NARAYANA
MEDICAL COLLEGE

DYNAMIC PUPILLOMETRY – A NOVEL, NON-INVASIVE METHOD FOR EVALUATION OF AUTONOMIC FUNCTIONS

COMMON ACADEMIC PROGRAMME: 26/06/2021

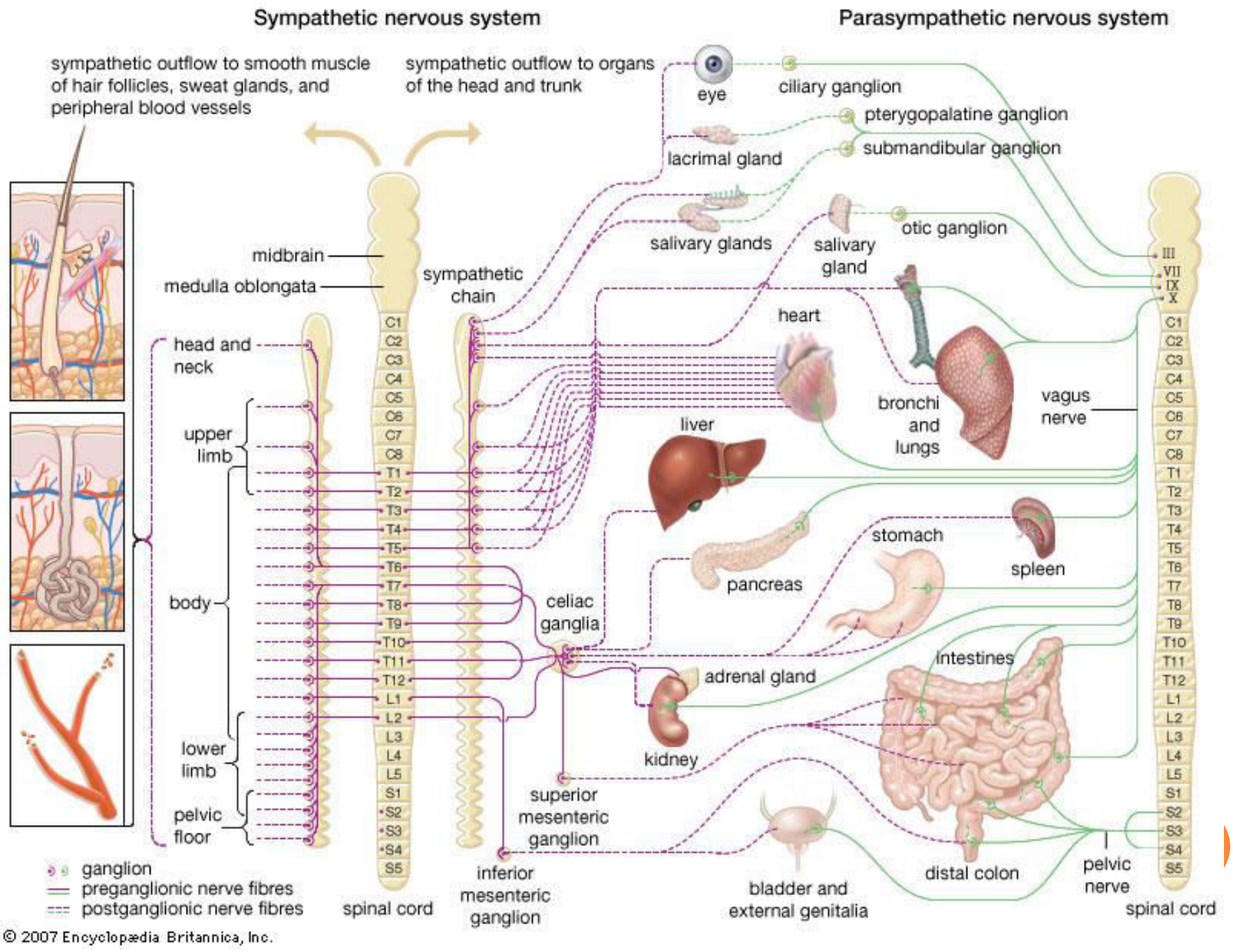
A.V. SIVA KUMAR, M.Sc, PhD.,

Dept. of Physiology

Narayana Medical college , Nellore

PREAMBLE

- Autonomic nervous system innervates all internal organs for involuntary actions – Glands, Smooth and Cardiac muscle.
- ANS enables to respond in emotions and to environmental challenges without consciousness of an individual.
- Heart rate, Respiration, Digestion, Pupillary response, urination and sexual behaviour – "INTERNAL HOMEOSTASIS".
- Sympathetic – "Thoracolumbar outflow – Fight/Flight".
- Parasympathetic – "Craniosacral out flow– Feed/Breed".



AUTONOMIC FUNCTION TESTS

- 1.Cardiovagal tests 2. Adrenergic tests 3. Sudomotor tests. (ANA guidelines -2014, AAS guidelines - 2019).
- Ewing's battery of tests are conventional methods to evaluate Cardiac autonomic function - (Ewing's et.al-1991).

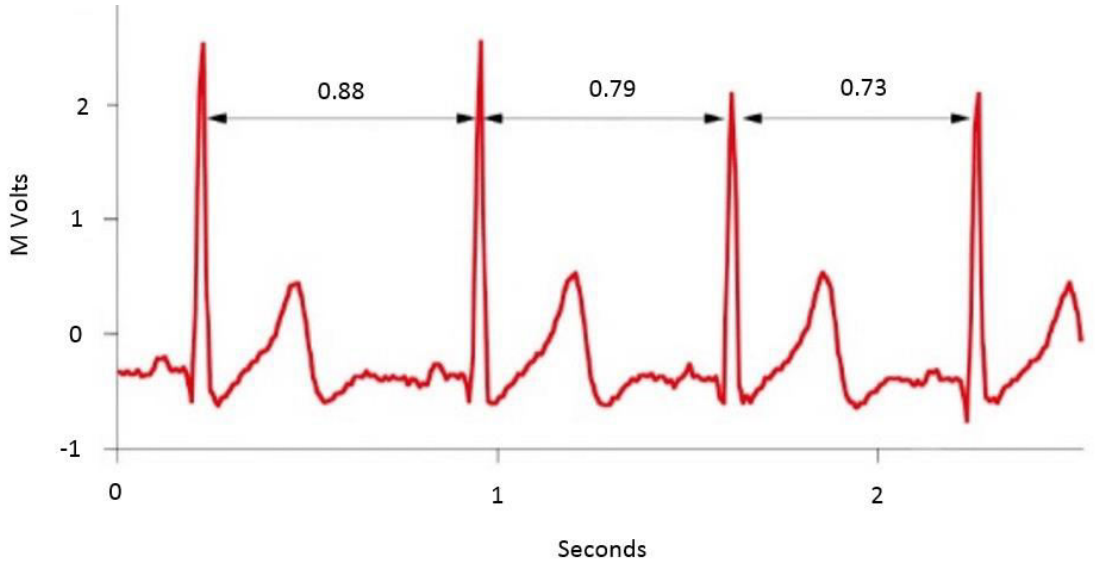
CARDIOVAGAL TEST	ADRENERGIC TEST	SUDOMOTOR TEST
Deep breathing test	Cold pressor	Sympathetic skin response
Valsalva ratio	Handgrip test	Thermoregulatory sweat test
HR - response to standing	BP response to standing	Quantitative Sudomotor Axon Reflex test (QSART)
HR - Cold pressor test	Muscle Sympathetic Nerve Activity (MSNA)	
HR - Hand grip test	Norepinephrine spillover test	

DRAWBACKS OF EWING'S BATTERY TESTS

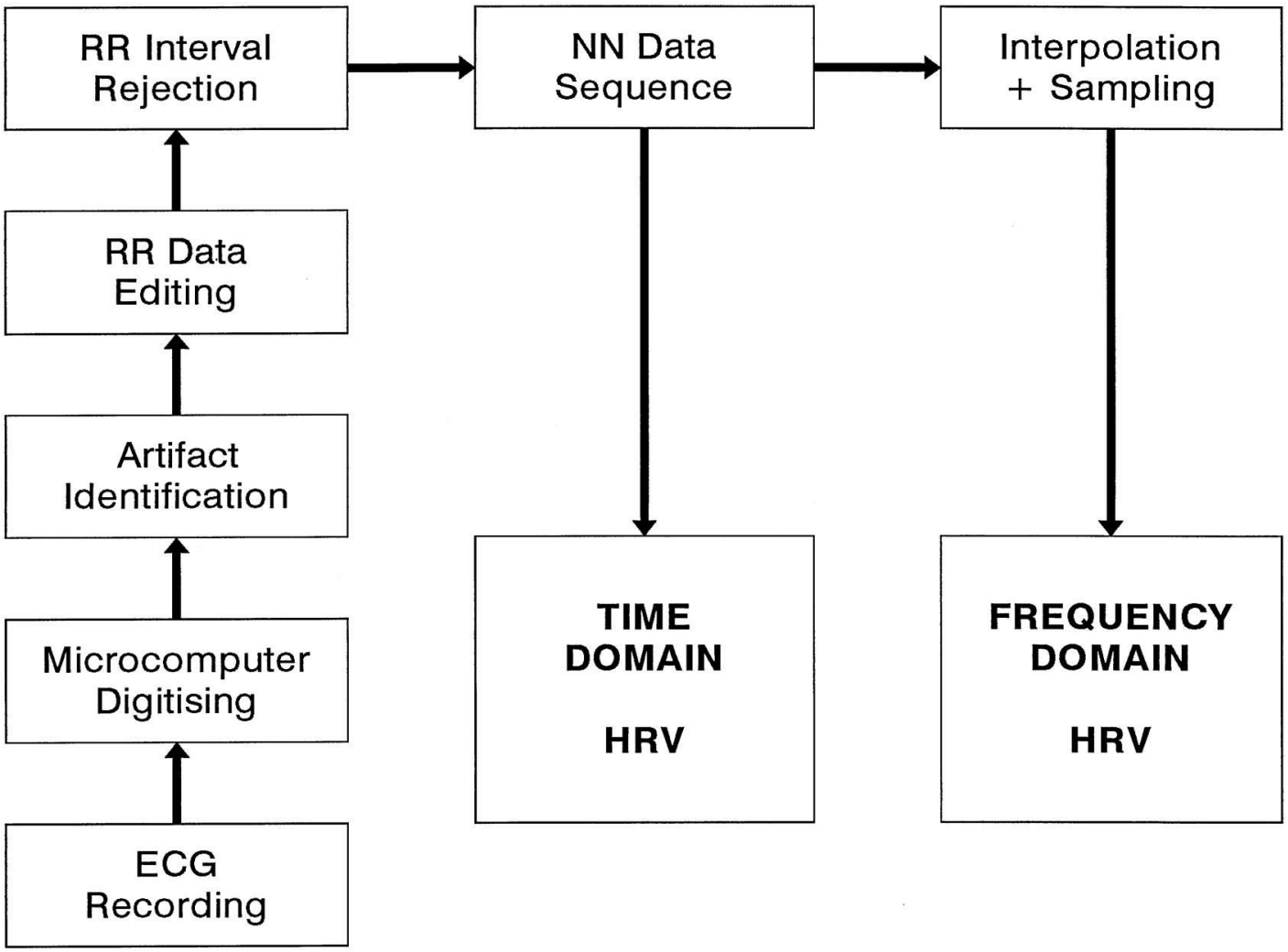
- Data collection requires a big lab setup(field studies are not possible). Acquisition of data is time consuming and tedious.
- Requires strict observation on test protocol and stabilization of hemodynamic parameters of the patient.
- Some of the tests are unpleasant and reluctant to reperform.
- Interpretation is very difficult to come to a conclusion.(Agnieszka Zygmunt et.al, Archives of Medical sciences - 2010)

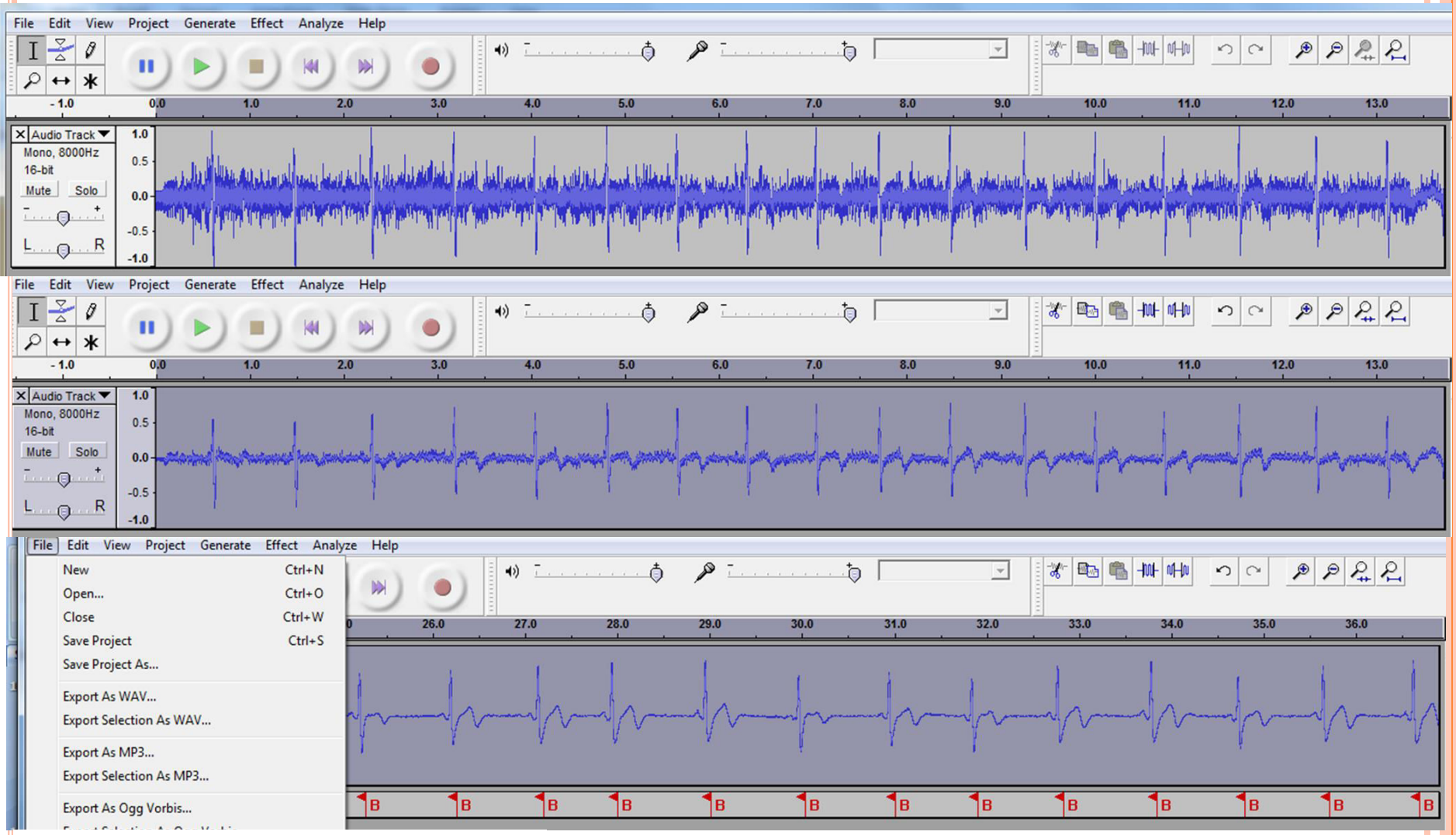
HEART RATE VARIABILITY (HRV) – SPECTRAL ANALYSIS

