THE USE OF A PINHOLE APERTURE DURING THE RECORDING OF PATTERN REVERSAL VISUAL EVOKED POTENTIALS

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SUMMARY

In young children, mentally retarded persons or in malingering persons, determining the optimal refraction is not always evident.
Because of the importance of this optimal refraction during the recording of pattern-reversal visual evoked potentials, we tried in this study to overcome these refraction errors by the use of a pinhole.

RÉSUMÉ

La réfraction optimale n'est pas toujours évidente chez les jeunes, chez des personnes avec un retard mental ou chez les simulateurs.
Pour obtenir des résultats optimaux avec un potentiel évoqué visuel, il est nécessaire de faire cet examen avec la réfraction correcte.
Dans cette étude nous avons essayé de contourner ces erreurs réfractives en employant un trou sténopéique.

KEY-WORDS

Pattern reversal visual evoked potentials, pinhole

MOTS-CLÉS

Potentiels évoqués visuels, trou sténopéique

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INTRODUCTION

Purpose : It is customary to use a pinhole aperture in the ophthalmic clinic in order to bypass a refractive error and to assess potential visual acuity. In this study, we evaluated the effect of a pinhole aperture for recording pattern-reversal visual evoked potentials (VEP) responses in subjects with an uncorrected refractive error.
In young children, mentally retarded patients or in malingering persons, the determination of refraction is not always evident. Because of the importance of an optimal refraction during a pattern visual evoked potential, we tried in this study to overcome these refraction errors by the use of a pinhole and studied the influence of the pinhole on the response of the pattern-reversal visual evoked potential.

METHODS

Subjects

All subjects tested were healthy volunteers of the department of Ophthalmology. We tested 15 subjects, 3 males and 12 females, ranging in age from 25 to 52 years. They all had best corrected visual acuity of at least 0.8. Thirteen subjects were myopic in a range of - 8 dioptres to -0.25 dioptres. Two subjects were emmetropic. No other ocular problems were present in any of the tested subjects.

Stimulus for pattern visual evoked potential (VEP) recording

A. The stimulus used was a high contrast (98%) black and white checkerboard generated on an ATRIS screen. The check size was 0.25 ° or 1° at a viewing distance of 114 cm. The stimulus field size was 15.5° by 11.5°. The mean luminance of the pattern stimulus was 90 cd/m^2 . The reversal frequency of the checkerboard was 2 reversals per second (transient recordings). The recordings were performed monocularly. This stimulus is used in the clinic as part of the standard pattern reversal stimulus [3].
B. The effect of the pinhole aperture was tested in different recordings presented in random among subjects. A standard single pinhole aperture (diameter: 1.5 mm) in an opaque material and a single pinhole aperture in frosted glass were used with and without the optimal correction (4 conditions).

VEP recordings

Recordings were made using the UTAS-2000 system (LKC-Technologies).
Electrodes used were Ag-AgCl cup electrodes with the single active electrode placed at 0_z (10% of the distance inion-nasion above the inion). The reference electrode was placed at the left ear and the ground electrode in the middle of the scalp (C_z).
Each recording was an average of approximately 100 reversals.
For each response the amplitude and latency of the major P100-component was measured. As figure 1 shows, the latency is measured from the onset of reversal to the first major positive peak. The amplitude is the difference in voltage between the preceding negative peak and the positive peak (P100). For the present recording conditions, the average latency values for the 0.25° and 1° check size are 114 msec and 111 msec resp. The upper limit of normal values (P95) is 120 msec and 119 msec resp. Statistical analysis (latency values) was performed using the ANOVA and t-test (two-tailed, $p<0.05$).

RESULTS

We compared the influence of the different stimulus conditions (with and without optimal correction, with and without pinhole aperture) on the latency and amplitude of P1.

