NAL - OAE ANALYSIS SOFTWARE

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ABSTRACT

To date screening using otoacoustic emissions has largely been restricted to neonates because screening criteria have been easy to establish - newborns should have high level emissions and so their records should have high signal-to-noise ratios and the commonly accepted criterion for a pass is virtually any discernable emission above the noise level which is taken to be evidence of normal outer hair cell function.

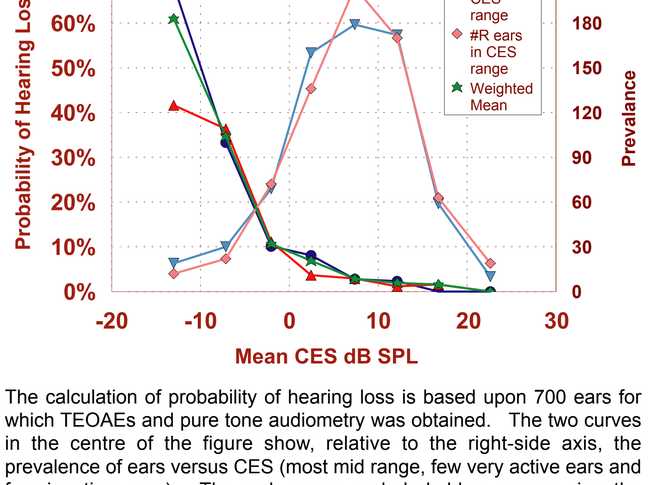
Research at NAL over the past decade has extended this narrow use of otoacoustic emissions to the arena of risk-management by determining and taking into account the age-dependence of emission strength and determination of a fairly well defined critically low-value at which mild hearing loss is encountered. Within the boundaries of test-retest variability we can express emission strength in terms of the effective age of any ear which may be compared with a person's chronological age to provide a measure of risk for hearing loss if average rates of decline continue without intervention. This is applicable across all ages.

We introduce software (NAL-OAE©) which makes the decision process of screening people of all ages for risk of hearing loss much easier. The Windows® software (version 2.0) takes TEOAE records obtained by Otodynamics ILO, in standard collection mode (or quick-screen mode for neonates); it displays the data and compares them with Australian population statistics obtained from the NAL database of 15000 records. It also relates the emission data from 1396 records with their comparable pure tone audiometric records to obtain a Probability of Hearing Loss together with a Hearing Loss Risk Indicator.

In times past, general hearing conservation programs were ineffective because warnings to workers in noisy environments could be ignored. The high variation in individual susceptibility meant that even annual warnings seldom equated to individual experience. By contrast, our software graphically displays individual risk for noise-induced hearing loss and is based on the notion of a critical level of outer hair cell damage. Because of the long lead-time between predictions and outcomes it is still too soon to determine how effective this strategy is (Murray and LePage, ASA, 2000) and several basic issues must still be resolved (LePage, et al., ASA, 2000). However, anecdotal evidence from many clients suggests that when an adult, who claims no hearing problems, is directly confronted with seeing their "fuel tank near empty" they tend to exhibit a change in attitude.

CES (Coherent Emission Strength) is a single number parameter calculated in dB (SPL). It is the peak sound level of the emission which is scaled according to the Waverepro% in order to separate highly coherent records from highly "noisy" records. That is, it is a measure of the coherent part of the emission, or the "noise-free" part of the emission which is common to both traces A and B of that record.

Probability of Hearing Loss is a strictly conditional probability, conditional upon a client's CES values; that is, within a particular band of CES (from >15 to <-10 dB SPL) the probability of hearing loss of 25 dB HL or greater at the average of frequencies 500 Hz, 1, 2 and 4 kHz.

