THE ASSR-PF

THE AUDITORY STEADY STATE RESPONSE PRESCRIPTION FORMULAE

Franz Zenker (1), Marta Suárez Suárez (2), Rafael Fernández Belda (1) and Jose Juan Barajas de Prat (3)

(1) Clínica Barajas (2) Fundación Canaria para la Prevención de la Sordera (3) Facultad de Psicología - Universidad de La Laguna.
C/Pérez de Rozas 8 - Santa Cruz de Tenerife - Canary Islands - Spain - Email: zenker@clinicabarajas.com

CLINICA BARAJAS
www.clinicabarajas.com

ABSTRACT

Universal newborn hearing screening will ensure that infants born with hearing-impairment will be fitted with hearing aids within the first few month of age. Unfortunately, accurate measurements are not always possible at this age and infants cannot provide reliable behavioural responses to sounds. Electrophysiological test can measure auditory function objectively. In the present study individual intensity functions were obtained from measures of loudness growth using the Contour Test and from the Auditory Steady State Responses (ASSR) amplitude measures of multiple amplitude-modulated (77-105 Hz) tones (500, 1000, 2000 and 4000 Hz) simultaneously presented to both ears and recorder over the scalp. This study further investigates the relationship between amplitude and intensity of the ASSR in a group of adults with normal hearing. We examine this relationship assuming that growth of loudness is related to the amplitude growth of the ASSR. Particularly, we propose a method to derive information of hearing aid characteristics from the amplitude- intensity function of the steady-state responses.This procedure enables determination of some basic properties of hearing aids, such as average gain, type of compression, compression factor and MPO. A hearing aid evaluation is discussed as an example of a sensorineural impairment.

INTRODUCTION

Over the past several years there have been many prescriptive fitting formulas developed and tested to fit hearing aids (1). The goal of these formulae is to choose a set of electroacoustic features related to the audiologic characteristic for listener with hearing impairment. Electroacoustic features include: Gain that is related to the degree of hearing loss, Frequency Response related to the audiogram configuration, the input signal determine by the LTASS (Long Term Average Speech Spectrum) and the Maximum Power Output (MPO) related to the Uncomfortable Loudness Level (UCL). These algorithms require accurate measurements obtained by psychoacoustic procedures.

The NAL-NL1 (2) and DSL I/O (3) are the most often used approaches in the adjustment of hearing aids in children. Moreover, the DSL approach was first used as a prescriptive method specifically developed for children. Both procedures require pure tone thresholds to facilitate their calculations. Unfortunately, accurate hearing threshold measurements by psycoacustical methods are not always possible in newborns.

The Auditory Steady-State Response (ASSR) is an evoked potential technique that uses continuous rather than transient stimuli to elicit a response from the auditory system (4). Auditory steady-state responses are much more frequency specific than the brief tones or clicks used with ABRs (5), are relatively unaffected by subject state (6) and are reliably present in children of all ages (7).

Amplitude of the ASSR can be used in the estimation of loudness growth function (8). In this poster we propose a method to derive information of hearing aid characteristics from the amplitude- intensity function of the steady-state responses. This procedure namely the **ASSR-PF** (Auditory Steady State Response Prescription Formulae) enables determination of some basic properties of hearing aids, such as dynamic range, frequency response, gain, compression factor, Input-Output function and Maximum Power Output. A hearing aid evaluation in a newborn is discussed as an example of a sensorineural impairment.

METHOD

Subjects

Twenty normal-hearing young adults (between 18 and 72 yr of age) were studied. Each subject underwent a complete audiologic evaluation before the evoked potentials exam.

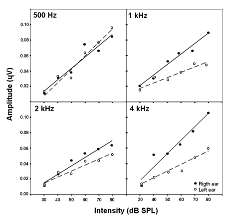
Stimuli

Multiple-frequency AM tones were presented monaurally through TDH 49 earphones at variable intensities between 80 and 30 dB SPL in 10.dB steps. The multiple-frequency (MF) stimuli consisted of a combination of four carrier tones of 0.5, 1, 2 and 4 kHz modulated in amplitude (95% depth) at rates of 81, 89, 97 and 105 Hz for the right ear and 77, 85, 93 and 101 for the left ear.

