Multivariate Analyses of Distortion Product Otoacoustic Emission Data for Clinical Application

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Introduction

- Distortion Product Otoacoustic Emission (DPOAE)
  - Sound generated by the inner ear in response to being stimulated by sound
  - Send two tones (f1 and f2)
  - Measure otoacoustic emission (2f1-f2)

Multivariate Analysis

- Logit function equation: a statistical transform incorporating emission and noise levels from several frequencies

Example:

\[
LF_{1500} = (0.025*DP_{1000}) + (0.136*DP_{1500}) + (0.078*DP_{2000}) + (0.03*DP_{3000}) + (0.038*DP_{6000}) + (0.034*N_{1000}) + (-0.036*N_{1500}) + (-0.076*N_{2000}) - 1.057
\]

Literature Review

- Gorga, Neely, and Dorn (1999)
  - First to use a multivariate analysis with DPOAEs
  - New approach improved test accuracy
  - Dependent on degree of hearing loss and frequency
  - Never produced more uncertainty

- Gorga, Dierking, Johnson, Beauchaine, Garner, and Neely (2005)
  - Are the results of multivariate analysis robust? Yes!
Hypothesis

- Analyzing Distortion Product Otoacoustic Emission data using a multivariate approach will increase test accuracy in the KUMC Pediatric Audiology Clinic and result in correctly determining hearing status as normal or impaired rather than uncertain.

Methods

- Data for spreadsheet
  - Behavioral thresholds and decision
  - Some interpolations at 1.5, 3, and 6 kHz
  - DP emission and noise levels and decision
  - LF Score and decision

- Analyzing Distortion Product Otoacoustic Emission data using a multivariate approach will increase test accuracy in the KUMC Pediatric Audiology Clinic and result in correctly determining hearing status as normal or impaired rather than uncertain.

Methods

- Subjects selected from KUMC Audiology Clinic pediatric data
  - 24 subjects (n=47 ears)
- Inclusion criteria:
  - DPOAEs
  - Behavioral audiometric data (VRA, CPA, conventional)
  - Normal tympanometry

Methods

- LF$_{1500}$ = (0.025*DP$_{1000}$)+(0.136*DP$_{1500}$)+(0.078*DP$_{2000}$) + (0.03*DP$_{3000}$)+(0.038*DP$_{4000}$)+(0.034*N$_{1000}$)+(-0.036*N$_{1500}$)+(-0.076*N$_{2000}$)-1.057
- LF Scores
  - Single Frequencies: 1500, 2000, 3000, and 4000 Hz
  - Pure Tone Averages (PTAs):
    - 3 frequency
    - 4 frequency
    - 5 frequency
- Comparisons of DP and LF decisions to audiogram decision

Results

- Uncertain: DP Emission = -0.6 dB SPL
  DP Noise = -7 dB SPL

- Impaired: LF Score = -1.8
Results: Combining Conditions
- Combining all single frequencies (1.5, 2, 3, and 4 kHz): \( p<.0001 \)
- Combining all PTAs (3, 4, and 5 frequencies): \( p=.001 \)

Results: Single Frequencies

Results: Pure Tone Averages

Discussion
- Decrease in number of errors when using the LF score versus our traditional approach
- Likewise, an increase in the number of correct decisions
- Few cases where the LF score caused an error and the traditional approach did not
- Direction of change in favor of LF score (multivariate approach) being correct

Discussion
- Original formulas developed with the Biologic system generalized to the ILO system
- Large contribution when traditional approach was uninterpretable and LF score made a correct decision
- Multivariate approach does not require any more participation from the patient
Limitations

- Limited data for logit function equation
  - To compute all frequencies, you need DP emission and noise values for 750, 1000, 1500, 2000, 3000, 4000, 6000, and 8000 Hz
  - Do not typically collect DP_{8000} or N_{750}
  - Extrapolation of DP_{8000} from DP_{6000}
  - Did not use equations requiring N_{750}
- Small sample size (n=47 ears)
  - Did not control the p-value for multiple comparisons

Future Research

- Use ILO system again
- Collect DPOAE emission and noise levels from 750 to 8000 Hz
- Larger sample size
  - Possibly include adults to find more hearing in the uncertain range by univariate analysis

Conclusion

- Multivariate analyses of DPOAE data can make more correct decisions regarding hearing status compared to the traditional univariate approach

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References