Learner Outcomes

•After this course learners will be able to describe the four new pieces of equipment in the Bio-logic range: the AudX, the AudX PRO, the AudX PRO FLEX and the NavPro ONE.

•After this course learners will be able to discuss the technology behind frequency modulated DPOAEs, as well as their benefits and clinical utility.
•After this course learners will be able to describe the technology behind binaural OAE, ABR and ASSR testing, their benefits and clinical utility.

•After this course learners will be able to discuss the technology behind multi-rate ASSR testing, its benefit and clinical utility.

•After this course learners will be able to describe the benefit of using spread spectrum technology for noise reduction in evoked potential testing.

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THE NEXT GENERATION BIO-LOGIC BY OTOMETRICS (NATUS)

1 Product Overview

2 New Technology in OAEs

3 New Technology in AEPs

Summary 4

Questions 5

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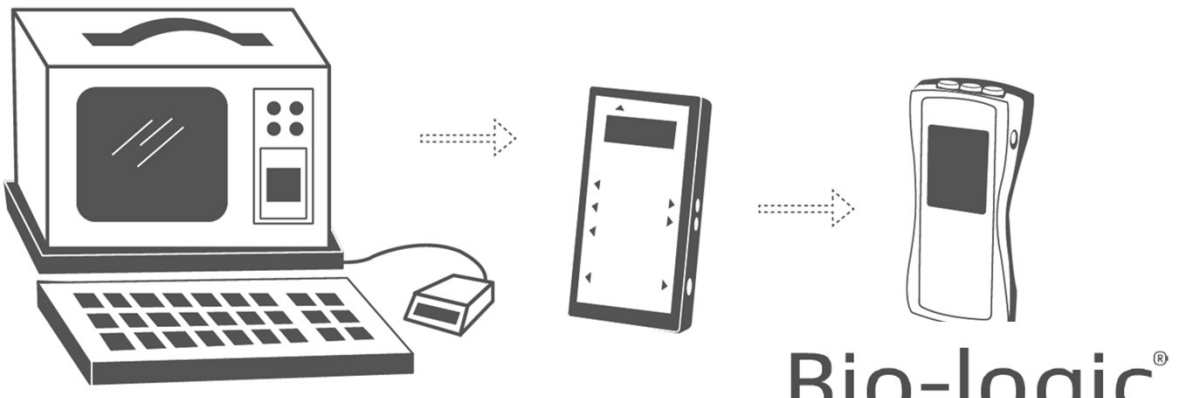
3

The Bio-logic legacy lives on



Bio-logic®

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INTERNAL COMMUNICATION

Meet Otometrics' newest family members

Screening Diagnostic

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NEW BIO-LOGIC SOLUTIONS

Bio-logic® AuDX®

Screening OAE (TE or DP)

Optional modules:

- Audiometry Screening
- MAGIC

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NEW BIO-LOGIC SOLUTIONS

Bio-logic® AuDX® PRO

Diagnostic and screening DPOAE

Diagnostic and screening DPOAE & TEOAE

Optional Modules:

- Diagnostic and Screening Audiometry (Air/bone or Air/Bone/Speech)

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NEW BIO-LOGIC SOLUTIONS

Bio-logic® AuDX® PRO FLEX

Screening Tympanometry

Diagnostic Tympanometry

Optional modules:

- Diagnostic TE/DPOAE
- Screening TE/DPOAE
- Screening Audiometry
- Diagnostic Audiometry (Air/Bone/Speech)

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NEW BIO-LOGIC SOLUTIONS

Bio-logic® NavPRO ONE

Auditory Brainstem Response (click and chirp)

Optional modules:

- ASSR – Auditory Steady-state Response
- EABR – Electrical ABR for cochlear implant
- Electrocochleography (EcochG) (included in US base)
- Frequency specific stimulus package (Included in US base)

- Diagnostic and Screening TE/DPOAE
- Diagnostic Audiometry (Air/Bone/Speech) including Screening Audiometry
- Diagnostic Immittance

