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BRAINSTEM RESPONSE AUDIOMETRY AS SUBJECTIVE AND OBJECTIVE TEST FOR NEUROLOGICAL DIAGNOSIS*

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ABSTRACT

Brainstem response audiometry as subjective and objective test for neurological diagnosis. J. J. Barajas (Tenerife, Spain).

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This investigation is a preliminary report in which the auditory brainstem response (ABR) cross-correlation evaluation method is applied to a group of patients with a definite diagnosis of multiple sclerosis. The analysis of the results shows that the cross-correlation procedure is able to detect the ABR abnormalities with at least the same degree of accuracy as the abnormality identification made by visual inspection. Furthermore, discriminant analysis of the cross-correlations results shows that by using the Z-maximum correlation from only two derivations it is possible to separate the multiple sclerosis group from the normal group with only two failures. Since the cross-correlation procedure allows the evaluation of the ABR waveform, avoiding the unsatisfactory limitations of subjective identification, this contribution supports the idea that the cross-correlation procedure can be a clinically promising method for objective evaluation of the ABR.

INTRODUCTION

Correct identification of the various waves of the auditory brainstem response (ABR) is obviously crucial for using this potential as a diagnostic tool. In this sense, the vast majority of the works dealing with ABR, a subjective identification, are based upon certain empirical attributes of the waves. Although the merit of the evoked potential (EP) pattern recognized by the expert cannot be replaced, the great need for an objective methods of analysis, with which to identify and assess EP abnormalities, cannot be denied. In this context, the cross-correlation analysis, first suggested by Rosenhamer (1977), was described by Elberling (1979) as an objective method of ABR evaluation procedure.

Parving et al. (1981), studied a group of patients with multiple sclerosis (MS) with the cross-correlation method and emphasized the importance of evaluating the ABR recordings objectively in neurological diagnosis.

The present study is a preliminary report in which the ABR, obtained from a group of patients suffering from MS, were evaluated according to the conventional subjective method of empirical identification and also by the cross-correlation method described by Elberling (1979), in an attempt to compare the two ABR evaluation procedures.

MATERIAL AND METHODS

The control group consisted of 30 healthy volunteers (20 females and 10 males), with a median age of 28 (range 18–53) years. None had a history of neurological problems or hearing difficulties. The patient group included 30 cases diagnosed according to the critera of McAlpine et al. (1972), as 'definite' MS. There were 8 males and 22 females, median age of 37 (range 26–52) years. The median duration of the disease was 11 years (range 3–20 years). All these subjects were tested by pure-tone audiometry and their hearing was found to be within the normal range (air conduction threshold equal to or better than 15 dB HL at the frequencies 250–8 000 Hz). All had the same threshold (±5 dB nHL) to the click stimulus.

Alternating phase monoaural clicks were used to elicit the ABR in this study. The clicks were generated by passing square wave pulses, 0.2 ms duration, through an earphone DT 48 above the hearing threshold for the click stimulus for each subject (70 dB SL). Masking white noise was presented to the other ear at 60 dB SL. Recordings were made simultaneously between the vertex and mastoid, ipsilateral and contralateral to the ear stimulated. The ground electrode was placed on the forearm. Electrode impedance was maintained below 5 kΩ. The responses were amplified to a gain of 10^5. Input (analog) filter bandwidth (3 dB down) was from 220 Hz (12 dB/octave) to 3 200 Hz (12 dB/octave). The average responses to 2 048 click stimuli were recorded with an *x-y* plotter. Testing was done in a quiet but not sound-shielded room. During each recording, the subject reclined in the supine