A. The effect of the stenopeic hole during a pattern-reversal VEP in an emmetropic subject.

As figure 1 shows (upper row), a clear response was obtained in the control condition (no correction needed and without the use of any pinhole). For the two different check sizes of 0.25° and 1°, normal latency values of 112 msec and 110 msec resp. were obtained.
When using the stenopeic hole (figure 1, lower row), the most remarkable difference is the increase in P100 latency. For the 0.25° and 1° check size we found 126 msec and 124 msec resp., which means an increase of 14 msec in both conditions.
The amplitudes, in the control condition for the two different check sizes of 0.25° and 1°, were 15.75 μV and 9.59 μV resp.
When using the stenopeic hole we found resp. 14,17 μV and 8.63 μV: 93% and 90% of the original amplitude in the control condition were preserved.
A second emmetropic subject was tested and showed comparable results: increase of latency values with 10 msec for 0.25° and 12 msec for 1°, there was no change in amplitude for the small check size and almost no change for the greater checks (97% of the original amplitude remained) when using the pinhole.

B. VEP recordings in a myopic subject with and without optimal correction and using different types of pinholes.

Figure 2 illustrates the results of a subject with a refractive error of -3 dioptres. This subject was unable to see the stimulus sharply without correction at the testing distance of 114 cm.
The upper row shows the responses when using the optimal correction of -3 D. P1 latency values of 121 msec for the condition with 0.25° and 112 msec for stimulus check size 1° were found; the amplitudes were 20.98 μV and 6.1 μV resp.
When deliberately omitting the correction, an obvious change in the responses is seen especially for the smaller check size (figure 2, sec-

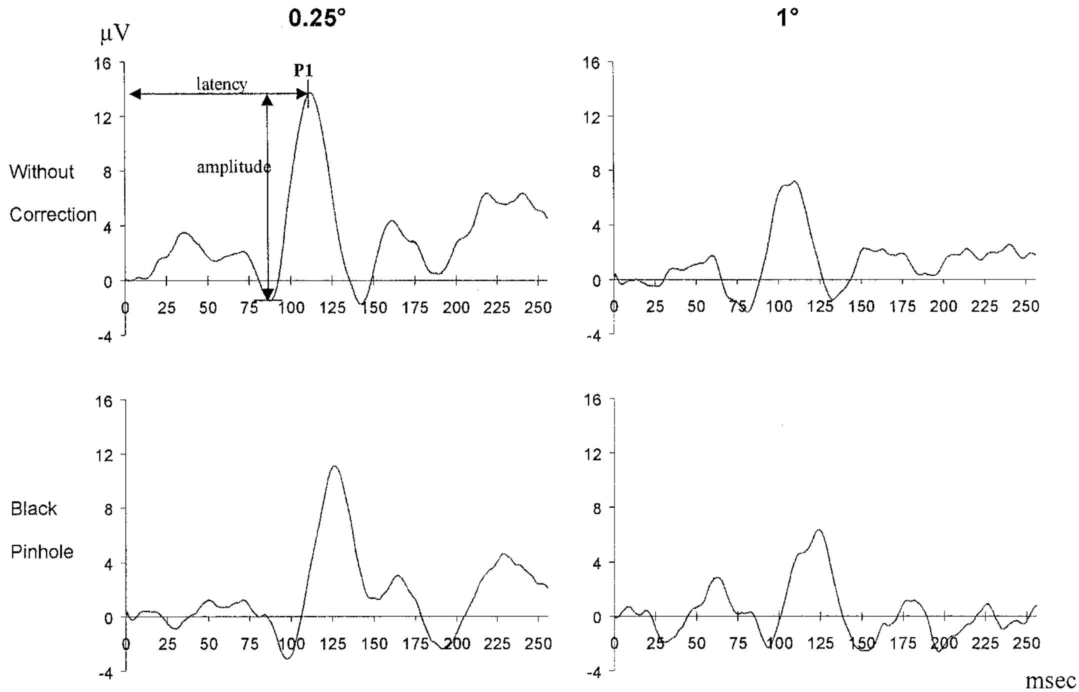

Figure 1: The effect of the stenopeic hole during a pattern-reversal VEP in an emmetropic subject.

ond row). The amplitude of the response at the smaller check size of 0.25° is clearly diminished (7.32 μV; 35% of original amplitude); the latency is increased to 136 msec, which is beyond the limit of normal values. For the larger check size, the latency is unchanged (112 msec) and the amplitude is only slightly diminished (5.54 μV, 91% of the original) but the shape of the waveform is less clear.

