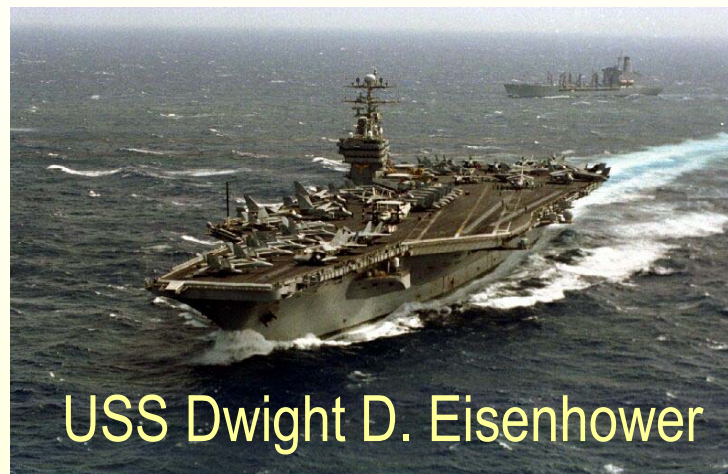
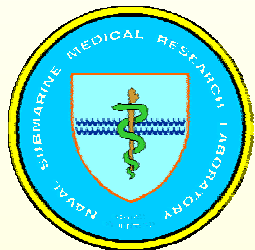


# #772 Changes in Evoked Otoacoustic Emissions and Hearing Thresholds After a Six-Month Deployment on an Aircraft Carrier

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# Abstract

Evoked otoacoustic emissions and hearing thresholds were measured in 339 sailors from the USS Dwight D. Eisenhower aircraft carrier before and after a six-month deployment to the Mediterranean. Sailors from the Air, Reactor, and Engineering departments were targeted because they were considered most at risk for noise-induced hearing loss. At pre-deployment and post-deployment testing, hearing thresholds (0.5 to 6 kHz) were measured using a modified Hughson-Westlake procedure and normal middle-ear pressure was established. Transient-evoked otoacoustic emissions (non-linear click stimulus at 74 dB pSPL) and distortion-product otoacoustic emissions ( $f_2/f_1=1.22$ , at four stimulus levels) were then measured using the Otodynamics ILO292 Echoport. There was no consistent change in average hearing thresholds for the group; however, some individuals showed significant threshold shifts. Temporary threshold shifts were confirmed for two sailors (two ears) and permanent threshold shifts were confirmed for fifteen sailors (eighteen ears), based on their noise history and a confirmatory audiogram. Some additional significant threshold shifts were unable to be confirmed. Preliminary group results indicated that after deployment there was a decrease in average distortion-product and transient-evoked otoacoustic-emission amplitudes. Changes in otoacoustic-emission amplitudes might be a more sensitive indicator of noise-induced damage to the inner ear than changes in hearing thresholds.

# Overview

- Are evoked otoacoustic emissions more sensitive than the audiogram to the effects of noise on the ear?
  - Our approach is to study hearing and otoacoustic emissions before and after hazardous noise exposures in ears that are at risk for noise-induced hearing loss
- The crew of the aircraft carrier USS Dwight D. Eisenhower (CVN69) are such a population



# Further Information

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# Method

## ● Subjects

- 339 sailors measured 3 months before and immediately after a 6-month deployment
- 29 controls subjects measured twice without intervening noise exposure (usually the same day)

## ● Measurements

- Noise history
- Audiogram (0.5-6kHz)
- Middle-ear pressure
- TEOAEs  
non-linear 74 dB pSPL,  
analyzed into 1/2 octave bands
- DPOAEs  
L1/L2= 65/45, 61/55, 59/50,  
and 57/45 dB SPL,  
f2/f1=1.22,  
f2=1.8, 2.0, 2.5, 2.8, 3.2, 3.6,  
and 4.0 kHz\*

\* 2.2 and 4.5 kHz dropped from all analyses due to electrical interference contaminating measurements

