FIRST RESULTS OF VEP MEASUREMENT WITH A GAZE CONTROLLED PERIMETER

A. Götze*, S. Berkes** and G. Henning*

*Ilmenau Technical University/ Dept. Biomedical Engineering, Ilmenau, Germany
** Eldith, GmbH, Gustav-Kirchhoff-Str. 5, 98693 Ilmenau, Germany

Andreas.goetze@tu-ilmenau.de

Abstract: In conventional Perimetry, there are two major problems: First, it is a subjective measurement and second: fixation on the fixation target is necessary. Both problems can be solved with a gaze controlled objective perimeter. Our objectives were to determine, if there are differences in the visual evoked potentials (VEP) between gaze controlled stimulation and common stimulation. Using a 30'' TFT monitor as stimulating unit, we stimulated several volunteers with two series if monofocal central stimuli. The first sequence had been stimulated with gaze controlled stimulation, so that the stimulus always had been at the actual gaze point of the eye. For comparison, in the second series a common monofocal stimulation had been recorded. The VEP of both measurements have been compared. There are no significant differences in the VEP, but the volunteers reported a subjective impression, that the gaze controlled stimulation is less stressful.

Introduction

Perimetry plays an important role in Ophthalmology for detecting and monitoring eye diseases. It is the only method to measure the human visual field. Conventional perimetry has two big disadvantages: First, it is a subjective measurement and second: the examined person has to fixate to a fixation target for the whole measuring time. The measurement is subjective because the examined person has to approve the recognition of the stimulus by pressing a button. There is no way to detect the visual field of people, who can not or will not cooperate during the measurement.

Gazing to the fixation target for several minutes is very hard, but it's necessary for stimulating the right area of the retina. Fatigue of the visual system is caused thereby. Another problem arises, if the examined person doesn't fixate on the fixation target. Especially the detection of small scotomata could be difficult, if there are fixation instabilities. [1]

The solution to both problems is a gaze controlled objective perimeter (Fig. 1). The gaze direction of the eye of the examined person is detected by an eye tracking system and the coordinates of the focal point on the screen are calculated. The optic stimulus pattern is presented at the focal point of the eye.

During the examination the EEG is recorded above the visual cortex. By signal processing the visual evoked potentials (VEP) are extracted out of the EEG signal.

Materials and Methods

The measurement system consists of a 30'' VGA-TFT-display (Fujitsu Siemens Myrica V30) as stimulating unit, an eldith Theraprax®-System [2] as EEG measuring unit and a two CMOS camera eye tracker for gaze direction acquisition.
The eye tracking system takes 2 pictures of the pupil of the examined eye. The two CMOS cameras have an angle of 70 degrees to each other. Thereby one yields 2 different images of the same pupil.

To avoid an influence on the stimulation, the pupil is illuminated with infrared light. Therefore, there are two clusters of IR LED's above the cameras. The camera lenses are covered by infrared filters, to avoid influence by the stimulation on the images of the pupil.

