



OCUSWEEP™

There's more to vision than meets the eye

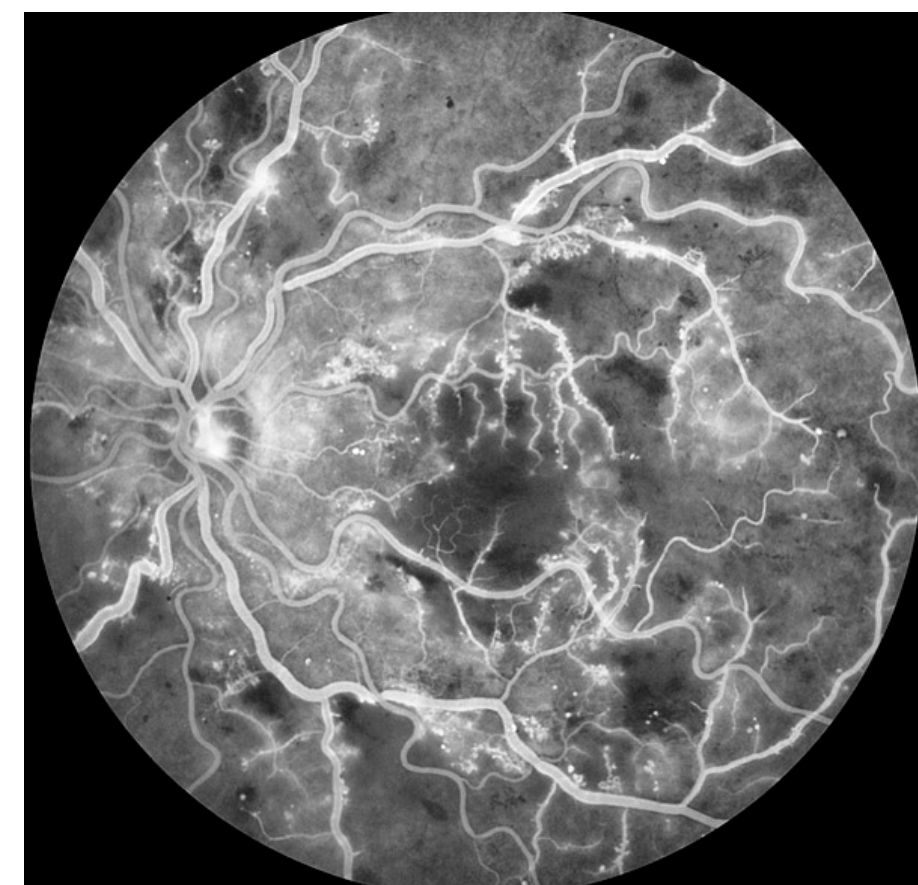
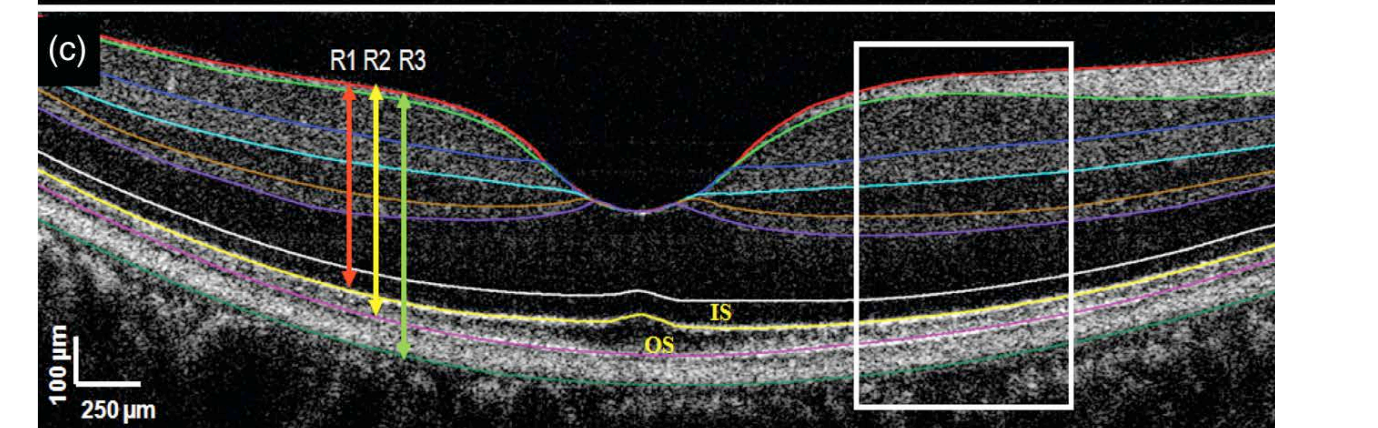
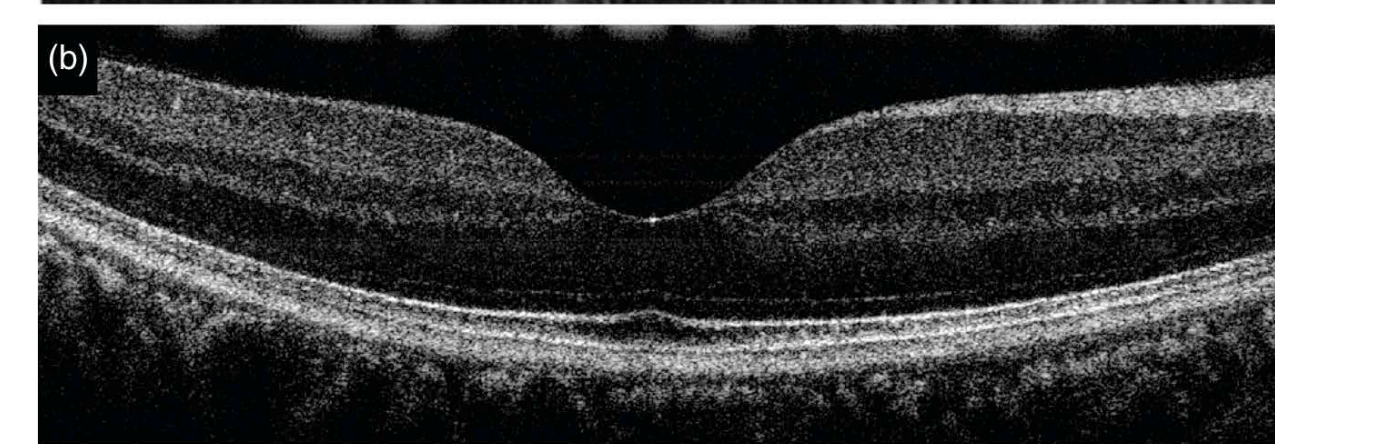
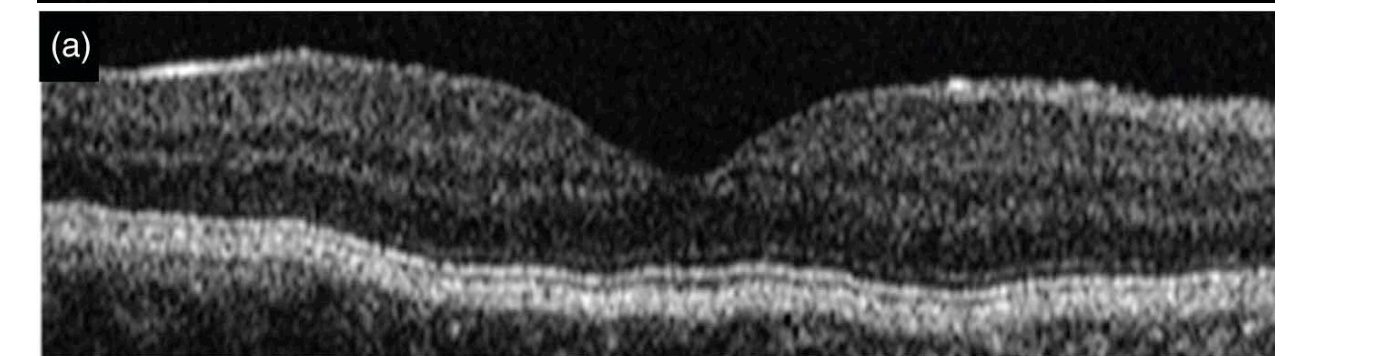
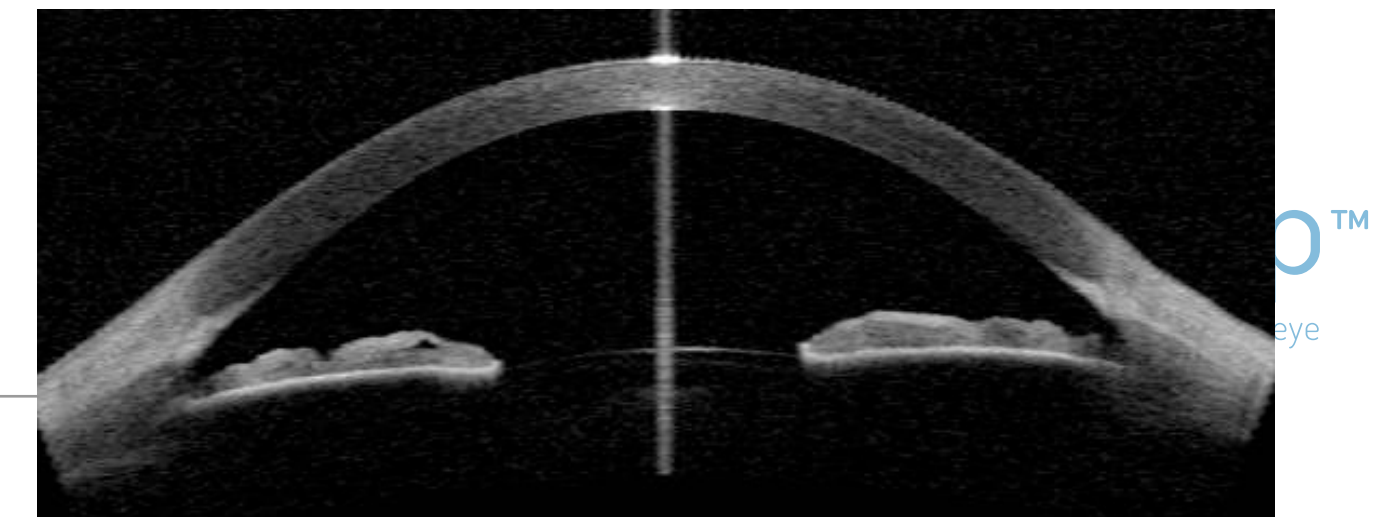
The Science behind Ocusweep



# Why Ocusweep?

*Function and structure as measures of disease progress*

- Progressing eye diseases cause changes...
- ...to the structures of the ocular tissues
- New ophthalmic imaging techniques have changed the diagnostics and follow-up of eye diseases
- Fundus photography, Wide field fundus photography, FAG (fluorescein angiography), FAF (Fundus autofluorescence), SLO (Scanning Laser Ophthalmoscopy), OCT (Optical Coherence Tomography)









# Why Ocusweep?

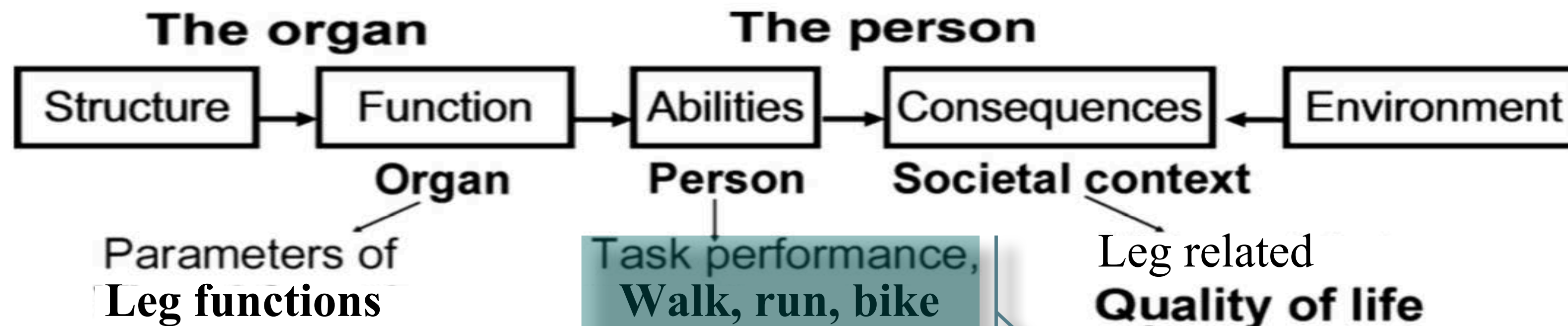
## Physical fitness

Monitoring the disease progress is important...

but more important is...

The Performance (or function) of the person with a disease.

- How is the person doing with the disease in his job or daily activities?
- Was the treatment of the disease worth the money (cost utility)?
- How much Performance the treatment gave (or slowed the decline)?





# Why Ocusweep?

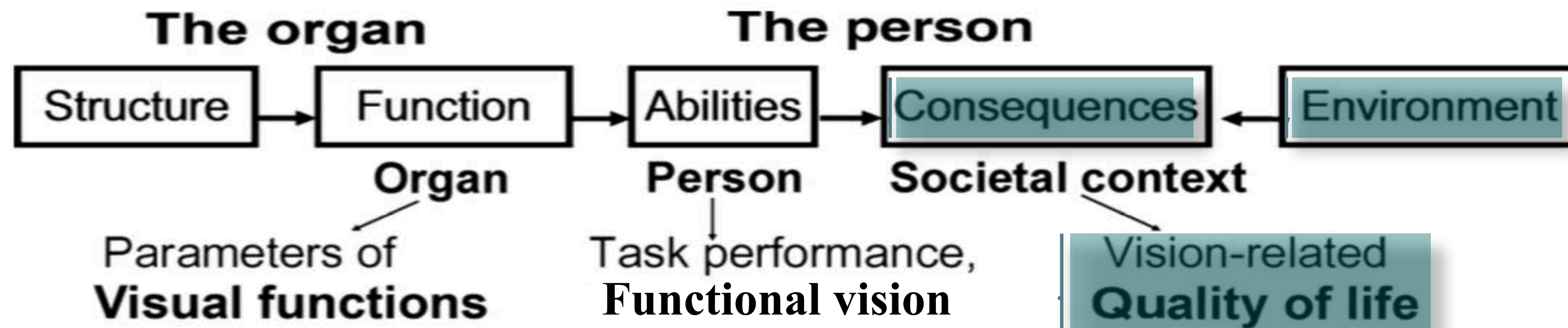
## Visual fitness...

Monitoring the disease progress is important...

but more important is...

The Performance (or function) of the person with a disease.

- How is the person doing with the disease in his job or daily activities?
- Was the treatment of the disease worth the money (cost utility)?
- How much Performance the treatment gave (or slowed the decline)?

