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An Overview of the
technologies used in NHS / UNHS
(Otoacoustic Emissions and Automated ABR)

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Contents of the Lecture

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- Part 2: OAE protocols and methods of analysis.
- Part 3: The Automated ABR (AABR)
- Part 4: The Clinical Reality: The OAE devices record different signals. AABR is difficult to obtain.
- Part 5: Conclusions.

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PART 1:
Definitions and Clinical Procedures

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Terminology

- **NHS** : Neonatal Hearing Screening
 - Targeted (ie specific groups in NICU)
 - Non-targeted (well-babies)
- **UNHS**: Universal Neonatal Hearing Screening, including ALL born infants. Minimum suggested coverage = 92% of the target territory.
- **UNHS** = **EHDI** set-ups (Early Hearing Detection and Intervention)

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Tools that we have at our disposal in EHDI programs

| | |
|--|---|
| <p>Detection Phase</p> <ul style="list-style-type: none"> • Acoustic technologies OAEs • EM technologies AABR | <p>Intervention Phase</p> <ul style="list-style-type: none"> • EM technologies ABR, EchoG, ASSR |
|--|---|

NOTE : The Tools are PHASE dependent


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Detection Phase

- **Otoacoustic Emissions – OAEs** (assessment of the auditory periphery).
- **AABR** (assessment of peripheral and central hearing components). With the combination of OAE /AABR data we can estimate the **AN/AD** incidence.

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Intervention Phase

- **ABR** (assessment of peripheral and central hearing components). Estimate of the hearing threshold .
- **ECoG**. Estimate of hearing threshold

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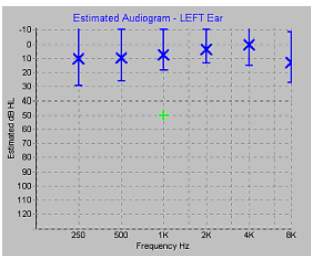
Intervention Phase

- **Auditory Steady State Responses-ASSR** (Assessment of peripheral, central and cortical components). **New entry, and very few studies.**
- **Very useful** in estimating thresholds for the hearing-aid fitting.
- **Possible** applications in NICU screening substituting AABR.

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ASSR threshold estimation


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PART 2a:
Otoacoustic Emissions (OAEs)


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- Otoacoustic Emissions are **acoustic** responses generated presumably in the **inner ear** and recorded in the external auditory meatus.
- Classically there are two classes of responses:
- Evoked:
 - ▶ **Transient** evoked by clicks- **CEOAEs**, by tone-bursts –**TBOAEs**. Mainly TEOAEs=CEOAEs.
 - ▶ **Distortion product OAEs** – evoked by two continuous tones having a particular relationship.
- Non-Evoked or **Spontaneous OAEs**.

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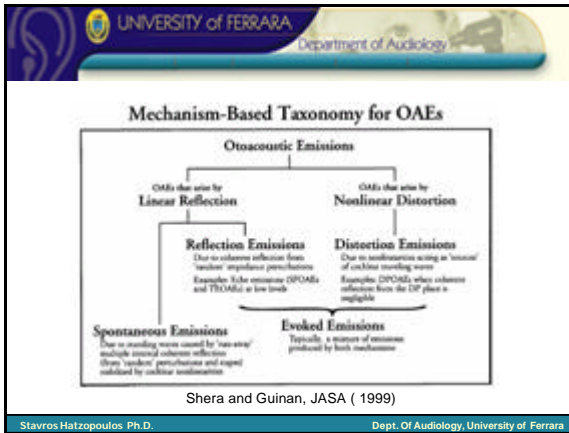


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Modern views


- ▶ **Shera and Guinan** (1999) postulated that the OAE signals (we commonly record), are the **cumulative** results of **nonlinear distortion processes** (generating the DPOAEs) and **reflection** mechanisms (generating TEOAEs). This modelling approach is known as the **two source interference model**.

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- For screening **well-babies** and **NICU infants** (at specific frequencies related to cochlear locations of the frequencies 2.0, 3.0 and 4.0 kHz) the following types OAEs are used:
 - ▶ **Transient Evoked** OAEs (clicks), with stimuli of **75-85** dB pe. SPL.
 - ▶ **Tone-Burst OAEs** (2.0, 4.0 kHz) with stimuli of **80** dB SPL.
 - ▶ **DPOAEs**.
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- The **DPOAEs** are the most complicated OAE type, because the DPOAE response depends on many protocol parameters (**stimulus intensity**, **relationship of the two tones** etc).
 - Normally we **compromise*** by accepting as good responses from a protocol having $L_1 = 65$ and $L_2 = 55$ dB SPL.
 - Although we can test many frequencies the latest DPOAE protocols provide assessment at **2.0, 3.0 and 4.0** kHz.
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PART 2b:
OAE equipment

