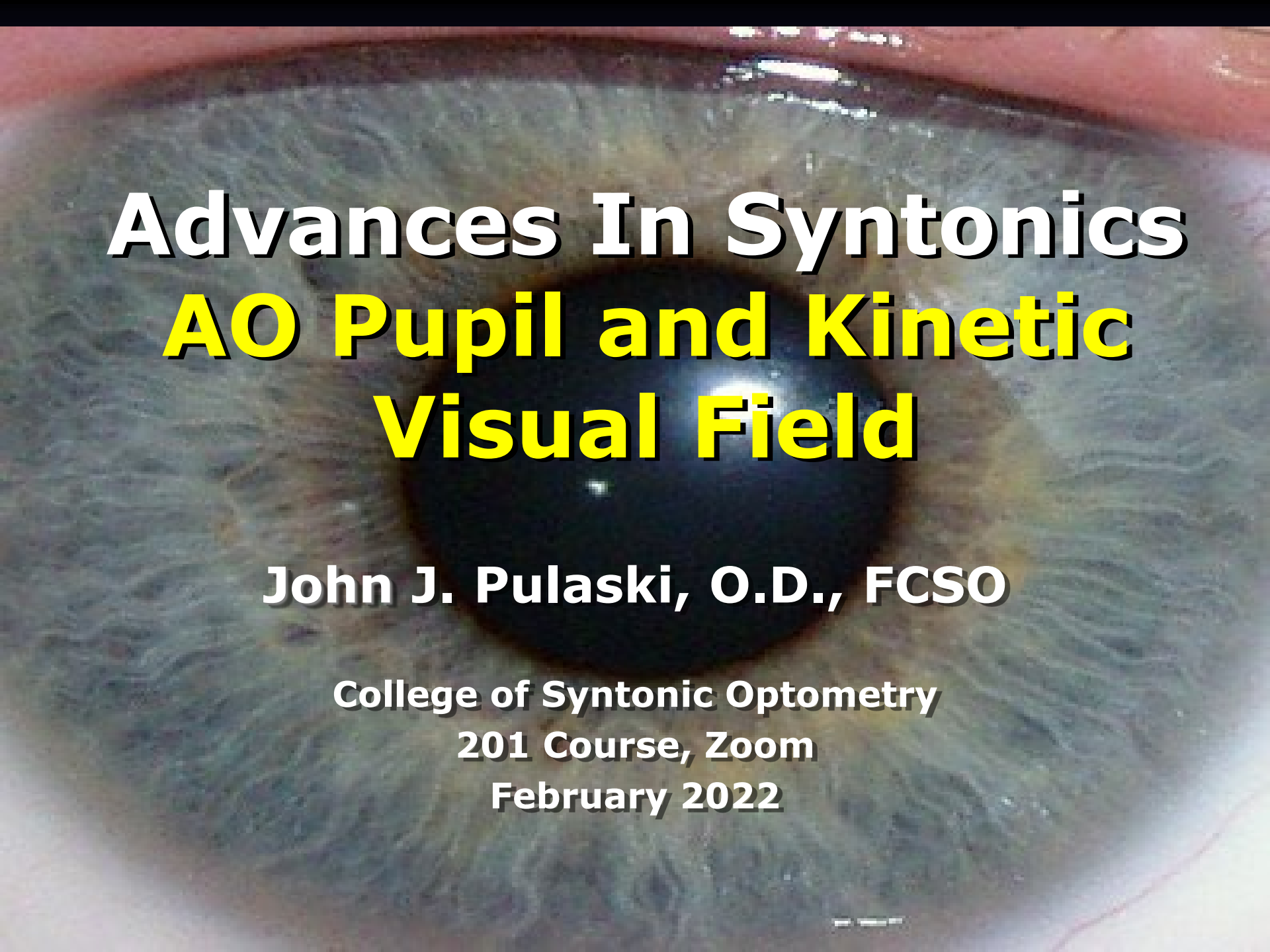


Advances In Syntonics
AO Pupil and Kinetic Visual Field

John J. Pulaski, O.D., FCSO

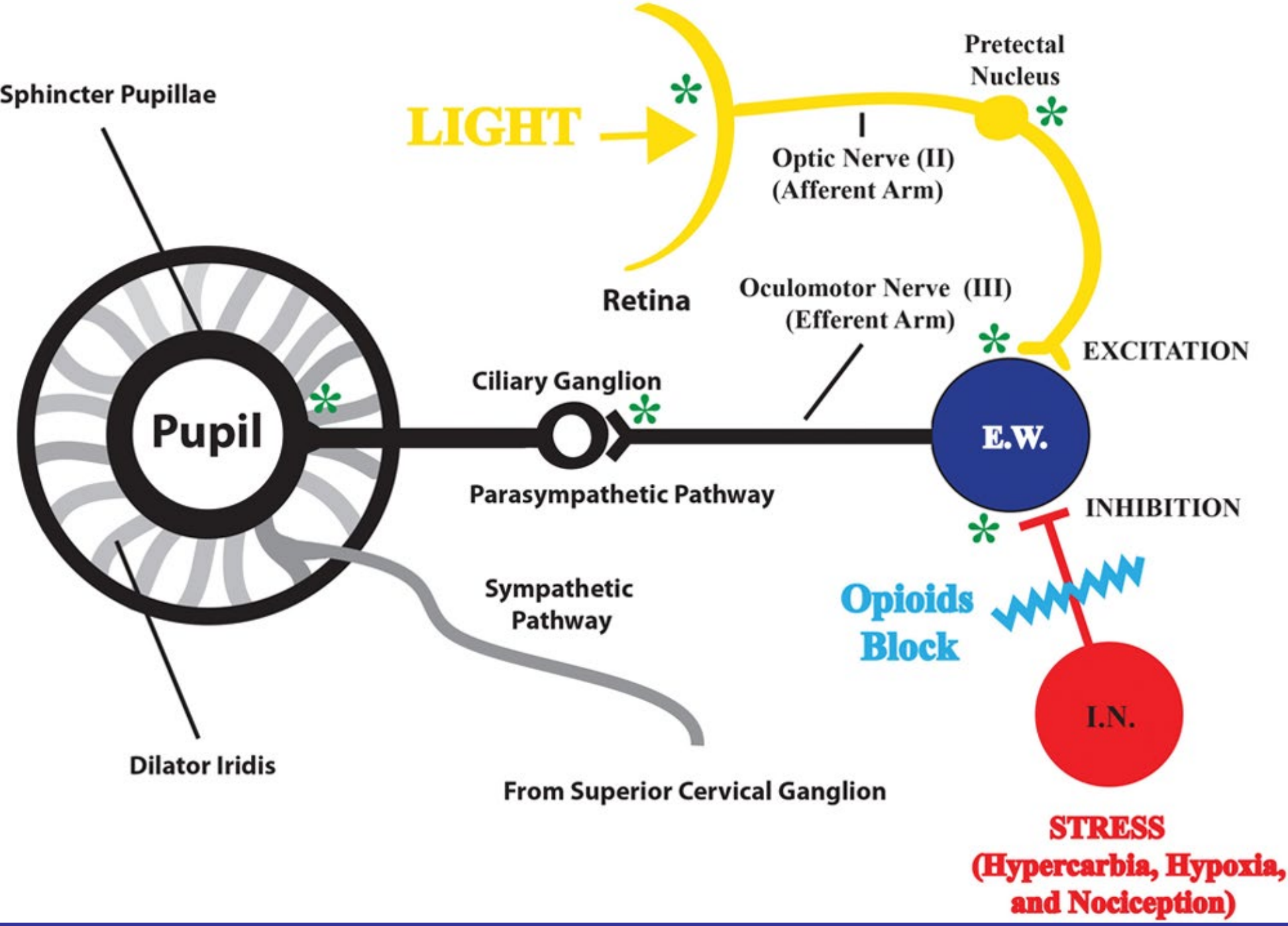
College of Syntonic Optometry
201 Course, Zoom
February 2022

The Pupil

One of the most sensitive measures of ANS activity.

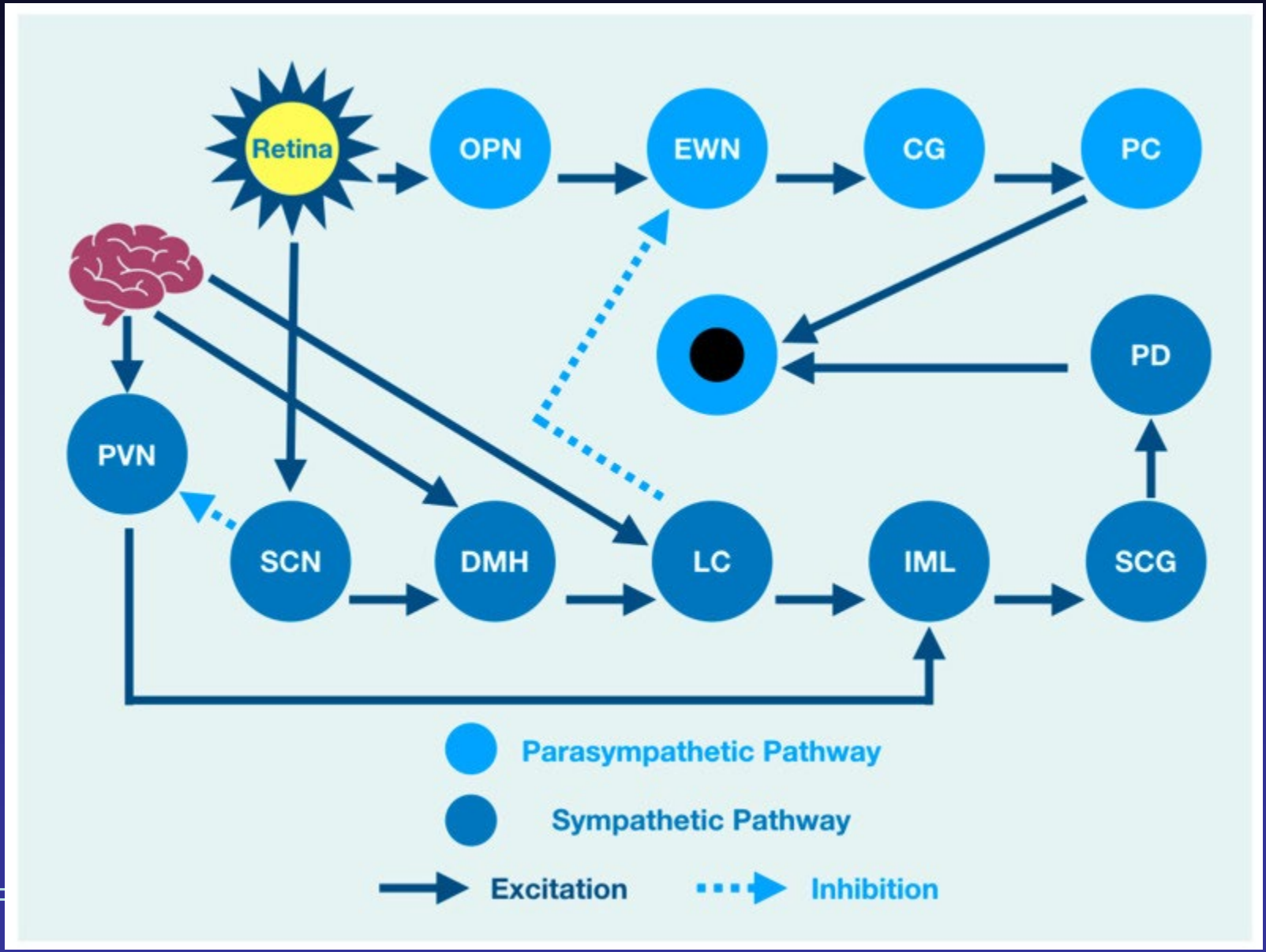
- ANS/Brainstem function
- "Eyes are the Window to the Soul" The Pupils are the Windows.
- Portal of Energy Reception and Projection. Portal through which we interact with our world.
- Non-verbal Communication and strong emotional indicator.
- Reception of "nutrition" - LIGHT

Pulaski AO Pupil


Sphincter Pupillae
LIGHT
Pretectal Nucleus
Optic Nerve (II)
(Afferent Arm)
Retina
Oculomotor Nerve (III)
(Efferent Arm)
EXCITATION
Ciliary Ganglion
Pupil
E.W.
Parasympathetic Pathway
INHIBITION
Sympathetic Pathway
Opioids Block
I.N.
Dilator Iridis
From Superior Cervical Ganglion
STRESS
(Hypercarbia, Hypoxia, and Nociception)

The Pupillary Light Reflex as a Biomarker of Concussion

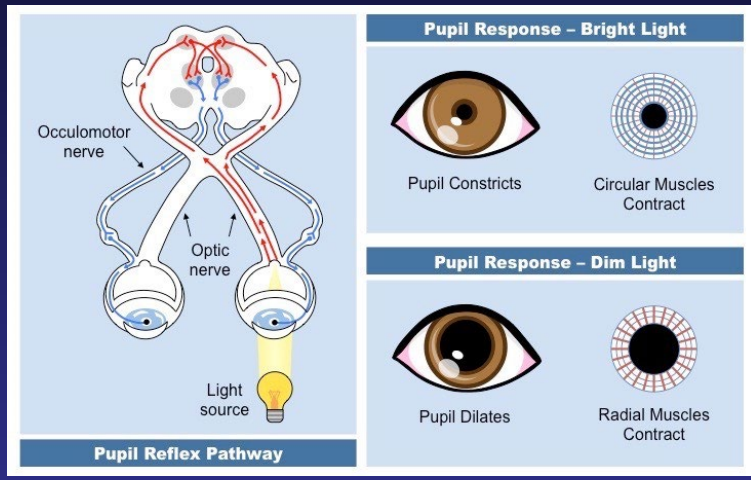
Frederick Robert Carrick[1,2,3,4,5], Sergio F Azzolino[5], Melissa Hunfalvay[5], Guido Pagnacco[5,6], Elena Oggero[5,6], Ryan C N D'Arcy[7,8,9], Mahera Abdulrahman[10], Kiminobu Sugaya[1,2]

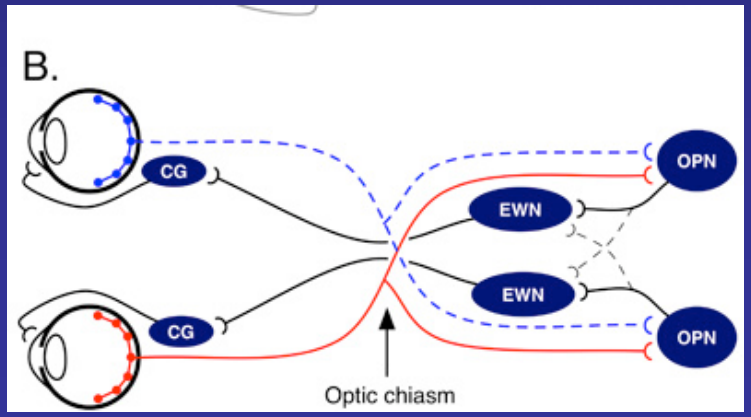


The Pupil
Neurological Pathways

Parasympathetic - Constriction
- The Pupillary Light Reflex (PLR)
- Influence on Iris Sphincter
- Light-Inhibited Sympathetic Path
- Trigeminal Nerve – sensory stimulation to eye/iris

