

An automated and objective cover test to measure phoria

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Disclosures

None of the authors have any commercial relationship related with this presentation.

Background

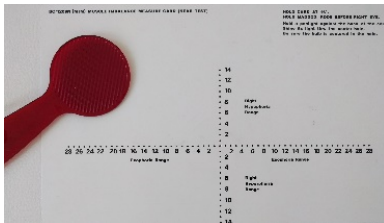
Clinical methods to measure phoria:

Prism cover test

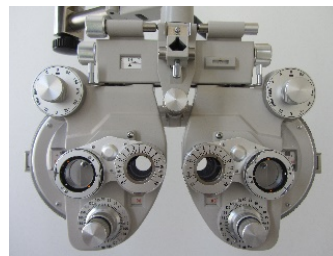


Maddox rod

Modified Thorington test



Von Graefe



Limitations:

- Subjectivity (patient, examiner)
- Poor resolution
- Covered eye cannot be observed
- Poor repeatability
- Limited field of view
- Unusual viewing conditions
- ...



overcome by using eye tracking systems

Purpose

To validate an automated and objective cover test to measure near phoria with an eye-tracker and compare its performance with the prism cover test and the modified Thorington test.

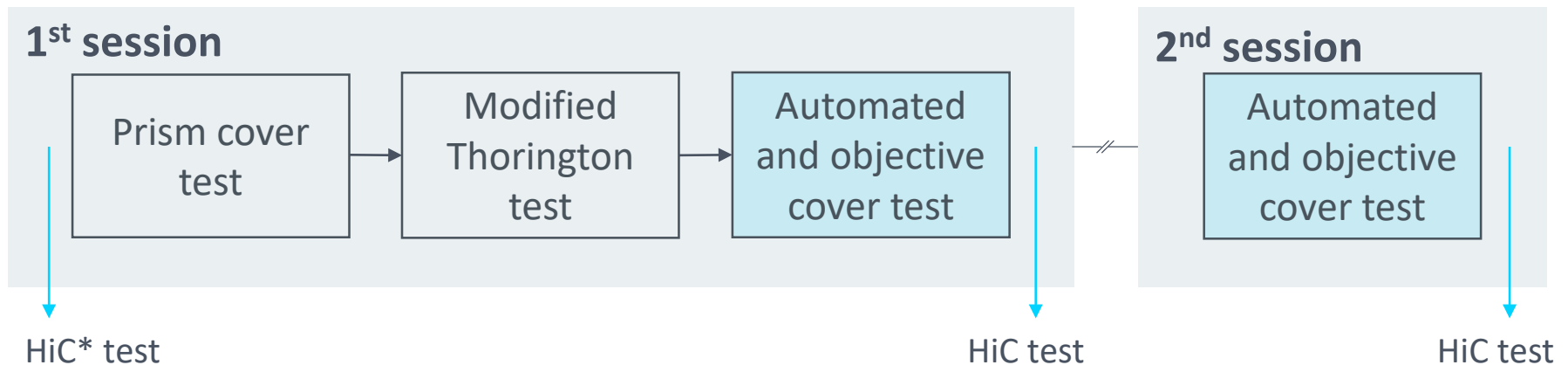
To analyze the effect of ocular dominance on the magnitude of phoria.

Methods

Subjects

- 30 participants
- Age from 21-38 years (mean \pm SD: 27.9 \pm 4.6 years)
- 20/25 or better corrected visual acuity at far and near distance
- Horizontal phoria at near from 14 PD esophoria to 14 PD exophoria (Prism cover test)
- No strabismus

Experimental procedure



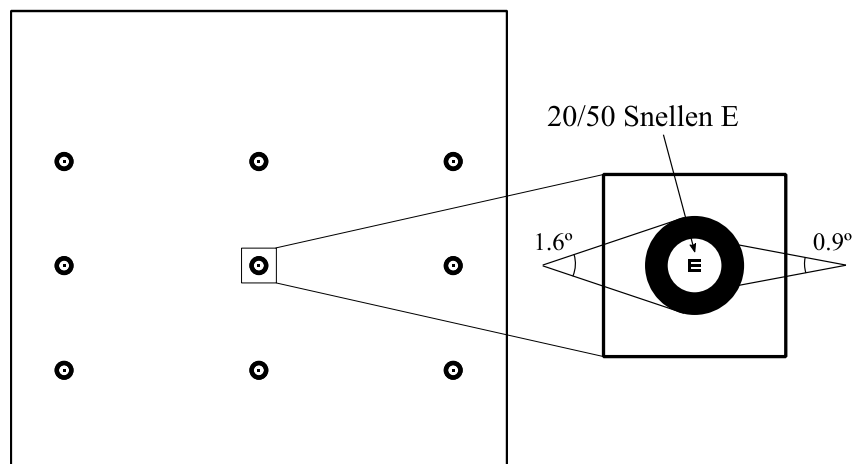
* Hole-in-the-Card test

Methods

Automated and objective cover test

Visual stimulus:

It covered a visual field of more than 40° at 40 cm.



