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Functional Exploration of Optokinetic System by a Full Visual Field Stimulation.

Kim Nam Gyun* , KOPP C.**

– Abstract –

In the present study, we described a test to explore the function of optokinetic system which subjected to a full visual field stimulation using two different stimulus images patterns.

Our results were interesting in a point of view that the stimulation image pattern had non-neglisible influence on the optokinetic response and that in a bidimensionnel image such as the randomly distributed spots images pattern the linearity of system was assured upto the stimulus velocity of about 50 deg / sec for normal subject. As for measuring human optokinetic after nystagmus, the regular stripes pattern was rather desirable than the randomly distributed spots pattern in this study.

1. Introduction

The prime function of optokinetic system is to stabilize images of the moving on the retina. When a stationary subject is suddenly exposed to continuous constant velocity displacement of a large image filling the full subject visual field, the subject produces a series of eys movements consisting of slow phase eye movement in the direction of stimulation and fast phase movement in the opposite.[1] This eye movement is called as optokinetic nystagmus(OKN). When we extinguish the stimulus illumination, eye continues to produce an polonged eye movement in the dark for some time. This phenomenon is known as optokinetic after nystagmus(OKAN).[2-3]

According to the present knowledge about the optokinetic system in clinic both OKN and OKAN can be a valuable clinical test in detecting and localizing a lesion in the oculomotor system. But it has been reproted by many authers that many problems awaiting solution such as an optimal stimulus condition and a quantitative and accurate method for the OKN and OKAN are lying in clinical use.[4-6] Especially it is pointed out that about the geometric characteristics of the stimulus images, narrow field stimulus, like the barany drum which is still often used, should be considered as to elicit smooth pursuit movement rather than the OKN and regular patterns such as stripes and checkboards are the most used.[7] However, recent results seem to indicate that rendomly distributed spots could be more effective pattern.[8-9] Due to the intrinsic nonlinearity of optokinetic reflex a complete test requires that several velocities are considered upto the proper ranges.[10]

Thus the purpose of this study is to describe an optokinetic test that we have found to be valuable in our laboratory for the above mentioned and to illustrate the effects of geometric characteristic of stimulus image pattern by using both randomly distributed spots and regular stripes

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*Dept. of Biomedical Engineering. Chonbuk National University Medical School.
**Lab. de Biomecanique. I.M.F.S. Universite Louis Pasteur de Strasbourg, France.

images at several stimulus velocities for some contributions to a pricise understanding of the oculomotor system.

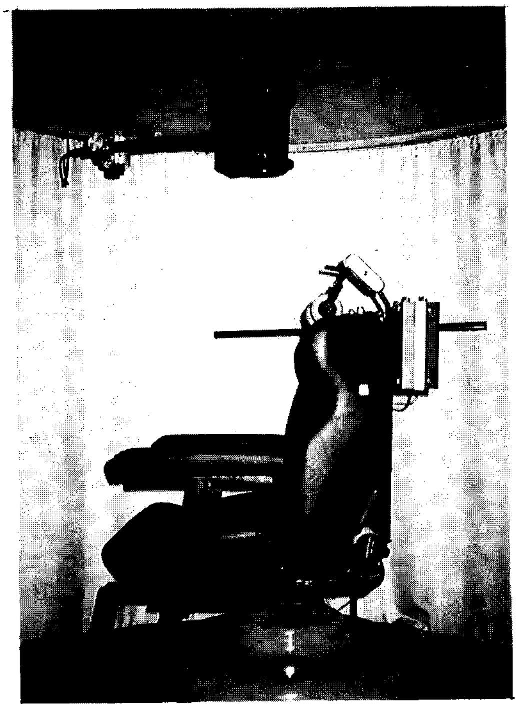

Fig. 1. Explorating system with screen and Optokinetic drum.

2. Methods

A system approach to the analysis of oculomotor system is to observe the system response to a predetermined stimulation in order to explore the funciton of interested system. For this object five human subjects were studied. They had no history or signs of opthalmic or neurological disorder.

The experimental procedure was the following:

A subject was seated with head fixed in the chair which was surrounded by a cylinderical screen with a radious of 120cm and a height of 180cm. The inside of screen was colored with white. Above the chair in the center there is an optokinetic drum which projected light slits(regular stripes images and randomly distributed spots images) onto the cylinderical screen and could be rotated at a constant velocity by the servo-control.(Fig. 1) This rotation of optokinetic drum stimulated the subject' s entire visual field.

For OKN the light source of optokinetic drum was turn on during 40sec. The light was turn off to measure OKAN in the dark during 40sec. Six tests were performed at a constant velocity of 5, 20, 35, 50, 65, 80 deg / sec. Before each test, the subject was instructed to loook forward but not to follow the moving projected images. During each test interval, the subject sat with eye closed in order to avoid impressing an after images of the stationary stimulus parttern on the retina.