- HRV is the cardiac beat to beat variation, depends on discharge of SA node influenced by autonomic tone. (Taskforce guidelines -1996).
- Time domain, Frequency domain, Non-linear analysis.
- Gold standard method – Sympathovagal balance



DATA ACQUISITION & PROCESSING





Time–Domain Results

Variable	Units	Value
Mean RR*	(ms)	692.4
STD RR (SDNN)	(ms)	56.0
Mean HR*	(1/min)	87.24
STD HR	(1/min)	7.31
RMSSD	(ms)	35.7
NN50	(count)	57
pNN50	(%)	14.6
RR triangular index		14.481
TINN	(ms)	275.0

Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF (0–0.04 Hz)	0.0195	1410	39.1	
LF (0.04–0.15 Hz)	0.0898	1169	32.4	53.1
HF (0.15–0.4 Hz)	0.1563	1030	28.5	46.8
Total		3611		
LF/HF		1.135		

LIMITATIONS OF HRV

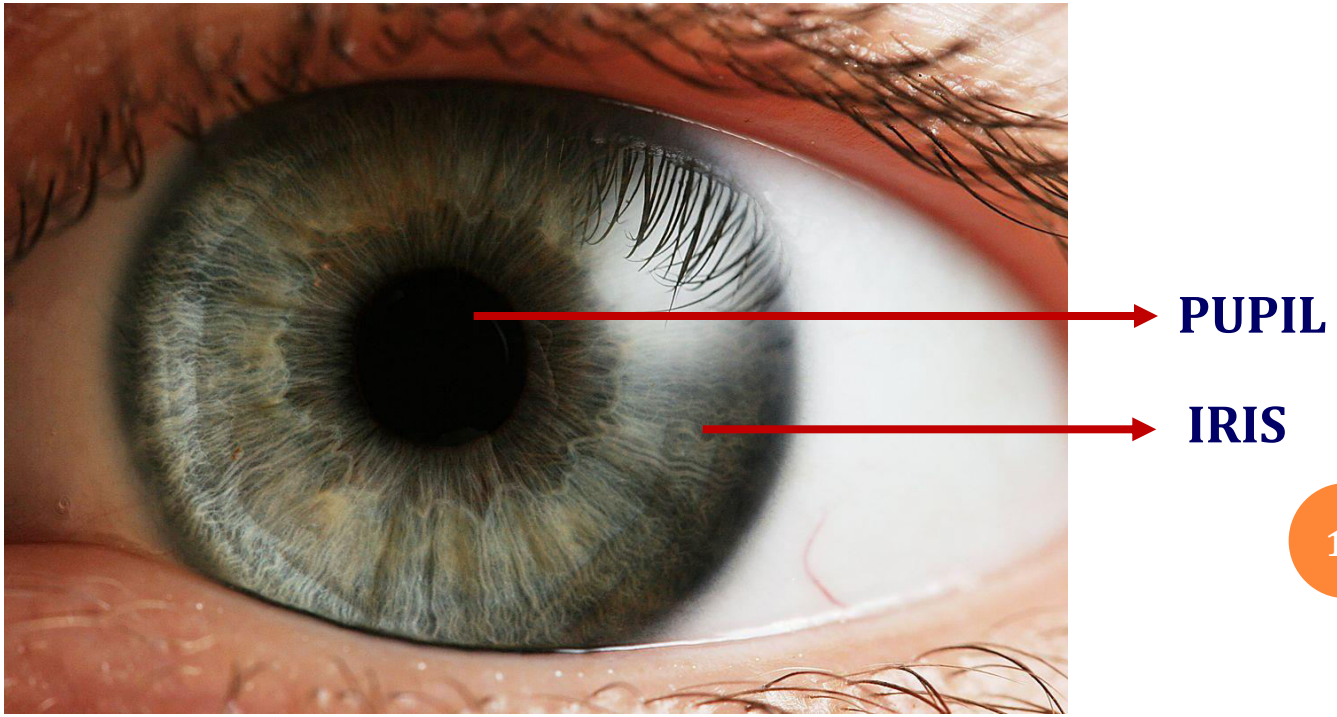
- HRV is not the direct indices of sympathovagal balance rather it is the result of the influence over its effectors (SA node receptors).
- There is a huge differences in HRV data between short term and long-term recording of ECG.
- The minimum sampling rate required for ECG is 1000/sec. however ECG machines in the clinical setup have the sampling rate of 250/sec which is not enough to analyze the variations.
- HRV can be confounded by posture, respiration, blood volume, BMR.

NOVEL APPROACH OF RESEARCHERS

- The assessment of ANS activity with these conventional tests is cumbersome and data acquisition, interpretation becomes difficult.
- The researchers have been working on alternate sources for autonomic function evaluation which should be convenient and easy to analyze the obtained data.
- Since the pupil is superficial, highly responsive among the organs that are innervated by ANS.
- So the pupil size and response can be used as a screening tool to evaluate the autonomic tone.

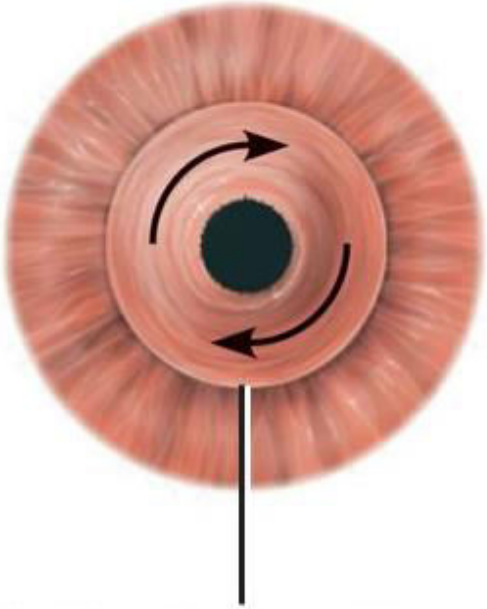
FUNCTIONAL ANATOMY OF THE PUPIL

- Central & transparent aperture
- 2 – 4 mm in Photopic vision
- 4 – 8 mm in Scotopic vision
- The pupils are circular, bilaterally symmetrical and centric positioned within the iris.

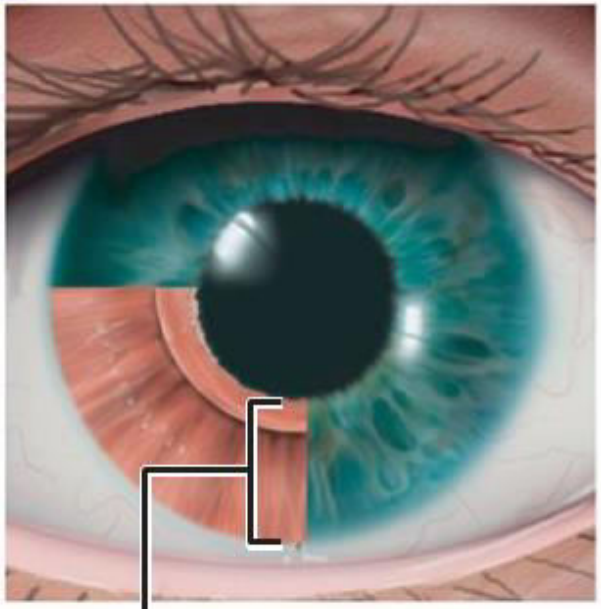


MUSCULATURE & INNERVATION

Parasympathetic +



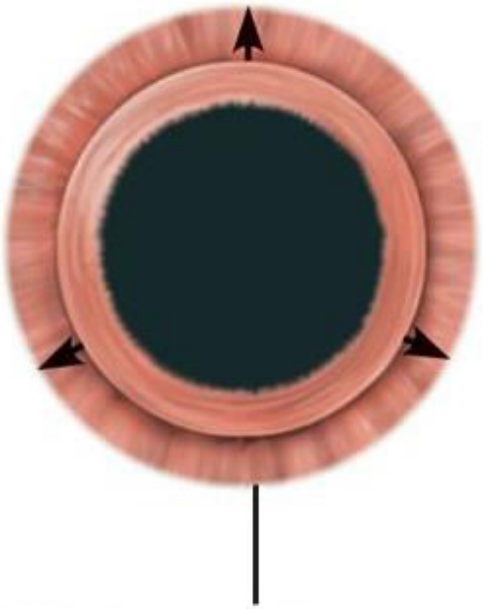
Sphincter pupillae muscle contraction decreases pupil size.



Iris (two muscles)

- Sphincter pupillae
- Dilator pupillae

Sympathetic +

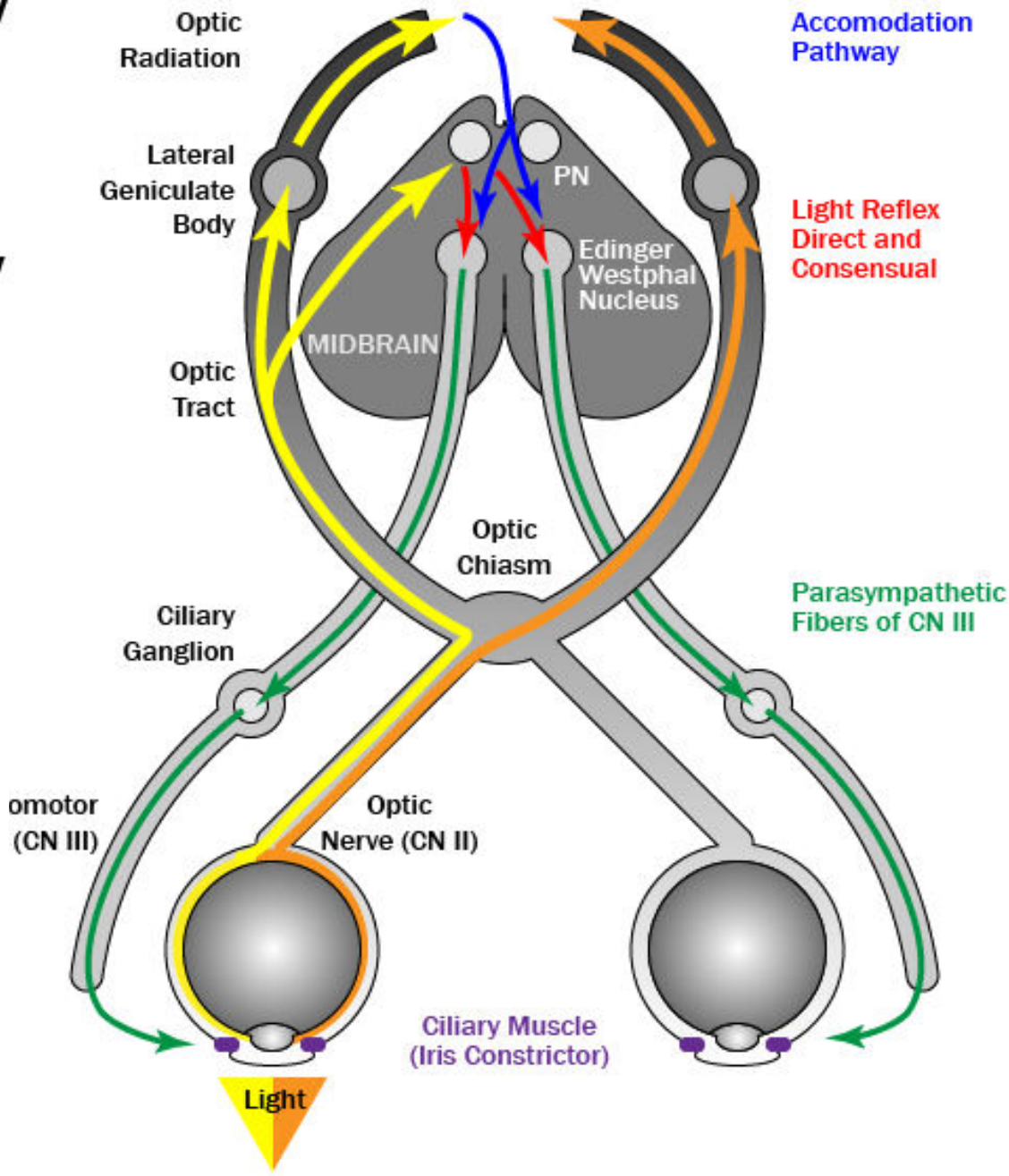


Dilator pupillae muscle contraction increases pupil size.

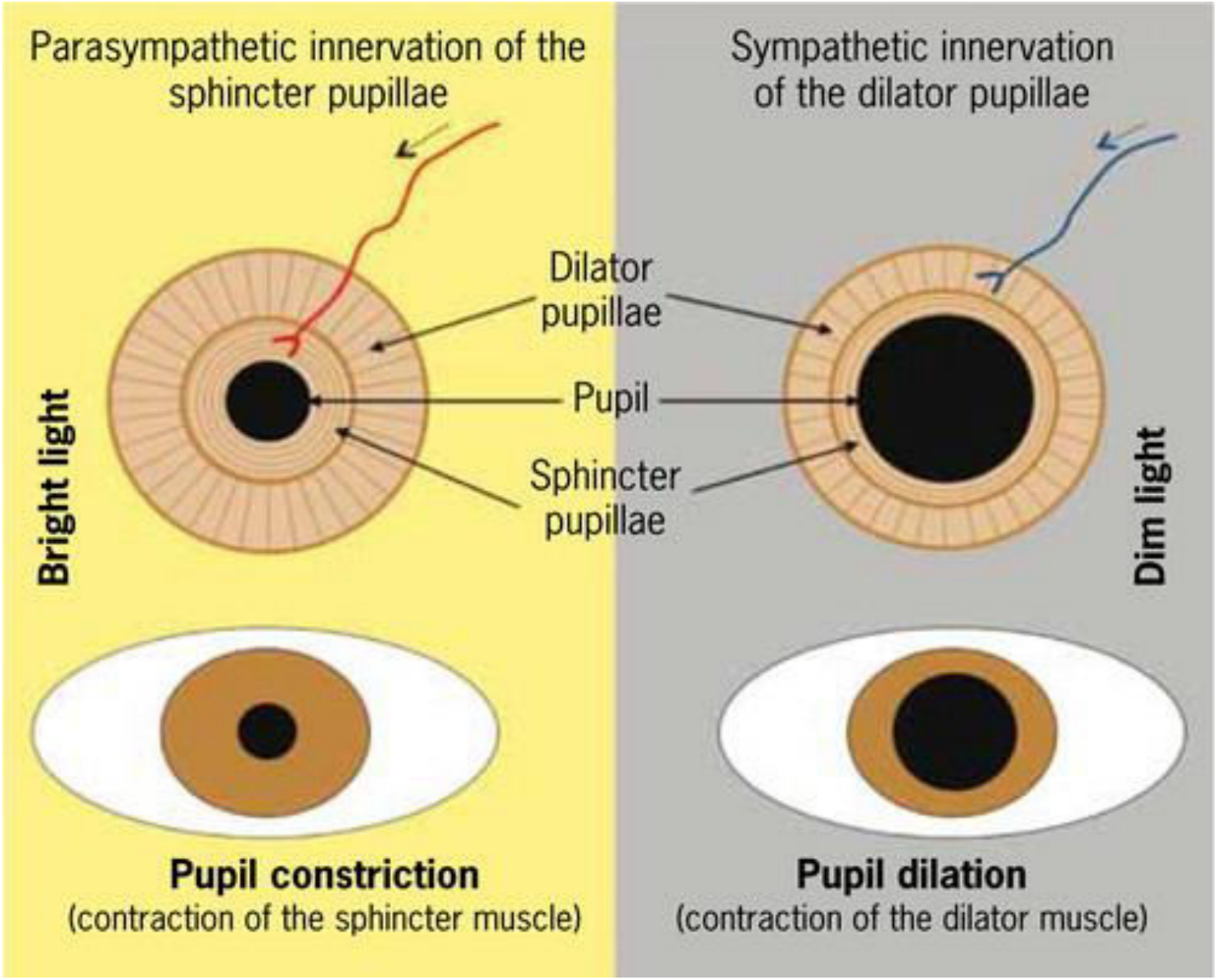
PUPIL SIZE INFLUENCED BY

- Age – Senile Miosis
- Ambient light – Light Miosis
- Near vision – Accommodation reflex
- Attention – Mydriasis (visual acuity)
- Cognition – Visio spatial discrimination, Reaction times
- Reflexive – Pupillary light reflex, Accommodation reflex

