A New Technique for the Clinical Evaluation of Visual Functions in Human Neonates

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1. Introduction

The goal of the present work is to evaluate the feasibility of performing routine visual function screening on neonates in an obstetric clinic. It is desirable that the technique be sensitive, reliable, easy to administer, require short test durations, and not involve a great number of medical personnel.

Existing techniques including preferential looking, optokinetic nystagmus, and electrophysiological responses were found impractical with respect to these criteria. A new approach involving the visual pursuit of a pattern stimulus is described. The results from a preliminary evaluation on 150 newborn infants in the obstetric clinic are presented.

2. Methods

Many methods have been proposed for the evaluation of visual functions in neonates.

Each involves a specific combination of stimulus and response but all have some limitations /1/, and none appear to be suitable for systematic acuity screening.

Preferential looking is time consuming and requires the subjective interpretation of eye movement fixations, which can only be performed by skilled observers.

Visual electrophysiology methods are limited by the lack of cooperation of these very young subjects. The influence of many artifacts such as body movements, eye movements, etc. may be controlled by the use of appropriate rejection criteria and statistical analysis techniques /2/.

The poor attention span of these patients makes the recording of responses from T.V. pattern stimulation extremely difficult on a routine basis. The visual pursuit technique has also been the object of several research reports /3- 11/. These studies have been limited to the visual pursuit of large objects: colored cubes, red woolen balls, "Mickey's head," black circles on a white background, schematic faces, etc. Attempts to measure visual acuity have been made by decreasing the size of the moving objects. However, in this situation it is not clear whether the response is affected by a local change in stimulus luminance or by a change in stimulus resolution.

These considerations led us to the design of a new type of electronically generated stimulus with an average luminance matching the background luminance. This stimulus covers a small part of the visual field (6 degrees of visual angle) and so does not elicit an optokinetic nystagmus.

3. Apparatus and Procedure

The visual pursuit method was implemented on a "Vision Monitor" system (Fig. l) which includes a microcomputer, a cathode ray tube (CRT) visual stimulator, and a biopotential recording unit. This system is specifically designed for the evaluation of visual functions. It includes vision tests for neonates, central and para central visual field and visual electrophysiology (VER and ERG).

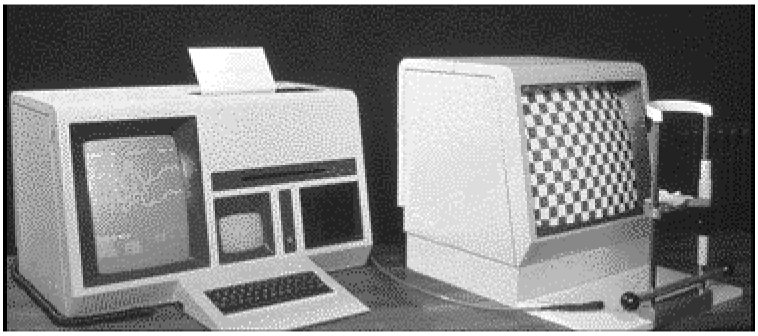

Figure 1

The CRT stimulator is a 20-inch, P31 white phosphor tube /12/. The electron beam scanning rate is 100 frames per second with 200 noninterlaced horizontal lines per frame. The stimulus is made of a small square area sustaining 6 degrees of visual angle and filled with a vertical grating (Fig. 2).

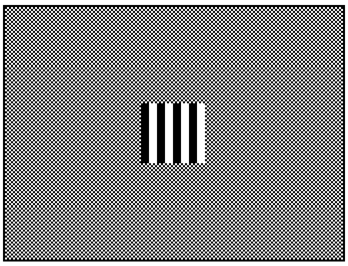

Figure 2

The stimulus average luminance matches the background luminance and it is put in motion along the hoizontal axis at a constant velocity. Stimulus size (spatial frequency), contrast and velocity are programmable. The examination is performed in a dark room in order to eliminate sources of visual stimulation other than the CRT. The child is seated in a baby chair. Two blocks of plastic foam are used to restrain head movements (Fig. 3).

Figure 3

Eye screen distance is 30 cm. The recording of eye movements was obtained using electrooculography. The clinical observation of eye movements as an adjunct to the objective measures was considered unsuitable due to its lack of quantification and the time involved in evaluation of eye movement from the position of the corneal reflex relative to the pupil was too expensive when performed automatically /13/. Eye movements are recorded from 2 temporal electrodes with a ground electrode located on the forehead. The biopotential recording system was set with a 0.1 Hz high-pass filter in order to eliminate problems associated with electrode polarization. A flickering white uniform stimulus is first presented at the center of the screen. Both eyes are stimulated and recorded simultaneously. The pursuit stimulus is generated as soon as the child appears to be watching the target. The test position and the electrooculographic signal are simultaneously displayed on the control screen. Five successive sweeps of the target are recorded for each test tun. This process requires between 20 and 40 seconds, depending upon the stimulus velocity. The complete testing procedure is usually performed within less than 3 minutes. Results are recorded on a floppy disk and processed after the examination session in order to determine the correlation between eye movements and the movement of the stimulus. At the present time, one person takes care of the child, applies the electrodes and observes the eye movements. A second person operates the computer system. However, one person could easily perform both tasks.

