GLOBAL RESEARCH ANALYSIS

ISSN No 2277 - 8160

Listed & Indexed with

ISSN Directory, Paris



Multi-Subject Journal

Volume : 1 | Issue : 2 | July 2012 | ₹ 250/-

GLOBAL RESEARCH ANALYSIS

ISSN No 2277 - 8160

GLOBAL RESEARCH ANALYSIS

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Volume : 1 | Issue : 2 | July 2012 • ISSN No 2277 - 8160

Research Paper | Medical Science

Comparision of Thresholds of Single Frequeny and Muti Frequency Auditory Steady State Responses in Normal Hearing Adults

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ABSTRACT

Auditory steady-state responses (ASSRs) evoked by amplitude-modulated (AM) tones at modulation frequencies (MFs) between 70 and 110 Hz have recently been shown to be a useful technique in estimating hearing thresholds ASSR is affected by many factors such as type of stimuli, test environment, subject's status, total test duration and response detection paradigm. Present study aims to investigate thresholds determined by multifrequency ASSR (500Hz, 1000Hz, 2000Hz and 4000Hz simultaneously) and single frequency ASSR (500Hz, 1000Hz, 2000Hz and 4000Hz individually) in same ear. 13 normal hearing subjects participated in study. Age of normal subject varied between 20 to 24. Intelligent Hearing System was used for single and multi frequency testing. Stimuli were presented in one ear individually. Two types of stimulus presentation techniques were studied in the same ear: single frequencies (500Hz, 1000Hz, 2000Hz and 4000Hz individually) and multifrequency (500Hz, 1000Hz, 2000Hz and 4000Hz simultaneously). Statistical analysis of data did not show significant difference (p>0.05) for any of the four test frequencies (500Hz, 1000Hz, 2000Hz and 4000Hz) in same ear. From present study it is evident that threshold measurement is greatly influenced by test method, single or multi-frequency. However, from the current study it can't be implied that, which measure is better.

KEYWORDS: Multi frequency ASSR, Single frequency ASSR, normal hearing

A steady-state evoked potential is a repetitive evoked potential "whose constituent discrete frequency components remain constant in amplitude and time over an infinitely prolonged time period." (Regan, 1989). Steady state responses are produced when stimuli are presented at a rate sufficiently rapid that the response to any one stimulus overlaps responses to preceding stimuli. After the first few stimuli the recorded potentials assume the periodic waveform of the steady state response. Auditory steady state responses can be obtained using many different stimulus rates. The most widely studied auditory steady-state response is evoked by stimuli presented at the rates near 40Hz. (Galambos , Makeig, and Talmachoff, 1981) This 40 Hz responses can be used to assess hearing (Dauman, Szyfter, Charlet, and Cazals, 1984) Multiple carrier frequencies, each modulated by its own signature modulating frequency, evoke multiple steady state responses, each measured at the particular frequency at which the carrier is modulated.

Auditory steady-state responses (ASSRs) evoked by amplitude-modulated (AM) tones at modulation frequencies (MFs) between 70 and 110 Hz have recently been shown to be a useful technique in estimating hearing thresholds in individuals with normal or impaired-hearing (Aoyagi , Furuse , Yokota , Kiren , Suzuki, and Koike 1994). Similar to tone-evoked ABR recordings, the ASSR may be recorded to single-frequency stimuli presented to one ear at a time. This is the "single-stimulus" ASSR method for which many clinical data have been published (e.g.Rance ,Rope, and Symons, 2005). Alternatively, it is also possible to record ASSRs to multiple stimuli (i.e., several frequencies) presented simultaneously to one or both ears. Although clinical data for this technique are more limited, this "multiple" ASSR technique has the potential to gather more information in a shorter amount of time, thus speeding up test time (Herdman & Stapells, 2001). If Studies presenting single AM tones modulated between 70 and 110 Hz, at varying intensities, indicate that ASSR thresholds can be recorded to within 16 and 30 dB of behavioral thresholds for carrier frequencies of 0.5 and 4 kHz, respectively (Lins, Picton, and, Picton 1995).

It is studied that ASSR is affected by many factors such as type of stimuli, test environment, subject's status, and general anesthesia total test duration and response detection paradigm. Luts and Wouters (2005) studied ASSR threshold by two different measurement instruments: AUDERA and MASTER systems. They found ASSR results can differ with respect to different measuring instrument.

