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The Significance of Luminance on Visual Evoked Potentials in Diagnosis of MS

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Summary. In view of the fact that with psychophysical methods monocular luminance changes may increase the detection rate of pathological interocular-latency differences in MS patients, we studied the influence of stimulus luminance on the detection rate of MS using checkerboard visual evoked potentials. Decrements of stimulus luminance covering a range of three log units were unable to increase the detection rate of VEP. Regression coefficients of the luminance-latency functions did not differ in MS patients and normals. Contrary to the hypothesis tested, the diagnostic significance of VEP decreases with decreasing stimulus intensity.

Key words: Visual evoked potentials – Stimulus luminance – Multiple sclerosis

Zusammenfassung. Nachdem psychophysische Experimente nahelegen, daß schon nach geringen Leuchtdichteänderungen die interokulären Latenzdifferenzen bei MS-Patienten beträchtlich zunehmen, untersuchten wir den Einfluß von Leuchtdichteänderungen auf die diagnostische Trefferrate der VEP bei der Multiplen Sklerose. Über einen Bereich von drei logarithmischen Einheiten brachten Leuchtdichteänderungen keine Zunahme der diagnostischen Ausbeute. Auch die Regressionskoeffizienten der Funktion VEP-Latenz gegen Leuchtdichte unterschieden sich bei MS-Kranken nicht von denen bei Gesunden. Da bei abnehmender Leuchtdichte die Trefferquote der VEP sogar deutlich abnimmt, muß diese Variable in der Klinik beachtet werden.

Introduction

Latencies of cortical potentials visually evoked by pattern reversals show considerable delay in many patients suffering from multiple sclerosis (MS). Since its first clinical application by Halliday et al. (1972) this method has become a routine

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examination in the diagnosis of demyelination of the optic nerve with and without clinical symptoms. Modifications of stimulus parameters have been introduced in order to increase the detection rate of MS by this method. Among them, luminance has been reported to be critical. Cant et al. (1978) recorded VEPs at five luminance levels from patients with multiple sclerosis and from normals. They found an abnormal slope of the increase in latency of P 100 per unit log decrease in luminance in approximately one third of their patients, as compared to normals. Wist et al. (1978) measured interocular latency differences in MS patients psychophysically using the Pulfrich phenomenon. In some patients, a filter with an attenuation of luminance of no more than 0.2 log units was able to produce a significant shift in the perceived depth of the moving pattern, a condition, which was never effective in normals. The effect was attributed to a stronger dependence of the retino-cortical latency on luminance in MS patients.

The purpose of the present study was to determine whether, as suggested by these reports, an increase in the detection rate of MS could be achieved by a decrease of stimulus luminance in visually evoked potentials (VEP).

Method

Twenty-three patients with multiple sclerosis (aged 21–57) were tested. According to the criteria of McAlpine et al. (1972), 18 were classified as having definite MS, 3 probable and 2 possible MS. Controls were provided by 20 volunteers. In all subjects, refraction errors were corrected by spectacles.

A checkerboard pattern (15° × 12°) consisting of 1° × 1° squares was generated on a television screen by use of a selfconstructed generator. The temporal stimulus frequency was 0.8 Hz for transient and 8.3 Hz for steady-state stimulation. Subjects fixated on a small red light below the upper margin of the television screen. Without filters the luminance of the bright squares was 72 cd/m^2 and the luminance of the dark squares 0.5 cd/m^2 (mean luminance: 36.25 cd/m^2). Neutral density filters with a density of 0.3, 0.6, 1.0, 2.0 and 3.0 log units were placed in front of the stimulated eye in order to reduce the luminance of the pattern. The temporal frequency of presentation, the stimulated eye and the filters were changed in random order between single trials. Electrodes were attached occipitally in the midline (O_z) and at the left ear lobe. Averages of 64 responses were obtained using a DISA 14601 digital averager and displayed on an X-Y plotter. Latencies of P 100 and the amplitude were measured by hand ($A = (N70 - P100) + (N200 - P100)/2$).

