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Schwerpunkt Kommunikationsstörungen

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Validation of a hand-held device for image-based pure tone audiometry and DPOAE threshold determination in children

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Introduction

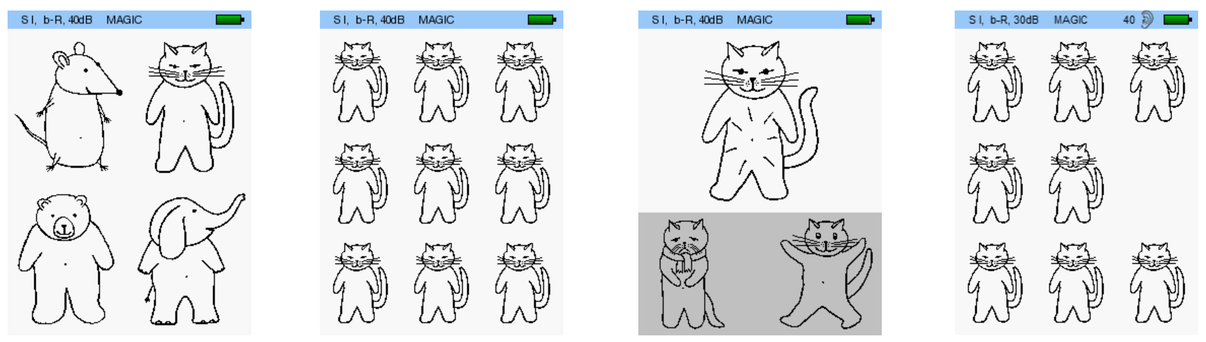
Play-audiometry is a well established method in pediatric audiology. However, the test procedure, in which the child must be continuously observant, is exhausting, and the task (usually placing a peg in a pegboard) is varied only little. In contrast, image-based and self-paced test procedures can considerably enhance the child's attentiveness [1]. In young children there is a high discrepancy between the behavioral audiometric hearing threshold (reaction threshold) and the actual hearing threshold. In order to test the hearing of these children more reliably an objective method has to be applied. Extrapolated distortion product otoacoustic emissions (DPOAE) Input/Output (I/O) functions are able to objectively determine cochlear hearing thresholds with a small estimation error [2]. The aim of the present multicenter study was to investigate the test performance of a new hand-held device (Sentiero, PATH medical, Germany), which provides both an image-based and self-paced determination of pure tone thresholds as well as frequency-specific and quantitative evaluation of cochlear integrity by means of extrapolated DPOAE I/O functions.

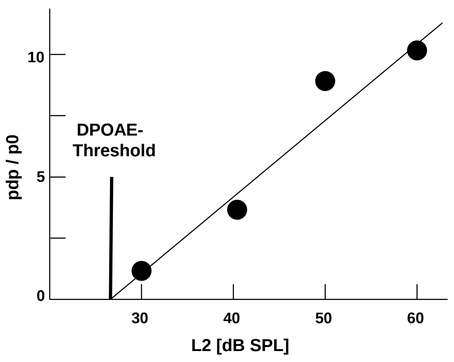
Materials and Methods

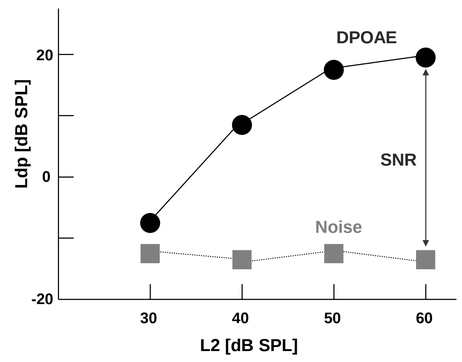
Image-based pure tone audiometry (**MAGIC**: **M**ultiple-choice **A**uditory **G**raphical **I**nteractive **C**heck) was performed in 108 children aged between 3;6-11;11 years at the frequencies 0.5, 1, 2, 4 kHz (n = 82) and additionally at 0.25, 3, 6, 8 kHz (n = 26). Different animals represented different frequencies (bear 500 Hz, elephant 1 kHz, etc.). Each animal was present in three variants: Neutral to start the sound presentation, happy/healthy and sad/sick for indicating the two conditions 'heard' and 'not heard'. Before measurement a story was told such that the child was instructed that healthy animals will make sounds and sick animals are not able to. The test procedure progress was visualized by a shelf, from which the current test animal was selected. The test was controlled by the child itself via touch screen. This includes sound presentation as well as input if the sound was heard (healthy animal) or not (sick animal). The examiner supervised the measurement and assisted the child with the entry when indicated. The examiner could also intervene in the measurement procedure at any time or do a retest at any frequency whenever necessary.

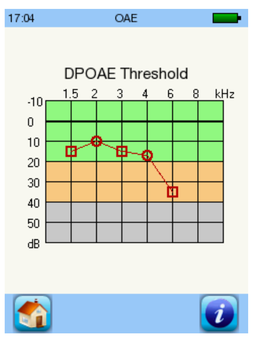
Hearing threshold estimation by means of **DPOAE I/O functions** [2] were performed in 36 children from the collective. DPOAE I/O functions were recorded at frequencies f2 = 1, 1.5, 2, 3, 4 and 6 kHz with primary tone levels (L2) in the range from 10 to 65 dB SPL and threshold were estimated by linear regression analysis [2]. Primary tone levels L1 and L2 were set according to the "scissors paradigm" [3]. The frequency ratio f2/f1 was 1.2.