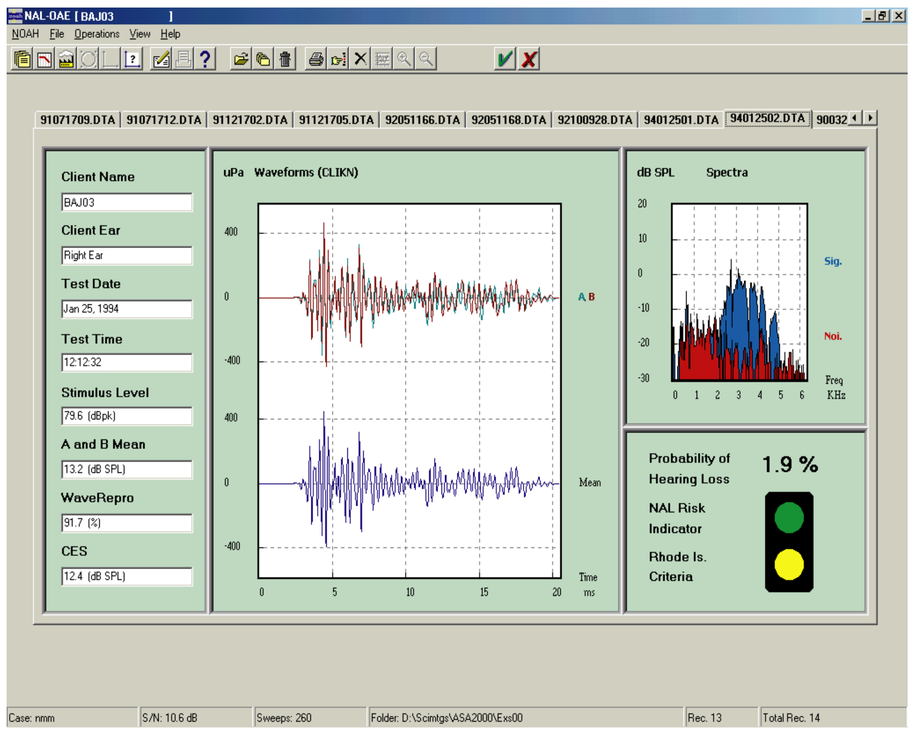


ABOVE: Data from 1396 ears with both TEOAE and PTA are used to obtain the Probabilities of Hearing Loss in seven equally spaced no-overlapping CES bands of 5 dB each. The results show significant increase in the probability of hearing loss in the lower CES bands, thus indicating high risk.

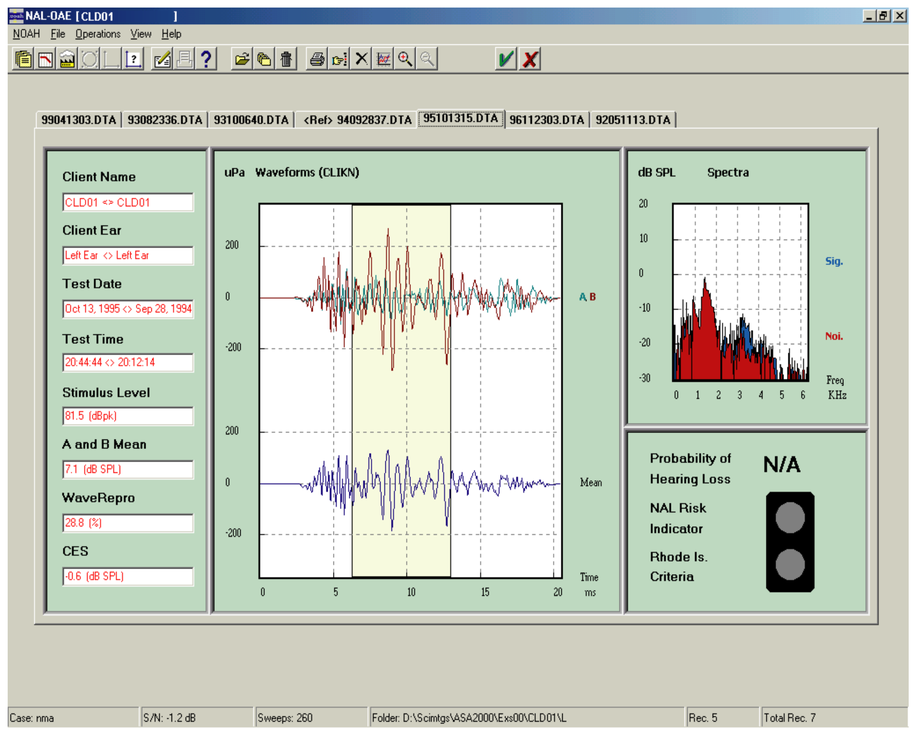
The calculation of probability of hearing loss is based upon 700 ears for which TEOAEs and pure tone audiometry was obtained. The two curves in the centre of the figure show, relative to the right-side axis, the prevalence of ears versus CES (most mid range, few very active ears and few inactive ears). The red, green and dark blue curves give the probability of hearing loss relative to the left axis. This is computed from the number of ears with the given CES which actually have a hearing level (>=25dB HL, 3FA:1,2,4kHz). The the sample for the lowest CES has many more left ears with a hearing loss than right ears (expected) and the weighted mean, which takes the ratio into account, is the origin of the histogram above.

