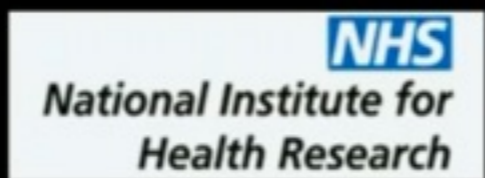


Full-field flash ERG, Pattern ERG & Multifocal ERG: an introduction



Dr Anthony G. Robson

**Moorfields Eye Hospital & UCL Institute of
Ophthalmology, London**

International Society for Clinical Electrophysiology of Vision

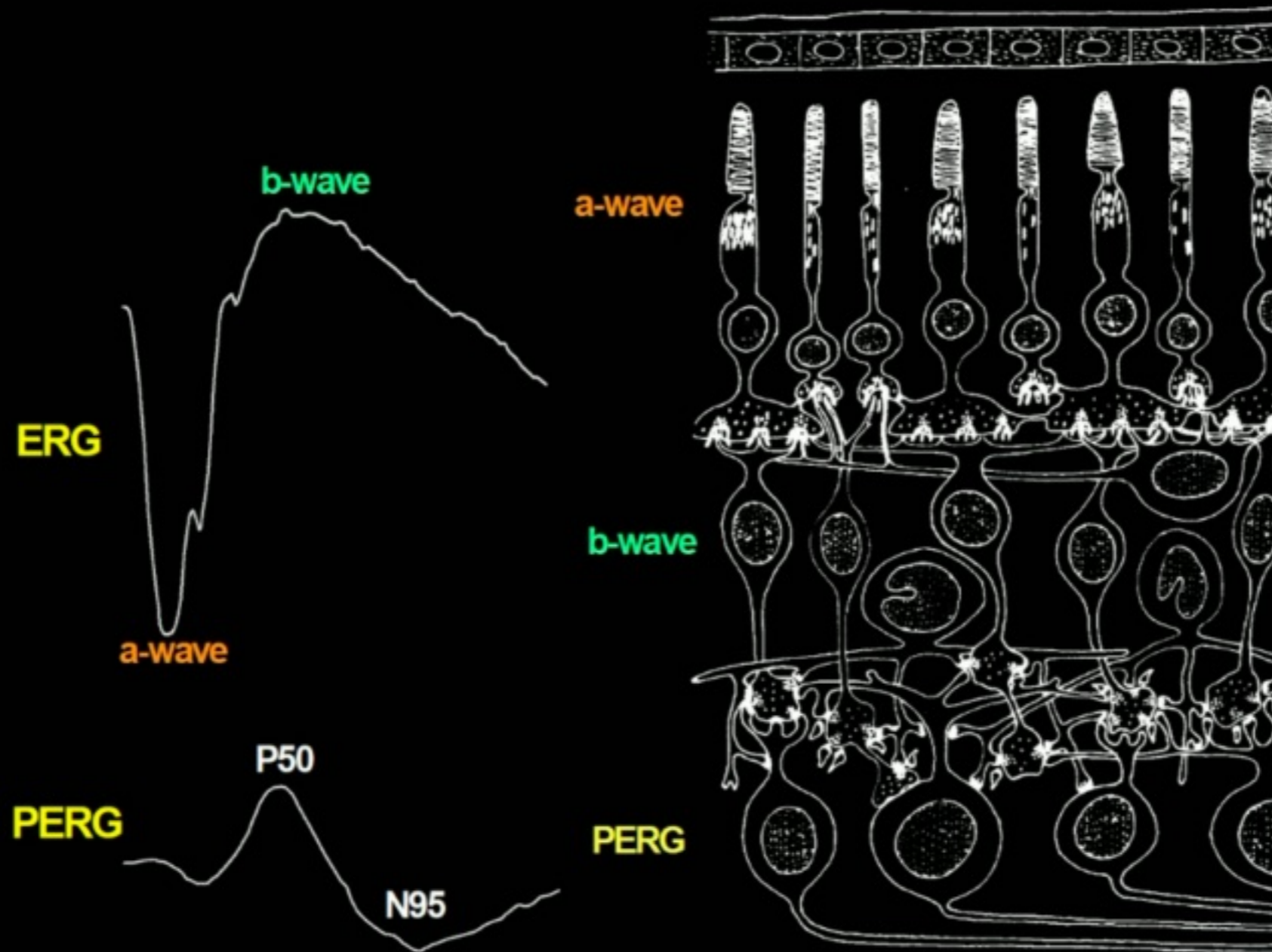
International conformity

Meaningful comparison between labs

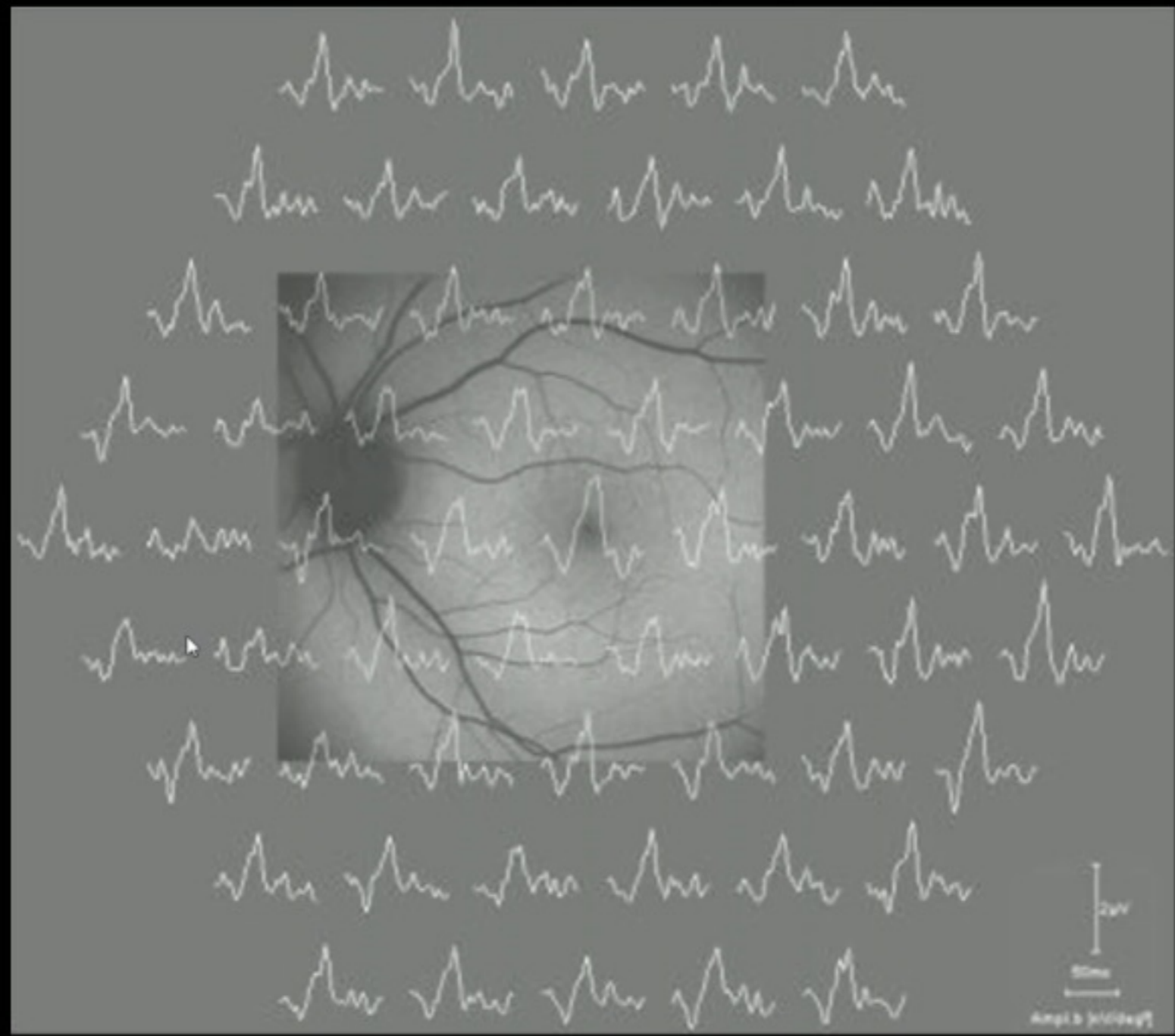
Minimise chances of misdiagnosis

Pooling of rare phenotypes





Electrophysiology and retinal structure



Multifocal ERG



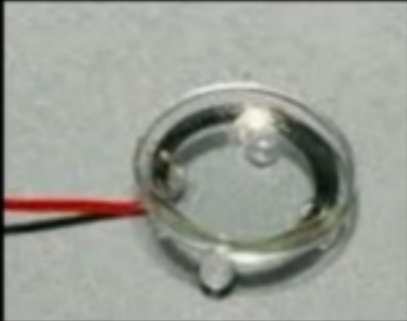
ISCEV Standard for full-field clinical electroretinography (2022 update)

Anthony G. Robson  · Laura J. Frishman · John Grigg · Ruth Hamilton  ·
Brett G. Jeffrey · Mineo Kondo · Shiyong Li  · Daphne L. McCulloch 



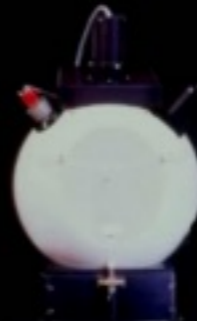
Corneal or skin recording
electrodes

Reference near orbital rim



Mydriasis

Non-mydriasis (with caveats)

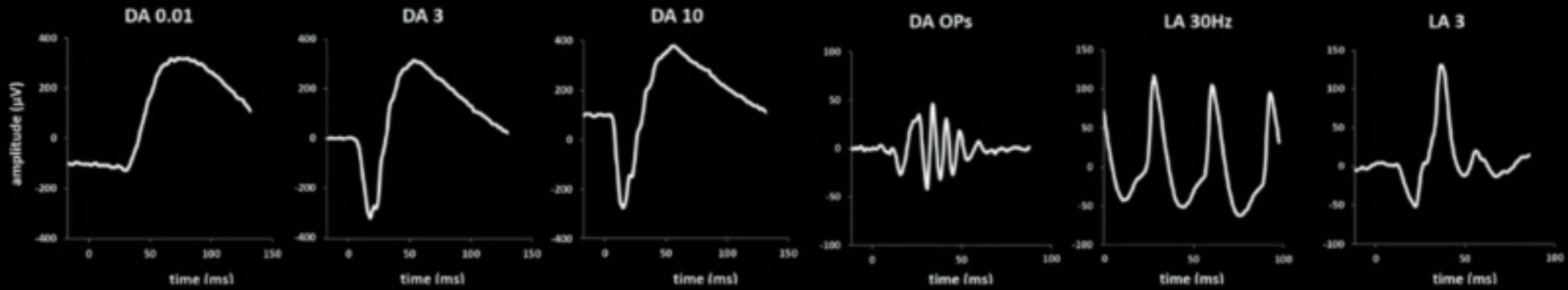


Ganzfeld stimulators

ISCEV-std full-field ERGs (2022)