Sympathetic – Dilation
- Direct stimulation of Iris Dilator through 3 neuron arc
- Inhibition of EW nucleus

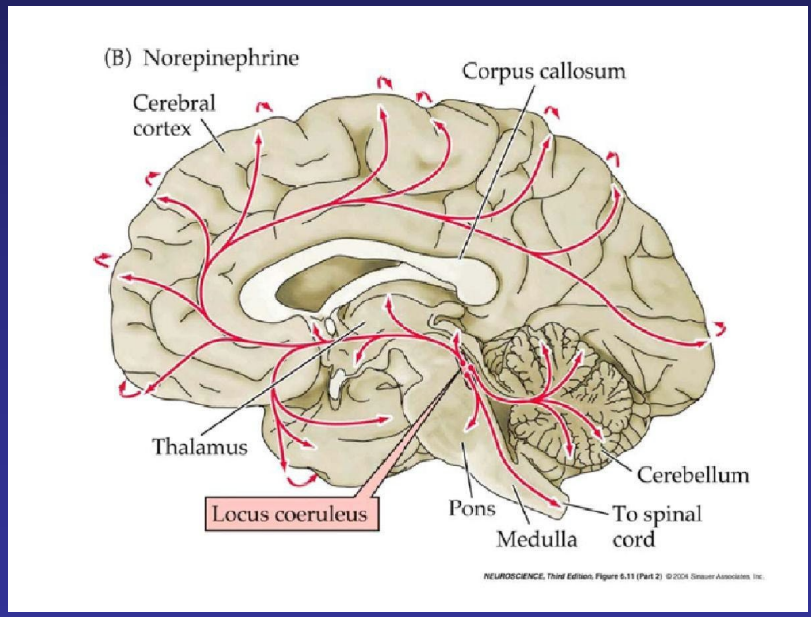




The Pupil
Neurological Pathways

Pathway of Dilation

- Direct Stimulatory - Iris dilator
  - Hypothalmus
  - Nucleus Coeruleus
  - Superior Colliculus
  - Frontal Eye Fields
- Inhibitory – EW nucleus
  - Nucleus Coeruleus
  - Superior Colliculus
  - Supernuclear Inhibition from the Reticular Activating Formation in brainstem

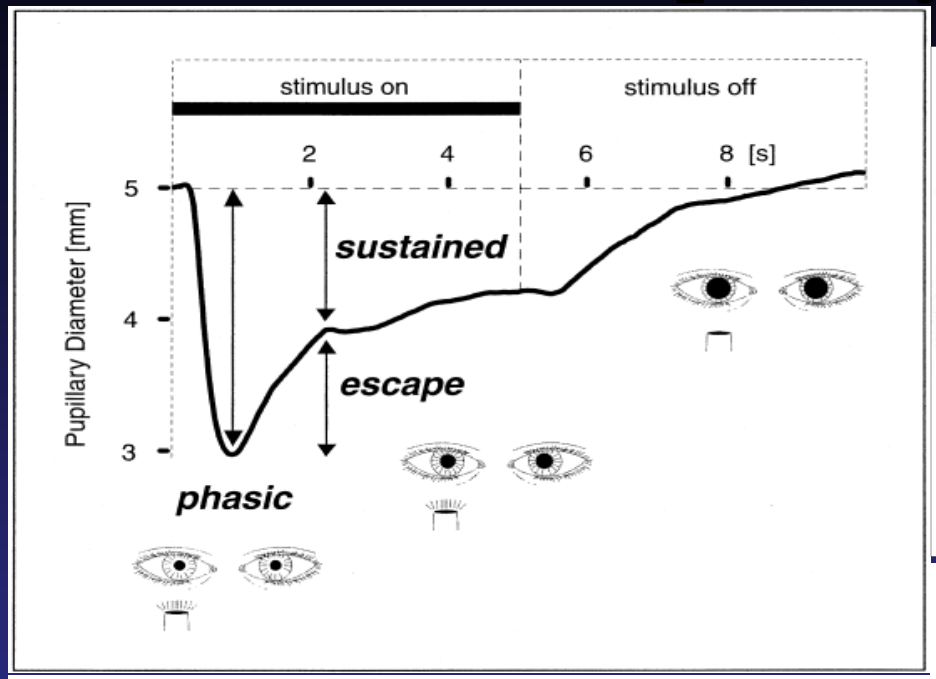


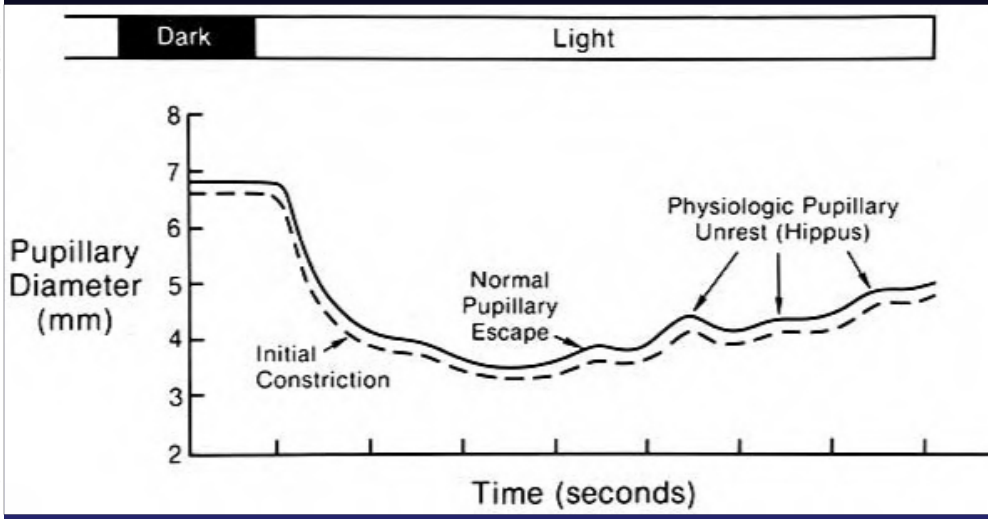
The Pupil
In Syntonics

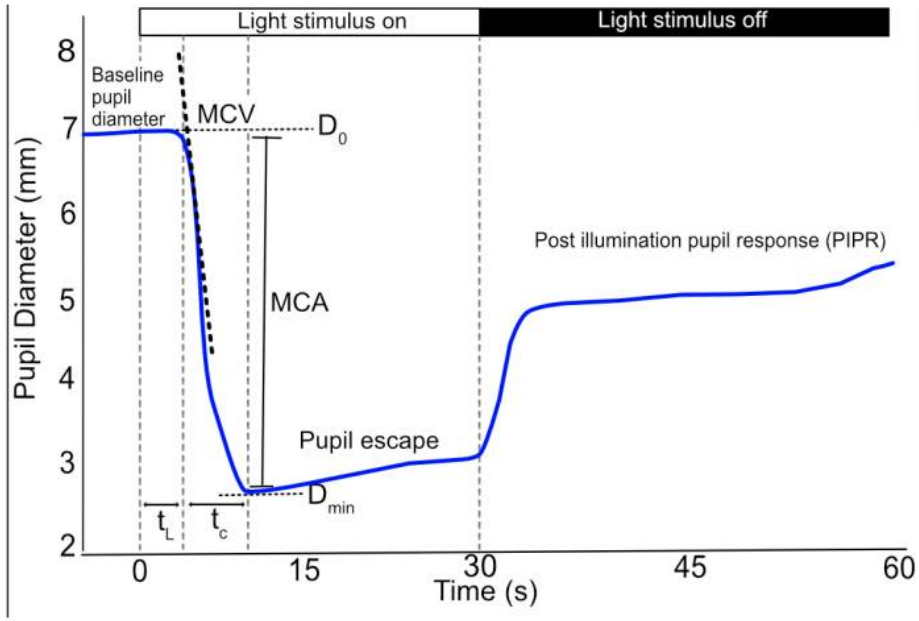
In Syntonics we are interested in the pupil as an indication of the well being of our patient particularly in regards to the state of the ANS. The two major reactions observed are:

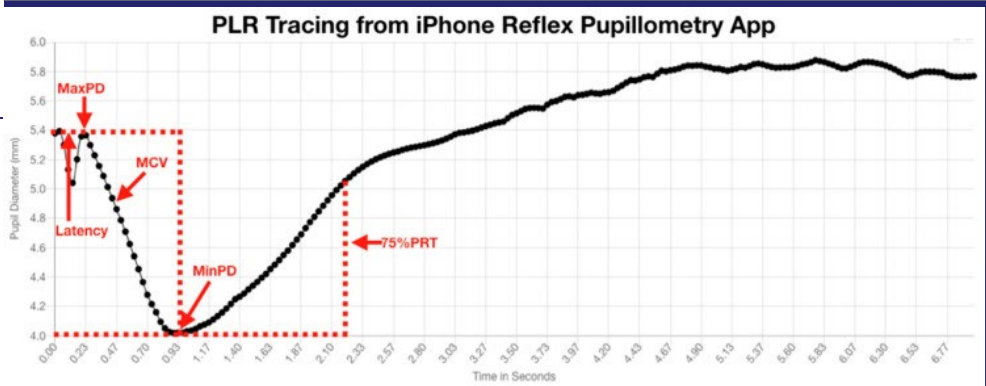
- Alpha Omega Pupil – response of pupil to **sustained** light stimulation
- Pupillary Light Reflex

Pupillary Reactions



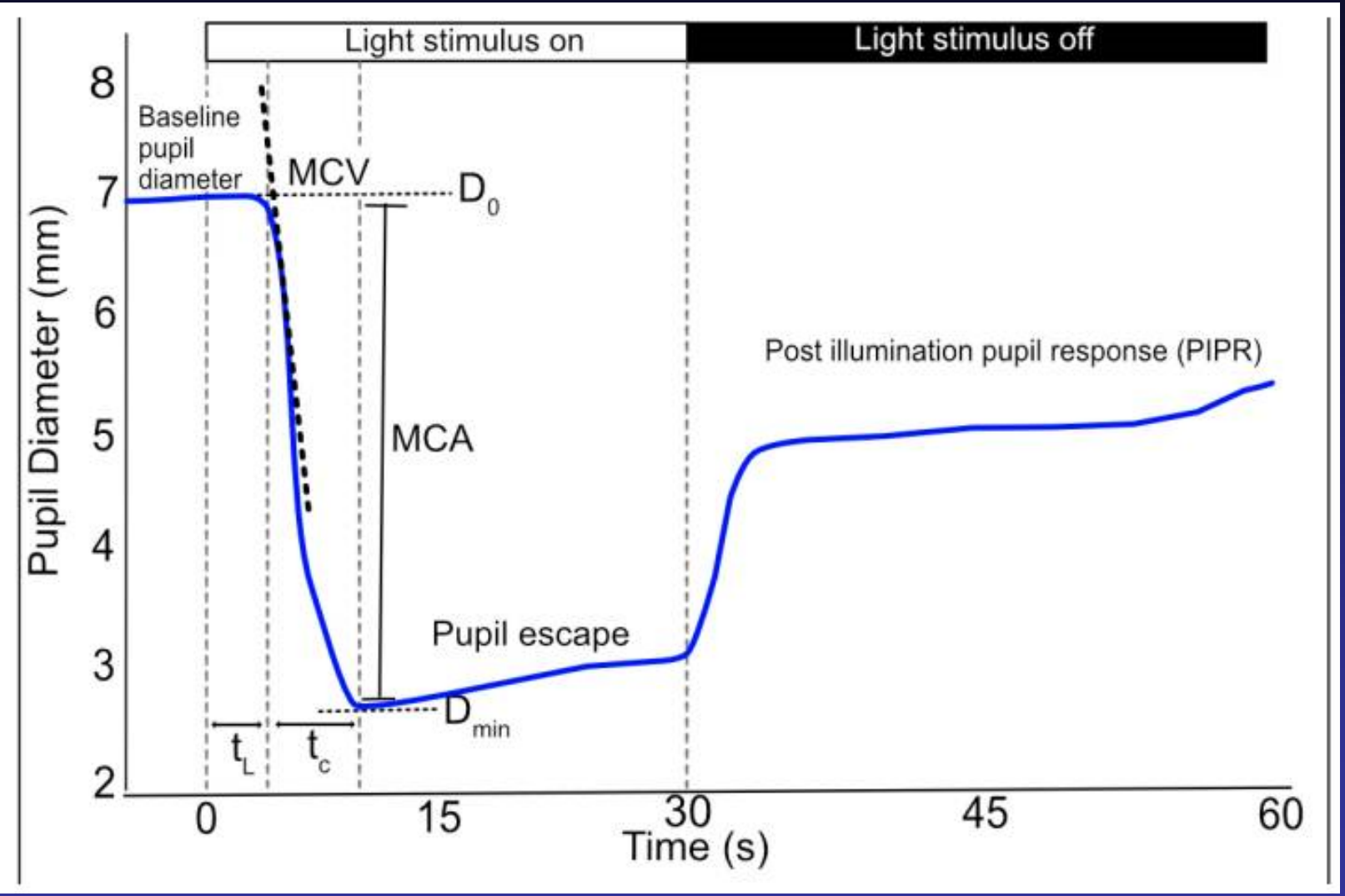






Latency	Time from light flash to pupil constriction
MaxPD	The maximum diameter of pupil before light flash
MinPD	The minimum diameter of pupil after light flash
MCV	The maximum constriction velocity of pupil constriction after light flash
75% PRT	The time for redilation of pupil to 75% of its previous maximum diameter after light flash