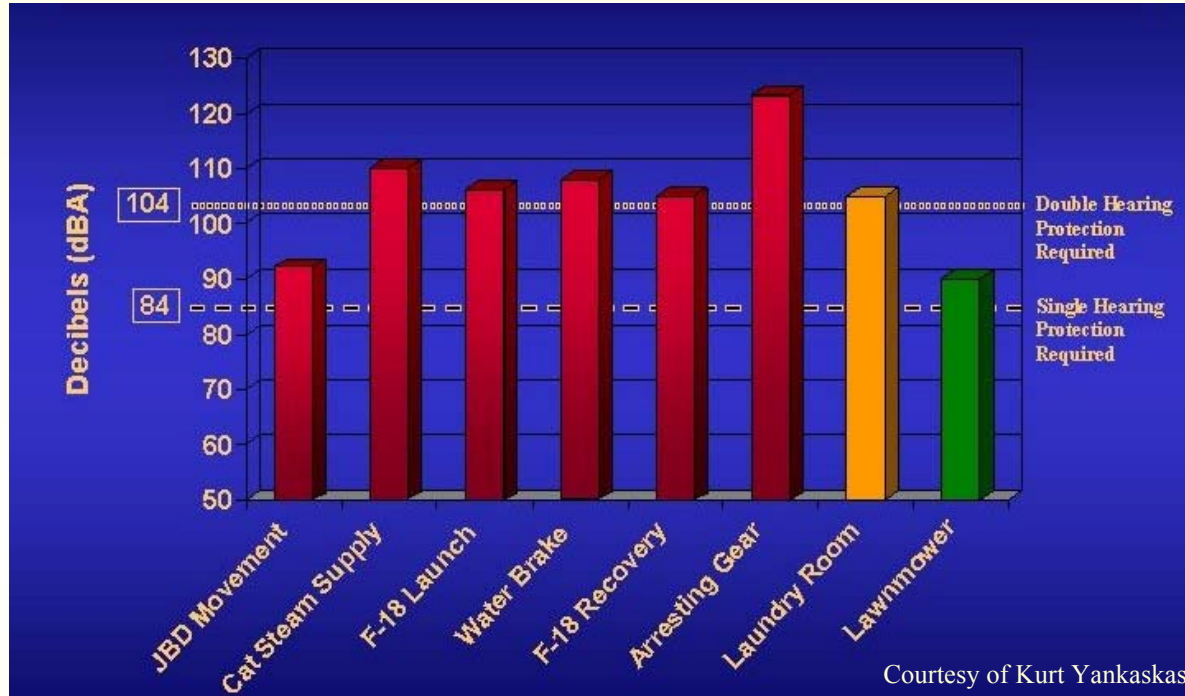


# Noise Exposure

- Aircraft carriers are noisy!
  - Exposure durations often exceed 8 hours per day
  - Few quiet areas for recovery
  - Some areas require double hearing protection



## Airborne Noise just below Flight Deck



- Flight Deck filled with planes
- Needle-guns, grinders, chippers, etc.
- Nuclear power plant
- Some sleeping compartments directly below flight deck

# Changes in Hearing—Individuals

- Significant threshold shifts
  - 15 sailors (18 ears) had permanent threshold shifts
  - 2 sailors (2 ears) had temporary threshold shifts
  - 21 sailors (25 ears) had unconfirmed significant threshold shifts
    - These shifts could not be categorized further into permanent or temporary shifts because a follow-up audiogram was not possible



# Subjects used for Group Analyses

- Group analyses used 75 subjects from noisy areas
  - Air (Flight Deck) n=34
  - Engineering n=12
  - Nuclear Propulsion n=29



- All subjects for these analyses had TEOAEs and DPOAEs\* at 2, 2.8, and 4 kHz at both pre and post-test\*\*
  - Vulnerable subjects may not be included because of requirement for measurable emissions

\*If the post-test EOAE was below the noise floor and the noise floor was lower than the pre-test EOAE then the noise floor was substituted for the EOAE. This underestimates the true difference.