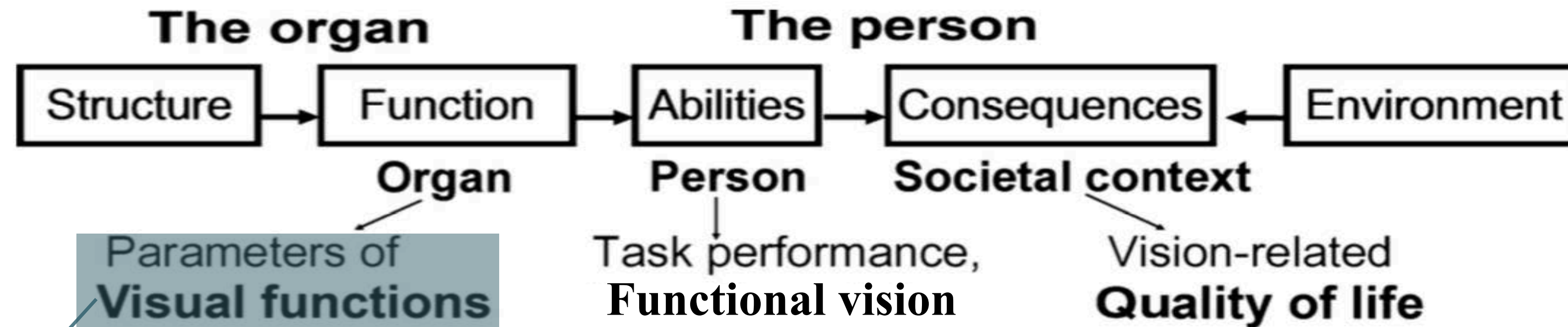


... for work, driving, computer work, sport, daily activities ...



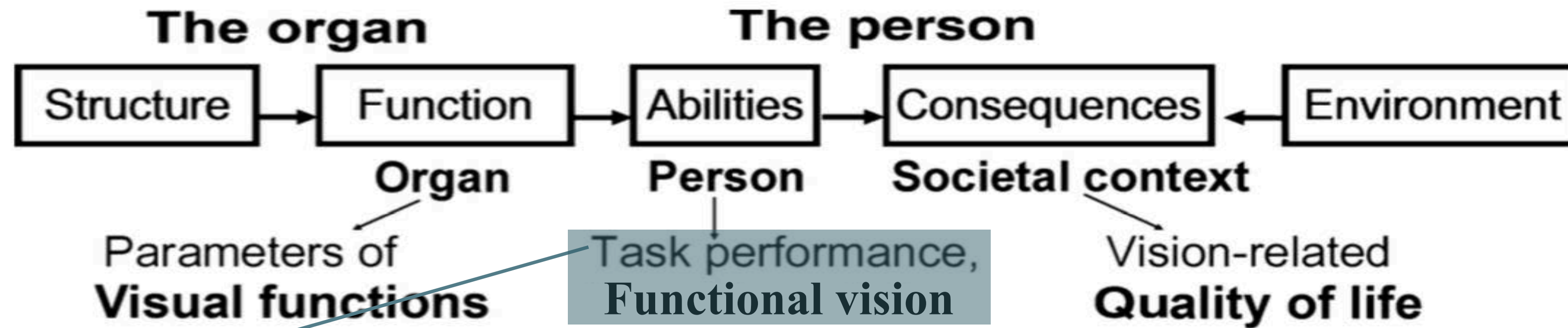


## Why Ocusweep?



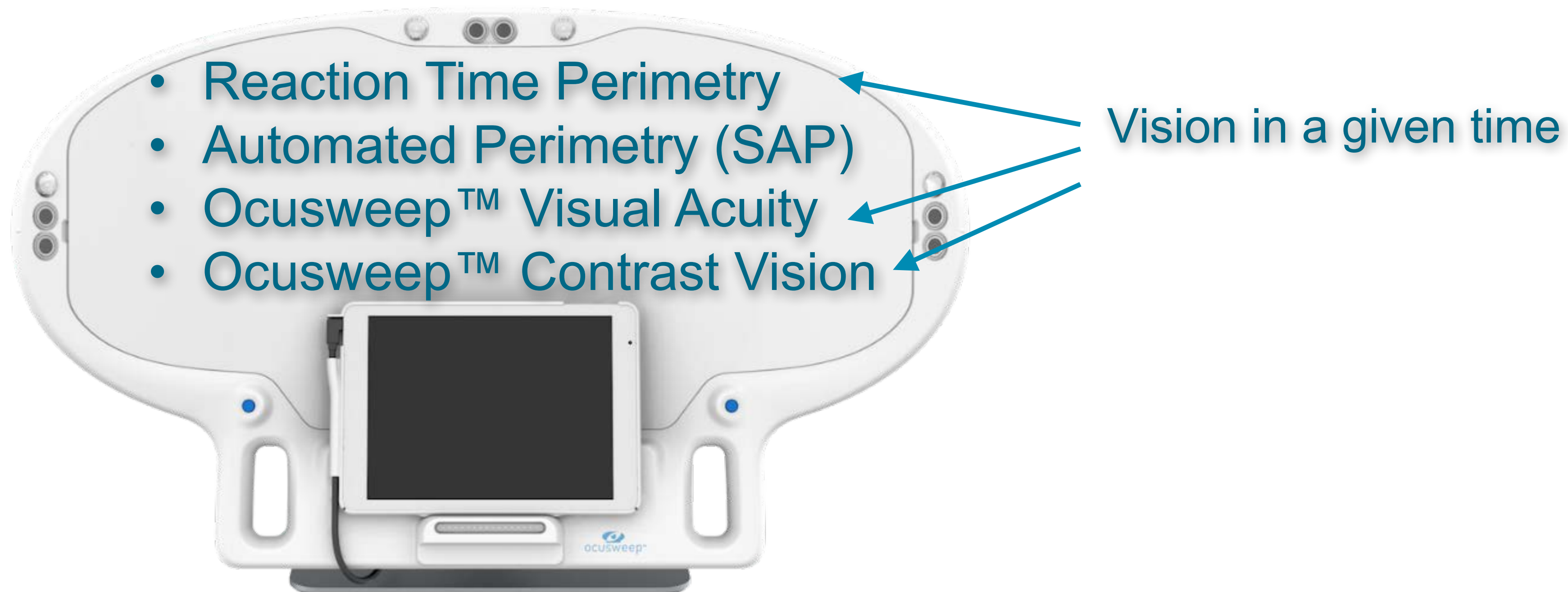
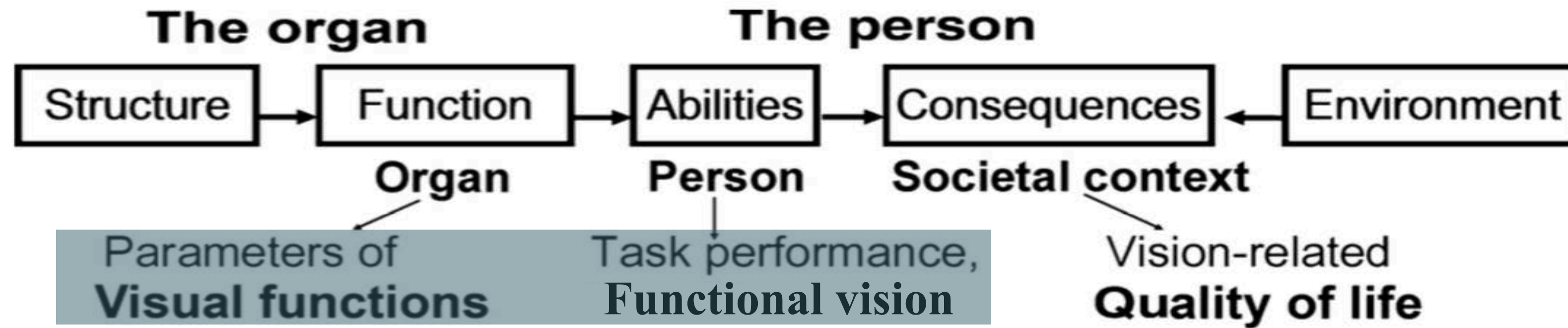
- foveal function: visual acuity, contrast sensitivity, color vision
- visual field: normal sensitivity and extent of both central and peripheral visual field
- sensitivity to glare (disability glare)
- adaptation to different ambient light levels
- oculomotor functions

# Why Ocusweep?



- attention: sustaining, dividing, shifting
- perceptual skills: integrating visual information with other senses
- memory: for recognizing objects, routes, places, faces...
- decision making: visual information must be interpreted and translated into behaviour
- reaction time: visual processing speed – critical in safe driving

# Ocusweep – for measuring Visual Fitness





# Visual Acuity Measurement



Sensitive test for indicating

- refractive error
- opacities in ocular media

Not sensitive for indicating

- disease progress in AMD, glaucoma or diabetic retinopathy
- vision related quality of life



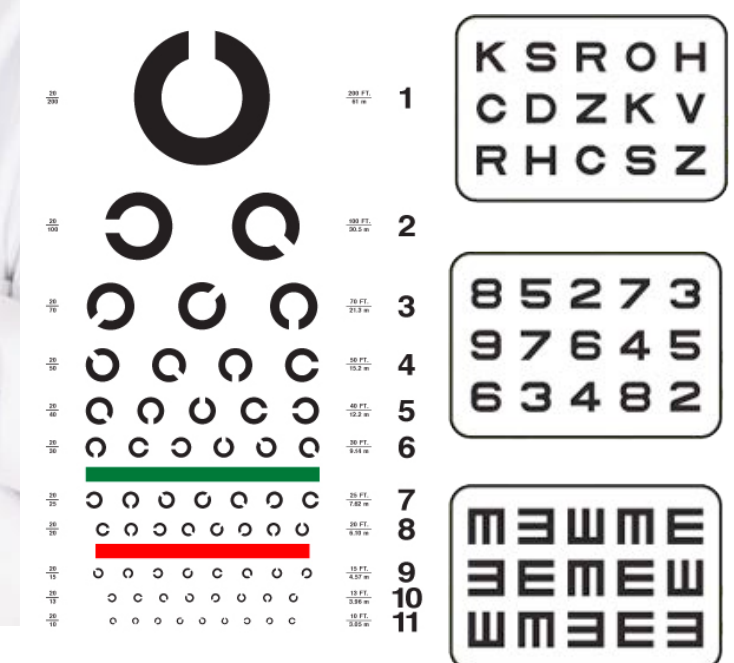
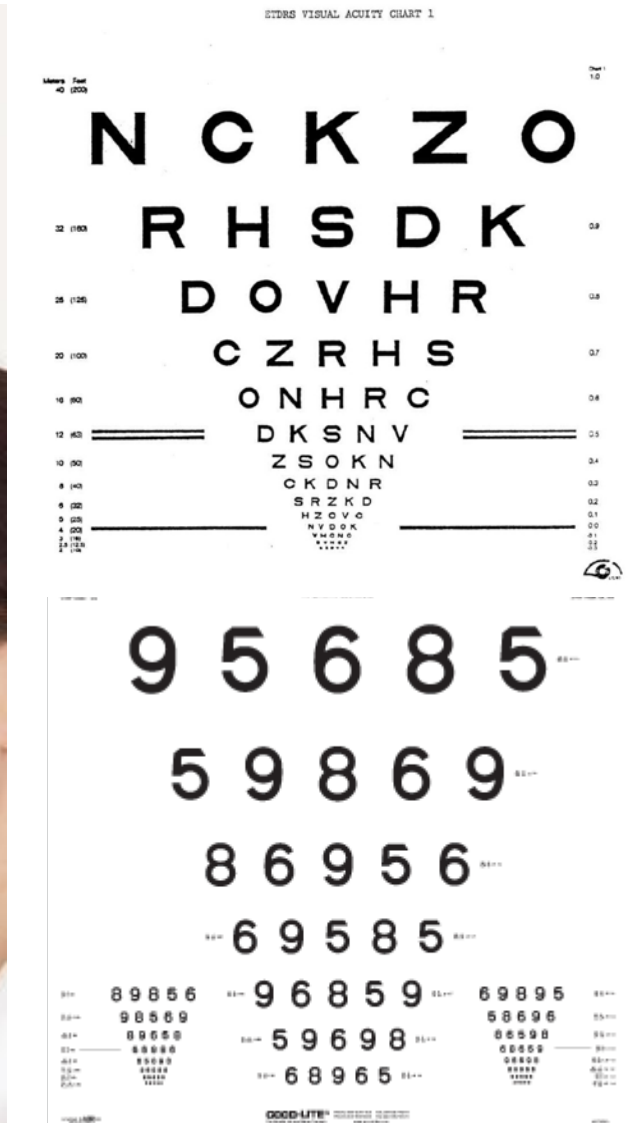


# Visual Acuity Measurement



Problems in current visual acuity measurements

- Thresholds are determined manually
- No proof of the reliability of the measurement
- Poor repeatability







# Ocusweep Visual Acuity Test: Data analysis of Clinical Evaluation

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

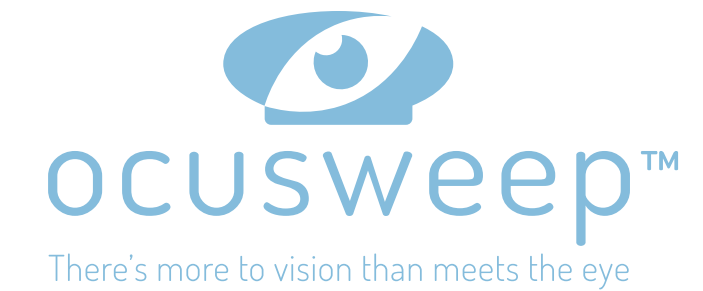
## Data analysis of the topics connected to the performance of Ocusweep Visual Acuity test

- New Ocusweep technology can be used for visual acuity measurements
- Visual performance can be measured by using limited viewing time - no unlimited viewing time in real life either

Topic	Data from literature	Data from clinical study	Long standing technology	New application of an existing technology	New technology
Optotype selection, sizes and progression	x		x		
Determining visual thresholds	x	x			x
Performance compared to existing technology					○ ○ ○
Correlation Score calibration (bias)		x			○ ○ ○
Repeatability		x			○ ○ ○

Table 3.6:5 Data analysis of the performance of Ocusweep visual acuity test.

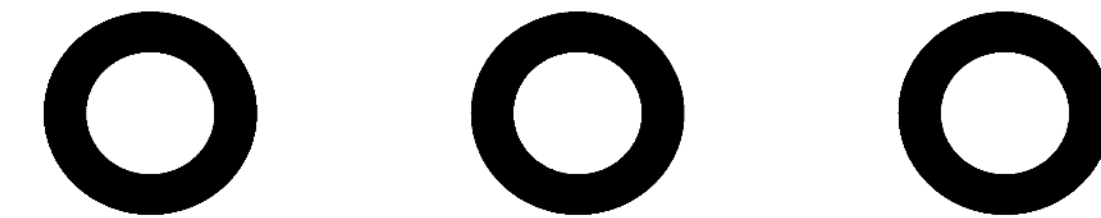




# Ocusweep Visual Acuity Test

From manual measurements to automated algorithms

- Design according international standard
- Viewing distances 3 m, 1 m, 0.40 m
- Measurement with automatic Ocusweep custom algorithm
- Highly standardized, repeatable measurements
- The correlation in repeated measurements was very high (0.87 ... 0.96) which means very high repeatability







# Ocusweep Visual Acuity Test: Repeatability

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

Very good repeatability

- Own clinical study: 23 patients scheduled for cataract surgery
- Repeatability of the measurements was good
  - Correlation between repeated measurements was 0.92

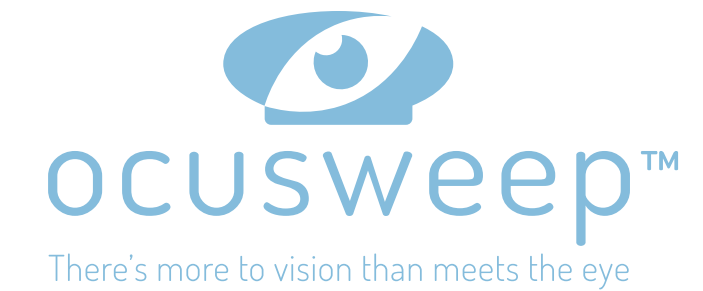
**Correlations (VA, cataract group) Marked correlations are significant at  $p < ,05000$  N=23 (Casewise deletion of missing data)**

Variable	Means	Std.Dev.	Ocu_Right_1	Ocu_Right_2	Ocu_Right_3
Ocu_Right_1	0,444638	0,260991	1,000000	0,916909	0,893154

Table 6:3 Correlations of repeated measures of the same test person. Cataract group.