Eye-tracker: EyeLink 1000 Plus at 250 Hz

Fusional vergence disrupted by means of two pairs of motorized crossed polarizers

Methods

Automated and objective cover test

Cover test sequence:



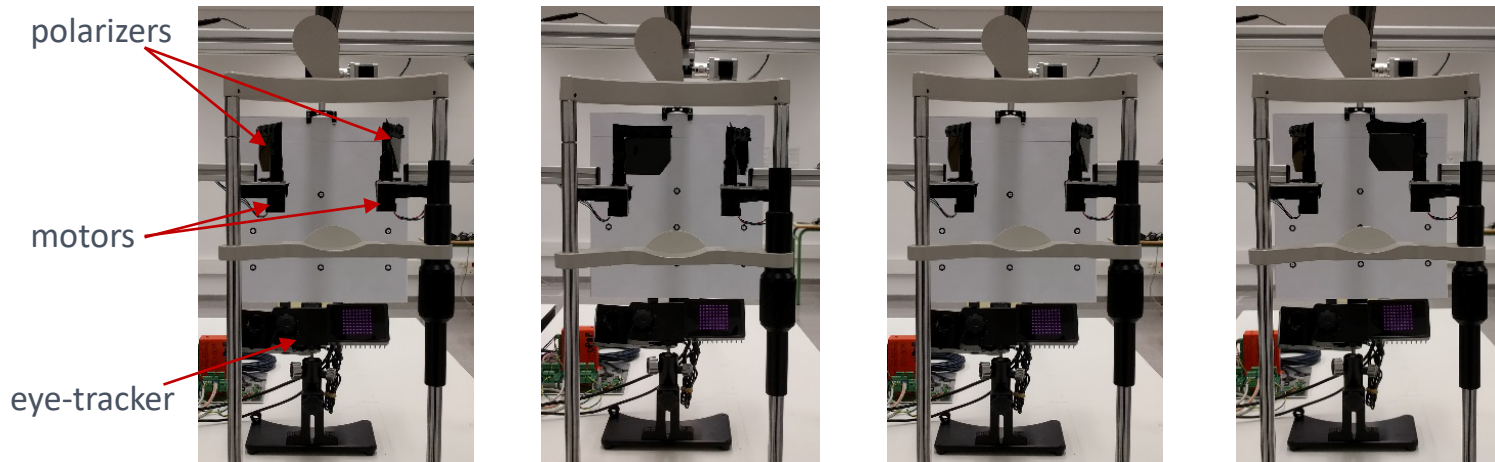
x 3

5 s

10 s

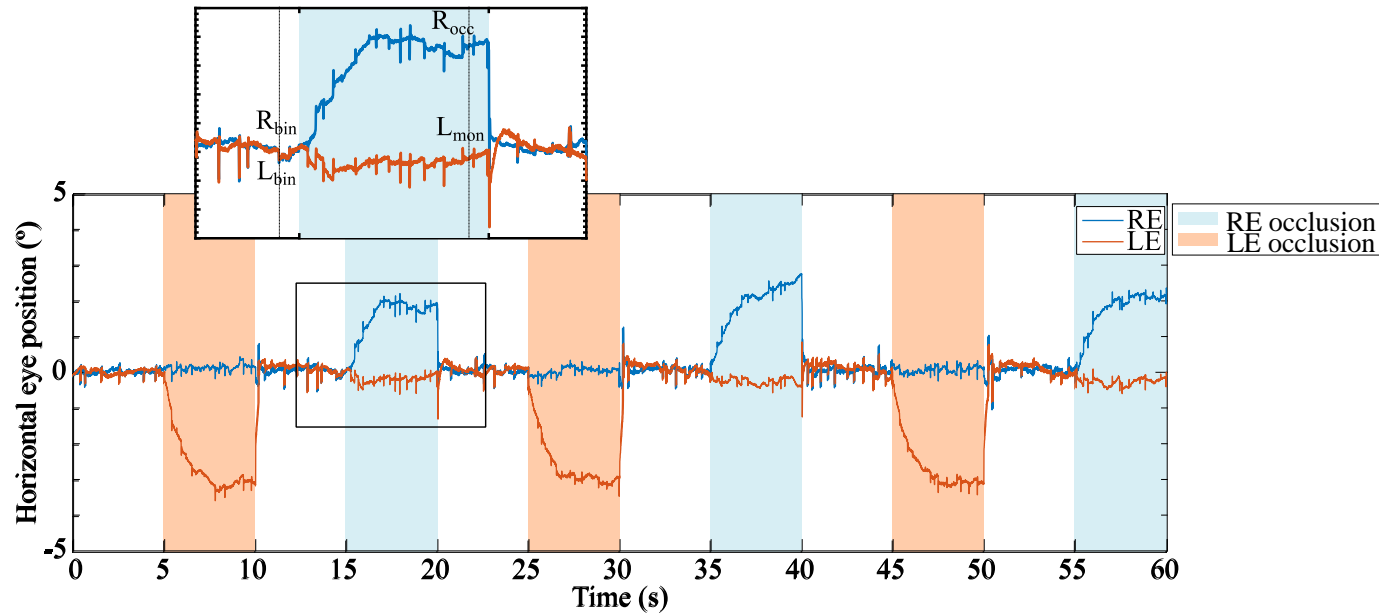
15 s

20 s



Methods

Automated and objective cover test