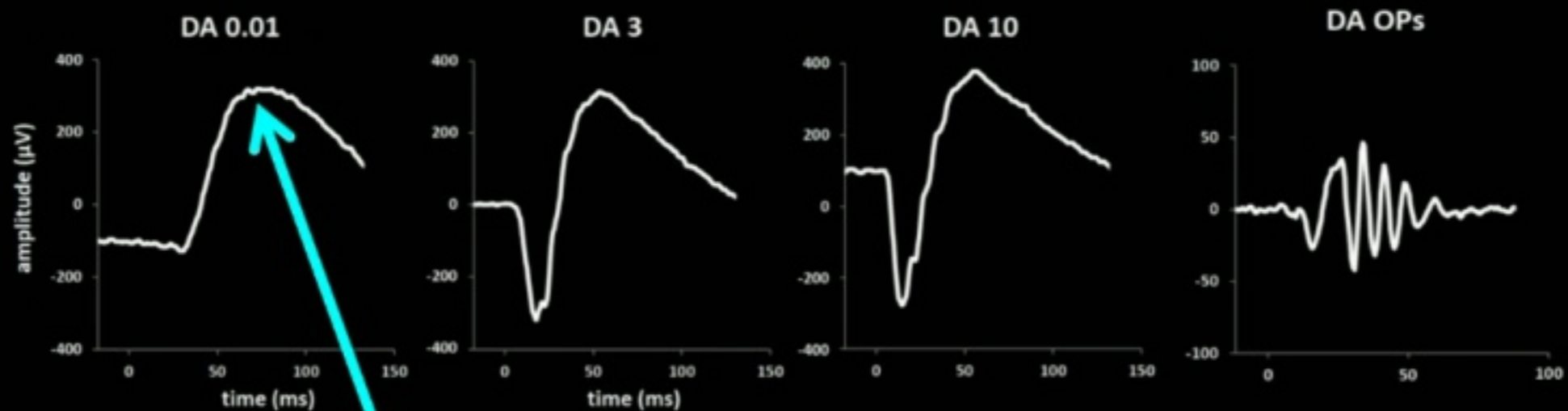
DA: dark-adapted

LA: light-adapted



ISCEV-std full-field ERGs (2022)

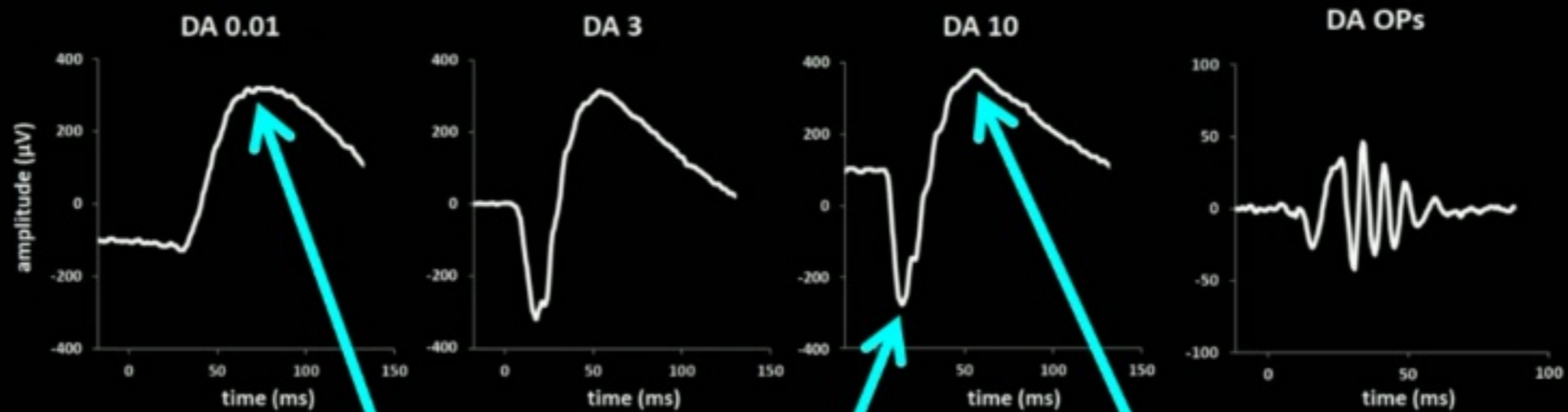
Dark adapted



rod bipolar
cells

ISCEV-std full-field ERGs (2022)

Dark adapted



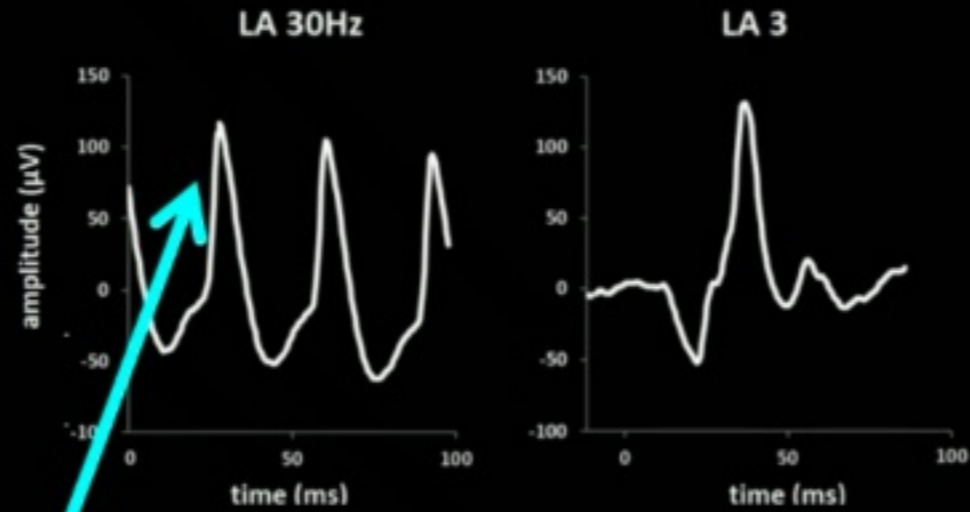
rod bipolar
cells

a-wave: rod
photoreceptors
+ cone system

b-wave: rod
bipolar cells
+ cone system

ISCEV-std full-field ERGs (2022)

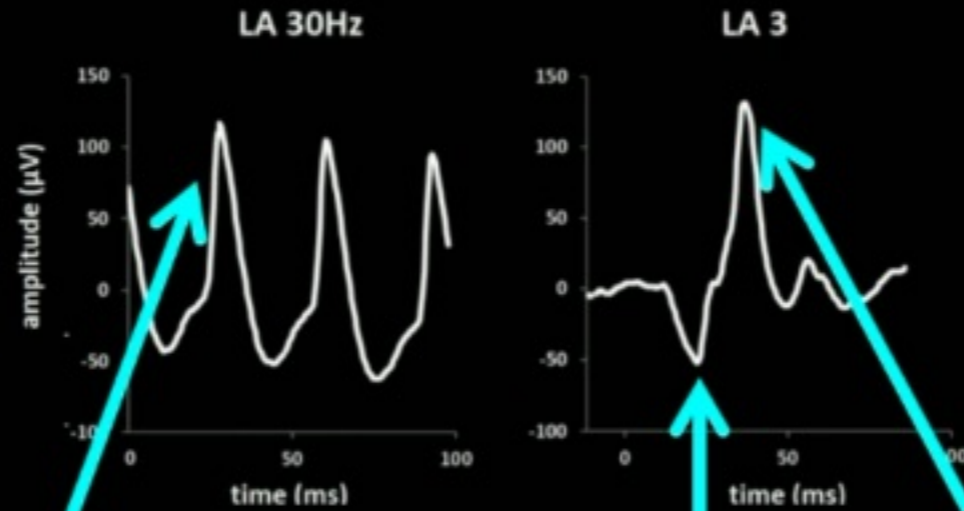
Light adapted



cone
On + Off bipolar
cells

ISCEV-std full-field ERGs (2022)

Light adapted



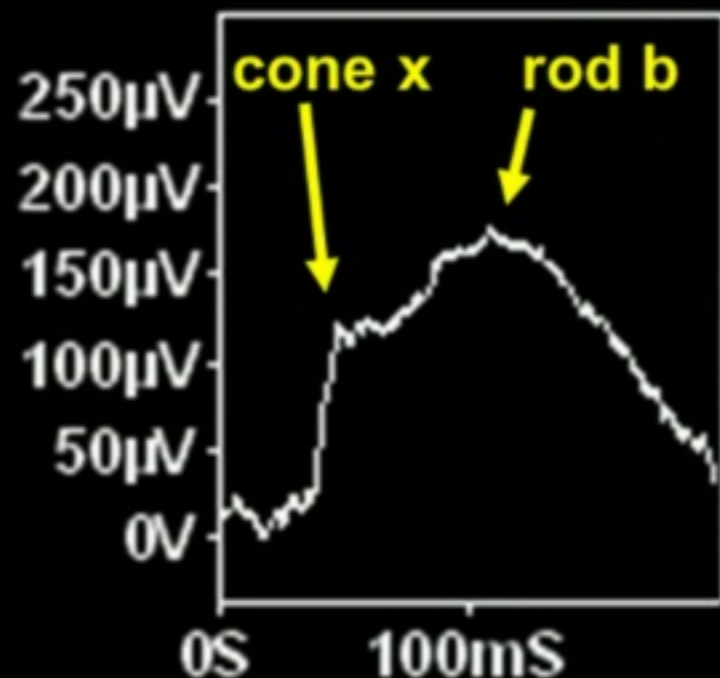
cone
On + Off bipolar
cells

a-wave: cone
photoreceptors +
cone Off bipolar
cells

b-wave: cone
On + Off
bipolar cells

ISCEV extended protocol for the dark-adapted red flash ERG (2018)

Dorothy A. Thompson · Kaoru Fujinami · Ido Perlman · Ruth Hamilton · Anthony G. Robson



When is it useful?