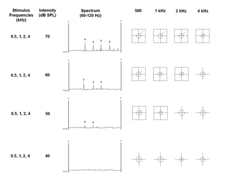
Recordings

All the responses were obtained with the AUDIX system (Neuronic S.A., Havana). The EEG was recorded using a forehead to ipsilateral earlobe/mastoid electrode montage, amplified and filtered at 10 Hz to 300 Hz. Impedance values were kept below 2k Ohms. The bioelectric activity was amplified with a gain of 100,000. Between 18 and 42 epochs of 8192 samples (1.37 ms sampling period) were averaged in each response. Artefact rejection was carried out with shorter epoch sections of 512 points. The Fast Fourier Transform (FFT) was calculated 'on line' with each long epoch. When an epoch contained electrophysiological activity exceeding ±90 nV, it was rejected. To detect the steady-state responses the Hotelling T2 (HT2) test was used (9). A response was considered present when the F-ratio of the signal to noise was significant at the p<0.05 levels.

RESULTS

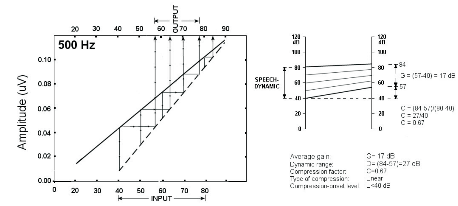


In this figure is shown the amplitudes of the ASSR averaged for the group of normal-hearing subjects for each frequency studied. Mean amplitude characteristics are obtained by linear regression. As expected the amplitude of the responses increase with increasing intensity above threshold.



This graph shows an ASSR of a newborn with a moderate sensorineural hearing loss. The presentation of the amplitude spectrum is limited to the range 60-120 Hz. In the spectrum, arrows indicate responses recognized as significantly different from zero.

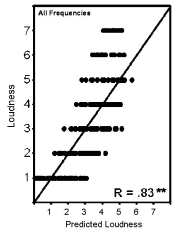
Dynamic Range, Gain and Compression Factor



At the left of this figure we shows the intensity-amplitude function of normal hearing displayed together with the curve of the baby recruiting ear. The input speech dynamic range between 40 and 80 dB is projected upwards on the normal curve. Finally, projection on the pathological characteristics yields the output dynamic range for this patient.

The **Gain** requirement can be estimated as the difference between hearing loss and the lower limit of the LTASS. **Compression Factor** is given by the ratio of the dynamic range of the patient to the normal speech dynamics.

Maximum Power Output



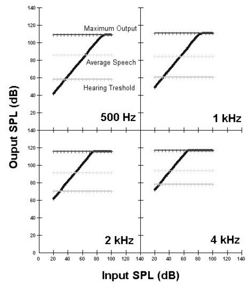
$Y_{(fo)} = B_0 + B_1 * \text{Intensity} + B_2 * \text{Amplitude}$

	.5 kHz	1 kHz	2 kHz	4 kHz	Total
B_0 (Y Intercept)	-0.33	-0.22	-0.34	-0.29	-0.43
B_1 (Intensity)	0.006	0.005	0.006	0.005	0.006
B_2 (Amplitude)	0.56	-1.09	3.42	5.01	1.84
Correlation coefficient (R)	0.85 **	0.84**	0.83**	0.82**	0.83**
Standard error of estimate	0.85	0.97	1.02	1.08	0.99

** P < 0.0001

From previous studies we establish the Loudness Discomfort Levels derived from the measurement of loudness growth using the Contour Test and from the ASSR amplitude and stimulus intensity. The MPO for this patient is established in 107 dB SPL, 111 dB SPL, 117 dB SPL and 118 dB SPL.

Input-Output Function



Finally different **I-O curves** can be obtained for each carrier frequency. In this figure we shows the patient hearing threshold, the average speech for each carrier frequencies, the MPO of the hearing aid and the final insertion gain prescribed. For all frequencies the LTASS is amplified comfortably between the dynamic ranges of the baby.

DISCUSSION

In the present study we derive information about the selection and adjustment of the hearing aid from the amplitude-intensity function of the steady-state responses. Summarizing the advantages of the **ASSR-PF,** it can be stated that the procedure described assist the clinician in the prescription of the electroacoustic characteristic of a hearing aid for newborns or non-cooperative subjects. Furthermore, this procedure derives basic hearing aid properties as dynamic range, frequency response, gain, compression factor and MPO for a specific type of hearing loss. The procedure described is no longer time-consuming since necessitates no additional examinations because diagnostic from ASSR are directly utilized for hearing-adjustment.

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