Pupillary Light Reflex Pathway



EFFECT OF AUTONOMIC NERVES ON PUPIL



CLINICAL IMPORTANCE

- Ophthalmology – Fundal & Retinal examination,
- Neurology – To localize lesions associated with pupil
- Emergency medicine – Brainstem activity
- Surgery – Brain tumours
- Psychiatry - Impaired cognition, Alzheimer's disease
- ANS activity – Autonomic neuropathy

STATIC & DYNAMIC PUPIL

- ✓ Static pupil evaluation– At any given point time estimation of pupil size in controlled illumination.
- ✓ Dynamic pupil evaluation – Dynamics of pupil changes in response to standardized stimulus measures amplitude, time and velocity.
- Pupillary light reflex, Accommodation reflex.
- Qualitative method – Swinging flash light test – subjective-PERRLA
- Quantitative method–Dynamic pupillometry – Valuable information

CLINICAL EVALUATION OF PLR

Swinging flash light test or Pen torch test

Categorical Data – Magnitude and rapidity (4+ to 0)

DYNAMIC PUPILLOMETRY

- Dynamic Pupillometry is the quantitative assessment of pupil size and reaction to light in relation to time which measures the pupil size - Amplitude and velocity of pupil constriction and dilation.
- Pupillometer is self contained camera that objectively captures and measures the pupil size – Static and dynamic variables.
- The automated pupillometers are portable, user-friendly digital systems using Infrared videography.
- Though Infrared light digital videography is highly advanced, still it is least used in the field of medicine as it is too expensive.

NEUROPTICS


ID: 123456789
05/16/2019 12:11:40
Right
Left
Diff
NPi
4.1
4.3
L > R 0.2
Size
3.63 mm
3.09 mm
R > L 0.54
RIGHT
LEFT
NEUROPTICS


NEUROPTICS
ForSite™
MENU
PRINT


EyeKinetiX

HOW TO OVERCOME?

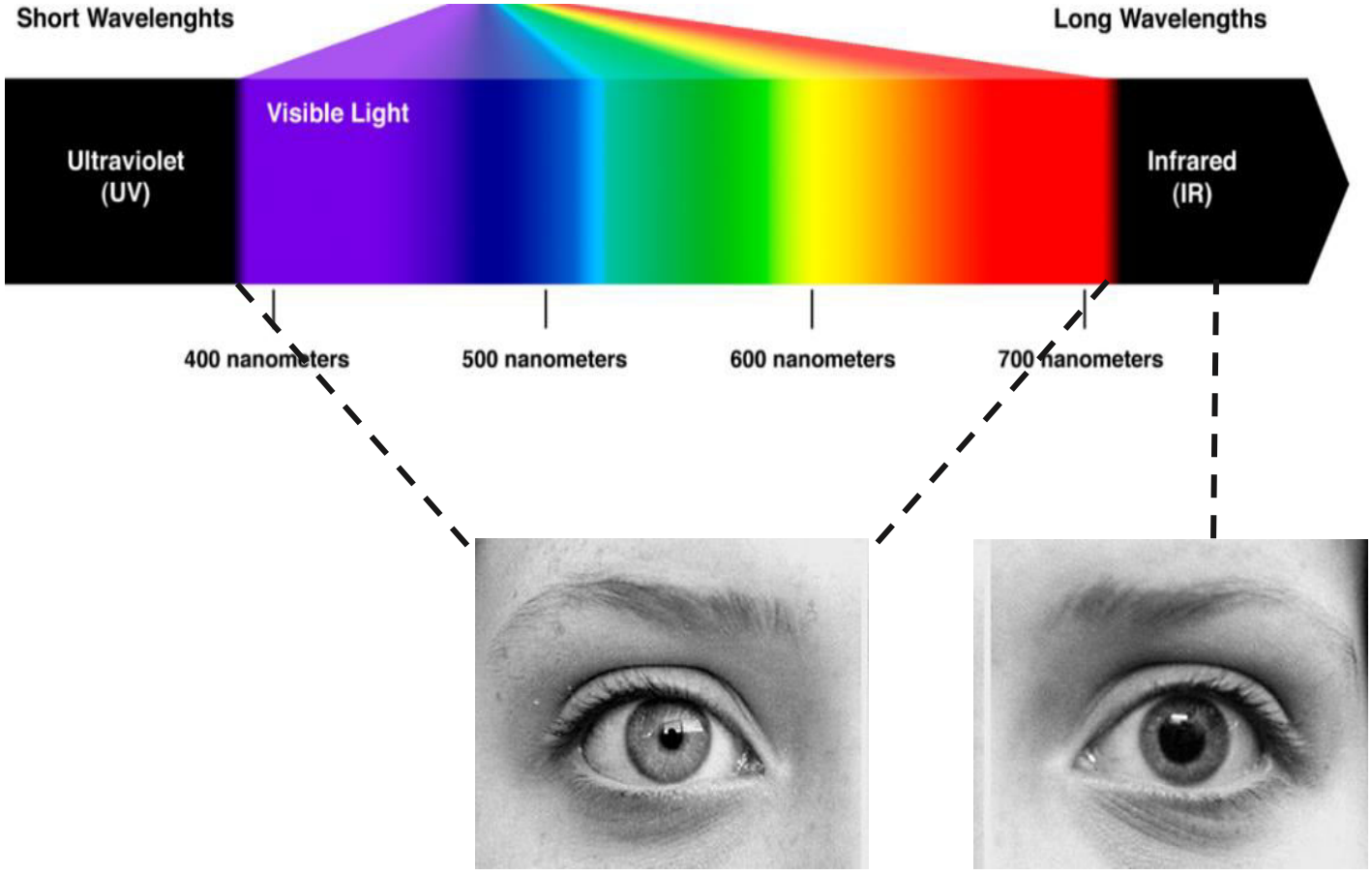
- We had designed and developed a cost effective PC based Dynamic Pupillometer from a regular web camera to measure the pupil size in relation to time.
- The system can be used to evaluate the status of Autonomic function by Quantitative pupillary light reflex (QPLR) using infrared videography.

CAN WE SEE A COMPLETE DILATED PUPIL WITH NAKED EYE?

We need a light source beyond visible spectrum to appreciate mydriasis

We can't see anything, But the Infrared camera can...

INFRARED ILLUMINATION



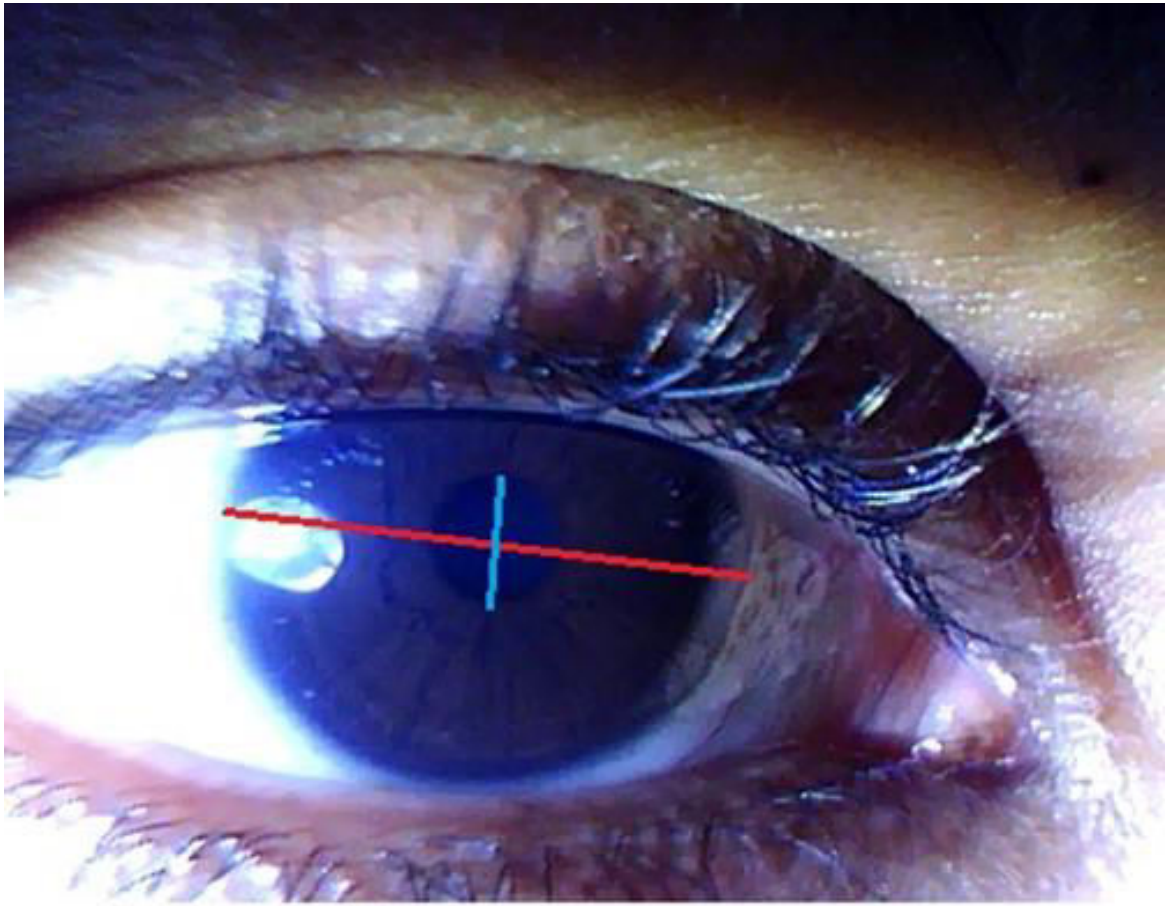
Myosis

Mydriasis

Effect of visible and infrared light on the pupil

PROOF OF CONCEPT

CALIBRATION OF IMAGE J SOFTWARE



Blue line is pupil diameter --?