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BIO-LOGIC

Full Modularity- Bio-logic family overview

Module	AuDX	AuDX PRO	AuDX PRO FLEX	AuDX NavPRO ONE
Scr DP	✓	Incl. With DX	+	Incl. With DX
Dx DP	or	✓	+	+
Scr TE	✓	and/or	+	Incl. With DX
Dx TE		✓	+	+
Scr Aud Air	+	Incl. With DX	+	Incl. With DX
Dx Ext HF Aud		+	+	+
Dx Aud Air		+	+	+
Dx Aud Air/Bone		+	+	+
Dx Aud Speech		+	+	+
MAGIC	+	+	+	+
Scr Tymp			✓	Inc. with DX
DX Tymp			+	+
Eustachian Tube Func.			+	+
ABR				✓
ASSR				+
EABR				+
ECochG				+

✓ Included in base device

+ add-on as module or license

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Frequency modulated DPOAE

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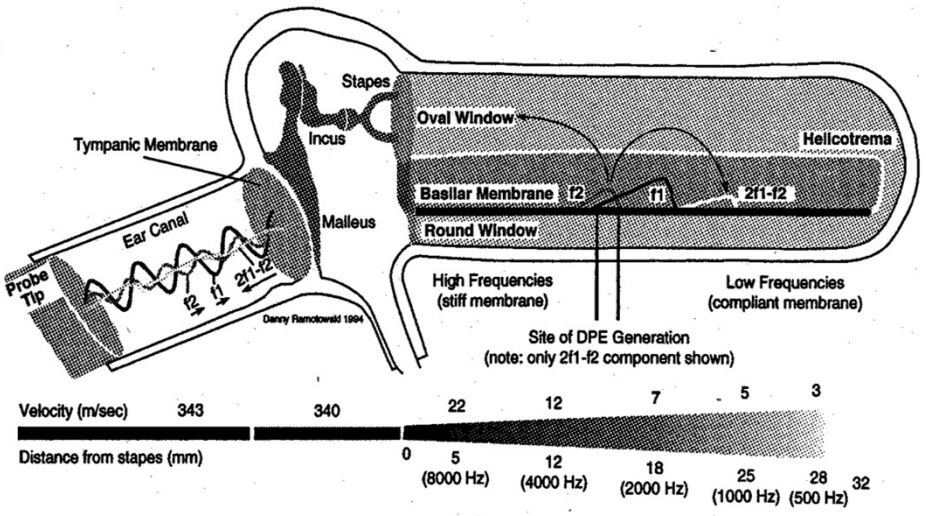

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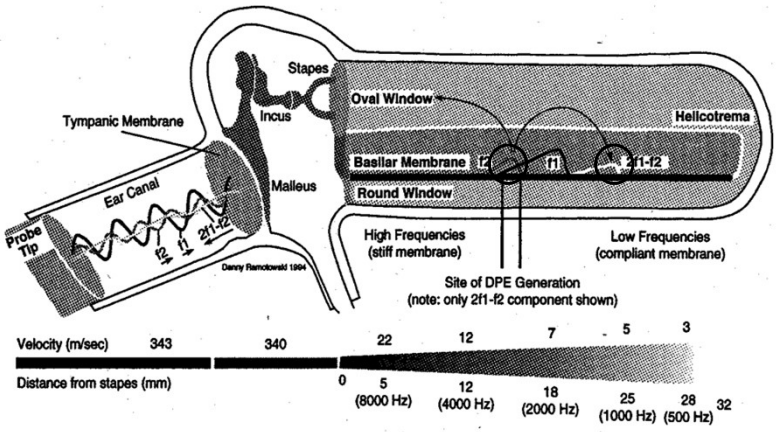
Frequency Modulated Distortion Product Otoacoustic Emission (FM-DPOAE™)

- When the ear is stimulated by two tones simultaneously, there are **two DPOAE sources**, one at the overlap of f1 and f2 close to the f2 place and the other at the 2f1 –f2 place.



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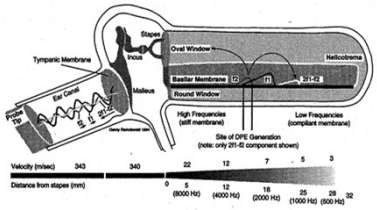
Frequency Modulated Distortion Product Otoacoustic Emission (FM-DPOAE™)

- There are several techniques to overcame this problem.
  - One is to use a third tone to suppress the second source at the 2f1-f2 place. However, for doing this, there is need for a third loudspeaker within the sound-probe.
  - Windowing method and onset-decomposition technique
  - Or a patented technique using frequency-modulated primary tones. To do this, primary tone frequencies are varied over time