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- From the **fourth** generation of devices (after 2000), the OAE equipment were designed to be (i) **handheld**; (2) equipped with simple patient / tests **databases** and (iii) with **OAE and ABR** recording facilities.
 - ▶ **Audioscreener** , from GSI / Viasys
 - ▶ **Scout Sport**, from Biologic (as an option to an EP system)
 - ▶ **AccuScreen** (GN-Otometrics, Fischer -Zoth)
 - ▶ **Eclipse-II** (LABAT, Italy)

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Audioscreener
Everest




Eclipse-II
Labat



AccuScreen
GN-Otometrics


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- OAEs are fast responses (good for hearing screening) but they provide **only** an assessment of the peripheral auditory function (**NOT** hearing) . Also they are **middle-ear** dependent.
- The OAEs have good overall **sensitivity** (identification of HL subjects) = **85%** and **specificity** (identification of normal hearing subjects) = **92%**


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- With the 4rth generation devices we are having **an automated evaluation** of the OAE responses.
 - ▶ A TEOAE response is a PASS when the S/N ratio at **two** of the tested frequencies is > than **6.0 dB**.
 - ▶ A DPOAE response is a PASS when the S/N ratio at **two** of the tested frequencies is > than **6.0 dB AND** the signal itself is larger than -15 dB SPL.

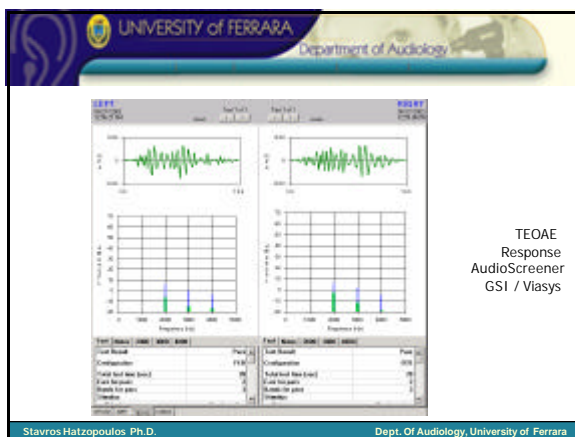
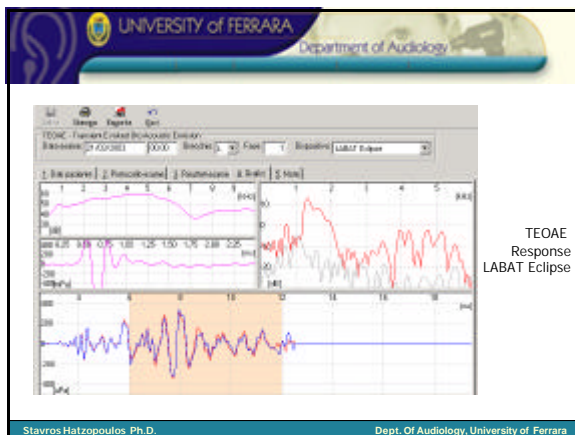
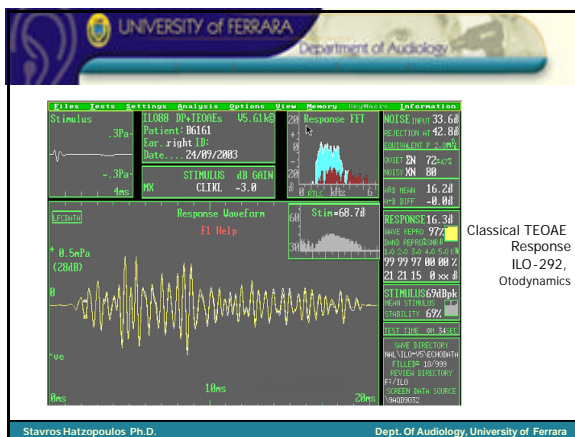
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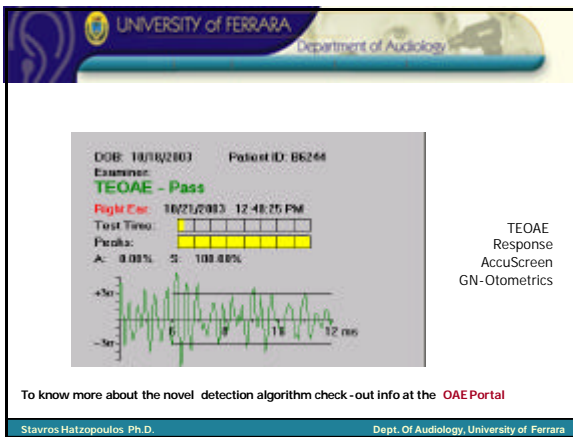