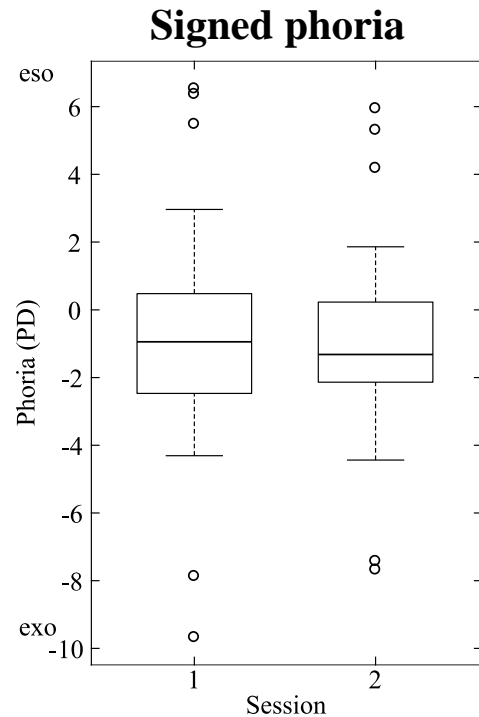
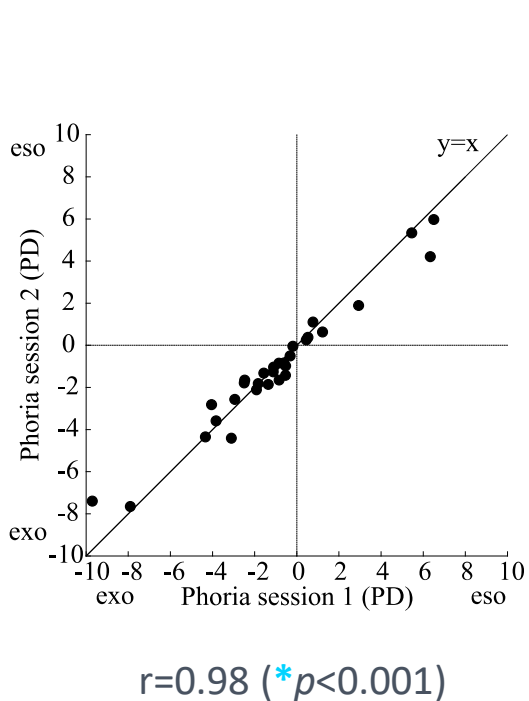
$$phoria\ RE = |R_{occ} - R_{bin}| - |L_{mon} - L_{bin}|$$

$$phoria = \text{median}\{phoria\ LE_1; phoria\ RE_1; phoria\ LE_2; phoria\ RE_2; phoria\ LE_3; phoria\ RE_3\}$$

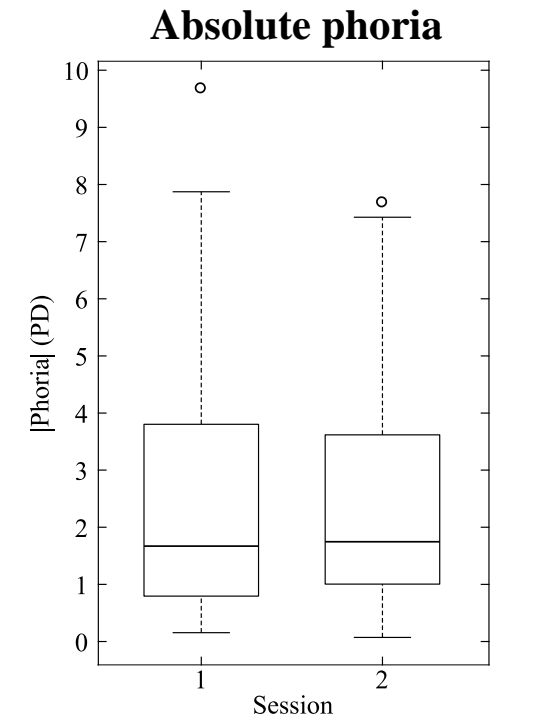
Results

Repeatability

Intersession repeatability:



Mean diff \pm SD: 0.15 ± 0.79 PD
(Paired t test: $p>0.05$)

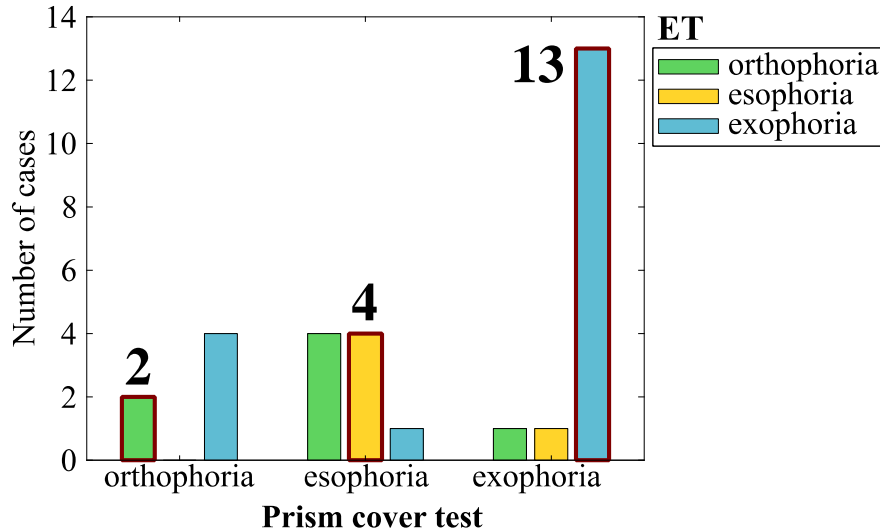


Mean diff \pm SD: 0.18 ± 0.79 PD
(Paired t test: $p>0.05$)

Results

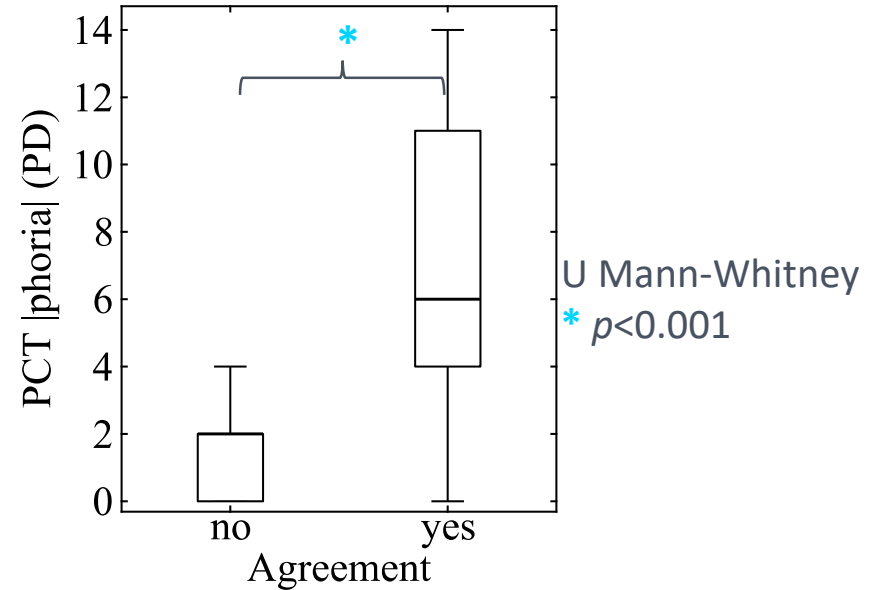
Agreement

Direction of the deviation: PCT – ET pair



The direction of the deviation measured with the PCT and the ET agreed in 63.3% of the cases.

PCT: Prism cover test
 TH: Modified Thorington test
 ET: Automated and objective cover test
 orthophoria: deviation < 1 PD

