

COMPARATIVE STUDY OF THREE DIFFERENT STEREOPSIS TESTS: TNO®, FLY STEREO ACUITY TEST® AND STEREO TAB®, IN STUDENTS IN HIGHER SCHOOL

Ilda Maria Poças, MSc; Ruben Morais, MD, Ana Miguel, MD, Denise Monteiro, MD, Cleide Cassandra, MD

Escola Superior de Tecnologia da Saúde de Lisboa, Instituto Politécnico de Lisboa, Portugal

INTRODUCTION:

Stereopsis is the perception of depth based on retinal disparity that can be fused for single vision (fine stereopsis). Global stereopsis depends on the process of random dot stimuli and local stereopsis depends on contour perception^{1,2}.

Stereopsis evaluation can be made through two types of procedures: anaglyphic, through the use of filters green/red or red/cyan; and vectograph, through the use of polarized filters³

The anaglyphic assessment is associated with random dot stereograms where there are no specific contours. There's lack of form only if there is retinal horizontal disparity associated with corresponding retinal areas – global stereopsis³ - TNO® and StereoTAB®.

The vectographic assessment is associated with tests of stereograms with outlines, which provide the viewer perceived monocular outlines - local stereopsis³ – Fly Stereo Acuity Test®. The retinal horizontal disparity in local stereopsis, does not depend on any other reference to the corresponding area of retina, facilitating the fusion process and reducing the need for precise oculomotor control³.

StereoTAB® is an electronic test, with an application for tablets, that uses random dot stereograms and red/cyan filters.

The TNO®, uses a random dot pattern with red/green filters, allowing each filter to isolate the corresponding color image in each eye, occurring disparity. Since there is no global stereopsis in the absence of local stereopsis, we choose this test as a reference in this study (gold standard)⁴.

AIM:

- ❖ Comparison of stereopsis values using three different tests to evaluate the results of local and global stereopsis: Fly Stereo Acuity Test® (Fly Test®), StereoTAB® and TNO®, considering the last one as a gold standard.
- ❖ Study of the correlation of stereopsis between all tests
- ❖ Study of the correlation between the TNO®, the Fly Stereo Acuity Test®, and the StereoTAB®
- ❖ Comparison of the accuracy of Fly Stereo Acuity Test® and the StereoTAB
- ❖ Study of the sensitivity and specificity of the Fly Stereo Acuity Test and StereoTAB
- ❖ Analysis of the correlation between vergences, near convergence point correction and symptomatology in relation to the results obtained in each test
- ❖ Determination of the applicability of StereoTAB® in clinical study.

Subjects - Forty-nine students from Escola Superior de Tecnologia da Saúde de Lisboa

(ESTE SL), with between 18-26 years of age were included.

Exclusion criteria:

- vision acuity (VA) of less than 0.8 to near vision and/or distance vision
- heterophorias with slow recovery and heterotropias.
- cover test to near (nf) and distance fixation (df)
- vergences (convergence and divergence) to nf and df with a fixated object
- near convergence point

Before stereopsis study was tested the binocular vision: - cover test to near (nf) and distance fixation (df)

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The VA was measured monocularly in both distance: 33 cm and 6 m with ETDRS scale.

Stereopsis was measured on each subject using:

- TNO®, test plates V-VII (15 a 480 seconds of arc) with red/green filters in fotopico environment, a 40 cm (Figure 1);
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It was considered normal stereopsis ≤65 seconds of arc and abnormal stereopsis >65 seconds of arc⁵.

RESULTS:

The sample was composed by 49 individuals: 38 (77.6%) were female and 11 (22.4%) males, with average age of 21.53 ± 1.52 years. Average values of Stereopsis: TNO® = 87.04 " ± 84.09 "

Fly Test® = 38.18 " ± 34.59 "
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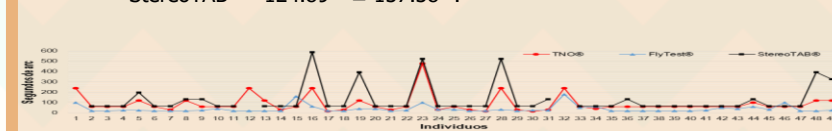


Figure 4, shows that there is a certain standard of responses between the values of the TNO® and StereoTAB®, with a tendency to be higher (< stereoscopic vision). In turn, the Fly Test® shows better results of stereopsis.

