Variation in latency times of visually evoked cortical potentials

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SUMMARY Latency times of visually evoked cortical potentials stimulated by reversal of a slow checkerboard pattern are highly dependent on the time needed to accomplish the reversal movement. If, owing to the method, the pattern reversal time is not kept stable, variability of the latency times is unnecessarily high for clinical purposes. This may be the case when television equipment is used.

Halliday *et al.* (1972, 1973) showed that measurement of latency times of the visually evoked cortical potentials (VECPs), elicited by the reversal of a slow checkerboard pattern, is a very sensitive method of detecting disease in the visual pathways, especially in cases of optic neuritis and multiple sclerosis. Later Asselman *et al.* (1975) confirmed these findings. With this method of measuring latency times problems may occur, one of which is caused by the method used. We fell into this trap and by publishing our experience hope to help others avoid it.

Television systems are increasingly used to produce pattern stimuli, since they are more versatile in respect of size of check pattern, modulation depth, and mean luminance than other methods (Arden and Faulkner, 1977). Applying a TV system to determine latency times as Halliday did to diagnose multiple sclerosis, we found that the spreading of the normal range was much greater than his data showed. Consequently, we compared the latency times obtained by our TV system with those obtained by Halliday's methods.

In experiments with the TV system, the pattern had a check size of 20', 40', or 80', a modulation depth of 98%, a mean luminance of 180 asb, and a field size of approximately 26°. Since no differences in the standard errors were found between the 3 check sizes used, only those obtained with the 40' check size are mentioned here.

The apparatus as used by Halliday is a projector with a checkerboard slide and a moving mirror in front of it (Cobb *et al.*, 1967). Its check size was 1°, the modulation depth 80%, the mean luminance 400 or 40 asb, and the field size 28°. In both groups of experiments the reversal frequency was 2 Hz (periodicity 1 Hz), the band width of the amplifiers

was 0.16 to 75 Hz, and 125 counts were averaged with an analysis time of 500 ms. The electrical potentials were led off from surface electroencephalograph electrodes positioned at 5 and 15% above theinion in the midline referential to the earlobe, as well as bipolar from 5 to 25% (10 to 20% EEG-system). Twenty normal subjects were examined.

Results

An example of the recordings obtained with the 2 methods is shown in Fig. 1; amplitude and latency time were measured as indicated. In Table 1 the data of the 2 methods are compared. It appears that the amplitudes of the projector system are somewhat higher and the latency times somewhat longer than those of the TV system. These differences may be due to differences in check size and mean luminance. Much more impressive, however, is the large standard deviation (SD) in latency times obtained with the TV system, which is about twice as high as that of the projector system. Standard deviations of the amplitudes relative to the mean value are approximately the same.

A large standard deviation in latency time was also found when bipolar leads were applied instead of referential leads (Table 2). By decreasing the mean luminance the latency time itself is lengthened and the standard errors are not much influenced. On the amplitudes and their standard errors the mean luminance had not much influence either, both being larger in the referential leads than in the bipolar leads (Table 3).

Discussion

It is evident that the large differences in standard errors between the 2 methods cannot be explained

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Fig. 1 Visually evoked cortical potentials after a slow checkerboard pattern reversal stimulation of 1 Hz, obtained with the TV system (upper curve) and with the projector system (lower curve)

by the relatively small differences in check size and modulation depth, nor by the differences in mean luminance or field size. When check size was varied, it did not seem to influence the standard error, nor did the mean luminance. The field size is relevant only inside a 20° visual field, since visually evoked potentials stimulated by patterns are mediated by the central part of the retina only (Bartl *et al.*, 1978).

The large standard error of readings from the bipolar leads is probably due to a summation effect of the standard errors of the 2 active electrode positions used, a summation of the values found in the referential leads.

As to the TV system, another and very logical explanation can be given. Asselman *et al.* (1975) reported that the latency time was influenced by the speed with which the reversal of the pattern was completed. In the projector system this time depends on the mirror movement in front of the projector, in the TV system on the frame frequency of the TV screen. In Asselman's set-up the mirror movement took 5 ms, in our projector system 6 ms, while it lasts 20 ms before a reversal movement is completed

on the TV screen. Furthermore, in a projector system the whole pattern picture moves at the same time, whereas on the TV screen the pattern reversal is not a real movement but a replacement which starts in the left upper corner and is finished in the right lower corner 20 ms later, provided the starting point of the replacement is synchronised with the frame of the TV screen. Such synchronisation, however, causes interference with 50 Hz signals, which are then averaged too.

For this reason we chose to work with asynchronous signals—i.e., the pattern reversal starts independently from the frame, therefore starts somewhere at random on the screen. How long the measured latency time will be now depends on the time lapse between the starting point of the pattern reversal, which is also the trigger point of the averager, and the moment the reversal movement enters the 'evoked potential visual field' or 'trigger point' of the evoked potentials. By the 'EP visual field' is meant that part of the visual field, from which the pattern evoked potentials are mediated. This time lapse can be 20 ms maximum and 0 ms minimum. The averaged mean will be

Table 1 Latency times and amplitudes, obtained with a referential lead and in the projector method a mean luminance of 400 asb

	Projector	TV
Latency	98.29 ms SE 8.63	94.27 ms SE 16.04
Amplitude	9.11 µV SE 4.08	6.9 µV SE 2.93

Table 2 Latency times obtained with the projector method at 2 different luminances from bipolar and referential leads

	400 asb	40 asb
Bipolar	109.7 ms SE 19.45	116 ms SE 20.76
Referential	98.29 ms SE 8.63	110.93 ms SE 7.61

Table 3 Amplitudes obtained with the projector method at 2 different luminances from bipolar and referential leads

	400 asb	40 asb
Bipolar	6.2 µV SE 2.85	5.62 µV SE 2.65
Referential	9.11 µV SE 4.08	8.10 µV SE 3.89

somewhat less than 10 ms, by which the difference in standard errors between the 2 systems is sufficiently explained.

The jitter in latency time, using a TV system can be improved, as mentioned above, by synchronising pattern reversal and frame, were it not that 50 Hz signals probably via the TV set seriously impaired the evoked potentials. Furthermore, if the fixation is not accurately and constantly in the middle of the screen, variations in latency times may also occur. This implies that TV systems like ours are less suitable for latency measurements than projector systems.

The influence of the mean luminance on the latency time itself needs attention if patients are examined with narrow or wide pupils. The relative difference of retinal illumination, being dependent on the pupil size (πr^2), between a pupil of 2 and 8 mm amounts to more than 1 log unit.

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