

TONE PIP ELICITED BER'S

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Since the initial work of Jewett and Williston in 1971, a remarkable degree of quantification and confirmation of brainstem evoked response data has been published. The consensus of findings has led to the clinical acceptance of BER as an intricate test in the diagnostic assessment of both normal and pathological subjects. BER studies continue to demonstrate that the BER technique does provide an objective means for assessing hearing, especially among infants and difficult-to-test patients.

The principle underlying BER is the same as that used for any evoked potential study. Basically, EEG changes resulting from auditory stimuli are recorded by scalp electrodes. These auditory evoked EEG changes are usually too small to be observable in the ongoing EEG and in order to extract these minute potentials, amplification and signal averaging must be used. It is necessary that the auditory stimulus be repeated a number of times. The electrical responses as recorded by the scalp electrodes are time-locked to stimulus onset. With the use of a signal averaging computer, any random background EEG activity that is not associated with the brain's response to auditory stimuli averages to zero, while the EEG responses to the auditory stimuli summate.

The subject's EEG is obtained via electrodes attached to specific portions of scalp, usually the vertex and both mastoids. The signal which is picked up is amplified by a preamplifier prior to its transmission to the signal averager. The EEG signals are amplified a minimum of 20,000 times for BER studies. The result is a specific wave form which may be recorded and the latency of each wave peak can be accurately measured.

All in all, there are seven different wave peaks that are available to use as measurement points, some more stable than others, each reflecting different areas of neural activity in the auditory pathways through the brainstem.

The individual peaks reflect changes in the auditory pathway that occur within the first 10 msec after the onset of the auditory stimulus. Each of the seven different waves has its own Roman numeral designator and anatomical location. Wave I is thought to be generated by the cochlea and auditory nerve, Wave II by the cochlear nuclei, Wave III by the superior olivary complex,

Wave IV by the nuclei of the lateral lemniscus, Wave V by the area around inferior colliculi, and Wave VI and Wave VII by the medial geniculate and auditory cortex areas. In brainstem evoked response audiometry, Wave V has been found to be the most diagnostically useful waveform. Accurate estimates of thresholds have been made from the curves described by the latency values of the Wave V's of BER's elicited by click stimuli. These thresholds refer to intensity only and lack the frequency specificity required for audiological assessment. Speculation exists that other stimuli, especially more frequency-specific stimuli, might provide additional frequency-specific information. Research continues in studies using BER technique.

While a number of different types of frequency-specific stimuli have been tested, the tone pip stimulus appears to be the most clinically useful frequency-specific stimulus to date. It can be shaped to a specific time and contain little or no plateau. The onset of the pip can be nearly instantaneous as is the click. The stimulus duration of the tone pip can be held to within the time constraints of the BER. The effect of frequency-specific tone pip stimuli on the Wave V component has not been studied to the extent that the click stimulus has. Only three studies to date have specifically investigated intensity, latency functions from selected tone pip stimuli. All three have demonstrated that a definite latency-intensity frequency function exists for BER elicited by frequency-specific tone pips.

The data in our study clearly illustrate such a latency-intensity function. The latency values of Wave V increased systematically as intensity decreased. For example, in a BER trace elicited by a 1000 Hz tone pip, the latency of Wave V at a 70 dB intensity level is shorter than the latency at any of the lower intensity levels.

Comparison across different frequencies illustrates a definite relationship among frequency-specific tone pips at the same intensity level.

The results also show that the latency of Wave V as elicited by a 4000 Hz tone pip is shorter than the latency of the Wave V component for either the 2000 Hz, 1000 Hz or 500 Hz tone pips. This type of a relationship was found in all the studies done with tone pip stimuli. Some differences in actual times did exist between studies, but I will refer to this more specifically later in the discussion.

Past tone pip studies clearly indicate that Wave V latency values elicited by tone pips consistently describe a curve in a manner similar to clicks. However, much research needs to be done in order to determine the optimum acoustic envelope for selected tone pip stimuli used in BER. In that all current research and diagnostic use of BER depends upon specific waveform parameters, it appears that additional study is needed to develop a clinical procedure which would result in a stable replicable BER technique for selected tone pip stimuli. Thus the purposes of our study were 1) to obtain Wave V latency curves for selected tone pip frequencies; 2) to compare the frequency-specific curves with previously obtained tone pip curves from other studies; and 3) to determine, if possible, the clinical utility of the selected procedure.