Among these techniques MASTER has gained more popularity and it is also widely used because of its features. It provides great flexibility to user to do ASSR from single frequency to any combination of frequencies and from monotic stimulation to simultaneous dichotic stimulation. ASSRs evoked by amplitude-modulated (AM) tones with modulation frequencies between 70 and 110 Hz have been used in the assessment of infant hearing using either single stimuli or multiple stimuli (Lins, Picton, Boucher, Durieux-Smith, Champagne, and Moran, 1996) and have shown great promise. However, only a few studies have directly compared ASSRs with single versus multiple simultaneous stimuli (Lins et al. 1995).

But there are very few researches done comparing thresholds by single frequency and that of multiple frequencies in same ear for this specific instrument. So it is interesting to know whether ASSR results are affected by different methods of presentation i.e. single frequency and multiple frequencies in the same ear. Present study aims to investigate thresholds determined by multifrequency ASSR (500Hz, 1000Hz, 2000Hz and 4000Hz simultaneously) and single frequency ASSR (500Hz, 1000Hz, 2000Hz and 4000Hz individually) in same ear.

Method

Subjects:

The 13 subjects (7 males and 6 females) were volunteers obtained from students of speech and hearing. Their age range ranged between 20 to 24 years. All subjects were screened for normal hearing for pure tones (500Hz to 4000Hz) at 15 dBHL. During the recording the subject sat in a comfortable reclining chair or lying on a bed inside a quite room. Subjects were asked to relax and /or sleep during the test.

Stimulation and recording:

Intelligent Hearing System was used for recording which incorporates M.A.S.T.E.R. system (John and Picton 2000). Air conduction stimuli were presented to single ear through ER-3A insert receivers. In all subjects, right ear was taken as test ear. Stimuli consisted of sine waves at carrier frequencies of 0.5, 1, 2, and 4 kHz that were modulated at frequencies of 79Hz, 87Hz, 95Hz and 103Hzfor right ear (RE).

Electrode sited was cleaned using New-Prep screen. Gold plated recording electrodes were used along with conduction gel. Positive electrode was kept at high forehead, negative electrode at test ear mastoid and ground electrode was kept at low forehead. Inter electrode and individual electrode was always lower than 3 kohms for all recordings. EGG was amplified 100000 times and filtered using a bandpass of 30 to300 Hz. Artifact rejection limits were set to 23 mV to eliminate potential due to muscle or movement artifact.

Mainly two recording condition were used. (1) Monotic Signal (MS) : AM tones of 0.5, 1, 2 and 4 kHz were presented separately to right ear (2) Monotic Multiple (MM): four AM tones of frequencies 0.5, 1, 2 and 4 kHz were presented simultaneously to the right ear

Initial presentation level was kept at 40 dBSPL. Response was detected by auto detection method used in Intelligent Hearing Software system. Intensity was decreased by 10 dB steps for presence of response, and increased by 10 dB stops for absence of response. Thresholds were

tracked or both conditions to find minimum intensity at which response are present. 10 dB of steps were incorporated. Total 400 stimuli were used for each recording.

Results

In present study ASSR thresholds were obtained for monotic single (MS) and monotic multiple (MM) conditions using MASTER ASSR instrument. ASSR thresholds were considered as minimum intensity at which ASSR is obtained by auto detection method.

SPSS 16.0 software was used for statistical analysis of the findings. Results are displayed in the Table 1. In SM condition for 500Hz, 1000Hz, 2000Hz and 4000Hz mean thresholds were obtained as 43.07dBHL, 36.94 dBHL, 41.53 dBHL and 46.15 dBHL. Standard deviation was 11.82 dBHL, 8.54 dBHL, 10.68 dBHL and 10.68 dBHL. ASSR thresholds ranged from 20-60 dBHL, 30-50dBHL, 20-50dBHL and 30-60 dBHL respectively for all four frequencies.

Similarly in MM condition, mean thresholds for 500Hz, 1000Hz, 2000Hz and 4000Hz were 40.76 dBHL, 35.38 dBHL, 40 dBHL and 46.92 dBHL. Standard deviation were 11.87 dBHL, 13.3 dBHL, 12.24 dBHL and 15.48 dBHL respectively while range was 20-60 dBHL were for all the frequencies.

Table 1: Mean, Standard deviations and range of thresholds in SM and MM conditions in dBHL.

Measurement Techniques	Frequency (Hz)	Threshold (dBHL)	Range (dBHL)
Single Monotic	*500*	43.07	20-60
	1000	36.92	30-50
	2000	41.53	20-50
	4000	46.15	30-60
Multiple Monotic	*500*	40.76	20-60
	1000	35.38	20-60
	2000	40	20-60
	4000	46.92	20-60

The obtained means and standard deviations were subjected to statistical test of significance to show if there is any significant difference between the thresholds of two measurement techniques. Paired sample t test was administered using SPSS 16.0 software. Table.2 shows p values as 0.534, 0.394. 0.656 and 0.551 for thresholds at frequencies 500Hz, 1000Hz, 2000Hz and 4000Hz respectively. The obtained results in the Table 2 did not reveal any significant difference between two measurement techniques at any of the given frequencies.

