

THE FUTURE IS NOW:  
EIGHT WAYS OTOACOUSTIC EMISSIONS CAN BE USED TO  
ADVANCE HEARING CONSERVATION PROGRAMS

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SAFETY FIRST



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**SAFETY PRIZES**, awarded by management to each employee at company plants which work a specified number of hours without a lost-time injury, encourage safety-consciousness and cooperation at Du Pont.

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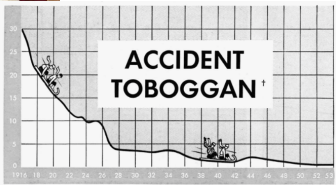
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COL (ret) Nancy Vause  
(Photo by Doug Valentin)

"What we are doing in our military HCPs is documenting the failure of those programs. We measure STS, but we don't prevent it or stop it."



**ACCIDENT TOBOGGAN<sup>†</sup>**

**STEEP—AND GRATIFYING—PLUNGE** in DoD injury rate over last 37 years resembles the downhill slide of a free-wheeling toboggan. Record was achieved despite influx of inexperienced war workers.

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**MAJOR ADVANCEMENTS**

HPDs  
Check-fit of HPDs



Custom HPDs



Рис. 3.

TCAP



Sgt. Jon Harston

† Adapted from Figure 2-20 of the 2010 DoD Injury Prevention Report, available at: <http://www.dodig.mil/Reports-and-Testimony/2010-03-04-DoD-Injury-Prevention-Report>

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**HCP AUDITORY TESTING SLOW TO IMPROVE**

- Poor pure-tone audiometry reliability, especially at 6 kHz – key freq for NIHL
- Difficult to quickly detect HCP deficiencies
- Can't quickly evaluate whether interventions are making a difference
- Do not know who is accumulating inner-ear damage that has not yet resulted in STS
- Among people doing the same job, cannot predict who is most at risk of NIHL
- Difficult to convince people to take STS seriously
- Vulnerable to malingering; needs active, alert cooperation




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## WHAT WE'RE TRYING TO DO

### Work with equipment manufacturers

- HCP systems
  - Multi-patient, tested simultaneously
  - High through-put
  - Binaural
  - Measure low-level OAEs
  - Track small change – not pass/refer
  - Automatic testing of a test battery with smart algorithms
  - Automated test interpretation
  - Unskilled testers
- Rugged systems for challenging situations

Work with researchers to translate science into clinical tests.

Work with end users to ensure needs are met.

## EIGHT WAYS OAES CAN BE USED IN HCPS

- What scientific data exist to justify that usage
- Is clinical equipment adequate to do the job, or is more precise/durable/usable equipment needed?

Ways	Science	Equipment

*DOD is funding development on most of these fronts – most are ready for beta-testing, field trials, and/or clinical use*

## EIGHT WAYS OAES CAN BE USED IN HCPS

Ways	Science	Equipment
Evaluate HCP success and interventions for groups	Yes	Ready
Detect preclinical change	Field trials needed	Ready
Track recovery from TTS	Yes	Ready
Predict PTS risk with low-level OAEs	Field trials needed	Ready
Predict PTS risk with MOCR	Field trials needed	Ready
Estimate hearing status for those unable to respond to hearing test	Yes	Ready
Functional hearing loss test	Yes	Ready
Education about inner-ear damage	??	Not funded

*DOD is funding development on most of these fronts – most are ready for beta-testing, field trials, and/or clinical use*

## COLLABORATIONS?

### Equipment Development

#### HCP beta-testing

- Help stress-test and refine the technology to meet HCP needs
- Ideally 2-person booths (start small)

#### Forward-deployed beta-testing

- Ruggedized, portable system with easy-to-administer tests

### Support Experiments

- Can provide more sensitive tests likely to pick up changes in hearing system faster than old-school PTA
- Noise exposure and interventions
- MOCR

Interested?

## ACKNOWLEDGMENTS

Thanks to...

Pat Jeng, Mimosa Acoustics

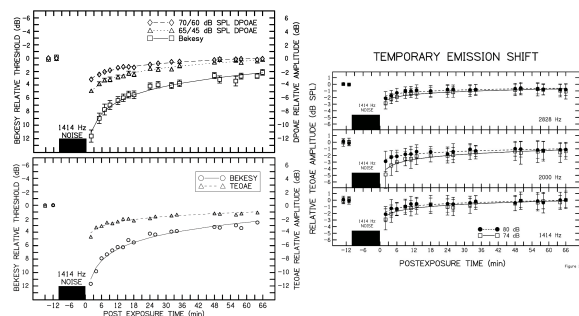
Kurt Yankaskas, Program Officer for NIHL at ONR