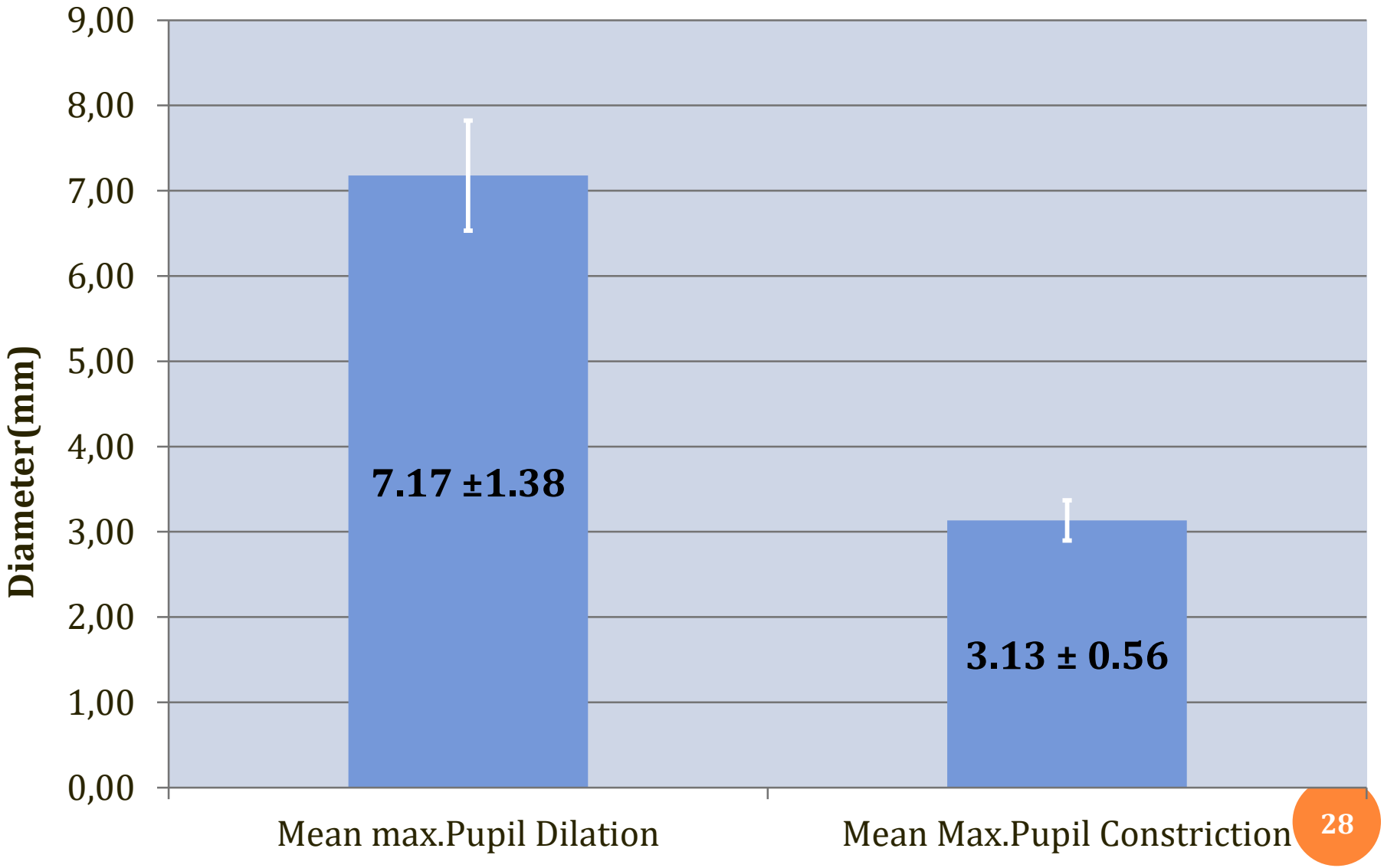
Red line is size of iris - 12mm

RAW IMAGES OF PUPIL

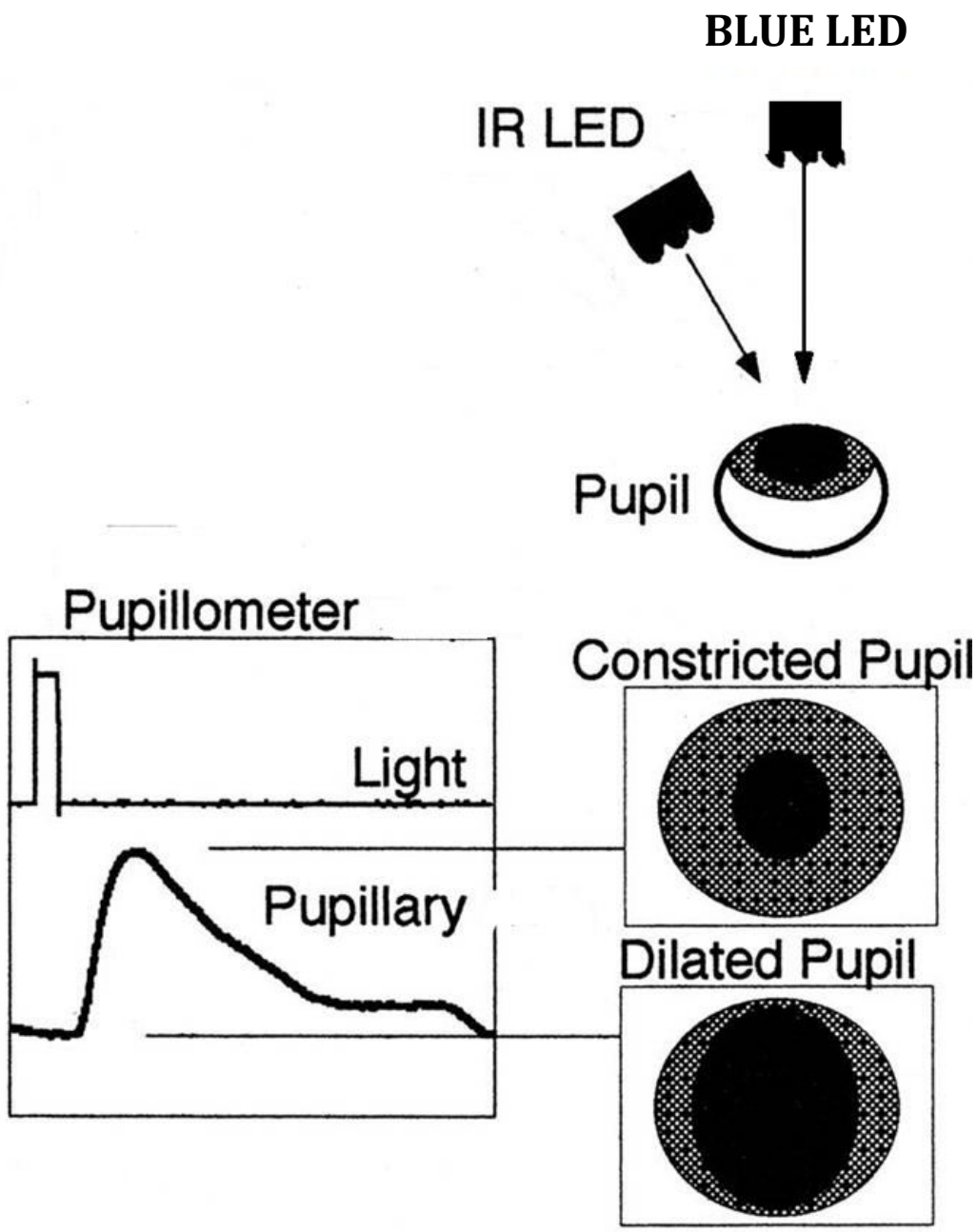
MINIMUM PUPIL DIAMETER

MAXIMUM PUPIL DIAMETER

PILOT DATA


9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
Diameter(mm)
7.17 ±1.38
3.13 ± 0.56
Mean max.Pupil Dilation
Mean Max.Pupil Constriction

DESIGN OF PUPILLOMETER



DESIGN OF PUPILLOMETER

VIRTUAL REALITY BOX

DISSECTION

2 – IR 850nm

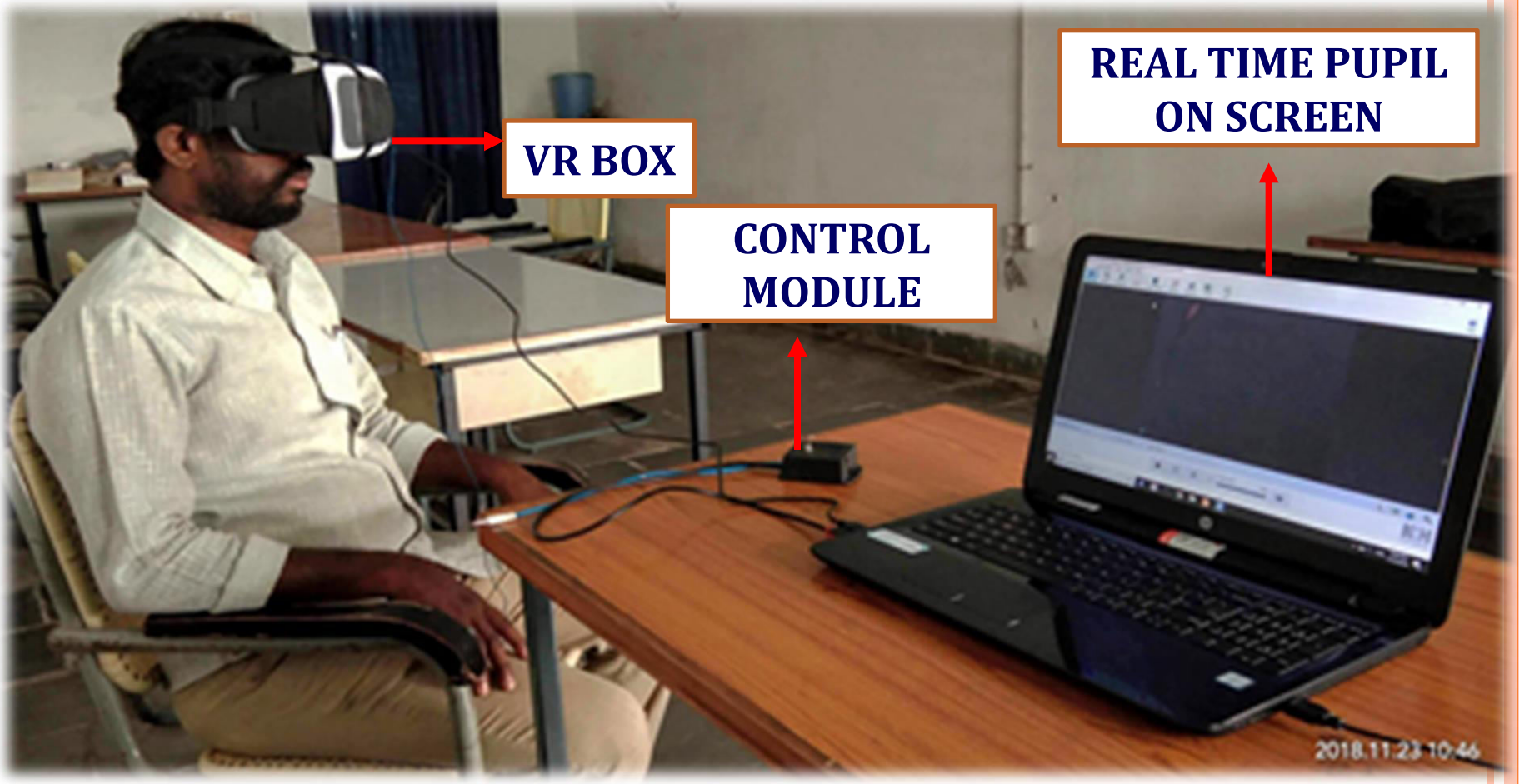
1 – BLUE 420nm

IR & BLUE LED

640X320 (30fps)

WEB CAMERA

DESIGN OF PUPILLOMETER



INTERNATIONAL CONTROL OF ILLUMINATION – INFRA RED LIGHT

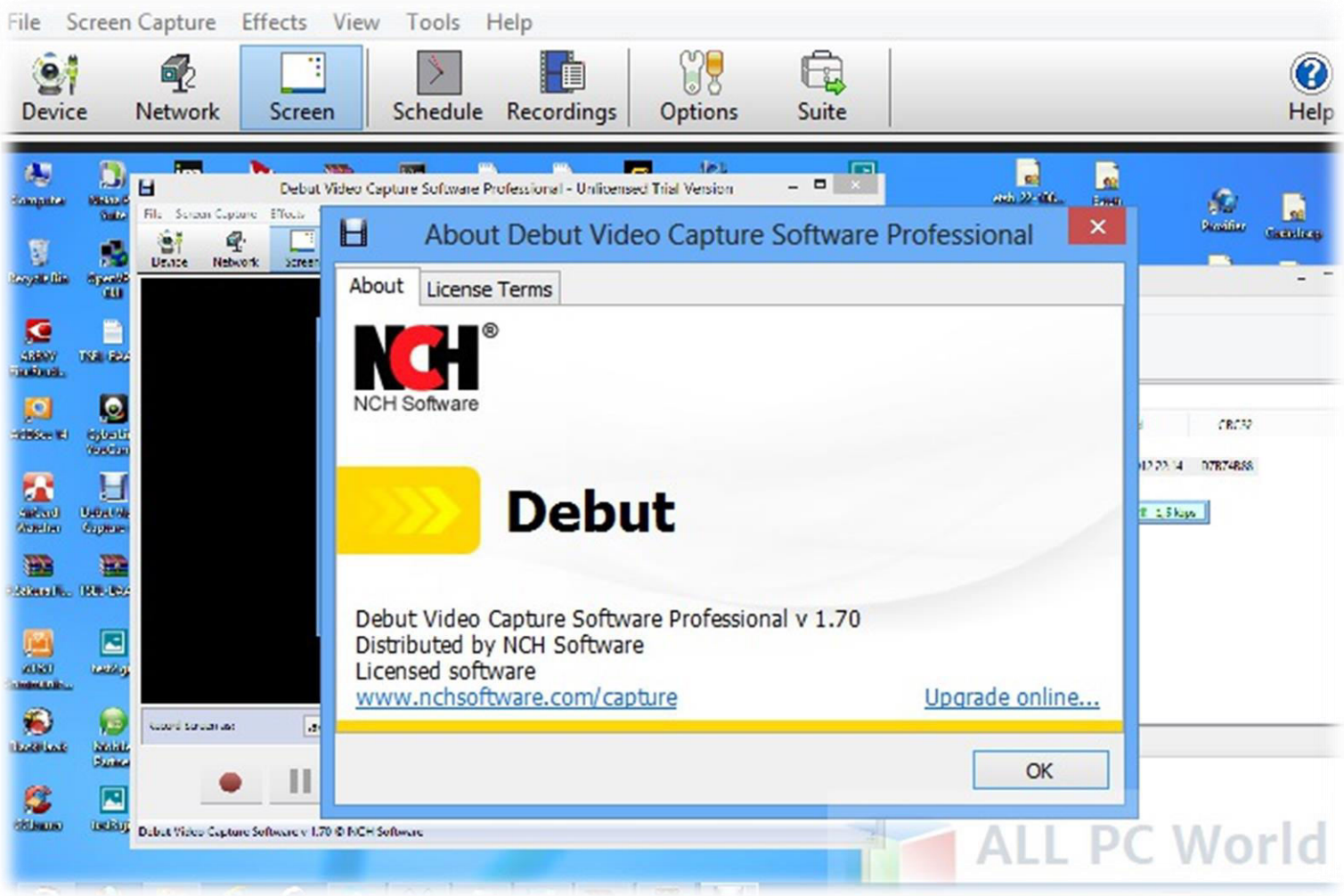
Near infra red light = 0.7-1.4μm – Optical image processing, Remotes

Intermediate wave length = 1.5 – 15 μm – Telecommunications, Missiles, Thermal imaging

Long wave length = 15 -1000μm - Infrared Laser light

SOFTWARES

- ✓ Debut software (version 5.09, NCH software).