# Ocusweep Visual Acuity: Repeatability

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

Very good repeatability

- Own clinical study: 63 healthy test subjects
- Repeatability of the measurements was good
- Correlation between repeated measurements was 0,90 (to second) and 0,88 (to third measurement)

**Correlations (VA, normal group) Marked correlations are significant at  $p < ,05000$  N=63 (Casewise deletion of missing data)**

Variable	Means	Std.Dev.	Ocu_Right_1	Ocu_Right_2	Ocu_Right_3
Ocu_Right_1	0,2907	0,2728	1,0000	0,8983	0,8754

Table 6:4 Correlations of repeated measures of the same test person. Normal group.



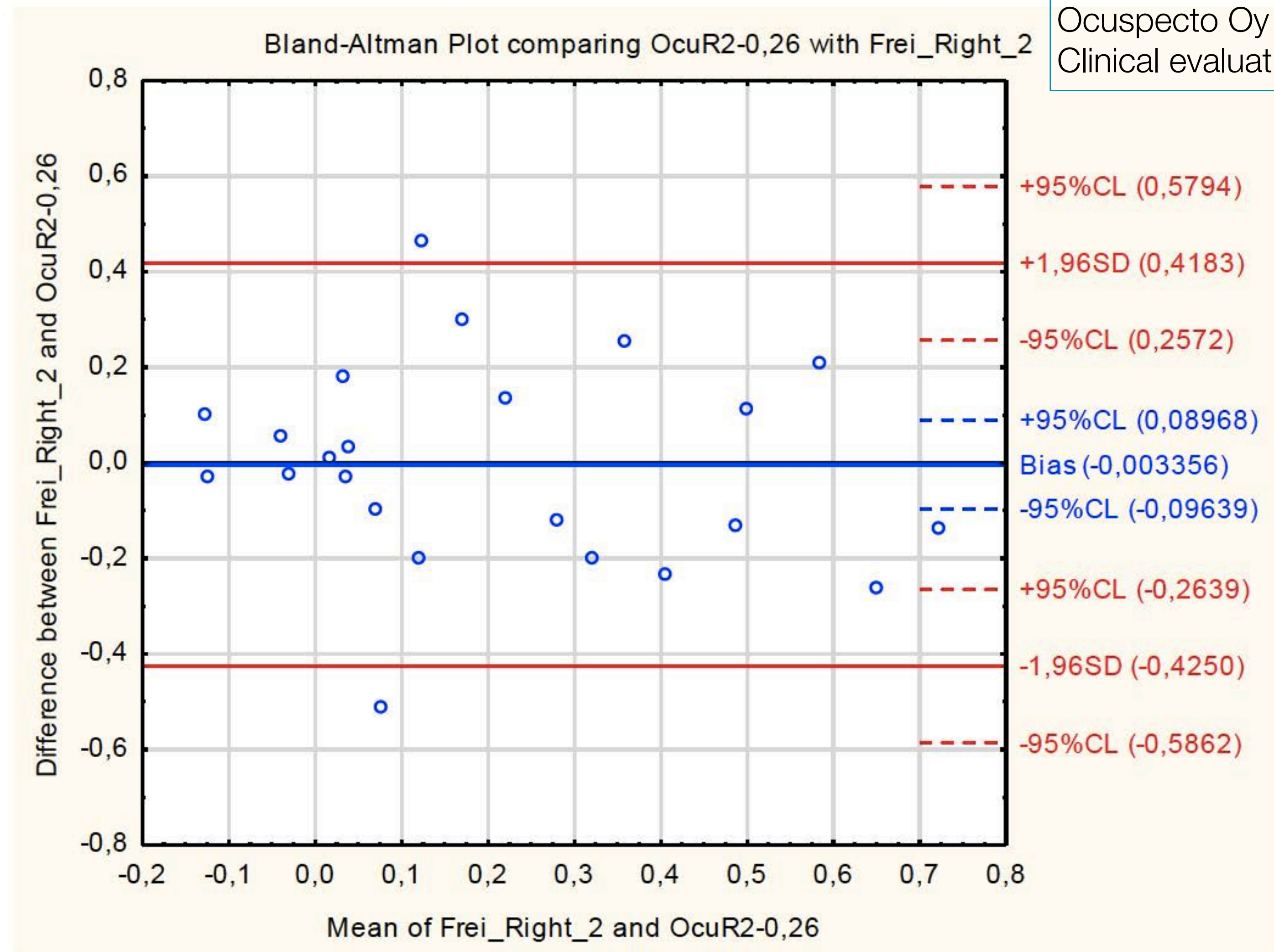


# Ocusweep Visual Acuity: Comparison to Freiburg test<sup>1</sup>



Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

- The correlation between the tests was high (0.69)
- The consistency measured by Cronbach alpha was good (0.81)
- Cronbach's alpha is an internal consistency estimate of reliability of test scores



**ICI**  
Bias of 0.26 logMAR caused by very tight crowding bars (20%)

<sup>1</sup> FrACT test used in over 600 scientific publications  
Bach M (1996) The "Freiburg Visual Acuity Test" – Automatic measurement of visual acuity. Optometry and Vision Science 73:49–53

Figure 3.6:2 Bland-Altman plot comparing Ocusweep and Freiburg visual acuity tests. Cataract group



# Contrast Vision measurements

- Contrast sensitivity defines the threshold between the visible and invisible.
- Provides another visual method to monitor the impact of treatment intervention

## Problems in current contrast vision measurements

- No normative data available for comparison
- Usability problems
  - hard to find a place for large wall charts - can't be moved to neighboring room
  - lengthy measurement protocols of computer based tests
- No generally accepted standards are available for measuring contrast vision







# Ocusweep Contrast Vision

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

- New Ocusweep technology can be used for contrast vision measurements
- Visual performance can be measured by using limited viewing time - no unlimited viewing time in real life either

**Data analysis of the topics connected to the performance of Ocusweep Contrast test**

Topic	Data from literature	Data from clinical study	Long standing technology	New application of an existing technology	New technology
Contrast target selection, displaying the targets	x		x		
Determining visual thresholds	x	x			x
Performance compared to existing technology					
Correlation Score calibration (bias)		x			
Repeatability		x			

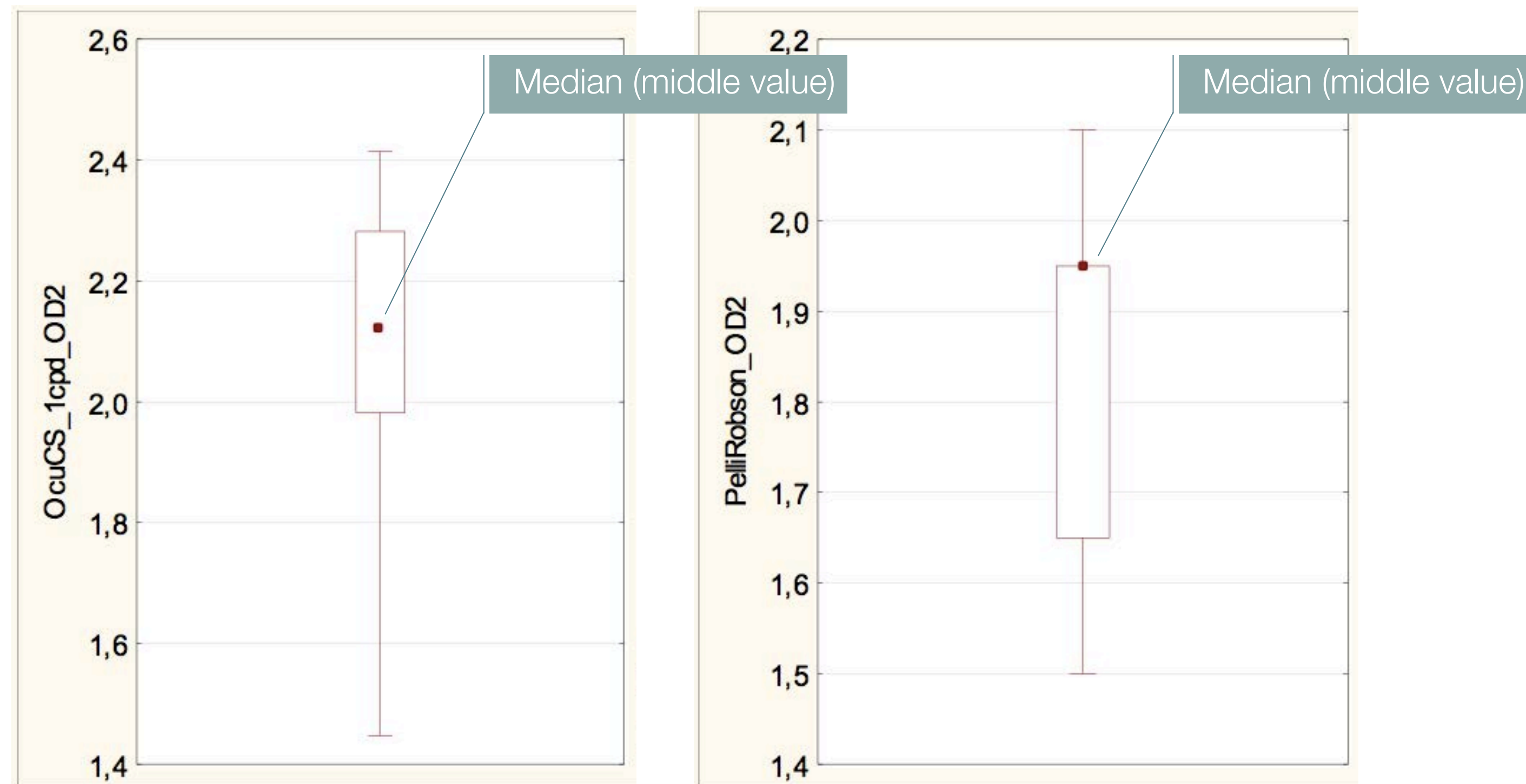


Table 3.7:8 Data analysis of the performance of Ocusweep contrast test.

# Ocusweep Contrast Vision: Comparison to Pelli-Robson

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

- The golden standard contrast test (Pelli-Robson) was unable to measure very good contrast vision (ceiling effect)



Boxplot of Ocusweep and Pelli-Robson contrast tests of the normal group.





# Ocusweep Contrast Vision: Comparison to Pelli-Robson

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

- Agreement of the tests was good with the exception of three outliers with good contrast vision
- Correlation between the results of the two tests was thus moderate (0.40 )
- The internal consistency measured by Cronbach alpha was moderate (0.52)

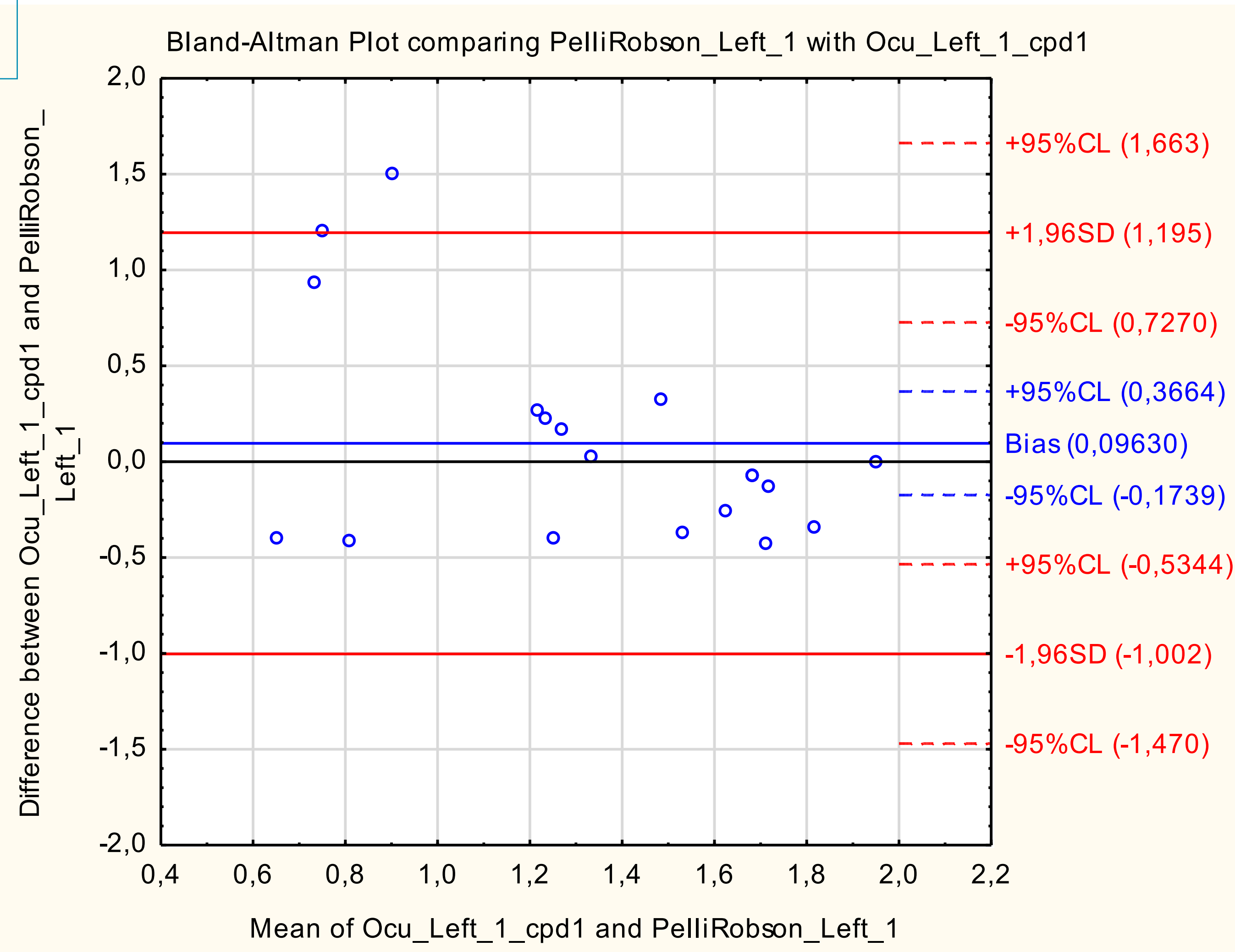


Figure 7:3 Bland-Altman analysis of Ocusweep and Pelli-Robson contrast tests of the cataract group.