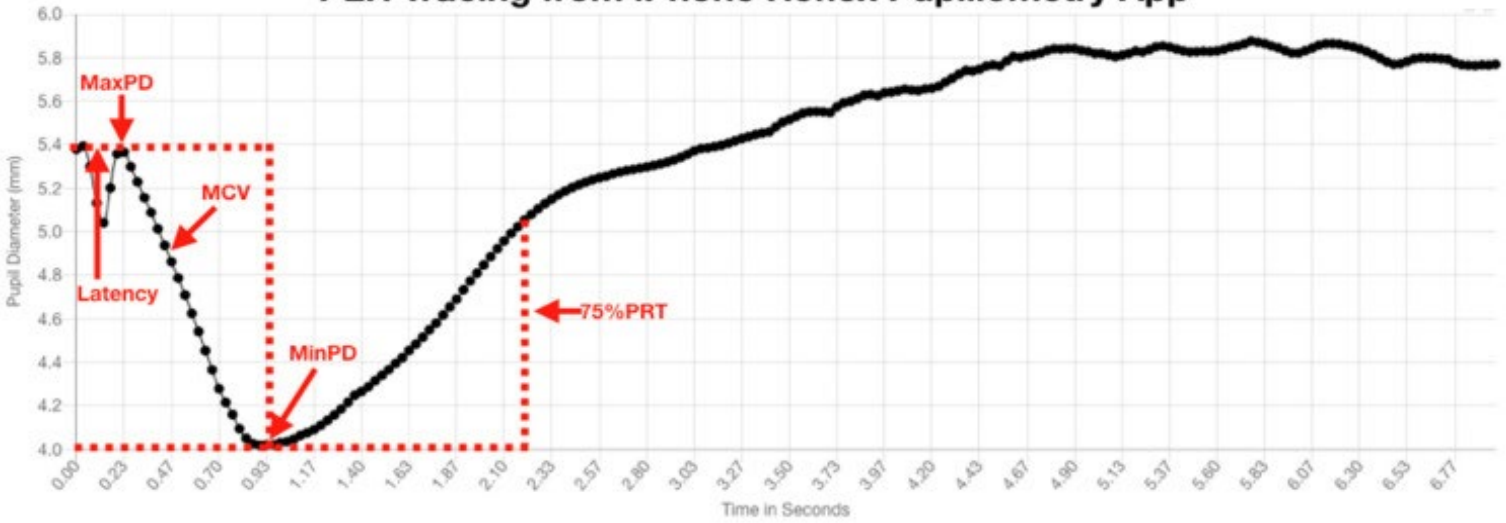
Pupillary Reactions



Pulaski AO Pupil

Pupillary Reactions
Bright Lamp

Carrick et al Life (Basel). 2021 Oct; 11(10): doi: 10.3390/life11101104



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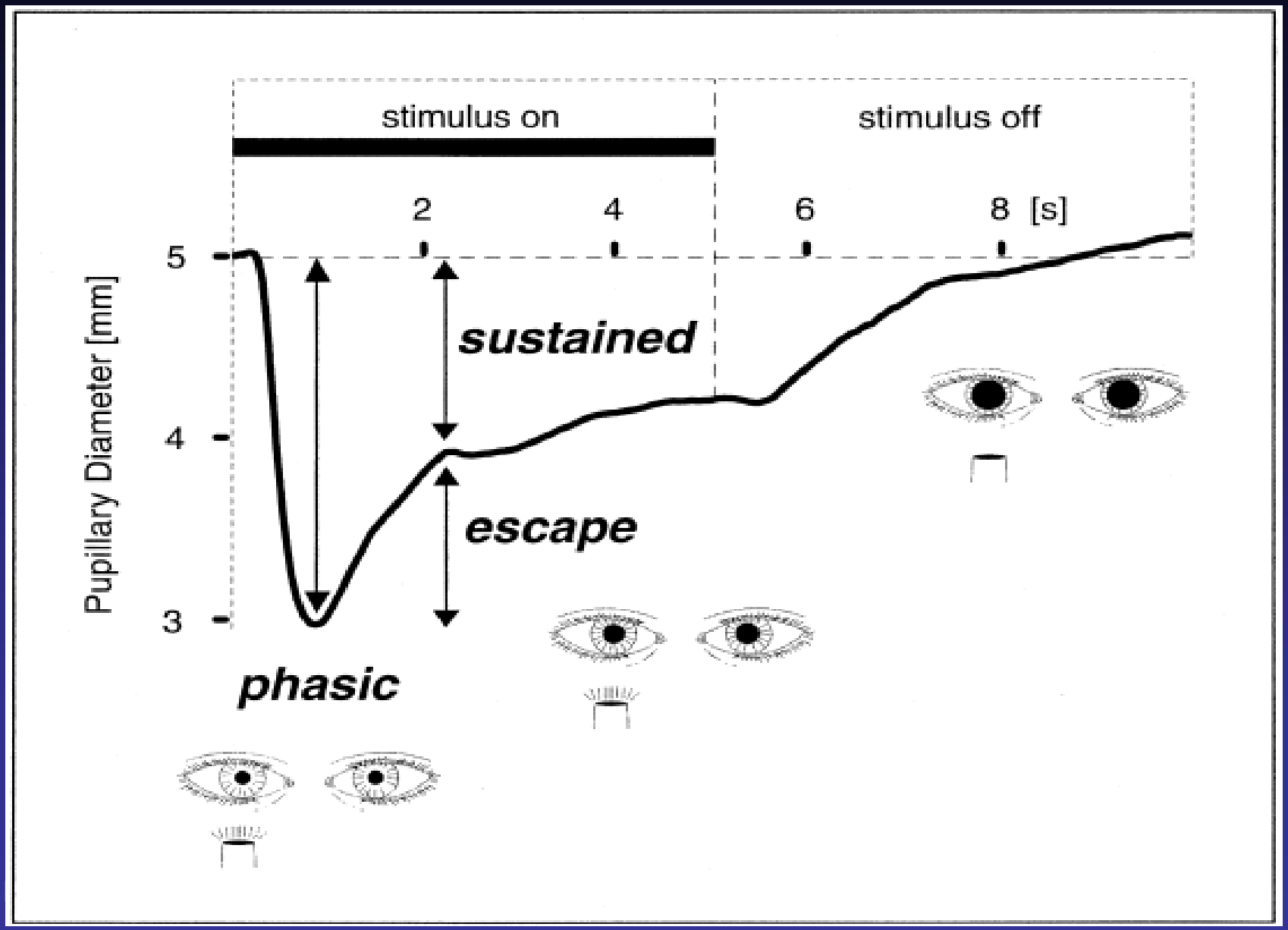
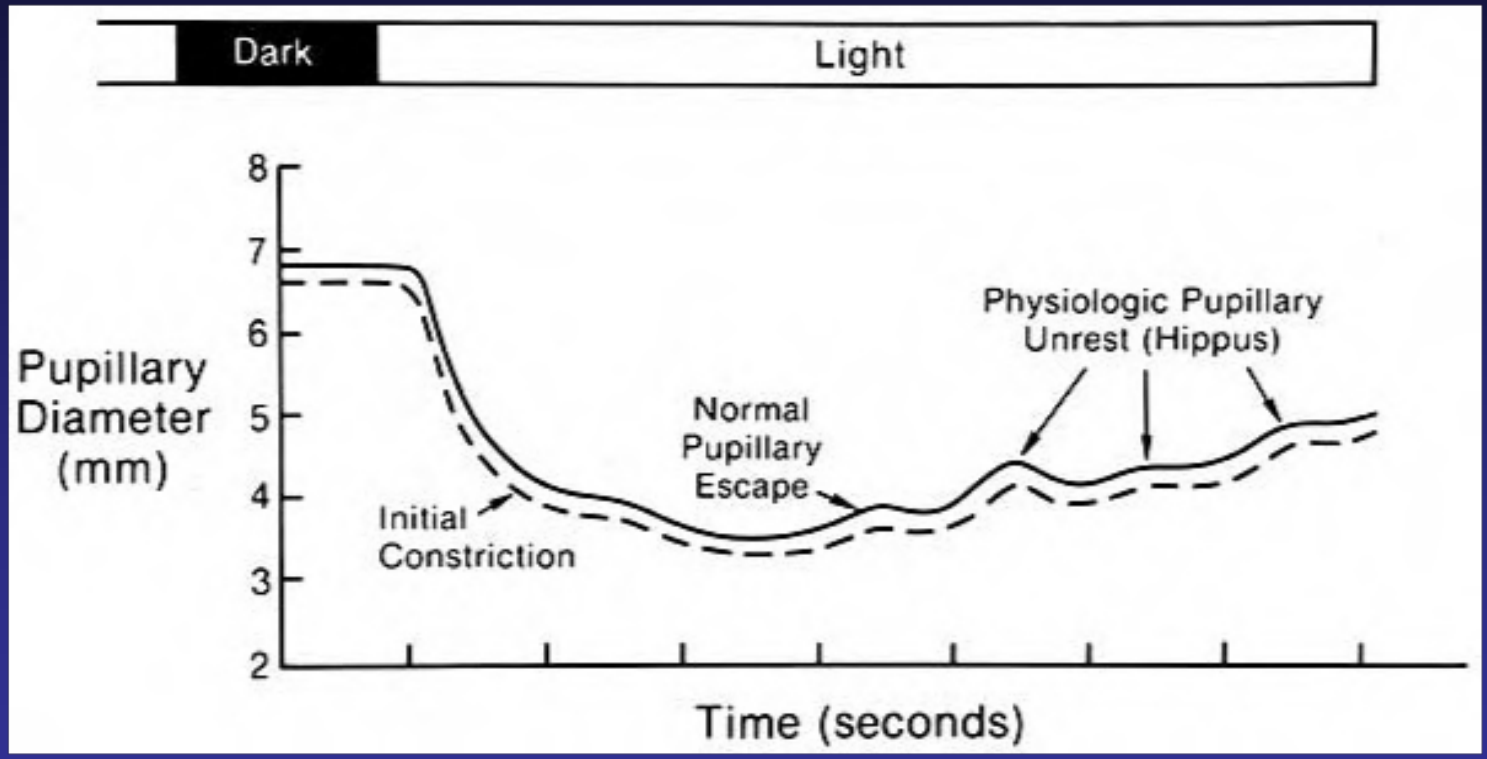
Pula

Pupillary Reactions



Pupillary Reactions



The "Normal" Pupil

Pupillary Unrest

Pupillogram of normal 24 y.o. female under sustained light

(Loewenfeld, "The Pupil")

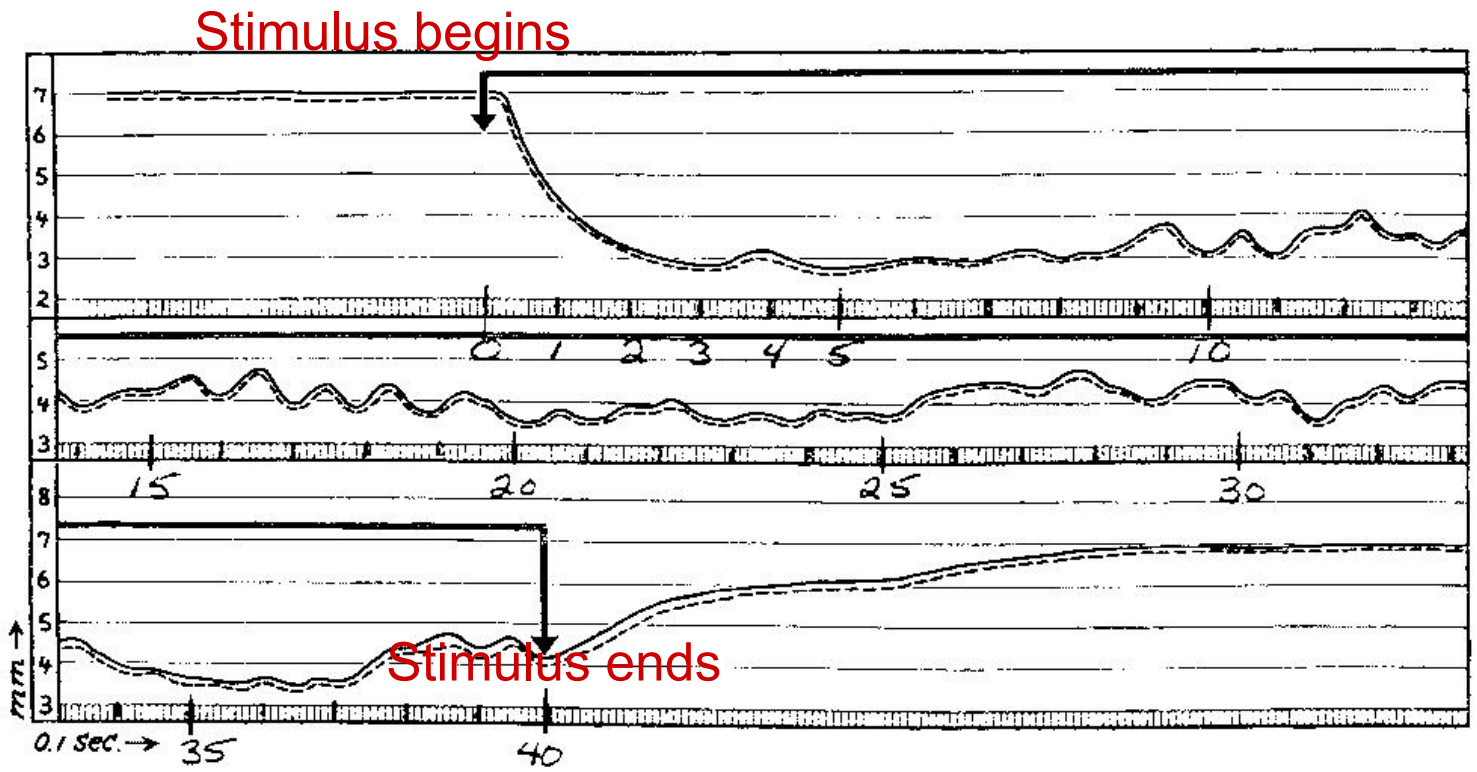
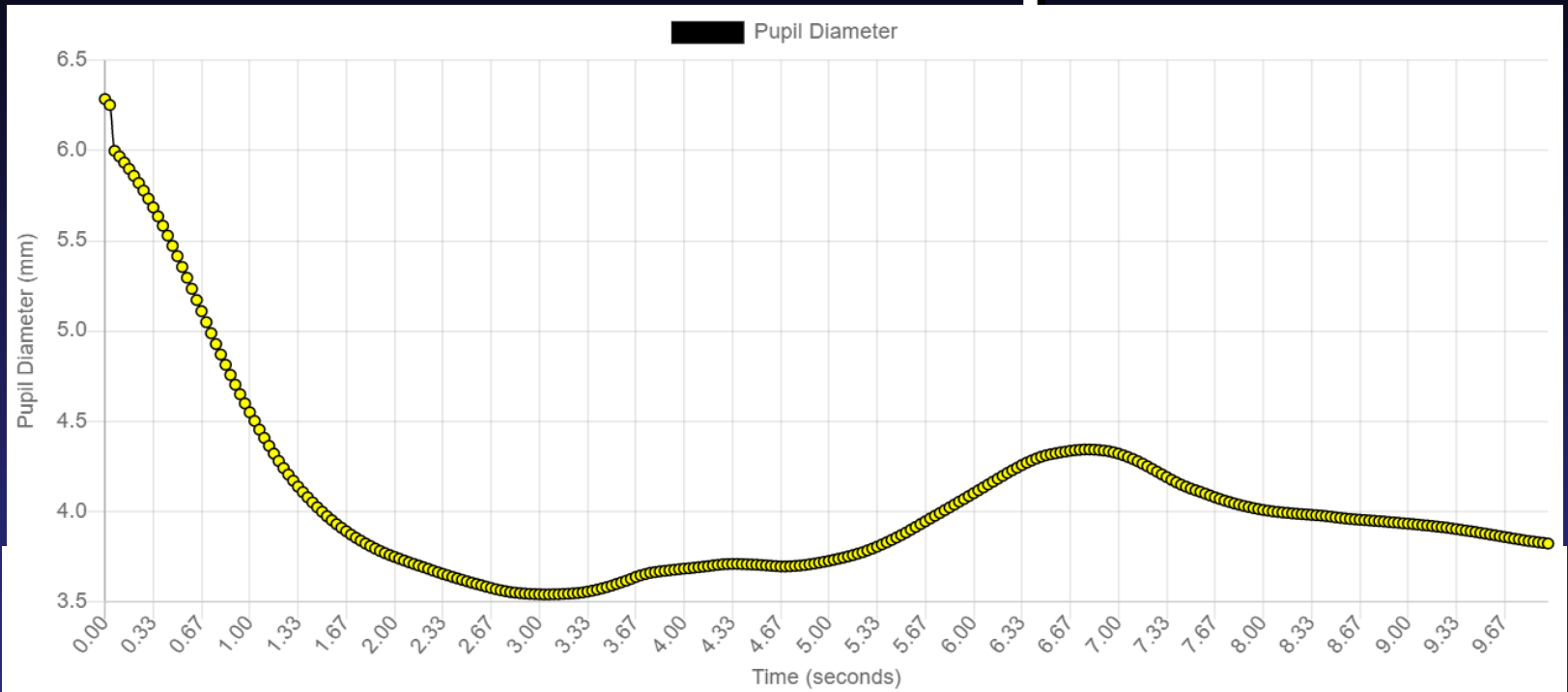
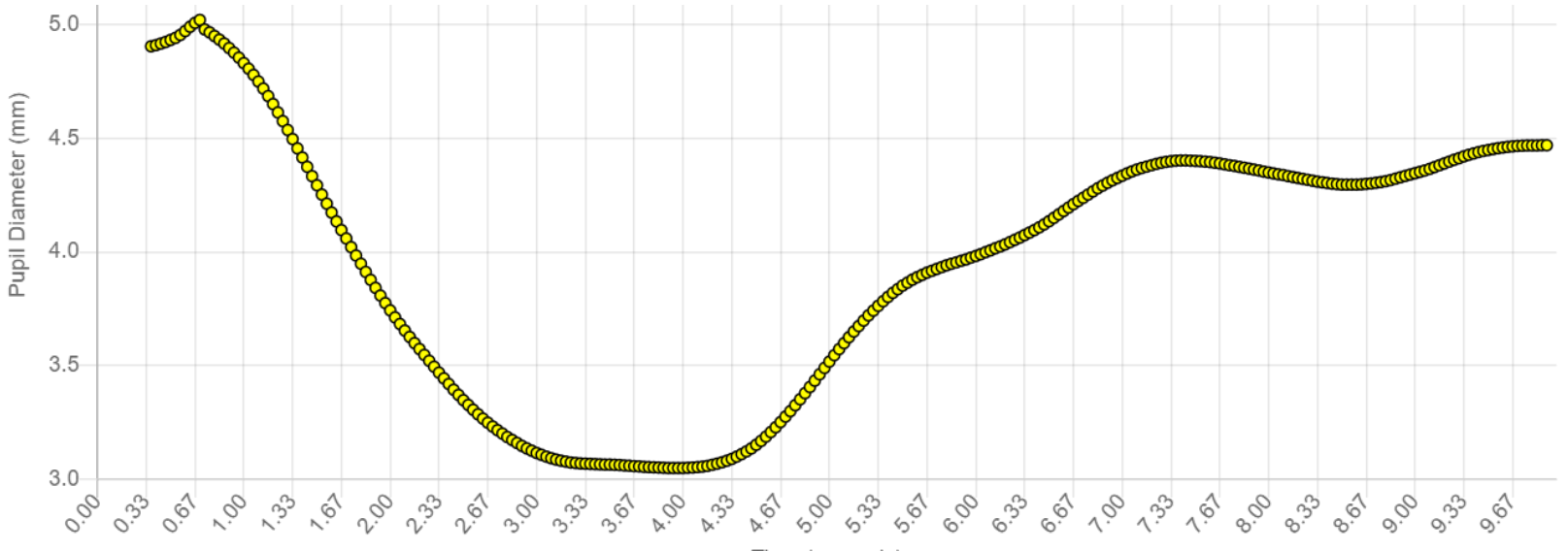


