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THE EFFECT OF SPECTRAL SPLATTER IN DETERMINING HEARING THRESHOLD USING TONE BURST AUDITORY BRAINSTEM RESPONSE (ABR) IN CLINICAL SETTING

by

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ABR	Auditory Brainstem Response
AEP	Auditory Evoked Potential
ANSI	American National Science Institute
PTA	Pure Tone Audiometry
WHO	World Health Organisation

Abstract

A prospective study to reveal the effect of spectral splatter in determining hearing threshold using tone burst Auditory Brainstem Response (ABR) in clinical setting. Ten subjects were participated in this study with total of twenty ears (right and left). Five subjects were male and five subjects were female. Subjects were 100% Malay adults. Subjects were recruited among students of University of Science Malaysia from April to May 2012. Test was done by changing the cycle of tone burst ABR, varying with 2-1-2, 1-1-1, and 0.5-1-0.5 cycle of rise-plateau-fall time during testing on subject with artificial hearing loss. Result shows significant difference of hearing threshold between 2-1-1, 1-1-1 and 0.5-1-0.5 of rise-plateau-fall time of tone burst ABR. The result's correlation of all three cycle was not differ much with Pure Tone Audiometry (PTA) results, but the highest correlation is 2-1-2 cycle of tone burst ABR. Thus, we can consider that 2-1-2 cycle of rise-plateau-fall time was the most recommended to be used in clinical setting in determining frequency specific hearing threshold using tone burst ABR.

Abstrak

Respon Auditori Akar Otak (ABR) ialah ujian objektif unutk menentukan status pendengaran seseorang. Walau bagaimanapun, ketepatan keputusan ujian ABR akan terjejas sekiranya penyebaran frekuensi berlaku semasa ujian dijalankan. Kajian prospektif ini dijalankan untuk menentukan kesan penyebaran frekuensi dalam menentukan tahap pendengaran seseorang menggunakan tona letupan sebagai stimulus untuk ujian Respon Auditori Akar Otak (ABR) dalam sesi klinikal. Sepuluh orang subjek mengambil bahagian dalam kajian ini dengan data bagi dua puluh telinga (kiri dan kanan) diambil. Seramai lima orang lelaki dan lima orang perempuan dewasa Melayu dijadikan sebagai subjek. Kesemua mereka dipilih di kalangan pelajar Universiti Sains Malaysia dari April sehingga Mei 2012. Dalam kajian ini, ujian Audiometri Tona Asli dijalankan ke atas setiap subjek dengan keadaan telinga tidak bersumbat dan bersumbat. Kemudian, ujian ABR pada frekuensi 500Hz dijalankan untuk kitaran 2-1-2, 1-1-1, dan 0.5-1-0.5 untuk masa naik-kekal-turun. Keputusan menunjukkan kesemua tiga kitaran mempunyai nilai perhubungan yang kuat dengan nilai tertinggi adalah pada kitaran 2-1-2. Ujian ANOVA menunjukkan ketiga-tiga kitaran stimulus ABR tidak banyak berbeza ($p>0.05$). Penemuan kajian ini adalah sama dengan penemuan kajian sebelum ini yang menyatakan kitaran paling ideal untuk ABR ialah kitaran 2-1-2. Konklusinya, kitaran naik-kekal-turun 2-1-2 adalah yang paling sesuai untuk menentukan tahap pendengaran bagi frekuensi yang spesifik menggunakan tona letupan sebagai stimulus dalam sesi klinikal.

CHAPTER 1

Introduction

The Effect of Spectral Splatter in Determining Hearing Threshold Using Tone Burst Auditory Brainstem Response (ABR) in Clinical Setting.

1.1 Background of Study

Auditory Brainstem Response (ABR) is one of the objective tests that have been used in clinical setting. It is used when conventional pure tone behavioural or audiometry cannot provide valid or reliable hearing threshold (Hood, 1998). When estimating hearing threshold using tone burst ABR, it is very important for responses be frequency specificity and as close as possible to behavioural pure tone hearing threshold. Therefore, over amplification at specific frequency can be avoided when fitting child with hearing aids.

