Verification of Hearing Aid Fitting using Aided Auditory Steady-State Response In Children

Thesis

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بسم الله الرحمن الرحيم

﴿وَعَلَّمَكَ مَا لَمْ تَكُنْ تَعْلَمُ وَكَانَ

فَضْلُ اللَّهِ عَلَيْكَ عَظِيمًا﴾

صدق الله العظيم

سورة النساء آية (١١٣)

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List of Abbreviations

Abb.	Full term
ABR	Auditory Brainstem Response
ACAP	Auditory compound action potential
AI	Articulation index
AM	Amplitude modulated
ASSR	Auditory steady-state response
CF	Carrier frequency
dB HL	Decibels hearing level
EEG	Electroencephalography
ERP	Event-related potential
FM	Frequency modulated
HIS	Intelligent Hearing System
LDL	Loudness Discomfort Level
LGOB	Loudness Growth in ½ octave Bands
MCL	Most Comfortable Level
MFs	Modulation frequencies
MLR	Middle Latency Response
REAG	Real ear aided gain
RSG	Repeating sequence gated
SADL	Satisfaction with Amplification in Daily Life questionnaire
SDT	Speech detection threshold
SIR	Speech intelligibility Rating
SRT	Speech reception threshold
SSEP	Steady State Evoked Potentials
WHF	Wurzhurg Hoer-: Feld

INTRODUCTION AND RATIONALE

Hearing is critical for the development of speech, language, communication skills, and learning. The earlier that hearing loss occurs in a child's life, the more serious is the effect on the child's development ***(Yoshinaga-Itano, 2004).***

Early detection and intervention through the concept of universal newborn hearing screening programs are believed to be critical steps toward proactive management of those children ***(American Speech-Language-Hearing Association. Joint Committee on Infant Hearing Position Statement, 1994; American Academy of Pediatrics, 1999, Harlor & Bower, 2009).***

The implementation of newborn hearing screening programs has reduced the age of identification of hearing loss and thereby age of intervention significantly ***(Uus & Bamford, 2006,Sininger et al., 2009;),*** the median age of fitting now ranging between four and six months ***(England, UK: Uus & Bamford, 2006,California, USA: Sininger et al., 2009, Auerbach, & Gershkovich, 2009, Ontario, Canada: Bagatto et al., 2010, NewYork, USA: Spivak, Sokol,).***

Management of hearing loss as early as possible, includes fitting the infant with an aid that properly compensates for the loss and verifying that the aid provides adequate benefit ***(Scollie & Seewald, 2001).***

The process of hearing aid fitting involves selection and verification of hearing aid output to match prescribed targets for a given hearing loss ***(American Academy of Audiology [AAA], 2013; JCIH, 2007)***. Hearing evaluation using behavioral test methods is a challenge in young infants and therefore hearing aids are usually fitted based on estimated hearing thresholds ***(Bagatto et al., 2005).***

Consequently, there is a great need for an objective tool which can help to predict the aided and unaided audiogram and which, when coupled with the electroacoustic measurements, can provide sufficient data for appropriate hearing aid prescription ***(Littman et al., 2002).***

Although the possibility of using ABR for functional gain measurements was demonstrated, the widespread use of this technique did not occur due to a number of technical challenges: First, the click stimulus is very brief and can be significantly distorted both in the sound-field speaker and in the hearing aid. The resultant stimulus artifacts may obscure interpretation of the responses ***(Garnham et al., 2000).*** Second, the fact that hearing aids react differently to rapidly changing stimuli, such as those used to elicit an ABR, than to more continuous stimuli which leads to distortion of the stimulus ***(Mahoney, 1985).***

Third, the click ABR is mainly related to high frequency gain, and correlation between wave V latency and loudness is low, particularly when there is a sloping hearing loss ***(Picton et al., 1998).*** Finally, the brief stimuli that are optimal for ABR recordings may not activate the hearing instrument's compression circuitry in the same way as longer duration speech sounds and may be treated as 'noise' by hearing instruments with speech detection algorithms. For these reasons attempts to use the ABR to evaluate hearing instruments have largely been abandoned ***(Brown et al., 1999; Alcantra et al., 2003; Purdy et al., 2005).***

More recently, the advent of the auditory steady-state response (ASSR) as a clinical tool for objective audiometry in infants has shown a promise as a useful way of determining aided thresholds ***(Picton et al., 1998; Rance & Rickards, 2002).***

Unlike the ABR, the ASSR is evoked by continuous stimuli modulated in amplitude and frequency. After the initial few stimuli, the response stabilizes and thereafter contains a constituent frequency component that remains constant in amplitude and phase over time ***(Picton et al., 1998).*** These stimuli are therefore unlikely to be distorted by amplification in either the sound-field speaker or hearing aid, and frequency-specific thresholds can be measured across the frequencies important for speech ***(Picton et al., 1998).***

Hence, the current study is conducted in an attempt to assess the role of ASSR as an objective tool in assessment and verification of aided performance in a group of children with severe to profound sensorineural hearing loss.

AIMS OF THE WORK

1- To investigate the value of ASSR as an objective tool in the assessment of aided response in children with hearing loss.

2- To compare results of aided auditory steady-state response (ASSR) threshold and behavioral aided response in children.

Chapter 1

VERIFICATION OF HEARING AID FITTING

Hearing Aid Evaluation

Saunders and Cierkowski, (2002) conducted a classification of the current approaches to hearing aid evaluation as following:

A- Subjective Approaches to Hearing Aid Evaluation:

Audition is a sensory experience. Thus, auditory awareness could be best evaluated through the psychoacoustic measures that involve the entire hearing mechanism ***(Duffy, 1987).***

Subjective approaches include threshold measurements, suprathreshold measurements (most comfortable level, loudness discomfort level), loudness scaling, speech audiometry and self-assessment scale.

1- Threshold measurements:

Pascoe (1975) popularized the term “functional gain" to define the psychoacoustic sound field measurement of the difference between the unaided and aided hearing threshold levels. Since then, many audiologists continue to use this procedure as a classical approach to assess the effective hearing aid gain. It has the advantages of being simple, flexible and any stimuli can be used such as narrow band noise ***(Pascoe, 1975);*** warble pure tones ***(Duffy, 1978)*** or amplitude modulated. pure tones ***(Goldberg, 1981).*** Most importantly is that it represents what the individual actually hear, and can be used in adult and children ***(Lewis, 2000).***

2- Suprathreshold measurements:

Most Comfortable Level (MCL) and Loudness Discomfort Level (LDL) measurements, individual determination of most comfortable level (MCL) and Loudness Discomfort Level (LDL) represents a complementary step in the hearing aid evaluation. ***Mueller and Hawkins (1990)*** studied the role of loudness discomfort level (LDL) determination in adjusting the maximum power output setting of the hearing aid. They concluded that loudness -discomfort level measurements provided more accuracy than loudness discomfort level estimation from the pure-tone hearing thresholds. This was done by the use of the best instructional set, the most valid stimuli, and the best delivery system. MCL determination was not popular because it: was variable, time consuming, and could not be used for children ***(Lewis, 2000).***

3- Loudness Scaling:

Loudness scaling is a psychophysical method used as a means for driving the relationship between the physical intensity of sound and their subjective loudness correlates ***(Hellbriick and Moser, 1985; Pascoe, 1988; Moore, 1997).*** Loudness Scaling of narrow band stimuli offered another