NAL-OAE Versions

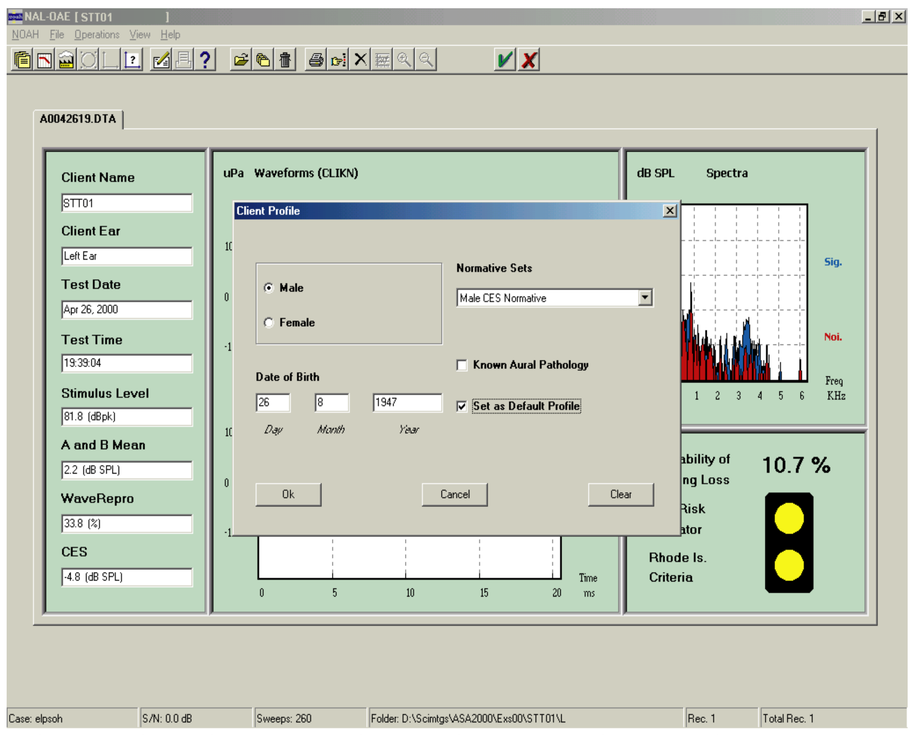
The NAL-OAE TEOAE analysis software is currently available in two versions; one available for exclusively ILO-88 series users and one available to GN Otometrics Capella users running NOAH2 and NOAH3. The Capella version is also backwards compatible in that it can read ILO files directly as well. If requesting information, please indicate which is your preference. The program is designed that it can make extra features available depending upon the capabilities of your computer.



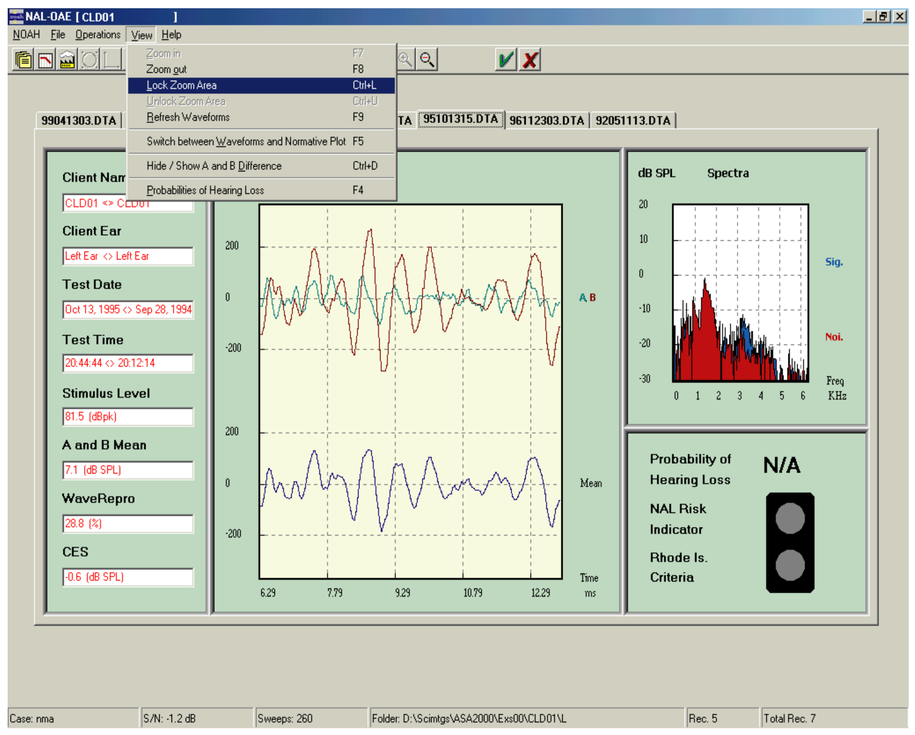
ABOVE: After selection and loading of files, each record's file name appears on a separate tab at the top of the screen. Left panels, including client details and test parameters, give similar information to that on ILO screen, but also include CES (dB SPL). The middle panel displays TEOAE time-waveforms. The top right panel depicts the emission spectrum (blue for coherent activity, red for incoherent or "noisy" areas of the spectrum). The bottom right panel gives the Current Status of the ear tested as the probability of that ear having a hearing loss (%) together with a set of traffic lights as an Indicator of Risk of Hearing Loss (see Probability of Hearing Loss Panel).