Table2: t values for 500Hz, 1000Hz, 2000Hz and 4000Hz.

Frequency	Measurement technique	Threshold (t)
500Hz	SM MM	0.534*
1000Hz	SM MM	0.394*
2000 Hz	SM MM	0.656*
4000 Hz	SM MM	0.551*

P<0.05 levels

Discussion

Current study was taken up to estimate difference between thresholds at single and multiple frequencies i.e. whether different measurement methods have any effect on the ASSR results. Statistical analysis of data did not show significant difference (p>0.05) for any of the four test frequencies (500Hz, 1000Hz, 2000Hz and 4000Hz) in same ear.

Table 3 illustrates the thresholds of all participants in dBHL for both MS and MM recording conditions. As shown in the Table, there was a great variability in thresholds. On an average, thresholds were found to be better for low frequency than high frequency. Thresholds obtained above 60dBHL were excluded while doing the analysis, as there is a great possibility that those measurements were due to artifact.

Table3: ASSR thresholds for MS (Monotic Single) and MM (Monotic Multiple) conditions for 500Hz, 1000Hz, 2000Hz and 4000Hz.

	500 Hz		1000 Hz		2000 Hz		4000 Hz	
	MS (dBHL)	MM (dBHL)	MS (dBHL)	MM (dBHL)	MS (dBHL)	MM (dBHL)	MS (dBHL)	MM (dBHL)
Subject 1	40	50	30	40	30	40	30	40
Subject 2	60	60	50	70	50	60	50	60
Subject 3	50	40	30	30	40	30	30	30
Subject 4	40	30	30	50	30	40	50	50
Subject 5	50	50	40	40	30	30	40	30
Subject 6	40	40	30	20	40	60	50	60
Subject 7	50	30	30	30	50	50	50	50
Subject 8	50	40	30	40	50	40	50	50
Subject 9	60	40	50	30	50	30	60	50
Subject 10	40	60	50	30	50	50	50	40
Subject 11	30	20	40	20	20	20	50	50
Subject 12	20	40	40	30	50	40	50	80
Subject 13	30	30	30	30	50	30	40	20

An important objective of this study was to determine if an interaction between responses to AM tones simultaneously to single ear would significantly alter ASSR thresholds or not as compared to that of singe frequency stimulation. Theoretically it is assumed that in ASSR when two modulation frequencies are used, they never interact. Present study did not show any significant difference between the two recording conditions.

However, there are sporadic evidences that, there can be distortion in the cochlea when multiple frequencies are presented simultaneously. Though the results of current study didn't reveal a statistical significant difference between test conditions, it is quite evident that, the thresholds of the same frequency tested within the same subject in a single session could vary at least 20dB and range up to 40 dB.

Previously John, Lins, Boucher and Picton (1998) used amplitude as a measure and compared single and multi-frequency ASSR in the same ear. They investigated absolute amplitudes of responses at threshold and moderate intensity level for SM and MM conditions. It was observed that the interaction is more evident at high level of multiple frequency stimulus presentation, resulting in amplitude reduction, and is negligible at low level presentation.

These findings suggest that the variability at threshold levels and at higher levels are either influenced by completely different variables or may be one single variable differentially influencing the variation at near threshold and at higher intensities. So far this variable in unknown, but it can be concluded that effect of this variable is less at moderate intensities and more at threshold level.

Though there was no statistical difference between two recording condition, because of within subject and between subject variability of the thresholds, authors could not extract any concrete inference from the available data since two measurements failed to show any specific pattern. This variability also questions reliability of ASSR threshold in MASTER system.

As sample size was quiet less in present study, research with more number of subjects is therefore required to come to definite conclusion. Further research is also advised in the pediatric population.

Conclusion

From present study it is evident that threshold measurement is greatly influenced by test methods, single or multi-frequency. However, from the current study it can't be implied that, which measure is better. But it can be concluded that ASSR thresholds are not affected by different measurement methods statistically i.e. it does not change with single and multi frequency recording in the same ear. And there is no definite pattern observed in thresholds of SM and MM recording conditions. But multiple frequency presentation of stimuli saves time. So principle clinical implication of this study can be considered as testing behavioral thresholds with multiple frequency presentation simultaneously.

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GLOBAL RESEARCH ANALYSIS

Multi-Subject Journal

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