\*\* DPOAE level 61/55 was not included due to too many unexplained outliers



# No Change in Group Hearing

- A three-way repeated-measures ANOVA (pre-/post-test, ear, frequency) indicated that group average hearing thresholds did not change after noise exposure
  - Significant main effect for ear and frequency ( $p < 0.05$ )
  - Interactions for test-by-frequency and test-by-ear-by-frequency
  - The interactions do not show changes consistent with NIHL



# Fig 1: No Change in Group Hearing

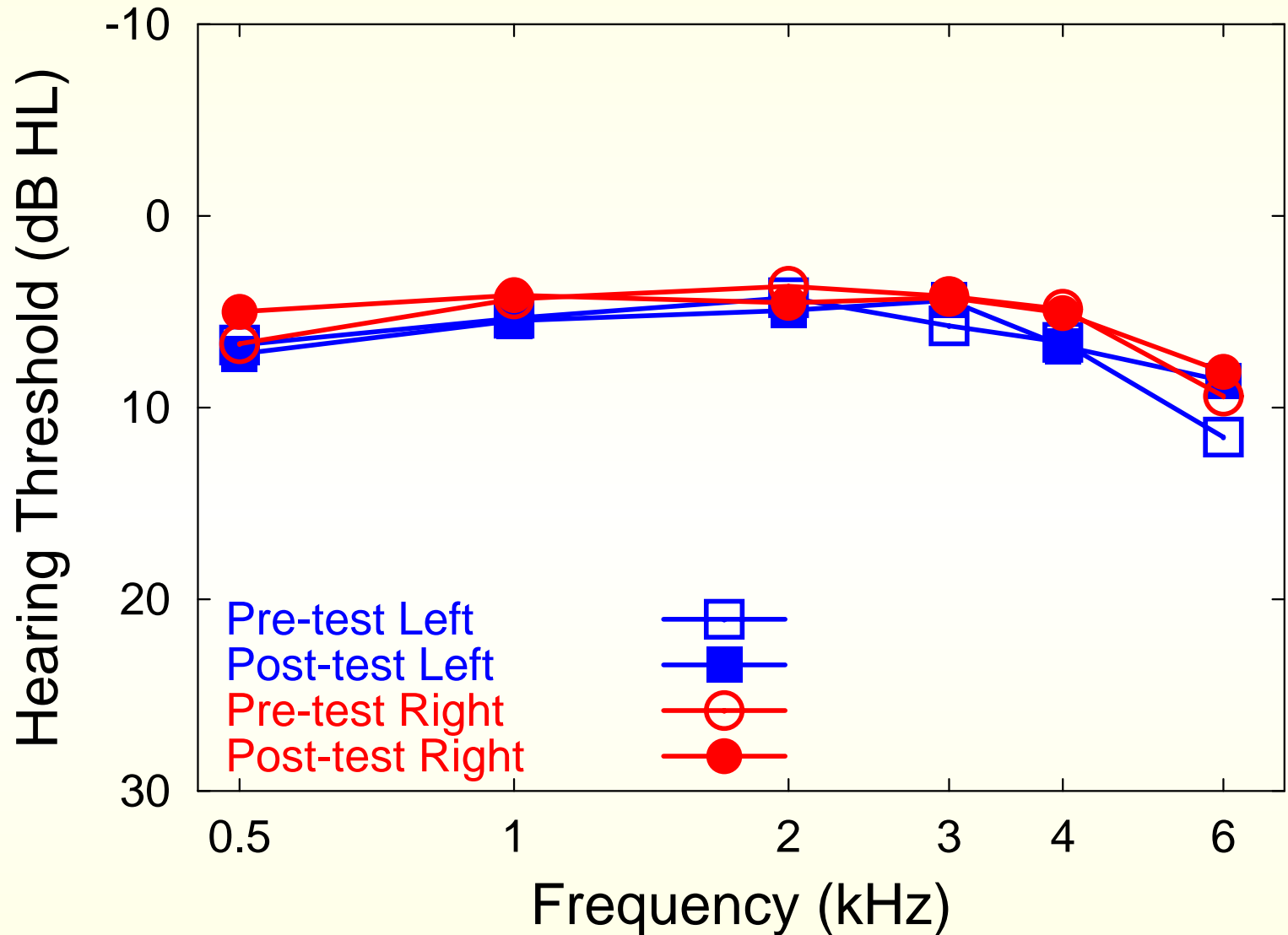


Fig 1. Group average hearing thresholds show no (main effect) change between pre and post test, for each ear (n=150)

# TEOAEs & DPOAEs Decreased

- A three-way repeated-measures ANOVA (pre-/post-test, ear, frequency) indicated that the group average TEOAE amplitude decreased after noise exposure (see Fig. 2)
  - Significant main effects for test, ear, and frequency ( $p < 0.05$ )
  - Significant interaction effects for test-by-frequency and ear-by-frequency
- Biggest decrease at 4 kHz
- A four-way repeated-measures ANOVA (pre-/post-test, ear, DP level, and frequency) indicated that the group average DPOAE amplitude decreased after noise exposure (see Fig. 3)
  - Significant main effects for test, level, and frequency ( $p < 0.05$ ), but not ear
  - Significant interaction effects for test-by-level, ear-by-level, and level-by-frequency
- Biggest decreases at lower levels