Figure 3-67. Pupillary oscillations during unilateral adaptation to a bright, steady light. Pupillogram of a normal 24-year-old woman. The solid line represents the right, the broken line the left pupil. **First line:** The pupils were large and quiet in darkness. When the right eye was exposed to a steady, bright light, both pupils contracted, then redilated somewhat and began to oscillate. **Second line:** Pupillary oscillations after the right eye had been light was turned off (arrow), the pupils enlarged and the oscillations disappeared. The movements of the right and left pupils remained equal throughout the experiment, even though the right eye alone was stimulated, while the left eye remained in darkness. (From O. Lowenstein and I.E. Loewenfeld, *Amer. J. Ophthal.*, 48, II [1959]:536; published with permission of *The American Journal of Ophthalmology*, © The Ophthalmic Publishing Company)

The AO Pupil


Pupil Diameter
Pupil Diameter (mm)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
0.00
0.33
0.67
1.00
1.33
1.67
2.00
2.33
2.67
3.00
3.33
3.67
4.00
4.33
4.67
5.00
5.33
5.67
6.00
6.33
6.67
7.00
7.33
7.67
8.00
8.33
8.67
9.00
9.33
9.67
Time (seconds)


Pupil Diameter (mm)
5.0
4.5
4.0
3.5
3.0
0.00
0.33
0.67
1.00
1.33
1.67
2.00
2.33
2.67
3.00
3.33
3.67
4.00
4.33
4.67
5.00
5.33
5.67
6.00
6.33
6.67
7.00
7.33
7.67
8.00
8.33
8.67
9.00
9.33
9.67

The Pupil

Sympathetic

Influences on Pupillary Reflex Dilation

The Normal Pupillary Reflex Dilation

Any sensory, emotional, or mental stimulus elicits reflex dilation. Any sound, touch or pain, fear, joy or anger or spontaneous thoughts and intentional efforts all dilate the pupils.

The amplitude of reaction depends on the degree of arousal caused by the stimulus and the subject's physical and mental state at the time of stimulation.

Loewenfeld

The Pupil
Influences on Pupillary Reflex

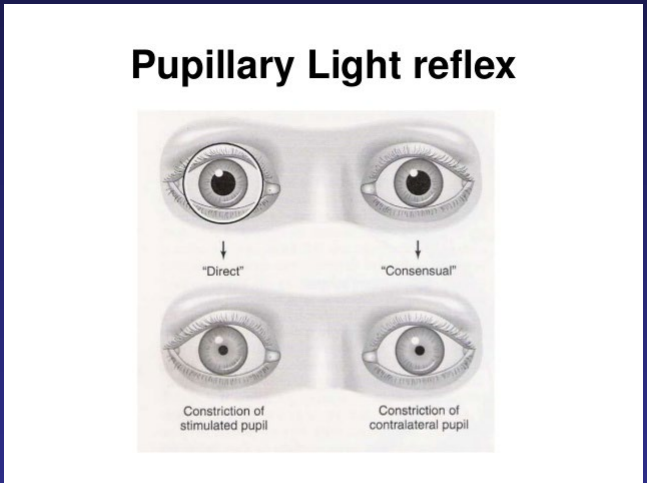
Increased Dilation	Increased Constriction
Increased attention	Mind wandering/Distraction
Orienting Reflex	Introspection
Increased mental effort	Poor task performance
Mental arithmetic	Disgust
Memory formation	Images of the sun
Pleasant sounds	High level scene processing
Perception of odors	Memory retrieval
Sexual arousal	
Dishonesty, Lying	
Enjoy/Dislike what is seen	

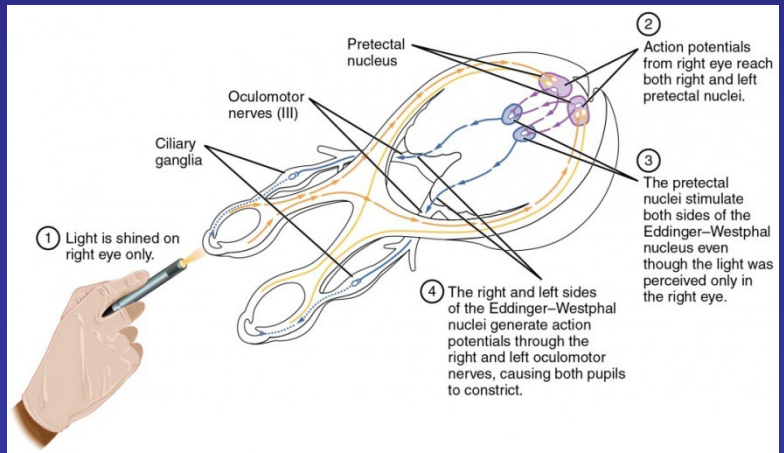
The Pupil

Reactions

Pupillary Light Reflex

- 10-20% of RGC axons relate to PLR
- 1% of ipRGC's
- Speed/Strength of contraction
- Coma, TBI, Stroke
- Excited Patient
- Relation to ANS

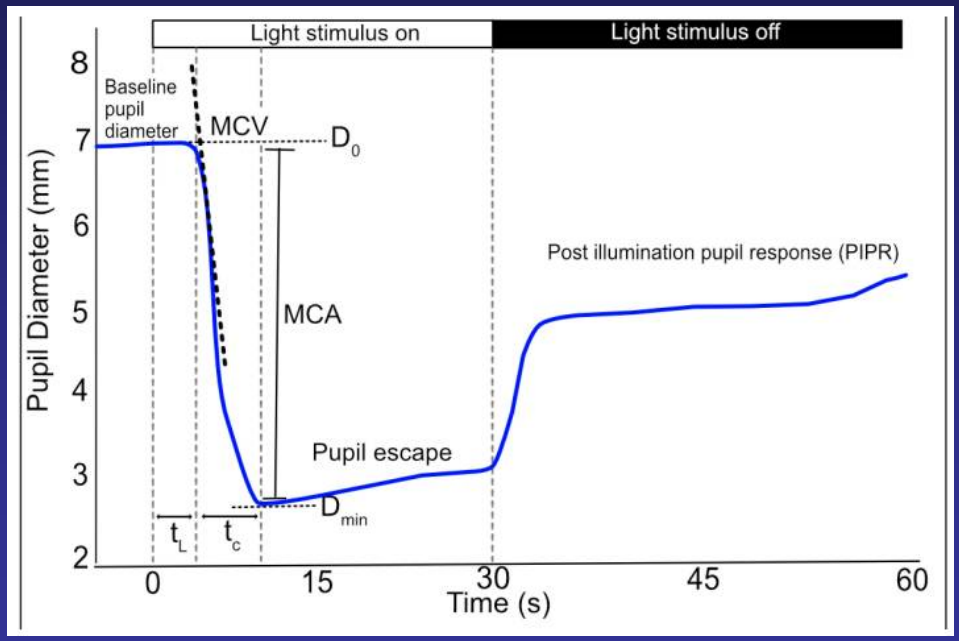




The Pupil
Reactions
Pupillary Light Reflex

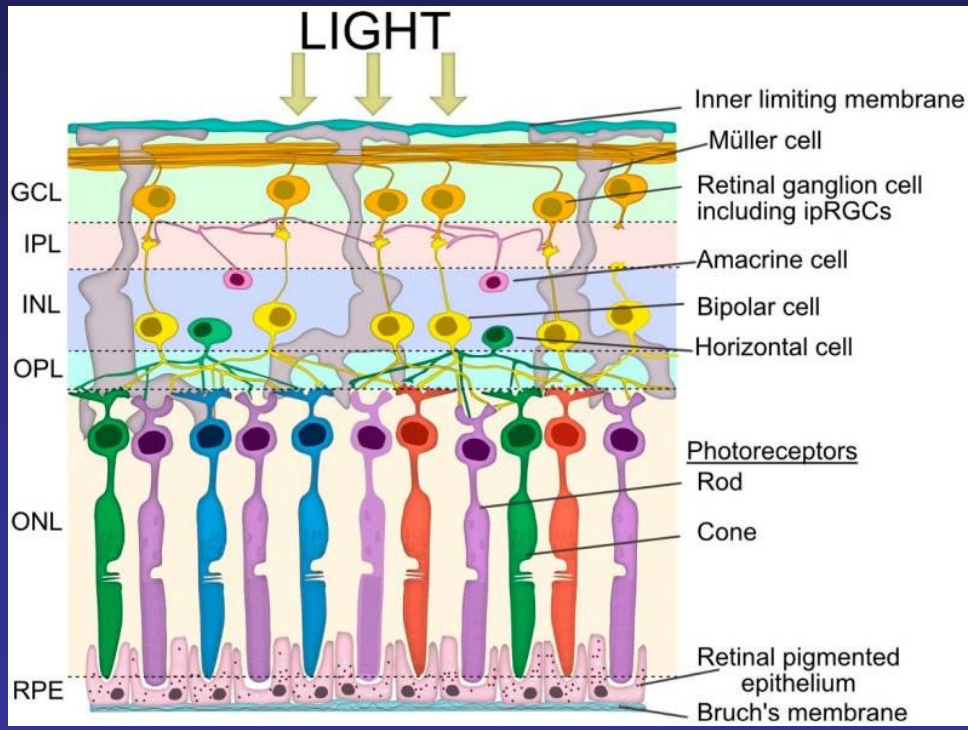
MCA, MCV predictors for

- Alzheimer's
- Parkinson's
- ABI/TBI
- Autism
- Drugs/Alcohol
- Infection
- ADD – increased MPD and MCV



The Pupil
Reactions
Pupillary Light Reflex

- ipRGC's very important in recovery phase (PIPR)
- Pupil both inhibited and activated by different wavelength sensitive cones
- Important in sustained constriction



Testing - Pupillometry

Conventional

- Subjective with many areas of variability

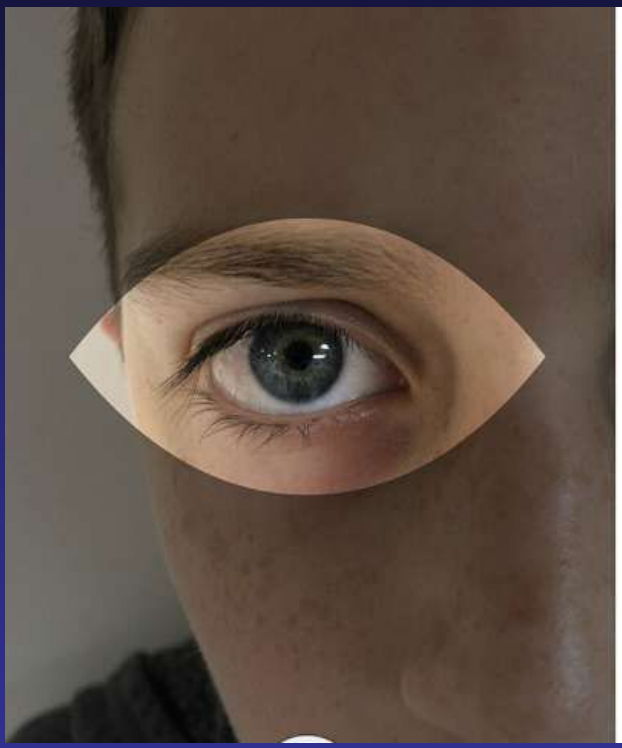
Automated Pupillometry

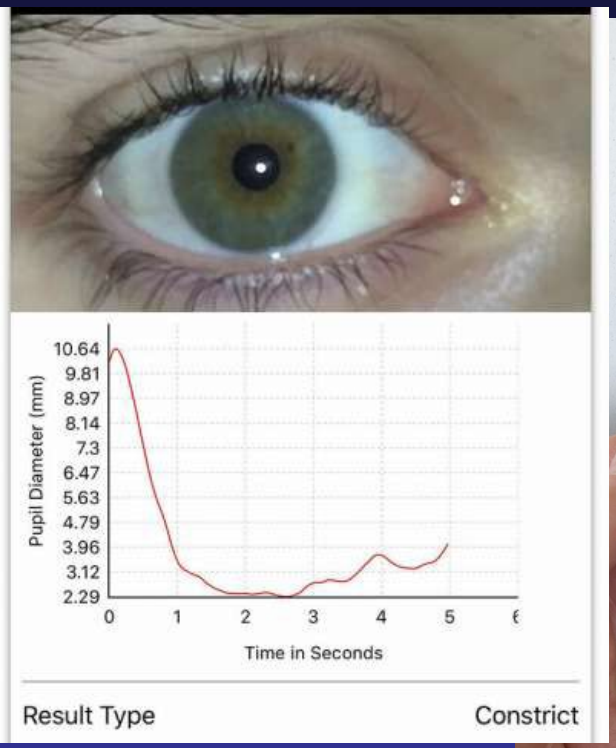
- Reliable quantitative objective testing
- Reproducible needed for comparative tesing over time especially important in monitoring our treatments and for research.
- Accurate immediate assessment of patient.

