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: Multiple-choice Auditory Graphical Interactive Communication) 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 presentation 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 f\(_{1,2} = 1, 1.5, 2, 3, 4, 6 \) and 6 kHz with primary tone levels (L\(_{1,2}\) ) in the range from 10 to 65 dB SPL and threshold estimated by linear regression analysis [2]. Primary tone levels L1 and L2 were set according to the “scissors paradigm” [3]. The frequency ratio f\(_{2}/f\(_{1}\)\) 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- und Ohrenklinik und Poliklinik, Universität 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 Nikosia (Cyprus).

Results

There was a highly significant correlation (p=0.001) 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.

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 test objects, 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-accoustical thresholds in children [8]. DPOAE thresholds allow for selectively assessing cochlear integrity and thus can extend 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 device for image presenting and psycho-accoustical measures may facilitate the diagnosis of hearing loss in infants and children and may help to better adjust hearing aids.

Literature