As stated Stapells & Oates, (1997) the air conduction clicks is the most widely used stimulus for estimating pure tone audiogram using ABR. But, due to its broad spectral content and rapid onset, it may be not the best choice to obtain frequency specific hearing level. This may cause problems in estimation of hearing level at specific frequency, especially in cases of high frequency hearing loss because the clicks stimulus will activated large area of basilar membrane, which is representing broad range of frequencies (Staple and Oates, 1997).

Hence, ABR using tone burst might be the effective solution in estimating frequency specific hearing level. According to Staple and Oates (1997), a short duration tone burst provides more frequency specificity and allows for more accurate estimation of the pure tone audiogram. Hall (1992) stated that tone burst has primary energy at a single characteristic frequency and ideally contains no energy at other frequencies; therefore, one may assume that a 500 Hz tone burst is only stimulating the neurons tuned to 500 Hz in the cochlea. However, tone burst has a brief stimulus onset, which may produce spectral splatter, or acoustic energy at unwanted frequencies. When splatter occurs it can generate a response that is not representative of the nominal frequency being tested (Hall, 1992). According to Burkard and Hecox (1983), low-frequency tone burst will typically produce longer ABR peak latencies due to the increased travelling wave delay to more apical cochlear region. When presented at high stimulus levels, low frequency tone burst may actually generate an ABR that arises from the higher frequency (more basal) region of cochlear. Study by Suzuki and Horiuchi (1981) demonstrate that the first few cycle of the tone burst envelope determine ABR peak latency, amplitude, and threshold. Based on this finding, an optimal tone burst, at least for ABR, is two cycle rise/fall time.

1.2 Problem Statement

Theoretically, tone burst with fast rise and fall time might cause spectral splatter. However, this spectral splatter effect has not been demonstrated clinically. Therefore, this study aims to reveal the effects of spectral splatter in clinical setting of ABR testing.

1.3 Objective of Study

1.3.1 General Objective

To determine the effect of spectral splatter in assessing hearing threshold using tone burst ABR

1.3.2 Specific Objectives

To reveal the effect of rise time and fall time of tone burst envelope towards frequency specificity in hearing assessment using ABR

1.4 Research Question

Is there any significant effect of rise time and fall time of tone burst envelope towards frequency specificity in hearing assessment recording using ABR?

1.5 Hypothesis

1.5.1 Null Hypothesis, H_o :

There is no significant effect of rise time and fall time of tone burst envelope towards frequency specificity in hearing assessment recording using ABR.

1.5.2 Alternative Hypothesis

There is significant effect of rise time and fall time of tone burst envelope towards frequency specificity in hearing assessment recording using ABR.

1.6 Significance of Study

The aim of this study is to reveal the effects of spectral splatter towards frequency specificity of tone burst ABR. This study will contribute to the understanding of effect of spectral splatter towards threshold seeking using tone burst ABR in clinical testing. Furthermore, it will provide the best procedure to obtained patient's hearing threshold using ABR.

CHAPTER 2

LITERATURE REVIEW

2.1 Hearing Loss

Hearing loss can be defined as complete or partial loss of ability to obtain auditory information from one or both ears and can be classified as mild, moderate,severe and profound (WHO, 2006). There are three types of hearing loss which is conductive hearing loss, sensorinneural hearing loss and mixed hearing loss. Conductive hearing loss is the condition where there is existence of sound barrier either from outer or/with middle ear. It is commonly treatable with surgically or medically and usually can lead until severe hearing loss. Sensorineural is the condition where there is disorder in the inner ear or auditory nerve system. It is generally irreversible and can be managed by aural rehabilitation and amplification using hearing amplification devices. Mixed hearing loss is the condition where there are existences of outer or/with middle ear problem and in the inner ear or/with auditory nerve system.

Hearing loss can bring extra social and economic burden towards individual, families, communities, and countries. Child with untreated hearing loss may face problem of delayed language development and cognitive skill. Thus, it will lead to communication problem and learning progress in school, making them become lower academic achiever while adult with untreated hearing loss may face problem to perform well in their jobs. To make worsen, usually child and adult with untreated hearing loss usually stigmatized and isolated by the community.