In the third and fourth condition we used a black pinhole and a pinhole in frosted glass resp. (figure 2, third and fourth row), still without the myopic correction. The latency values remain increased; 138 msec and 123 msec for the condition using a black pinhole and 136 msec and 118 msec for the pinhole in frosted glass condition.

When the stimulus is viewed through a pinhole aperture especially for the smaller check size, the P-component regains higher amplitude and has a clearer configuration, whether it is a single black pinhole or a pinhole in frosted glass. The amplitude comes back to 75% for the black pinhole and 44% for the pinhole in frosted glass for 0.25° and 100% for the black pinhole and 82% for the pinhole in frosted glass for 1° of the original amplitude when using the optimal correction.

C. VEP recordings in the group of myopic subjects

As stated in the methods section, 13 myopic subjects were tested. One subject showed a myopic error of only -0.25 dioptres and confirmed essentially the results obtained in the emmetropic subjects. The remaining 12 myopic persons showed a refractive error of -1, -1.25, -2,-2, -2.25, -3, -4, -6 and -8 dioptres.

a. Latency values.

Table 1 shows the average values of the latency of these 12 myopic subjects.

When using the small 0.25° check size, the average values of latency are significantly greater when omitting the correction (127 msec without correction versus 114 msec with optimal

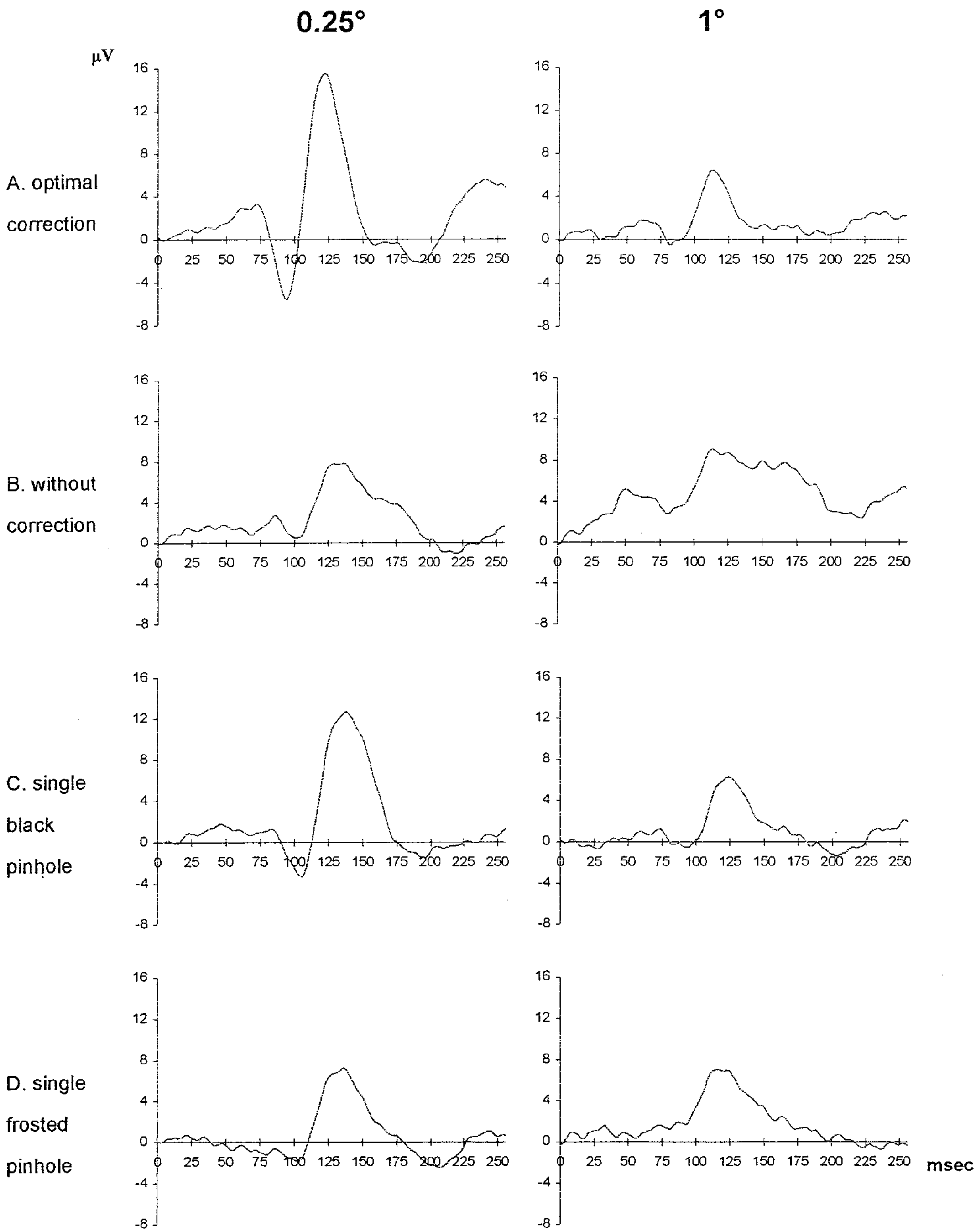

Figure 2: Pattern reversal VEP recordings in a myopic subject with and without optimal correction and the use of the two different types of pinholes.

Table 1: *Average latency (msec). C=correction; WC=without correction; WCBH=without correction and the black stenopeic hole; WCFG=without correction and pinhole in frosted glass.*

