Distortion Product Otoacoustic Emissions in Canines: Systematic Changes in Amplitude as a Function of f2/f1 Ratio

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PURPOSE

Background: Distortion product otoacoustic emissions (DPOAEs) are part of hearing screening measures and the comprehensive audiologic test battery in humans. Brainstem auditory evoked response (BAER) test is currently the gold standard for assessing hearing sensitivity in canines. DPOAEs can be a quick, beneficial, and noninvasive method for providing ear-specific information on cochlear function of a canine. Performing DPOAEs on canines for screening and/or diagnostic purposes is a relatively new area of research and there is currently a lack of canine-specific testing equipment, protocols and universally accepted clinical normative data.

Purpose: Determine what stimulus frequency ratios would produce the most robust DPOAEs in canines to support future clinical use of DPOAEs to aid in diagnosis of hearing status in canines.

RESEARCH QUESTIONS & HYPOTHESES

Q1: When measuring distortion product otoacoustic emissions (DPOAEs) in canines, does the amplitude pattern across frequencies for the 2f1-f2 distortion product change with changes in the f2/f1 ratio?

H1: The amplitude patterns across frequencies for the 2f1-f2 distortion product will vary with changes in f2/f1 ratio for canine DPOAEs.

Q2: When measuring distortion product otoacoustic emissions (DPOAEs) in canines, do specific f2/f1 ratios produce different overall amplitudes of the 2f1-f2 emission?

H2: Changing the f2/f1 ratio produces different overall amplitudes of the 2f1-f2 emission.

METHODS

Subjects: Convenience sample of 10 canines recruited through the Facility for Education and Testing of Canine Hearing & Laboratory for Animal Bioacoustics (FETCHLAB) at the University of Northern Colorado

Inclusion criterion: 2-8 years old, 10-90 lbs., and normal hearing sensitivity. No attempt made to control for breed and gender.

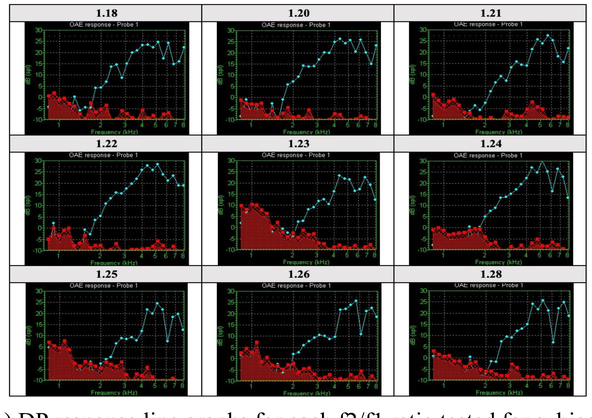
Testing environment: Single-walled sound-treated booth.

Equipment: Otodynamics Ltd. ILO-v6 clinical OAE software set up for a DPOAE diagnostic test.

Set up: Owners brought subjects to the University of Northern Colorado Speech-Language Pathology and Audiology Clinic. Then case history, otoscopy, probe tip attached to probe and inserted into vertical portion of right ear canal (testing performed on right ear only), MuttMuffs® placed and secured with Velcro to cover test ear.

Settings: L2=55dB SPL, L1=65dB SPL, f1 varied for 9 total f2/f1 frequency ratios while f2 was fixed, calibration test run prior to testing each subject, initial check-fit test for each test (pass=30+ good check-fit sweeps)

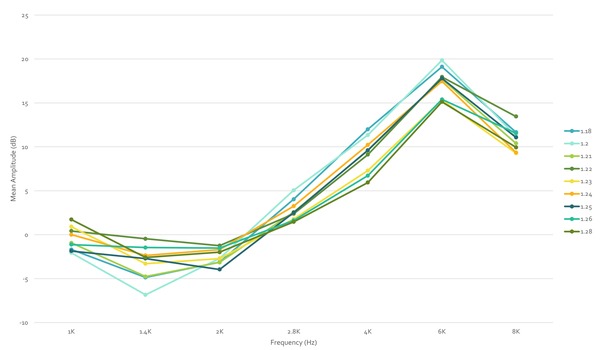
Methods: Two DPOAE tests using optimal f2/f1 ratio for humans (1.22) completed to confirm reliability of initial test results. Then, f1 altered to produce the following f2/f1 ratios in a randomized order: 1.18, 1.20, 1.21, 1.22 (complete), 1.23, 1.24, 1.25, 1.26, 1.28



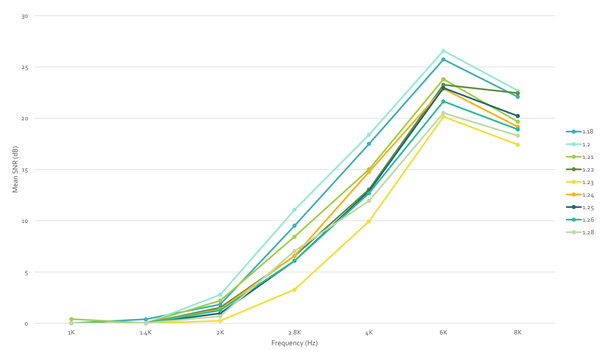
Ex.) DP response line graphs for each f2/f1 ratio tested for subject 4.

RESULTS

Average DPOAE amplitude values at each f2 frequency tested for each f2/f1 ratio



Average signal to noise ratio (SNR) values (in dB) across all subjects at each frequency tested, for each f2/f1 ratio



- On average 6k Hz had the largest amplitude and SNR, followed by 8k Hz.
- At 2k Hz and below, mean amplitudes were typically <0dB and SNRs were very low.
- Though not shown in the figures, on average 8k Hz had the lowest noise level and as frequency decreased noise levels increased.

- **Statistical analysis:** analysis of variance was run to evaluate statistical significance of amplitude, noise, and SNRs across frequencies for the f2/f1 ratios tested.
- It showed no significant difference among different **ratios** tested: p-value ($p<0.05$) of 0.479 (amplitude), 0.326 (noise), and 0.445 (SNR).
- It did show **frequency** to be significant: p-value ($p<0.05$) of 0.003 (amplitude), 0.001 (noise), and 0.025 (SNR). Significance with frequency is to be expected based on what a typical DPOAE looks like; response and noise floor, and therefore SNR, will be different for different frequencies.

CONCLUSIONS

- All 10 subjects showed consistent DPOAE responses across different f2/f12 ratios tested. Therefore, it can be concluded that DPOAEs can be elicited from the canine ear.
- f2/f1 ratios between 1.18 and 1.28 did not produce statistically significantly different DPOAE responses, and the pattern across frequencies did not significantly change when the f2/f1 ratio changed.
- Results indicated the typical canine DPOAE response is 2k Hz and above because of lack of DPOAE responses below 2k Hz regardless of noise floor levels, low ambient noise, and level of canine compliance.
- In general, canine DPOAE responses are robust enough that f2/f1 ratio does not seem to significantly impact the overall amplitudes.
- Due to lack of a specially designed probe for canine ears, recommend use of MuttMuffs® (or similar device), though further research is necessary to determine if MuttMuffs® impact DPOAE responses.
- A f2/f1 ratio of 1.18-1.22 is recommended at this time because ratios in that range had the most robust responses overall.