4. Results

157 full term infants from the obstetric clinic in Roubaix have been tested with this technique. Ages ranged from 1 day to 13 days with an average of 5 days. Only 4 children rejected the electrodes. Forty-eight children fell alseep before any response could be recorded. Appropriate following responses were elicited in 105 children. Table 1 summarizes the performances obtained for the different tests. The tests were not presented systematically: The procedure started with the presentation of a 146-minute test moving at 7 degrees/second.

The subsequent tests were presented according to the child's response to the first test. If a pursuit was obtained, the spatial frequency of the stimulus was increased. If no response was elicited to the first trial, the spatial frequency was decreased. Each infant's examination involved a maximum of 4 tests. Some of the early recordings were made with a stimulus velocity of 15 degrees/second, but the majority were performed at 7 degrees/ second.

Resolution	Velocity 7 deg/sec	Velocity 15 deg/sec
36 min	33%	
73 min	59%	33%
146 min	74%	72%
293 min	50.8%	19.0%

Table 1
Percentages of pursuit as a function of stimulus velocity and resolution

5. Discussion

Visual pursuit scores were obtained in 70% of the infants tested. The highest spatial frequency (36 minutes) was followed by 33% of the infants.

This result is in good agreement with the visual acuity measurements reported for this age group with the preferential looking technique, i.e.: 30 min. arc /14/ and a resolving angle of 28 min. arc using visual evoked potentials /15/.

Different forms of pursuit behavior were recorded in this study (see infant data shown in Fig. 4).

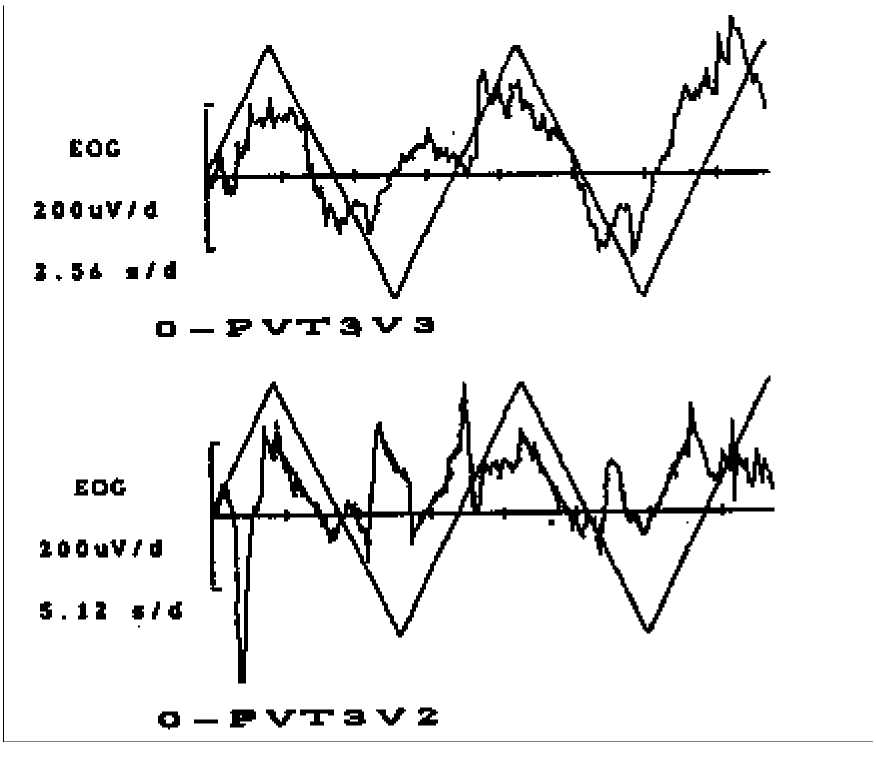

Figure 4
Typical recordings from 4 (upper) and 5 (lower) day old infants

As previously reported by BARTEN et al. (1971), some recordings are characterized by a saccadic pattern with rather precise pursuit for short periods of time but show poor correlation with the electrooculographic representations of stimulus movements due to saccades.

Other recordings show a good global correlation but a less precise pursuit.

6. Summary

These preliminary results are extremely encouraging.

Future developments of objective measures of infant visual acuity include the systematic screening of a larger sample of obstetric clinic patients with a follow-up of the infants with low performance during the tests.

We are also undertaking development of a system that performs simultaneous analysis of head and eye movements and which produces models of the different types of pursuit behavior which have been observed.

7. References

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