Latency (msec)	C	WC	WCBH	WCFG	p-value
0.25°	114	127	130	127	<0.05
1°	111	110	118	115	<0.05

correction, p-value < 0.05) (Table 2). For the greater check size, the average latency is unchanged (p>0.05).

When using a pinhole (whether it is black or in frosted glass), at 1°, the latency is identical to the values obtained without correction.

At 0.25°, the use of a pinhole results in a statistically higher latency compared to the values obtained with and without correction.

b. Amplitude values

Figure 3 illustrates the results of three representative subjects A (-1.25 D), B (-8 D) and C (-3 D), with optimal correction, without correction and with the use of a single black pinhole.

1. Using the optimal correction for the small check size (0.25°), we found in subjects A, B and C resp. 6.15 μV, 9.85 μV and 20.98 μV. Without correction, we found resp. 6.85 μV, 3.02 μV and 7.32 μV and with the single black pinhole we found resp. 7.39 μV, 5.78 μV and 16 μV. Amplitude changes were minor for subject A; in B and C the decrease in amplitude, when omitting the correction, was partially restored when using the pinhole.
2. For the 1° check size we found similar results for subjects B and C. For subject A the amplitude changes are again minor. With optimal correction for the great check size (1°), we found in subjects A, B and C resp. 8.49 μV, 12.17 μV and 6.10 μV.

Without correction we found resp. 8.78 μV, 5.27 μV and 5.54 μV and with the single black pinhole we found resp. 6.76 μV, 6.5 μV and 6.27 μV.

Subjects B and C show the highest amplitude when using the optimal refraction and a partial amplitude recovery when using the pinhole comparing with the results without correction. Subject A on the contrary shows comparable amplitudes for the three conditions.