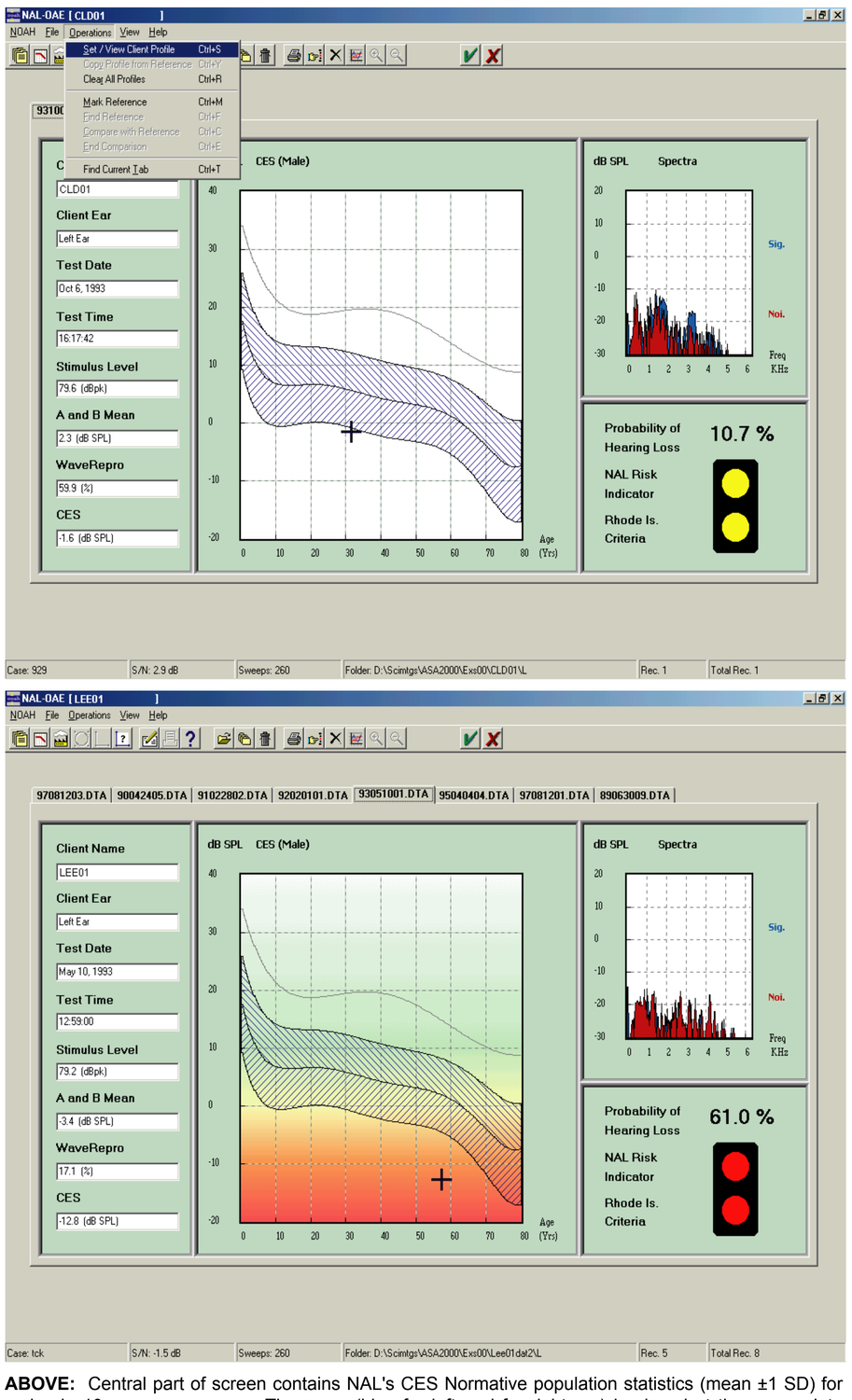
ABOVE: Comparison of two ILO-TEOAE data files - useful, for example for detection of changes over time, changes with stimulus level, or fluctuant changes such as occur in perilymphatic fistulae. Reference file is selected and "marked" under the Operations menu. Comparison file is selected and by clicking "Compare with Reference File" under the "File" menu the waveforms of the two files will be overlaid (Reference "B" - in brown; comparison file "A" - aqua). Contents of left panels indicate in red that a comparison is displayed. The CES value will be recalculated to reflect the change. NB. Probability of Hearing Loss and Risk indicator do not provide meaningful information and are disabled.