For the recording, eye position signal was recorded by the classical E.O.G method. Agcl electrods were positioned at each outer canthus with a ground electrod in the center of forehead. Eye position signal were amplified and low-pass filtered before being sampled at 100Hz. The calibration of eye movement were taken from voluntary saccades by using a target with built in light emmiting diodes which are located 10 deg to the left or right of the primary fixation position at the center of the target.

The data analysis such as the detection of fast phase, the separation of two phases, the removal of fast phase, the reconstruction of slow phase and the calculation of slow phase velocity were realized

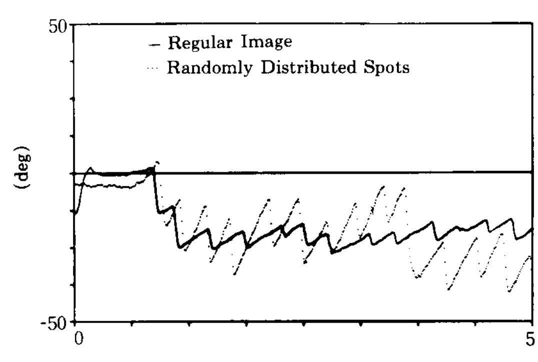

Fig. 2. Optokinetic nystagmus obtained from a subject to two different stimulus images.

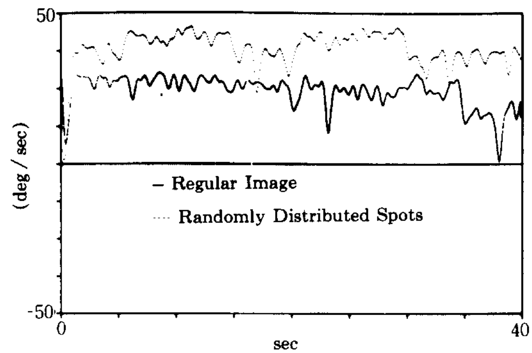

Fig. 3. Slow phase velocity during OKN to two different stimulus images.

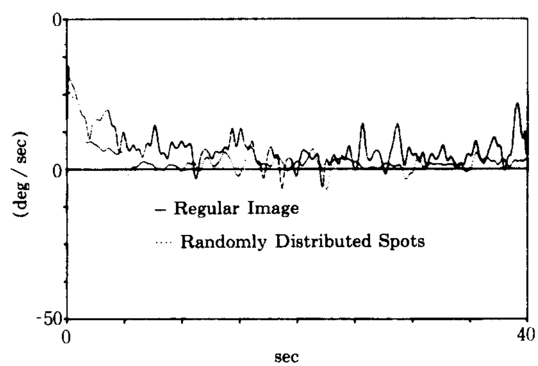

Fig. 4. Slow phase velocity during OKAN to two different stimulus images.

by real time processor(IN110) with the help of the software[11-12] which was developed in our laboratory.

3. Results

Fig. 2 is the optokinetic nystagmus obtained from a subject who was submited to two different stimulation patterns:one is the regular stripes pattern and the other is the randomly distributed spots. The stimulus velocity is at 50 deg / sec. The optokinetic nystagmus demonstrates a regularity of frequency and amplitude in both cases. Fig. 3 shows that the slow phase velocity of OKN reaches the value near stimulus velocity immediately after the onset of stimulus motion. This does not correspond with the case of animals without fovea where we can see a slow build-up phenomenon. It seems to indicate that in human the component of direct path can be dominant. We can also see that the stimulus with regular images pattern gives larger slow phase velocity than one with randomly distributed spots images pattern. But an inverse phenomenon is observed in the slow phase velocity of optokinetic after nystagmus as shown in Fig.4 It seems that indirect path is more sensitive to the stimulus with regular images patterns than to that with randomly ditributed spots images pattern in our experimental conditions. Fig.5 is the cumulative eye position which is the integral of slow phase velocity theoreticaly. The cumulative displacement curve remains fairly linear during OKN in both stimulus images pattern, indicating an essentially constant eye dis-

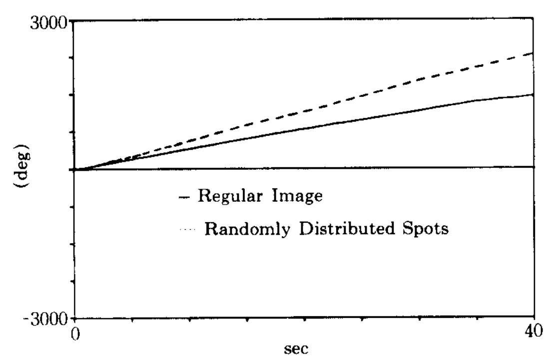

Fig. 5. Cumulative eye positions during OKN.