For comparison, play-audiometry pure tone thresholds were determined at the corresponding frequencies. The measurements were performed at Schwerpunkt Kommunikationsstörungen, Hals-, Nasen-, Ohrenklinik und Poliklinik, University Mainz (Department for Communication Disorders, ENT-Department of the University of Mainz Medical School´s hospital), at the ENT clinic of Klinikum rechts der Isar, Technische Universität München, and at Cyprus Audiology Center Nicosia (Cyprus)



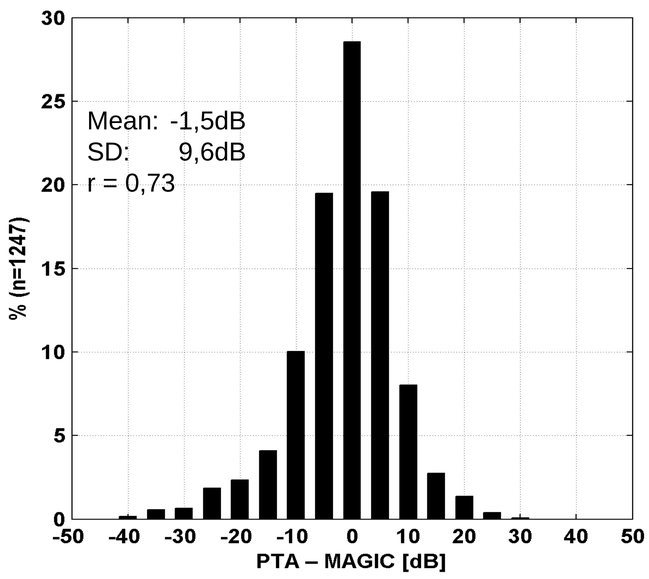






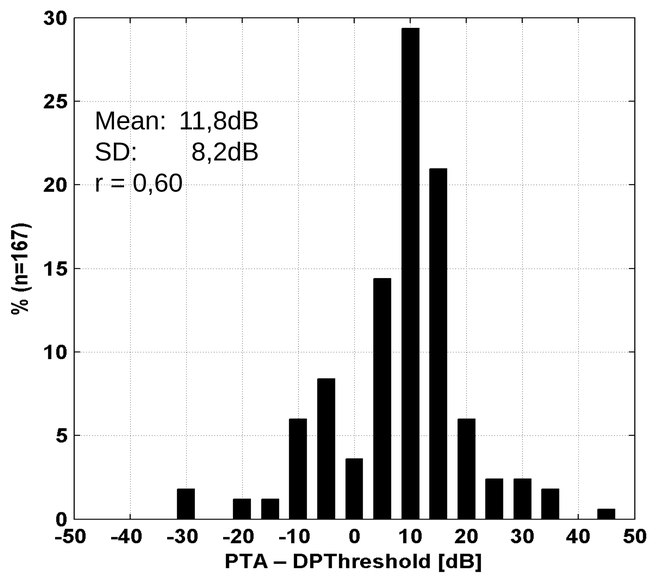
Results

MAGIC



There was a highly significant ($p<0.001$) correlation between image-based (MAGIC) and play-audiometry (PTA) thresholds. The correlation coefficient (r) over all 1247 measurements was 0.73. The histogram of the difference between image-based and play-audiometry thresholds showed normal distribution. Mean and standard deviation of the differences amounted to -1.5 dB and 9.6 dB, respectively. Test time per frequency (one ear) was on average about 30s, ranging from 14s to 91s. Test time decreased with increasing age.

DPOAE Threshold



There also was a significant correlation ($r = 0.60$, $p < 0.005$) between DPOAE threshold estimates (DPThreshold) and play-audiometry pure tone thresholds (PTA). Mean and standard deviation of the difference between of both measures amounted to 8.2 dB and 11.8 dB, respectively. Histogram of the difference is illustrated on the left. Test time per frequency (one ear) was about 1 min.

Discussion

MAGIC and conventional pure-tone thresholds exhibited a close correspondence. The scatter of their differences was in accordance with the range of pure-tone thresholds in children younger than 12 years as reported in the literature [3, 4, 5] and was slightly larger than in adults [6]. By using animals as visual amplifiers and using a self-controlled measuring procedure the child's attentiveness could be enhanced. Thus, MAGIC may have an advantage over common pure-tone audiometry.
As already shown in adult patient with cochlear hearing loss [7, 8] there was a close correlation between DPOAE thresholds and behavioural pure-tone thresholds. The lower DPOAE thresholds proved the known discrepancy between physiological and psycho-acoustical thresholds in children [8]. DPOAE thresholds allow for selectively assessing cochlear integrity and thus can extent the audiological test battery along with tympanometry and auditory evoked potentials. Especially in children, where a high discrepancy between the behavioural threshold and the actual threshold is expected, DPOAE thresholds may provide a suited means for a more reliable assessment of hearing loss.
Sentiero as a portable hand-held device offering both physiological and psycho-acoustical measures may facilitate the diagnosis of hearing loss in infants and children and may help to better adjust hearing aids.

Literature

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