# Ocusweep Contrast Vision: Repeatability

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

Very good repeatability

- Own clinical study: 19 cataract patients scheduled for operation
- Repeatability of the measurements was good (correlation 0,86)

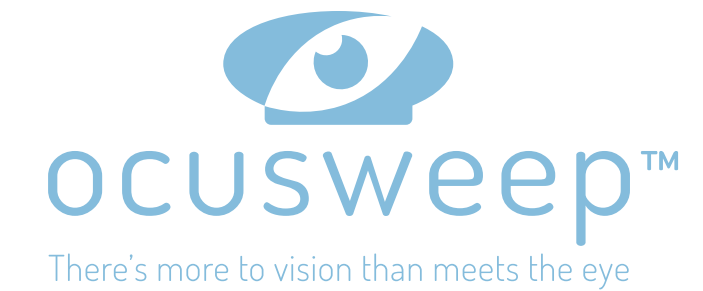
**Correlations. Marked correlations are significant at  $p < ,05000$  N=19 (Casewise deletion of missing data)**

Variable	Means	Std.Dev.	Ocu_Right_1_cpd1	Ocu_Right_2_cpd1
Ocu_Right_1_cpd1	1,605329	0,423599	1,000000	0,855763

*Correlations of repeated measures of the same test person. Cataract group*







# Ocusweep Contrast Vision: Repeatability

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

Very good repeatability

- Own clinical study: 19 cataract patients scheduled for operation
- Correlation between repeated measurements was 0,86 (to second) and 0,62 (to third measurement)

**Correlations (CS @ 1 cpd, normal group) Marked correlations are significant at  $p < ,05000$  N=46 (Casewise deletion of missing data)**

Variable	Means	Std.Dev.	OcuCS_1cpd_OD 1	OcuCS_1cpd_OD2	OcuCS_1cpd_OD 3
OcuCS_1cpd_OD1	2,115112	0,258630	1,000000	0,856141	0,618572

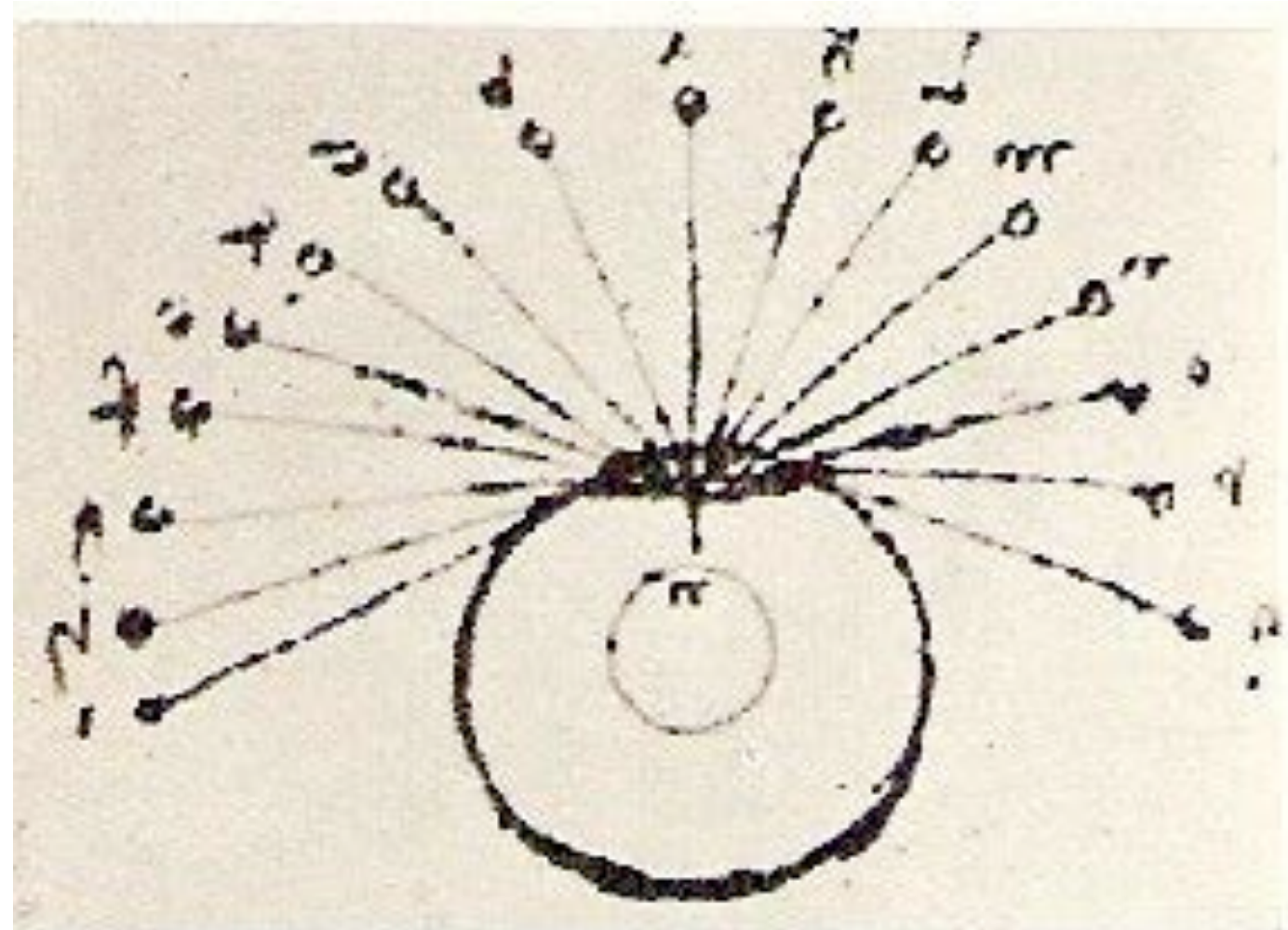
*Correlations of repeated measures of the same test person. Normal group*



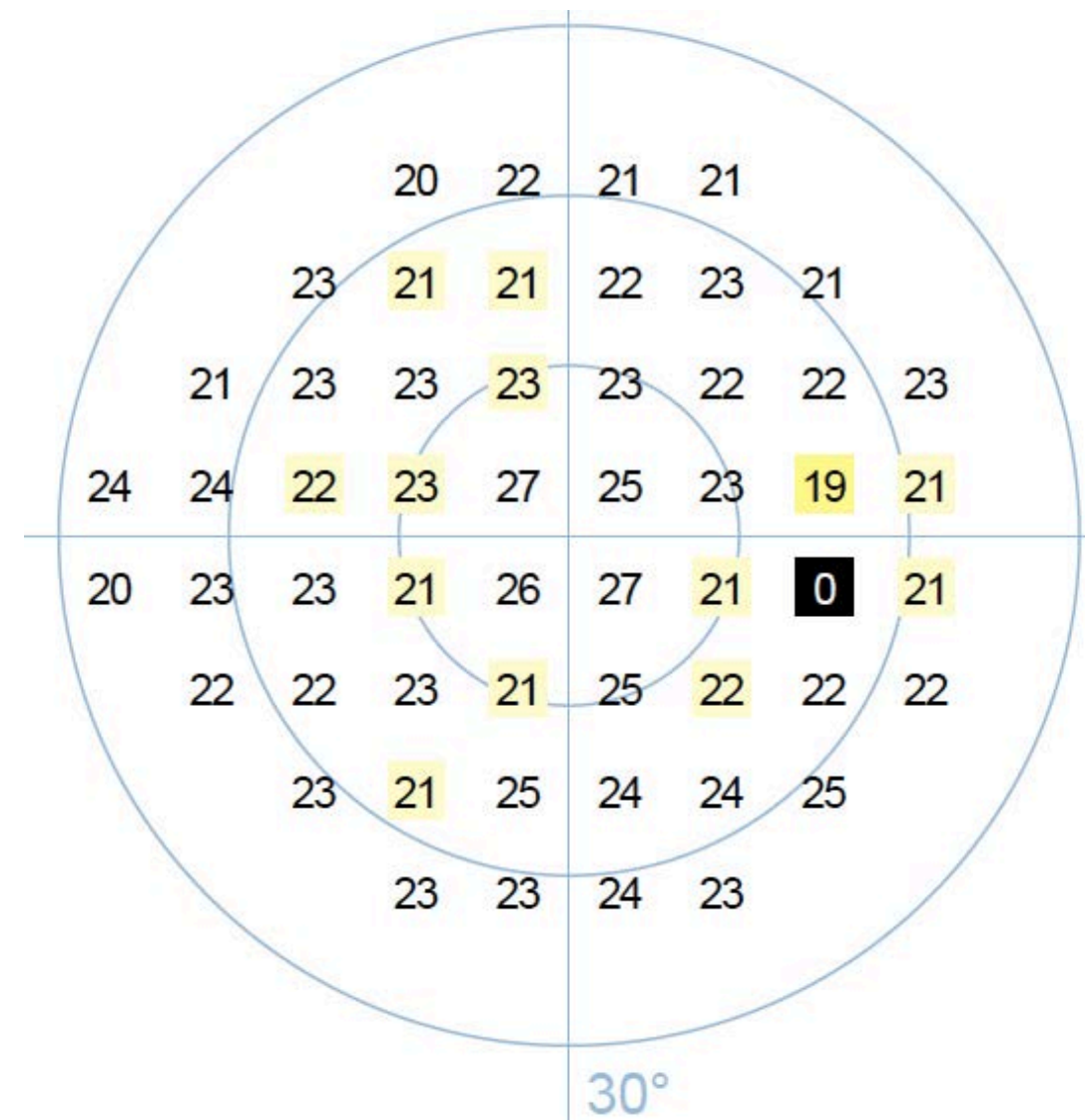
# Automated Perimetry



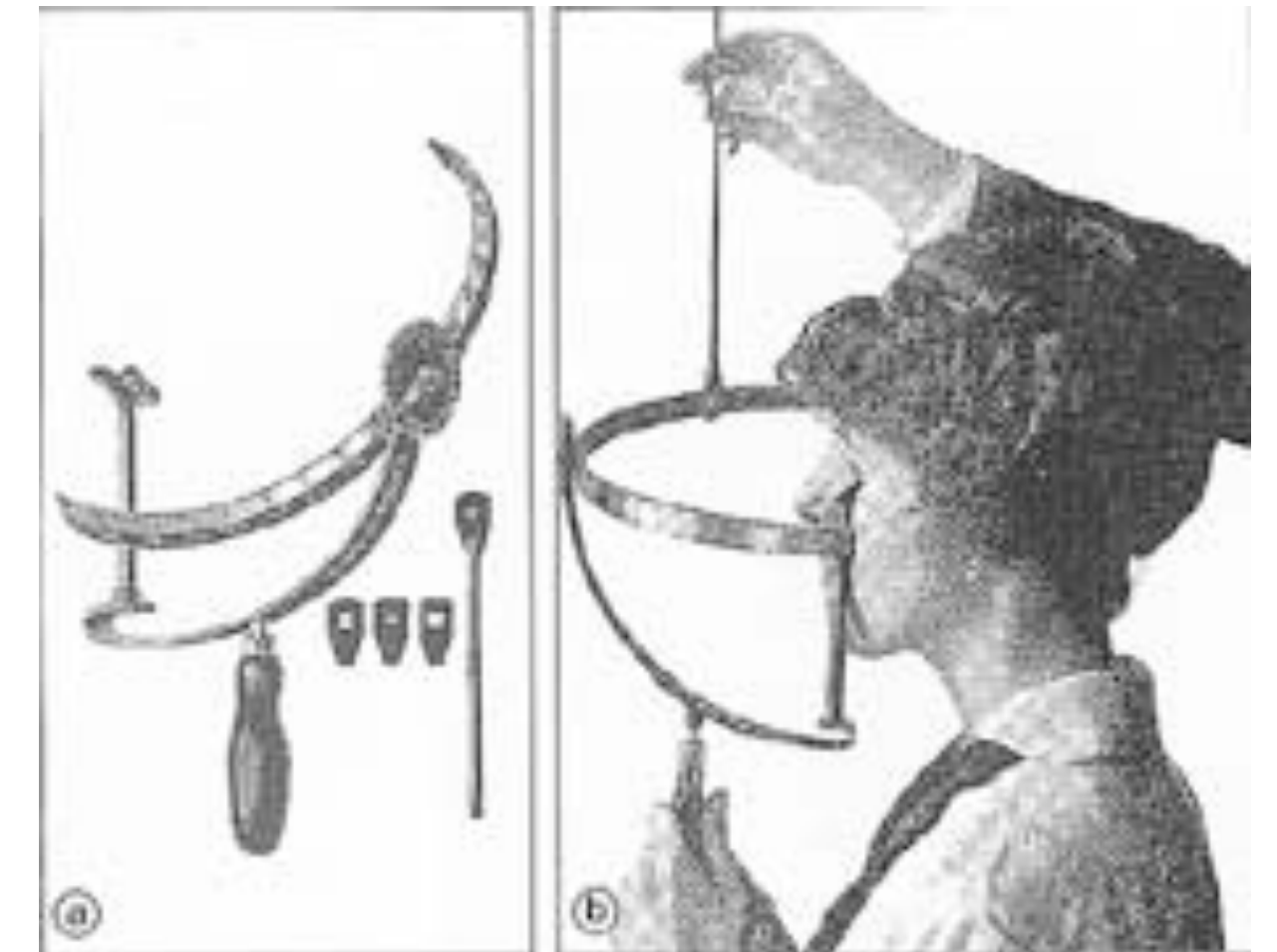
- Perimetry: evaluating the status of peripheral visual function in the management of ocular and neurologic diseases