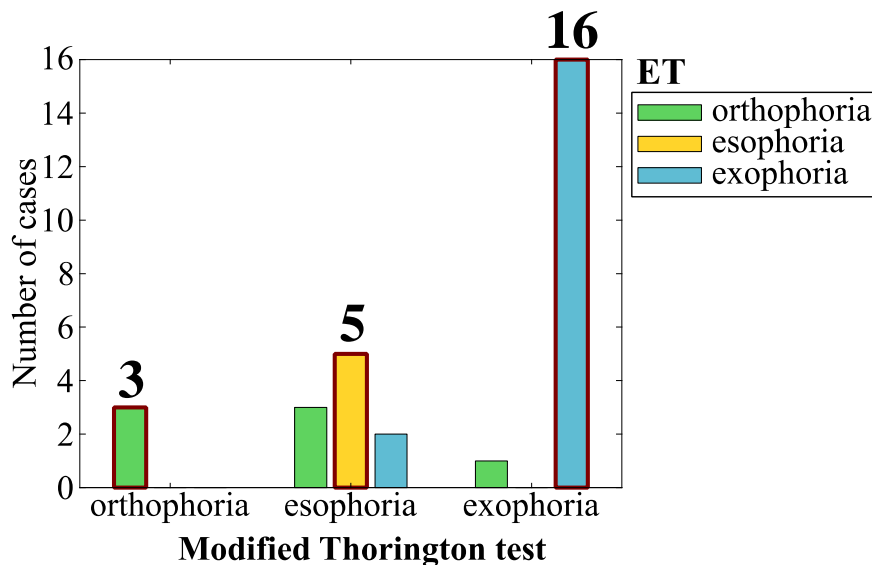


The magnitude of phoria of the cases in which there was not agreement was significantly smaller.

Results

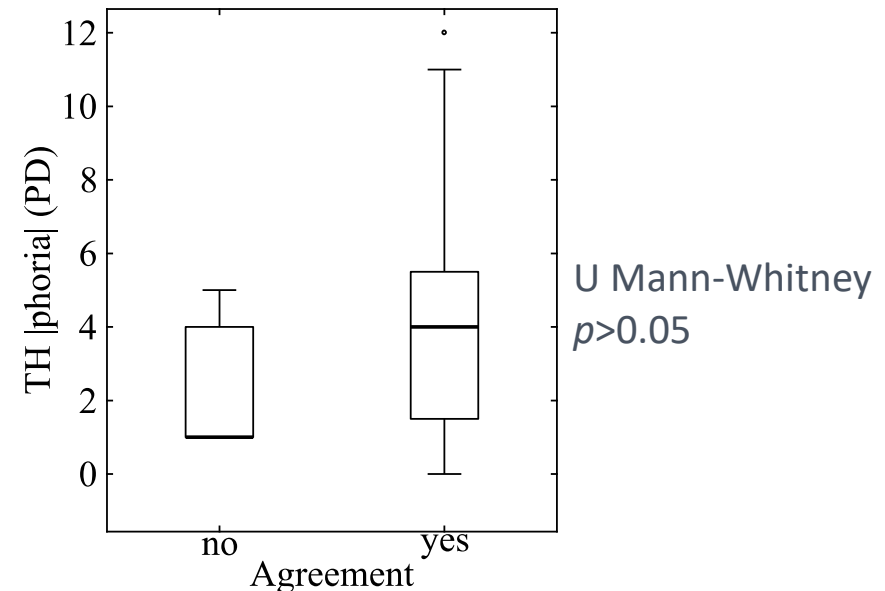
Agreement

Direction of the deviation: TH – ET pair



The direction of the deviation measured with the TH and the ET agreed in 80% of the cases.

PCT: Prism cover test
 TH: Modified Thorington test
 ET: Automated and objective cover test
 orthophoria: deviation < 1 PD

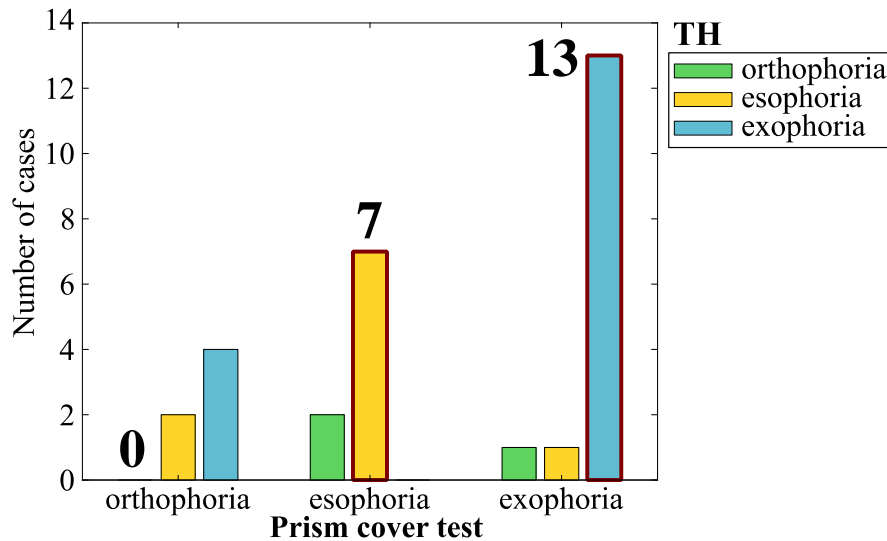


The magnitude of phoria was not significantly different.