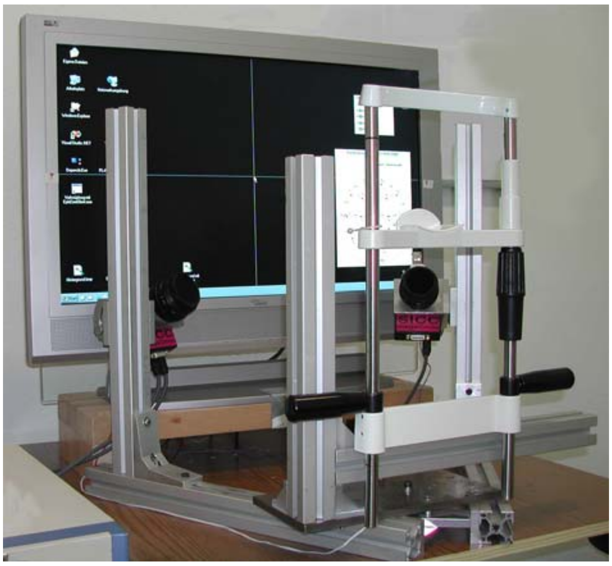

Figure 1: Eye tracker and stimulation monitor

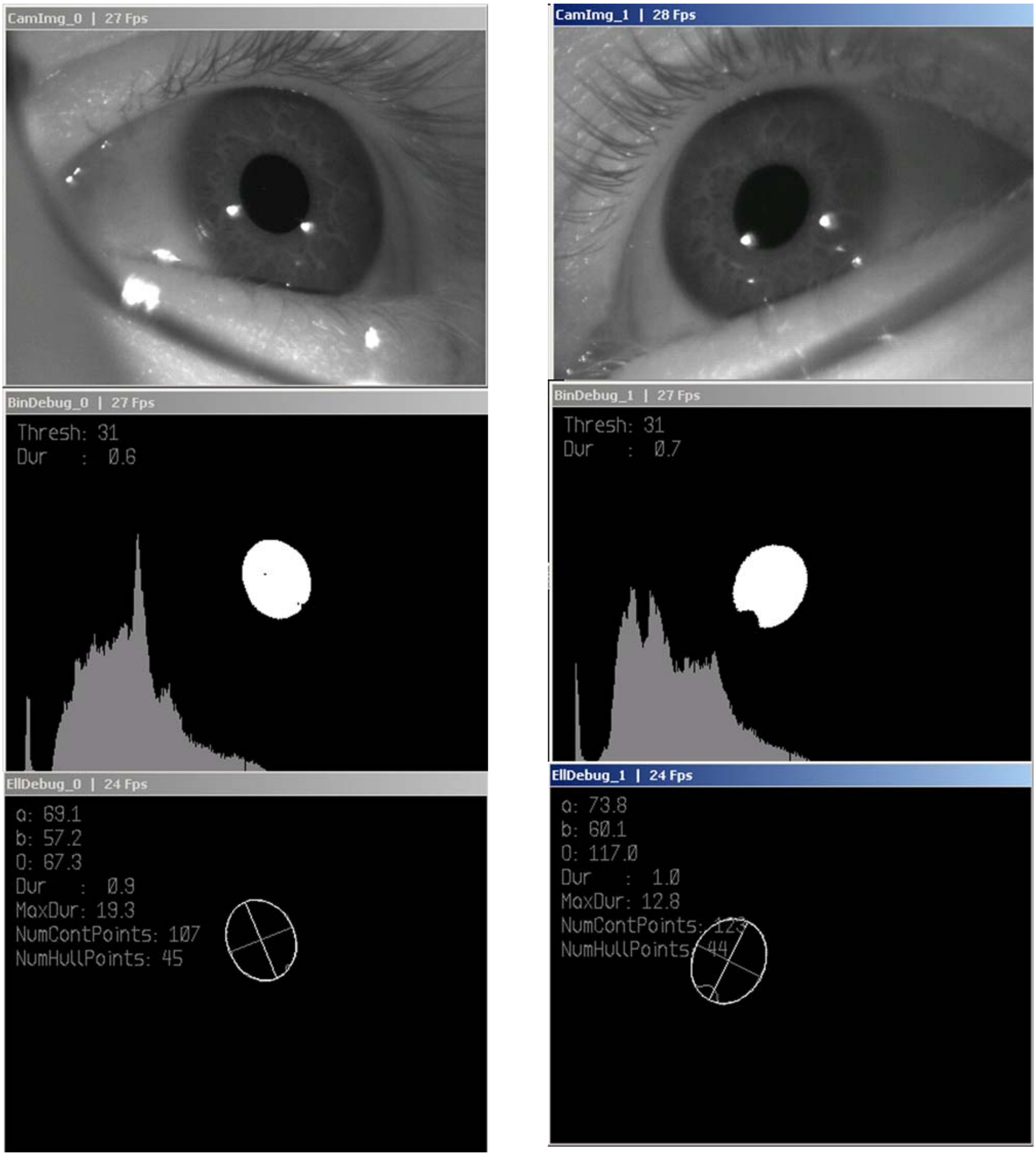

Figure 2: extraction of gaze parameters from the pupil

After binarization of the two images (Fig. 2, middle pictures) and processing with an edge detecting algorithm and other image processing methods, one yields two images, containing the edges of the pupil (Fig. 2, lower pictures). Because of the camera angle, the shapes of the pupil are ellipses. The parameters of the ellipses are determined using a Hough transformation algorithm [3]. From the parameters of these two ellipses, the gaze direction can be calculated. Because the position of the cameras, the eye and the screen are known, the focal point on the screen can be derived [4, 5]. The eye tracker does not need to be calibrated.

The eye tracking system determines the optic axis of the eye. But the eye fixates on the fovea, the region of the sharpest vision. Unfortunaly, the fovea is not right in the centre of the eye, but some degrees beneath it (Fig 3). So, by normal fixation, one gazes not along the optic axis, but along the visual axis. Therefore, there must be a correction to achieve the real gaze point.

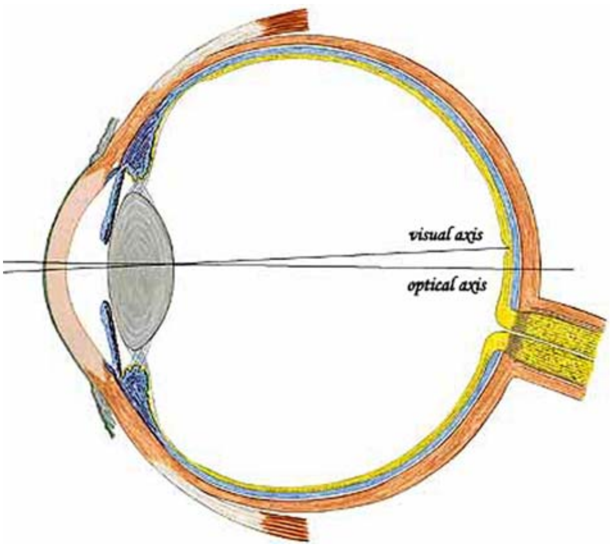

Figure 3: Difference between optic axis and visual axis

The position of the fovea, and by that the distance between the optic and the visual axis, is different for each eye. That's why the correction has to be made for every examined eye. A fixation target is presented to the eye and the person is asked, to fixate on that point and the difference for the real gaze point is detected and will be corrected for the measurement.

