BINOCULAR VISION AND BALANCE MEASUREMENT AND ANALYSIS

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Abstract

An individual's ability to see and function visually is determined largely by the relative contributions of a number underlying components of vision designated as visual abilities. These visual abilities are: acuity, visual field, motility, brain functions and light and colour reception others consider also contrast, accommodation and binocular vision.

The efficacy of our visual system influences the way as we collect and we process the information. It is through the conjugated movement of the two eyes that we can fix and pursue one object. The ocular movements and the binocular vision are linking and they are influence mutually.

The measurement device most often used for measuring eye movements is commonly known as an eye tracker.

In order to characterize the mechanisms of fixation and persecution and the way how binocular vision influences them, we use in our study the Eye Tracking System-ASL 504, because allows an evaluation next to the natural conditions. Our sample was composed by young adults, distributed in two groups, one formed by individuals with normal binocular vision evaluated in two different conditions (binocular and monocular) and another one by individuals with convergence insufficiency, both with 24 participants. The individuals observing a small target, moving in four directions (left-right; right-left; up-down; down-up). The selected variables were: mean duration of the fixation and mean saccadic amplitudes.

The study of normality seems to indicate that the Eye Tracker is an efficient system for the study of the ocular movements (fixation and pursuit).

The eye tracking system that we use showed a good discrimination for the selected variables. We think that this study show the important contribution that eye tracking can give in the analysis, of the functional alterations of the binocular vision, because allows to evaluate them in conditions very next to the reality.

Introduction

Functional vision refers to an individual's ability to use vision in the everyday tasks of real life. An individual's ability to see and function visually is determined largely by the relative contributions of a number underlying components of vision designated for several authors as visual abilities (Corn & Koenig, 1996; Lueck, 2004). These visual abilities are: acuity, visual field, motility, brain functions and light and color reception (Corn & Koenig, 1996) others authors consider also contrast, accommodation and binocular vision (Lueck, 2004; American Academy of Optometry & American Optometric Association, 1999).

The efficacy of our visual system influences the way as we collect and we process the information. It is through the conjugated movement of the two eyes that we can fix and pursue one object. The ocular movements and the binocular vision are linking and they are influence mutually.

The measurement device most often used for measuring eye movements is commonly known as an eye tracker. There are four broad categories of eye tracking methodologies: electro-oculography, scleral contact lens/search coil, photo and video-oculography and video-based combined pupil and corneal reflection (provide the point of the regard measurement).

The objective study of ocular movements in humans remotes to the beginning of 20th century although subjective methods based on the after-image to be used since the beginning of 18th century (Land, 2006).

Robinson (1968) cited by Duchowski (2003) relates that the first method for the objective measurement of the ocular movements was the corneal reflex reported to 1901.

Electro-oculography is one of the methods of register of the ocular movements more used since about forty years ago, and still being very used. It measures the electric differences of potential of the skin, through the electrodes that are placed around the eyes. The recorded potentials are in the range 15-200µV, with nominal sensitivities of order of 20µV/º of eye movement. This technique measures eye movements relative to head position and so is not indicated for point of regard measurements unless head position is also measured using a head tracker Duchowski (2003).

According the last author one of the most precise eye movement measurement methods involves attaching a mechanical or optical reference object mounted on a contact lens which is then worn directly on the eye. This technique evolved to the use of a modern contact lens is necessarily large, extending over the cornea and sclera. Various mechanical or optical devices have been placed on the stalk attached to the lens. The principal method employs a wire coil, which is then measured moving through an electromagnetic field. This method also measures eye position relative to the head. Although the scleral search coil is the most precise eye movement measurement method, it is also the most intrusive method which may cause discomfort.