Results

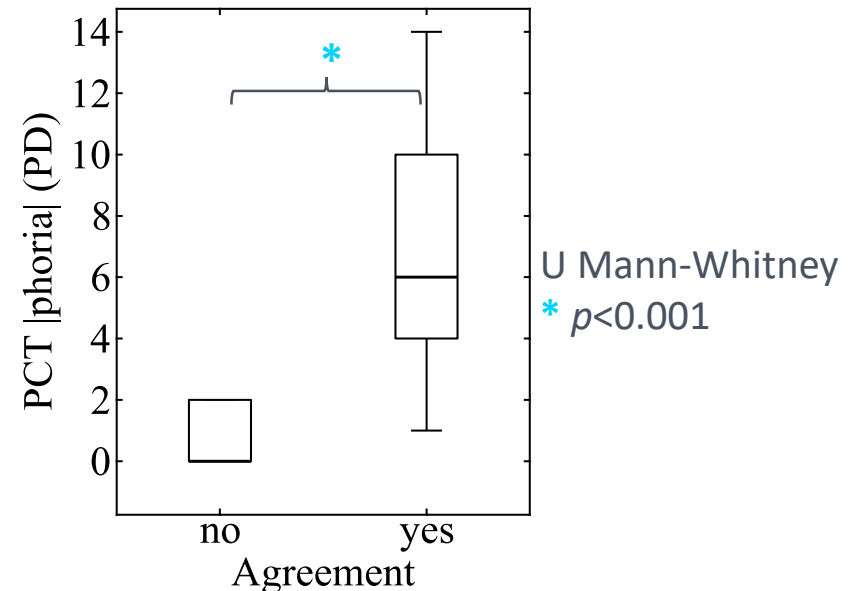
Agreement

Direction of the deviation: PCT - TH pair



The direction of the deviation measured with the PCT and the TH agreed in 66.7% of the cases.

PCT: Prism cover test
 TH: Modified Thorington test
 ET: Automated and objective cover test
 orthophoria: deviation < 1 PD



The magnitude of phoria of the cases in which there was not agreement was significantly smaller.

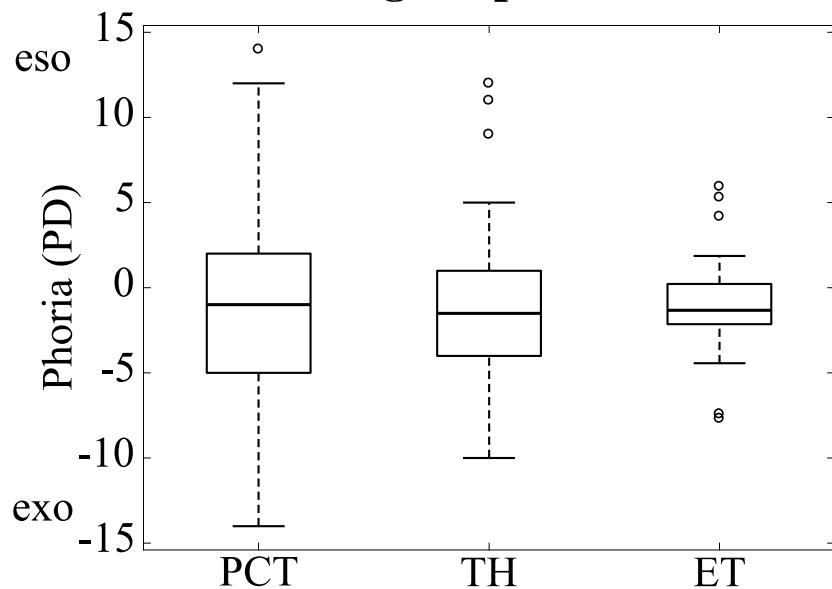
Results

Agreement

Magnitude of the phoria:

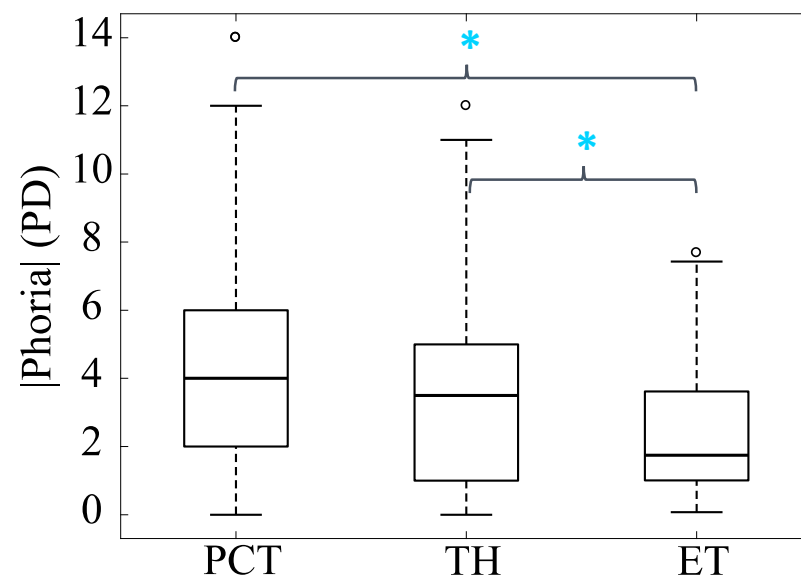
PCT: Prism cover test
 TH: Modified Thorington test
 ET: Automated and objective cover test