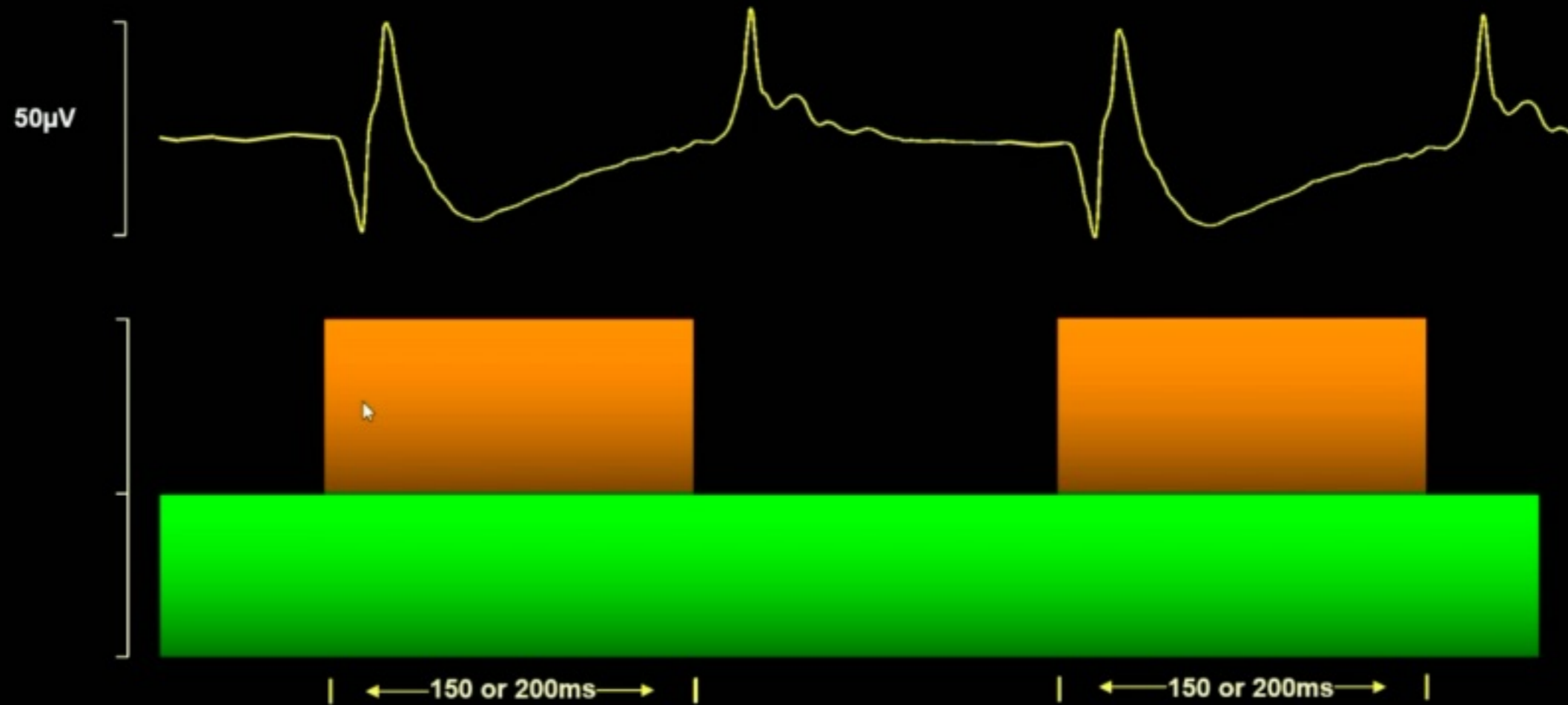
To assess relative involvement of rod and cone systems

To assess origins of residual DA ERGs

In presence of photophobia

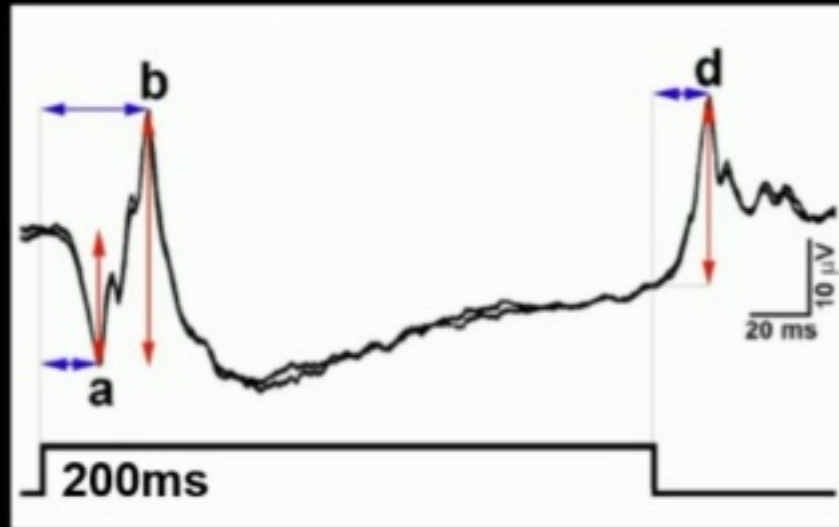
To establish some diagnoses

Photopic On-Off ERG



ISCEV extended protocol for the photopic On-Off ERG (2018)

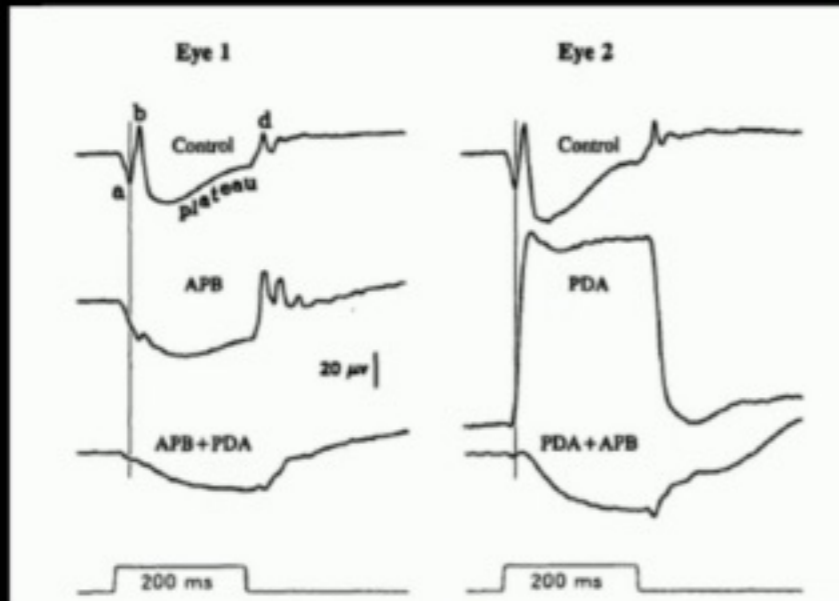
Maja Sustar · Graham E. Holder · Jan Kremers · Claire S. Barnes ·
Bo Lei · Naheed Khan · Anthony G. Robson



When is it useful?