Values obtained in all tests were abnormal (28.6% in StereoTAB®, 26.5% in the TNO® and 10.20% in Fly Test®).

MATERIALS AND METHODS:



Figure 1. TNO®



Figure 2. Fly Stereo Acuity Test®



Figure 3. StereoTab®

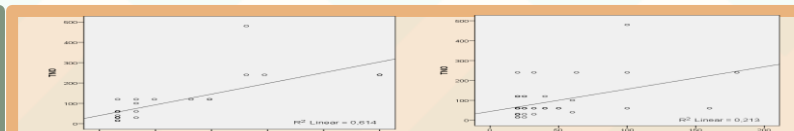


Figure 5 e 6: Scatterplot of TNO vs Stereo TAB and TNO vs Fly Test.

The association analysis of TNO® with StereoTAB® it was obtained a Phi and Cramer's V = 0.848 (p=0,000), with contingency coefficient (CC) of 0.647. In turn, the association of TNO® with the Fly Test®, it was obtained a Phi and Cramer's V = 0.256 (p=0,74) with CC 0.248. Spearman's correlation coefficient showed a positive correlation between TNO® and StereoTAB® (r = 0.784). The ROC curve (Figure 7) of StereoTAB® is close to the corner (0,1) of the unit square. With an area under the curve (AUC) of 0.934 compared with Fly Test®, with an AUC of 0.588, showing that StereoTAB® achieved the highest performance.

The study of sensitivity and specificity of the StereoTAB® and FlyTest®, having the TNO® as gold standard, there is a 92.3% sensitivity for the StereoTAB® and 23.1% for the FlyTest® and a specificity of 94.4%.

There was no association between the Stereopsis measured by each test and independent variables (symptomatology, optical correction, near convergence point and vergences).

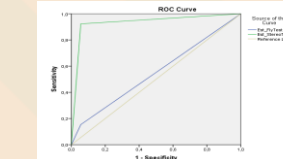


Figure 7. ROC curve of Stereopsis tests tested

DISCUSSION/CONCLUSION:

Fly Test® achieved the best values of stereopsis for studying the local stereopsis. Our results meet other studies^{3,6}.

The coefficient of determination of the scatter plot, it turns out that there is a pattern at 61.4% of individuals where the greater the stereopsis in TNO® is greater that of the StereoTAB®.

Phi Association coefficient and CC, it was found that there is a strong association between the TNO® and the StereoTAB®, showing a significant positive correlation in the results, as opposed to the weak association between the TNO® and the Fly Test®. The highest value of AUC was obtained by StereoTAB®, indicating that the accuracy is higher, showing the best discriminatory power. The Fly Test®, is a good test to detect people who have normal stereopsis, considering the values obtained for specificity. Taking into account the high values of sensitivity and specificity in the StereoTAB® test, this is indicated for individuals who correctly sensing the stereopsis abnormal and normal, making feasible its application, with advantage of being a digital test, with easy access.

References: ¹Giaschi D, Narasimhan S, Solski A, Harrison A, Wilcox L. On the typical development of stereopsis: Fine and coarse processing. *Vision Research*. 2013; 53:136-139 // ²Lee SY, Koo NK. Change of Stereodacuity with Aging in Normal Eyes. *Korean Journal of Ophthalmology*. 2005; 19(2):136-139 // ³Momeni-Moghadam H, Kundart J, Ehsani M, Gholami K. Stereopsis with TNO and Titmus Tests in Symptomatic and Asymptomatic University Students. *Journal of Behavioral Optometry*. 2012; 2(23):35-39 // ⁴Fricke T, Siderov J. Stereopsis, stereotests, and their relation to vision screening and clinical practice. *Clinical and Experimental Optometry*. 1997; 80(5):165-172 // ⁵Zaroff C, Knutelska M, Frumkes T. Variation in stereoaucuity: normative description, fixation disparity, and the roles of aging and gender. *Investigative Ophthalmology & Visual Science*. 2003; 44(2):891-900 // ⁶Yamada T, Scheiman M, Mitchell L. A comparison of stereopsis testing between red/green targets and polarized targets in children with normal binocular vision. *Optometry*. 2008; 79:138-142

