3-1982

Objective visual field testing

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Abstract

The present research explored possibilities for objective visual field measurement devices and schemes and assessed their clinical application. A visual field measurement taken without cognitive patient response was sought. Instruments used were biomicroscopes and transilluminators, Eye-Trac, grain of wheat light board, infrared eye monitoring spectacles connected to a strip chart and audio-output device, and an EOG monitoring system. It was hypothesized that a discrete, involuntary eye movement toward a peripheral light occurred if the light was seen by the subject. No specific eye movement toward the stimulus was ever consistently detected. However, it was noted under certain conditions, identifiable refixation eye movements occurred when the peripheral stimulus was extinguished. Using grain of wheat bulbs, scotomas eight degrees in size or larger could be detected. This procedure could be clinically useful in the evaluation of visual fields in malingerers or other persons unable to be tested with present visual field testing procedures.

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

William M. Ludlam

Subject Categories

Optometry

OBJECTIVE VISUAL FIELD TESTING

A SENIOR THESIS

Presented to

The Faculty of the College of Optometry

Pacific University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Optometry

by

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March 1982

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Accepted by the Faculty of the College of Optometry, Pacific University, in partial fulfillment of requirements for the Doctor of Optometry.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS

We extend our thanks to Dr. William Ludlam for his ideas and help on this project. We also express appreciation to Randy Pitman, Roger Hirons and Dr. Niles Roth for their time and labor. Thanks must also be expressed to the Phi Theta Upsilon International Optometric Fraternity for their grand to us, which covered the cost of materials used during the research.

ABSTRACT

The present research explored possibilities for objective visual field measurement devices and schemes and assessed their clinical application. A visual field measurement taken without cognitive patient response was sought.

Instruments used were biomicroscopes and transilluminators, Eye-Trac, grain of wheat light board, infrared eye monitoring spectacles connected to a strip chart and audio-output device, and an EOG monitoring system.

It was hypothesized that a discrete, involuntary eye movement toward a peripheral light occurred if the light was seen by the subject. No specific eye movement toward the stimulus was ever consistently detected. However, it was noted under certain conditions, identifiable refixation eye movements occurred when the peripheral stimulus was extinguished. Using grain of wheat bulbs, scotomas eight degrees in size or larger could be detected.

This procedure could be clinically useful in the evaluation of visual fields in malingerers or other persons unable to be tested with present visual field testing procedures.

INTRODUCTION

The development of instruments for measuring visual fields commenced in 1857, when the first perimeter was introduced by Aubert and Foster.[1] Many techniques and designs have been developed since that measure the motion, form, and color discrimination ability of the peripheral vision system.

Until recently, every device or technique for visual field measurement required a cognizant response from the patient. Regardless of the test or instrumental controls that were designed to decrease measurement variables, each method remained a patient-subjective test.

There would be a number of advantages to a visual fields test that did not require a subjective response from the patient. Such an objective visual fields test would be useful for testing malingerers and persons unable to understand instructions or unable to respond in the normal manner.

To date, two methods of objectively recording visual fields have been reported in the literature. Copenhaver and Beinhocker[2] reported in 1963 on the use of a visual evoked response to determine visual pathway and visual field intactness. Later, Regan and Milner[3] elaborated on the earlier work and determined that several limitations existed with the use of an evoked response for field plotting. Firstly, visual evoked responses that are generated in differently located regions of the cortex have maximums located in different scalp locations. If one evoked response had a larger amplitude than another evoked response, it could be due to one maximum being closer to the electrode site. The distributions of maximums also varies widely between normal subjects.

Another limitation applies to flicker evoked potential perimetry. The amplitude of the potential is different for various flicker frequencies. This difference varies between retinal quadrants. The evoked potential for individual quadrants can also differ between subjects and between the right and left eyes of individual subjects.

Lastly, Regan and Milner suggest the use of the VER for field measurements is not a feasible procedure for the average practitioner.

Jernigan[4,5] is at present the only author of research literature regarding eye movement detection and field plotting. Both of his reports were on the same technique, the latter a more sophisticated approach than the first. Basically, he recorded the eye movement of a subject after exposing a peripheral stimulus. The patient fixated a central target until the stimulus was presented. This peripheral presentation, if seen, began the eye movement called acquisition wherein the subject fixated the new stimulus. If the stimulus was not seen, a search response was detected.

A decision algorithm was used to determine whether the eye movement was indeed an acquisition or a search response. A Biometric Eye-Trac was modified to record vertical as well as horizontal eye movements. In an acquisition response the subject performed one major saccade in the direction of the stimulus and one or more corrective saccades thereafter to fixate the target. A search response consisted of more than one noncorrective saccade and short fixation durations.

Limitations exist with this technique. To plot 45 positions requires 15 minutes. Jernigan also noted that a "blind sight" response from the superior colliculus may occur and the decision algorithm would

indicate "seen" when a "miss" actually occurred.