VIDEO TO JPEG CONVERTER

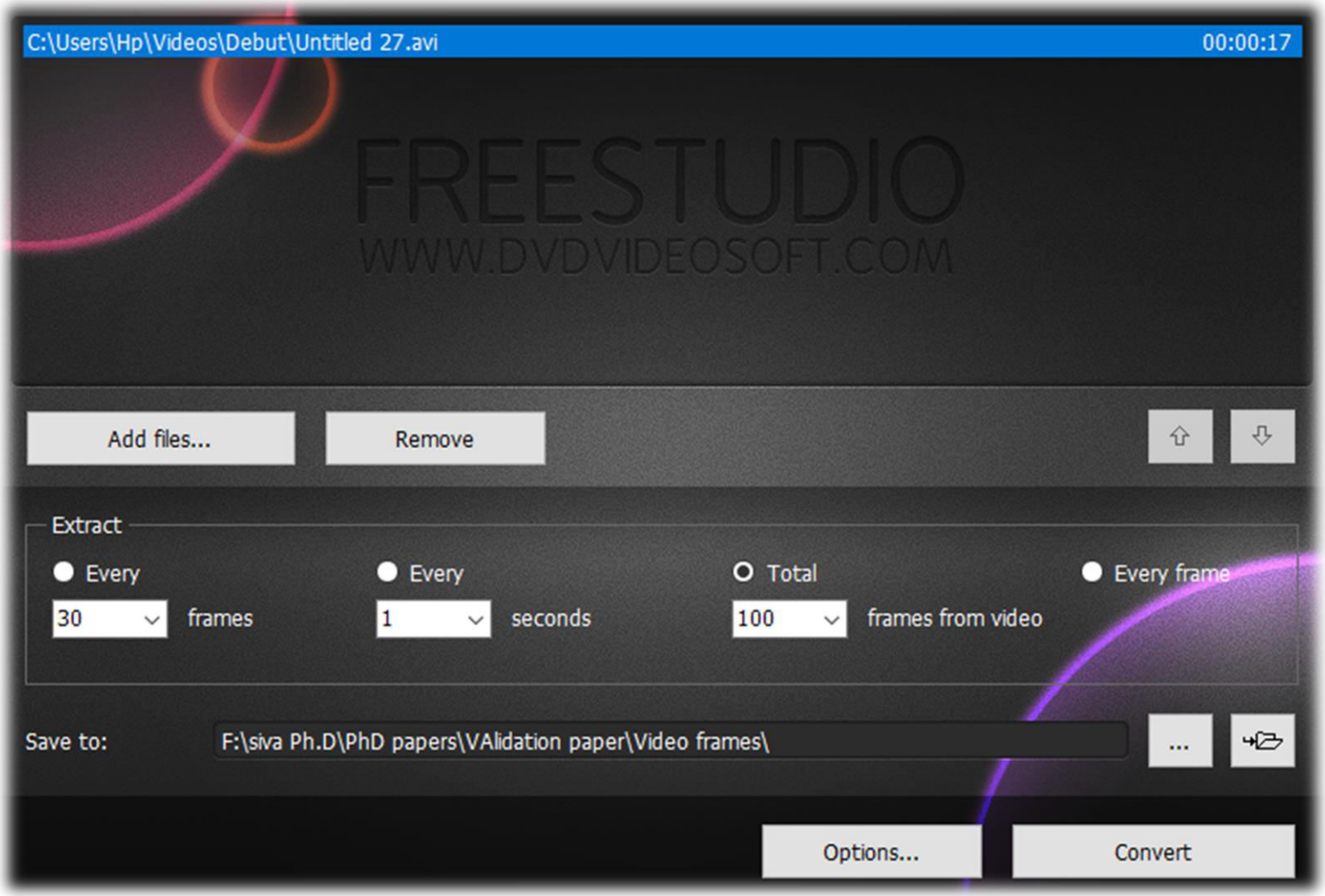
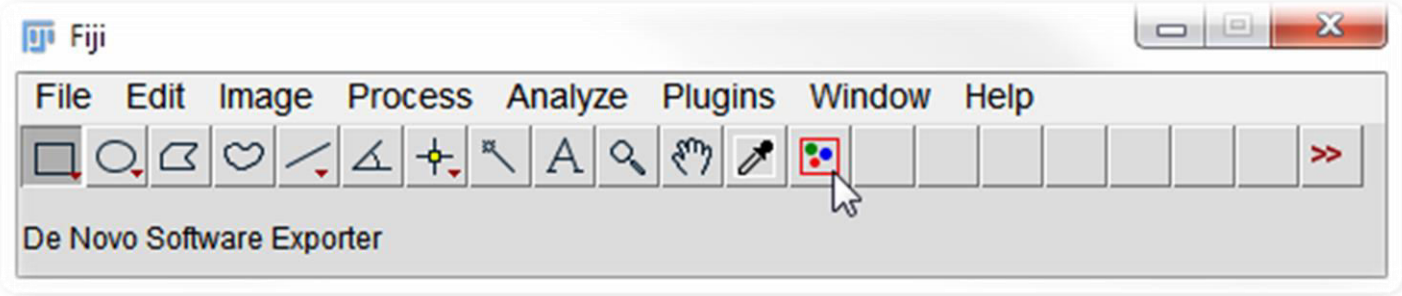
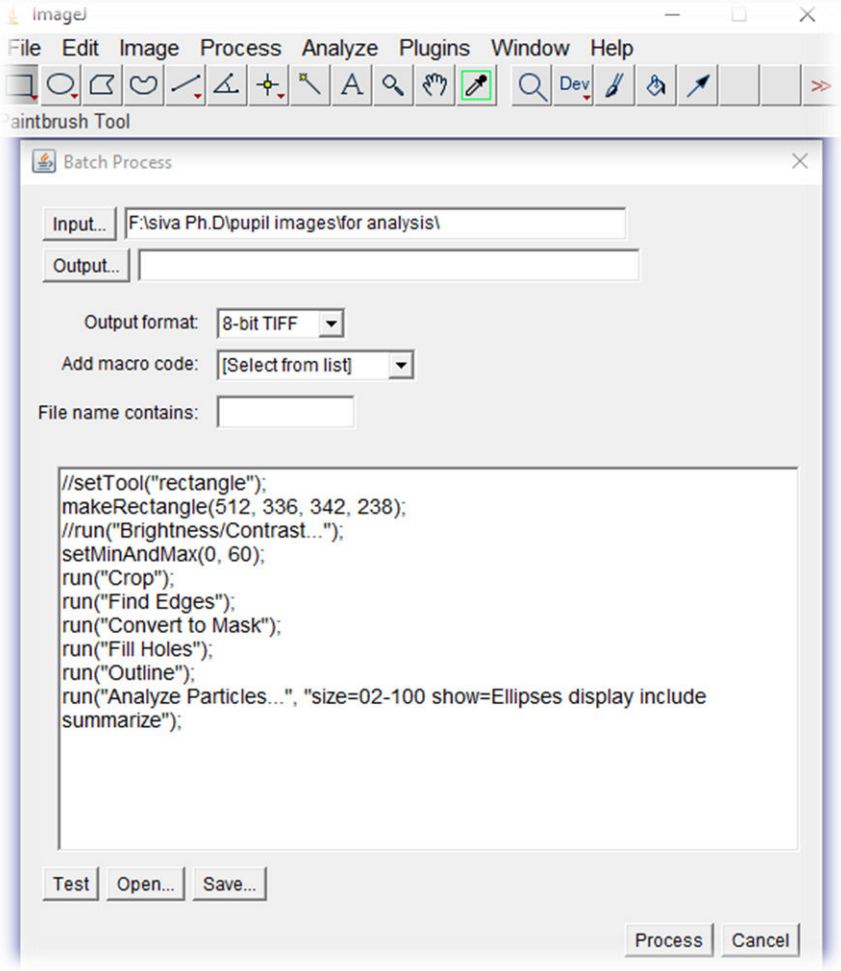


IMAGE J (NIH)


Fiji
File Edit Image Process Analyze Plugins Window Help
De Novo Software Exporter


ImageJ
File Edit Image Process Analyze Plugins Window Help
Paintbrush Tool
Batch Process
Input...
F:\siva Ph.D\pupil images\for analysis\
Output...
Output format:
8-bit TIFF
Add macro code:
[Select from list]
File name contains:
//setTool("rectangle");
makeRectangle(512, 336, 342, 238);
//run("Brightness/Contrast...");
setMinAndMax(0, 60);
run("Crop");
run("Find Edges");
run("Convert to Mask");
run("Fill Holes");
run("Outline");
run("Analyze Particles...", "size=02-100 show=Ellipses display include
summarize");
Test
Open...
Save...
Process
Cancel

DILATED PUPIL(MYDRIASIS) UNDER IR ILLUMINATION

CONSTRICTED PUPIL(MIOSIS) IN BRIGHT LIGHT ILLUMINATION

METHODOLOGY

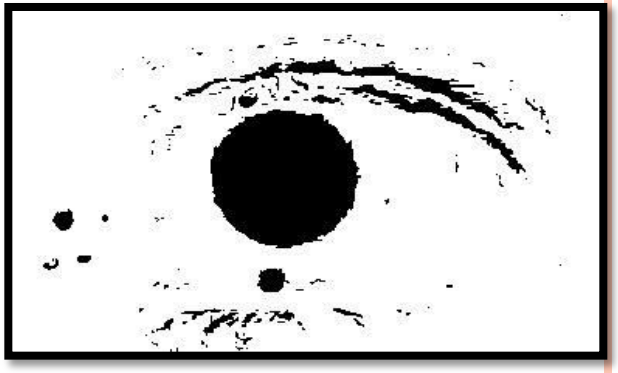
- 10 seconds of real-time PLR - computerized DP system.
- Resting dilated pupil - IR illumination
- flash of light stimulus - constriction of pupil
- pupil redilates on subsequent light exposure – Pupil Escape
- video clip - Debut software (version 5.09 of the NCH software).
- video clip - Jpeg images (Video to jpeg converter Ver.5.0.101.201).
- Image processing and analysis -"Image J" (ImageJ ver.1.43u, NIH, USA)

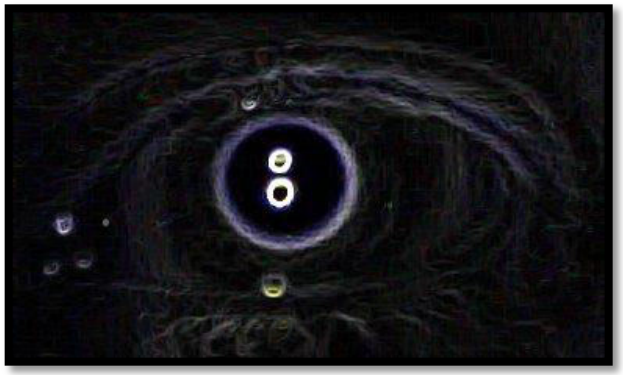
DIGITAL PUPIL LIGHT REFLEX

IMAGE PROCESSING

Raw pupil

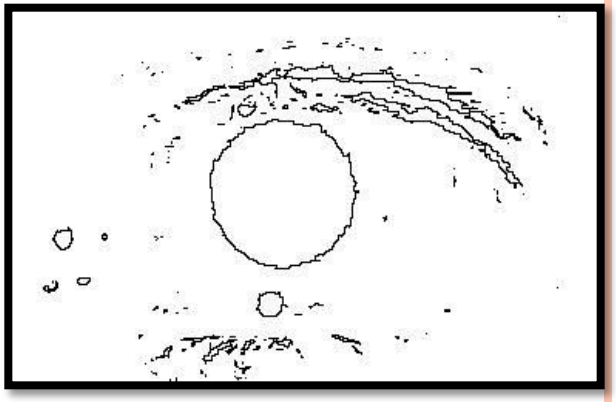
Elimination of LED reflection

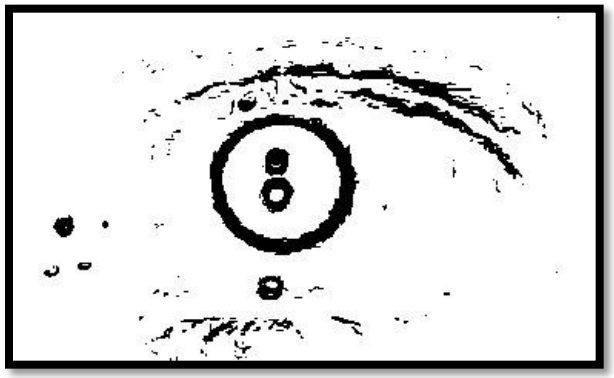




Pupil edges

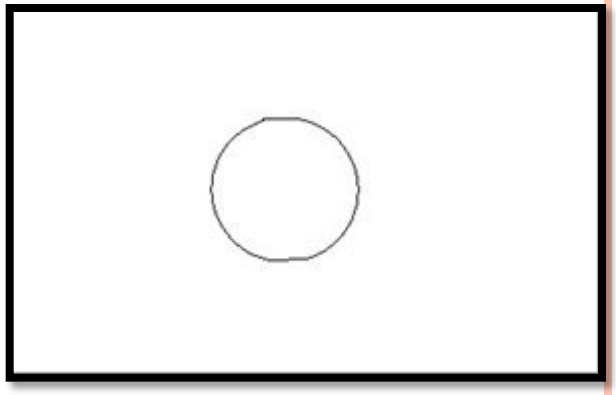
Pupil outline



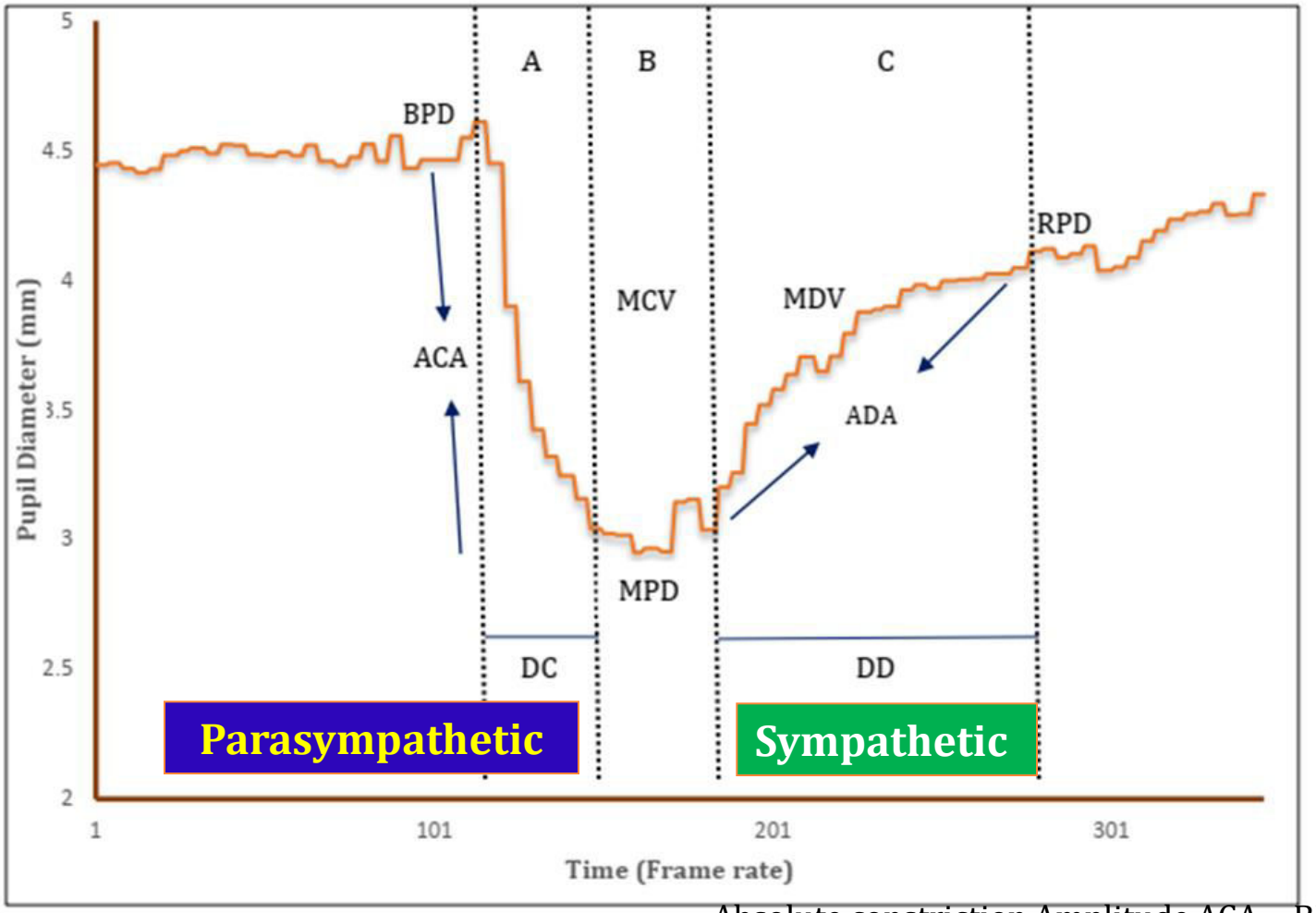


Binarization

Absolute pupil



PUPILLARY LIGHT REFLEX ('V' GRAPH)



Baseline pupil diameter (BPD)- before stimulus (Resting)

Reflex Latency (RL)