The photo and video-oculography encloses a great variety of eye movements recording techniques involving the register of other ocular variants as the size of the pupil, the induced position of the limbus and corneal reflections induced for a direct source of light, normally infra red. The register of these variants may or may not be made automatically. These techniques do not made the measurement of the point of fixation. Träisk, Bolzani and Ygge (2005) had compared the techniques of search coil magnetic scleral and the methods of infra red reflection in the analysis of the saccadic movements of the eye. The results had disclosed that the infra-red ray system reaches a higher peak of velocity and generally shows a bigger inter-individual variability.

Although the techniques previously related are generally satisfactory in the measurement of the ocular movements, they do not have in account the point of fixation. In the video-based combined pupil and corneal reflection, having in consideration this fact, the head must be fixed so that the position of the eye relatively to the head coincides with the point of fixation, or then, must be registered other ocular parameters to distinguish the head movements from the eyes movements (e.g., corneal reflex and centre of the pupil). Video-based trackers utilize relatively inexpensive cameras and image processing hardware to compute the point of regard in real-time.

The objective of the analysis of ocular movements through Eye Tracker is to characterize the signal having in account the type of ocular movement that means saccadics and fixation movements. Habitually, the objective of the analysis is to locate regions where the signal brusquely changes position, indicating the end of the fixation and the beginning of saccade. Later the signal assumes a stationary position, indicating the beginning of a new fixation (Duchowski, 2002). The Eye Tracker data allow us to evaluate reading, in a situation near to the natural one, creating new possibilities of characterization of the visual function.

Methods

In order to characterize through fixation and pursuit we opted to study a group of 24 individuals with normal binocular vision (NBV), in conditions of binocularity (NBV1) and monocularity (NBV2), as well as another group also formed for 24 individuals with convergence insufficiency (IC) that is the alteration most frequent of the binocular vision. Our sample was composed by individuals, men and women, with ages between 18 and 23.

To achieve those objectives we had used the following variables: mean duration of the fixation in seconds (left-right LRMD; right-left RLMD; up-down UDMD; down-up DUMD), mean saccadic amplitudes in visual angle degrees (left-right LRMA; right-left RLMA; up-down UDMA; down-up DUMA).

In order to characterize the mechanisms of fixation and persecution and the way how binocular vision influences them, we use in our study the Eye Tracking System-ASL 504, because allows an evaluation next to the natural conditions and in real time.

The Eye Tracking ASL - 504 are a complex device that allows to register two parameters of the eye: the movement of this on the visual field (what it corresponds to the line of vision of an individual) and the size of the pupil. This device allows us, in an objective way (without verbalize), to get the necessary parameters that make possible to identify the individual look point, with a great precision. These registers are based on the size of the pupil and the principle of the corneal reflexion. The equipment is composed for the following components: central system of control and interface; chamber of ocular register of high speed (50, 60, 120 y 240 Hz); monitors (2); software of retraction of data EYEPOS and Software of analysis of data EYENAL.

The used stimulus (scene) was constructed in PowerPoint and presented with resolution of 1024x768 pixels in 60Hz with 15" computer LCD monitor. This stimulus, it consists of a white circle with 5mm of diameter, in its interior presents a black cross with 3mm. The target was displayed on a black background and presented at a distance of 50cm in two horizontal and vertical direction, and in the two possible senses, left to right (LR), right to left (RL), in the horizontal direction and up to down (UD), down to up (DU), in the vertical direction.

The target was shown in the horizontal line (in both senses) in nine sequential positions and in vertical line (in both senses) in seven sequential positions, in each second between each position in both situations.

The register process is based in the size of the pupil and in the corneal reflex. The variables values were obtained from the data analysis using the EYENAL program.

Results

We used the Kolmogorov-Smirnov-Lilliefors and Shapiro-Wilk test to verify if the variables had a normal distribution ((level of significance $p<0,1$). In table 1 we can observe the study of normality. The variables are organized by the carried segments.

We verified that in the segments most usual LR and UD the variables present a normal distribution with exception of the variable MA in the monocularity condition. As for the segments less usual, we verified normality of the data in all variables in conditions of binocularity with exception of MA in the RL, being although, very next to the value of significance (0,095).