The coordinates of the focal point are delivered to the stimulating system. According to these parameters, the stimulus is presented at the focal point. So, the examined person can move the gaze freely on the monitor and has not to fixate to one fixation point.

During the measurement, the EEG is recorded with 7 Ag/AgCl electrodes by the Theraprax®-System. The electrodes where applied on certain positions above the visual cortex (Fig. 4). By averaging technology, the Visual evoked potentials (VEP) are extracted out of the EEG. Stimulation and EEG recording are synchronised by a trigger signal. There is a trigger pulse for each stimulus.

Several normal adults have been stimulated with a monofocal 5 degree central flash with a duration of 50 ms and an interstimulusintervall (ISI) of 250 ms. The testing for each individual consisted of two measurements with 500 stimuli; one with gaze controlled stimulation and one without. The two measurements have been compared.

Results

After signal processing and extracting the segments from the measured EEG using the trigger signal, one yields the visual evoked potentials (VEP) by averaging of the 500 segments.

There are VEP in both measurements. The analysis of the VEP with and without eye tracking shows, that both types of measurement gain similar results (Fig. 5). The red line shows the VEP of a common stimulation with fixation and the green line for a gaze controlled stimulation. Particular, the potentials with eye tracking are slightly higher than without tracking. The measurement with the gaze controlled stimulation was more comfortable to the examined people.

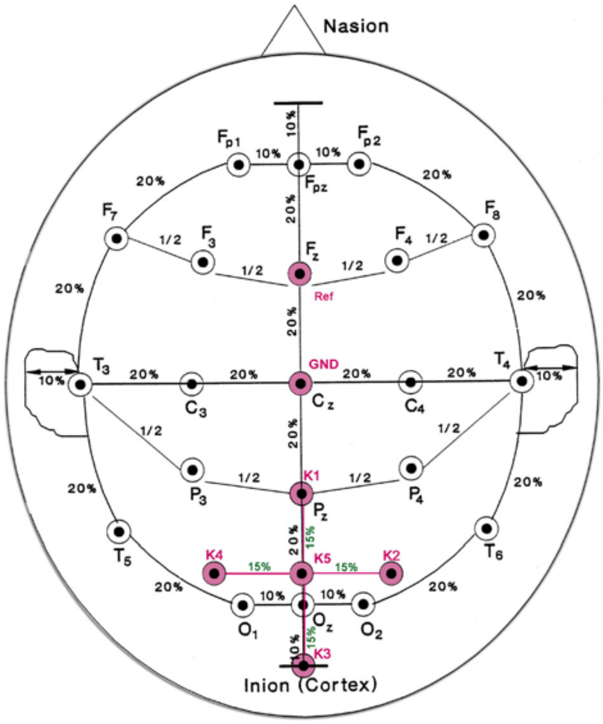

Figure 4: Electrode configuration

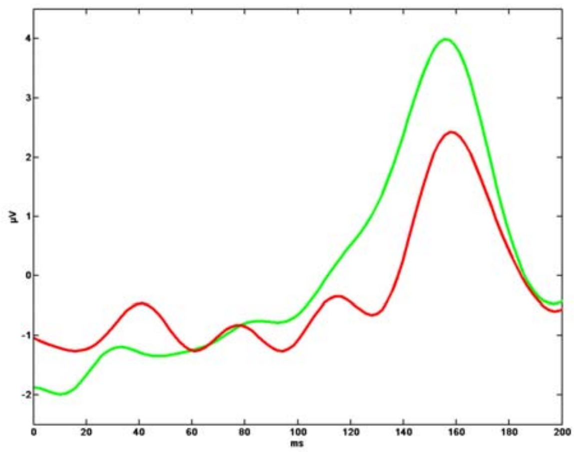

Figure 5: VEP using stimulation with fixation (red line) vs. gaze controlled stimulation (green line)

Discussion

The results for both measurement types are similar (Fig. 5). This result could have been expected, because the volunteers fixated to the fixation target during the uncontrolled stimulation. Further examinations have to be made to compare measurements without fixation on the fixation target with gaze controlled measurements to simulate fixation instabilities [1].

Measurements with people with central scotomata or fixation problems should follow.

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Conclusions

Visual evoked potentials generated by stimuli with gaze controlled stimulation but without target fixation and with less concentration are comparable to the results with target fixed eye a high patient's concentration and alertness. Thus the examination is simplified for the examined person. Gaze controlled perimetry connected with stimulus presentation on display is an improvement of the conventional perimetry.

Acknowledgement

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