2.2 Electrophysiological Test – Auditory Evoked Potential (AEP)

Auditory Evoked Potential (AEP) is activity within the auditory system (ear, auditory nerve, or auditory regions of the brain). It was produced or stimulated (evoked) by sounds (or acoustic stimuli). On the other words, AEP can be concluded as brain waves (electrical potentials) generated when the person is stimulated with sounds (clicks – very brief, sharp sounds), tones or speech sounds. There may be high (loud) to low (faint) intensity or strength of sounds (corresponding to how loud they are). Sounds with greater intensity will produce larger auditory brain responses and vice versa. The sounds are presented to the subject's with some type of an acoustic transducer such as headphone, insert phone or bone conductor.

Electrode was placed on the specific areas on the scalp (e.g., high on the forehead) and near the ears (e.g, on the ear lobes or mastoid). It is functioning to pick up activity from the ear and brain that was evoked by sounds presented to the ears. Clinically used electrode usually consist of a wire with a disc or adhesive patch at one end that makes contact with the skin, and a pin at the other end, which plugs into an electrode box or preamplifier. The activity evoked by the sound arises from structures within the ear, nerve and brain at some distance from these electrodes. Stimulus-evoked sensory and neural activity is conveyed from the auditory structures through body tissue and fluids to the surface electrodes, to the preamplifier, to filter, to analog-to-digital converter, and finally displayed graphically in a computer. (J. W. H. III, 2007).

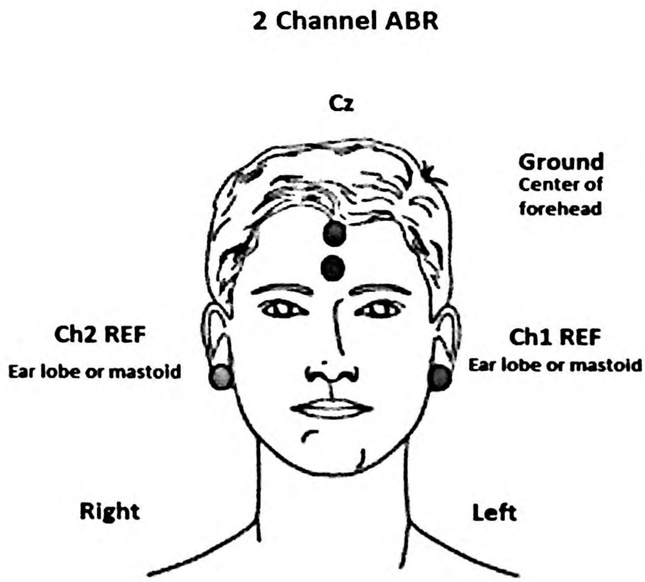

Figure 2.1 Electrode Placement of AEP – 2 Channels Auditory Evoked Potential

(Reprinted from

http://www.audiologyonline.com/articles/pf_article_detail.asp?article_id=2368)

If the response from all auditory nervous system structures was simultaneously measured following presentation of an acoustic stimulus, the activity in the cochlear, auditory nerve, auditory brainstem, medial geniculate body, and auditory cortex will be recorded. Multiple brain regions would be activated at the same time. It is possible to record a series of responses from the scalp (using noninvasive surface electrode) that have latencies ranging from one-thousandth to several tenths of seconds. It is popular to classify Auditory Evoked Potential based on their response time following the onset of transient stimulus (Robert Burkard and Kathleen McNerny, 2009). Responses with the shortest latencies are generated by the inner ear and the auditory nerve. A few miliseconds later, there are unique response patterns reflecting activity within the auditory brainstem. Recording still later are response patterns due to activity in higher auditory portions of the brain, such as the cerebral cortex. It has produced some useful correlations among response patterns, the periods after the stimulus, and the generators of AEPs. The terms in referring different categories of AEP are related to the auditory structures that give rise to the response (Hall III, J.W, 2006).

