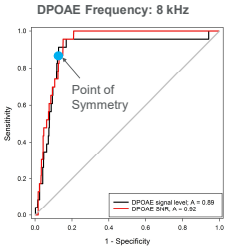


Mean ambient absorbance values for the NH, CHL, SNHL/MHL groups. Brackets represent the 95% confidence intervals.

ROC Analysis

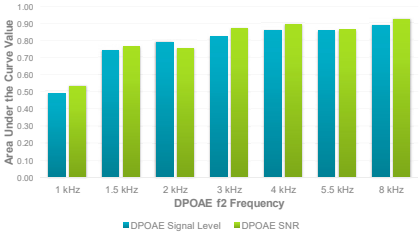
(Birth to 4 months)

- Purpose is to evaluate discrimination accuracy of a diagnostic test
- Determine optimal DPOAE signal level and SNR cut-off values for clinical interpretation



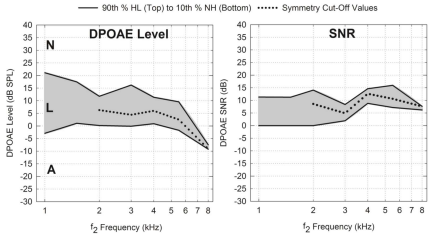
Prediction of Hearing Loss

(Birth to 4 months)

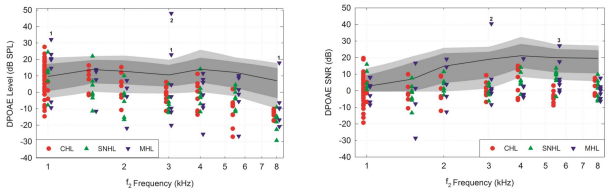


Normal and Impaired DPOAE Distributions

(Birth to 4 months)

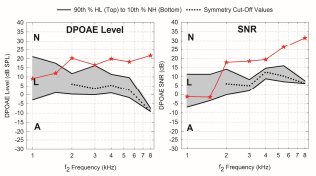


Infant DPOAE Interpretation compared to Gorga (1997) Norms

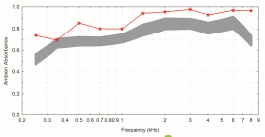


Discussion & Case Examples

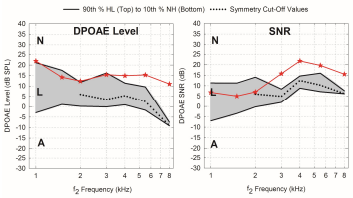
- Group data look good, but….
- Individual data can be a bit messy!
- What's an audiologist to do?



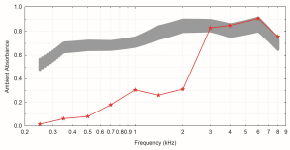
Case 1:
Infant from NICU
30 week GA
C-section
Phototherapy
Pass NHS



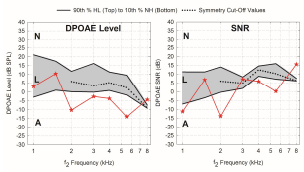
Hearing Test Results:
- Diagnostic ABR normal
- VRA normal



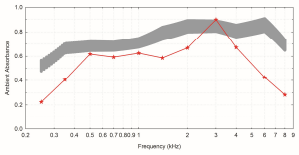
Case 2:
Well Infant
37 week GA
No risk factors
Pass NHS



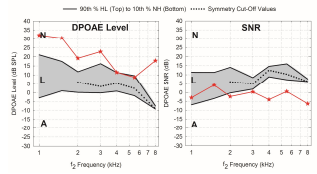
Hearing Test Results:
- Diagnostic ABR normal
- VRA normal



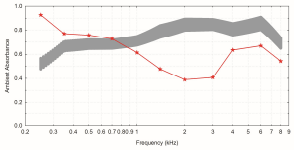
Case 3:
Well Infant
40 week GA
No risk factors
Pass NHS



Hearing Test Results:
- Diagnostic ABR borderline-normal
- VRA normal



Case 4:
Infant from NICU
30 week GA, C-section
Phototherapy, Gentamicin
Refer NHS



Hearing Test Results:
- Diagnostic ABR moderate hearing loss
- VRA moderate mixed HL

Summary: Prediction of Hearing Loss

- Prediction of conductive hearing loss is somewhat poorer than for SNHL or MHL.
- Prediction of all types of hearing loss >25 dB is good to excellent at 3 – 8 kHz, and increases with frequency.
- Best prediction of overall hearing loss is based on 3-4 frequencies in normal range out of 5 tested.
- Both SNR and Signal level should be examined compared to normal cutpoints.

Acknowledgements

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Questions?