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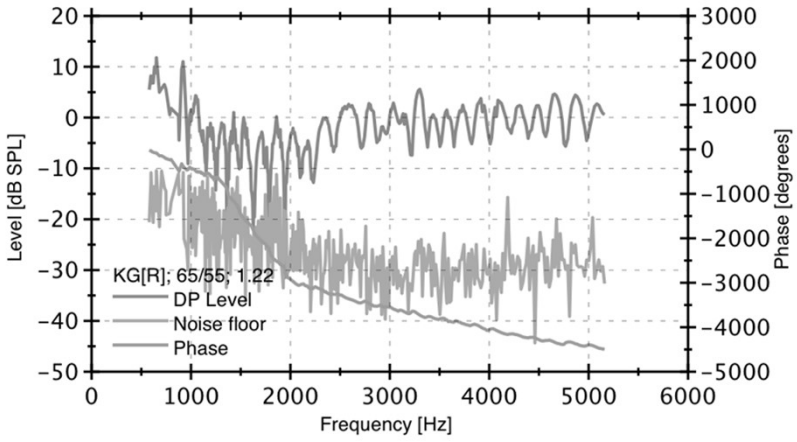
DPOAE fine structure



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http://www.otoemissions.org/guest_editorials/2009/dhar_2009.htm

Frequency Modulated Distortion Product Otoacoustic Emission (FM-DPOAE™)

- Primary tone frequencies are shifted between ±100Hz with a modulation rate of about 1.5 Hz. Because of the associated phase shift the impact of the second source is reduced. As a consequence, DPOAE detection and hence hearing threshold estimation is significantly improved.

- Due to frequency modulation the number of stimulated OHCs is increased resulting in a higher DPOAE level. Thus, FM-DPOAE does not need any additional stimuli and does not extend test time.

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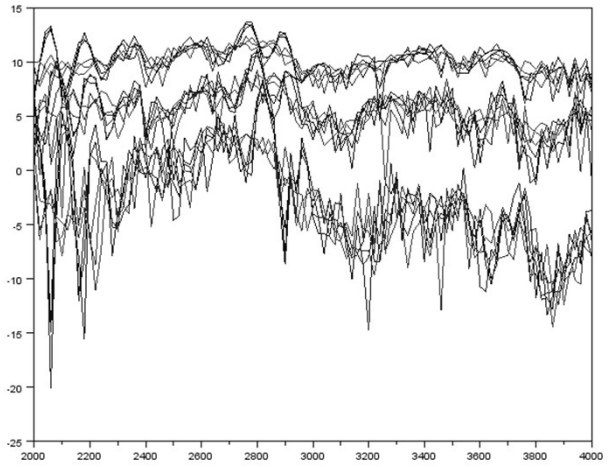
Result examples DPOAE vs. FMDPOAE

L_2 = 60, 45, 30 dBSPL



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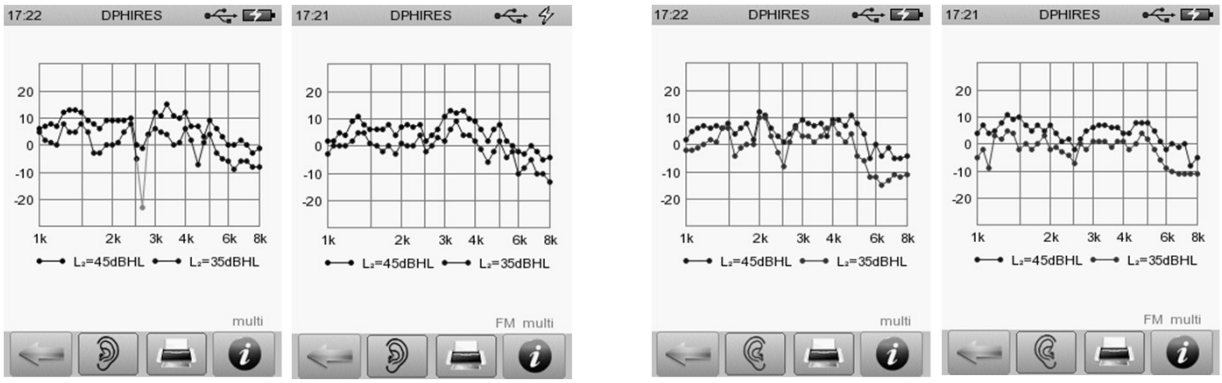
Example data without (left figures for right and left ears) and with FM (right figures for right and left ears)