Table 1
Test of Normality.

	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
Variables	Statistic	df	Sig.	Statistic	df	Sig.
LRMDNBV1	,117	24	,200(*)	,973	24	**,746**
LRMDNBV2	,100	24	,200(*)	,960	24	**,431**
LRMDCI	,091	24	,200(*)	,981	24	**,906**
LRMANBV1	,125	24	,200(*)	,939	24	**,152**
LRMANBV2	,096	24	,200(*)	,967	24	**,606**
LRMACI	,174	24	,057	,939	24	**,156**
RLMDNBV1	,129	24	,200(*)	,943	24	**,187**
RLMDNBV2	,158	24	,124	,909	24	,033
RLMDCI	,123	24	,200(*)	,978	24	**,852**
RLMANBV1	,146	24	,200(*)	,929	24	,095
RLMANBV2	,114	24	,200(*)	,936	24	**,135**
RLMACI	,191	24	,023	,910	24	,036
UDMDNBV1	,105	24	,200(*)	,960	24	**,439**
UDMDNBV2	,122	24	,200(*)	,956	24	**,361**
UDMDCI	,076	24	,200(*)	,983	24	**,950**
UDMANBV1	,108	24	,200(*)	,980	24	**,895**
UDMANBV2	,168	24	,077	,916	24	,048
UDMACI	,098	24	,200(*)	,984	24	**,955**
DUMDNBV1	,093	24	,200(*)	,967	24	**,588**
DUMDNBV2	,131	24	,200(*)	,924	24	,072
DUMDCI	,148	24	,188	,892	24	,015
DUMANBV1	,105	24	,200(*)	,942	24	**,181**
DUMANBV2	,147	24	,196	,904	24	,026
DUMACI	,183	24	,037	,866	24	,004

* This is a lower bound of the true significance.
a Lilliefors Significance Correction

Discussion/Conclusions

The eye tracking system that we use showed a good discrimination for the selected variables.

The existence of normality in the segments most usual even in situations where the binocular vision is not present or is modified seems to indicate that the Eye Tracker is an efficient system for the study of the ocular movements (fixation and pursuit). The trainings due to the execution of habitual tasks, it will could to favour the existence of normality even in the presence of changes of the binocular vision.

Relatively to the segments less usual where the training factor does not play a determinative paper, the existence of normality in the group of normal binocular vision was only verified, in binocularity conditions, such fact seems to be, mainly, related with the loss of binocularity or with alterations of the binocular vision as it is the case of the convergence insufficiency.

We think that this study show the important contribution that eye tracking can give in the analysis, of the functional alterations of the binocular vision, because allows to evaluate them in conditions very next to the reality. In the context of vision and eye movements, knowledge of the physiological organization of the optic tract as well as of cognitive and behavioural aspects of vision is indispensable in obtaining a complete understanding of human vision (Duchowski, 2003).

References

American Academy of Optometry & American Optometric Association (1999). A Joint Organizational Policy Statement - Vision Therapy: Information for Health Care and Other Allied Professionals.

Corn, A. & Koenig, A. (1996). Foundations of low vision. New York, AFB Press.

Duchowski, A. T. (2002). A breadth-first survey of eye tracking aplications. Behavior Research Methods, Instruments, and Computers, 1, 1-16.Vis Sci, 46, 2914.

Duchowski, A. (2003). Eye tracking methodology – Theory and practice. London, Springer.

Land, M. F. (2006). Eye movements and the control of action in everyday life. Progress in Retinal and Eye Research, 25, 296-324.

Lueck, A. (2004). Functional Vision. New York, AFB Press.

Träisk, F. H. M., Bolzani, R. & Ygge, J. (2005). A comparison between the magnetic scleral search coil and infrared reflection methods for saccadic eye movements. analysis. Invest Ophthalmol.