Results

The lower half of Fig. 1 shows the linear increase of the function relating log latency (P 100) to the logarithm of decreasing luminance (increasing filter density) in normal subjects (open circles and squares) and MS patients (dark symbols). The latencies obtained with steady-state stimulation were generally longer than those of transient stimulation. Interindividual standard deviations increased with decreasing stimulus intensity. It may be seen that the functions representing normals and patients converge at lower luminance levels. Using the criterion of the mean latency of normal subjects plus two standard deviations as the upper limit of normality, 24 out of the 46 eyes under investigation showed increased latencies at filter 0 (36.2 cd/m^2) when transiently stimulated, 26 eyes gave abnormal results

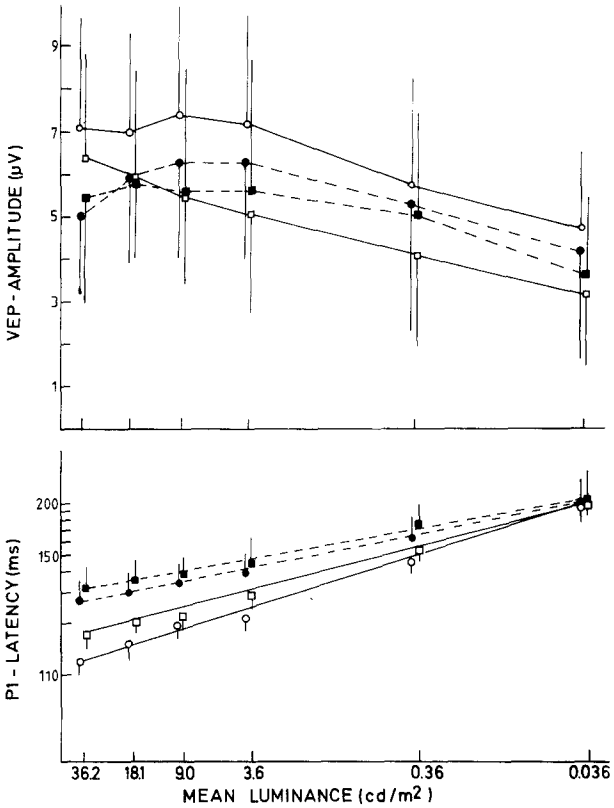

Fig. 1. Means and standard deviations of the P 100 latency *(lower part)* in relation to the mean luminance of the stimulus pattern. White symbols from 20 normal subjects, dark symbols from 23 MS patients. The circles indicate results obtained with transient stimulation, the squares those with steady-state stimulation. The lines are regression functions, calculated by the method of least mean square deviations. The upper part of the figure shows the means and standard deviations of VEP amplitudes

with steady-state stimulation. The difference between normals and MS patients decreased continously with decreasing luminance of the stimulus. At a luminance of 0.036 cd/m^2 only 1 of the 46 eyes within the MS group showed an abnormal latency at transient stimulation (9 of the 46 eyes with steady-state stimulation).

Considering the amplitudes of the VEP in normals (upper half of Fig. 1) a decrease in luminance causes a linear decrease in VEP-amplitude with steady-state stimulation (open squares). With transient stimulation VEP-amplitudes are saturated above luminances of 3.6 cd/m^2 (minus one log unit). The initial difference between the VEP-amplitudes of normals and MS patients decreased with decreasing stimulus luminance. Statistical analysis showed a significant difference in amplitude between normal subjects and MS patients only for transient stimulation at the highest luminance ($P < 0.01$). For reduced luminances and steady-state stimulation no significant differences were found.

Following the procedure of Cant et al. (1978), we also fitted linear regression lines to the luminance related latency values between 36.2 and 3.6 cd/m^2 obtained