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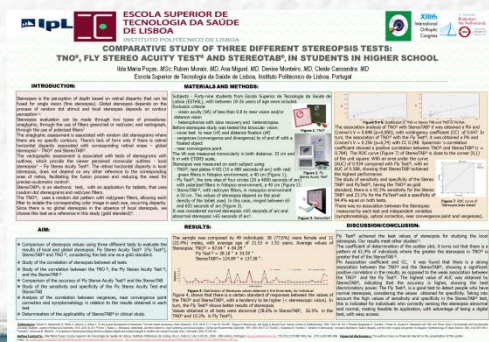
27 - 30 June 2016
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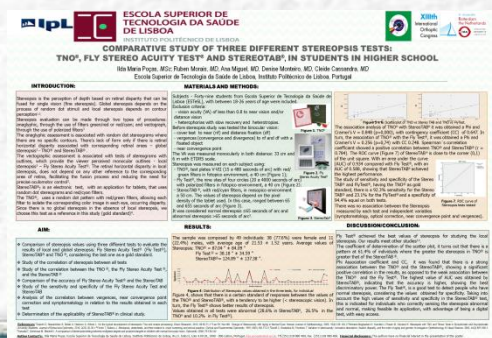
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There's lack of form only if there is retinal horizontal disparity associated with corresponding retinal areas

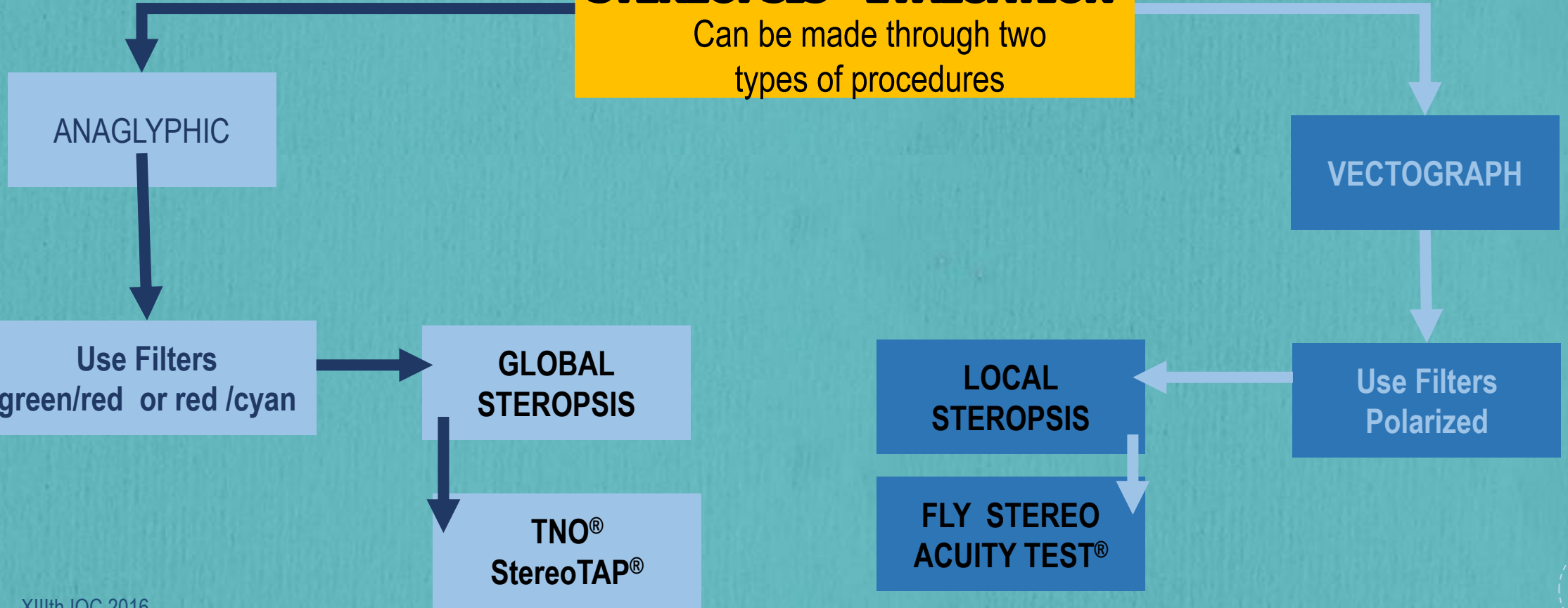
Local stereopsis depends on contour perception.
The retinal horizontal disparity does not depend on any other reference to the corresponding retinal areas, facilitating the fusion process and reducing the need for precise oculomotor control³.