To assess cone On- and Off system activity

To characterize function post-phototransduction

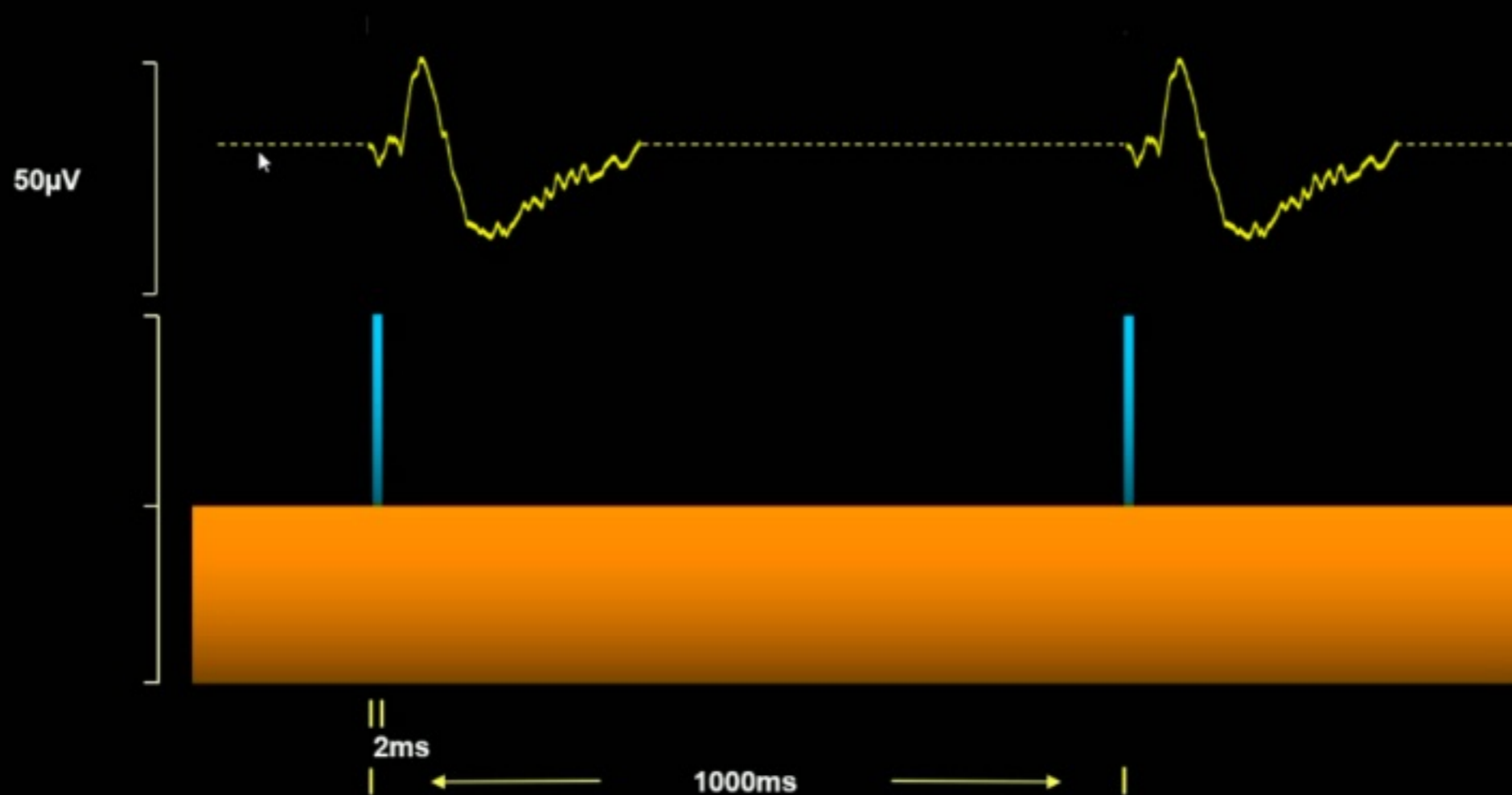


Origins of ERG On- and Off-components; established using pharmacological agents


Bush & Sieving 1994

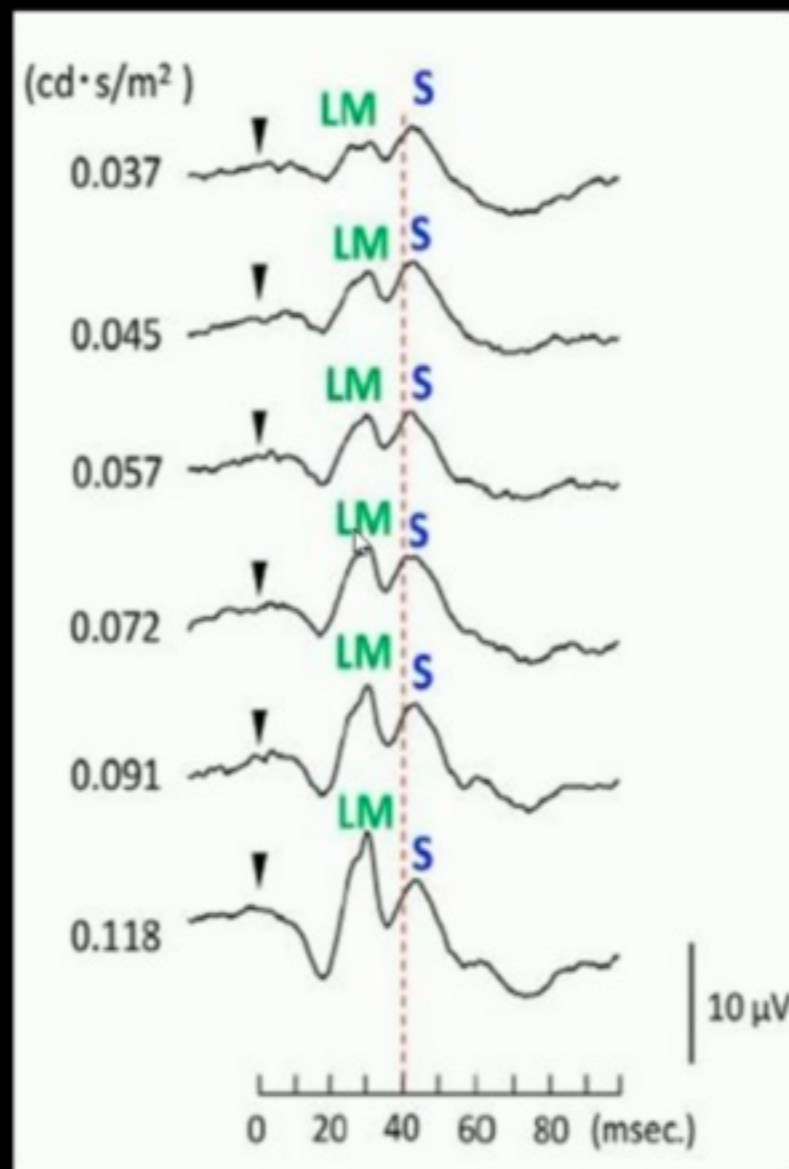
Short-wavelength flash ERG

(S-cone ERG)



ISCEV extended protocol for the S-cone ERG (2020)

Ido Perlman  · Mineo Kondo · Enid Chelva · Anthony G. Robson ·
Graham E. Holder



Main applications

ACH vs SCM

ESCS

Tritanopia

Flash stimulus

duration = < 5ms

wavelength 450-470nm

strength $0.05 \text{ cd}\cdot\text{s}\cdot\text{m}^{-2}$

Background

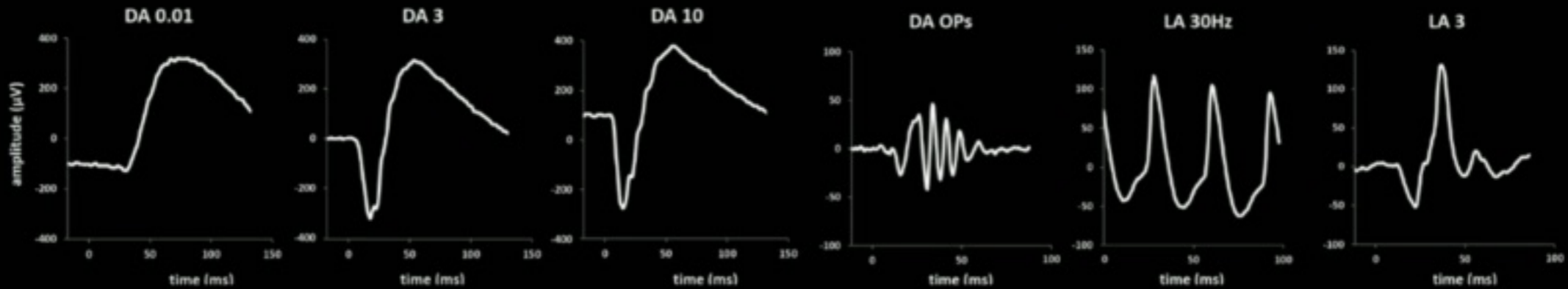
Wavelength 570-620nm

Luminance $300 \text{ cd}\cdot\text{m}^{-2}$

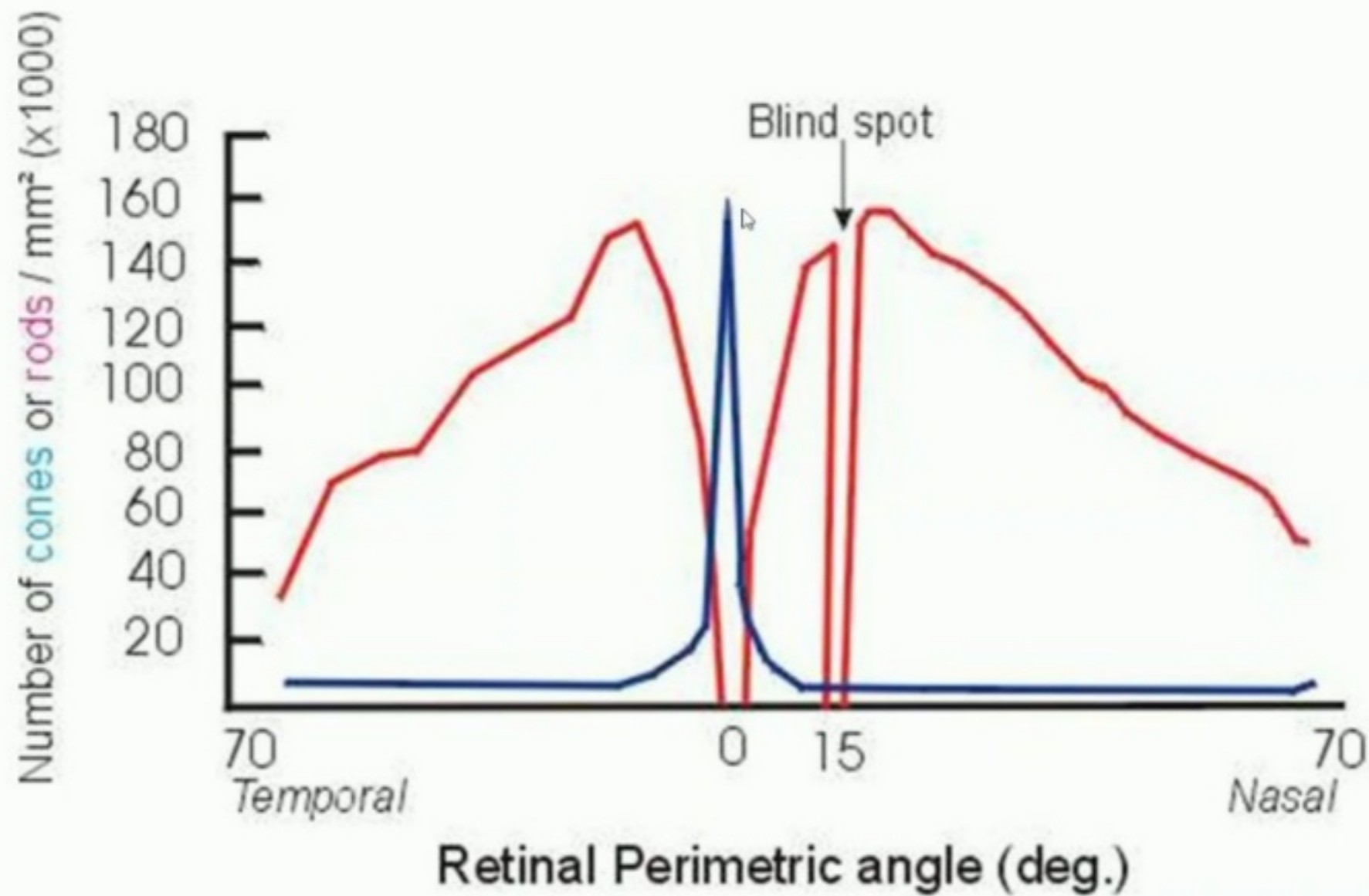
ISCEV-std full-field ERGs (2022)