Signed phoria



Repeated measures ANOVA: $p=0.71$

Absolute phoria



Friedman: * $p=0.006$

Results

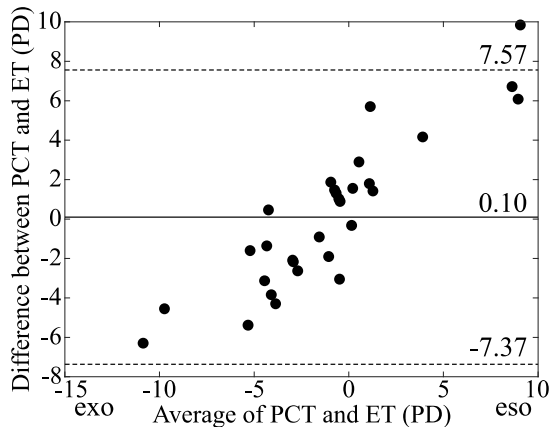
Agreement

PCT: Prism cover test
 TH: Modified Thorington test
 ET: Automated and objective cover test

Magnitude of the phoria:

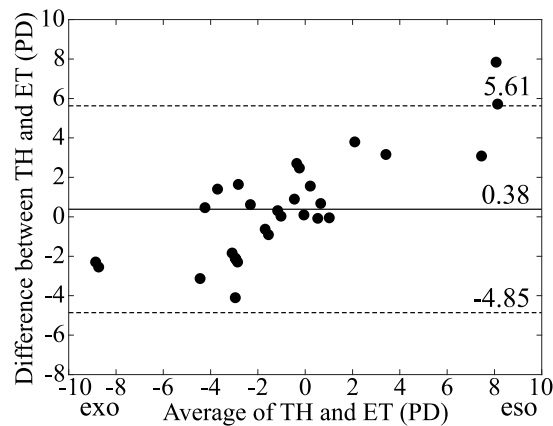
None of the methods were clearly biased towards more esophoric or exophoric values.