COMPARATIVE STUDY OF THREE DIFFERENT STEREOPSIS TESTS: TNO®, FLY STEREO ACUITY TEST® AND STEREO TAB®, IN STUDENTS IN HIGHER SCHOOL

INTRODUCTION

STEREOPSIS - EVALUATION
Can be made through two
types of procedures



COMPARATIVE STUDY OF THREE DIFFERENT STEREOPSIS TESTS: TNO®, FLY STEREO ACUITY TEST® AND STEREO TAB®, IN STUDENTS IN HIGHER SCHOOL

INTRODUCTION

GLOBAL STEROPSIS

LOCAL STEROPSIS



TNO®

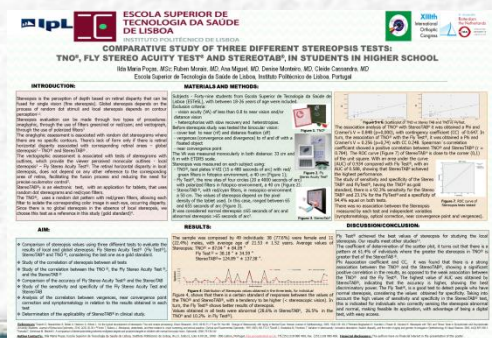
Gold Standard

StereoTAB®

FLY STEREO ACUITY TEST®

Use a random dot pattern, allowing each filter to isolate the corresponding color image in each eye, occurring disparity.

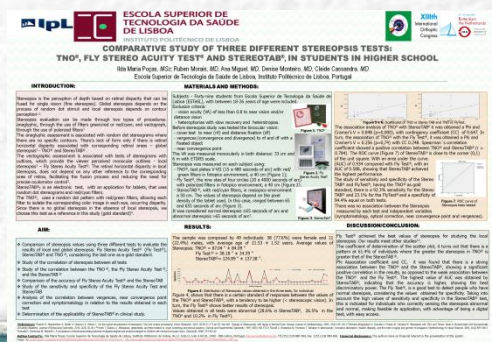
Is an electronic test, with an application for tablets. Use random dot stereograms and red/cyan filters.



COMPARATIVE STUDY OF THREE DIFFERENT STEREOPSIS TESTS: TNO®, FLY STEREO ACUITY TEST® AND STEREO TAB®, IN STUDENTS IN HIGHER SCHOOL

THE AIM OF THIS STUDY WAS:

- ❖ Comparison of stereopsis values using three different tests: Fly Stereo Acuity Test® (Fly Test®), StereoTAB® and TNO®, considering the last one as gold standard
- ❖ Study of the correlation of stereopsis between all tests
- ❖ Study of the sensitivity and specificity of the Fly Stereo Acuity Test® and StereoTAB®
- ❖ Analysis of the correlation between vergences, near convergence point, correction and symptomatology in relation to the results obtained in each test
- ❖ Determination of the StereoTAB® applicability in clinical study.



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MATERIALS and METHODS

Forty-nine students from Escola Superior de Tecnologia da Saúde de Lisboa (ESTeSL), between 18-26 years of age were included.

Exclusion criteria: - vision acuity (VA) of less than 0.8 to near vision and/or distance vision

Before stereopsis study was tested the binocular vision:

- cover test to near (nf) and distance fixation (df)
- vergences (convergence and divergence) to nf and df with a fixated object
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The Vision Acuity was measured monocularly with ETDRS scale, to near and distance – 33 cm and 6m
Stereopsis was measured on each subject using:

- TNO®, test plates V-VII (15 a 480 seconds of arc)
- Fly Test®, the nine stes of four circles (20 a 4000 seconds of arc)
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RESULTS

The sample was composed by 49 individuals: 38 (77.6%) were female and 11 (22.4%) males, with average age of 21.53 ± 1.52 years.