DA: dark-adapted

LA: light-adapted

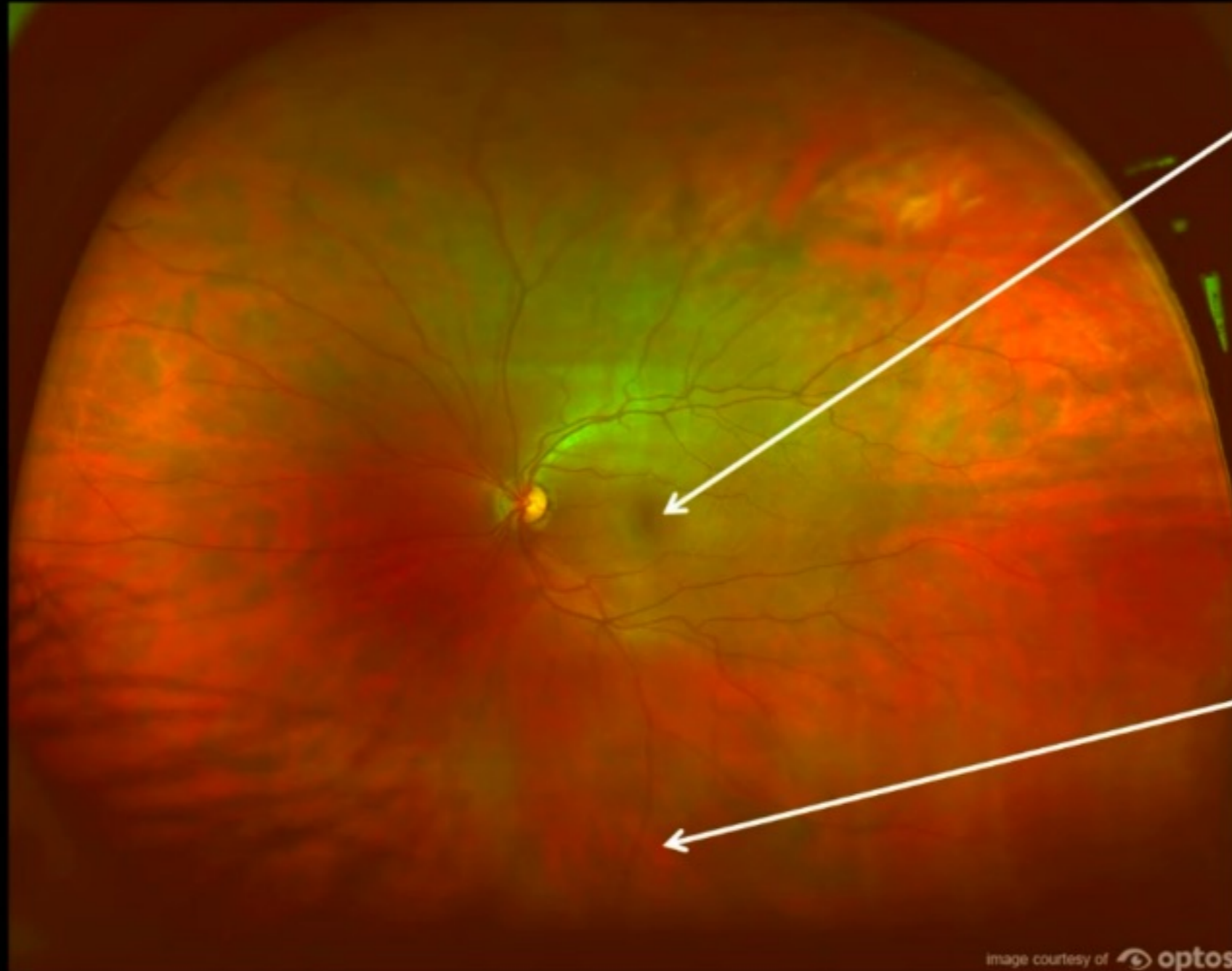


No significant contribution from the macula



Adapted after Østerberg, 1935

Wide-field fundus image (200°)

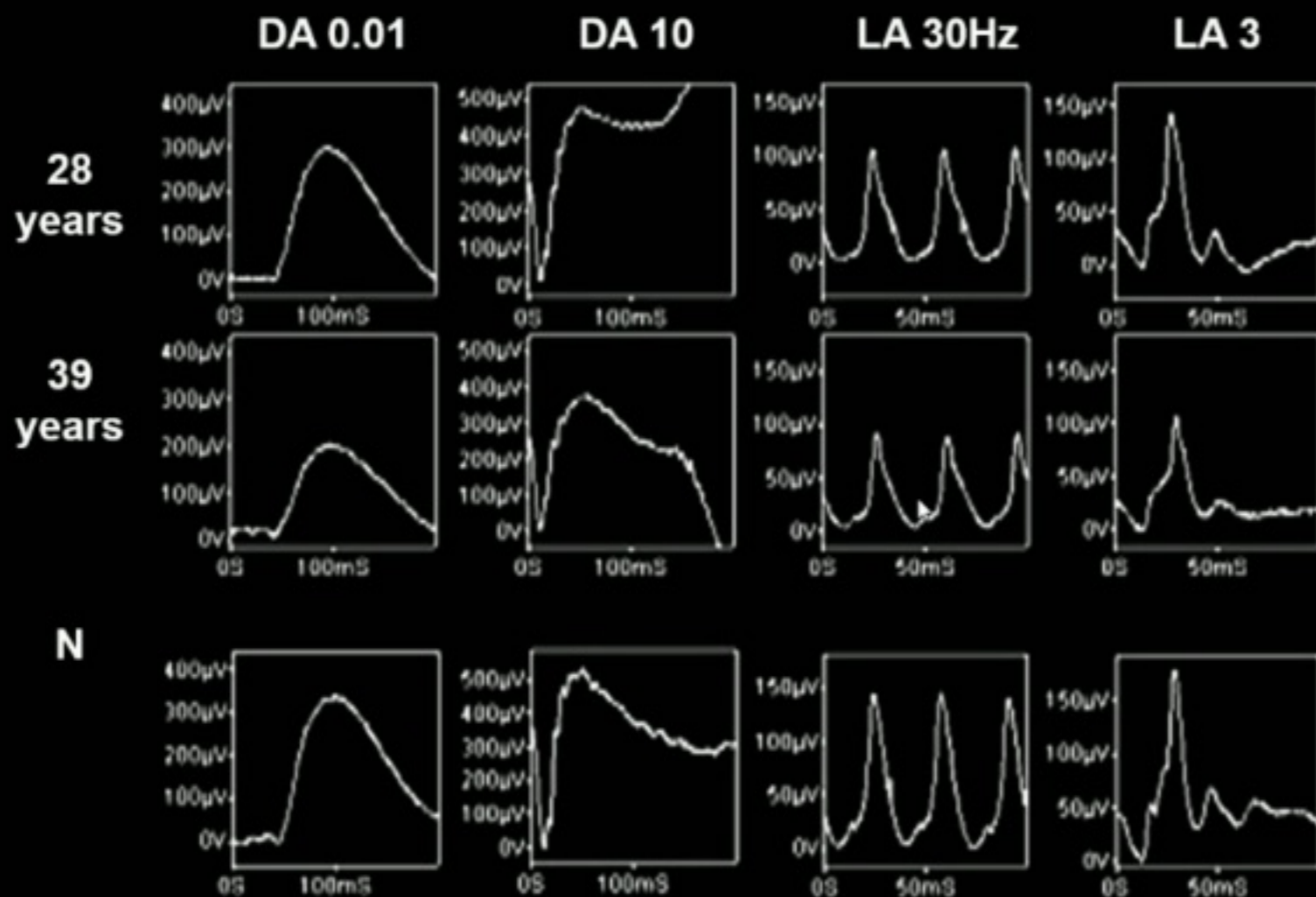
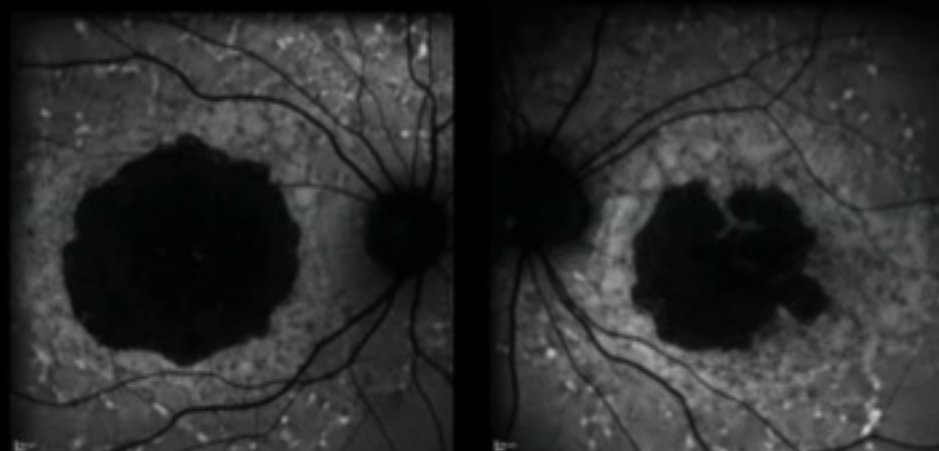


Fovea
(~5 degrees)
200,000 cones

Periphery
(~240 degrees)
7million cones

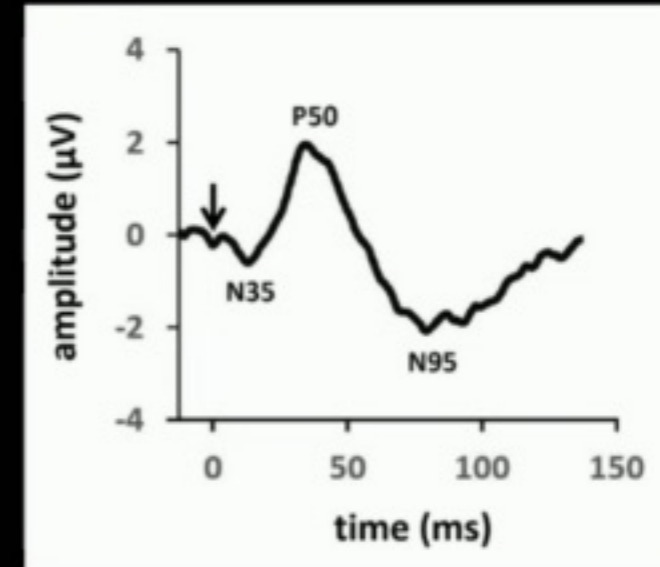
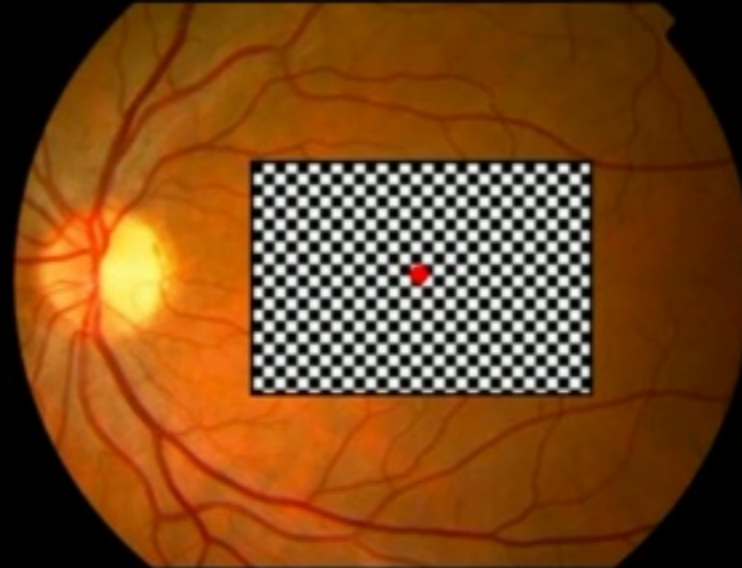
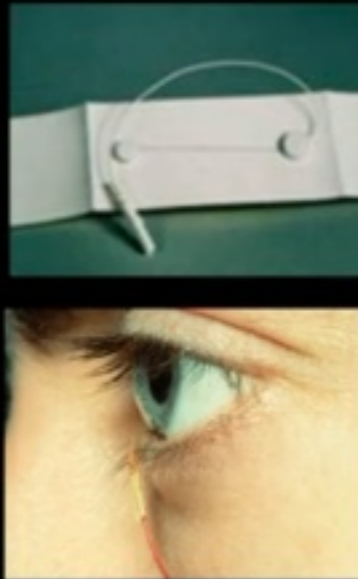
Macular dystrophy