ABOVE: First Screen following entry of client profile (sex, date of birth). Left panels give similar information to that on ILO screen, but also include CES (dB SPL).

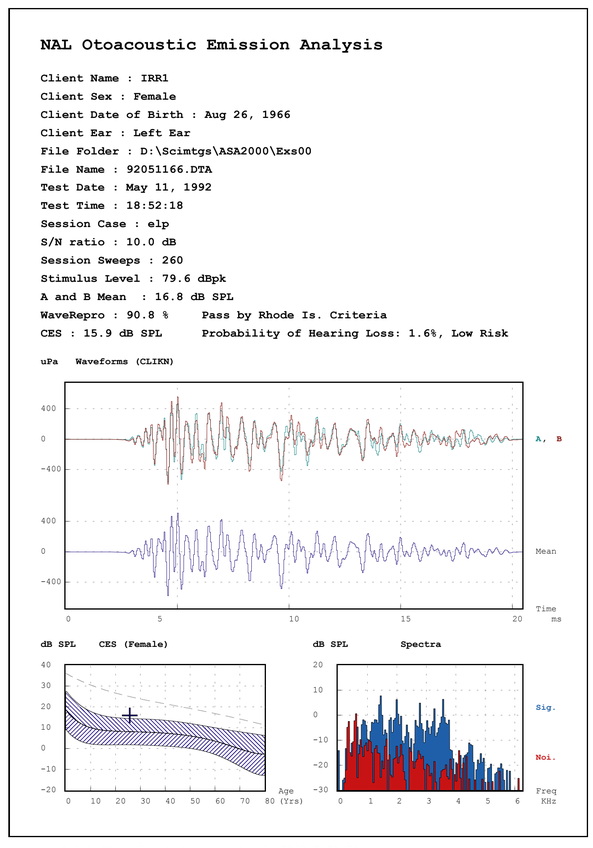


ABOVE: A closer examination of differences in latency between features of waveform A and waveform B may be made by use of the "Zoom" function. The area to be displayed may be "marked" and will be displayed as a yellow shaded area. Once a zoom area is marked the displayed area may be examined by "Zoom in" under the "View" menu. Once the area is marked for the currently displayed record, this same zoom area can be applied to all records on the analysis desktop by "Lock Zoom Area" under "View" menu.



ABOVE: Central part of screen contains NAL's CES Normative population statistics (mean ±1 SD) for males in 10-year age ranges. The cross (blue for left, red for right ear) is placed at the appropriate result point for the particular ear tested. This plot may be switched to time-waveform plot with "Switch between Waveforms and Normative Plot" under "View" menu.

Printed patient-ear record



ILO-TEOAE data file may be printed in black and white or colour with all relevant details for each ear, including Waverepro%, CES (dB SPL) value, % Probability of Hearing Loss and High/Medium/Low Risk indicator together with graphics of Emission Spectrum, Timewaveform and the relevant NAL Normative Australian age data with the ear plotted against the appropriate age and CES value. The trace representing the noise waveform may be displayed and printed as an optional extra.

In addition to the record printouts a log file may be generated. This allows an analysis summary of all the records on the desktop can be imported into a spreadsheet.

SUMMARY:

A key finding from a decade of NAL research into transient evoked otoacoustic emissions is the picture of decline in emission strength as functions of age and gender and this trend is the focus of version 2 of NAL-OAE software. TEOAE records obtained with ILO equipment may be post-analysed to determine risk of a hearing loss, and this "early warning" forms the basis of a more modern strategy for the prevention of hearing loss.