NONPATHOLOGICAL CONSIDERATIONS IN THE DETERMINATION OF BRAINSTEM ELECTRIC RESPONSE ACTIVITY

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Abstract

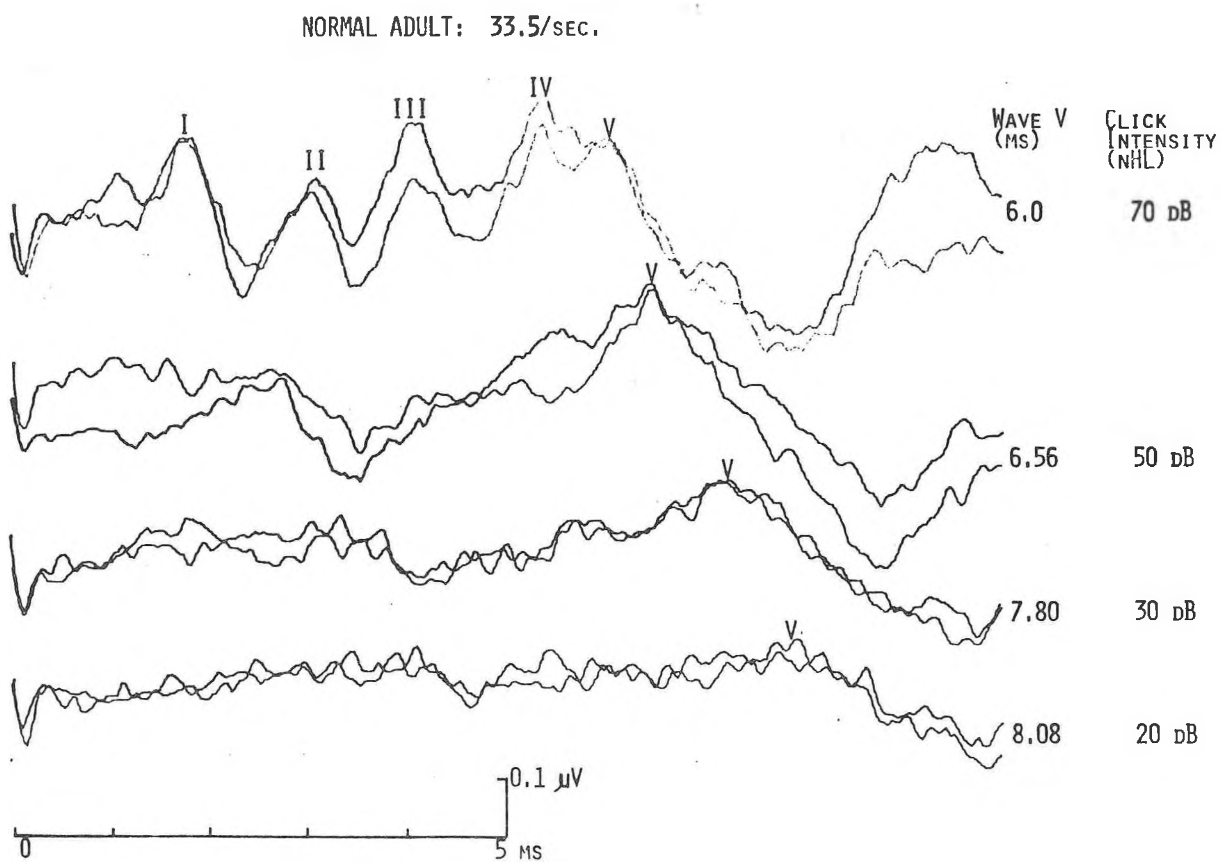
The introduction of brainstem auditory evoked potentials has provided a relatively new technique for monitoring neural activity from the auditory nerve and brainstem nuclei. It is the purpose of this paper to present the effects of stimulus presentation rate and sex on brainstem response activity. Ten normal hearing adult subjects (five male and five female) received click stimuli presented at intensity levels of 70, 50, 30, and 20 normal hearing level (nHL) at presentation rates of 10.5, 33.5, and 80.5 per second. Significant Wave V latency differences were found between male and female subjects as well as between presentation rates. Results suggest the establishment of male, female normative latency data at known presentation rates prior to the accurate assessment of auditory sensitivity or neurological brainstem disorders.

Brainstem auditory evoked potentials are measurements of electrical activity generated from the auditory pathway within the first 10-12 ms post stimulus onset. This technique, which was first reported by Jewett (1969, 1970) and his colleagues (Jewett, Romano, and Williston, 1970; Jewett and Williston, 1971) involves the use of a signal averager and focuses on the extrication of brainstem electrical potentials from random EEG activity. These brainstem potentials consist of seven measurable wave forms (Jewett and Williston, 1971), each separated in latency by approximately one millisecond and each representing successive activity within the auditory nerve and brainstem nuclei (Davis, 1976; Picton and Smith, 1978).

Research and clinical investigation in brainstem electric response (BER) activity to auditory stimuli has centered on two principal areas: 1) those concerned with neurological function and disorders and 2) those involving the auditory assessment of the peripheral hearing mechanisms (Don, et al., 1979).