Visual field by Leonardo da Vinci in 1550



Physiological blind spot first reported in 1668



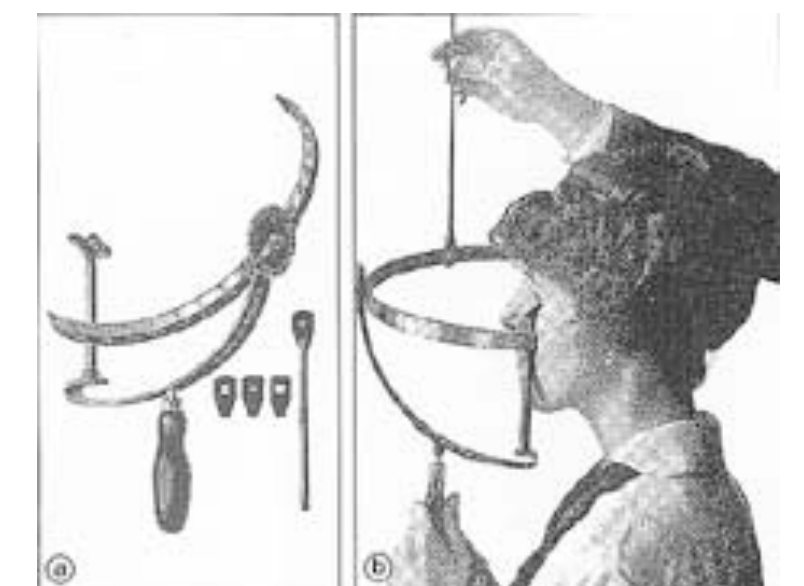
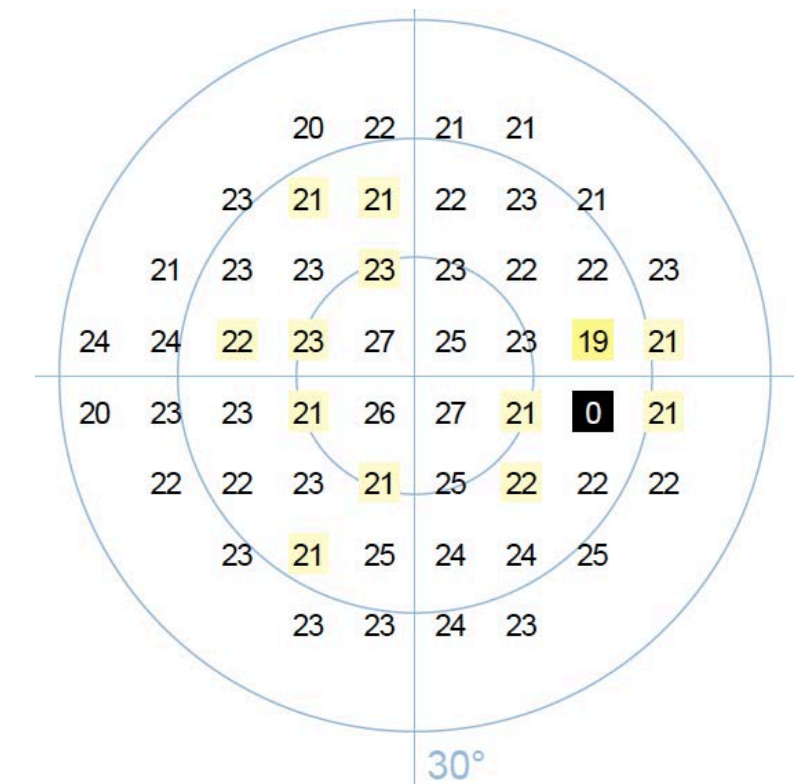
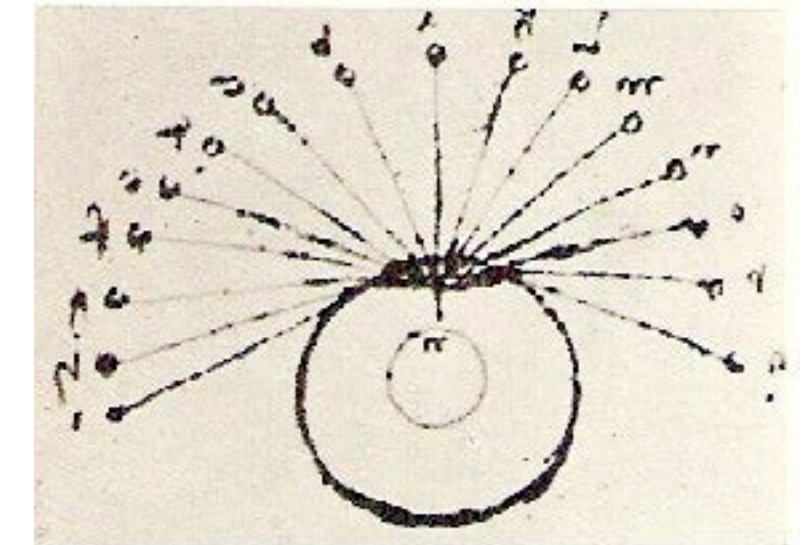
Arc perimetry in 19<sup>th</sup> century



# Automated Perimetry



- Automated Perimetry introduced in 1980's
  - No more operator influence on test results
  - Minimal training for the operator required
  - Automated algorithms
    - Threshold measurements
    - Reliability measures for the testing (catch trials)
  - Accuracy of the diagnostics and follow up enhanced
  - Possible to calculate indexes to describe and follow the progression of visual field





# Automated Perimetry: Data Analysis

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

## Data analysis of the topics connected to the performance of Ocusweep SAP test

- New Ocusweep technology can be used for visual field examinations
- Visual field can be measured also in normal room lighting
- No head rest is needed
- Eye position control (fixation stability) is adequate

Topic	Data from literature	Data from clinical study	Long standing technology	New application of an existing technology	New technology
Background luminance compensation	x	x			x
Monitoring the orientation of the eye	x	x			x
Controlling the viewing distance	x			x	
Performance compared to existing technology					
Determining differential light sensitivity		x			
Interindividual variation		x			



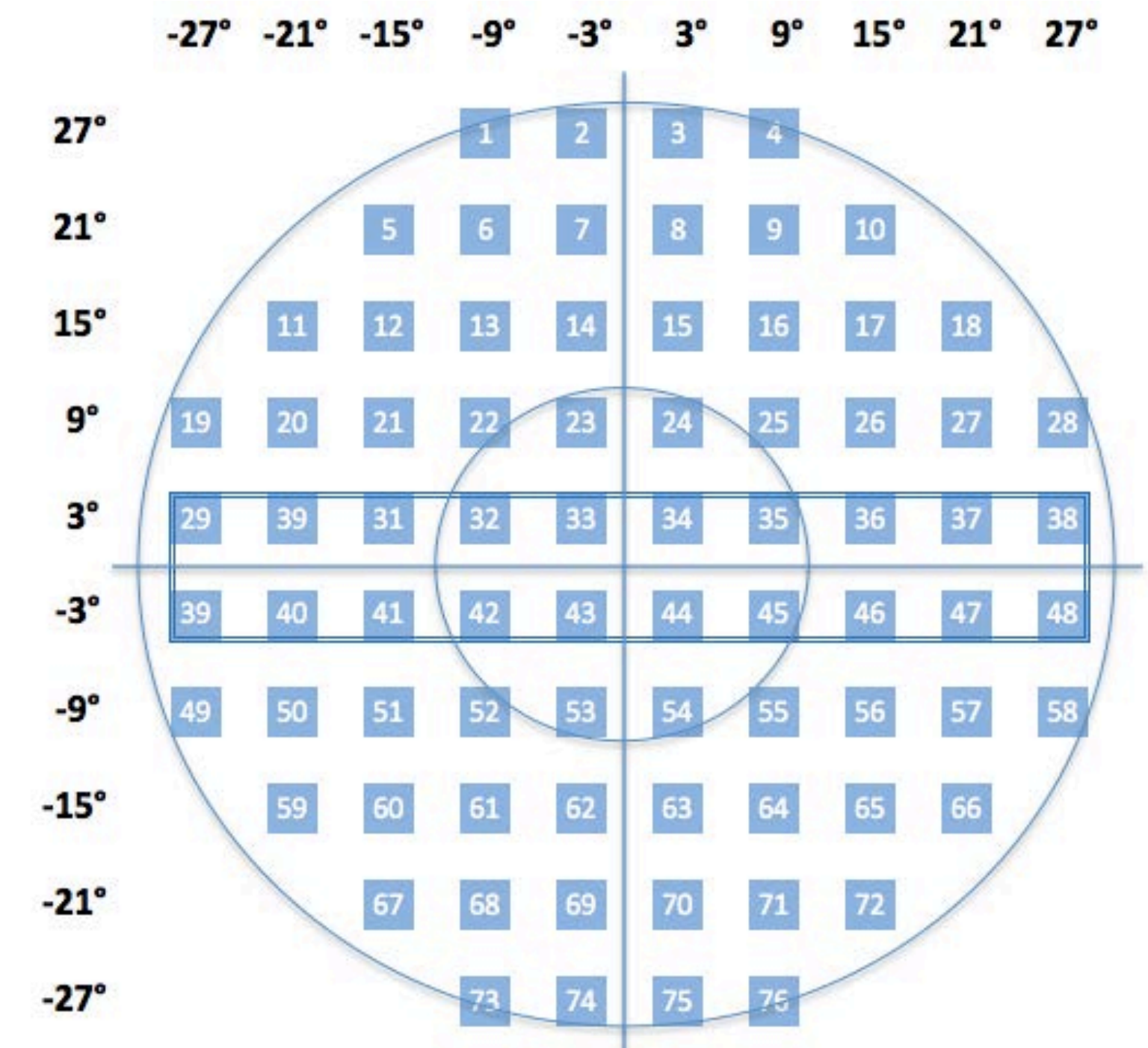
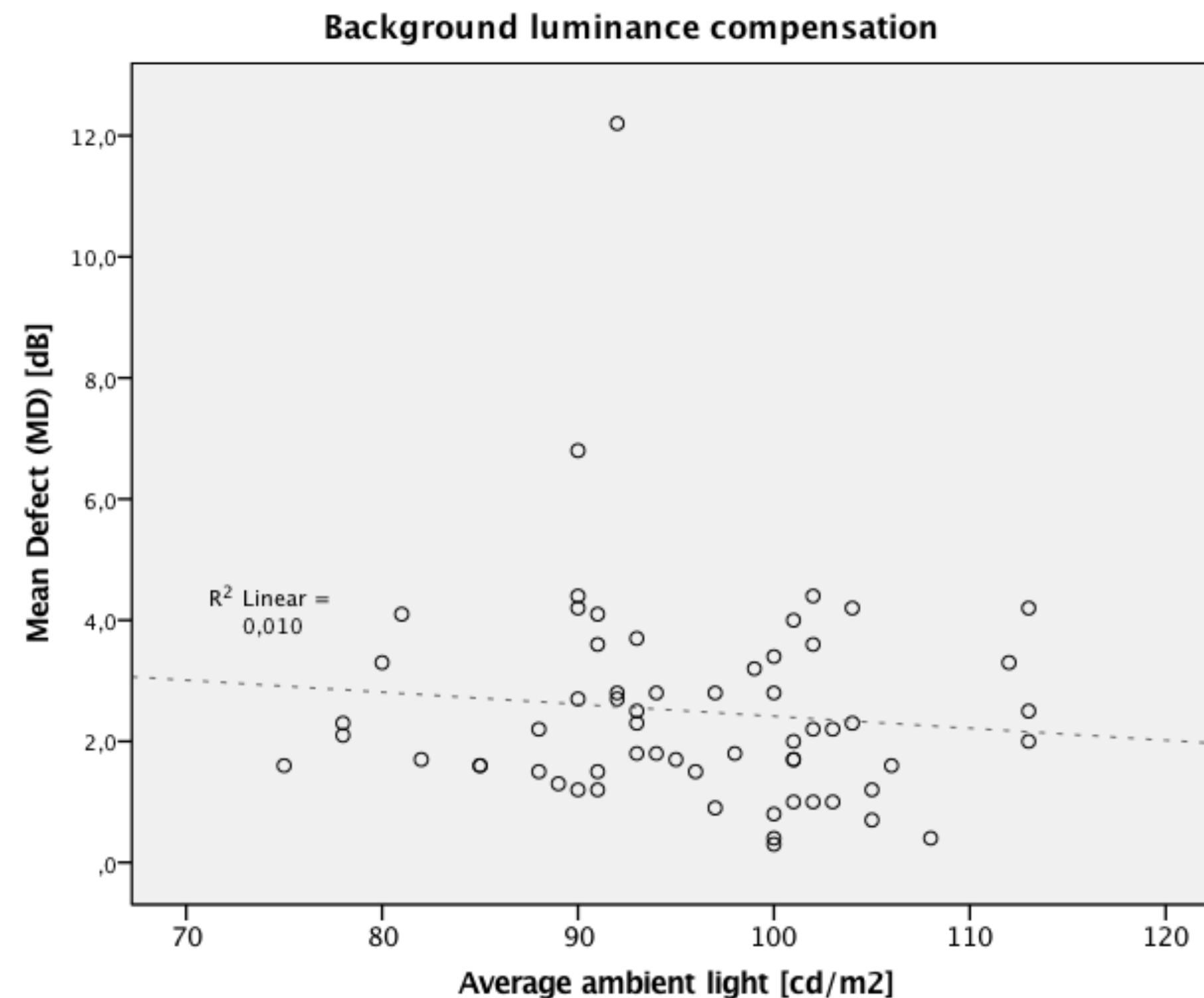
# Automated Perimetry: Room lighting compensation

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

Measurements can be done in variable room lighting

The effect of ambient room lighting variation

- No correlation (Pearson correlation -0.099) between ambient lighting and Ocusweep MD (mean defect)
- Good performance of the luminance compensation.



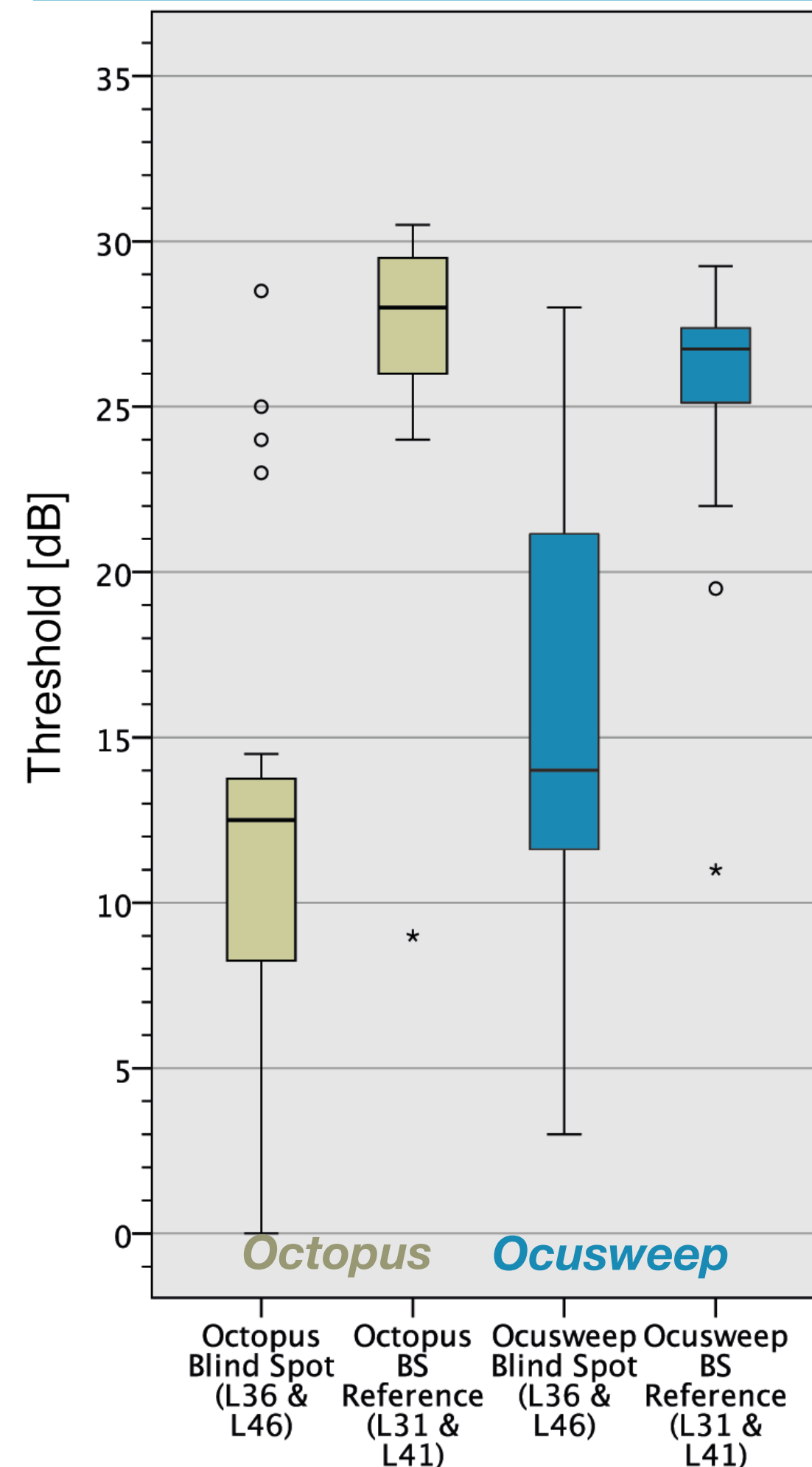
55 eyes of test persons with normal vision was measured with Ocusweep SAP using visual field grid 30-2