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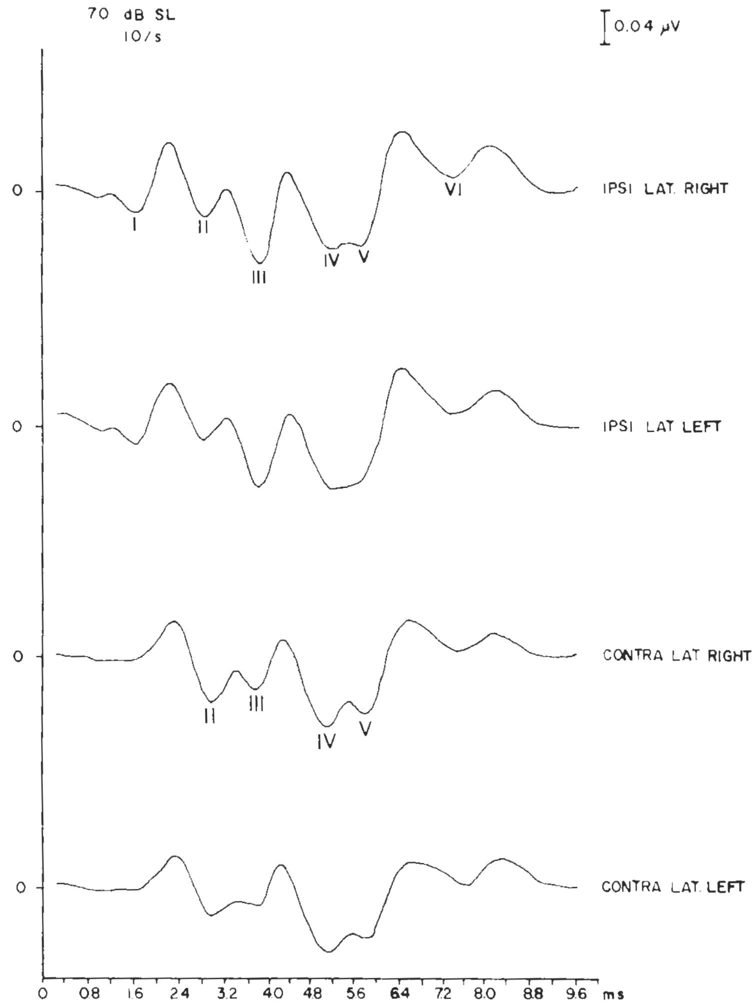

Fig. 1. Templates obtained from each derivation (mean of the recordings from 30 normal subjects) in response to an alternating 0.2 ms duration click at a repetition rate of 10/s.

position to minimize postural muscle activity in neck and head. All the subjects were asked to keep as still as possible and many of them fell asleep during the procedure which lasted about 60 min.

Subjective method of ABR evalution

The identification of the different waves was done in a subjective way, taking into account the different empirical attributes of each wave. All the waves were measured in ipsilateral and contralateral recording, with the exception of wave I which was consistently recordable only ipsilaterally. The latencies were measured from stimulus onset (electrical) to the positive peaks (absolute latency), and the interwave latencies between I–III, III–V, and I–V were also obtained (by cursor). The absolute amplitude was measured from the positive peak to the subsequent negative peak. Since all the subjects from our control group consistently produced a wave I ipsilaterally smaller than wave V, the amplitude ratio between I/V and III/V was used, as suggested by Starr & Achor (1975), as abnormality criteria. The descision to score a particular wave as 'absent' was based upon the failure to find a reproducible wave within the normal latency range and the absence of a second wave in neighbouring latency range. Absence of a wave was taken as an amplitude abnormality. The upper limit of normal for each determination was taken as the normal mean ±3 standard deviation derived from the normal subjects (Barajas, 1982).

Objective method of ABR evaluation

An ABR template that represents the average in a 9 ms time window from 0.2 to 9.2 ms is produced for each derivation from the normal 30 recordings (Fig. 1). The individual normal subject's responses were compared with the normative ABR template by shifting in the time domain the individual normal responses and making the comparison using the cross-correlation function computed via the Fourier transform. The maximum of the cross-correlation coefficient was automatically computed, and also its relative latency. The relative latency is measured