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Summary 1

- FMDPOAE can eliminate or reduce unwanted DPOAE fine structure
- Can reduce fine structure related refers---provides speed and efficiency by reducing the need for re-tests
- Threshold estimation is probably more accurate
- FMDPOAE could be used instead of standard DPOAE in virtually any protocol

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Binaural Stimulation and Multifrequency Stimulus

- Ability to test both ears as the same time
- Ability to test multiple frequencies at the same time

- =TIME SAVINGS!
- the binaural presentation of single-pair stimuli had subtle effects on DPOAE levels
- the effects of contralateral inhibition created by binaural stimulations are negligible

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Binaural DPOAE test

Test both ears!
two frequencies per ear = four frequencies **simultaneously!**

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THRESHOLD ESTIMATION USING OAES

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DPOAE -Threshold

DPOAE Threshold (patented method by PATH)
→ Estimating hearing loss by means of extrapolated DPOAE I/O-functions

DPOAE Quick test
→ Indicating the presence of a valid DPOAE at one or more selected primary tone levels and frequencies.

Two different protocols are available:
Screening (at a selected screening level) and Diagnostic (multiple selections of stimulus parameters).

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DPOAE -Threshold

- DPOAE I/O functions are measured at 1000 (optional), 1500, 2000, 3000, 4000, 6000 Hz and 8000 Hz (optional).
- Before the measurement of each frequency starts, a fine adjustment is performed, in order to check at which frequency the emission can best be recorded (fine structure, jitter +/-100 Hz).

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DPOAE THRESHOLD ESTIMATION

DPOAE thresholds = DPOAE audiograms

Quantitative and frequency-specific assessment of hearing loss by means of extrapolated DPOAE I/O-functions

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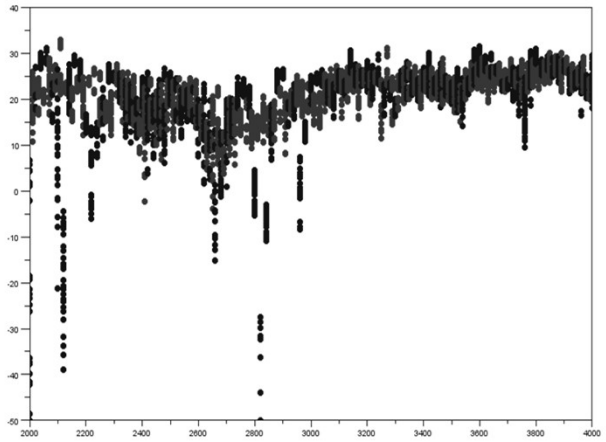
Estimated threshold from DPOAE vs. FMDPOAE



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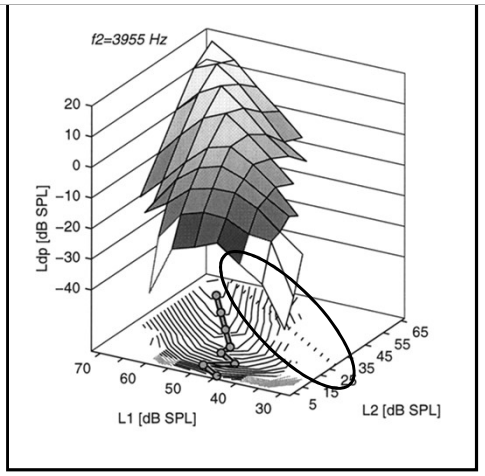
DPOAE level as a function of L_1 and L_2 stimulus levels

65/55
55/45
45/35
35/25
25/15



L1 = 0.4 L2 + 39 „scissors paradigm“
Kummer et al., Hearing Research, 2000

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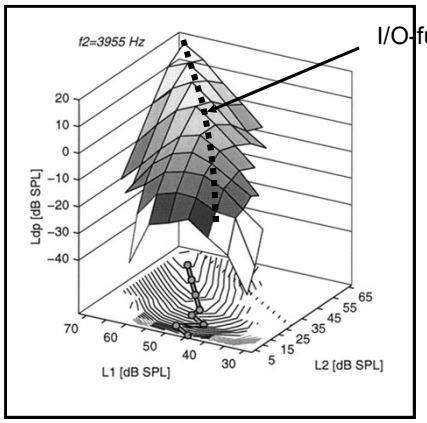
Optimized stimulus levels for testing the DPOAE I/O function