PCT – ET pair



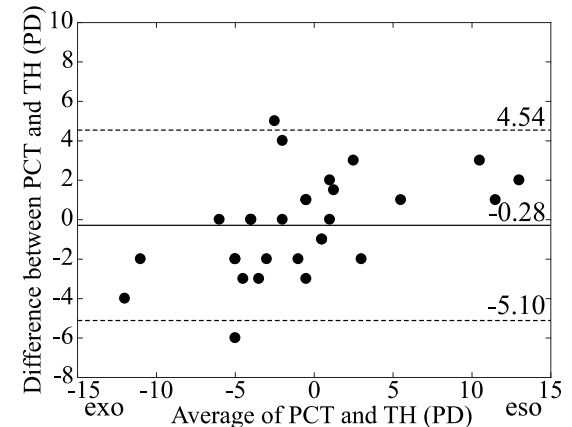
$r=0.90$; * $p<0.001$

TH – ET pair



$r=0.81$; * $p<0.001$

PCT – TH pair



$r=0.51$; * $p=0.004$

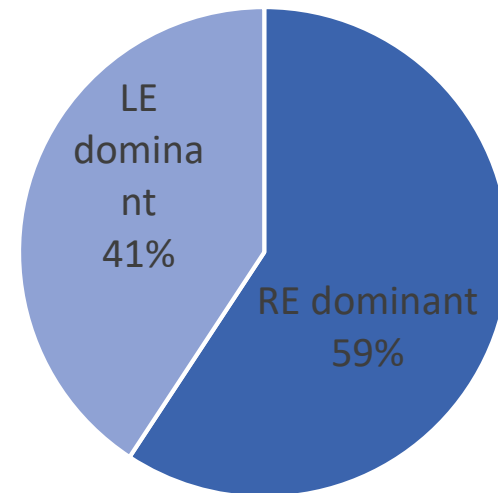
Results

Effect of ocular dominance on phoria

$$phoria_{RE} = \text{median}\{phoria_{RE_1}; phoria_{RE_2}; phoria_{RE_3}\}$$

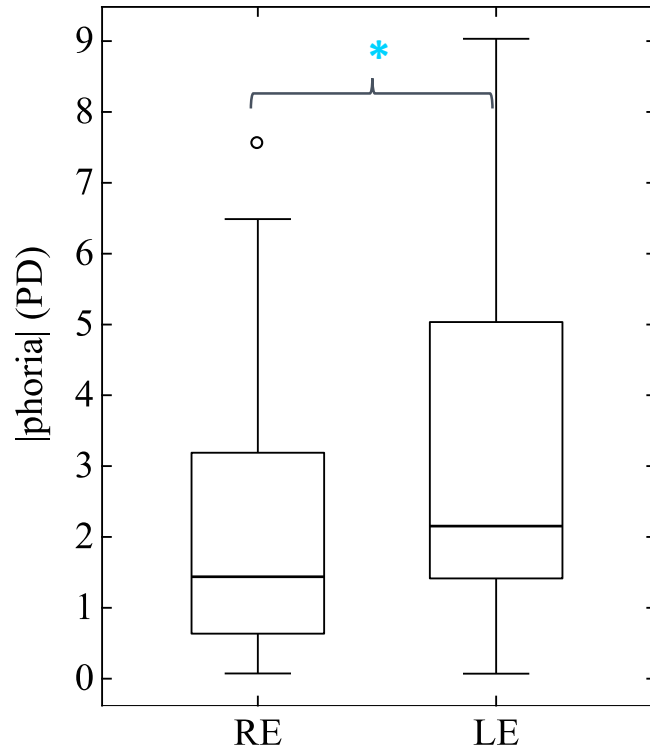
$$phoria_{LE} = \text{median}\{phoria_{LE_1}; phoria_{LE_2}; phoria_{LE_3}\}$$

The direction of the phoria between the two eyes agreed in 27 subjects. The other 3 were removed from this analysis.

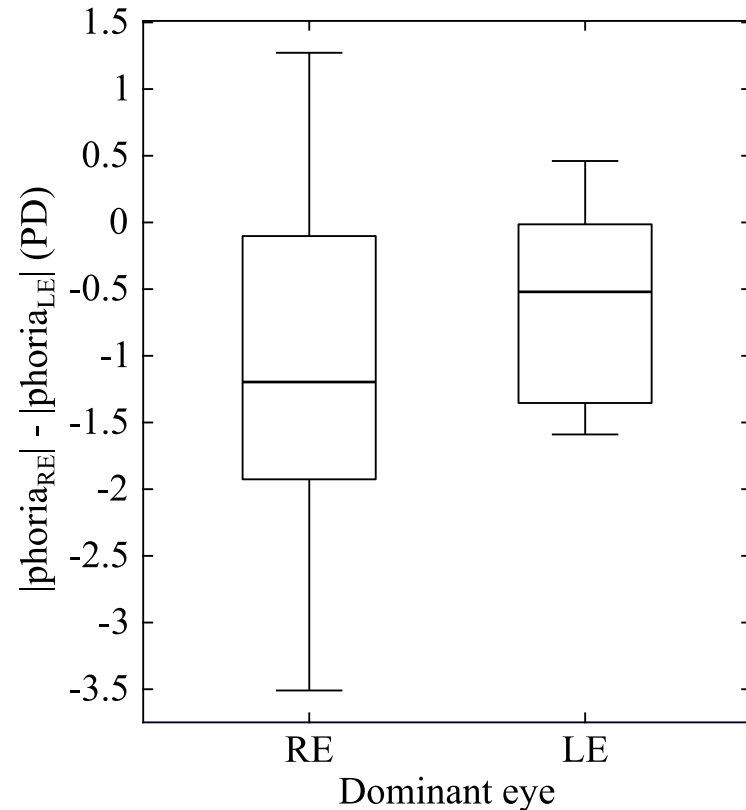


Results

Effect of ocular dominance on phoria



Mean diff \pm SD: -0.96 ± 1.07 PD
 (Paired t test: * $p < 0.001$)



Mean inter-eye difference \pm SD:
 RE dominants: -1.19 ± 1.23 PD
 LE dominants: -0.64 ± 0.72 PD
 (Independent t test: $p > 0.05$)

Conclusions

- **The proposed method is significantly more repeatable than the clinical methods.**

The found variability is likely due to physiologic variations of vergence system.

- **None of the existing methods to measure phoria are interchangeable.**

None of the methods compared is biased towards more esophoric or exophoric values. However, the objective and automated cover test gives smaller values than the prism cover test and the modified Thorington test.

There is a tendency towards poorer agreement for larger phoria in all three pairwise comparisons.

- **The amplitude of the movement during the cover phase might be independent of ocular dominance.**

- **The use of eye-trackers to measure phoria offers valuable advantages**

Objective measurement

Better resolution

Possibility to register movements of the occluded eye, which provides new insights into the oculomotor dynamics during the cover test.



Thank you

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