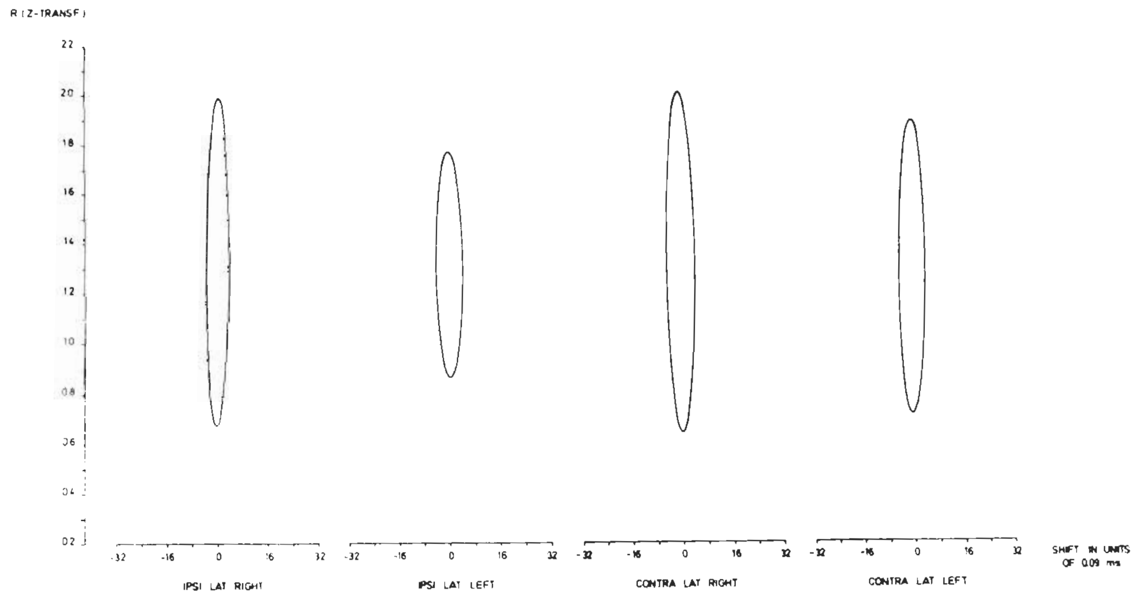

Fig. 2. Normative ellipses obtained from the *Z*-transform of maximum correlation and the latency shift in unit of 0.09 ms.

in units of 0.09 ms. Since the values of the maximum correlation are not normally distributed, the Fischer's *Z*-transform was performed. The Fischer transformation coefficient and the relative latency are correlated and the 95% tolerance ellipse is produced for each derivation (Fig. 2). The individual responses from the selective normal-hearing group of MS patients were compared with the template in the same way and the cross-correlation function and the relative latency obtained.

An example of the ABR recordings, templates, and the corresponding cross-correlation function with indication of the maximum correlation (*R*) the *Z*-transform maximum correlation and relative latency shifts in units of 0.09 ms are shown in Fig. 3. This figure also shows the distribution of the *Z*-transform maximum correlation and the relative latency values in relation to 95% boundary ellipses.

RESULTS

Table I establishes the comparison between both ABR evaluation procedures. The cross-correlation method was able to identify all the abnormal cases detected by visual inspection of the tracing. However, from the four cases with normal ABR by subjective judgement, one case was on the borderline of the 95% tolerance ellipse and one was out of the normative ellipse. Fig. 4 shows the results obtained by discriminant analysis using the Fischer *Z*-transform obtained from the ipsilateral left and contralateral right of the recordings. We were able to separate the two groups with only two failures. One normal was identified as an MS patient and one MS patient was identified as normal.