# Automated Perimetry: Eye position stability

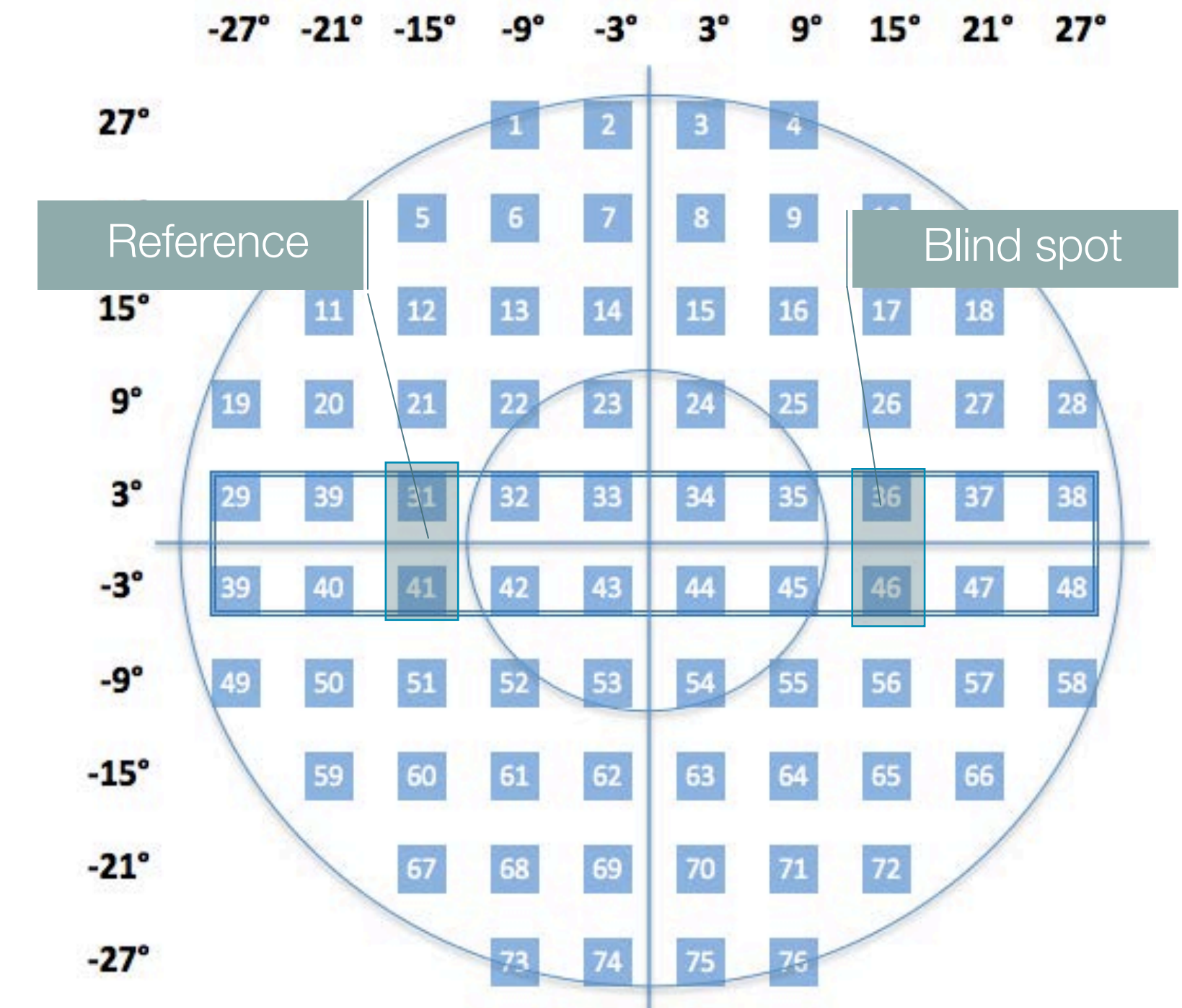
Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

Eye position stability is adequate

- Physiological blind spot clearly detectable in 85 % of test persons (similar to Octopus perimeter)



Blind spot area thresholds (BS) were compared to nasal reference area (BS Reference). Threshold difference between normal and blind spot locations of the visual field



30 right eyes of test persons with normal vision was compared to Octopus SAP using visual field grid 30-2





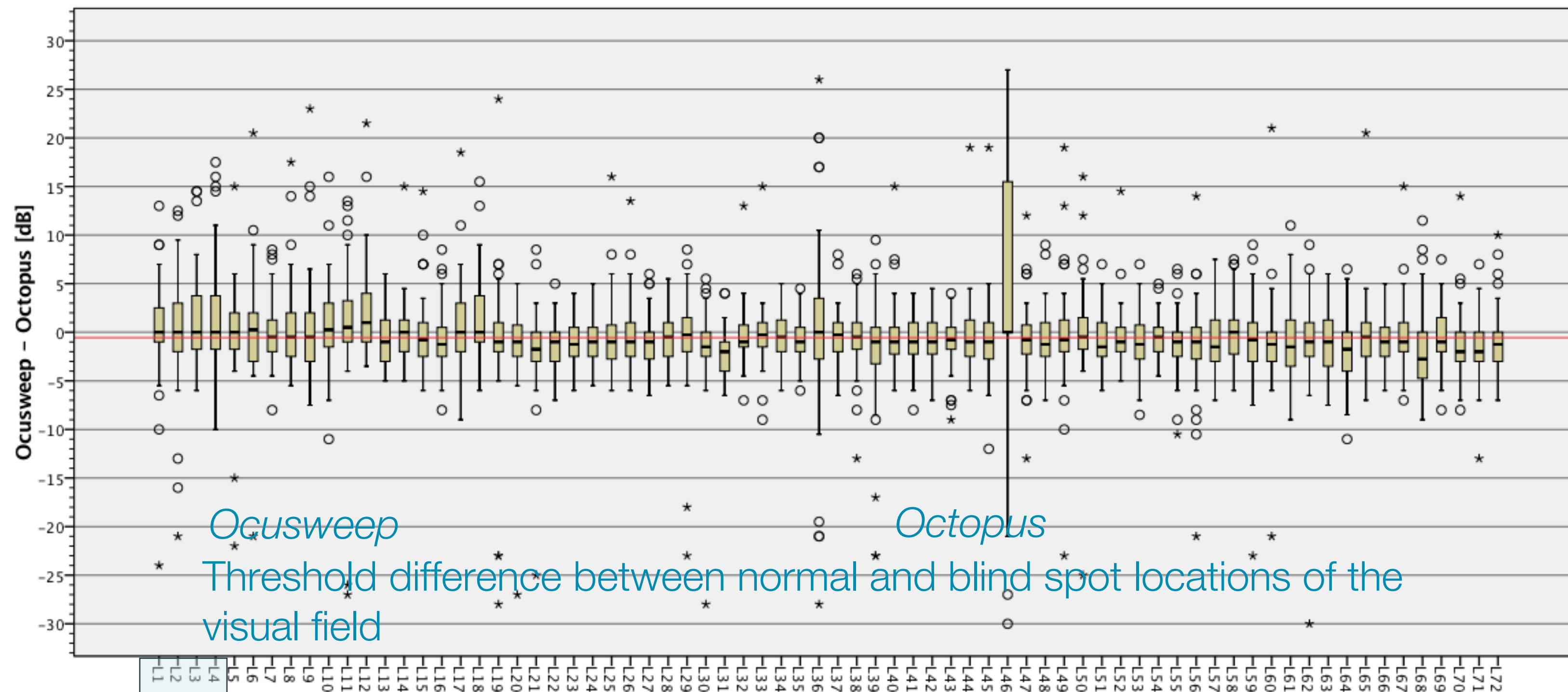
# Automated Perimetry: Measurement accuracy

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

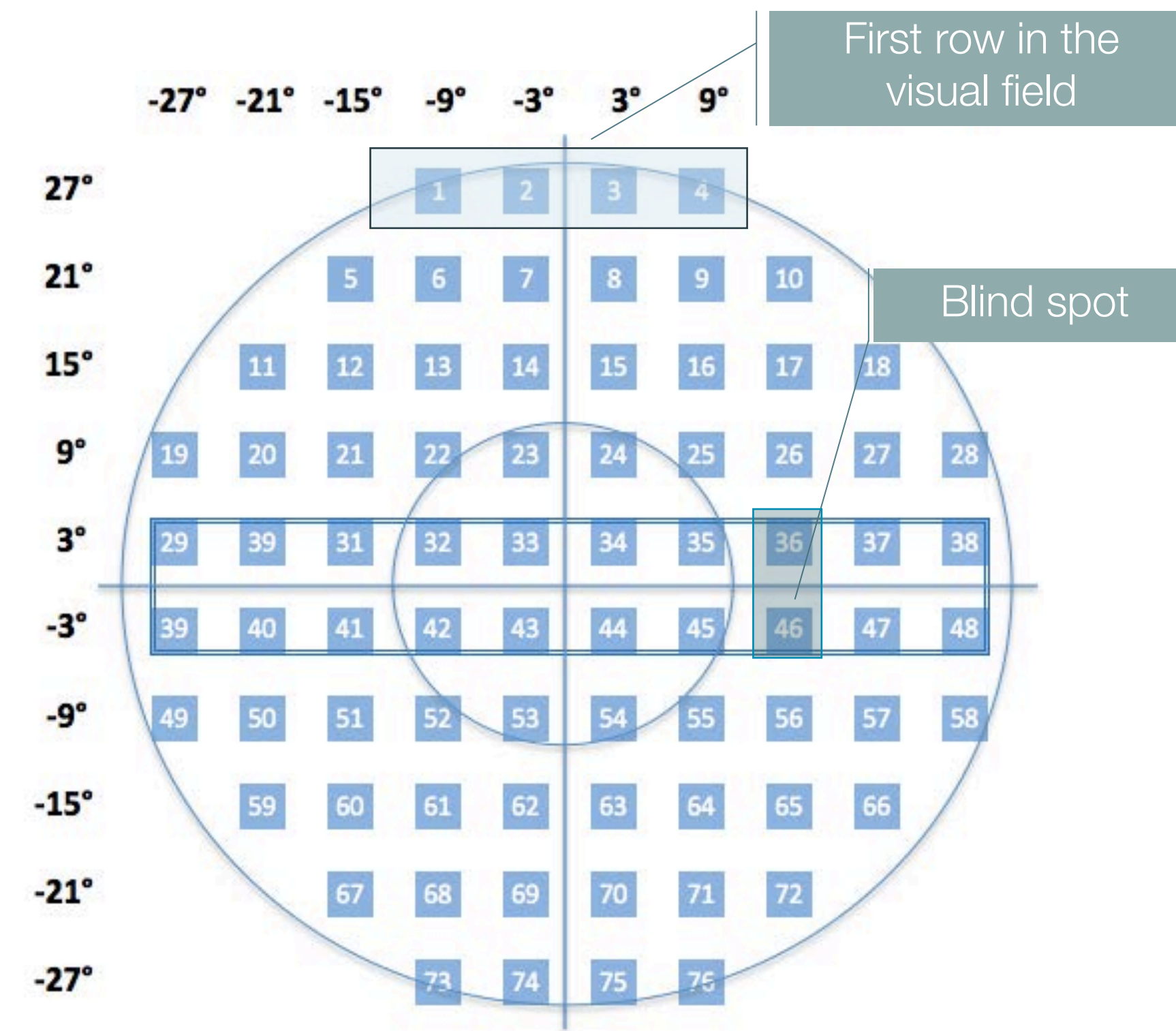
Ocusweep gives the same numbers as Octopus

- The mean of the differences of the thresholds was -0,54 dB

SAP 30-2, normal group: comparison of Ocusweep and Octopus thresholds



Ocusweep  
Octopus  
Threshold difference between normal and blind spot locations of the visual field



30 right eyes of test persons with normal vision was compared to Octopus SAP using visual field grid 30-2

First row in the visual field

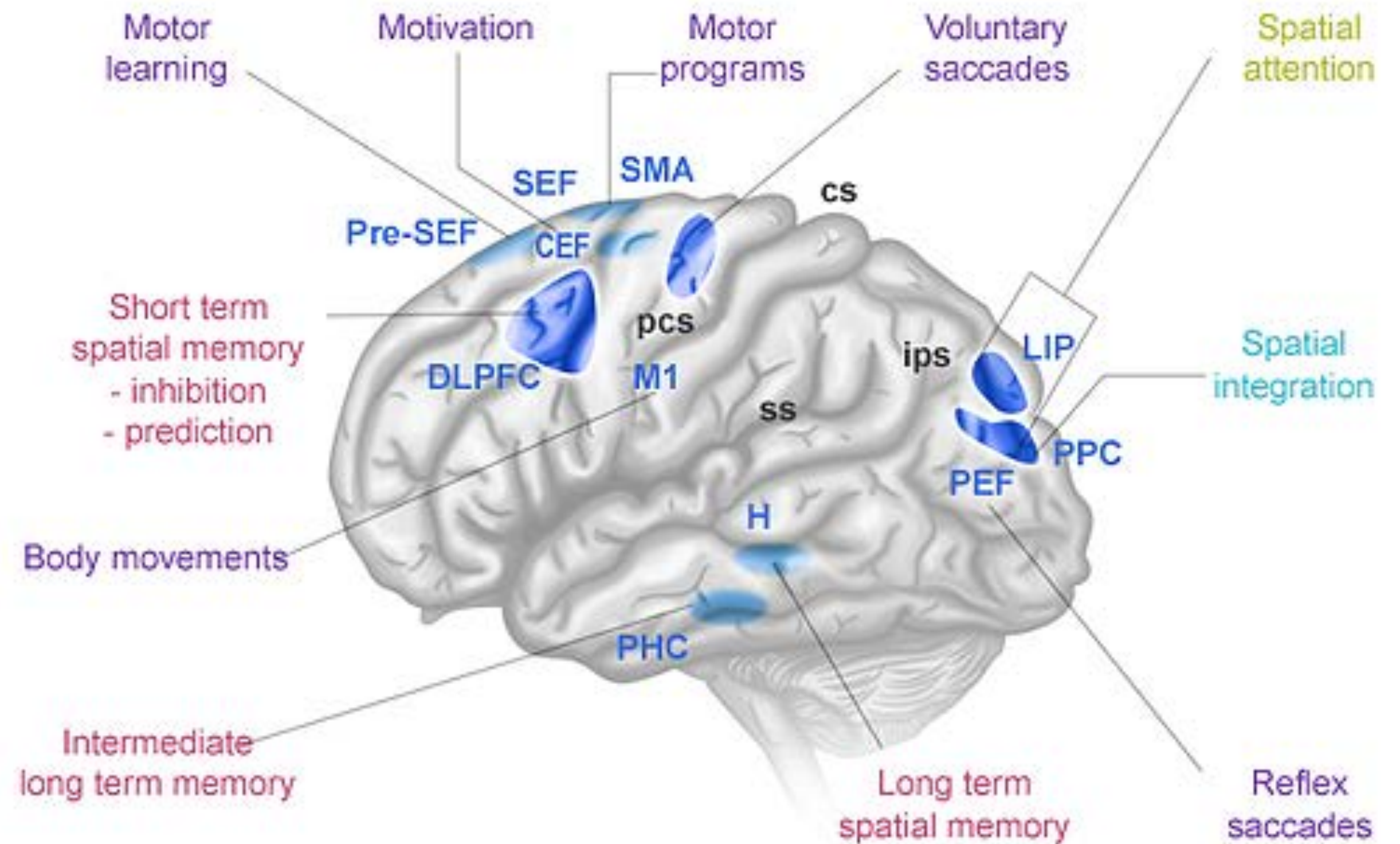


# Ocusweep Reaction Time Perimetry: Why?



Visual field defects can be quantified by standard automated perimetry (SAP), but it has limited power to predict the impact of disease on the ability to perform activities of daily living