METHOD

Subjects

Ten normal hearing adults, five females and five males, ranging in age from 22 through 47 years of age (mean age 31 years) volunteered to be subjects. Each S had hearing thresholds better than 10 dB re: ANSI 1969 for the frequencies tested.

Stimulus Parameters

The decision was made to test 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. All of these frequencies had been tested in one or more of the previous studies but no two studies had all these frequencies in common. In addition, these frequencies have clinical diagnostic value because of their importance in the reception and perception of speech and language.

The stimulus envelope which we used was diamond shaped with a 5 msec rise/fall time. Four intensity levels were considered sufficient to permit observation of a latency shift. Levels of 70 dB, 50 dB, 30 dB and 10 dB were selected. A presentation rate of 33.3/sec was used. This meant that each subject heard 33 tone pips each second. A large number of samples is required to elicit the BER and by presenting at a rate of 33.3/sec, the latency of Wave V was not appreciably affected but it did decrease the time required for testing as compared to a presentation rate of 10/sec, which was used in one of the studies previously referred to.

Procedure

Three silver-silver chloride electrodes were attached to the scalp with the active electrodes placed on the vertex (Cz, 10-20 system) and the reference electrode placed on the mastoid ipsilateral to the ear being stimulated. A ground electrode was attached to the opposite mastoid during all testing procedures. The subjects rested on a cot in a double-walled electrically shielded booth. Shielded earphones were placed over the ears so as not to occlude the external auditory canal.

Each tone pip stimulus was delivered through shielded TDH-39 earphones to the test ear. The EEG signal was amplified by a physiological amplifier (Nicolet AGA-1000) with a gain of 10^4 . The signal was routed through a band-pass filter set between 150-3000 Hz and fed to a clinical averager (Nicolet CA-1000). The time base was 20 msec and 2000 repetitions were used for each BER. Each BER was replicated to judge repeatability.

Responses were plotted using an X-Y plotter (Hewlett-Packard 7010A). Whenever possible, the Wave V component was identified and latency measures were recorded. The traces were labelled for later blind analysis.

Three qualified observers, trained in BER analysis, independently judged all BER traces to determine the presence or absence of the Wave V component. Agreement among all three observers was required for acceptance of the existence of Wave V. The Wave V component is identified by the characteristic sharp negative deflection, the latency of which varied in our study between 6.5 msec and 13.5 msec.

RESULTS AND DISCUSSION

The mean latency values and standard deviations for all four tone pip frequencies at tested intensity levels were derived along with normative click latencies for the same intensity levels. At a 70 dB intensity level the Wave V component was well defined for all frequencies. However the probability of unanimous agreement in the identification of Wave V by the judges decreased as intensity level decreased.

These latency values were the means of the number of subjects who produced BER's with recognizable Wave V components for each frequency and intensity. Wave V latency intensity curves for the specific tone pips presented at four intensity levels were virtually parallel except at the lower intensity levels.

While the frequency-specific latency values compare favourably with the previously mentioned studies, there are differences which may be attributed to variations in methodology, particularly rise/fall time and presentation rates, none of which were consistent across studies. The specific procedure which we used in our study proved practical for the collection of BER data elicited by tone pip stimuli. The traces produced by the normal subjects permitted a better than 85% agreement among the observers in respect to identification of the Wave V component. This particular procedure, however, did not result in clear resolution of Wave V at intensity levels below 30 dB for some of the subjects. Tone pip frequencies with shorter rise/fall times might permit better synchrony of the auditory nerve resulting in a more conclusive Wave V component at the lower intensity levels. But more study is needed to confirm or reject this hypothesis. Evaluating the BER traces collected by the procedure used in our study, we have been able to establish systematic Wave V latency values for each of the four frequencies tested.

These values compare with previous studies and do appear to indicate reasonably accurate values for estimating normal frequency-specific thresholds.

The norms which were established in our study are currently being used in our clinic at Dalhousie University to assess thresholds with clinical patients.

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