Table I. *Comparison of ABR results between the subjective and cross-correlation method (N=30)*

	Normal	Abnormal
Subjective method	4	26
Cross-correlation method	3	27

DISCUSSION

This preliminary study shows that the cross-correlation method is able to detect the ABR abnormalities at least with the same degree of accuracy as the abnormalities identified by visual inspection. A reasonable explanation that can be invoked to explain this good correlation is the fact that this work is consistent with the bimodal distribution of the ABR abnormalities in definite MS patients reported by Robinson & Rudge (1977), and Chiappa et al. (1980), in the sense that the ABR were either completely normal or markedly abnormal, making it easier to distinguish between normal and pathologi-

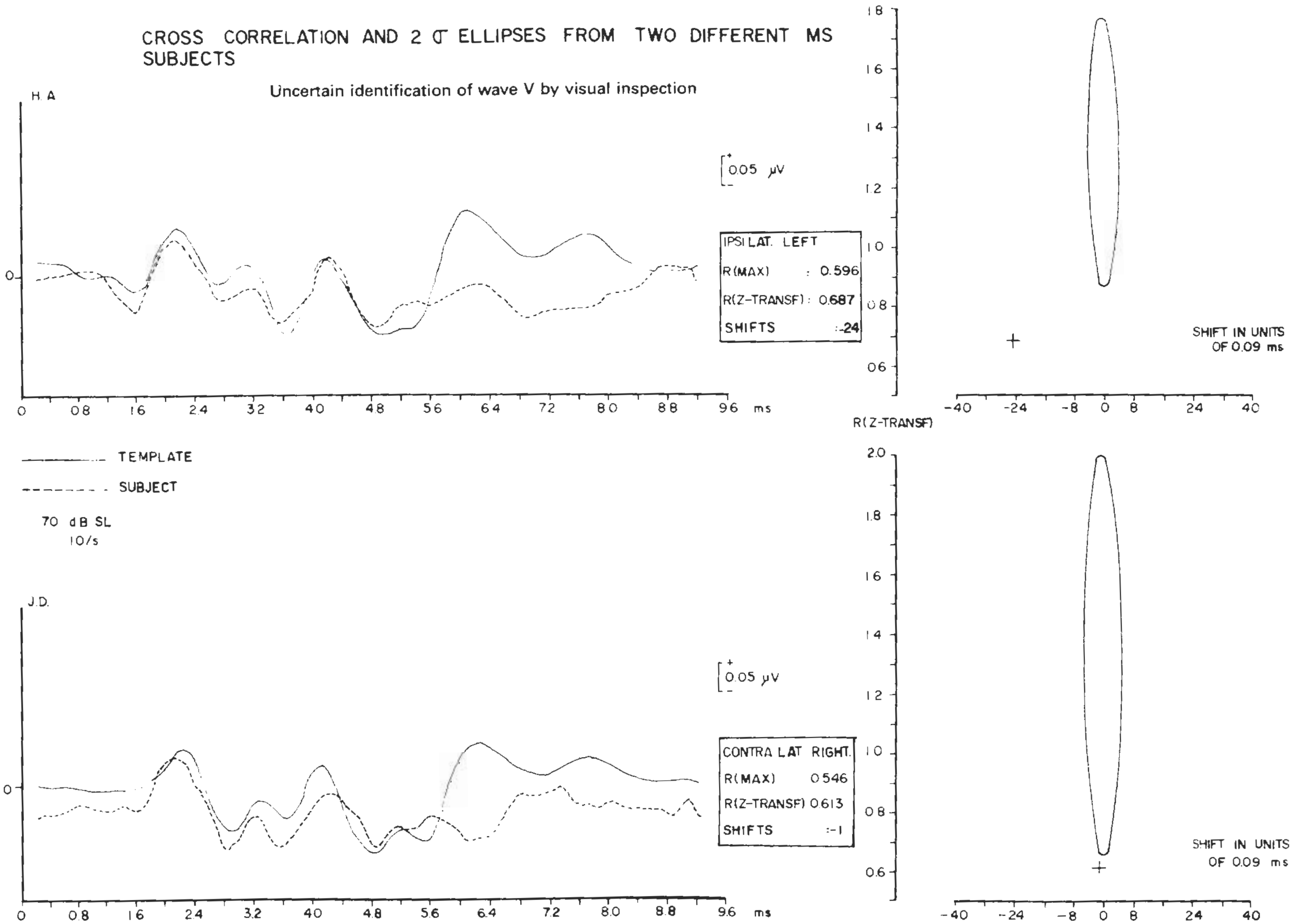

Fig. 3. Example of an ipsilateral and contralateral recordings and templates from two different patients. At the right the *Z*-transform of maximum correlation and the latency shifts in units of 0.09 ms.