- Can't be used to measure visual fitness

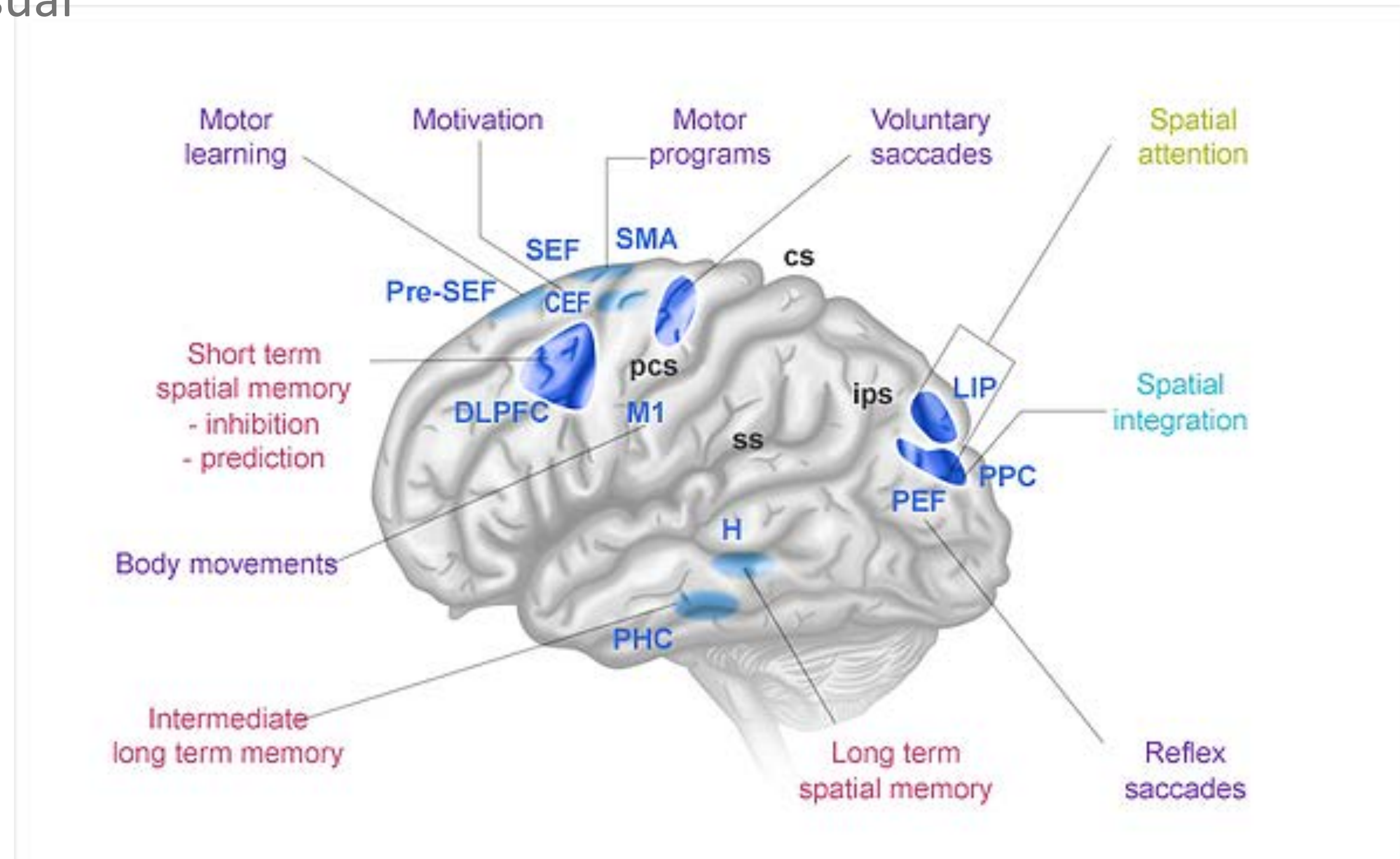




# Ocusweep Reaction Time Perimetry: Why?



The fundamental feature of the human visual system is the ability to move the eyes towards an object perceived in the peripheral visual field in order to fixate with the fovea

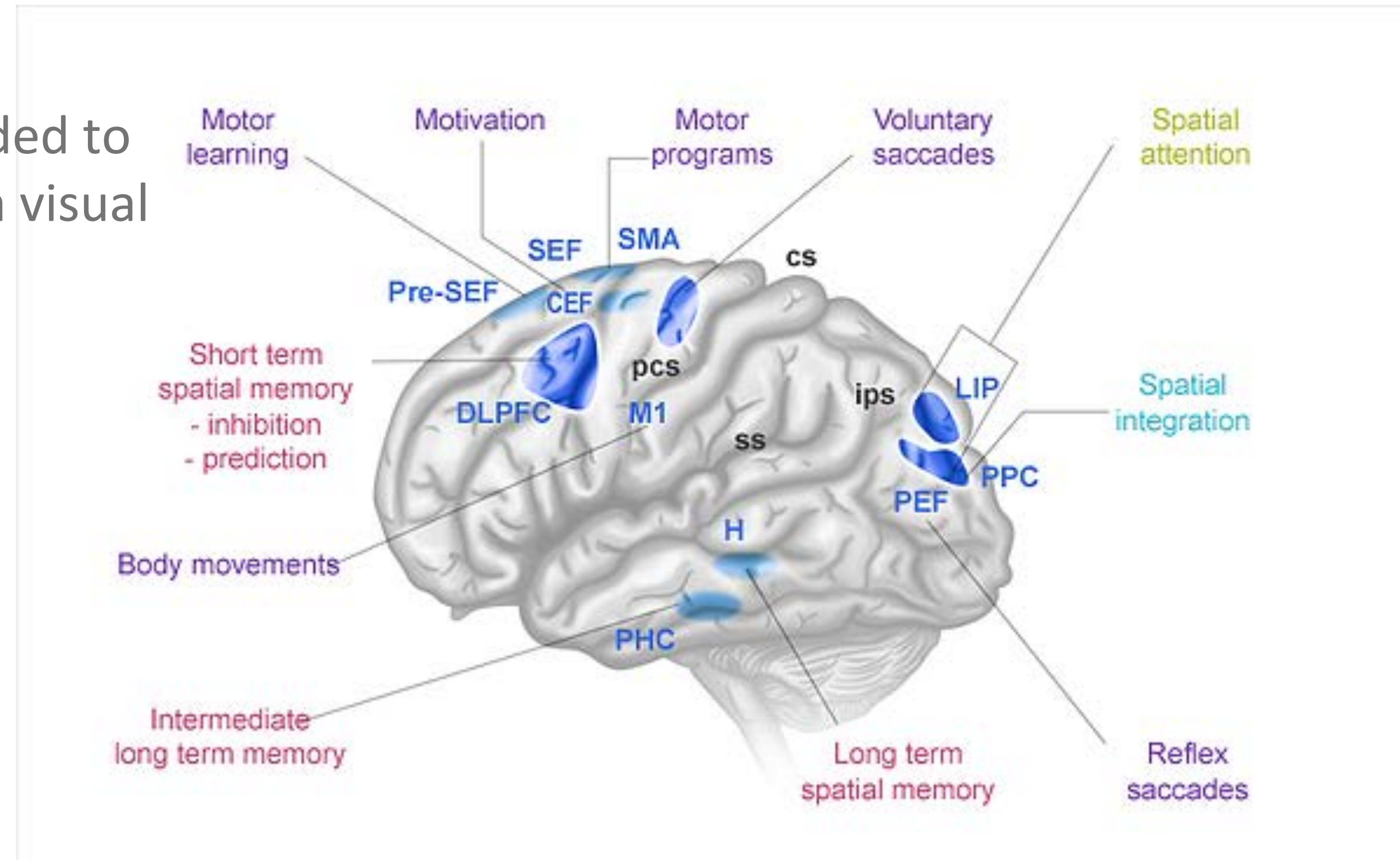




# Ocusweep Reaction Time Perimetry: Why?

Visual ability of a person can be measured by...

- combining eye movements together with
- visual processing speed,
- which is defined as the time needed to make a correct judgment about a visual stimulus

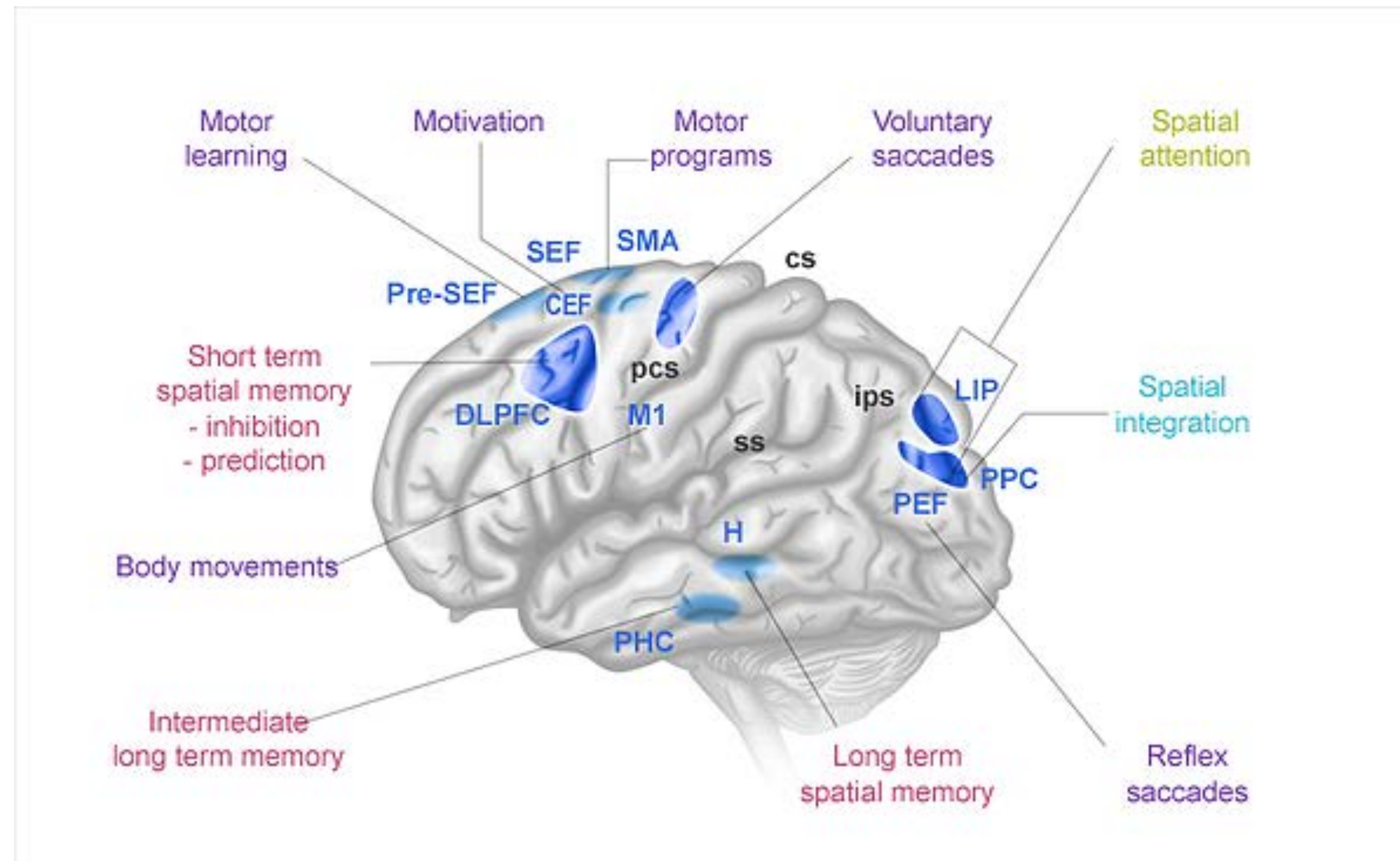




# Ocusweep Reaction Time Perimetry: Why?

Good results in Reaction Time Perimetry can be achieved if

- visual field is normal
- eye movements are normal
- visual processing speed is good



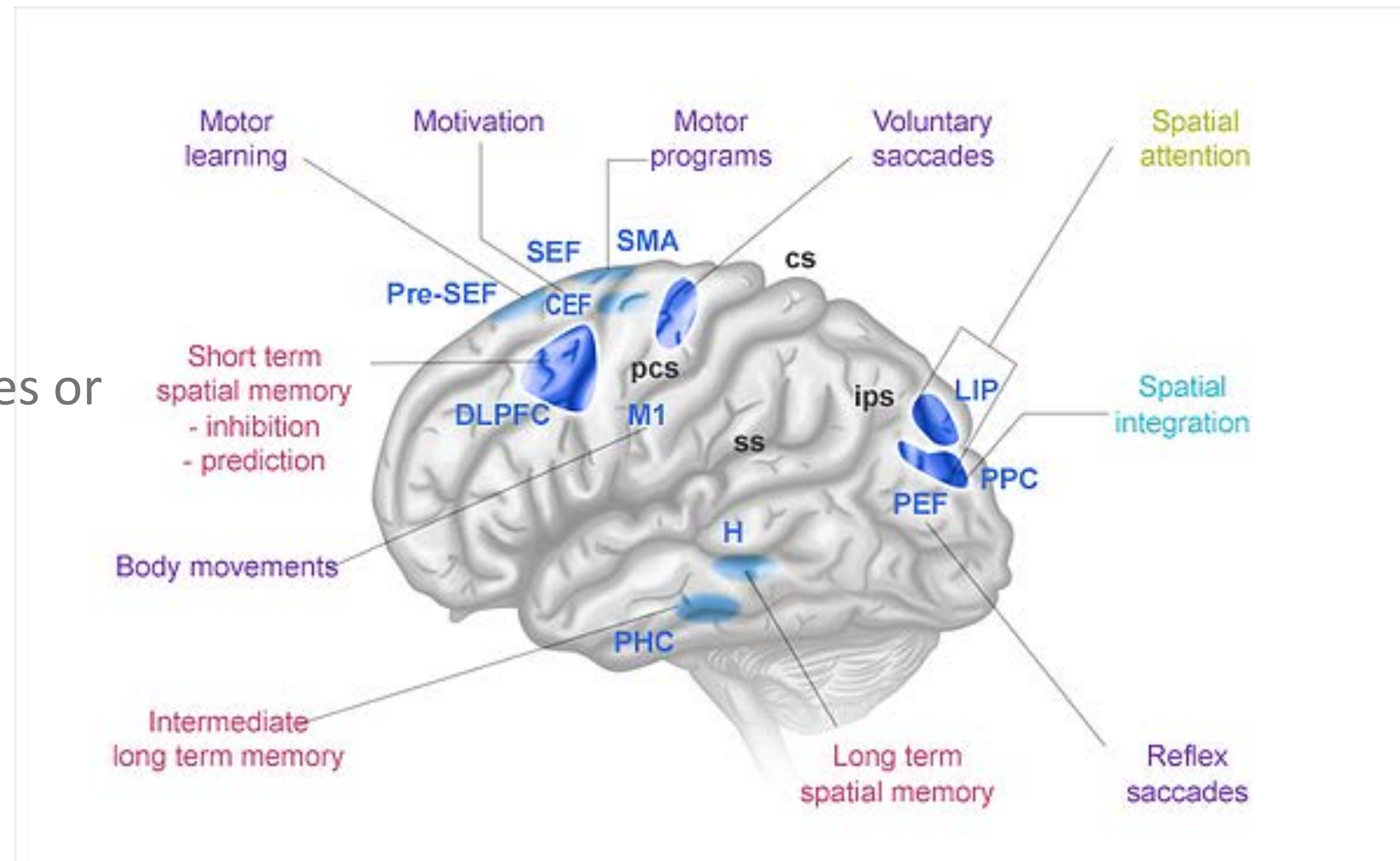


# Ocusweep Reaction Time Perimetry: Why?

Good results in Reaction Time Perimetry can be achieved if

- visual field is normal
- eye movements are normal
- visual processing speed is good