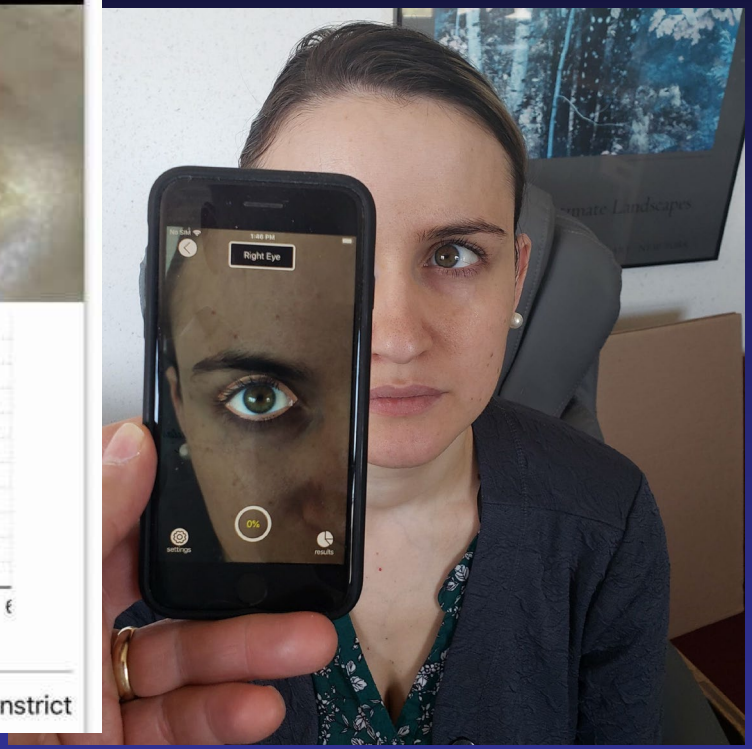
The Pupil
TESTING

Automated Pupillometry

The Pupil
Automated Testing – BrightLamp Reflex







The Pupil
Automated Testing
BrightLamp Reflex Pro

For Objective Testing

Reflex is a clinically validated tool that is easy, objective, and repeatable. Our convenient barcode scanning system makes data entry fast and simple. Just hold the phone up to your patient's eye and initiate the test, easy as that.

Use Reflex in your practice:

- as an objective biomarker for vision rehabilitation
- to assess the alpha omega pupil
- as a tool for concussion diagnosis and recovery monitoring

The Pupil
Automated Testing – BrightLamp Reflex
Pupil Parameter Normal Ranges

• Avg. Constriction Speed	0.45 - 1.159 mm/sec
• Avg. Diameter	3.169 - 3.816 mm
• Avg. Dilation Velocity	0.888 - 2.699 mm/sec
• Constriction Time	1.178 - 2.217 sec
• Latency	0.138 - 0.279 sec
• Max. Constriction Speed	4.013 - 9.136 mm/sec
• Max. Diameter	3.662 - 5.186 mm
• Min. Diameter	2.861 - 3.317 mm
• 75% Recovery Time	3.945 - 4.54 sec

The Pupil
Automated Testing – Bright Lamp
BrightLamp Reflex

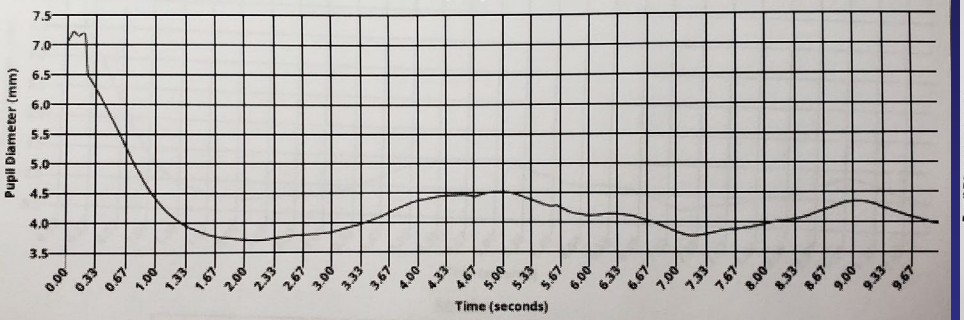
Patient Information

Birth Date	05/09/2008
Sex	Female
Eye Location	Left
Concussion Date	N/A
Asymptomatic?	Yes

Test Information

Test Date & Time	03/12/2020 05:27:57 PM
Test Administrator	John PulaskiOD
Test Type	Full Spectrum w/Torch
Torch Level	50%
Flash Status	Off
Video Duration	10.5 sec
Torch Duration	10 sec

Pupillogram



Results

Metric	Results (red values are 2σ > mean normative range)	Normative Data
(Beta) Reflex Score	Error: 3	0 - 5
Avg. Constriction Speed	**1.762 mm/sec**	0.45 - 1.159 mm/sec
Avg. Diameter	**4.259 mm**	3.169 - 3.816 mm
Avg. Dilation Velocity	N/A	0.888 - 2.699 mm/sec
Constriction Time	2.1 sec	1.178 - 2.217 sec
Latency	0.233 sec	0.138 - 0.279 sec
Max. Constriction Speed	8.4 mm/sec	4.013 - 9.136 mm/sec
Max. Diameter	**7.229 mm**	3.662 - 5.186 mm
Min. Diameter	**3.703 mm**	2.861 - 3.317 mm
75% Recover Time	N/A	3.945 - 4.54 sec

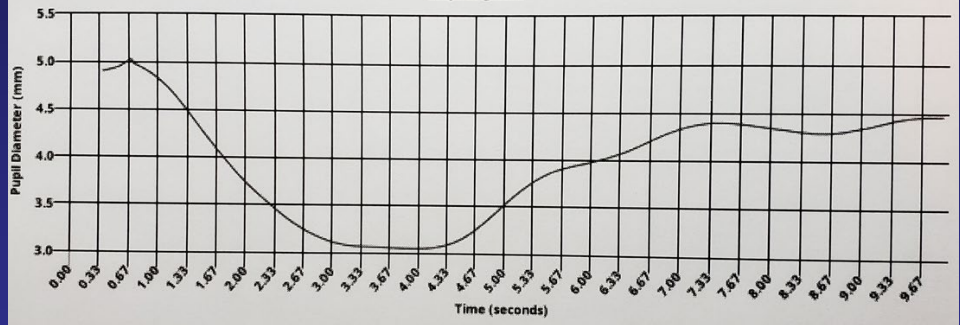
Patient Information

Birth Date	03/11/2006
Sex	Male
Eye Location	Left
Concussion Date	N/A
Asymptomatic?	Yes

Test Information

Test Date & Time	03/13/2020 09:10:42 AM
Test Administrator	John PulaskiOD
Test Type	No Light
Torch Level	0%
Flash Status	Off
Video Duration	10.5 sec
Torch Duration	10 sec