$L_1 = 0.4\ L_2 + 39$ „scissors paradigm“

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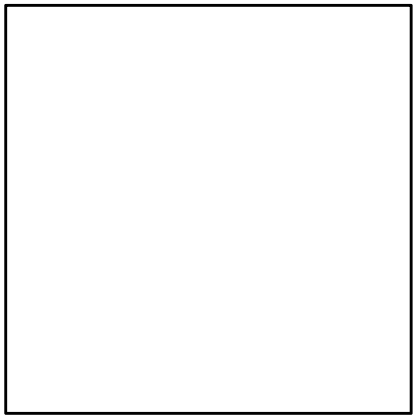
Scissor paradigm

Scissors paradigm

L1	L2	
65	65	
63	60	f2/f1 = 1.2
61	55	
59	50	
57	45	
55	40	
53	35	
51	30	
49	25	
47	20 dB SPL	



L1 = 0.4 L2 + 39 dB SPL

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Correlation between behavioral pure tone threshold L_T and estimated DPOAE threshold L_{EDPT}

118 adults
with cochelar hearing loss

Boege and Janssen
JASA 2002

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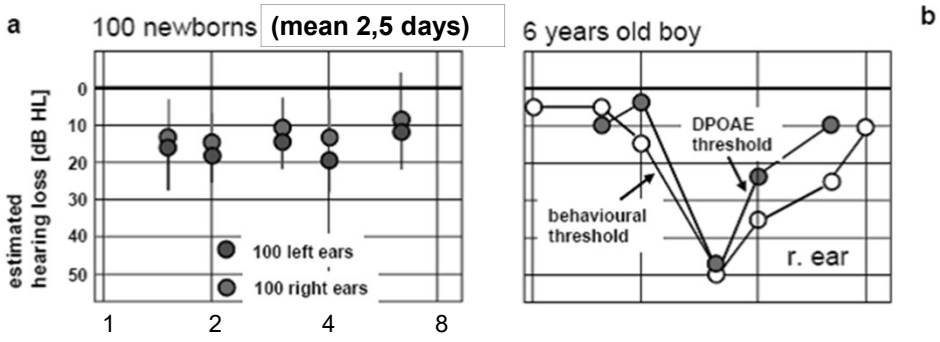
Supporting DATA



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Study...in UK

- 20 brick workers assessed for NIHL
- Full PTA both ears
- DPOAE Threshold testing at 2 and 4 KHz
- 80 results to compare to PTA
- Average difference 8.7dB

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DPOAE Threshold

Select the frequencies that you want to test.

Options for FMDPOAE and Multi channel are available

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DP Threshold in progress

A quick sweep of frequencies performed to find best start frequency

DPOAE I/O functions are measured from L2 = 65 dB SPL in 10-dB-steps decreasing to L2 = 15 dB SPL.

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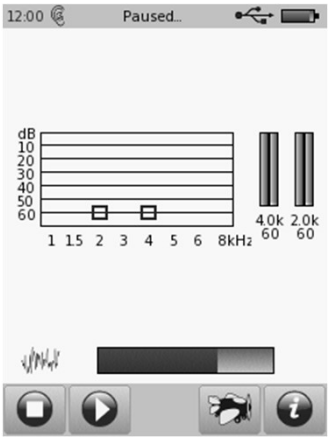
DP Threshold in progress – cartoon mode



An cartoon video can be shown to maintain the children's interest and avoid artifacts

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DP Threshold results

An arrow pointing down from the 50 dB line indicates that no sufficient emissions could be measured in order to fulfil the criterion. A hearing loss greater than 50dB could be the case.