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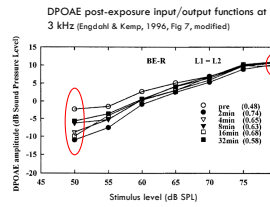
## NSMRL TTS DATA



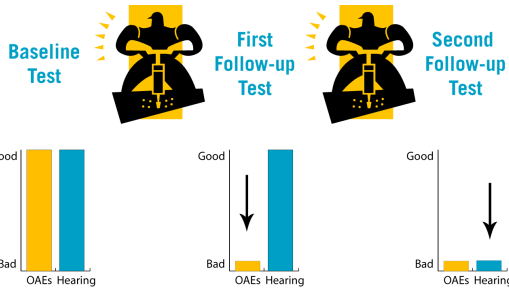
## EARLY NIHL DATA FROM KEMP:TTS

Engdahl & Kemp (1996) examine post-exposure DPOAE microstructure changes

- Lower-level primaries show higher sensitivity to noise
- Microstructure not measurable in all subjects at all frequencies
- Frequency band average may be the best measure

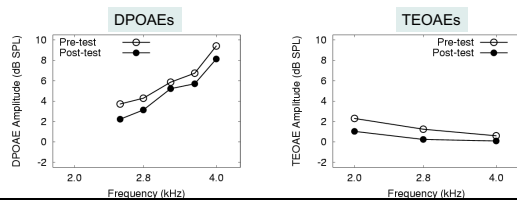


## OAES AS SUBCLINICAL NIHL INDICATORS



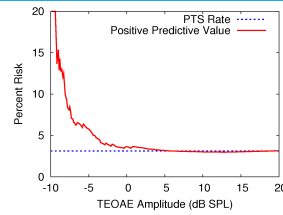
## MARINE BASIC TRAINING

- Frequency range 2-4 kHz
- OAEs decreased in amplitude
- DPs and TEs worsened by 1 dB
- Hearing levels did not change
- More permanent emission shifts



## Do low-level OAEs predict NIHL?

### Continuous noise overlaid with impact

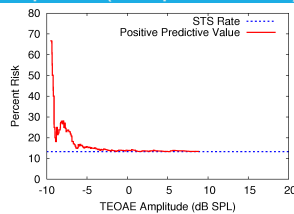


- Observed population PTS incidence 3%
- For all ears, use pre-test OAE as predictor for whether an ear was in the PTS group or the non-shifting group.
- Probability of a PTS given a low-level OAE is up to 20%
- As OAE level decreases, PTS risk increases
- TE stimulus level 74 dB pSPL; 4 kHz half-octave band

Lapsley Miller, J. A., Marshall, L., Heller, L. M., & Hughes, L. M. (2006). JASA, 120(1), 280-296

## Do low-level OAEs predict NIHL?

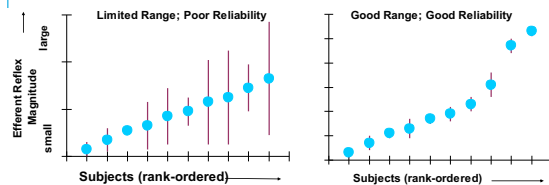
### Impulse (weapons noise)



- Observed population STS incidence 13%
- Take ear with lowest pre-test OAE, use as predictor for whether individual got STS in either ear.
- Probability of an STS given a low-level OAE is up to 70%
- As OAE level decreases, STS risk increases
- TE stimulus level 74 dB pSPL; 4 kHz half-octave band

Marshall, L., Lapsley Miller, J. A., Heller, L. M., Woigemuth, K. W., Hughes, L. M., Smith, S., Kopke, R. (2009). JASA 125(2), 895-1013.

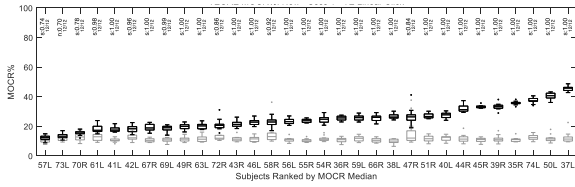
## EFFERENT REFLEX TEST



A good clinical efferent reflex test will have a wide range of values between subjects and small within-subject test-retest variability

Our current research is investigating adequate test protocols

## LATEST ITERATION OF MOCR TEST



Lapsley Miller, Reed, & Perez (unpublished data)

## WHAT DOES IT NEED TO DO?

All-in-one system with same insert earphone

Multi-person and individual testing

Automated

Flexible

Integrated

Configurable

Smart test-sequences

Reporting

### Key tests

- PTA: hearing, malingering
- MEPA: middle ear
- OAEs: inner ear
- Binaural MOCR: efferent

### FPL real-ear calibration

- High frequency audiometry