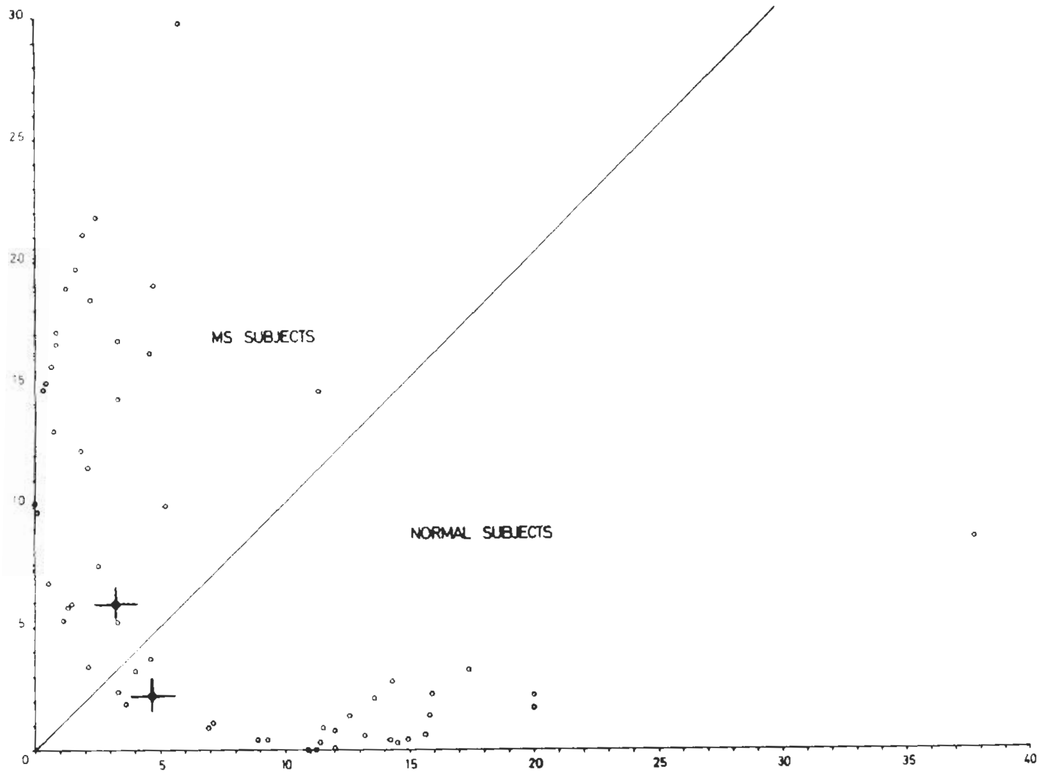

Fig. 4. Discriminant analysis using the *Z*-transform of maximum correlation obtained from the ipsilateral left and contralateral right of the recordings. One normal was identified as an MS patient and one MS patient was identified as normal. The 2 subjects falsely identified by the discriminant analysis are indicated by +.

cal tracing, even by simple inspection of the recordings.

The results obtained from the application of the discriminant analysis are particularly interesting. However, this discriminant function needs to be interpreted with caution since it was obtained from the same group of subjects that were afterwards classified by the function. Further studies are necessary in order to classify more subjects with the discriminant function already obtained.

Although no clinicopathological correlation derived from the ipsilateral and contralateral recordings can be made from this study, the additional use of the contralateral derivation improved the sensitivity and reliability of the test. These results are in agreement with previous works (Prasher & Gibson, 1980; Barajas, 1982).

Since the method used to identify the different ABR waves should not be self-verifying, in the sense, for example, that wave V ought not to be identified solely on the basis of its being the fifth vertex positive component following the stimulus —which it often is not—we are in agreement that the cross-correlation method proposed by Elberling (1979), can be promising as an ABR evaluation procedure.

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