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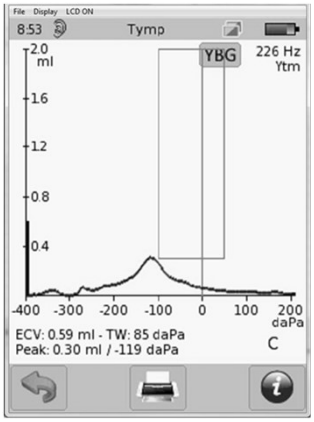
Pressurized OAEs
AuDX PRO FLEX

- OAEs conducted at peak admittance pressure to maximize amplitude of the response



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NEW TECHNOLOGY IN EP

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Bio-logic®

NavPRO ONE

ABR

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BIO-LOGIC

Binaural Recordings

- AEP in general can be recorded from both ears simultaneously.
- A traditional recording scheme is to just apply different but constant stimulus rates to both ears, e.g. 37 Hz and 41 Hz.
  - A more preferable choices would be stimulus rates that do not have a common period (1Hz in the example), such as 37.3 Hz and 41.1 Hz etc.
- If averaging is done in synch to each ear's stimulus rate, responses can be recorded independently

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BIO-LOGIC

Spread Spectrum

ABR recording with spread spectrum technology

- Traditionally, ABR recording (time domains) is done with a constant stimulus rate, although it does not necessarily require a constant stimulus rate
- Modifying the rate during testing can drastically improve the robustness against artifacts caused by electric noise sources
- Moreover, binaural recording can be performed with equal average stimulus rates, which can be preferable over fixed different rates for both ears (such as 37 and 41 Hz)

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Weighted averaging

- Natural artifacts, such as myogenic activity, interfere with ASSR and ABR measurements
- Weighted averaging is the preferred method to implement artifact management

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BIO-LOGIC

Statistical Analysis

Template matching

- ABR responses have a typical waveform e.g. I, III, V.
- This knowledge can be used to improve automatic detection of ABR responses.
- The recorded signal can be cross-correlated with a template that represents a typical waveform, and the correlation signal can then be statistically analyzed instead of the unprocessed signal.
- This technique can also be used to estimate the latency of the response, which can get a better estimation in noisy recordings than a plain peak search would.

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ABR Technology

- Using the techniques described above, the Bio-logic ABR module was designed for efficiency. It makes use of spread spectrum, template matching, weighted averaging and chirp stimuli.
- Tracings are shown as the original recording, while all statistics, if enabled, are performed on the template convolution signal. This combines detection performance with real trace view.

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BIO-LOGIC

ASSR

Stimulus Rates

Variable rates

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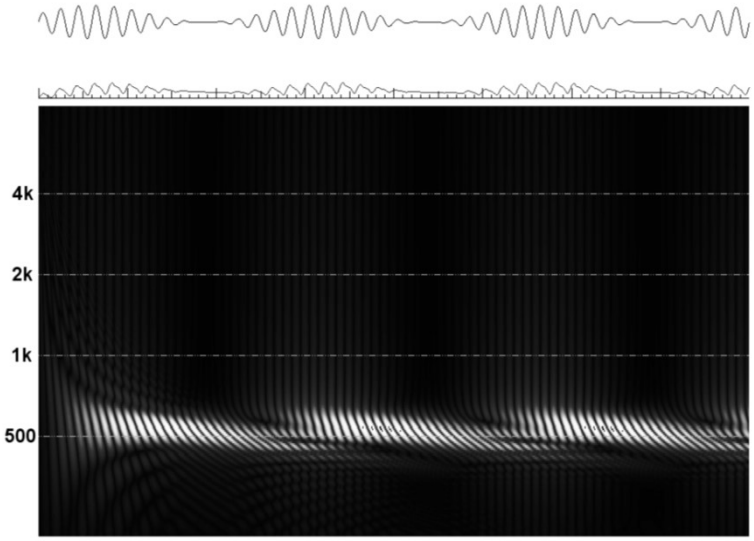
BIO-LOGIC