The criteria used for BER interpretation is based primarily on the latency of individual wave peaks and their interpeak latencies. Due to its consistency and stability, the fifth wave has been considered prominent in the interpretation of auditory threshold sensitivity. Figure 1 illustrates an auditory electric response recorded from a normal hearing adult to a click stimulus. Four intensity levels and their respective Wave V latencies are given. Unfortunately, Wave V latency-intensity function may be affected by numerous extrinsic and intrinsic parameters (Weber and Fujikawa, 1977; Picton, et al., 1977). Two of these parameters include stimulus presentation rate and sex. Consequently, in order to establish normative data that is comparable between subjects and across clinics, and thereby the criteria for abnormality, variables must be systematically eliminated. Therefore, it is the purpose of this study to report the effects of stimulus presentation rate and sex on the BER Wave V latency-intensity function.

Figure 1. Typical brainstem electric responses recorded from a normal hearing subject to monaural click (33.3/sec) stimulus at various intensities. Note Wave V latencies increase as stimulus intensity decreases. Each traces sums 2000 responses with superimposed replicated traces obtained during the same session.



METHOD

SUBJECTS

Ten normal hearing subjects, five males and five females, were used in this experiment. Each subject had hearing threshold sensitivity of 10 dB (re: ANSI, 1969) or better at frequencies 500, 1000, 2000, 4000, and 6000 Hz. Subjects were auditorily tested immediately prior to BER using a modified method of limits.

STIMULUS

The stimuli used to elicit BER's were transient acoustic clicks. The output of each click was generated by passing square wave pulses, 80 microseconds in duration, each attenuated and amplified by a Nic 1007A Noise Masking Module and delivered to TDH 39 earphones with MX/AR 41 cushions. An alternate pulse polarity was used to reduce stimulus artifact during response averaging. The spectrum earphone output was measured in a 6 cm^3 coupler with a condensor microphone (Bruel and Kjaer 4144) housed in an artificial ear (B&K 4152) and connected to a precision sound level meter (B&K 2209). Two major peaks of energy concentration were measured at 2500 and 6300 Hz which reflect neural activity primarily from the basal portion (high frequency region) of the cochlea only.

INTENSITY

Four intensity levels of 70, 50, 30, and 20 dB normal hearing level (nHL) were chosen and randomly presented to each ear of the 10 subjects in the present study. These intensities were sufficient to permit observation of the latency shift of the Wave V component as a function of intensity change. Additionally, three presentation rates of 10.5, 33.5, and 80.5/second were counterbalanced.

TEMPORAL CONSIDERATION

An important consideration in the determination of behavioral thresholds are the temporal intergration characteristics, both stimulus duration and interstimulus latency. In order to equate threshold levels at each presentation rate, behavioral threshold levels were determined using click stimuli identical to that used for BER. To this point, behavioral thresholds were measured using a modified method of limits for each subject at each presentation rate accounting for the change in sound energy due to temporal intergration differences.

PROCEDURES

Two gold Grass clip electrodes were attached to each earlobe (A_1, A_2). One earlobe electrode was used as reference and placed ipsilateral to the stimulated ear; the contralateral clip electrode was used as ground for the remainder of the testing procedure. A silver-chloride cup electrode was attached to the vertex (Cz) as the active electrode for each of the subjects tested. Each subject rested on a reclining chair in a double-walled electrically shielded booth. Electrode resistance was measured and maintained at a level less than 3 K ohms throughout the testing procedure.

The BER's were amplified by a physiological amplifier (Nic HGA-100) with a gain of 10^4, routed through a band pass filter set at 150-3000 Hz and fed to a clinical averager (Nicolet CA-1000). A time base of 10 ms was employed and 2000 stimulus repetitions were used to obtain each BER tracing. All BER's were replicated and plotted on a Hewlett-Packard 7010 X-Y recorder for permanent storage.

RESULTS/DISCUSSION

The means and standard deviations for Wave V latencies at intensity levels of 70, 50, 30, and 20 dB nHL at three presentation rates, 10.5, 33.5, and 80.5 per second may be seen in Table 1. Three observations will be discussed from this Table. First, and consistent with previous BER research, the Wave V latency function systematically increases as stimulus intensity decreases. This consequence is due primarily to a reduction in synchronous neural firing associated with stimulus attenuation and, therefore, an increase latency in synaptic transmission; second, a Wave V latency difference is seen between male and female subjects; finally, a relationship appears to exist between presentation rate and Wave V latencies, that is, as click stimulus rate increases, Wave V latencies also increase.

In order to test each measure, a three-way analysis of variance with repeated observations for Factor B, presentation rate, and Factor C, intensity level, was conducted. Significant Wave V overall mean latency differences were computed between male/female subjects ($F=9.08$; $df=18.1$; $p < 0.01$), intensity levels ($F=308.42$; $df=54.3$; $p < 0.01$), and presentation rates ($F=18.70$; $df=36.2$; $p < 0.01$). Although the analysis of variance produced significant interactions, it could not be concluded that significant differences occurred between latencies for individual presentation rates. Subsequent *t* scores for the three presentation rates were computed. Although temporal integration characteristics were

TABLE 1. The means and standard deviations for BER Wave V latency-intensity function. For males and females at presentation rates of 80.5, 33.5, and 10.5/second. Click stimulus presented monaurally.