2.3 Estimation of Hearing Levels – Auditory Brainstem Response (ABR)

Auditory brainstem response (ABR) is a series of five to seven peaks arising from auditory nerve and brainstem structures (Moller, 1994), occurring within 10ms of the onset of moderate-intensity click stimulus in ontologically, audiologically, and neurologically intact adults. Jewett and Williston (1971) label the peak with capital Roman numerals (I through VII) as the convention label and followed by most investigators. According to its time window rather than its generators, the ABR also referred to as early or short latency AEP. It was the most useful AEP at the present time for estimating hearing threshold, differential diagnosis of peripheral and central abnormalities.

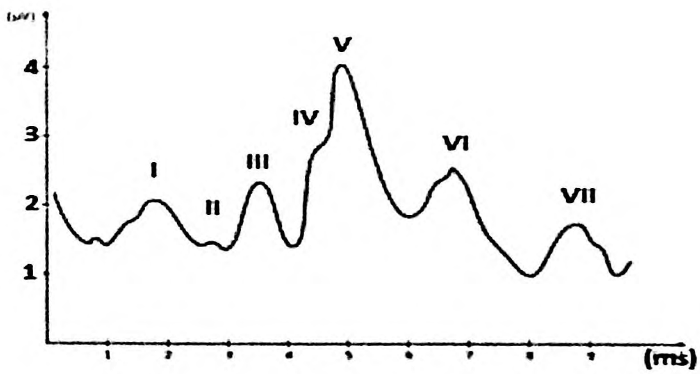

Figure 2.2 Normal hearing wave function chart

Measurement of ABR is one way to estimate frequency specific hearing thresholds in patients who cannot provide valid or reliable hearing threshold using conventional pure tone behavioural or audiometry (Hood, 1998). Frequency specificity, as defined by Stapells and Oates (1997), refers to how autonomous a threshold is at one frequency from contributions by surrounding frequencies. When estimating hearing thresholds using the ABR, it is important that responses be as frequency specific and as close to the behavioural pure-tone hearing thresholds as possible.

2.4 Stimuli Typically Used to Elicit AEP

Two of the most typically used stimuli to elicit AEP clinically are clicks and tone burst.

A click is produced by exciting a transducer with a brief-duration (typically 100microseconds for human studies) electrical pulse. It has energy over a wide range of frequencies and is a broadband stimulus. It often becomes a choice to be used during hearing screening, site of lesion testing and intraoperative monitoring.

Tone burst is another stimulus that can be used to elicit AEP. In determining an electrophysiologic estimate of the behavioural audiogram, a tone burst can be used. According to ANSI S3.6-2004 (ANSI, 2004), which review on the technical, for specifications for audiometers, state that for audiometric purposes, a tone must be presented for a duration of not less than 200ms and having a rise time and fall time ranging between 25 and 100ms. The time required for the tone burst envelope to increase from zero to its maximal amplitude is termed its rise time. Plateau time is the time that the tone burst envelope remains at its maximal amplitude while the time required for tone burst to decrease its amplitude from maximal to zero is called fall time. A tone that is infinitely long in duration only has energy at the carrier frequency. For the tone burst, there will be significant energy over the range of frequencies and this spread of energy to frequencies above and below the carrier frequency is referred as spectral splatter.

2.5 Spectral Splatter Phenomenon of Tone Burst

Spectral splatter is referred to spread of energy to frequencies above and below the carrier frequency of tone burst that occur because of rapid onset and offset of stimuli, heard as a click when tone burst is brief. In general, tone burst envelope with rise time/fall time of two-cycle and brief plateau time (e.g. zero to two cycles) is an optimal choice (Suzuki & Horiuchi, 1981) for ABR testing. If shorter rise and fall time was used for tone burst, spectral splatter happened as described in Figure 2.3. (Sony Sound Forge Pro 10.0 software was used for spectrum analysis).