Simple Cochlear Model



Cochlea response to a 500 Hz modulated tone

47

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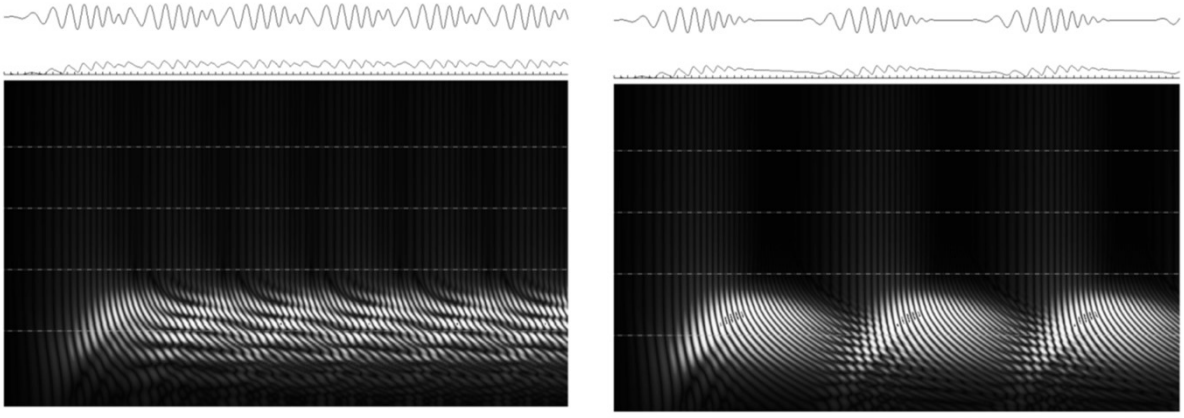
Cochlea response to 500 Hz octave-wide chirp at 80 Hz vs. 40 Hz stimulus rate



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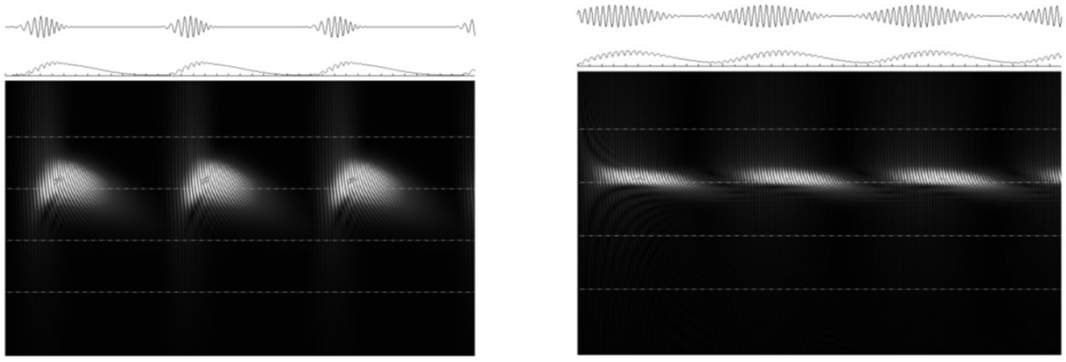
Type of Stimulus Affects Cochlear Response

2kHz narrow band chirp at a rate of 80Hz, compared to a modulated sine stimulus



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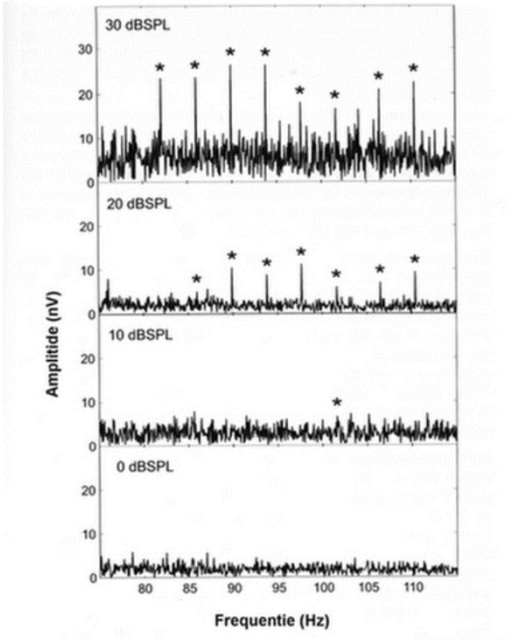
Binaural ASSR

Selecting different rates for the two ears also allows binaural ASSR recordings. This figure contains responses from eight different stimulus rates, four were presented to each ear.



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Spread Spectrum ASSR

The rate variation during testing is moderate: a ±1 Hz variation of the rate (centered at 37 to 160 Hz) does not impact AEP recording but improves robustness against interference significantly

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BIO-LOGIC

ASSR Technology

- Since recording ASSR is a fully automated procedure, not too many parameters need to be configured.
- The main decision is to select a stimulus bandwidth, which is a trade over between test performance and frequency specificity.
  - Wider band stimuli excite larger portions of the cochlea and therefore generate stronger evoked responses.
- Spread spectrum is always enabled in the Bio-logic ASSR module.

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Thank you!

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