Minimum pupil diameter (MPD)- after stimulus

Recovered pupil diameter (RPD)- post recovery to stimulus

Absolute constriction Amplitude ACA = BPD-MPD

Absolute dilation Amplitude ADA=RPD-MPD

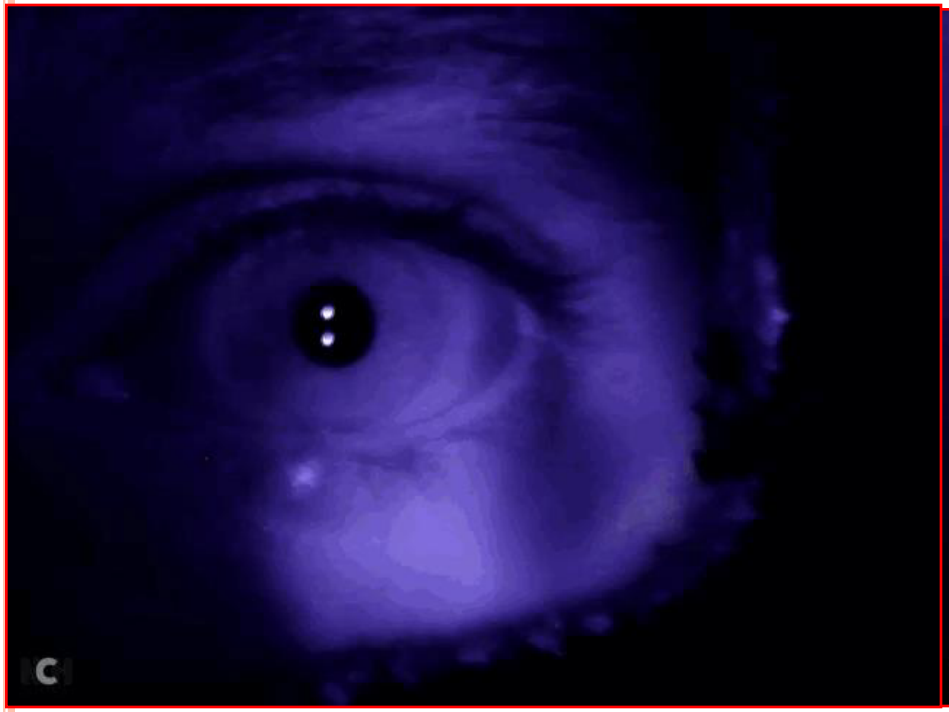
Duration of Constriction & Dilation (DC&DD)

Mean constriction & dilation velocity (MCV&MDV)

PLR variables	Definition	Normal range	ANS Indicator
1. Reflex latency (RL)	It is the period from the point at which light stimulus is applied to the eye to the onset of pupil response.	100 -300 m.sec	Parasympathetic activity
2. Baseline Pupil Diameter (BPD)	Resting diameter of the pupil in complete darkness under infrared light	3 -7mm	Sympatho – parasympathetic balance
3.Absolute constriction amplitude(ACA)	Change in pupil size from BPD to MPD after exposure to light stimulus. ACA = BPD – MPD	1 – 3 mm	Parasympathetic activity
4.Duration of constriction (DC)	The time for constriction of the pupil from BPD to MPD is taken. The strength and duration of the stimulus affect it.	500-1800m.sec	Parasympathetic activity
5.Maximum Constriction Velocity (MCV)	Rate of constriction which indicates rapidity of the PLR.	2 – 6mm/sec	Parasympathetic activity
6. Minimum Pupil Diameter (MPD)	Minimum pupil diameter attained after the light reflex	2 – 4 mm	Parasympathetic activity
7. Recovered Pupil Diameter (RPD)	Redilated pupil diameter up to 75%	3 – 6 mm	Sympathetic activity
8.Absolute redilation amplitude(ADA)	Change in pupil size from MPD to RPD. It is due to the constriction of dilator pupillae.	1-2.5 mm	Sympathetic activity
9. Duration of redilation (DD)	Time is taken for the redilation of the pupil from MPD to RPD.	1000 – 2500 m.sec	Sympathetic activity
10.Maximum Redilation Velocity (MDV)	Rate of redilation of the pupil after light exposure, indicating rapidity of the dilation of the pupil	2 – 5mm/sec	Sympathetic activity

DIABETIC AUTONOMIC NEUROPATHY (DAN)

PLR OF DIABETIC PATIENT

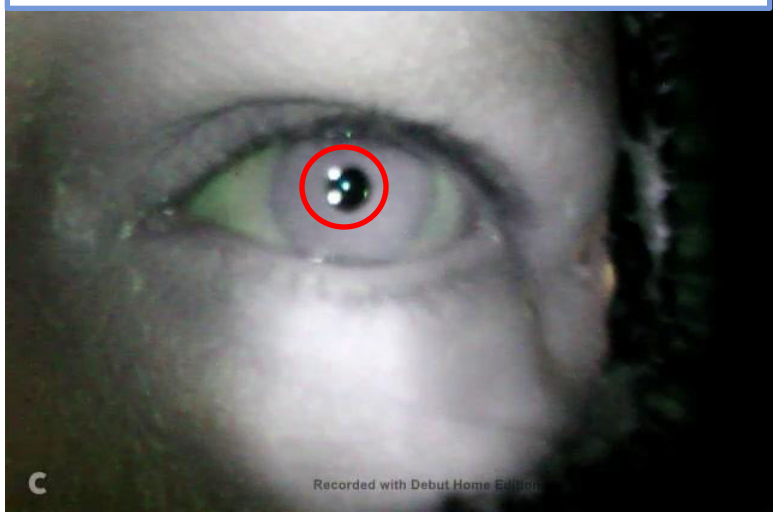


PLR OF HEALTHY PARTICIPANT

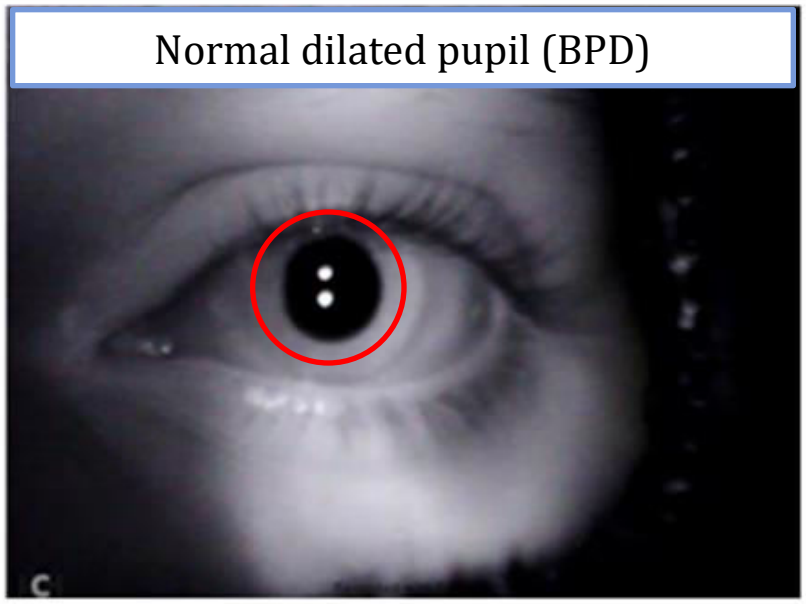
COMPARISION OF PUPIL IMAGES

DM patient dilated pupil (BPD)

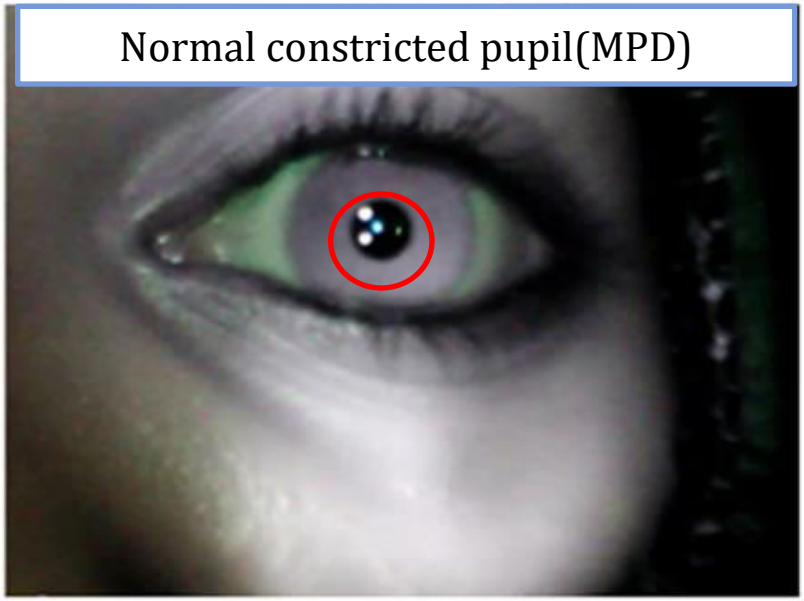
DM patient constricted pupil(MPD)



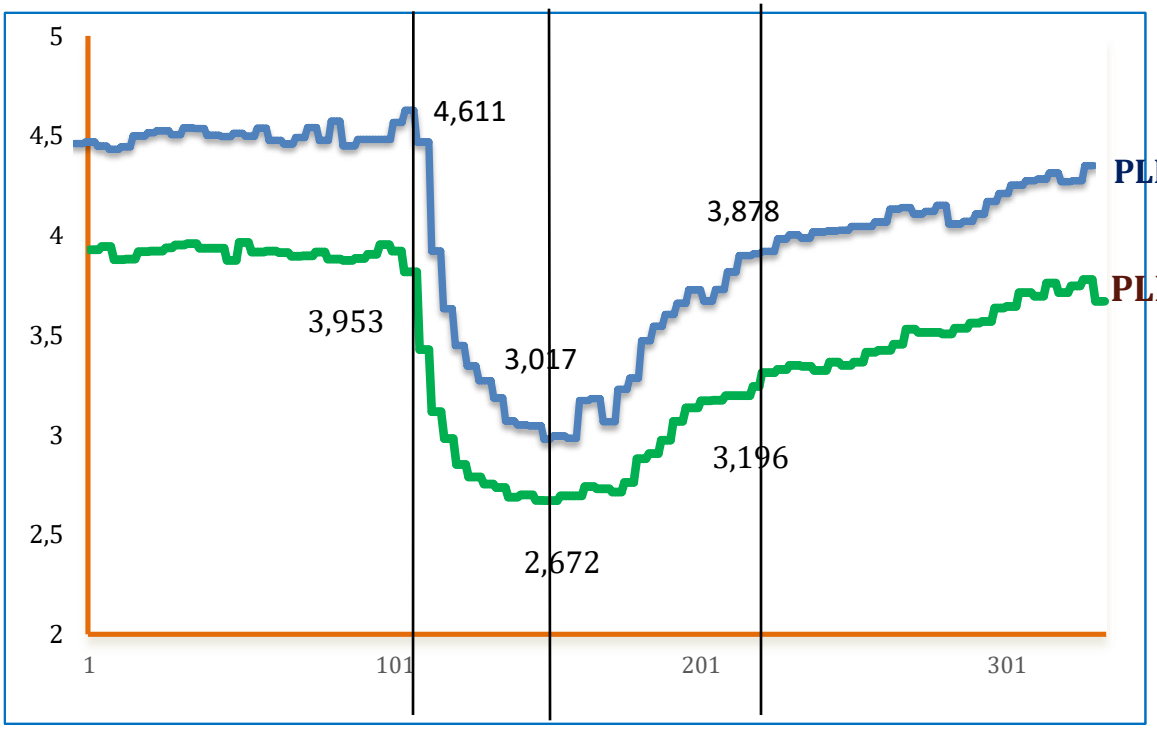
Normal dilated pupil (BPD)



Normal constricted pupil(MPD)



COMPARISON OF PLR GRAPH



ADVANTAGES

- Creates darkness & external light has no influence on the results
- Pupil – Large computer screen
- Inexpensive, Non invasive tool – Evaluation of ANS activity.
- The procedure takes less than 10seconds which does not require active patient participation. It requires minimal computer knowledge compared with other neuro-imaging techniques.
- It is portable which can be used in community studies to screen large population.
- This is the first ever Indian study on indigenous Dynamic Pupillometry to the best of our knowledge.

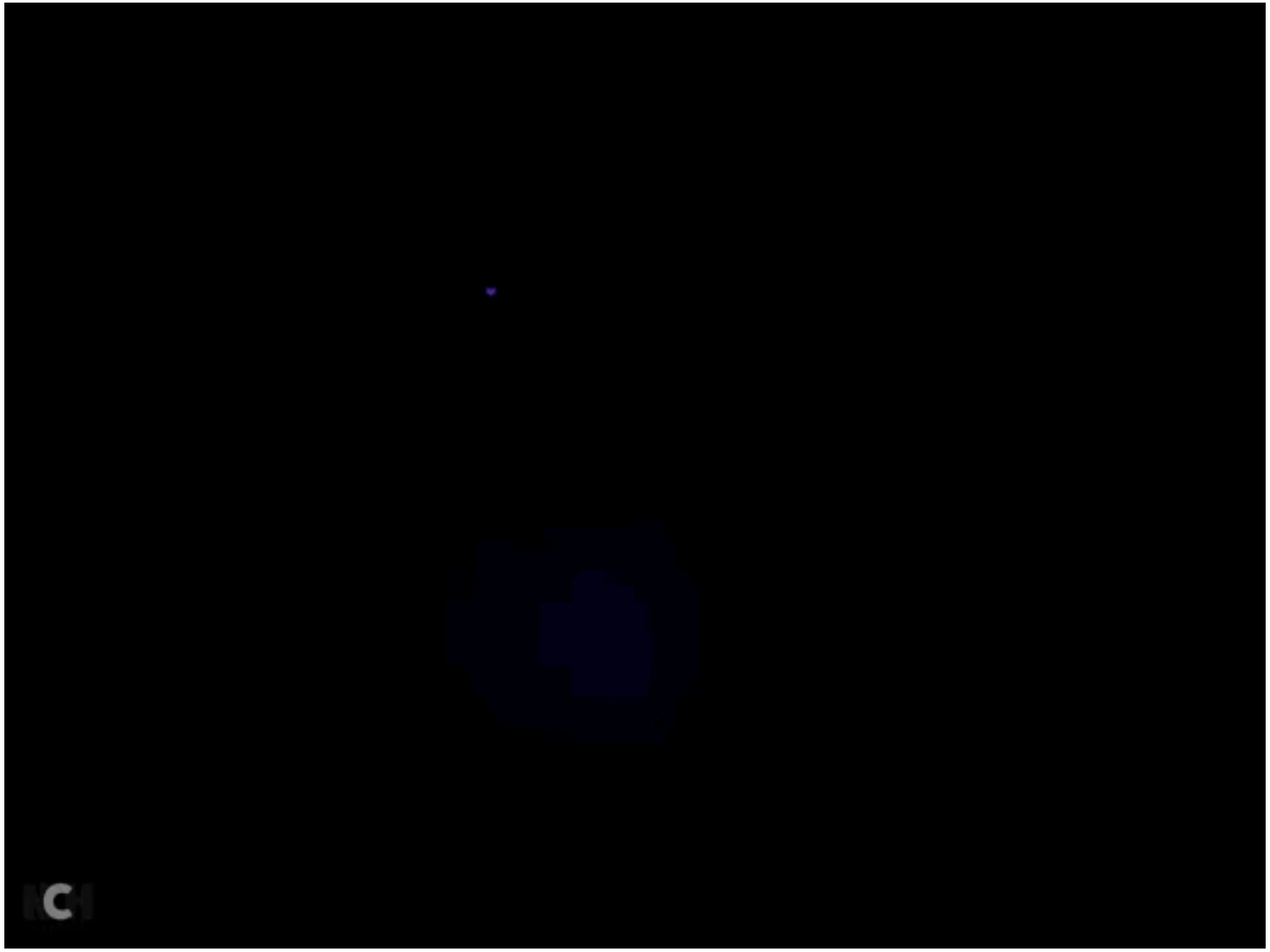
LIMITATIONS

- The data is processed offline due to which real time results are not possible.
- We can not record binocular pupillary light reflex simultaneously.
- Multiple softwares were required and data processing is tedious. Velocities should be calculated from the graphic plot.
- We are also planning to make a second version in which the results are displayed in real time and the stored data can be shared to cloud.