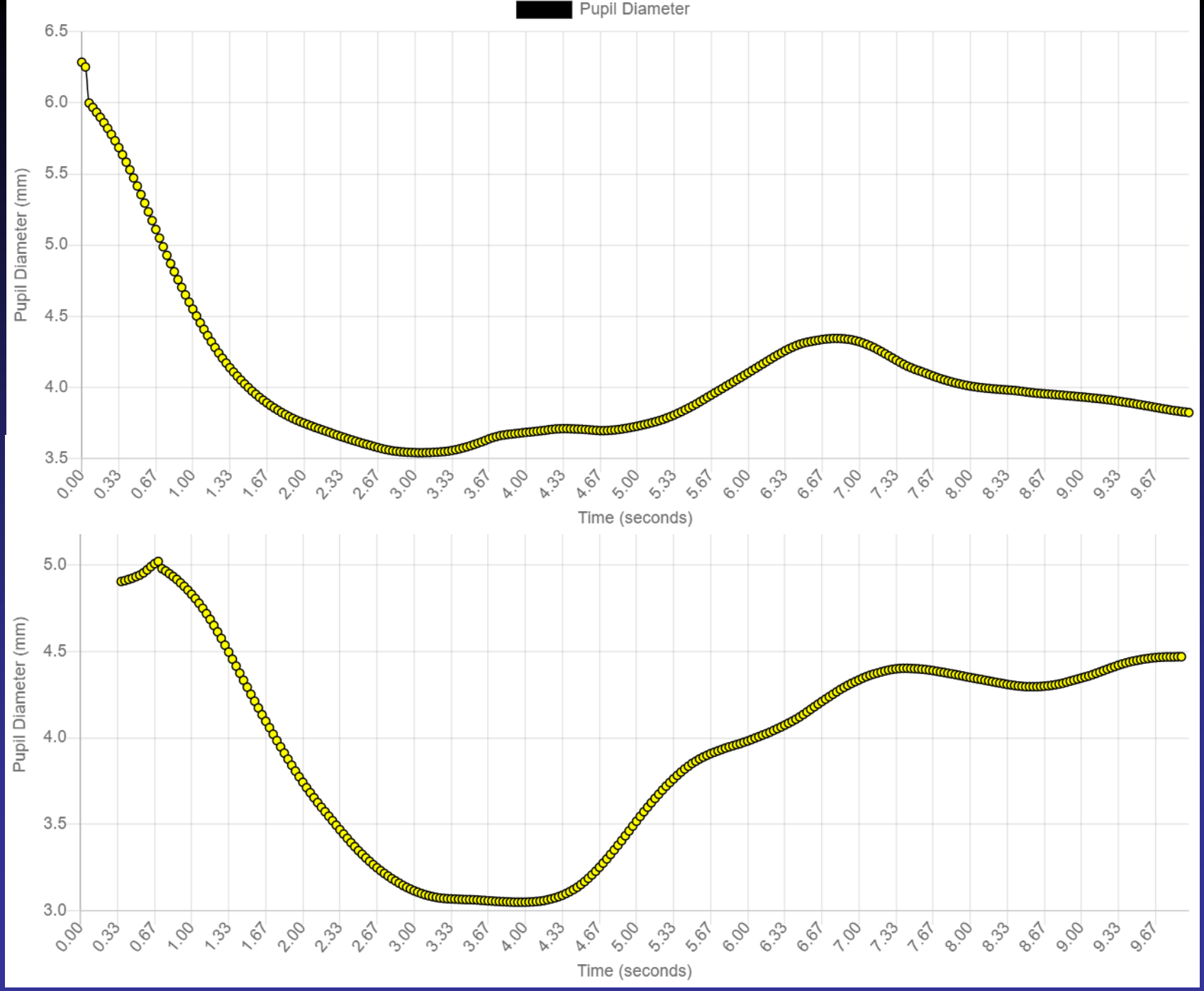
Pupillogram

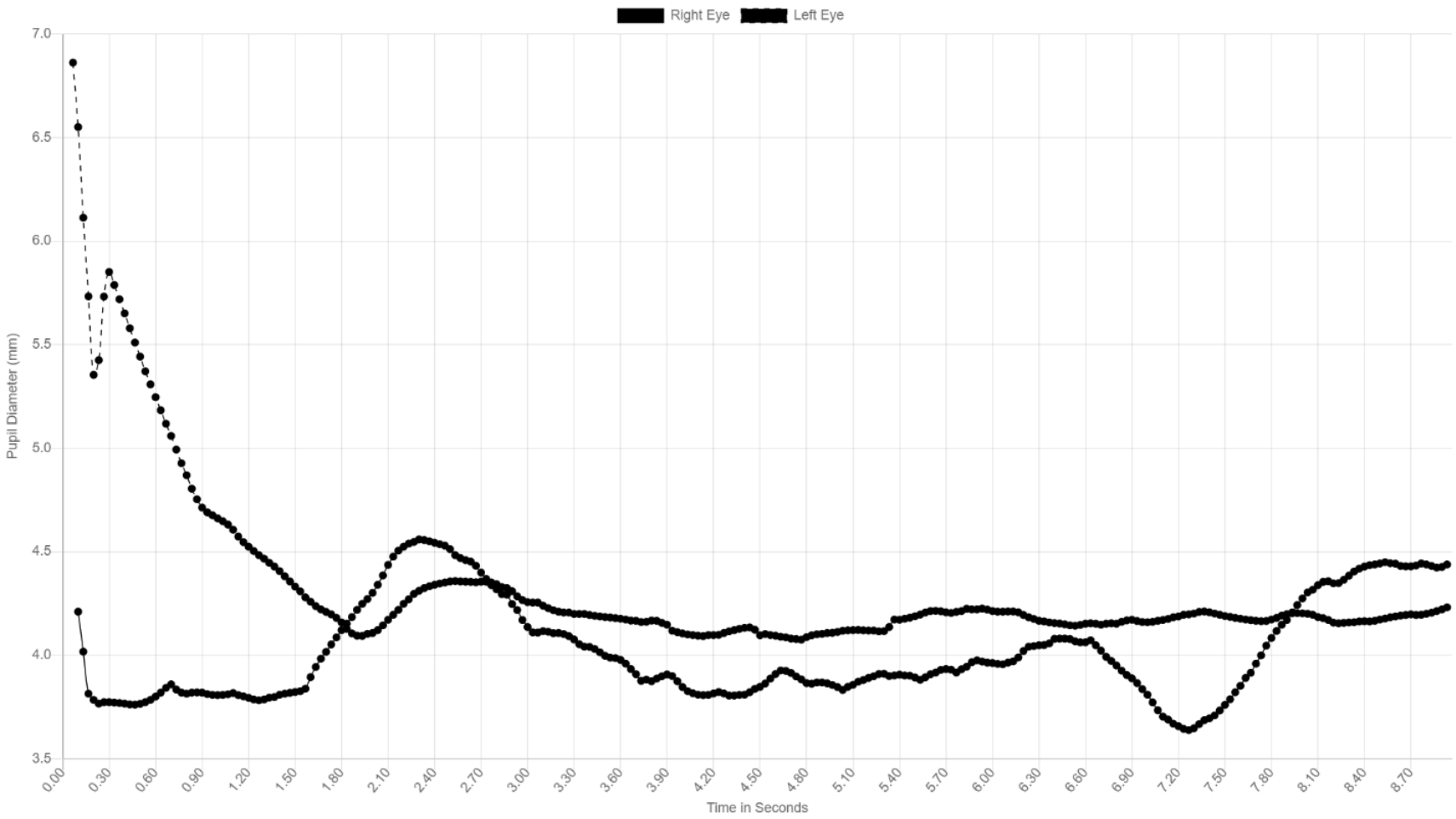


Results

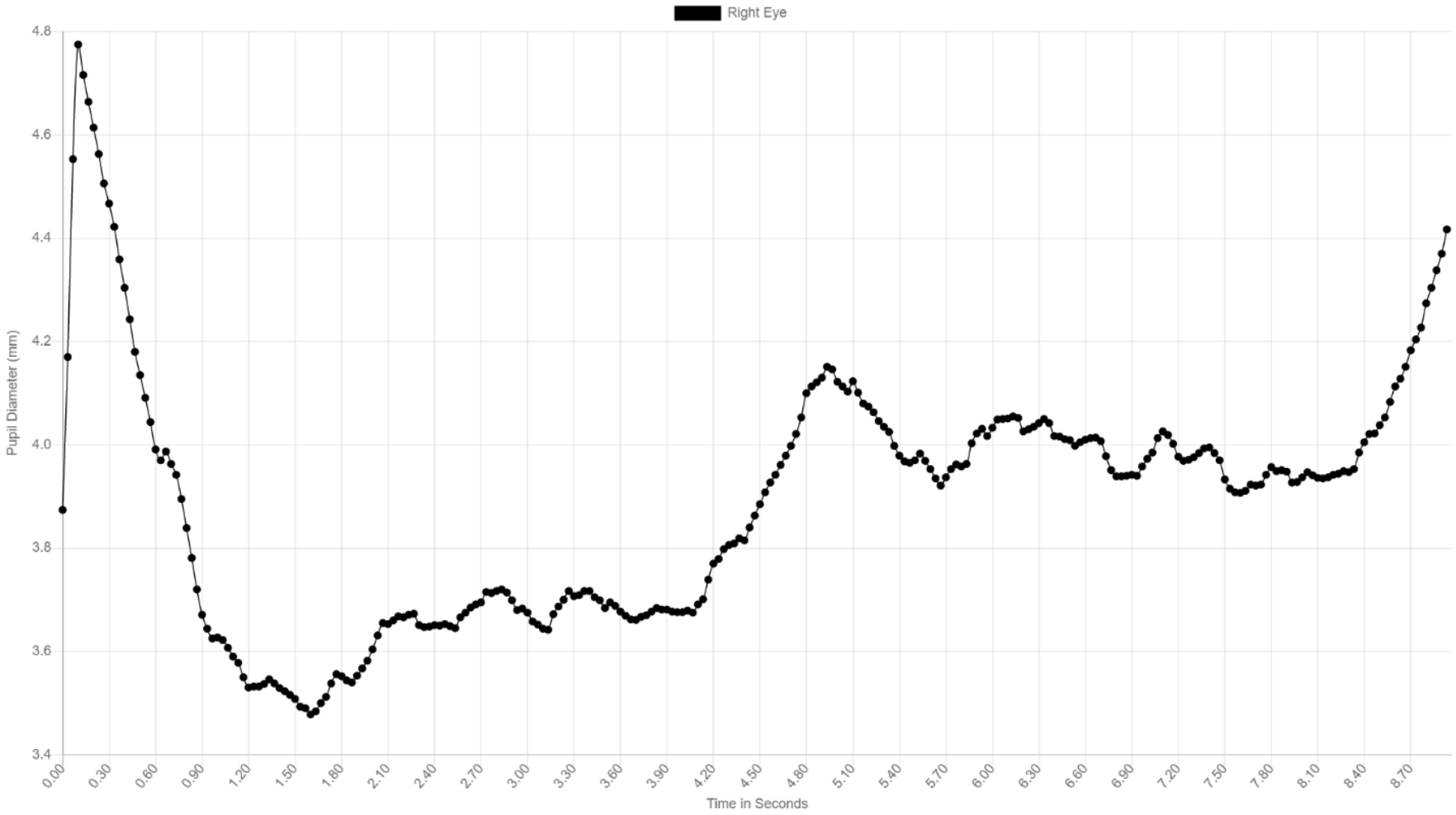
Metric	Results (red values are 2σ > mean normative range)	Normative Data
Avg. Diameter	3.958 mm	3.626 - 5.161 mm
Max. Diameter	5.02 mm	3.825 - 5.545 mm
Min. Diameter	3.05 mm	3.427 - 4.847 mm

Reflex - PLR Analyzer is designed to help assess and monitor cognitive and neuro-ocular function by providing quantitative data of the Pupillary Light Reflex (PLR). This data can be used by health care professionals to assist in diagnostic decisions and treatment/recovery management. For more details regarding the clinical relevance of PLR, and for more information about Reflex, go to brightlamp.org.


Pupil Diameter
Pupil Diameter (mm)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
0.00 0.33 0.67 1.00 1.33 1.67 2.00 2.33 2.67 3.00 3.33 3.67 4.00 4.33 4.67 5.00 5.33 5.67 6.00 6.33 6.67 7.00 7.33 7.67 8.00 8.33 8.67 9.00 9.33 9.67
Time (seconds)
Pupil Diameter (mm)
5.0
4.5
4.0
3.5
3.0
0.00 0.33 0.67 1.00 1.33 1.67 2.00 2.33 2.67 3.00 3.33 3.67 4.00 4.33 4.67 5.00 5.33 5.67 6.00 6.33 6.67 7.00 7.33 7.67 8.00 8.33 8.67 9.00 9.33 9.67
Time (seconds)

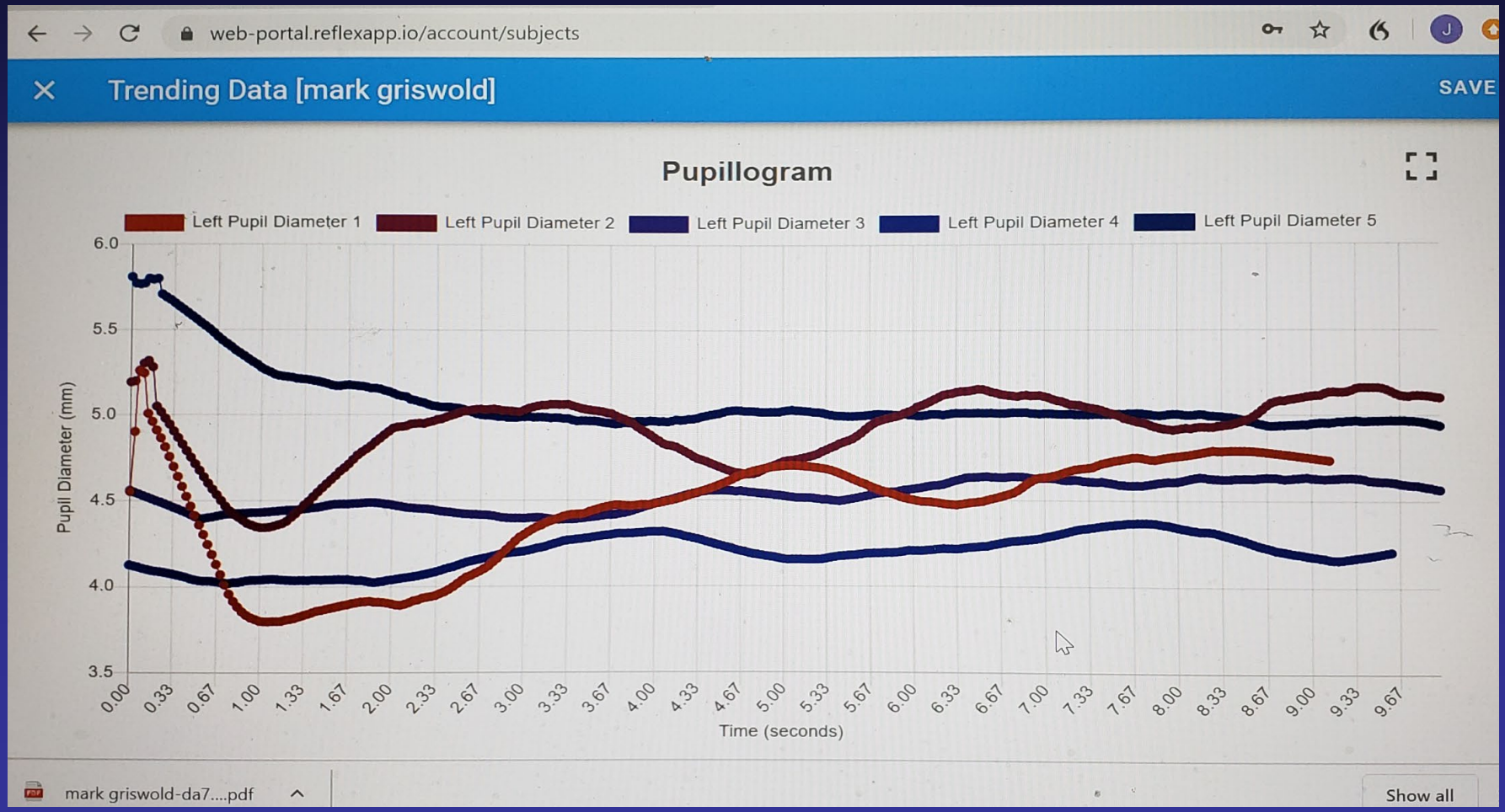


Pulaski AO Pupil



Pulaski AO Pupil

The Pupil
Automated Testing – BrightLamp Reflex



The Pupil
Automated Testing – BrightLamp Reflex

The Pupillary Light Reflex as a Biomarker of Concussion

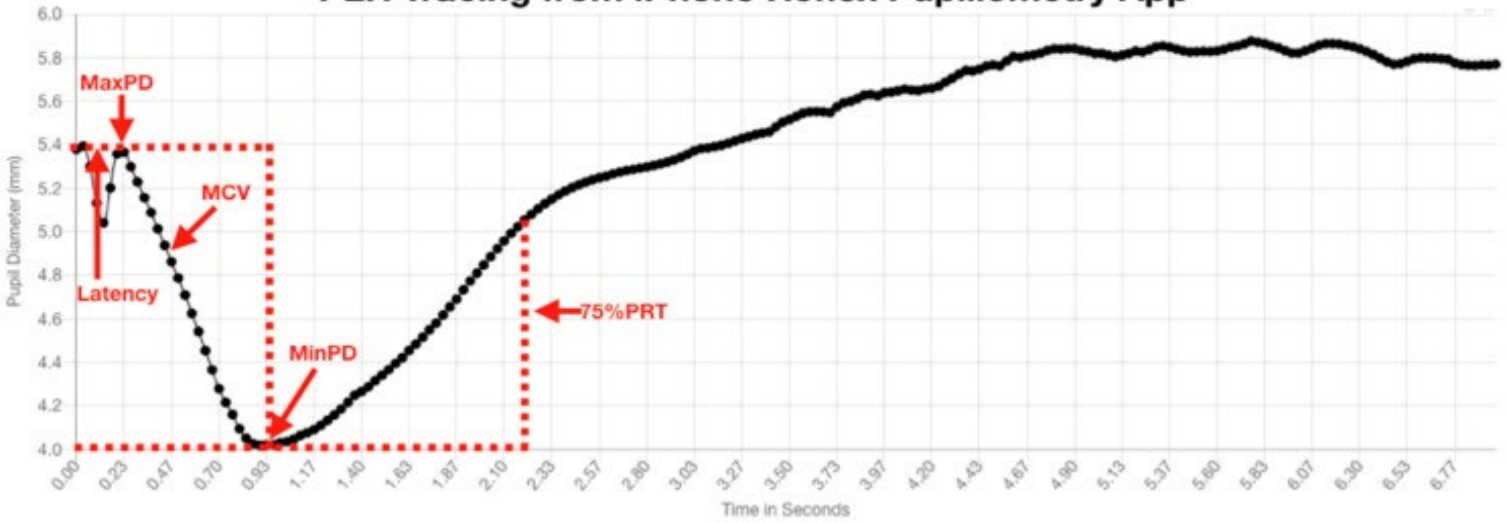
Frederick Robert Carrick,[1,2,3,4,5,*] Sergio F. Azzolino,[5] Melissa Hunfalvay,[5] Guido Pagnacco,[5,6] Elena Oggero,[5,6] Ryan C. N. D'Arcy,[7,8,9] Mahera Abdulrahman,[10] and Kiminobu Sugaya[1,2]
Gary Peh, Academic Editor

Life (Basel). 2021 Oct; 11(10): 1104.
Published online 2021 Oct 18. doi: 10.3390/life11101104
PMCID: PMC8537991
PMID: 34685475

Pupillary Reactions

Bright Lamp

Carrick et al Life (Basel). 2021 Oct; 11(10): doi: 10.3390/life11101104



Latency	Time from light flash to pupil constriction
MaxPD	The maximum diameter of pupil before light flash
MinPD	The minimum diameter of pupil after light flash
MCV	The maximum constriction velocity of pupil constriction after light flash
75% PRT	The time for redilation of pupil to 75% of its previous maximum diameter after light flash

The Pupillary Light Reflex as a Biomarker of Concussion

Frederick Robert Carrick et al 2021

- Looked at the parameters of the PLR in concussed versus non-concussed patients, presence of concussion symptoms, age and gender.
- Large Retrospective Study reviewing their clinical patient records – 01/2019 to 01/2020. Over 20,000 patients.
- Used of new automated pupillary testing – BrightLamp Reflex iPhone App. Reproducible diagnostic test.

The Pupillary Light Reflex as a Biomarker of Concussion

Frederick Robert Carrick et al 2021

Parameters of the PLR studied

- Maximum Pupillary Diameter (MPD)
- Minimum Pupillary Diameter (MinPD)
- 75% Pupillary Recovery Time (75% PRT)
- Maximum Constriction Velocity (MCV)
- Latency of PLR

.