Average values of Stereopsis: TNO® = 87.04" ± 84.09"
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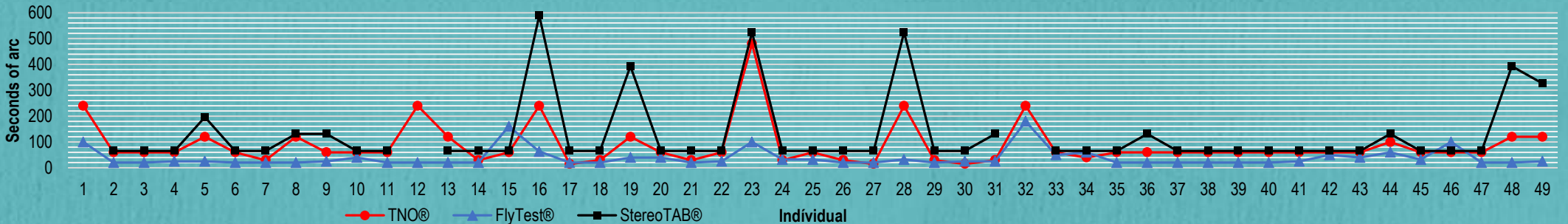
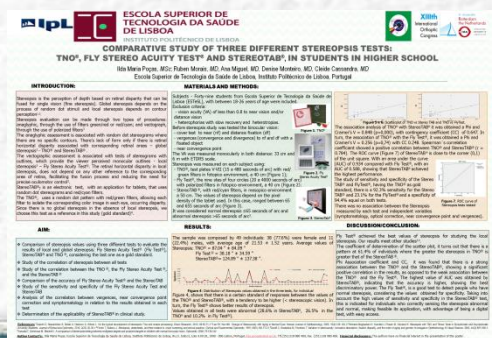


Figure 1. Distribution of Stereopsis values obtained in the three testes, for individual

The Figure, shows that there is a certain standard of responses between the values of the TNO® and StereoTAB®, with a tendency to be higher (< stereoscopic vision).

In turn, the Fly Test® shows better results of stereopsis. Values obtained in all tests were abnormal (28.6% in StereoTAB®, 26.5% in the TNO® and 10.2% in Fly Test®).



COMPARATIVE STUDY OF THREE DIFFERENT STEREOPSIS TESTS: TNO®, FLY STEREO ACUITY TEST® AND STEREO TAB®, IN STUDENTS IN HIGHER SCHOOL

RESULTS

❖ **Spearman's correlation coefficient** showed a positive correlation between TNO® and StereoTAB®

($r=0.784$)

❖ The ROC curve of StereoTAB® is close to the corner (0,1) of the unit square. **The StereoTAB®** achieved the highest performance.

❖ **The study of sensitivity** and specificity of the StereoTAB® and FlyTest®, having the TNO® as gold standard, showed there is more sensitivity for StereoTAB® (92.3%) and 23.1% for the FlyTest® and a specificity equal on both tests (94.4%)

❖ **There was no association** between the Stereopsis measured by each test and independent variables (symptomatology, optical correction, near convergence point and vergences).

Correlations					
		Est_TNO	Est_FlyTest	Est_StereoTAB	
Spearman's rho	Est_TNO	Correlation Coefficient	1,000	,158	,848**
		Sig. (2-tailed)	.	,277	,000
		N	49	49	49
Est_FlyTest	Est_TNO	Correlation Coefficient	,158	1,000	,141
		Sig. (2-tailed)	,277	.	,332
		N	49	49	49
Est_StereoTAB	Est_TNO	Correlation Coefficient	,848**	,141	1,000
		Sig. (2-tailed)	,000	,332	.
		N	49	49	49

** . Correlation is significant at the 0.01 level (2-tailed).

Figure 2. Spearman's correlations

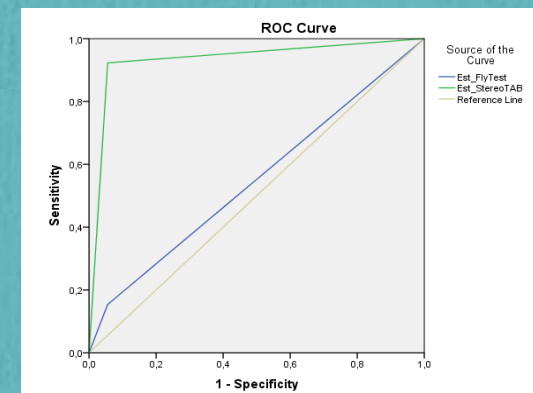
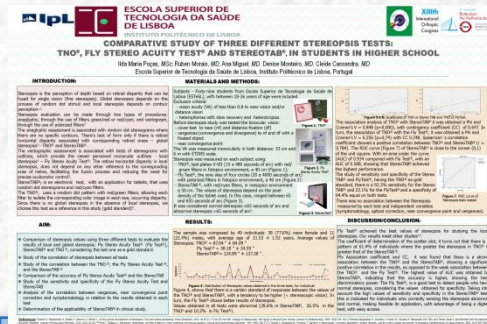


