EFFECT OF LIGHT FLASHES ON SACCADIC OCULOMOTOR CONTROL

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Abstract- **The ability to make quick and accurate saccadic eye movements for exploring the existing environment requires multiple regions of the brain working with the saccadic oculomotor control system. The goal of this experiment was to study how light stimuli affect this system. This was tested by presenting intermittent light flashes in three subjects as they visually attempted to locate a target. The subject was presented with a target at 15 degrees to the right accompanied by a photic stimulus at midline, 15 degrees to the left, or 15 degrees to the right. For comparison, a control comprised of a target 15 degrees to the right with no photic stimulation was also presented. Data were collected using the Skalar infrared limbic tracking system and a custom LabVIEW program. Dynamics were quantified using a latency analysis program written in MatLAB. Results show that the latency to saccade to the desired target increased when light flashes occurred in various positions, compared to targeting without photic stimulation. These increases in latency suggest that light has an effect on the saccadic oculomotor system, affecting physiological performance.**

I. INTRODUCTION

An afterimage is a visual phenomenon in which some features of an image persist after the visual stimulus ceases. After a flash of bright light, cells within the light-exposed area of the retina become less sensitive to light compared to those outside that area, so they fail to respond as well to the same level of light. Exposure to bright light can produce an afterimage lasting for minutes to hours to days depending on the intensity and duration of the source light.

Afterimages can have undesired effects such as spatial disorientation while operating aircrafts or vehicles. In fact, afterimages caused by expedient lights such as flashlights, flares, headlights, and ground lighting can provoke spatial disorientation in pilots and drivers [1].

The saccadic oculomotor system rapidly shifts the fovea to a visual target in the periphery. Saccades usually have two characteristic features: high velocity and a nearly identical eye movement measurement of both eyes [2]. Burst and tonic nerve cells in the mesencephalic reticular formation control the velocity and position of saccades.

Previous studies have found that variances in saccadic latency occur with multiple stimuli. In particular, a competition for visual attention appears to contribute to saccadic latencies [3,4]. This study investigates the effect of competing light flashes on the latency of saccadic eye movements.

II. METHODOLOGY

Three subjects participated in this study. All subjects understood the experimental protocol and signed informed consent forms approved by the institution's review board.

This study investigated how afterimage affected saccadic eye movements. Horizontal eye movement data were collected with LabVIEW software in response to six stimuli: no flash with a 15 degree target movement into the right visual field (control), center foveal flash with a 15 degree target, left flash with a 15 degree target, right flash with a 15 degree target, center foveal flash with a 15 degree target movement into the left visual field and no flash with a 15 degree target movement into the left visual field. The last two stimuli were presented to avoid subject prediction where all responses analyzed were 15 degree eye movements from the subject's midline into the right visual field. A target consisted of a small vertical green LED bar. The subject was asked not to blink if possible during the experiment and had the choice to pause anytime if fatigued. The subject was told to visually locate the LED target after the trigger push. A bell sound signified the end of an experimental session.

The experiment began with five-point calibration between ±20 degrees. After calibration, the subject was asked to fixate on the center target then push a trigger to initiate the experiment. Once the trigger was pushed, the target was presented following a random delay of 0.5 to 2 seconds (to prevent subject prediction). Then one of the 6 types of stimuli was randomly presented. Each experimental response lasted 3 seconds. Five-point calibration was recorded every 10 experimental trials. For every stimulus type, approximately 10 to 20 responses were collected per subject.

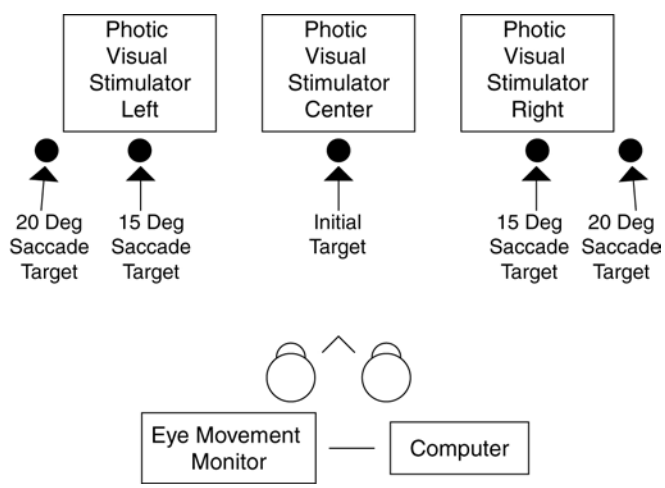

Fig. 1. Experimental set-up

The apparatus is shown in Figure 1. It consisted of 3 Grass PS33-Plus photic stimulators adjusted to flash intensity settings of 8 placed 57 cm from the subject, 5 LED targets also 57 cm from the subject, and a limbic tracking system which collected eye movement data. The photic stimulators were at midline and at 15 degrees in the left and right visual fields. The saccade LEDs were located at 15 and 20 degrees from the midline in the right and left visual fields. The Skalar Iris model 6500, a limbus-tracking device, was used to record data which were sampled at a rate of 1000 Hz. This eye movement monitor had a resolution of 2 minutes of arc and a linearity of ± 25 degrees. This instrument was placed on the subject's head and adjusted to the left and right eye. It collected data from each eye where left and right eye movements were individually stored to be analyzed post-experiment.