His technique eliminates the verbal response but has replaced it with another subjective response. The patient must be able to understand spoken instruction as with other fields tests.

A technique requiring no patient communication, other than fixating a central target, would be the ideal situation. If a deaf patient, elderly patient, retarded patient, etc., could be given an objective visual field test without verbal instruction, the test could be performed relatively quickly.

The present investigation proposed that in each presentation of a seen peripheral stimulus an eye movement toward the stimulus occurs that can be detected and used to determine the subject's visual field extent. The central target is fixated by the subject, thus, that instruction is the only necessary communication between examiner and patient. When the peripheral stimulus occurs, an eye flick toward the stimulus can be measured or detected. This flick is not the saccade measured by Jernigan. No literature on this hypothesis has been printed to date.

METHODS

A population study was not attempted in this work. Subjects served to verify eye flick response. Both investigators acted as subjects, alternately. Also tested were four uninformed persons from the Pacific University College of Optometry community. All subjects were between 25 and 30 years of age, had correctable visual acuity of 20/20 OU, and normal visual fields.

Four monitoring systems were used to detect the eye flick or retinomotor reflex. Each system was evaluated for its detection of a reflex, sensitivity, ease of operation, and degree of objectivity.

The four systems used were direct observation with and without a biomicroscope, Eye-Trac, infrared eye monitoring spectacles, and EOG. Prior to each of these methods, it was verified that the peripheral stimulus was not located in the subject's blind spot. Instructions to the subject were, "Observe the central target".

The first procedure involved the attempt to visually observe the retinomotor reflex using a biomicroscope. The subject was seated normally at the instrument. The observer positioned the slit lamp and the microscope approximately 90° temporal to the subject. Throughout this procedure magnification from 6X to 40X was used. To detect ocular movement an optic section 1 mm in length was aligned with a blood vessel in the bulbar conjunctiva. Slit lamp illumination was losered as much as possible to reduce internal light scatter in the subject's eye. The opposite eye was occluded.

The first set of targets consisted of a central fixation light and a moveable peripheral light. The central fixation light was a pen-

light with a pinhole aperture, while the peripheral light was a transilluminator held by the observer.

Initially, the central fixation light was left on and the peripheral light was flashed intermittently in various locations of the subject's visual field while the eye position was being monitored.

The hand held method was rather unwieldy, therefore a random lights board was devised. The board was painted flat black. The light bulbs were "grain of wheat" bulbs with an illumination of 4 footcandles at 7 cm. A twelve volt battery supplied the energy to the lights. Two 3-point toggle switches were combined to provide a randomness to the on-light location.

Peripheral light variations included the unfiltered bulb and a 1 mm pinhole aperture over the bulb. Central fixation target variations included the unfiltered bulb, bulb with colored tape over it to reduce brightness, and a non-luminated white circle of paper 5 mm in diameter.

Following the use of the biomicroscope, the Biometric Eye-Trac model 106 was used to monitor the subject's eye movement response. With the subject seated, a central non-luminous target was observed at one meter. A peripheral hand held transilluminator was the peripheral stimulus and positioned from 5 cm to 40 cm from the central target. The eye movement was recorded while the peripheral light was flashed. As with the biomicroscope, a random light board was later used for better control of the peripheral stimulus.

The standard Eye-Trac sensor orientation was used to monitor horizontal eye movements. Therefore, center, left, and right light

positions were used exclusively.

Again, with the patient seated at one meter from the target, the peripheral target was turned on, either left or right. The light positions were varied from 5 cm to 40 cm from the central target using the light board and an Adam's collimated flashlight pointer. Background illumination varied from none to standard room illumination.

A strip chart recorded the eye movements as the investigator flashed the stimulus according to a preplanned random schedule. Only the right eye was monitored for simplicity.

Other variations were performed using the above procedure. The patient target distance was increased to 1.70 m, the central target was changed from luminous to non-luminous, uninformed subjects were tested, and filters were used to cover the bright alignment lights.

The third system used for reflex detection was the infrared eye position monitoring spectacles. It was used in two situations. First, the spectacles were coupled with an auditory-output that began producing sound when the eye moved 1.5 to 2.0 prism diopters from central fixation.

The same glasses were later used with a strip chart, however, an eye movement of approximately 2 to 4 prism diopters was required to produce a discernible pen deflection. Central and peripheral lights were varied as before.