Normal ERGs
Undetectable pattern ERGs



ISCEV standard for clinical pattern electroretinography (PERG): 2012 update

Michael Bach · Mitchell G. Brigell · Marko Hawlina ·
Graham E. Holder · Mary A. Johnson · Daphne L. McCulloch ·
Thomas Meigen · Suresh Viswanathan

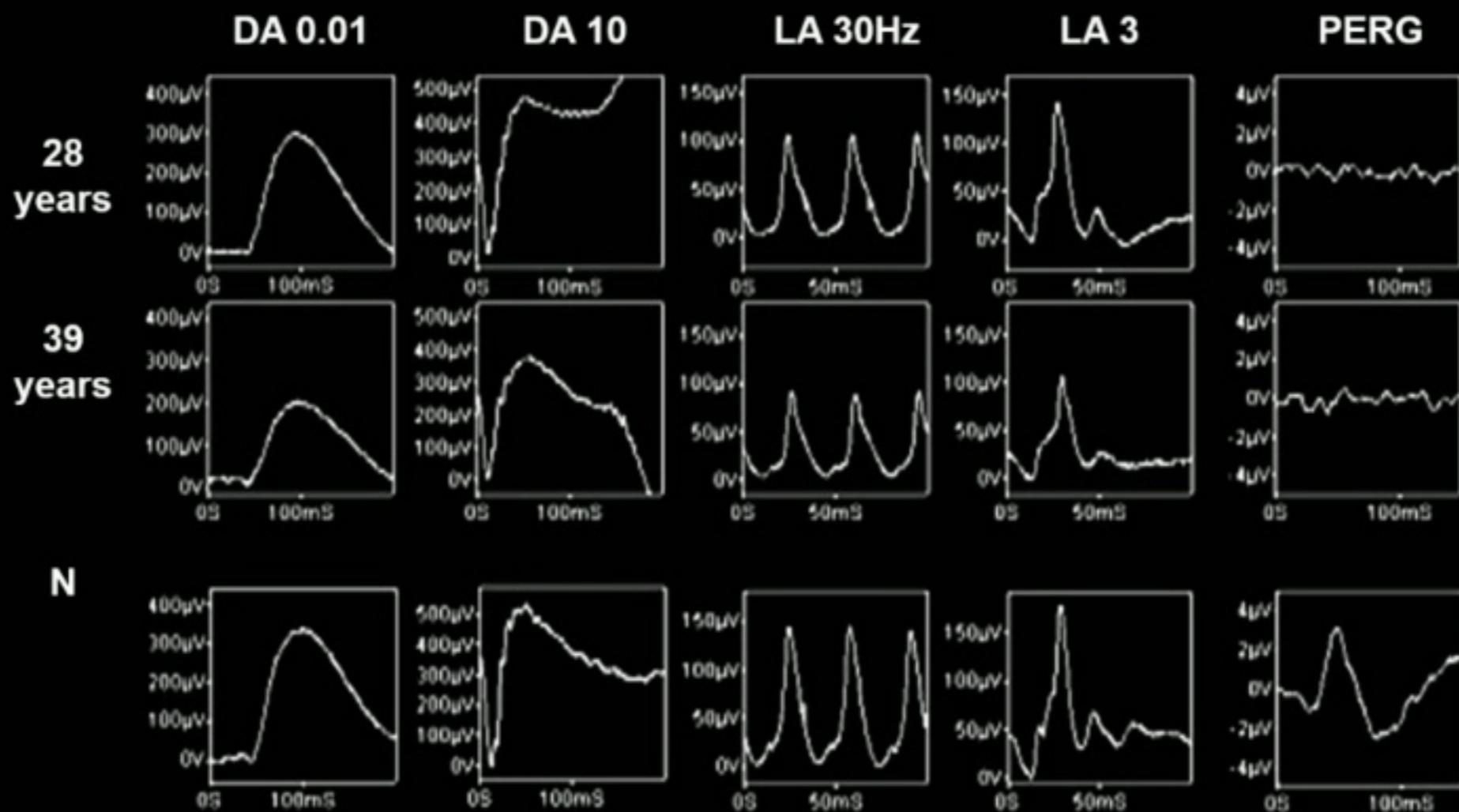
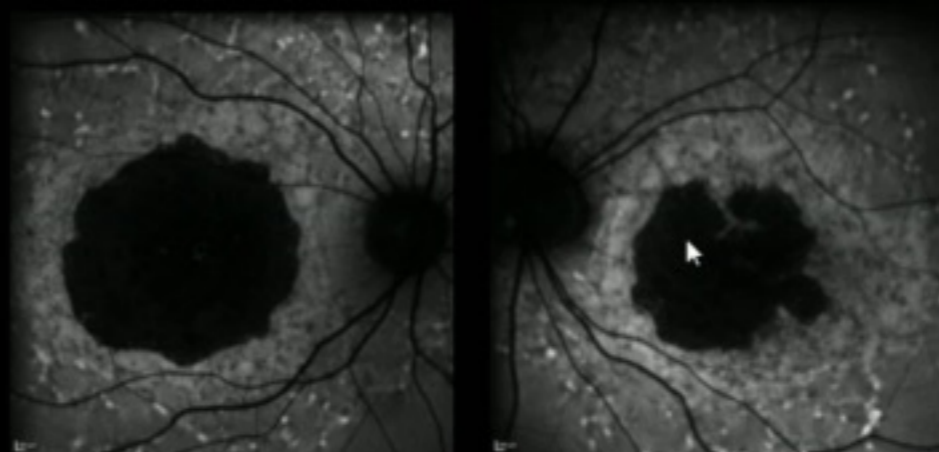


P50 – macular function (70% from RGCs)

N95 – RGC function (100% from RGCs)

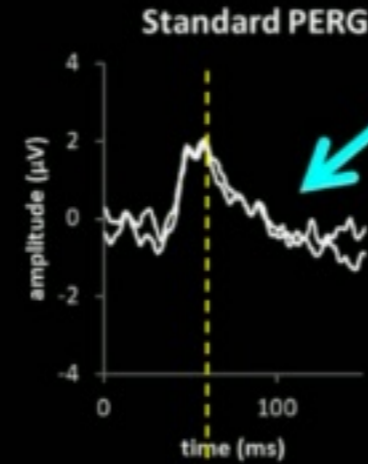
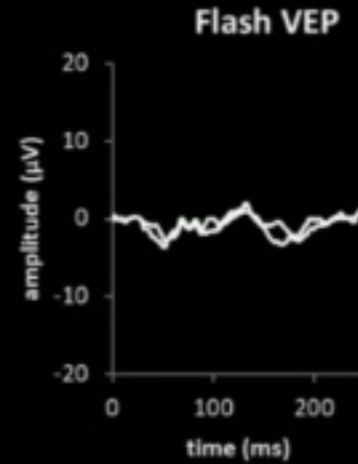
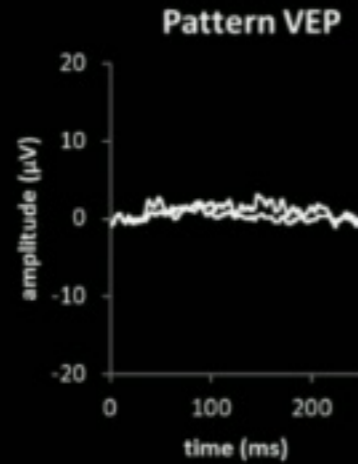
Macular dystrophy

Normal ERGs
Undetectable pattern ERGs



F 19 years. Leber hereditary optic neuropathy

RE
3/60

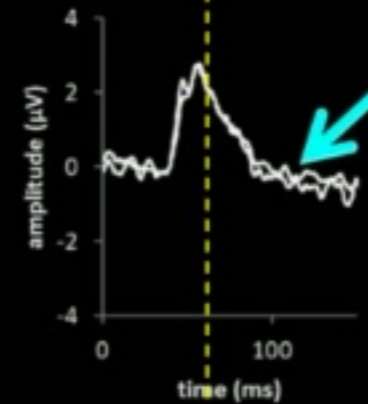
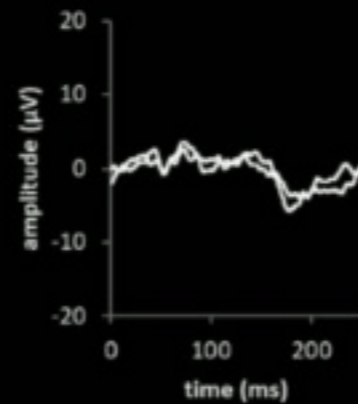
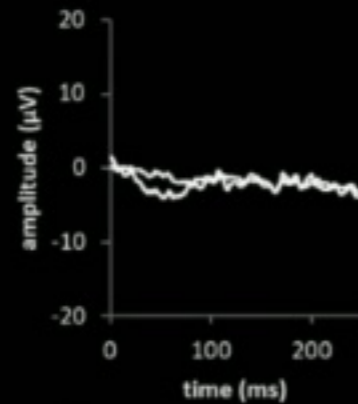


N95 reduced in acute stage

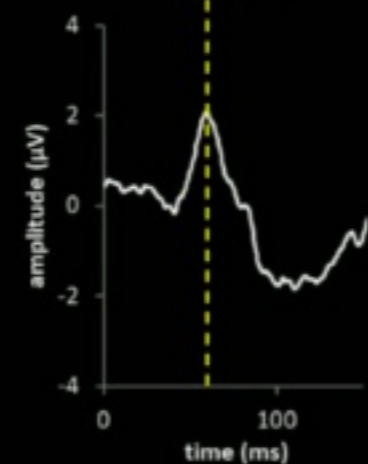
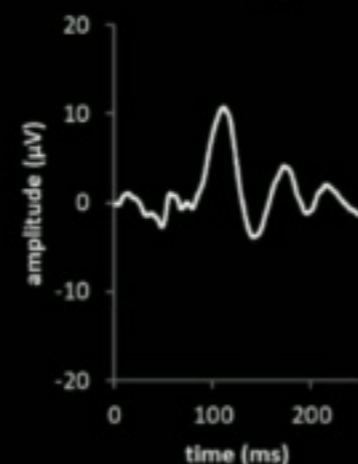
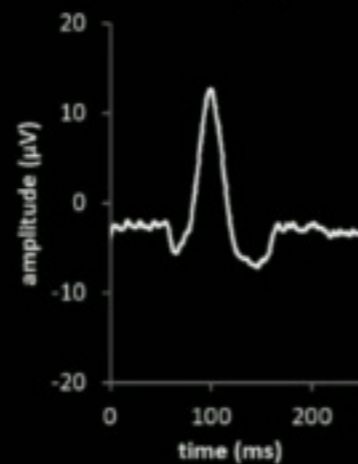
Indicates primary RGC disease