# Fig 2: TEOAEs Decreased

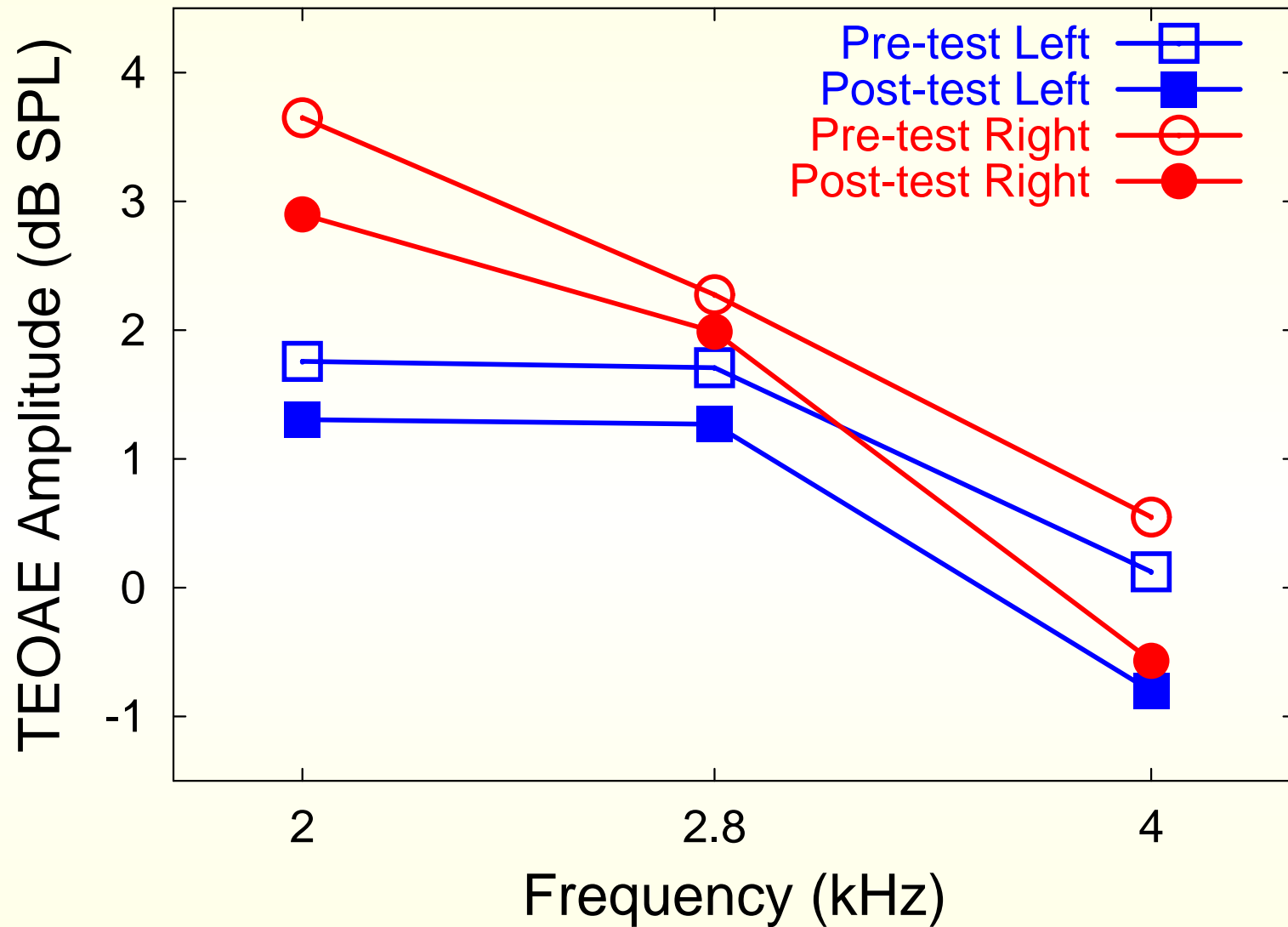


Fig 2. Group average TEOAE amplitude decreased between pre and post test, for each ear (n=150)