WAVE V LATENCY

FEMALE

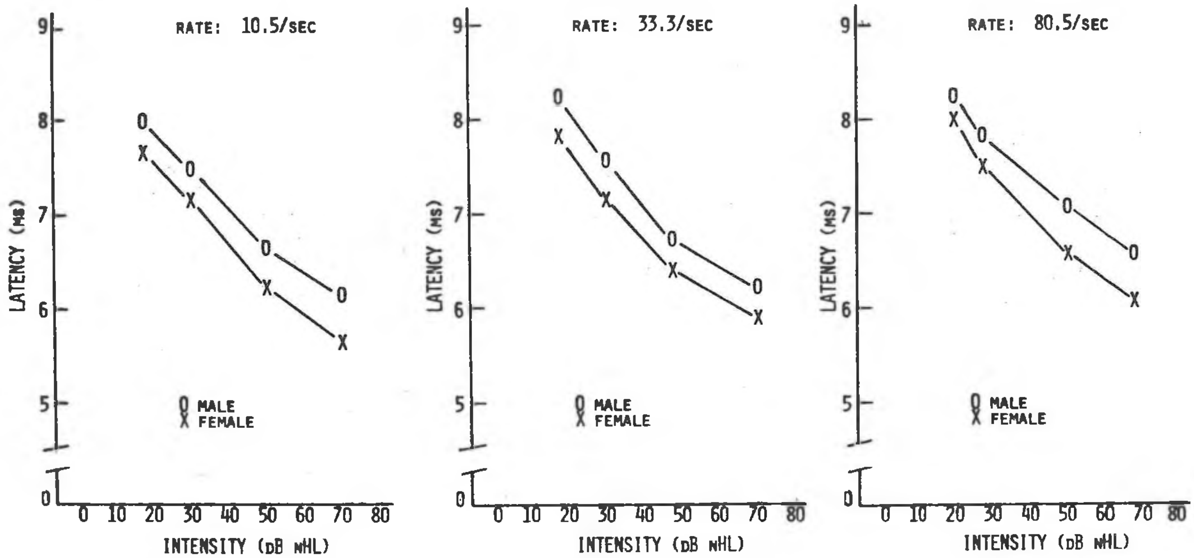
	RATE: 80.5				RATE: 33.5				RATE: 10.5			
INTENSITY	70	50	30	20	70	50	30	20	70	50	30	20
$\bar{X}$	5.95	6.68	7.46	8.0	5.91	6.15	7.12	7.77	5.66	6.20	7.14	7.72
S.D.	.297	.196	.271	.433	.243	.366	.311	.435	.206	.263	.366	.524

WAVE V LATENCY

MALE

	RATE: 80.5				RATE: 33.5				RATE: 10.5			
INTENSITY	70	50	30	20	70	50	30	20	70	50	30	20
$\bar{X}$	6.55	7.10	7.72	8.29	6.20	6.71	7.56	8.29	6.12	6.52	7.44	7.99
S.D.	.414	.346	.229	.326	.262	.283	.374	.492	.550	.401	.449	.377

Figure 2. Mean Wave V latency-intensity function for brainstem electric responses at presentation rates of 10.5/sec., 33.3/sec., and 80.5/sec. for 10 male (0) and 10 female (X) ears.



compensated for in respect to behavioral thresholds, significant Wave V mean latency differences occurred for each of the three presentation rates when compared to each other: 80.5/33.5 ($t=4.35$, $df=19$, $p<0.001$); 80.5/10.5 ($t=4.125$, $df=19$, $p<0.001$); 33.5/10.5 ($t=3.75$, $df=19$, $p<0.01$). These differences in Wave V latency are most likely due to rapid repetition rate changes that occurred within the temporal integration period. While Wave V maintains its stability and measurability, increased presentation rates decrease BER resolution and may render BER uninterpretable, particularly Waves I through Wave IV.

A graphic illustration comparing the significant Wave V latency differences between male and female subjects at each of the three presentation rates may be seen in Figure 2. One factor responsible for the latency variance between males and females may be attributed to the anatomical differences associated with the distance between common synaptic junctions of the afferent auditory pathway (Stockard, et al., 1978). In particular, the area between the innervation of the acoustic nerve in the cochlea and the inferior colliculi in the midbrain. Evidence has shown consistently shorter interpeak latencies in females between these two descriptive anatomical references, attributing in part, to latency differences described in this study.

In conclusion, the results of our presentation should accurately reflect the importances of eliminating potential variability in the measurement of BER's. Sex, intensity, and presentation rate all play a significant role in the interpretation of Wave V latency values. Consequently, before establishing the limits of normalcy and thereby subsequent pathological diagnosis, non-pathological variables such as those mentioned in the present study must be well defined.

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