Eye Tracker, Binocular Vision and Oculomotor Balance

Exploratory Study

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Introduction

It is not clearly determined if vision provokes movement or if it is movement itself that provokes and propitiates the visual search and exploration. Lacks of concentration phenomena, localization mistakes and excessive visual effort are associated with binocular functions alterations and therefore they can restrict or even turn the daily routine in the different areas of the human activity impossible. The study of visual tracking will enable us to characterize the fixation and saccadic movement.

Keywords: eye tracking; binocular vision; monocular vision; convergence insufficiency; fixation

Objective

The study aims to analyse the eye tracking of individuals with alterations of oculomotor balance or of the binocular vision, by comparing them with individuals without these alterations.

Methodology

The individuals Selection obeyed to the following criteria (Table 1):

Table 1: Including criteria.

NBV Group	CI Group
Age ≥ 18 and ≤ 25	Age ≥ 18 and ≤ 25
V. Acuity RE and LE ≥ 8/10	V. Acuity RE and LE ≥ 8/10
Near convergence point ≤ 8cm	Asthenopic symptoms
Near convergence ≥ 25^{Δ} and ≤ 40^{Δ}	At least one of the following:
Near divergence ≥ 8^{Δ} and ≤ 14^{Δ}	Near convergence point ≥ 11cm
Near stereopsis ≤ 40''	Near convergence ≤ 19^{Δ}
Maddox wing ≤ 4^{Δ} X or E	Maddox wing ≥ 6^{Δ} E

The sample consisted of 40 individuals men and woman, with ages between 18 and 23. They were divided into two groups. The first one was composed by individuals with normal binocular vision (NBV) evaluated in two different conditions (binocular and monocular). The second group was composed by individuals with convergence insufficiency (CI), (Table2).

Table 2: Sample characterization.

	Total Sample			NBV Group			CI Group		
	N	Percent	Mean Age	N	Percent	Mean Age	N	Percent	Mean Age
Men	4	10%	21,3	3	15,8%	22,0	1	4,8%	19,0
Woman	36	90%	20,3	16	84,2%	20,1	20	95,2%	20,6
Total	40	100%	20,4	19	100%	20,4	21	100%	20,5

The Eye Tracker System ASL – 504 was used to study the eye tracking behaviour of the two groups. The register process was based in the size of the pupil and in the corneal reflection. The individuals were placed in front of a computer monitor at 50cm distance, observing a small white target in a black background, moving in four directions (left-right; right-left; up-down; down-up).

To analyze eye tracking behaviour we used the following variables: number of fixations (left-right LRF; right-left RLF; up-down UDF; down-up DUF), number of inversions (left-right LRI; right-left RLI; up-down UDI; down-up DUI), 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). The values of the variables were obtained from the data analysis using the EYENAL program.

The first part of our study includes the analyses of the above mentioned variables concerning the NBV group and CI group. The second one was concerned with the analyses of the two different conditions of NBV group (binocular and monocular).

Results

Using the Kolmogorov-Smirnov-Lilliefors and Shapiro-Wilk, we observed that the variables (LRMD, LRMA, RLMD, RLMA, UDMD, UDMA, DUMD, DUMA), had a normal distribution. A parametric test (T-test) was then used.

Concerning variables LRF, LRI, RLF, RLI, UDF, UDI, DUF, DUI, a nonparametric test (Mann-Whitney, Wilcoxon) was used. The significance level used was $p \leq 0.05$.

As for the comparison between the NBV group and CI group no significant differences were found in all variables except for the number of fixations from left-right and right-left directions, in the number of inversions from the right-left, as we can observe in Table 3, and in the variables mean duration of fixation and mean saccadic amplitudes (Table 4).

Table 3: Number of fixations and inversions - NBV and CI group.

Mann-Whitney Test			
	LRF	RLF	RLI
Mann-Whitney U	111,500	68,500	127,500
Wilcoxon W	301,500	258,500	317,500
Z	-2,419	-3,577	-2,129
Asymp. Sig. (2-tailed)	,016	,000	,033

In the last two variables (mean duration of fixation and mean saccadic amplitudes) we observed a significant difference in the saccadic amplitudes concerning the left-right direction and the mean duration of fixation in the opposite direction, right-left (Table 4).

Table 4: Mean duration of fixation and mean saccadic amplitudes - NBV and CI group.

T-Test – Independent Samples			
Variables	t	df	Sig. (2-tailed)
LRMA	2,254	38	,030
RLMD	4,128	38	,000

Table 5: Number of fixations and inversions NBV group (binocular and monocular conditions).

Wilcoxon Test		
	LRF2 LRF1	RLF2 RLF1
Z	-2,652(a)	-2,872(a)
Asymp. Sig. (2-tailed)	,008	,004

Regarding the comparison between the two conditions of the NBV group (binocular and monocular) we observed the existence of significant differences in the number of fixations from left-right and right-left directions, as showed in Table 5.

Concerning the variables mean duration of fixation and mean saccadic amplitudes we also observed a significant difference in the saccadic amplitudes concerning the left-right and the right-left direction and the mean duration of fixation in the same two directions (Table 6).

Table 6: Mean duration of fixation and mean saccadic amplitudes NBV group (binocular and monocular conditions).

T-Test – Paired Samples				
Variables		t	df	Sig. (2-tailed)
Par 1	LRMD1 LRMD2	2,854	18	,011
Par 2	LRMA1 LRMA2	2,684	18	,015
Par 3	RLMD1 RLMD2	2,582	18	,019
Par 4	RLMA1 RLMA2	3,296	18	,004

Conclusions

The analysis of the studied variables showed that the absence of binocularity or the alterations of that condition, as in the convergence insufficiency, entail clearly a loss of the quality of visual pursuit.

In monocular conditions or in the presence of a convergence insufficiency, the mean duration of the fixations as well the saccadic amplitude is diminished.

In relation to the NBV group in binocular conditions the number of fixations and inversions presents lower values than the CI group and NBV group, in monocular conditions. It seams, thus, that binocular condition fixations and saccadic movements are more stable, showing that visual pursuit had a better accuracy when synergy and synchronism of the eyes are present.

A normal binocular vision guarantees a physiological answer in the movements of pursuit of the gaze, which contributes to added quality. The maintenance or the re-establishment of normal binocular vision is fundamental for adequate visual comfort in the performance of daily life activities.