Table 2: *p-values from T-test for the latency values between the different conditions for 0.25° check size*

0.25°	C	WC	WCBH	WCFG
C	------------	< 0.05	< 0.05	< 0.05
WC		------------	0.149	0.054
WCBH			------------	0.343
WCFG				------------

Table 3: *p-values from T-test for the latency values between the different conditions for 1° check size*

1°	C	WC	WCBH	WCFG
C	------------	0.256	< 0.05	< 0.05
WC		------------	< 0.05	< 0.05
WCBH			------------	< 0.05
WCFG				------------

The pattern of subjects B and C was found in 7/12 subjects (-2.5D,-3D, -2D, -4D, -2D, -6D, -8D) for the small check size and in 5/12 subjects (-2D, -3D, -2D, -4D, -8D)for the greater check size.

The pattern of subject A (-3D, -2D, -2D, -1.25D, -1D) was found in 5/12 subjects for the small check size and in 7/12 subjects (-3D, -2.5D, -2D, -1.25D, -1D, -2D, -6D) for 1° check size. The refraction errors in group A are for 0.25°: -3D, -2D, -2D, -1.25D, -1D and for 1°: -3D, -2.5D, -2D, -1.25D, -1D, -2D, -6D. The refraction errors for group B/C are for 0.25°: -2.5D, -3D, -2D, -4D, -2D, -6D, -8D and for 1°: -2D, -3D, -2D, -4D, -8D.

DISCUSSION

The pinhole aperture test is routinely used in visual screening to determine potential acuity in eyes with uncorrected refractive error for distance.

It improves vision by contracting the image cone and enhancing the eye's depth of focus.

The optimal pinhole size was determined to be between 0.94 mm^2 and 1.75 mm^2.

A larger aperture diminishes the depth-of-field enhancing effect, and a smaller size results in loss of resolution and blur from diffraction.

Clinically, failure to improve visual acuity with the pinhole test is interpreted as evidence of impaired vision due to organic disorders.

The use of the pinhole further causes loss of retinal illuminance [1].

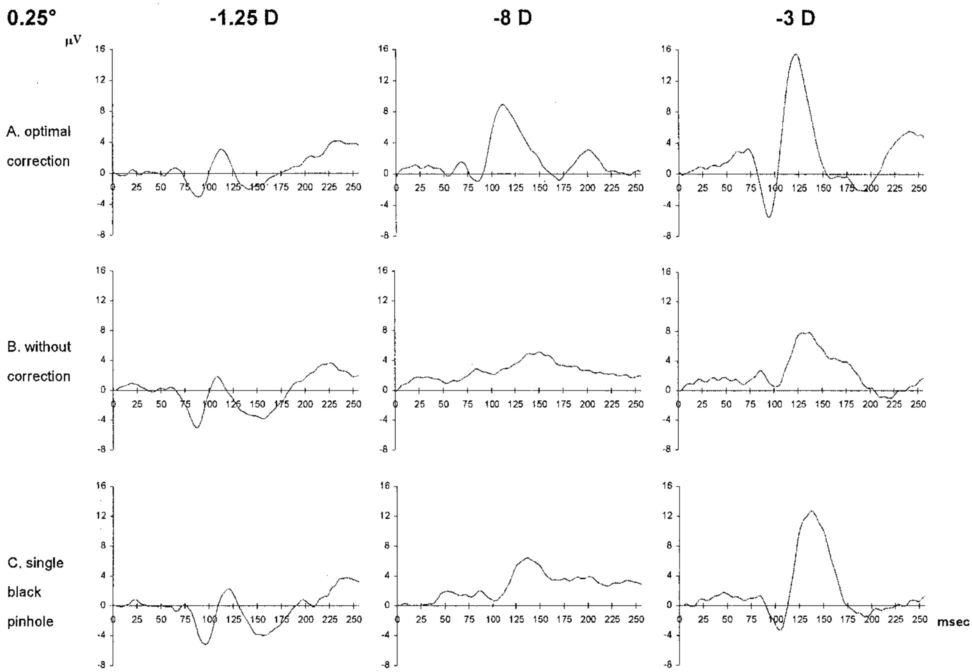

Figure 3: Pattern-reversal VEP recordings of three myopic subjects A, B and C of resp. -1.25 D, -8 D and -3 D, check size=0.25°, with and without optimal correction and the use of the black stenopeic pinhole.