# Fig 3: DPOAEs decreased

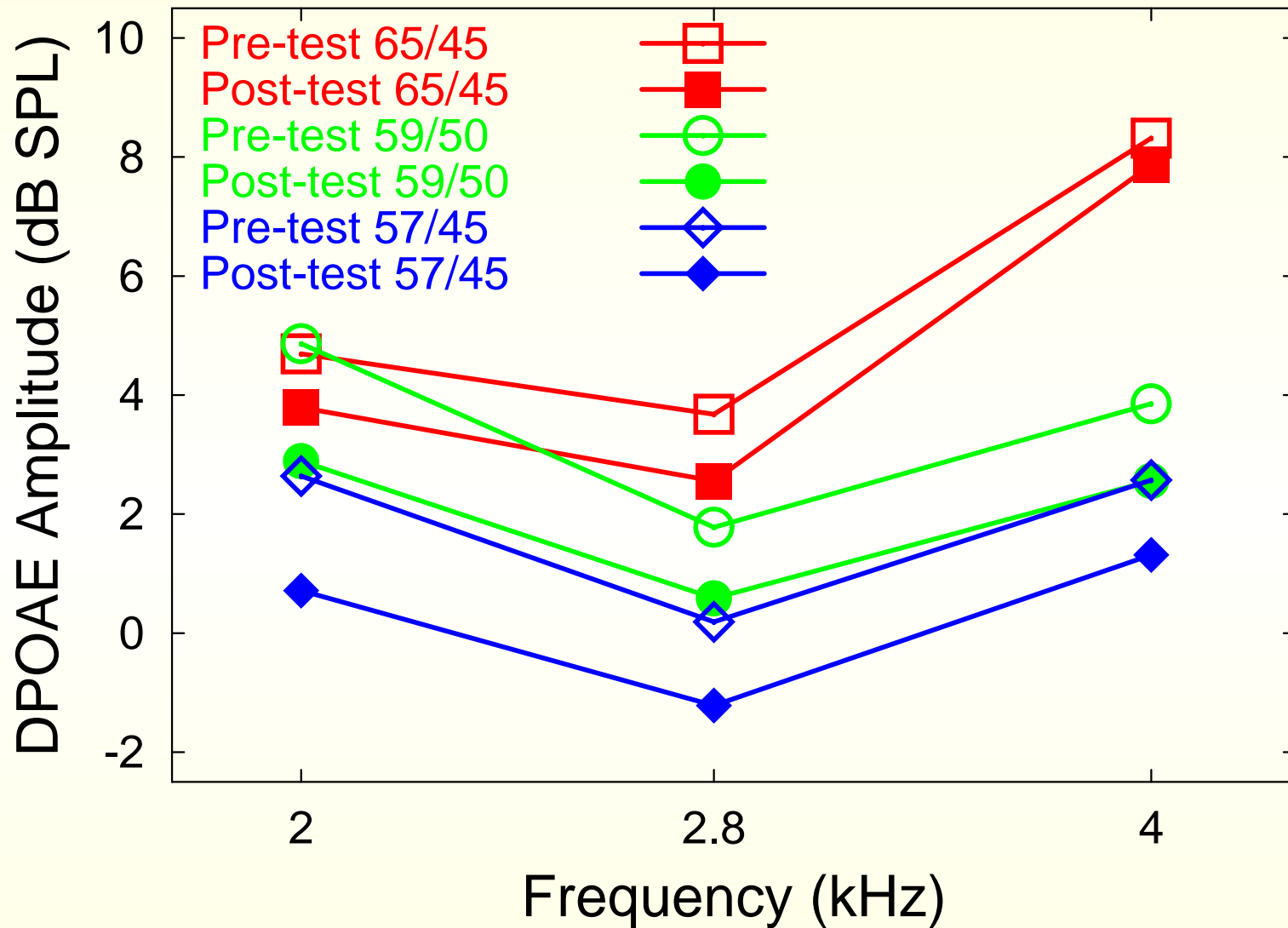


Fig 3. For each level, group average DPOAE amplitude decreased between pre and post test, averaged over ears (n=150)

# Hearing & OAE Shift Agreement

- No correlation between changes in hearing and changes in TEOAEs or DPOAEs ( $r < 0.3$ )
- Each individual ear ( $n=150$ ) classified for presence of a significant decrement in hearing and/or a significant decrement in emission amplitude
  - A significant shift is greater than three times the standard error of measurement of control group
- Only weak agreement between hearing and emission decrement categories
- For both TEOAEs and DPOAEs, emission-shift category was not a good predictor of hearing-shift category

		Hearing Shift	
		Yes	No
TEOAE Shift	Yes	3	29
	No	7	111

		Hearing Shift	
		Yes	No
DPOAE Shift	Yes	4	40
	No	6	100

# TEOAE & DPOAE Shift Agreement

- Changes in TEOAEs and DPOAEs were correlated ( $0.3 < r < 0.6$ )
- Each individual ear (n=150) classified for presence of significant TEOAE and/or DPOAE shifts at 2, 2.8, and 4kHz
  - A significant shift is greater than three times the standard error of measurement of control group
  - Any shift (decrements and increments) and decrements-only considered separately
- There is moderate agreement between the two types of emission shift.

		DPOAE Any Shift	
		Yes	No
TEOAE Any Shift	Yes	33	13
	No	24	80

		DPOAE Decrements	
		Yes	No
TEOAE Decrements	Yes	23	6
	No	19	102

# Summary

- Otoacoustic emissions are more sensitive to the early stages of inner-ear changes related to excessive noise exposure (after noise exposure, group average TEOAE and DPOAE amplitudes both decreased, but group average hearing levels did not worsen)
- More individuals had significant changes in emission level than significant changes in hearing
- Changes in OAEs do not agree with changes in hearing
- Changes in TEOAEs and DPOAEs are somewhat consistent
- Future analyses will examine characteristics of significant emission shifts in individuals and susceptibility to noise-induced hearing loss