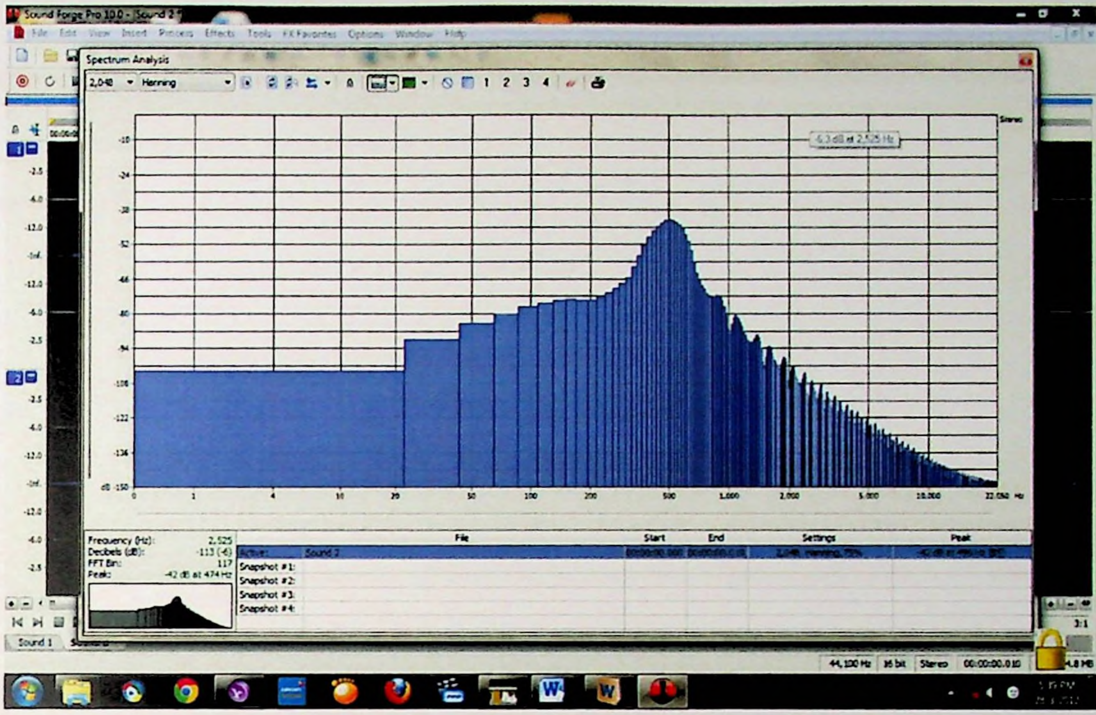

Figure 2.3 (a) Spectrum analysis of 500Hz tone burst frequency with 2-1-2 rise time/plateau/fall time.