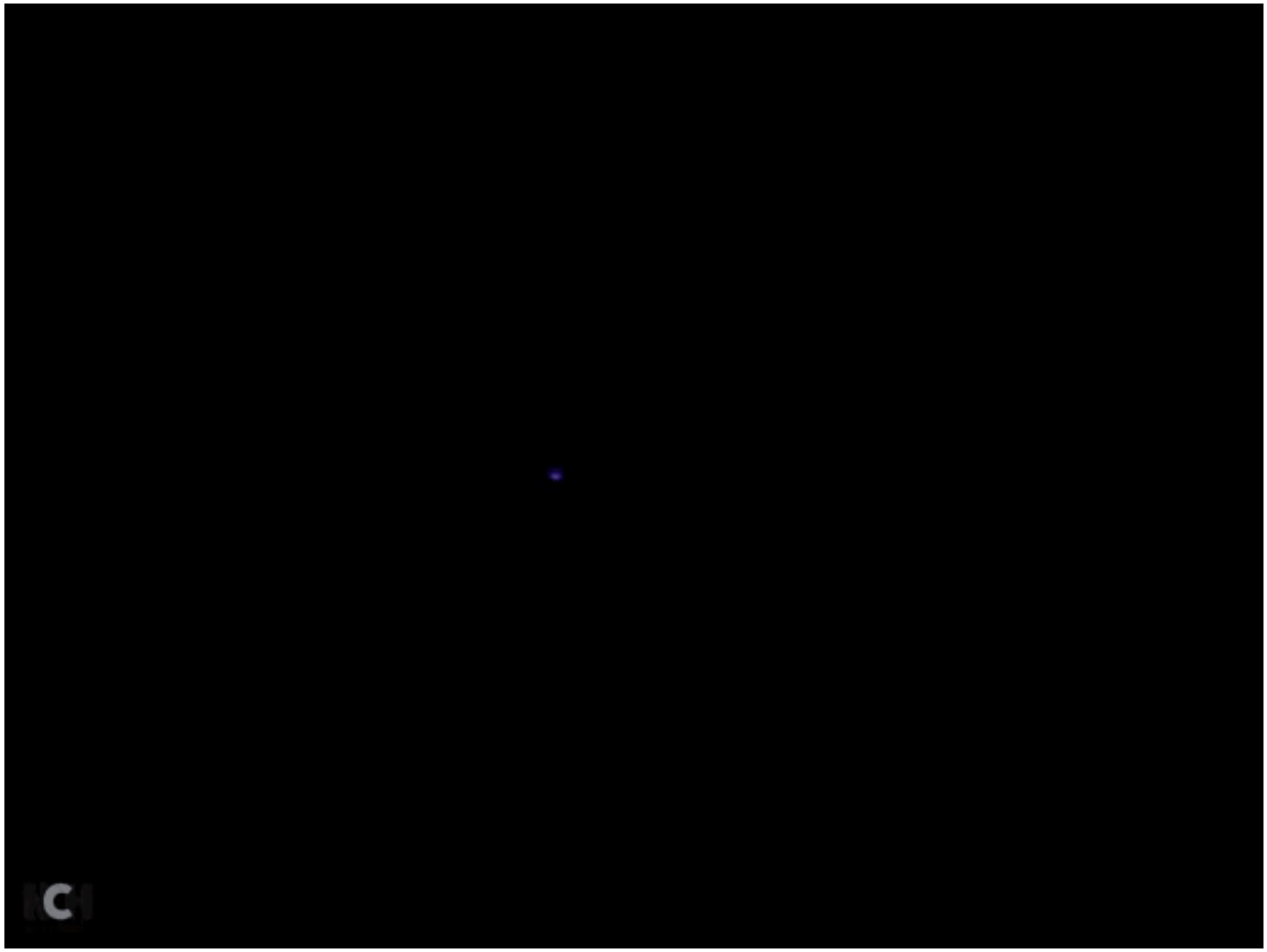
APPLICATIONS OF DYNAMIC PUPILLOMETRY

- To evaluate the early diagnosis of Autonomic dysfunction (Muppidi et al – 2013)
- To find out the activity of higher centers in Head injuries (Kenneth etal – 2017)
- To approximately localize the Brain tumours (JG Park – 2015)
- To distinguish the effect of various drugs on the higher centers (Fliegert et al - 2005)
- Pre-surgical evaluation during surgical procedures. (Lukaszewick etal-2015)
- To Diagnose autism and neurodevelopmental disabilities (E Blaser et al - 2014)
- To monitor Intensive care Unit patients (CS Vrettou et al – 2020)
- To diagnose neurodegenerative diseases like Parkinson's and Alzheimer's disease (Shaun frost et al – 2017)
- To measure cognitive disabilities (A Trapper et al - 2021)

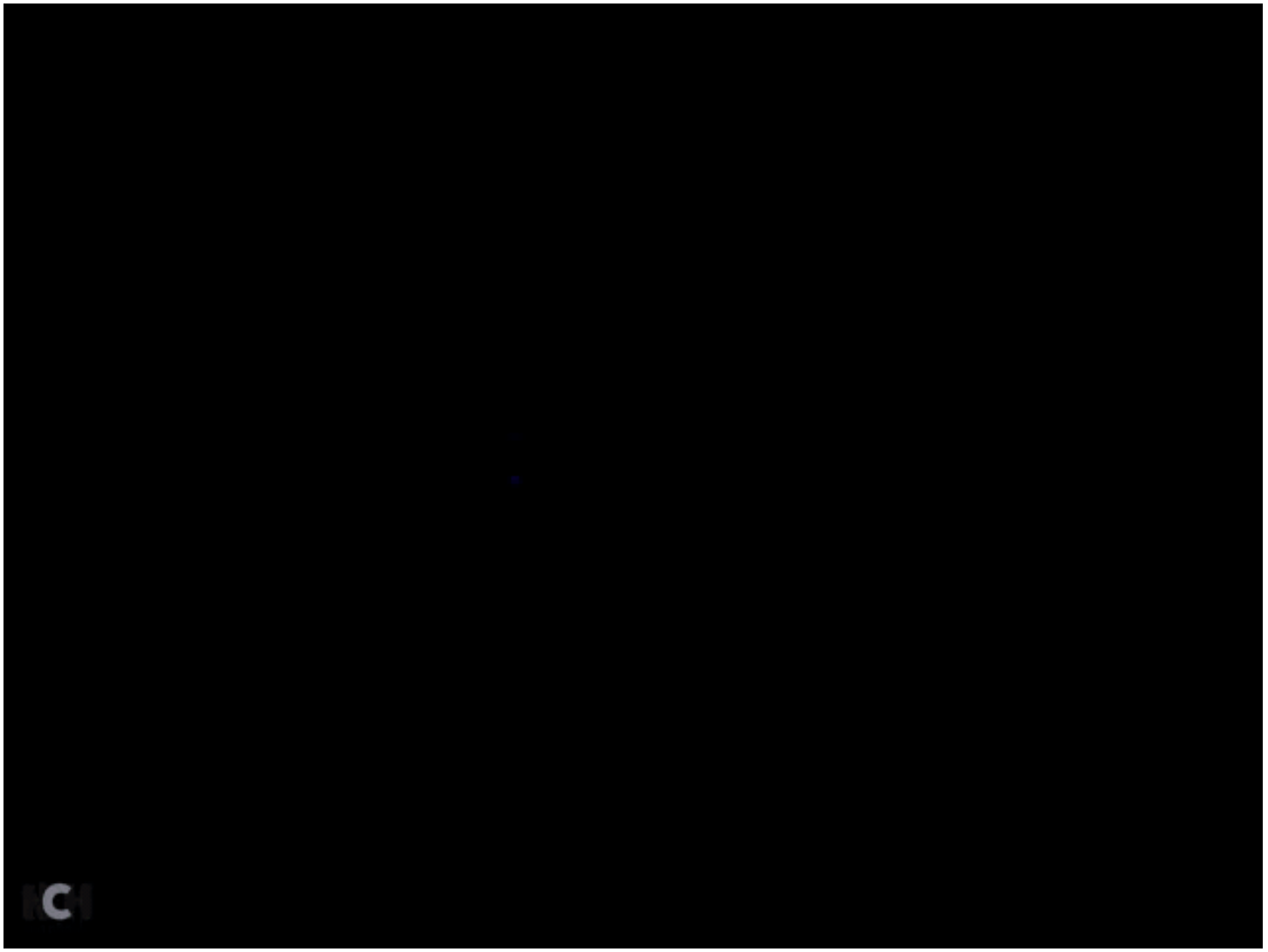
HORNERS SYNDROME



OCCULOMOTOR NERVE PALSY



CUSHING'S SYNDROME



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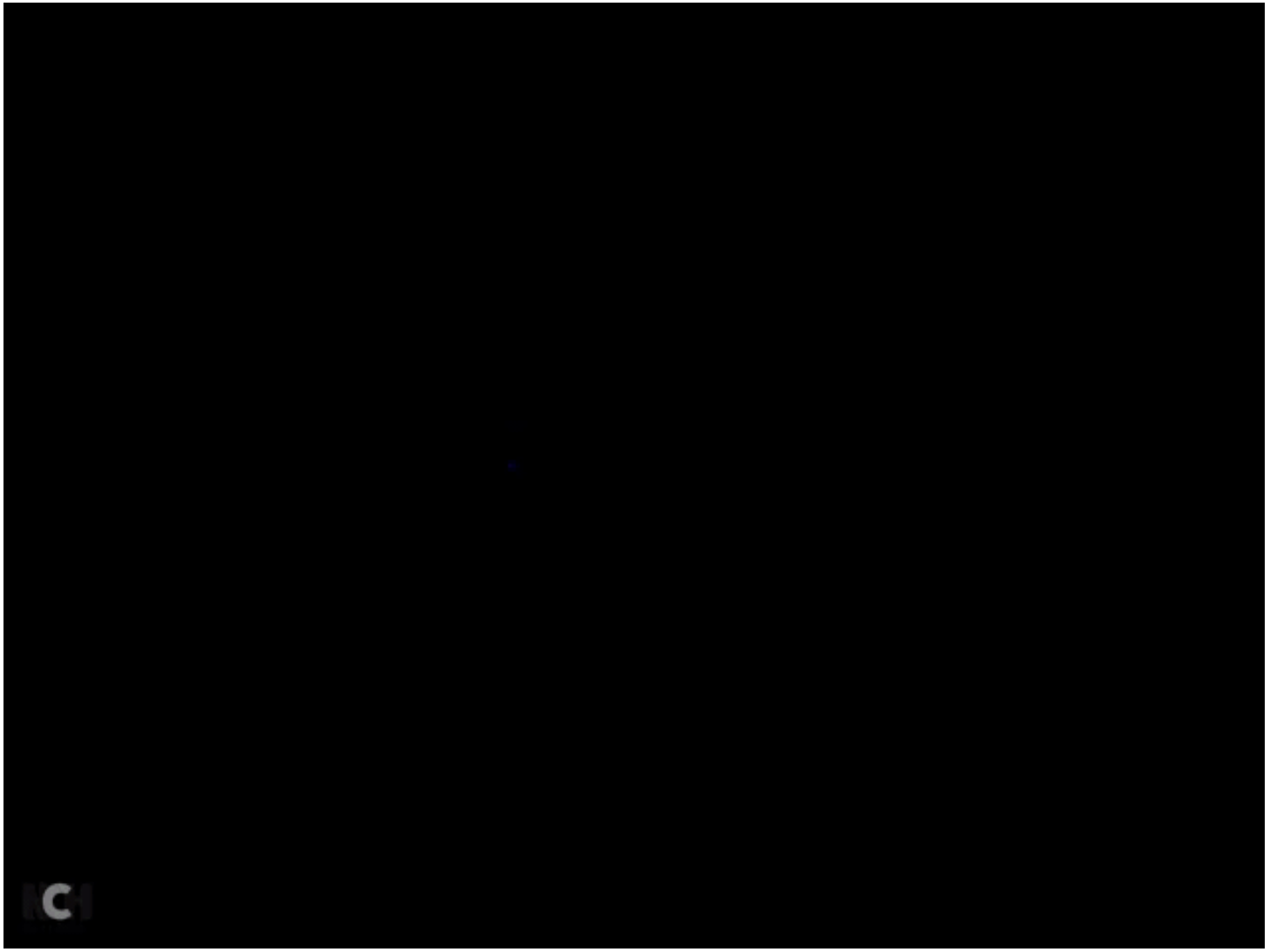

SUMMARY

- Dynamic pupillometry is a novel, simple noninvasive screening tool to quantify the pupil size using simple infrared digital videography.
- 'V' shaped graphical plot provides numerous static and dynamic PLR variables.
- Phase–A = Parasympathetic activity, Phase–C = Sympathetic activity
- Static variables – BPD, MPD & RPD.
- Dynamic variables – ACA, ADA, DC, DD, MCV & MDV
- It has more advantages compared with the clinical examination.
- Inexpensive, and user friendly tool which has significant role in neuroscience and clinical practice.

LIST OF PUBLICATIONS

Contents lists available at ScienceDirect

Clinical Epidemiology and Global Health

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Original article

Quantitative determination of pupil by dynamic pupillometry using infrared videography – Role in evaluation of autonomic activity

A.V. Siva kumar[a], K.N. Maruthy[b], R. Padmavathi[c,*], B. Sowjanya[d], K. MaheshKumar[e]

[a] Dept. of Physiology, Sri Ramachandra Medical College & Research Institute, Porur, Chennai, Tamilnadu, 600116, India
[b] Dept. of Physiology, Narayana Medical College, Nellore, Andhra Pradesh, 524003, India
[c] Dept. of Physiology, Sri Ramachandra Medical College, Porur, Chennai, Tamilnadu, 600116, India
[d] Dept. of Biochemistry, Narayana Medical College, Nellore, Andhra Pradesh, 524003, India
[e] Dept. of Physiology & Biochemistry, Govt. Yoga and Naturopathy College & Hospital, Chennai, Tamilnadu, 600104, India

ARTICLE INFO

Keywords:
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Infrared videography
Validation
Pupillary light reflex

ABSTRACT

Introduction: Pupillometry is a simple, non-invasive method capable of measuring static and dynamic pupil response in several physiological and clinical conditions. The latest digital camera can be slightly modified to obtain real time pupil response under infrared videography and analyzed by image analysis. So the current study has undertaken to confirm characterization of the system by comparing with manual measurements in healthy volunteers.

