MADSEN AccuScreen®

Automated Methods for TEOAE Detection in Neonatal Hearing Screening

Otoacoustic emissions are side effects of active processes in the inner ear and known as a very good indicator for proper inner ear function. As the vast majority of congenital hearing problems are located in the middle ear or inner ear, OAEs are a very accurate method for newborn hearing screening. This, of course, is only true if the detection method has a high detection rate in normal hearing subjects (specificity), and a very high rate of correctly identified pathologic cases (sensitivity). These parameters differ depending on the handling of instruments, and do also vary strongly between instruments and detection algorithms.

Different kinds of OAE

Otoacoustic emissions are commonly classified into spontaneous otoacoustic emissions (SOAE), and evoked otoacoustic emissions. The latter are divided into transiently evoked otoacoustic emissions (TEOAE) and distortion product otoacoustic emissions (DPOAE). All OAEs are generated by the outer hair cells within the inner ear, which represents the first amplifier stage of hearing.

As SOAE are only present in a part of normal hearing subjects, they are of no relevance for hearing screening. TEOAEs are the easiest emissions to detect, and have some more advantages in hearing screening. Apart from this, DPOAE are generated in well-defined locations of the cochlea, and can therefore detect frequency depending hearing losses.

Rationale for Automated Detection

Universal newborn hearing screening for early detection of hearing loss has dramatically increased the number of infants tested prior to hospital discharge. Requirements to limit the experts in the staff have increased the interest in objective screening procedures with 'automated' results in order to allow existing staff and non-technical employees to operate screening equipment reliably and accurately. During the past decade, techniques have been developed to automate OAE detection, including AccuScreen's AOAE® technology and several other analysis methods, such as cross-correlation analysis, signal-to-noise analysis, frequency analysis and neuronal networks. These techniques are not identical and require knowledge of their individual features in order to evaluate their utility for newborn screening.

TEOAE with AOAE

The AccuScreen AOAE detection scheme is based upon signal statistical analysis which guarantees high specificity and sensitivity, with minimal impact of background noise and recording conditions.

The binomial statistics algorithm presumes that the newborn is hearing-impaired until enough click responses have been evaluated to conclude with a very high degree of probability that the baby has satisfactory inner ear function. Because the statistics of a non-response condition is very well defined, this probability can be precisely controlled and has shown a clinical sensitivity of more than 99%, without requiring decisions or equipment adjustment by the user as described below.

Different from standard methods, the impact of non-random noise is very low. Modulated, narrowband or tonal noise is often present in clinical environments and can easily lower the sensitivity of standard detection methods down to 90%. This is not the case with the AccuScreen detection rationale.

Besides this, the AccuScreen AOAE technique involves a unique artefact handling scheme which proved to be much better than standard methods in varying noise conditions.

Other Analysis Methods

Cross-correlation analysis compares two or more sets of measured TEOAE click responses with each other and attempts to identify the presence of a common synchronous signal which is assumed to be the TEOAE. An important drawback of this method is that the probability to detect TEOAEs

erroneously (if only noise is present: "false pass") strongly depends on the nature of background noise. In the case of tonal or narrow-band acoustic back-ground noise, the sensitivity can be extremely poor.

Signal-to-noise analysis basically also compares two subsets of averaged data by assuming that the sum of these buffers represents signal and noise, while the difference only represents noise. The ratio between these two is used as an SNR estimation, and from a defined value on a pass result is issued. Again, the sensitivity of this method strongly depends on the nature of background sound.

Black-Box algorithms that use neuronal networks or other self- learning or pre-trained algorithms are also used for TEOAE detection. Usually, the algorithmic parameters are tuned in a training phase to give maximum correlation to the classification that an "experienced expert" does. Besides the limitations of this expert (the automated system can never be better), the main disadvantage is that these methods act very much like a black box, and the features that are used to detect TEOAEs are more or less unknown. Therefore, the behaviour in certain noise or operating conditions can not be predicted. This implies the risk of high false pass rates.

Informed Choice and Quality Assurance

It is essential to understand that these differences in OAE detection methods mean that OAE hearing screeners cannot be considered equal. The ability to adjust screening parameters and the requirement for waveform review or interpretation by trained professionals may have a significant impact on performance reliability, consistency and cost in Newborn Hearing Screening programs.

Unfortunately, these issues are often not addressed by manufacturers reported clinical performance and even more concerning is that strict product sensitivity & specificity are rarely provided in writing.

The AccuScreen TEOAE detection algorithm uses a signal statistical method which reduces the original signal to binomial data which delivers well-known and defined low probabilities for erratic results. This means that the sensitivity is well known and extremely high. No user adjustments are provided, to assure this high sensitivity cannot be sacrificed by the user.

References

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