P50 may have short peak time (+/- reduction)

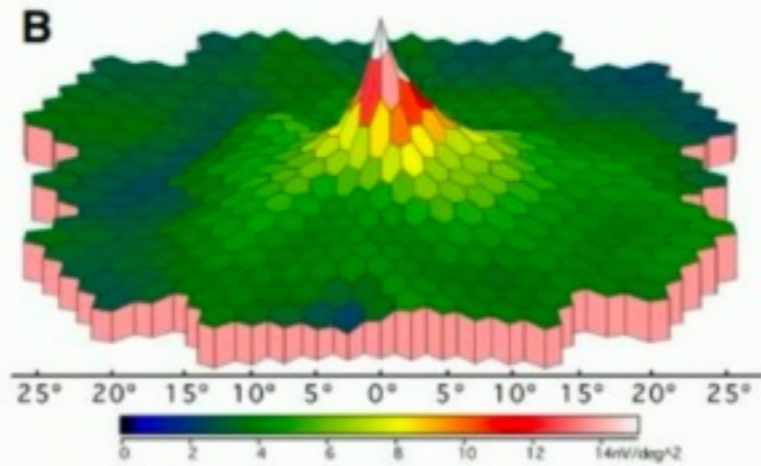
LE
3/60




N

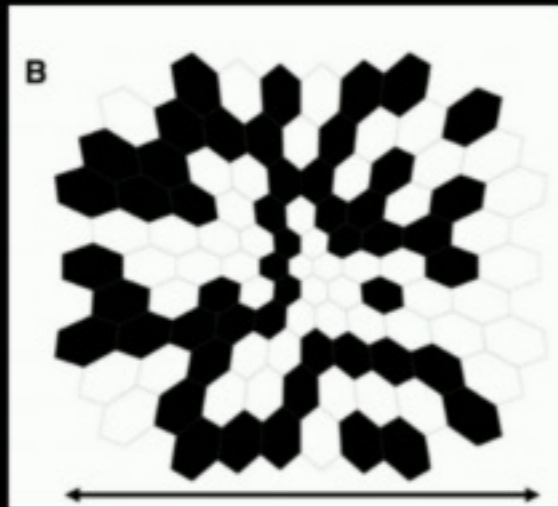
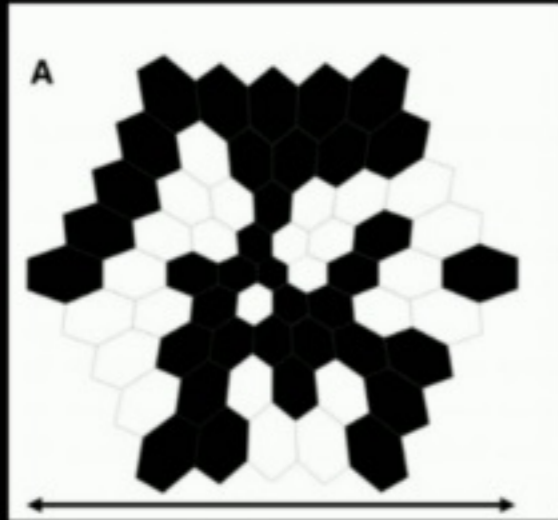


Multifocal ERG



ISCEV standard for clinical multifocal electroretinography (mfERG) (2021 update)

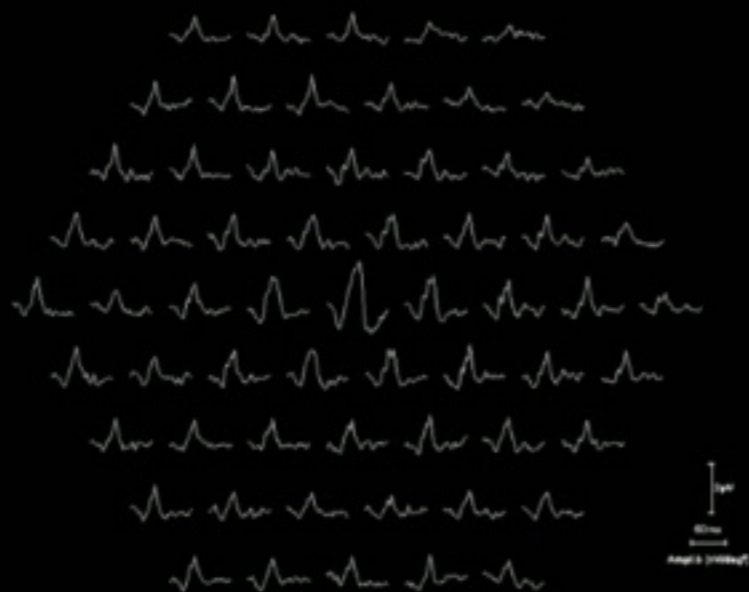
Michael B. Hoffmann  · Michael Bach · Mineo Kondo · Shiyong Li ·
Sinead Walker · Karen Holopigian · Suresh Viswanathan · Anthony G. Robson



40-50°

1. 61- or 103- element stimulus array
2. Elements illuminated according to a predetermined m-sequence
3. Responses are mathematical extractions associated with the time that one element is illuminated
4. Assessment of localised cone system function across the posterior pole