Methods: This study was conducted in 40 healthy volunteers aged between 18 and 25 years. The system was calibrated by measuring the known length of 3 different lines for reliability. Later real time static pupil pictures were measured and compared with the manual examination of pupil determined by a ruled scale with 0.5 mm accuracy.

Results: The Image J software was precalibrated with known length and estimated 5 mm, 10 mm and 15 mm lines respectively. The results are 5.01 ± 0.14 mm, 10.01 ± 0.36 mm and 15.02 ± 0.23 mm. There were no significant differences observed between the values analyzed by two examiners. Later the results were compared between manual examination and real time image analysis.

Conclusion: The present study suggested that the static and dynamic pupil measurements with real time pupillometer are accurate and probably as reliable as those obtained by manual examination of the pupil using the flashlight test. This system is cost-effective, portable in nature which can produce authentic results of the pupil.

1. Introduction

Pupillometry is a convenient, feasible technique that is routinely used in the clinical set up as well as in research, to measure pupil size in various physiological and pathological conditions.[1] The pupillary response can be influenced by exposure of the eye to bright light by means of pupillary light reflex, fixing gauge at a near point by accommodation reflex.[2] These two reflexes lead to pupil constriction mediated through parasympathetic nerve activation (Occulomotor nerve). The Pupil is dilated in darkness, through sympathetic modulation.[3–5] So the pupil size for the light stimulus can be a sensitive indicator for evaluation of Autonomic nervous system activity.[6–9] Apart from diagnosis of autonomic derangement, these quantified values of the pupil can help in traumatic brain injuries, pre-operative ophthalmic surgical procedures, and cortical nuclei damages.[10] Various studies have shown that there are different automated pupillometers designed and established for pupil analysis.[11] The infrared digital photographic devices and automated pupillometers are precise, accurate and repeatable for computation of static and dynamic measurements of the pupil diameter.[12] However, these instruments are highly expensive, unaffordable, especially in poor and developing countries. Even though it is not feasible to use these devices for other setups such as semi-urban and rural OPDs and clinics. Nowadays the digitalization was profoundly developed and high-resolution web cameras become cost-effective and its usage also too easy.[13] With the advancement of optics such as image stabilization, offline corrections and capturing good quality images has become comfortable and user-friendly. These cameras can also be employed to capture the pupil size and responses to the light stimulus that satisfy the necessities of clinical as well as research purposes. These are accessible and convenient tools that are commercially available in the

* Corresponding author.
E-mail addresses: reddy.sivakumar5@gmail.com (A.V. Siva kumar), dr.maruthy@gmail.com (K.N. Maruthy), rpadmavathi@sriramachandra.edu.in (R. Padmavathi), phanisowji@hotmail.com (B. Sowjanya), doctormahesh1985@gmail.com (K. MaheshKumar).

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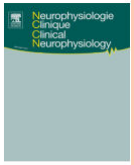

ORIGINAL ARTICLE

Computerized dynamic pupillometry as a screening tool for evaluation of autonomic activity

Venkata Sivakumar Avuluru[a], Maruthy Kalburgi-Narayana[b], Maheshkumar Kuppusamy[c], Ramaswamy Padmavathi[a,*], Bachali Sowjanya[b]

[a] Sri Ramachandra Institute of Higher Education and Research (SRIHER), Chennai, India
[b] Narayana Medical College and Hospital, Nellore, India
[c] Govt. Yoga and Naturopathy Medical College & Hospital, Chennai, India

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KEYWORDS
Autonomic activity;
Pupillary light reflex;
Heart rate variability;
Dynamic pupillometry;
Infrared videography

Abstract

Objectives. — Dynamic pupillometry is a simple screening tool for quantifying pupillary light reflex (PLR), to indicate autonomic nervous system (ANS) activity. Heart rate variability (HRV) is the gold standard method for assessing ANS effects on the heart. The present study aimed to compare ANS activity as measured using dynamic pupillometry (DP) with short term HRV in healthy volunteers.

Methods. — The study includes 200 participants aged between 20—60 years. PLR was measured using infrared videography and categorized into different quantitative parameters that reflect ANS activity. Simultaneously, Lead II ECG was recorded for 5 min to evaluate the short term HRV of time and frequency domain parameters. The data obtained from the two methods were compared with each other to provide the relationship between PLR and HRV.

Results. — Study participants' mean age was 36.95 ± 9.45 years. The different pupillary indices of PLR and all the HRV parameters were within the range of normative data. Several PLR indicators of the parasympathetic function include mean constriction velocity (MCV; $r = 0.60$, $P < 0.001$), absolute constriction amplitude (ACA; $r = 0.57$, $P < 0.001$) baseline pupil diameter (BPD; $r = 0.44$, $p < 0.001$), and minimum pupil diameter (MPD; $r = -0.35$, $p < 0.001$) were significantly correlated with high-frequency power (HF in normalized units) of HRV signal.

Conclusion. — PLR variables showed a significant relationship to HRV indices. Dynamic pupillometry can be a complementary tool to HRV for evaluating ANS activity.

* Corresponding author at: Department of Physiology, Sri Ramachandra Institute of Higher Education and Research (SRIHER), Porur, Chennai, Tamil Nadu, 600116, India.
E-mail address: rpadmavathi@sriramachandra.edu.in (P. Ramaswamy).

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0987-7053/

LIST OF PUBLICATIONS

DOI: 10.7860/JCDR/2019/41051.12805

Short Communication

Physiology Section

An Innovative Technique to Evaluate Quantitative Pupillary Light Reflex by Dynamic Pupillometry using Infrared Videography

AV SIVA KUMAR[1], R PADMAVATHI[2], KN MARUTHY[3], B SOWJANYA[4], K MAHESH KUMAR[5]

ABSTRACT

Introduction: An innovative approach was designed to quantify the pupillary light reflex using infrared and white light illumination. This method is convenient to detect pupil edges, area and the diameter of pupil contour recorded in different ambient light conditions.

Aim: To establish newer methodology, to quantify pupillary light reflex using image analysis.

Materials and Methods: A standard web camera was modified as an Infrared camera to capture the real time pupil response to various intensities of illuminations. Pupillary response to a flash of light was video graphed and split into video frames. These images of the pupil thus obtained were subjected to an image analysing software. This methodology also provides a solution to exclude infra-red LED reflection within the pupil circle. The orientation of pupil within iris can be appreciated with this protocol.

Results: The steps were tailored to measure various parameters of pupillary light reflex like minimum, maximum and mean pupil diameters. It also facilitates to calculate constriction and dilation velocities. The capture, cleavage and offline analysis of these video frames were done using all open source softwares.

Conclusion: This simple, user-friendly, innovative technology can be used for quantifying the pupil response which can be used as an indicator for autonomic dysfunction.

Keywords: Autonomic nervous system, Baseline pupil diameter, Image J, Light-emitting diode, Maximum constriction velocity

INTRODUCTION

The pupil is the central aperture of the iris that controls intensity of the light falling on the retina [1]. The pupil is controlled by sphincter pupillae and dilator pupillae [2]. The bright light and accommodation declines pupil size mediated by parasympathetic nerves [3]. The other stimulants like cognitive load and dark light cause dilation of pupil [4-6]. So the pupil size provides potential information in the diagnosis of the patient [7]. The measurement of the pupil's reaction to light serves as a non-invasive tool in the field of neuroscience [8]. The initial pupillometers were time consuming, low precision due to the low frame rate [9].

But, recently the automated pupillometers were evolved with high precision, reliability. However, these pupillometers are very expensive. The accuracy of the pupillary measurements increased over the years due to availability of cameras with good resolution and frame rate. With the advancement of optics, capturing good quality images has become easy. These cameras can also be used to capture pupil. The present study was aimed establish novel methodology to quantify pupillary light reflex.

MATERIALS AND METHODS

Instrument Design

The PC based infra-red pupillometer was developed from a web camera (Technotech ZB V90 WEBCAM-640×380). The camera was dissected to remove the infra-red filter to capture pupil in darkness under infrared illumination. The camera was fixed to a virtual reality box to create darkness. It is the easiest way to eliminate confounding factors related to illumination. Later the camera was surrounded with two 5 mm infra-red light emitting diodes 850 nm (5 milliwatt- for continuous illumination) to provide infra-red illumination in darkness for which pupil does not respond. A white LED (5 milli watt for 2000 milli second flash) was also fixed near the camera to produce a flash of white light stimulus. The camera was fixed at a spatial distance of seven centimetres from the anterior curvature of the eye which does not initiate accommodation reflex. The frame rate of the camera is 30 frames/sec with a resolution of 33.3 milli sec/frame. The system was connected to a microcontroller based electronic circuitry to control the intensity of Infra-red LED for continuous illumination and to provide two seconds white light flash. The electronic circuitry was powered through the USB port of the computer. As the system works with 5 volt DC and its electronic circuit does not come in contact with the body surface and it is very safe to use.

Methodology

The modified flexible virtual reality box fits for everyone and also creates darkness. The recordings cannot be influenced by illumination of the surroundings due to the closed box. The real-time pupil examination can be seen on a large computer screen which is not possible in portable pupillometers. The video recording was done using Debut software (version 5.09, NCH software). It is free software for non-commercial use and was used in the current study for recording of the real-time pupillometry. It is user-friendly and easy to navigate with a logical layout. This software can modify the quality and resolution of the recording video offline. However, it does not change the dimensions of pupil throughout video frames. These video recordings were split into jpeg images using video splitter software (Video to jpeg converter Ver.5.0.101.201). Further, these images were subjected to image analysis software (ImageJ ver.1.43u National Institute of Health, USA). **Image J:** It is a Java-based image processing software developed at the National Institutes of Health (NIH) and the Laboratory for Optical and Computational Instrumentation. Image J was developed with an open source layout that can be customise with recordable macro java plugins for image processing and analysis. Image J built-in development environment has made it a popular platform for processing of images. The video frames obtained from recording pupil response were analysed in a batch using Image J software by customising java based macro plugin [10].

Steps of Image Processing

Images can be analysed either individually or as a batch of images. These pictures for pupil can be measured either in pixels or in physical units with known distances as fixing the scale which provides the area and diameter of the pupil. The following steps can be followed in order to identify and measure pupil dimensions [Table/Fig-1].

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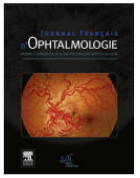

SFO COMMUNICATION

An impaired pupillary light reflex indices in Orbital Apex Syndrome — A rare case report

Indices réfléchissants de lumière pupillaire améliorés dans le syndrome d'apex orbital — un rapport de cas rare

A.V. Siva Kumar[a], R. Padmavathi[a,*], S. Mahadevan[b], K.N. Maruthy[c], K. Maheshkumar[d]

[a] *Department of Physiology, Sri Ramachandra Institute of Higher Education and Research (SRIHER), 600116 Chennai, Tamilnadu, India*
[b] *Department of Endocrinology, Sri Ramachandra Institute of Higher Education and Research (SRIHER), Chennai, Tamilnadu, India*
[c] *Departmentof Physiology, Narayana Medical College and Hospital, Nellore, Andhra Pradesh, India*
[d] *Department of Physiology & Biochemistry, Government Yoga and Naturopathy Medical College and Hospital, 600104 Chennai, Tamilnadu, India*

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KEYWORDS
Pupillary light reflex;
Dynamic pupillometry;
Supraorbital fissure

Summary

Background. — The clinical presentation of reduced pupillary responses in orbital apex syndrome is currently not well understood clinically. The pupillary light reflex (PLR) is determined using dynamic pupillometry.

Case details. — A newly diagnosed 35-year-old diabetic female patient had ocular symptoms including orbital pain and ptosis, but no visual loss. Cranial nerve autonomic impairment was identified with dynamic pupillometry and compared with cardiac autonomic activity using heart rate variability (HRV).

Results. — PLR showed that pupil size and response were severely affected, with a small resting pupil size, and minimal response to a bright white light flash was seen, due to decreased sympathetic activity. However, HRV showed normal cardiac sympathetic activity.

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Non-SCI Journal: Journal of clinical and Diagnostic Research (2019)

Affiliation Address Ph.D Research scholar, Department of Physiology, Sri Ramachandra Medical College, SRIHER, Porur, Chennai.

Date & Location: 15th January, 2020, Puducherry, India

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Dr A V Siva Kumar

for having presented a poster titled

Evaluation of Autonomic function in T2DM patients using an indigenously developed Dynamic Pupillometry system for quantitative Pupillary light reflex

in the 8th Annual Conference of the Endocrine Society of Tamil Nadu & Puducherry - "Trendo 2020" held from 4th to 6th December 2020 and won the 2nd prize in the Poster Session.

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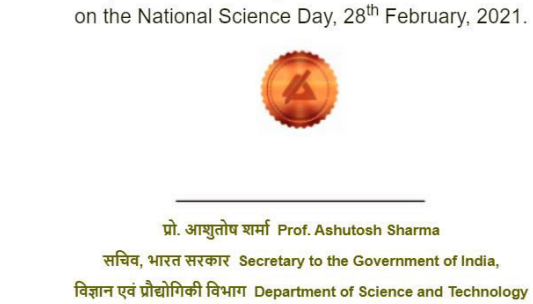

This Certificate of Appreciation is Presented to

A V Siva Kumar

for his Popular Science Story Selected Under Ph.D. Category, on the National Science Day, 28th February, 2021.

प्रो. आशुतोष शर्मा Prof. Ashutosh Sharma
सचिव, भारत सरकार Secretary to the Government of India,
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REFERENCES

- **Siva Kumar A V**, Padmavathi R, Maruthy KN, Sowjanya B, KUMAR K. An Innovative Technique to Evaluate Quantitative Pupillary Light Reflex by Dynamic Pupillometry using Infrared Videography. Journal of Clinical & Diagnostic Research. 2019 Apr 1;13(4).
- Ramadevi.P P, Maruthy KN, Padmavathi R, **Siva Kumar A V**, Kareem SK. Evaluation of Static Pupil Size Using Digital Web Camera through Image Analysis. International Journal of Physiology. 2019;7(3):7-11.
- Quantitative determination of pupil by dynamic pupillometry using infrared videography–Role in evaluation of autonomic activity. **A.V. Siva Kumar**, Maruthy KN, Padmavathi R, Sowjanya B, Mahesh Kumar K. Clinical Epidemiology and Global Health. 2020 Jan 25. https://doi.org/10.1016/j.cegh.2020.01.010.
- Computerized Dynamic Pupillometry as a screening tool for the evaluation of the autonomic activity – **A.V. Siva Kumar**, Maruthy KN, Padmavathi R, Sowjanya B, Mahesh Kumar K, Neurophysiologie Clinique - Clinical Neurophysiology. 11,Oct 2020. https://doi.org/10.1016/j.neucli.2020.09.004

"Humans may either blush or turn pale when emotionally agitated, but his pupils always dilate." ***- LOEWENFELD (Father of Pupillometry)***