Figure 3. ROC curve of Stereopsis tests tested



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DISCUSSIONS/CONCLUSION

GLOBAL STEROPSIS

LOCAL STEROPSIS

TNO® StereoTAP®

FLY STEREO ACUITY TEST®

Strong association showing a significant positive correlation in the results. Where the greater the stereopsis in TNO® is greater that of the StereoTAB® (The coefficient of determination of the scatter plot)

Showned the best values of stereopsis
Our results meet other studies^{3,6}
Have a high specificity values.
Is the less sensitivity test.
Is a good test to detect people who have normal stereopsis.

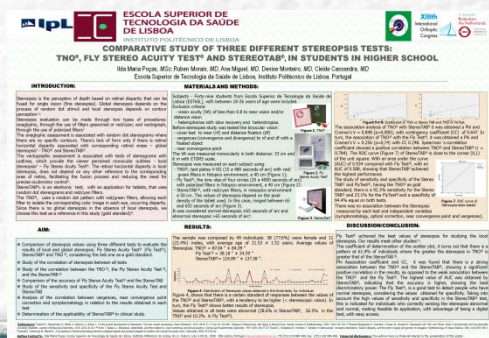
TNO®

Fly Test®

As opposed to weak association between the TNO® and the Fly Test®.

StereoTAP®

The best discriminatory power. Is the test with more sensitivity and specificity (very high values).
Is indicated for individuals who correctly sensing the stereopsis abnormal and normal.
Advantage of being a digital test, with easy access.



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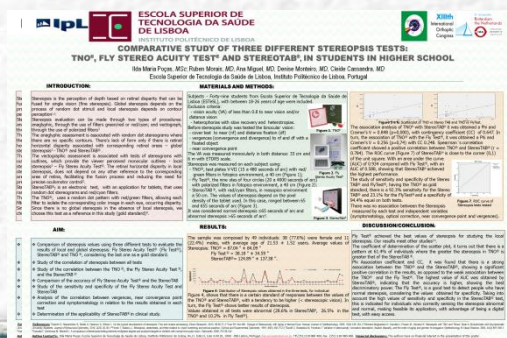
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Thank You

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Financial disclosure:

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http://www.graftonoptical.com/assets/products/775/thumbs/large_1282824011_AC7305001Stereo_TNO.jpg

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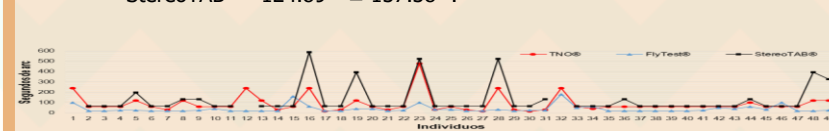


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Figure 1. TNO®



Figure 2. Fly Stereo Acuity Test®



Figure 3. StereoTab®

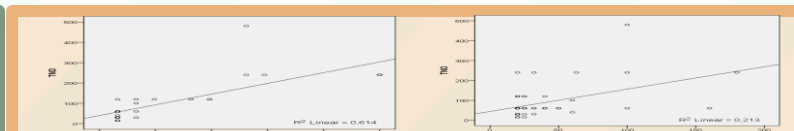


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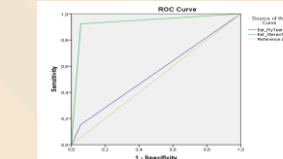


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Fly Test® achieved the best values of stereopsis for studying the local stereopsis. Our results meet other studies^{3,6}.

The coefficient of determination of the scatter plot, it turns out that there is a pattern at 61.4% of individuals where the greater the stereopsis in TNO® is greater that of the StereoTAB®.

Phi Association coefficient and CC, it was found that there is a strong association between the TNO® and the StereoTAB®, showing a significant positive correlation in the results, as opposed to the weak association between the TNO® and the Fly Test®. The highest value of AUC was obtained by StereoTAB®, indicating that the accuracy is higher, showing the best discriminatory power. The Fly Test®, is a good test to detect people who have normal stereopsis, considering the values obtained for specificity. Taking into account the high values of sensitivity and specificity in the StereoTAB® test, this is indicated for individuals who correctly sensing the stereopsis abnormal and normal, making feasible its application, with advantage of being a digital test, with easy access.

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