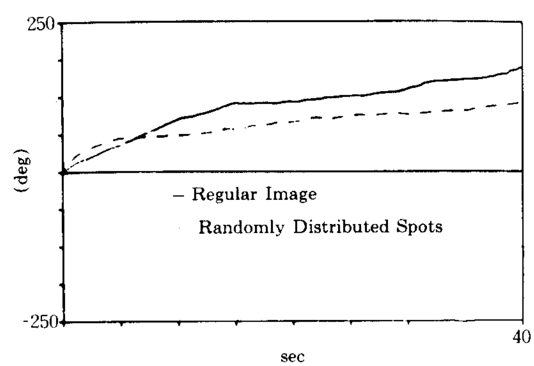

Fig. 6. Cumulative eye positions during OKAN.

placement in successive slow phases. On the contrary, the cumulative displacement curve of OKAN is not linear as shown in Fig.6.

Fig.7 represents the slow phase velocity during OKN according to the stimulus velocity in ranges from 5 deg / sec to 80 deg / sec to two different images patterns. Each point indicates the mean value of slow phase velocity. For velocities to be inferior to 35 deg / sec, curve points are identical regardless of stimulus images patterns. From about 35 deg / sec to 70 deg / sec the slow phase velocity to the stimulation with randomly distributed spots images pattern is larger than that to one with regular strips image pattern. This can be explicated by the fact that the difference of response is due to the change of local luminance between the vertical and the vertico-horizontal. For velocities to be superior to about 65 deg / sec, the gain of OKN to two different stimulus images patterns are reduced simultaneously. It is possible that for high stimulus velocity the function of direct path decreases rapidly and the stimulus signal passes through the indirect path. It seems that the fovea vision can be abolished by very great velocity of target-eye slip which results in giving a circular vection phenomenon to the subject submitted to this high stimulus velocity.

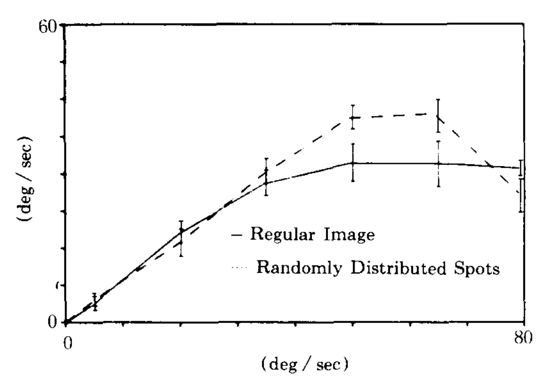

Fig. 7. Slow Phase velocity during OKN with stimulus velocity at 5, 20, 35, 50, 65, 80(deg / sec).

4. Discussion and conclusion

In this study, we have described the optokinetic test which we have found to be valuable in our laboratory in order to contribute to a pricise understanding of oculomotor system. We also tried to find a practical stimulation for exciting optokinetic system well by using two differents stimulus images patterns.

Through our tests we remarked that for velocities between 35 deg / sec and about 70 deg / sec the randomly distributed spots images pattern provocated higher gain than the regular stripes pattern. This augmentation of gain is due to only the pursuit system because in general the optokinetic stimulation elicites both direct and indirect path of oculomotor system simultaneously. It has been reported by many authors that the pursuit system in human was equivalent to components of the direct of optokinetic system. That is to say, the pure optokinetic component can not be elicited easily by the classical stimulation which is most commonly used in optokinetic test. So we will be asked to find an optimal stimulation for pure optokinetic component in the future eye movement research.

But our results are interesting in a point of view that the stimulus image pattern has non-neligible influence on the optokinetic response and that the system rests linear globaly for stimulus velocities to be inferior to about 35 deg / sec and that the gain of optokinetic nystagmus depends on stimulus velocity. Espectialy in a bidimensional image such as the randomly distributes spots pattern the linearity of system is assured upto stimulus velocity of 50 deg / sec at least for nomal subject.

As for the OKAN, human OKAN might be an useful indicator of graded levels of brainstem of labylinthine dysfunction and be of considerable clinical value in disgnosis of vestibular related disorder as well as providing a sensitive tool for the future research of the nature of oculomotor control system. But our experiment touched only comparing the magnitude of slow phase velocity between two stimulus image patterns. It is desirable to find out an optimal stimulus image pattern in order to evoke OKAN well, by using several image patterns. Therefore an analytical procedure for accurate quantification of the response of optokinetic system after ligh-out is need to satisfy the object mentioned aboved well in the near future.

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