The Pupillary Light Reflex as a Biomarker of Concussion

Frederick Robert Carrick et al 2021

Other Parameters Considered

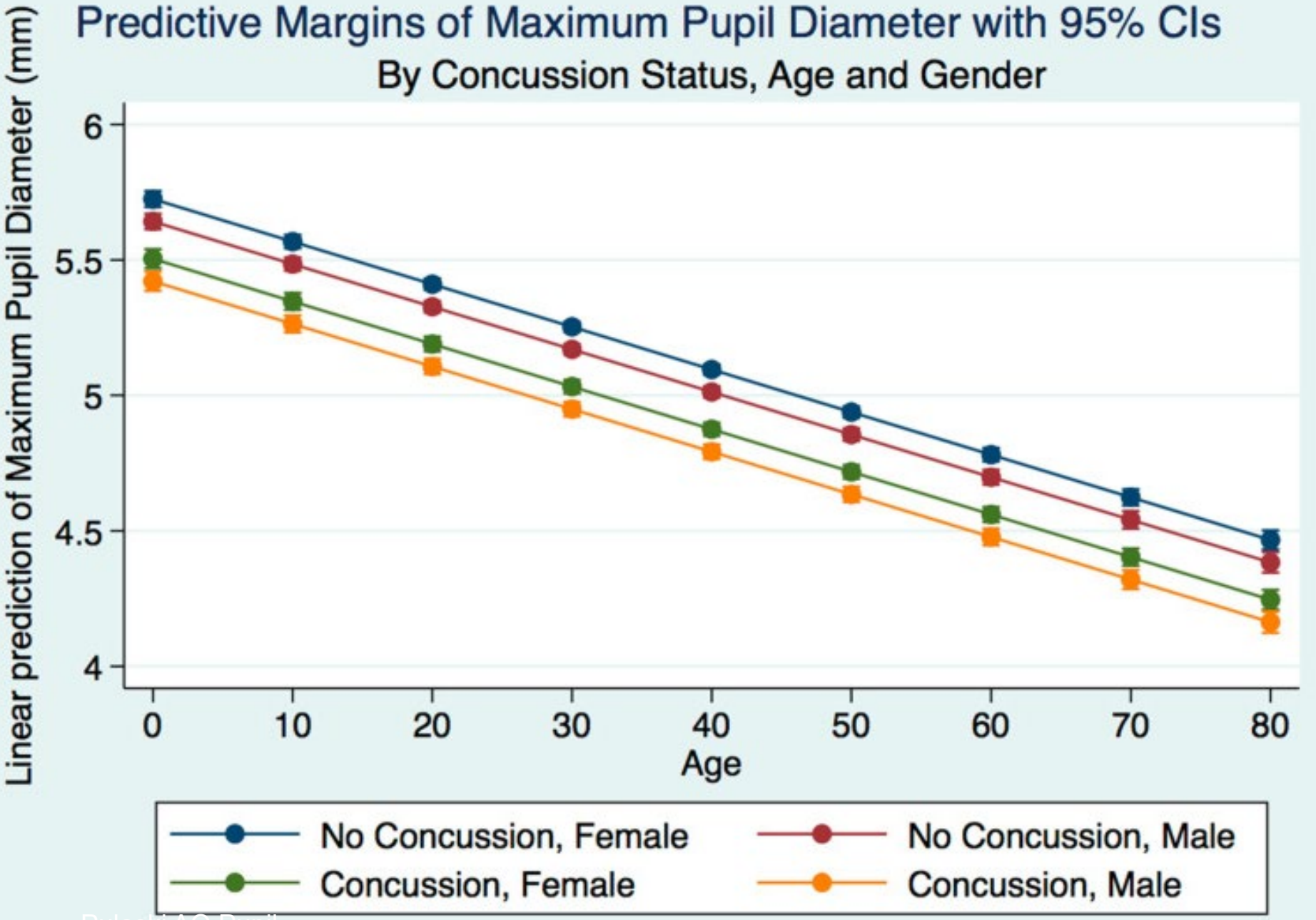
- Concussion versus No concussion
- Concussion symptoms present
- Male versus Female
- Age

The Pupillary Light Reflex as a Biomarker of Concussion

Frederick Robert Carrick et al 2021

Maximum Pupillary Diameter (MPD)

- No significant difference between MPD in males and females who did not suffer a concussion or had no symptoms.
- MPD smaller for both male and female after concussion compared to non-concussion.
- Males had smaller MPD than females in both concussion and non-concussion groups.
- As age increased the MPD decreased for all groups.
- Largest MPD was females with symptoms but both males and females with symptoms had a larger MPD than those without symptoms.
- Statistical analysis showed nonsignificant changes in the size of MPD over time.



The Pupillary Light Reflex as a Biomarker of Concussion

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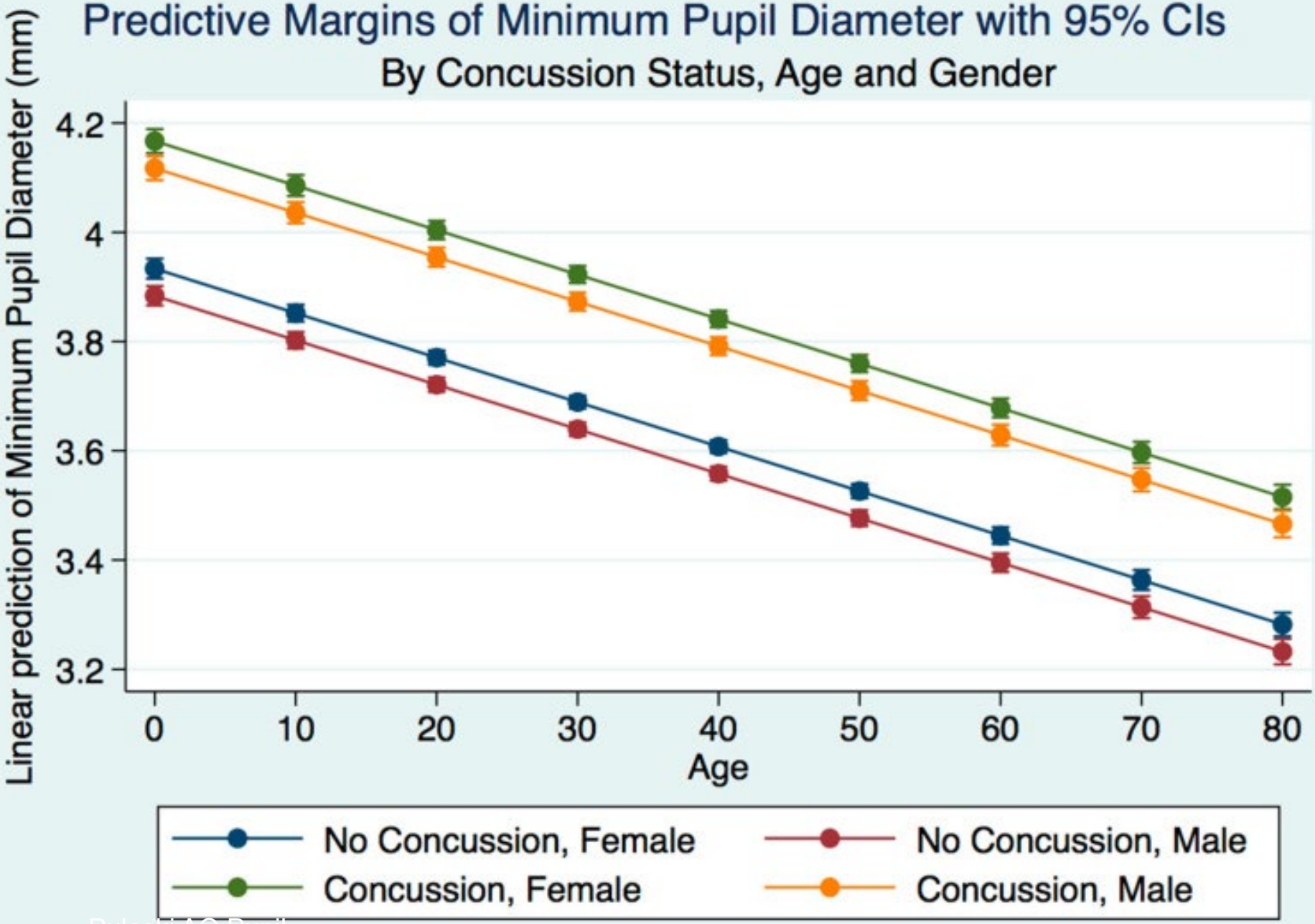
Minimum Pupillary Diameter (MinPD)

- Larger MinPD for both males and females after concussion compared to non concussion.
- Males showed smaller MinPD than females in both groups.
- The MinPD decreased with age.
- There was a decreased range of pupil constriction (MPD-MinPD) in concussion versus non-concussion patients.


Predictive Margins of Minimum Pupil Diameter with 95% CIs
By Concussion Status, Age and Gender
Linear prediction of Minimum Pupil Diameter (mm)
4.2
4
3.8
3.6
3.4
3.2
0
10
20
30
40
50
60
70
80
Age
No Concussion, Female
No Concussion, Male
Concussion, Female
Concussion, Male

The Pupillary Light Reflex as a Biomarker of Concussion

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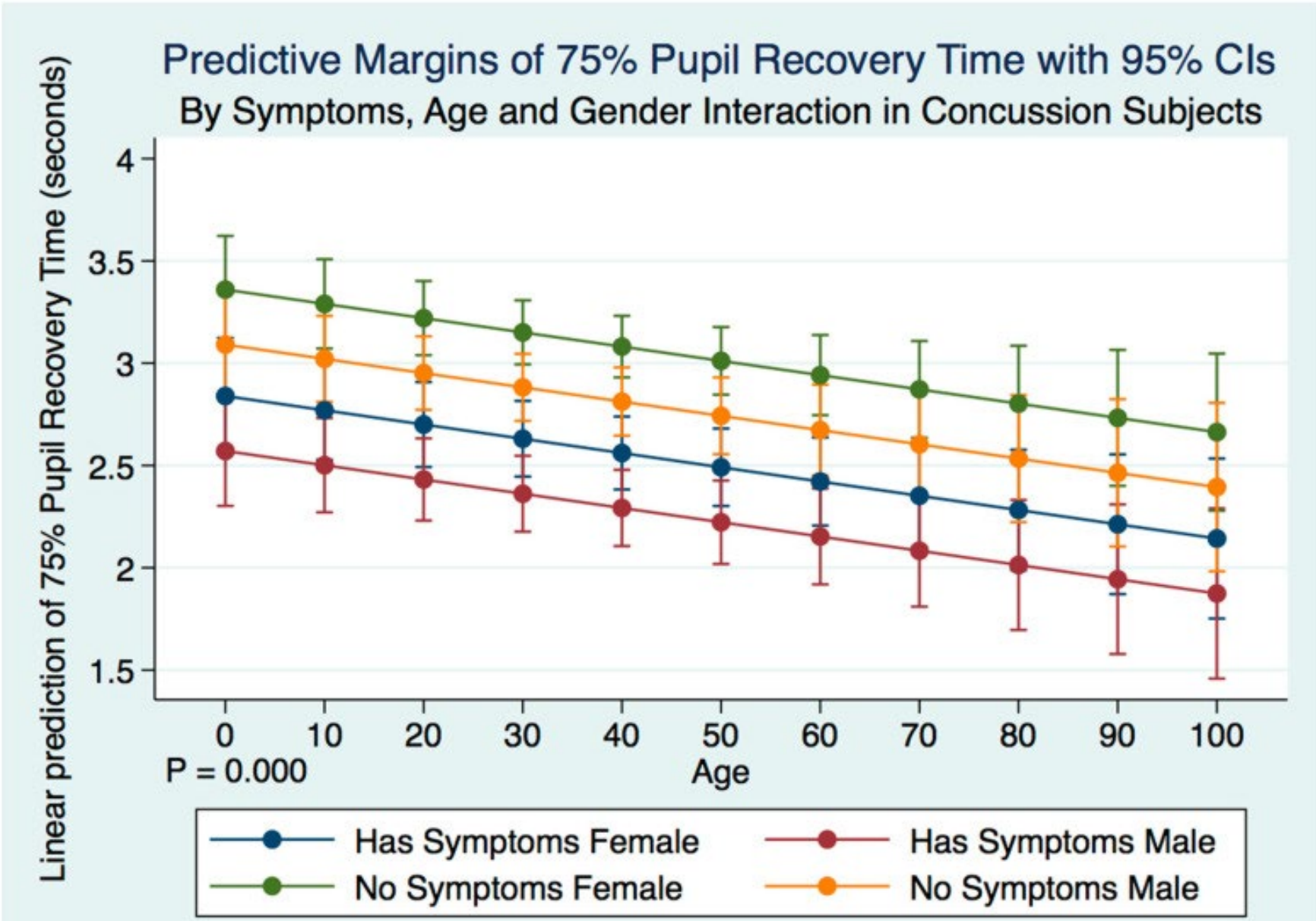
75% Pupillary Recovery Time (75% PRT)

- No statistical difference in 75% PRT between males and females with no concussion.
- Is statistical difference for both genders with faster 75% PRT in concussed groups versus no concussion.
- In concussion group males had a faster 75% PRT than females that increased with age.
- In both the concussion and non-concussion groups the 75% PRT increased faster over their lifespan.
- Symptomatic concussion patients had a slower 75% PRT than the asymptomatic concussion patients.


Predictive Margins of 75% Pupil Recovery Time with 95% CIs
By Symptoms, Age and Gender Interaction in Concussion Subjects
Linear prediction of 75% Pupil Recovery Time (seconds)
4
3.5
3
2.5
2
1.5
0
10
20
30
40
50
60
70
80
90
100
P = 0.000
Age
Has Symptoms Female
Has Symptoms Male
No Symptoms Female
No Symptoms Male

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Maximum Constriction Velocity (MCV)

- Is statistical difference with slower MCV in non concussion group except if under the age of 20.
- In non concussion subjects the MCV decreased significantly with age with females having a quicker MCV than males.
- In contrast in concussion subjects the MCV increased with age with no gender difference.
- Females without symptoms after concussion had the fastest MCV.