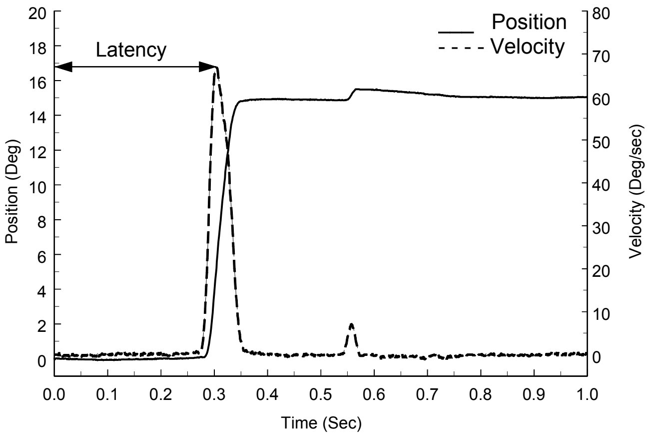

Fig. 2. Latency Analysis where time was measured from stimulus onset to time where peak velocity occurred

Data analysis occurred offline with MatLAB software where the left and right eye responses were summed, then halved, to yield an average saccadic response. Latency analysis, where time was measured from stimulus onset to the time where peak velocity (saccade to a target) occurred, is shown in Figure 2. The solid line (position) and the dashed line (velocity) were plotted as a function of time.

III. RESULTS

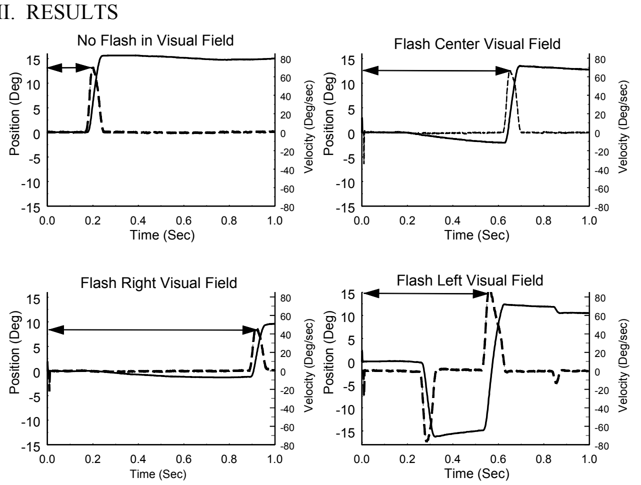

Fig. 3. Typical examples of 15-degree saccadic eye movements of control (no photic stimulation), and of photic stimulation in the center, right, and left visual fields.

Fifteen-degree saccadic eye movement responses to no photic stimulation and photic stimulation to the left, center, and right visual fields are shown in Figure 3. An increased latency in peak velocity occurs with photic stimulation to the left, center, and right visual fields compared to no photic stimulation. Also, the lower right graph shows that photic stimulation to the left visual field sometimes results in a saccade to the left before a saccade to the target on the right.

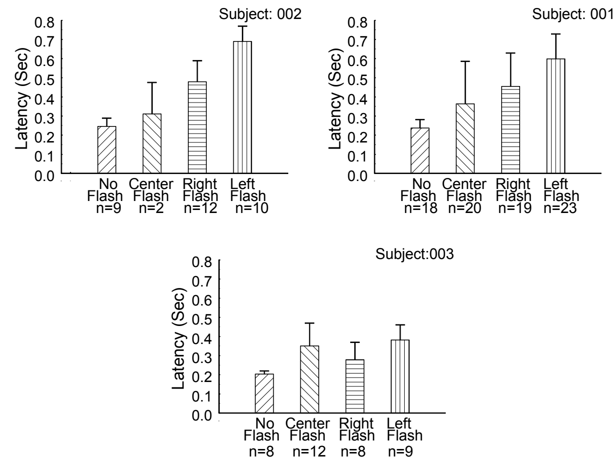

Fig. 4. Latency Analysis for three subjects studied. Subject 002 only had 2 responses to center flash due to blinks.

Figure 4 illustrates a summary of the means and the standard deviations of the latencies. On average, a flash 15 degrees to the left with a target 15 degrees to the right caused the greatest latency. Two subjects, 001 and 002 had greater latencies with a right flash compared to a center flash while subject 003 had greater latency with center flash compared to a right flash. For all subjects, photic stimulation resulted in latencies much longer than no photic stimulation.

IV. DISCUSSION

The data collected demonstrate that a photic stimulus accompanying visual location of a target causes an increase in latency. The greatest latency occurred when the photic stimulus was the greatest distance from the target. This latency may be due to afterimage as well as a competition for visual attention [3,4]. This suggests that light flashes have an effect on the dynamics of the saccadic oculomotor system, affecting physiological performance. Due to differences in trends between center flash and right flash among the three subjects, more data collection is needed to determine which tendency persists. In addition, latency from a 15-degree left target needs to be investigated to determine whether it yields trends symmetric to those found in this study.

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REFERENCES

[1] R.T. Schmidt, "Reduce risk of inducing spatial disorientation using physiologically compatible ground lighting", *Aviation, Space, and Environmental Medicine*, vol. 70(6), pp. 598-603, June 1999.

[2] A.E. Yarbus, *Eye Movements and Vision*, New York: Plenum Press, 1967.

[3] T.L. Hodgson, "The location marker effect. Saccadic latency increases with target eccentricity," *Experimental Brain Research*, vol. 145(4), pp. 539-42, August 2002.

[4] J.J. Clark, "Spatial attention and latencies of saccadic eye movements," *Vision Research*, vol. 39(3), pp. 585-602, February 1999.