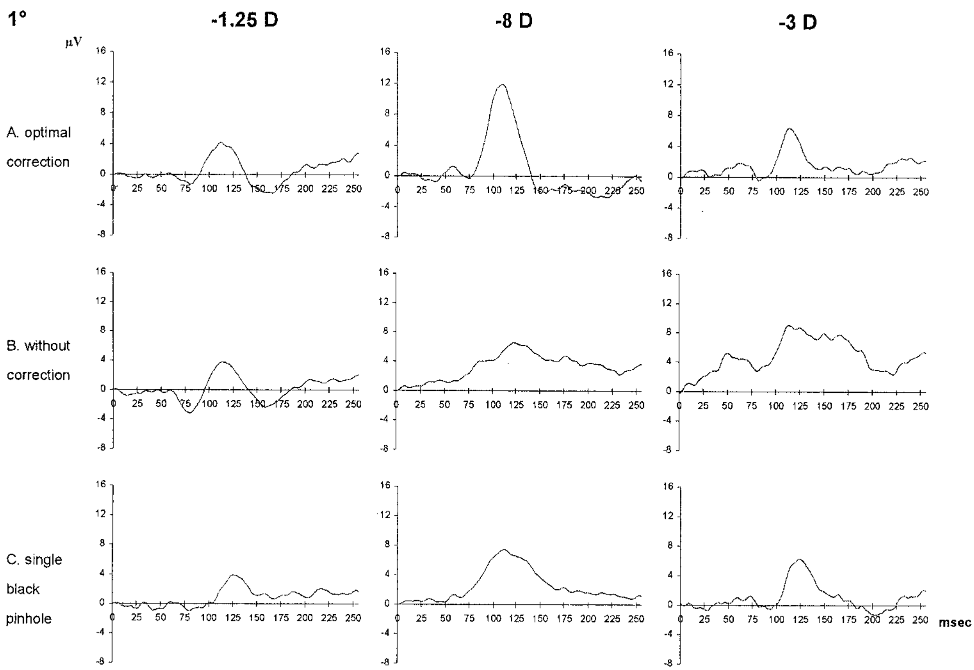

Figure 4: Pattern-reversal VEP recordings of three myopic subjects A, B and C of resp. -1.25 D, -8 D and -3 D, check size = 1°, with and without optimal correction and the use of the black stenopeic pinhole.

Pinhole apertures allow only the most central light rays into the eye, producing retinal images that are dimmer than those of most natural pupils.
The fundamental cause of the increase of latency of the VEP is related to the reduced quantity of light entering the eye.
It has been shown that a logarithmic relationship exists between stimulus brightness and latency [2,4,6].
The latency effect by defocusing the image is in the same direction; i.e. an increase.
One possible explanation for the increase in latency with retinal blur is that blur reduces contrast (more for small than larger checks) which in turns causes an increase in latency [9].
It has also been shown that the amplitude of the pattern-reversal VEP, at least for small pattern elements, is reduced as the retinal image is increasingly defocused. In this study defocusing is obtained when no refraction is used [5,7,8,10].

CONCLUSION

1. This study proves again the importance of a precise refraction when performing a pattern-reversal VEP [10].
2. The effects of a pinhole aperture on the pattern reversal VEP responses are related to attenuation of the photic stimulus [2].

In the presence of a refractive error, a pinhole aperture can improve the recorded VEP (increased amplitude and latency).
In patients for whom the determination of the refraction is not evident (mentally retarded people and young children), the use of a pinhole can therefore give in some subjects a more precise idea of the visual function.

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