Pulaski CSO

The Pupillary Light Reflex as a Biomarker of Concussion

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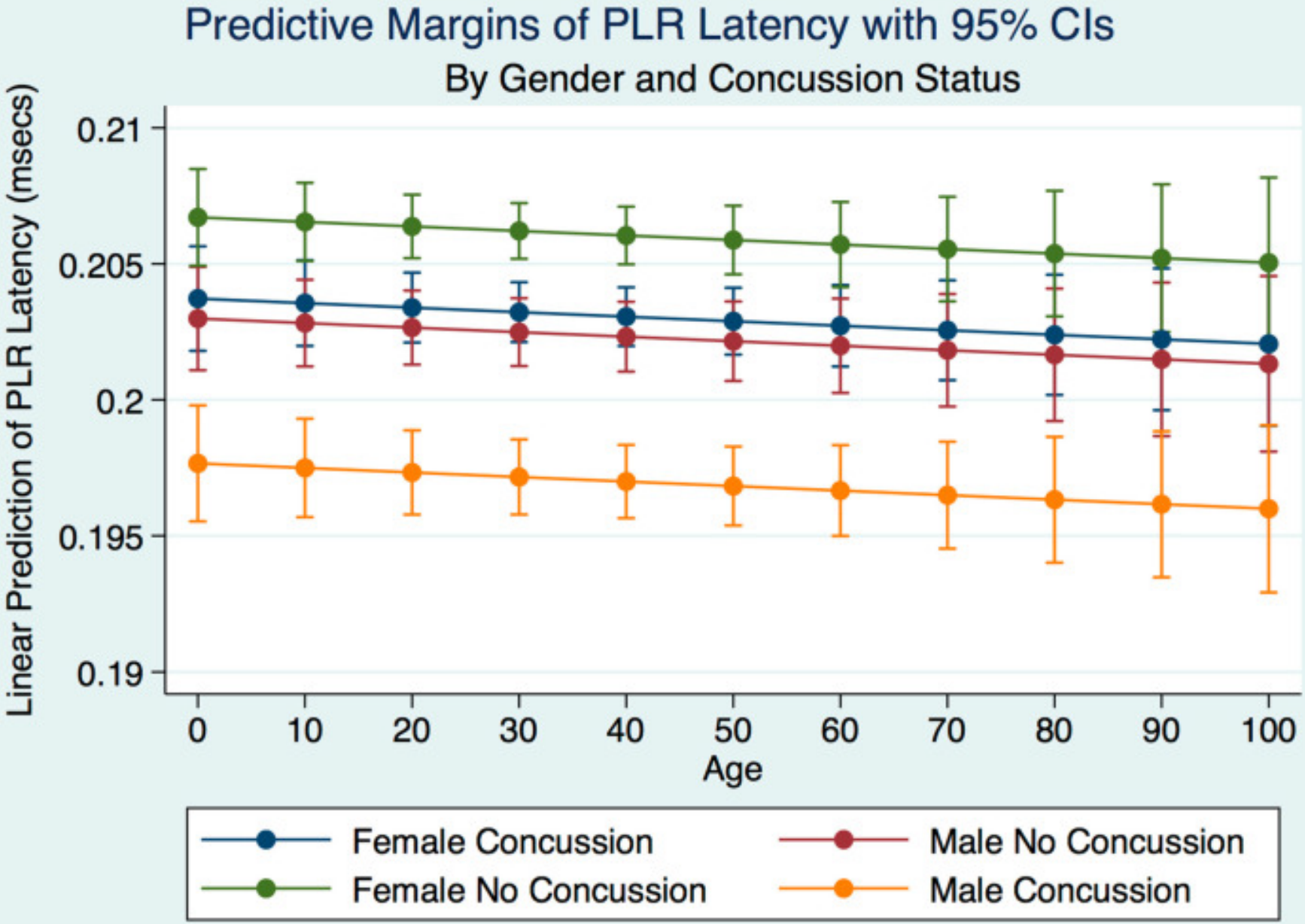
PLR Latency

- Latency of PLR was slower for patients with concussion versus with no concussion.
- Females without concussion had the fastest latencies. Males with concussion at the slowest latencies.
- There was a trend for decreasing latencies over lifespan.


Predictive Margins of PLR Latency with 95% CIs
By Gender and Concussion Status
Linear Prediction of PLR Latency (msecs)
0.21
0.205
0.2
0.195
0.19
0
10
20
30
40
50
60
70
80
90
100
Age
Female Concussion
Female No Concussion
Male No Concussion
Male Concussion

The Pupillary Light Reflex as a Biomarker of Concussion

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Conclusions

- PLR metrics contribute greatly to understanding other functional integration of the brain after TBI.
- Even though symptoms may disappear after a TBI, PLR metrics may not return to normal indicating continued impaired functional brain states.
- The PLR can be a useful diagnostic marker of treatment effectiveness.

The Pupillary Light Reflex as a Biomarker of Concussion

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Conclusions

- Author states that their findings suggest that light is but one of many integration variables governing the size of the pupil and that brain function variables may be more critical than even the light source.
- They further state that the results of this study indicate that the PLR can be used effectively in non- clinical based settings such as in a gym, sporting field or hospital ward.

The Pupillary Light Reflex as a Biomarker of Concussion

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Conclusions

- There exists a gender and age difference in pupillary reactions related to the PLR.
- TBI significantly affects PLR findings and varies depending on the presence of symptoms and across age groups. These include PLR latency, pupils size, velocity of constriction and dilation in recovery times.
- Long-term effects of PCS have been quantified with the permanency of functional changes of the PLR after concussion.

The Pupillary Light Reflex as a Biomarker of Concussion

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Conclusions

- Automated pupillometry such as the portable iPhone medical device (Brightlamp) is a reliable and reproducible instrument thatcan provide immediate evaluation and management of the TBI patient. The authors opinion is that this should contribute to decreasing the associated morbidity and mortality of brain injury.

Importance to Field of Syntonic Optometry and Neuro-Optometry

- We now have in our possession a device to accurately record not only the reactions of the pupil under sustained light illumination (AO Pupil) but also the additional metrics of the PLR. These are directly related to autonomic nervous system balance and vitality.
- This can allow us to more specifically assess and diagnose our patients and to provide more specific and accurate treatment through our filters.
- These reactions can now serve as additional accurate biomarkers and baselines to assess the effectiveness of our treatment.

Importance to Field of Syntonic Optometry and Neuro-Optometry

- Results from objective test important supporting clinical data in Medical/Legal cases
- Biomarkers for determining effectiveness of other modalities of rehabilitative care.
- Research Studies

Questions or Comments?

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The Pupil
Automated Testing – BrightLamp Reflex

The Pupillary Light Reflex as a Biomarker of Concussion

Important statements

1. PLR not a simple reflex, significant cognitive modulation with many areas of brain involved Includes brain, brainstem and spinal cord.
2. PLR first described by Rhazes of Baghdad – 9th century
3. Not a linear reaction due to effects of attention, accommodation, etc.
4. Pupils may be more sensitive than other measures of autonomic function
5. Gender difference in ANS. Higher parasympathetic and lower sympathetic in females compared to males similar to cardiovascular system.

The Pupil
Automated Testing – BrightLamp Reflex

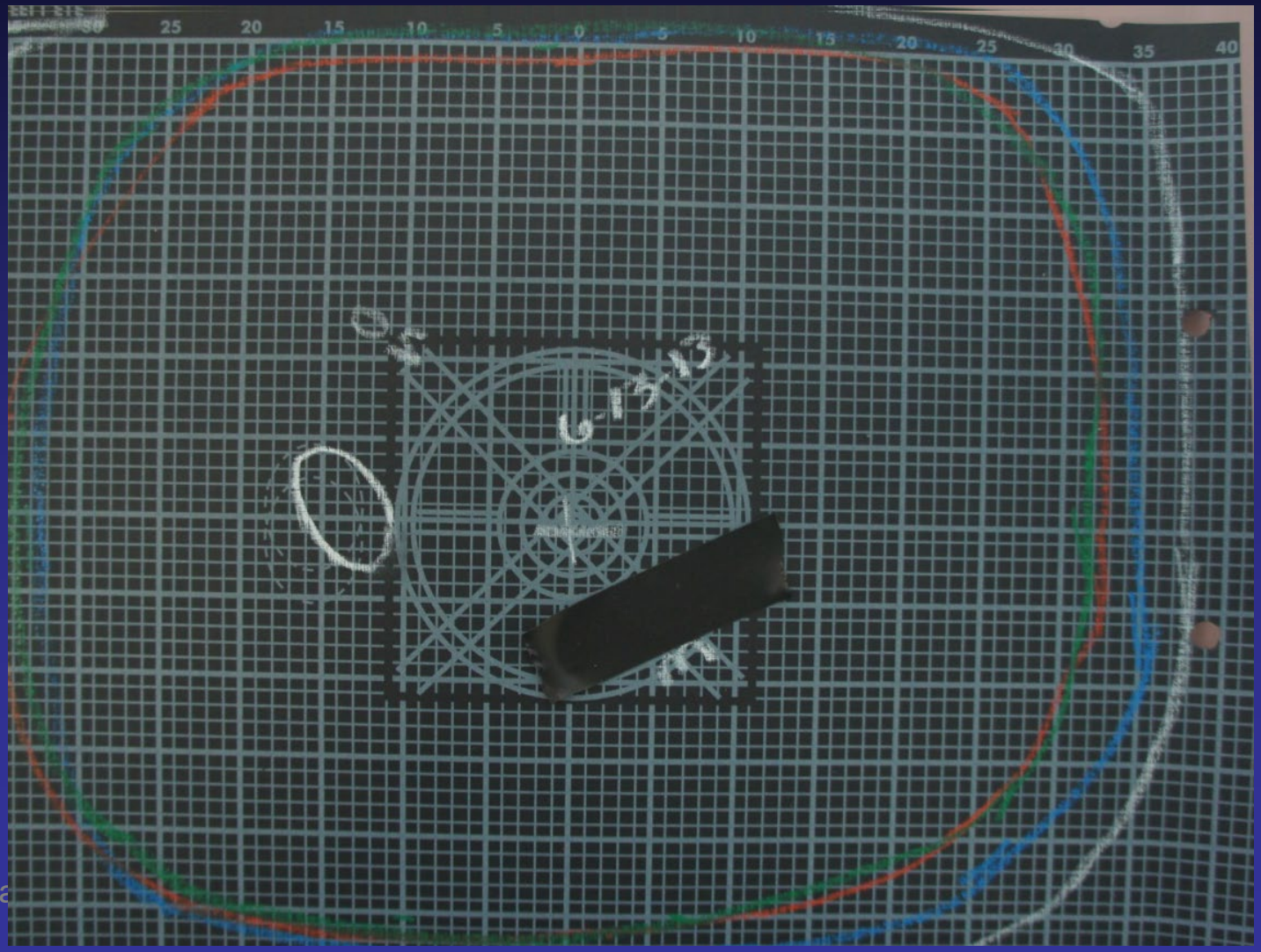
The Pupillary Light Reflex as a Biomarker of Concussion

Important statements

6. PLR also correlated with heart rate variability
7. TBI effects cognitive processes that are central to the prefrontal cortex f function which modulates the PLR.

The Kinetic Visual Field

The Normal Visual Field



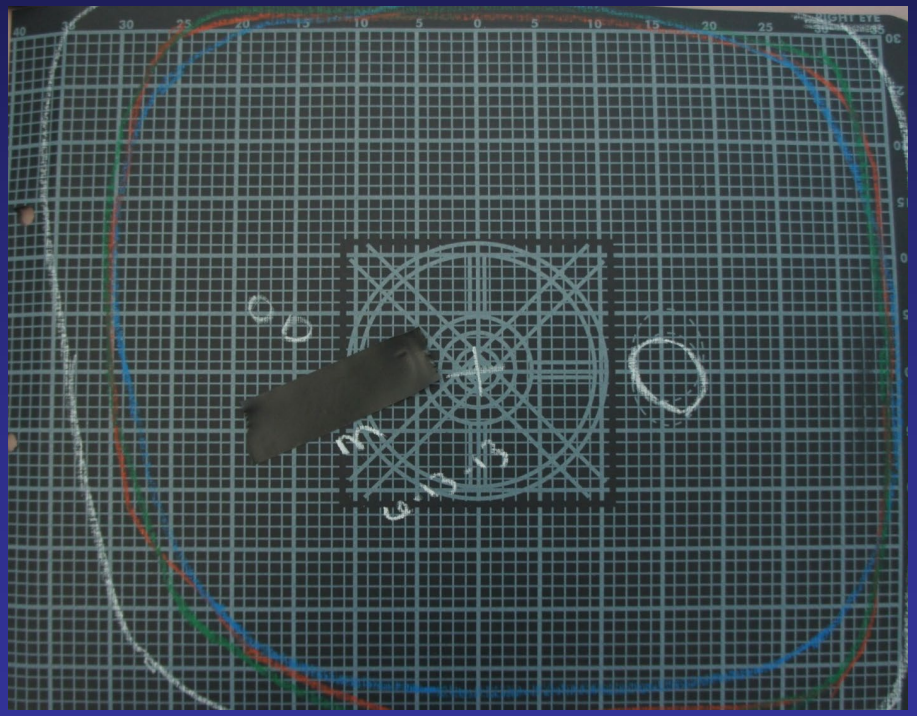
Norms for Visual Fields

Campimetric College Unit

Pulaski

White

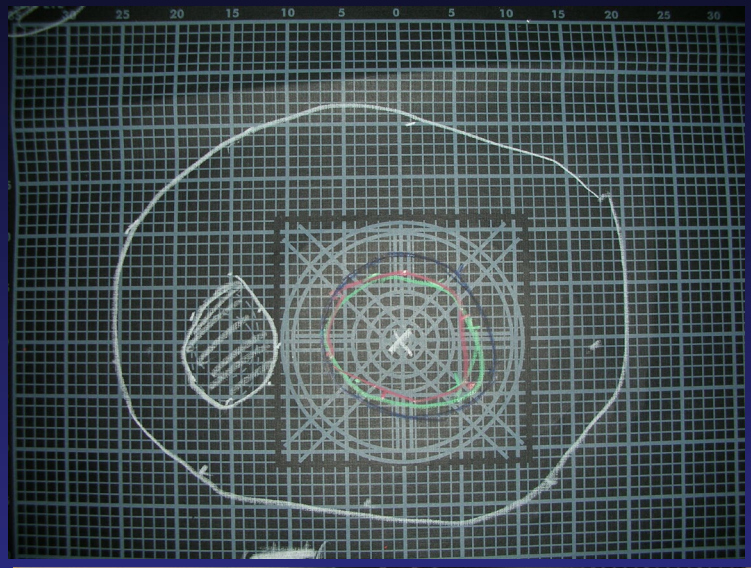
Superior	**34˚**
Superior Temporal	**42˚**
Temporal	**38˚**
Inferior Temporal	**42˚**
Inferior	**32˚**
Inferior Nasal	**36˚**
Nasal	**38˚**
Superior Nasal	**40**



Pulaski AO Pupil

Blind Spot

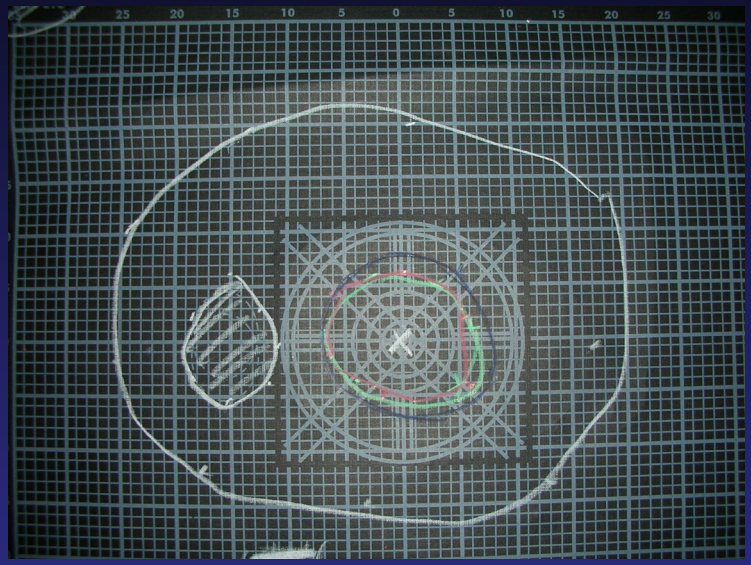
- The blind spot size is likely the most important indicator of spatial compression.
- In Syntonic treatment normalizing the blind spot and expanding the field is key to restore optimum visual functioning.
- Plotting the blind spot should include 8 points and be done slowly and exactly.



Pulaski AO Pupil

Blind Spot

- In fully opened field the blind spot is usually smaller than expected.
- If fields are normal in size but blind spot is enlarged, results will not hold unless the blind spot is normal size




Thank You!