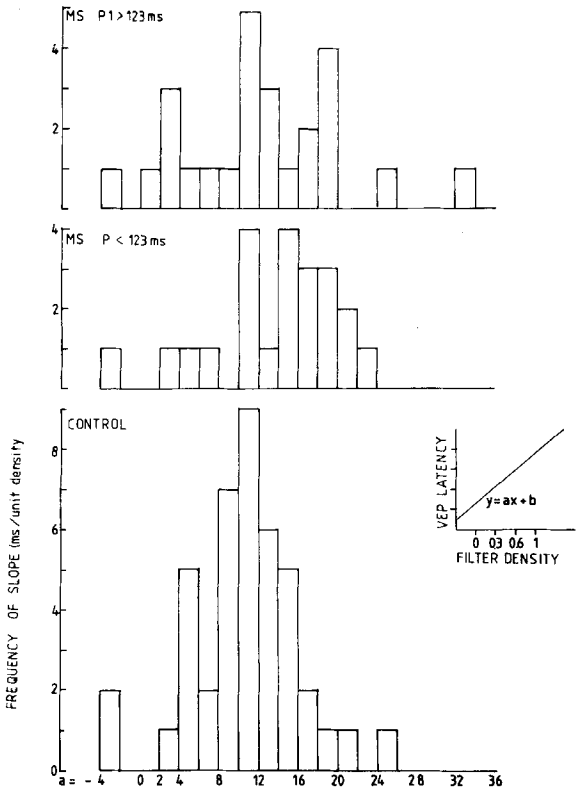

Fig. 2. Frequency distribution of slope coefficients for the latency-luminance functions (a) between 36.25 and 3.6 cd/m^2. Coefficients for the eyes of MS patients with a pathological latency are displayed in the uppermost section, those of their eyes with normal latency in the middle, the distribution for the normals on the bottom

for each eye of normals, MS patients with a normal latency (< 123 ms) and MS patients with more than 123 ms latency. Figure 2 shows the frequency distribution of slope coefficients. Statistical analysis (χ^2-test) showed no significant difference in the distribution of slope coefficients for the three groups tested. We were also unable to find an increasing number of pathological interocular latency differences in MS patients with decreasing luminance.

Comments

Our results are in disagreement with those of Cant et al. (1978). We did not observe an increase in the ability to distinguish between MS patients and normals by reducing the luminance of the stimulus pattern. The slope coefficients of the latency-luminance functions between 36 cd/m^2 and 3.6 cd/m^2 were identical in both groups. Using the absolute latency for a criterion, the diagnostic value of the VEP also decreased with decreasing pattern luminance, mainly due to an increase of the standard deviation in both groups. The difference in luminance at the

Table 1

References	Mean luminance (cd/m^2)	Mean detection rate of MS (%)
Asselman et al. (1975)	1,025	67
Diener and Scheibler (1980)	36.25	65
Halliday et al. (1973)	59.3	71
Hennerici et al. (1977)	25.85	61
Hennerice and Wist (1981)	25.75	60
Kjaer (1980)	108.5	62
Kjaer (1981)	193	85
Lowitzsch et al. (1976)	30.25	73
Matthews et al. (1977)	147	62
Oepen et al. (1981)	25.82	55.2
Tackmann et al. (1980)	50	70
Trojaborg and Petersen (1979)	1,580	74

$r = 0.5934$ ($P < 0.05$)

maximal value tested (55 cd/m^2 in the study of Cant et al., 36.2 cd/m^2 in our study) may not account for this difference. Hennerici and Wist (1981) confirm our results using checkerboard stimulation. Varying luminance over a range of 1 log unit, they were also unable to increase the detection rate for MS patients. When they used a foveal stimulus, a significant increase in VEP-latencies could be observed in MS patients, whose VEP-latencies were marginal without luminance attenuation. We omitted this stimulus, since in our hands it was often impossible to obtain an unequivocal VEP with foveal stimulation and reduced luminance. Hennerici and Wist (1981) use the foveal stimulus just for this reason, for they never had problems obtaining foveal VEPs in normals.

In summary, we conclude that an attenuation of stimulus luminance with checkerboard stimulation is not able to increase the detection rate of pathology with VEP in MS patients. On the contrary a decrease in luminance may decrease the diagnostic significance of this method. Since the standard deviation of the latency of P 100 increases with decreasing stimulus luminance, VEPs should be elicited by very bright stimuli. To test this hypothesis we compared the mean luminance of the stimulus pattern used and the percentage of multiple sclerosis patients showing abnormal pattern reversal responses in the literature (Table 1). The Spearman-rank correlation coefficient between the mean luminance of the checkerboard pattern and the detection rate in MS patients was significant ($r = +0.5934$, $P < 0.05$).

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