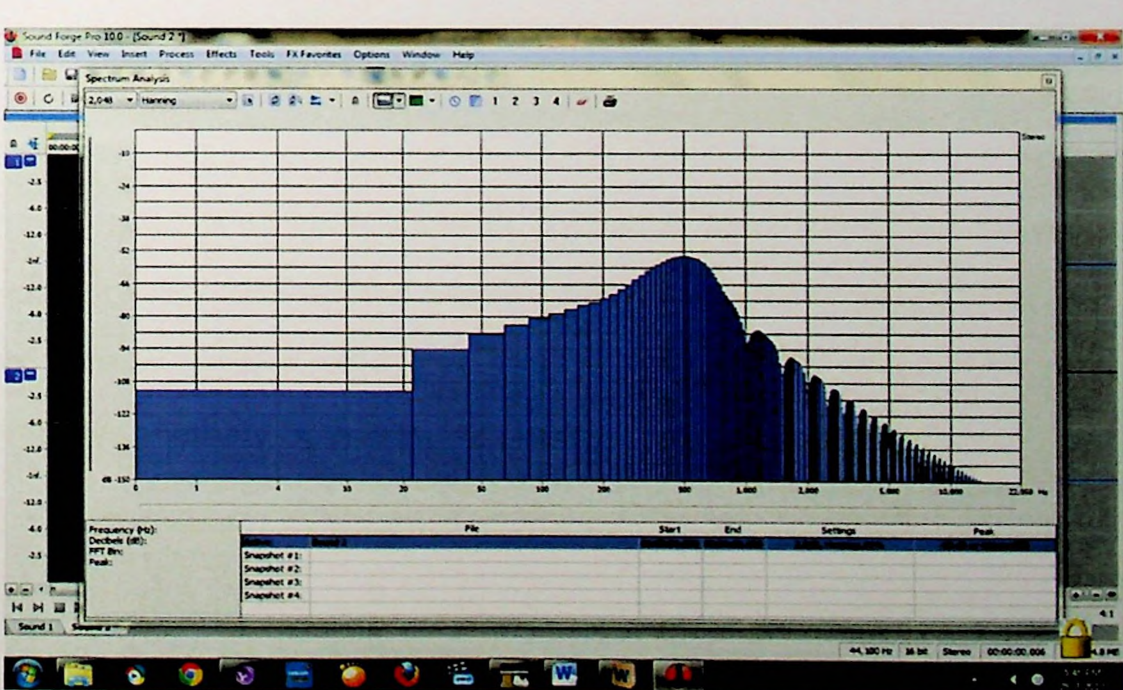

Figure 2.3 (b) Spectrum analysis of 500Hz tone burst frequency with 1-1-1 rise time/plateau/fall time.

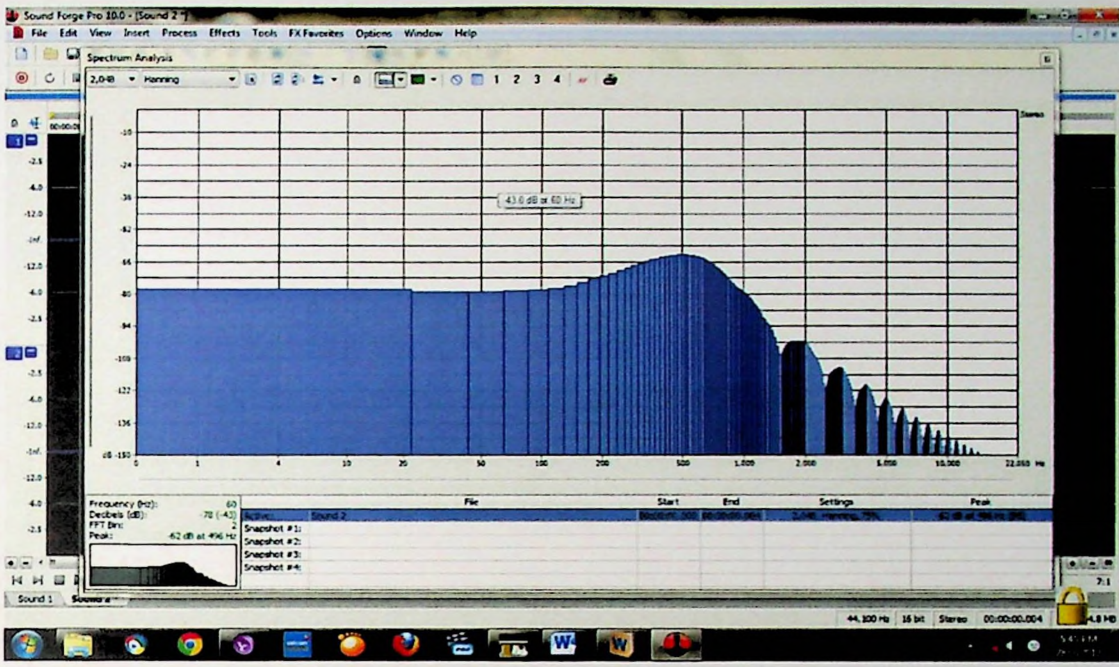

Figure 2.3 (c) Spectrum analysis of 500Hz tone burst frequency with 0.5-1-0.5 rise time/plateau/fall time.

Based on the spectrum analysis, the used of shorter rise/fall time will cause spread of energy across the other frequency. However, stimulus frequency (500Hz) still the dominant and most robust energy even there are spread of energy on the other frequency, which largely on lower frequency.

CHAPTER 3

Methodology

3.1 Research Design

This is a perspective design with repeated measurement. Summary of this study is shown in flow chart in procedure (3.1)

3.2 Detailed Methodology

3.2.1 Participant

Inclusion Criteria

i. Normal hearing subjects

ii. Age between 18-65 years old

iii. Have no conductive element involved