Several neurodegenerative brain diseases or traumatic brain injury, can cause eye movement abnormalities

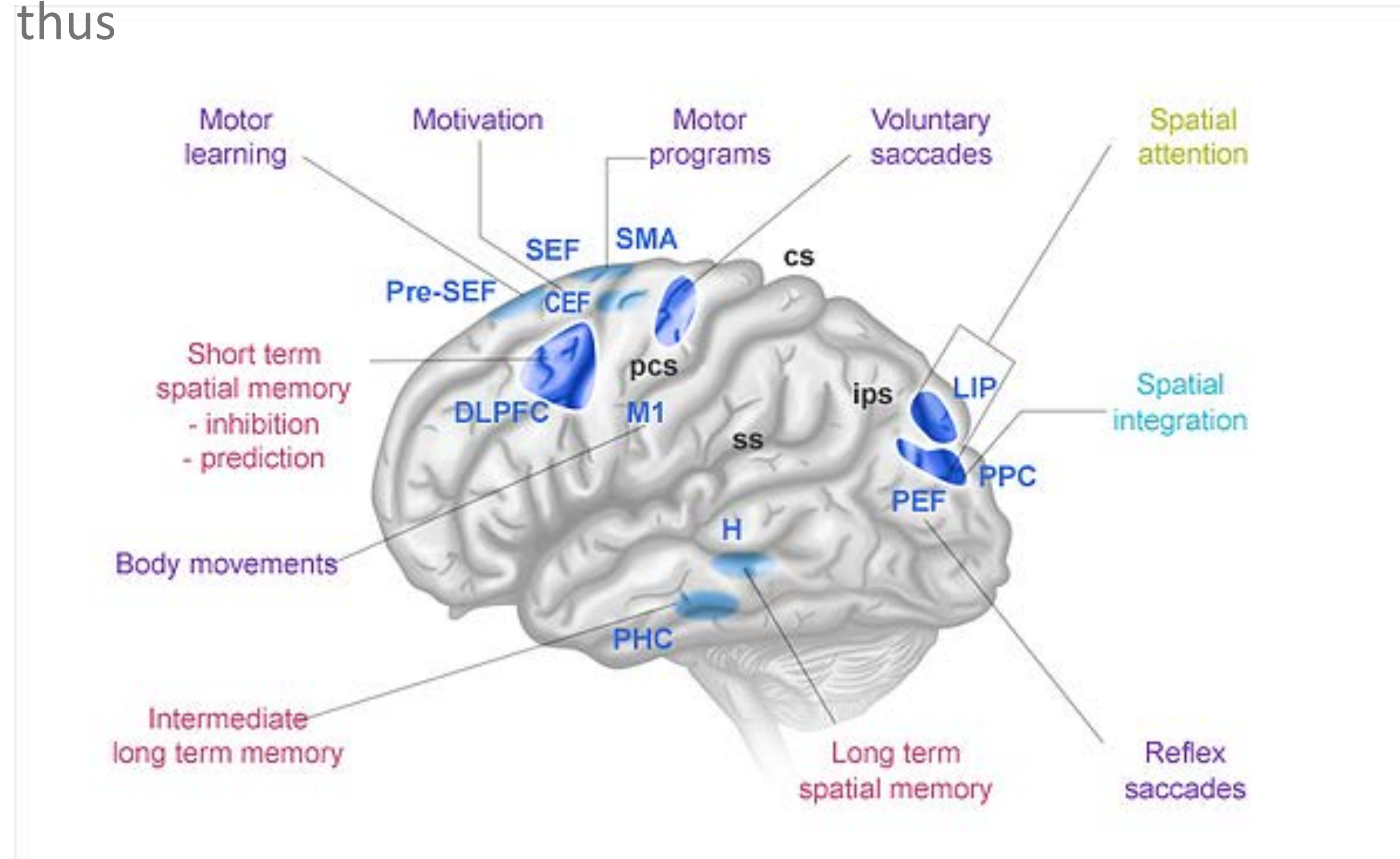




# Ocusweep Reaction Time Perimetry: Why?



→ Ocusweep Reaction Time Perimetry is a measure of the whole visual system and thus reflects the brain function





# Measuring the dysfunction of the visual system in traumatic brain injury diagnostics <sup>1</sup>

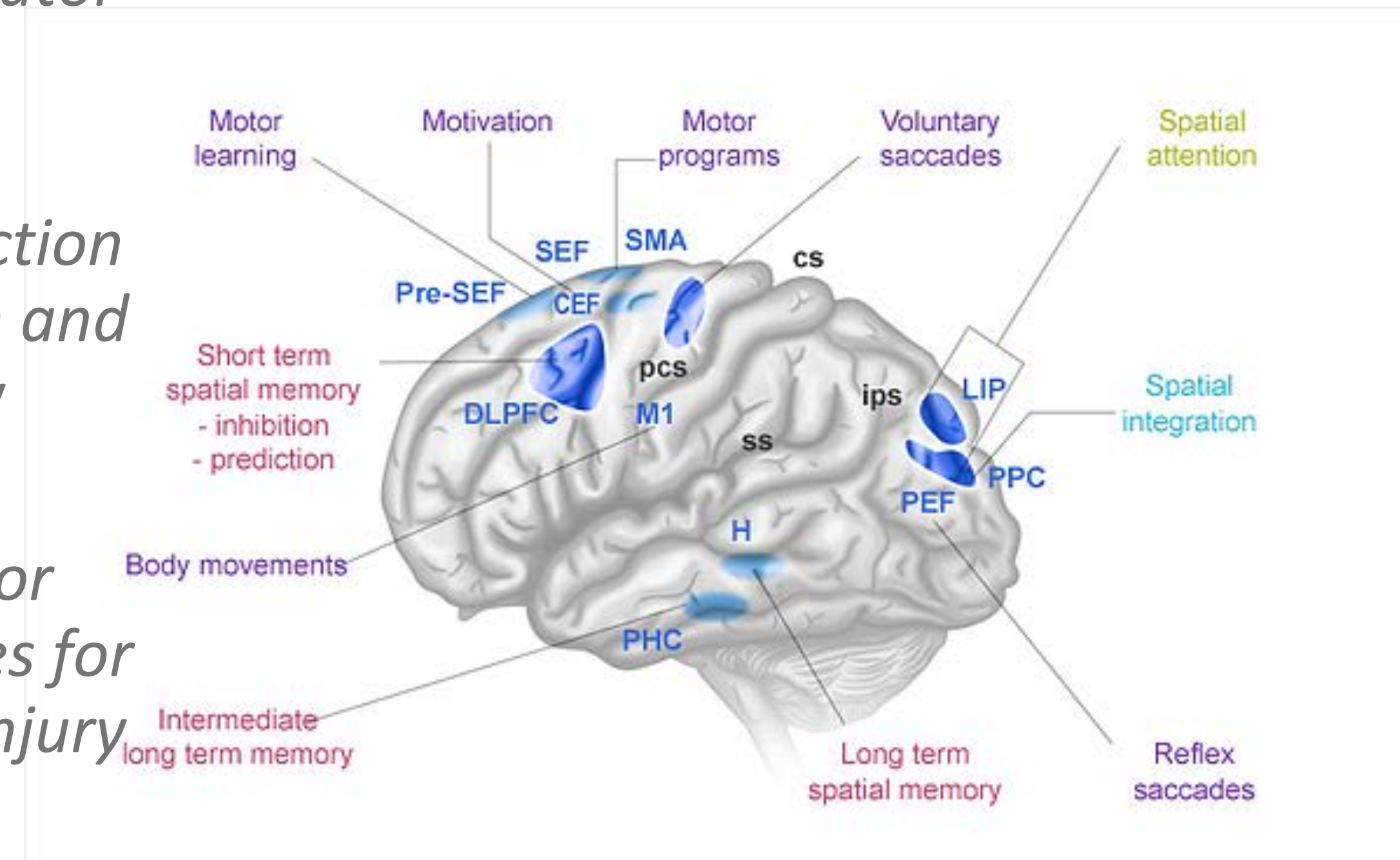


## Conclusions

*The function of the visual system seems to be a good indicator for the function of the brain*

*The score of the Rivermead Post Concussion Symptoms Questionnaire and several variables of the Ocusweep Reaction Time Perimetry test are measuring the same phenomenon and thus Ocusweep could be used for follow up of the recovery phase symptoms in traumatic brain injury*

*The results of this study indicate that Ocusweep oculomotor tests (anti- and prosaccade tests) could be good candidates for assessing objectively the recovery of the traumatic brain injury patients*



<sup>1</sup> Jenni Yliaho (2017), Turku University, Faculty of Medicine, Neurology, Thesis for Medical doctor. Supervised by Olli Tenovuo, Docent, University of Turku and Head of Department, Turku University Hospital, Division of Clinical Neurosciences, Turku Brain Injury Center of Excellence





# Reaction Time Perimetry: Data Analysis

Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

- Ocusweep Reaction Time Perimetry can be used for
  - measuring visual reaction time
  - measuring visual reaction time to stimuli within visual field
  - measuring the visual field
- **It reflects the brain function**
- Eye position (fixation stability) control is adequate

**Data analysis of the topics connected to the performance of Ocusweep RTP test**

Topic	Data from literature	Data from clinical study	Long standing technology	New application of an existing technology	New technology
Visual reaction time measurement	x		x		
Monitoring the orientation of the eye	x	x			x
Measurement of reaction times to visual stimuli within visual field	x	x		x	

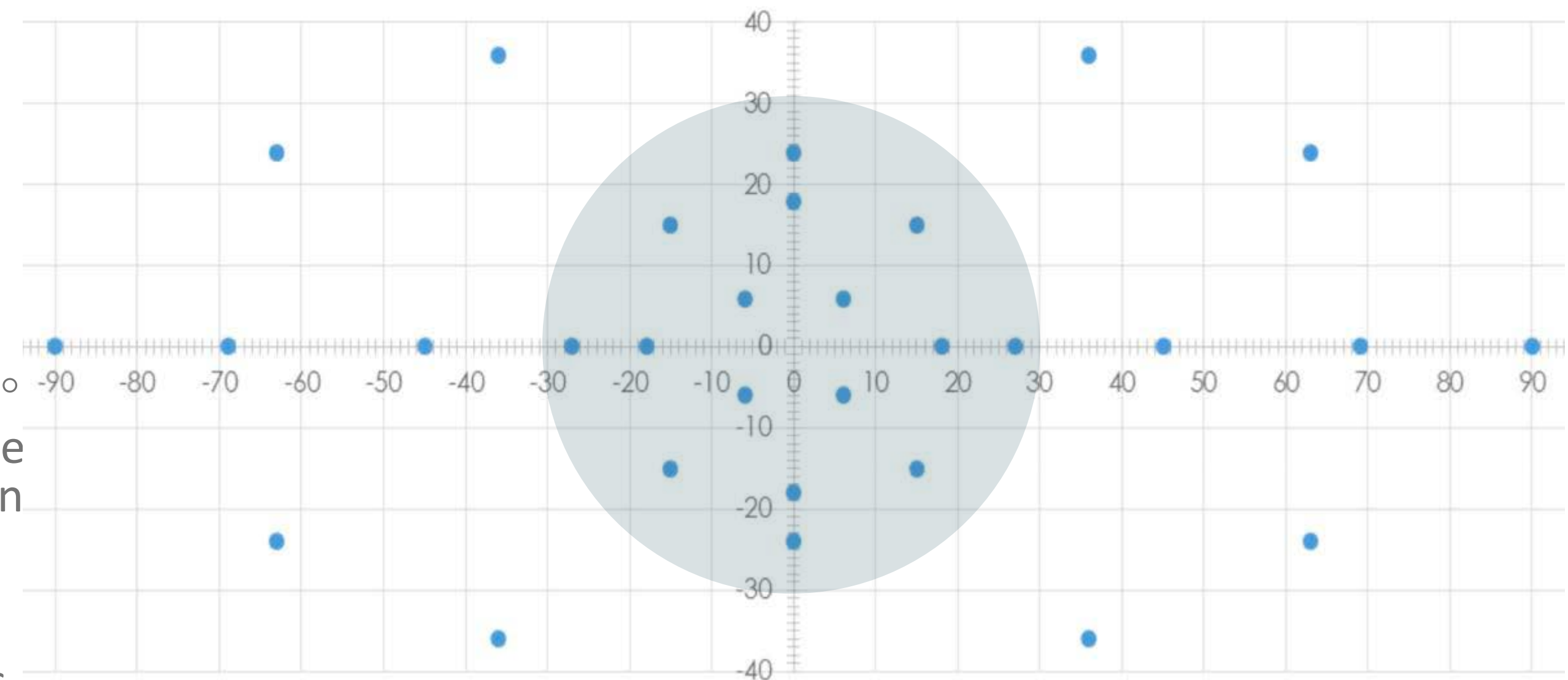
# Reaction Time Perimetry: Measurement accuracy



Ocuspecto Oy (2015): VAL1006  
Clinical evaluation of Ocusweep

Own clinical study: 34 healthy test subjects

- Reaction Time Perimetry (RTP) can be used for assessment of the visual field
- Sensitivity of the visual field corresponds to Standard Automated Perimetry (SAP)
- RTP and SAP visual field index values in the central ( $< 30^\circ$  visual field) are very close to each other (mean difference 1.4 dB, std 1.0 dB in MS). The difference and variability in single location sensitivities are larger.
- RTP visual field measurements are repeatable
- The results indicate that RTP visual field threshold test is highly repeatable especially in global visual field indices (MS difference is only 0.8 dB, std 2.9 dB). Single location difference has larger variability.



*Right eyes of 34 test persons with normal vision were measured with Ocusweep Reaction Time Perimetry (RTP) and Ocusweep Standard Automated Perimetry (SAP).*