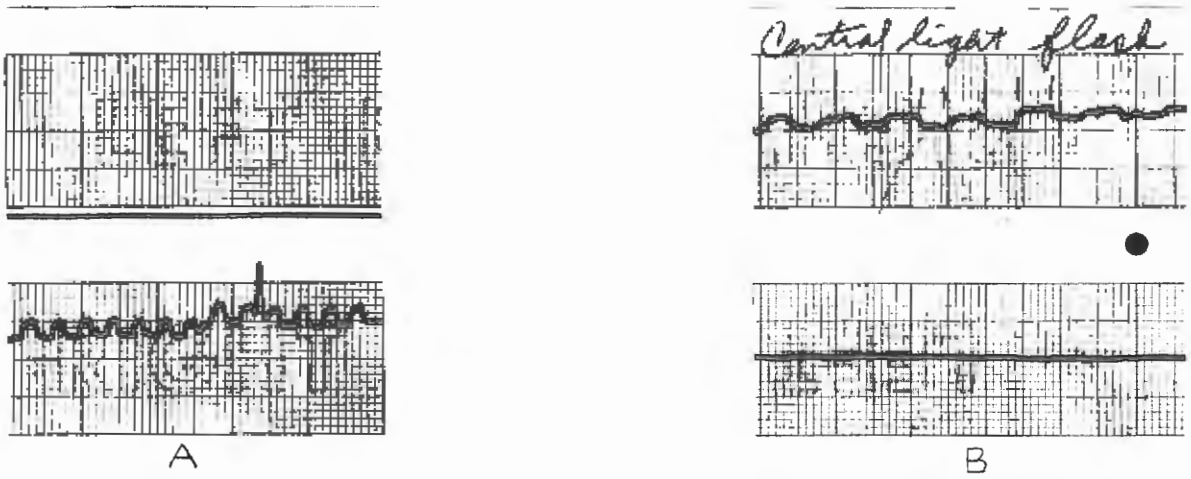
The fourth system for eye movement monitoring was an EOG measurement using the OEU-4. As with the Eye-Trac and the infrared sensing spectacles, the light board was incorporated. Large eye movements, that is over 4 prism diopters, were needed to produce differential pen deflections.

RESULTS

Using the biomicroscope, no discrete ocular movement in the direction of the peripheral light stimulus was ever consistently observed by either investigator. Movements did occur from 20 to 30% of the time during stimulus presentation, however, the eye movement could not be consistently repeated and approximately one half of the movements were in the direction away from the stimulus.

The infrared spectacles with the auditory output did not indicate any discrete eye movement at the time of stimulus presentation. No specific reflex movements were detected with the spectacles and the strip chart. Fluctuating sensitivity was a major problem with this system.

Initially, the Eye-Trac did display a discrete pen deflection whenever a peripheral light stimulus was presented. (A)



However, the pen deflection continued to occur when the central fixation light was flashed on and off. (B) The deflection increased in size when the brighter light from a flashlight beam was shown onto the subject's eye. Thus, the pen deflection was not from an eye movement but from the

stimulus light reflecting on the subject's eye. It was concluded that the Eye-Trac could not be used to detect the reflex due to this artifact.

While the EOG is not directly influenced by light as are the infrared sensing spectacles, the results of the two systems were similar in that sensitivity of the EOG as well as that of the infrared sensing spectacles, with strip chart or auditory-output, was rather low. No discernible movement of the pen or distinguishable change in frequency was made for small eye movements.

Though no specific eye movement toward the peripheral stimulus was observed, another eye movement pattern was detected under certain conditions. Using the 5 mm paper fixation target and a background illumination of 0.1 footcandles, it was noted by the subject that the central fixation target was lost from view when the peripheral light was turned on. Upon extinguishing the peripheral stimulus, the observer noted through the biomicroscope at 6X that the subject's eye made a short series of small, rapid saccadic movements to refixate the central target. The refixation movements measured 0.13 mm, or approximately 1 prism diopter.

The same refixation movements occurred regardless of peripheral light stimulus location except when the stimulus was placed within the center of the subject's blind spot. When this was done, the subject reported that a minimal glow could still be seen. The subject was able to maintain fixation under this condition. When the stimulus was moved 1 cm toward, or away from the central fixation target, the subject reported the peripheral stimulus became brighter and the central target was no longer visible. The subject's blind spot measured 12 cm wide.

Including the 1 cm of movement in each direction from the central target, this equals 14 cm. A 14 cm circle is approximately an 8 degree area of visual field at 1 meter.

The refixation movement also did not occur when the luminance of the peripheral stimulus was decreased by using a 1 mm aperture. With the aperture in place, the central fixation target did not become lost from view.

DISCUSSION

The hoped for involuntary eye movement toward the peripheral stimulus was not observed in any of our testing procedures. However, a different objective patient response was noted when using the biomicroscope.

This response was observed when the background lighting was very low and a non-luminous central fixation target was used. The response occurs when the brightness of the peripheral light stimulus causes the subject to lose fixation of the central target. Upon extinguishing the peripheral stimulus, an increased frequency of central target refixation movements was observed. The refixation movement was not observed when the peripheral stimulus did not result in the loss of the central target. This occurred if the luminosity of the peripheral stimulus was reduced, or if the peripheral stimulus was placed within the subject's blindspot. With the grain of wheat bulb as the stimulus, scotomas 8 degrees in size or larger could be detected.

This procedure could be clinically useful for the visual field testing of malingerers and those patients who cannot respond to conventional testing.

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