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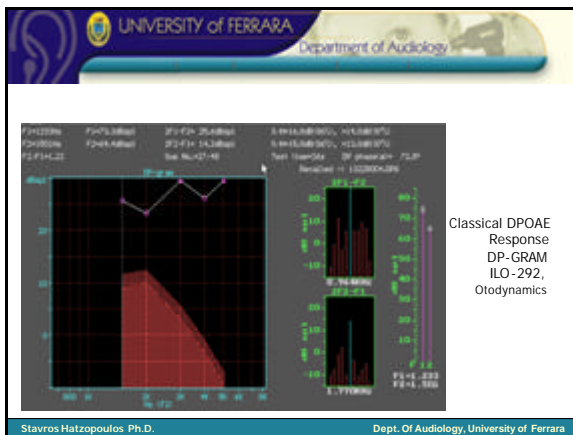
PART 2c:
Examples of responses

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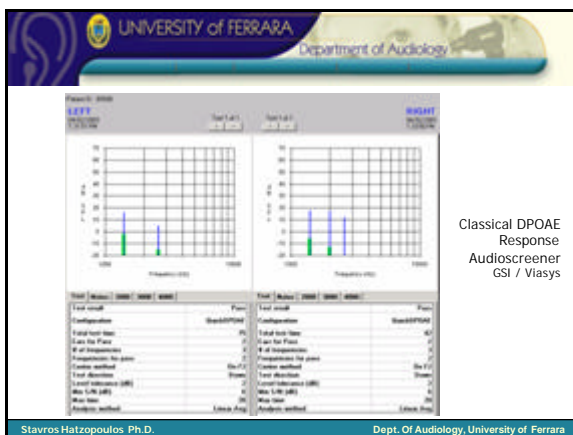




TEOAE
Response
AccuScreen
GN-Otometrics




Classical DPOAE
Response
DP-GRAM
ILO-292,
Otodynamics



Classical DPOAE
Response
Audioscreener
GSI / Viasys



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PART 3:
Auditory Brainstem Responses
(and AABR)

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- ABR was the first methodology applied to neonatal screening (NICU infants).
- It is characterized by excellent **sensitivity** and **specificity** = 95%
- Requires **special ambient** conditions (EM shielded rooms).
- The ABR recordings require **numerous** averages (ie long recording times per ear).

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- The Automated ABR (AABR) uses specialized algorithms and signal templates to detect the location of Wave I-V in an latency interval.
- An AABR recording is **PASS** when a statistical measurement of the AABR algorithm is satisfied (**probability of detection 98%**)

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- OAE devices of the 4rth generation provide adequate AABR testing.
- There are also vailable dedicated AABR devices, such as the Algo portable and Algo 3i by Natus.



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Classical ABR
Response
Audioscreener
GSI / Viasys

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PART 4:
The Clinical Reality

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OAE Devices

- Due to different OAE probes used, the available 4rth generation OAE devices provide responses with statistically **different** characteristics (ie signal properties) in the frequencies of 2.0, 3.0 and 4.0 kHz.
- **Different** TEOAE correlation estimates are also common.

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OAE Devices

- This implies that the PASS / REFER criteria are **relative** to the device used !!!
- **Further** Cross-product studies are needed to verify the similarity of clinical results.

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OAE Devices

- OAE test times per ear can be as low as 10s if the infant is collaborating (sleeping).
- Some devices have probes which cannot be used easily in the NICU (large probes , small ear canals).
- If a positive assessment is not possible, an additional OAE test does not increase excessively the cost of the NHS program.
(Mention time-Restrictions)

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Data Management Software

- As the EHDI programs grow is is absolutely necessary to develop GOOD data management systems , which will track the REFER cases.
- From the available OAE devices only TWO provide the grounds for such a system (LABAT, OTODYNAMICS) the others RELY on expensive third-party software.


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AABR Devices

- With the AABR devices it is possible to resolve the issue of Auditory Neuropathy.
- The AABR 4rth generation devices are extremely sensitive to ambient conditions and the status of the infant.

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AABR Devices

- It is **almost impossible** to do AABR in all tested infants (WB + NICU), due to hostile clinical conditions and long recording time requirements.
- The **costs of AABR** testing of all born babies can be quite high, even for mature EHDI programs.
- These conditions make a universal AABR testing **un-realistic** for a European clinical reality.

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Conclusion

- OAEs** are still the **best** and **quickest** method to do NHS in the **WB** population.
- AABR** can be used very efficiently with the **NICU** population (test at discharge-time), where greater incidence of HL is expected and where **AN** cases are mostly reported (**OAE+AABR**).


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INTERNET Resources
Otoacoustic Emissions
PORTAL

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Cybernetic OAE Depository:

<http://www.otoemissions.org>

- The **Otoacoustic Emissions Portal** is a web site dedicated exclusively to all aspects of Otoacoustic Emissions. It is a **free** cybernetic depository of all available OAE information.
- It brings together respected **European, American** and **Australian** scientists from **9** different countries, who form a **17-member** web editorial committee.

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www.otoemissions.org or www.oae.it



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That's all Folks !!

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