ISCEV standard for mfERG display and measurement



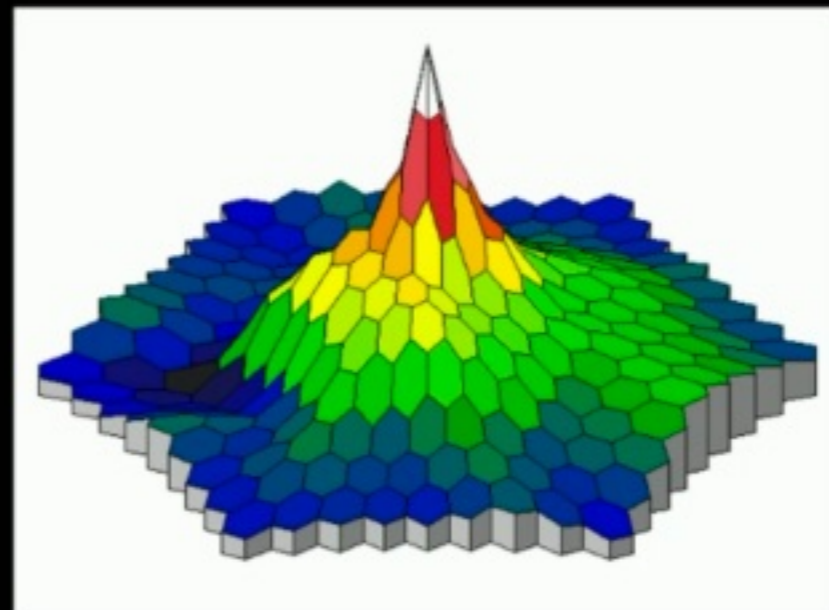
Trace array is essential

Topographic variations

Quality of recordings

Calibration marks

Field view or retinal view



Signal per unit area

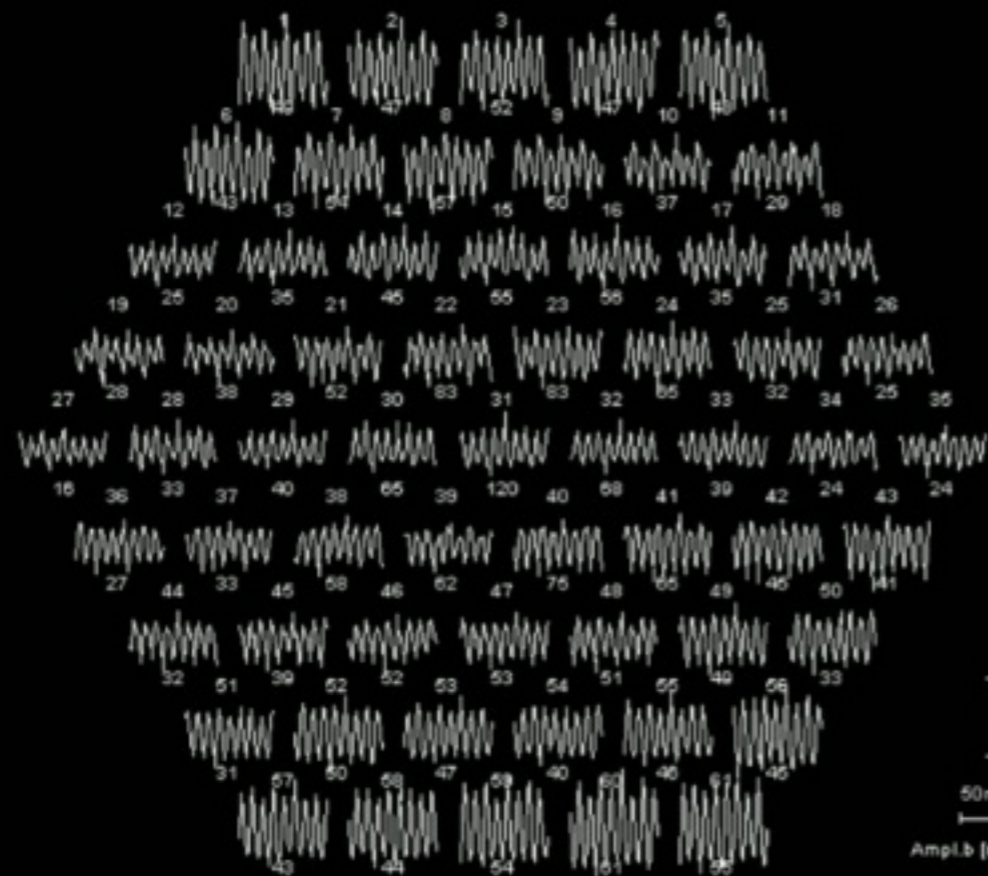
Combines N and P components

Fine-scale interpolation

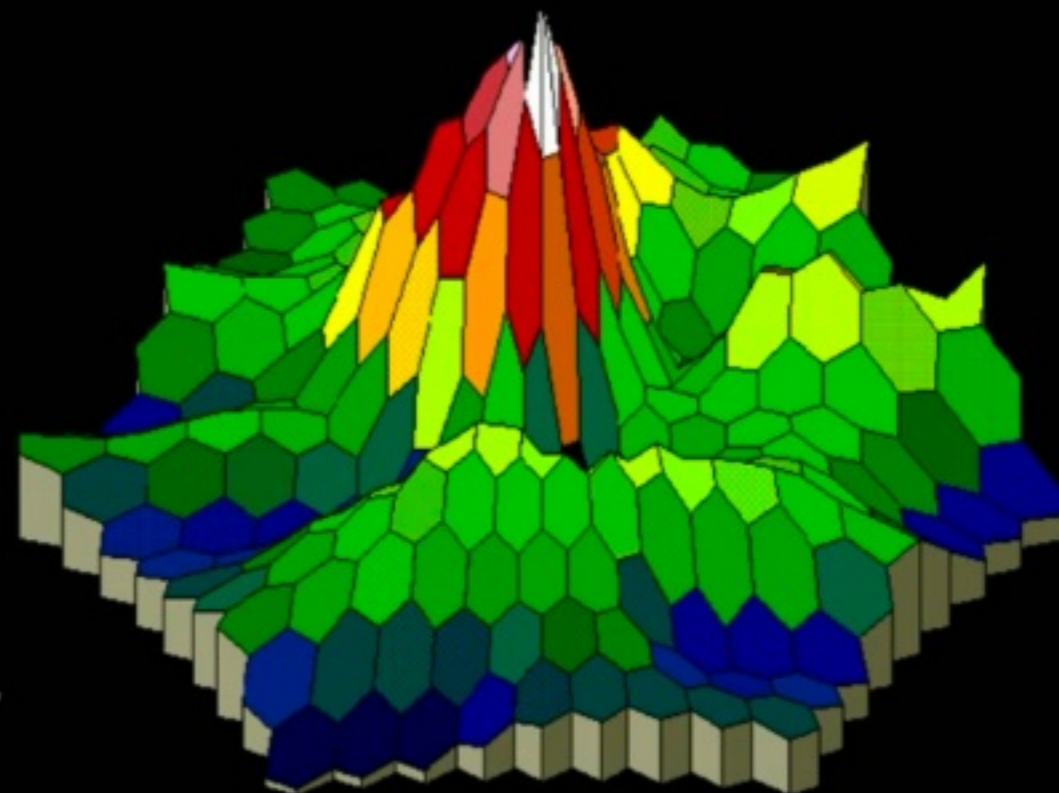
Delays may be invisible

Scaling artefacts

Multifocal ERG: electrical interference

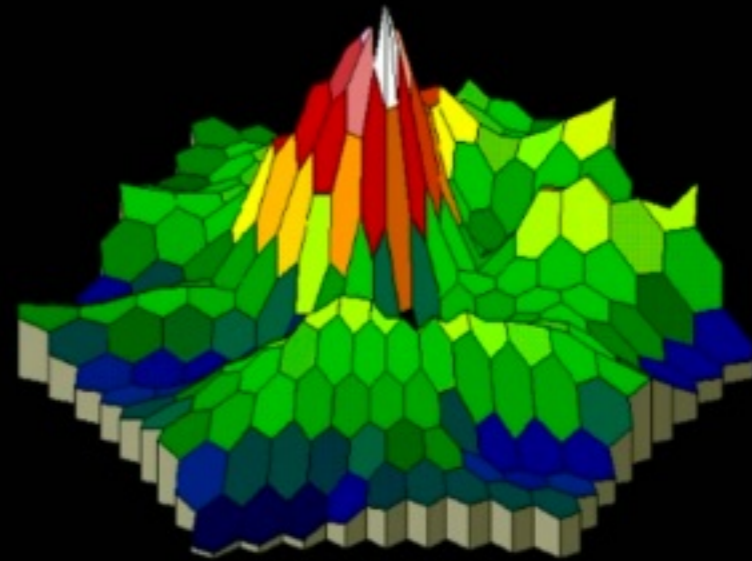
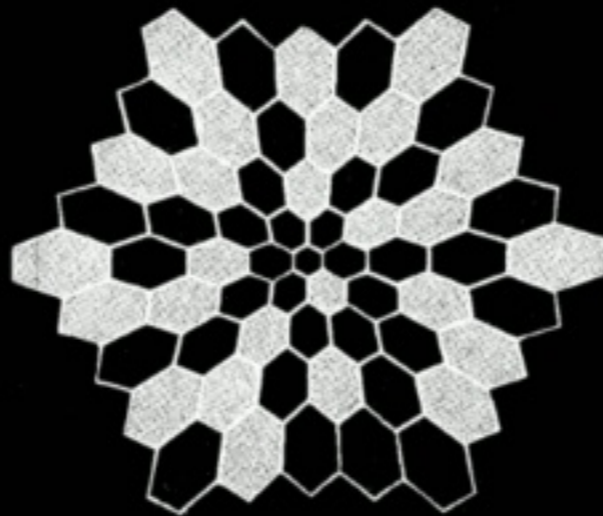


2 μ V
50ms
Ampl. b [nV/deg]



noise can mimic a
normal response

Multifocal ERG: electrical interference



Clinical examples & interpretation

Retinitis pigmentosa

Approx. 1/4000

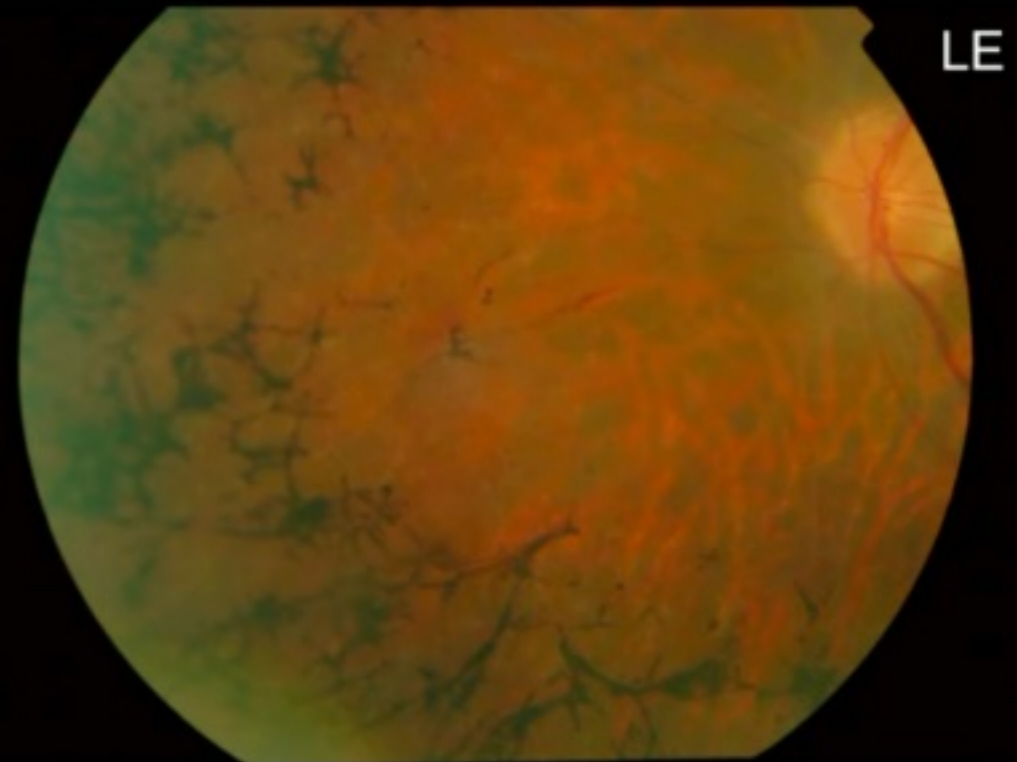
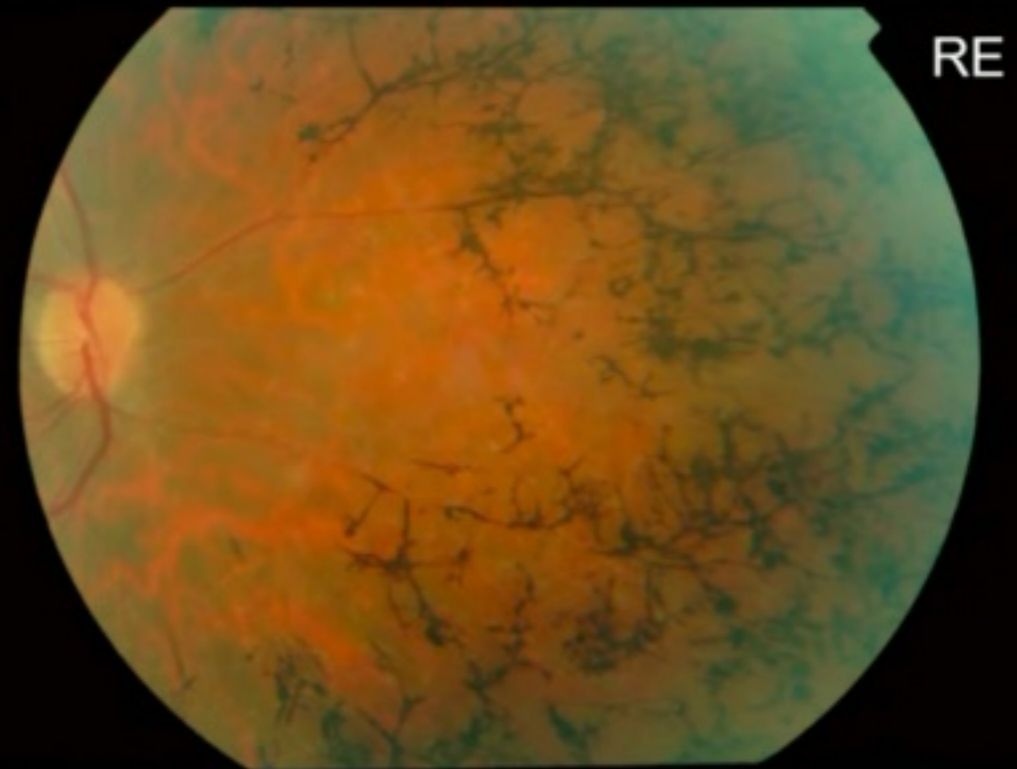
> 100 genes identified

AD, AR, XL, Sporadic

Night blindness, VF loss
VA often preserved

Bone spicules
attenuated vessels
disc pallor

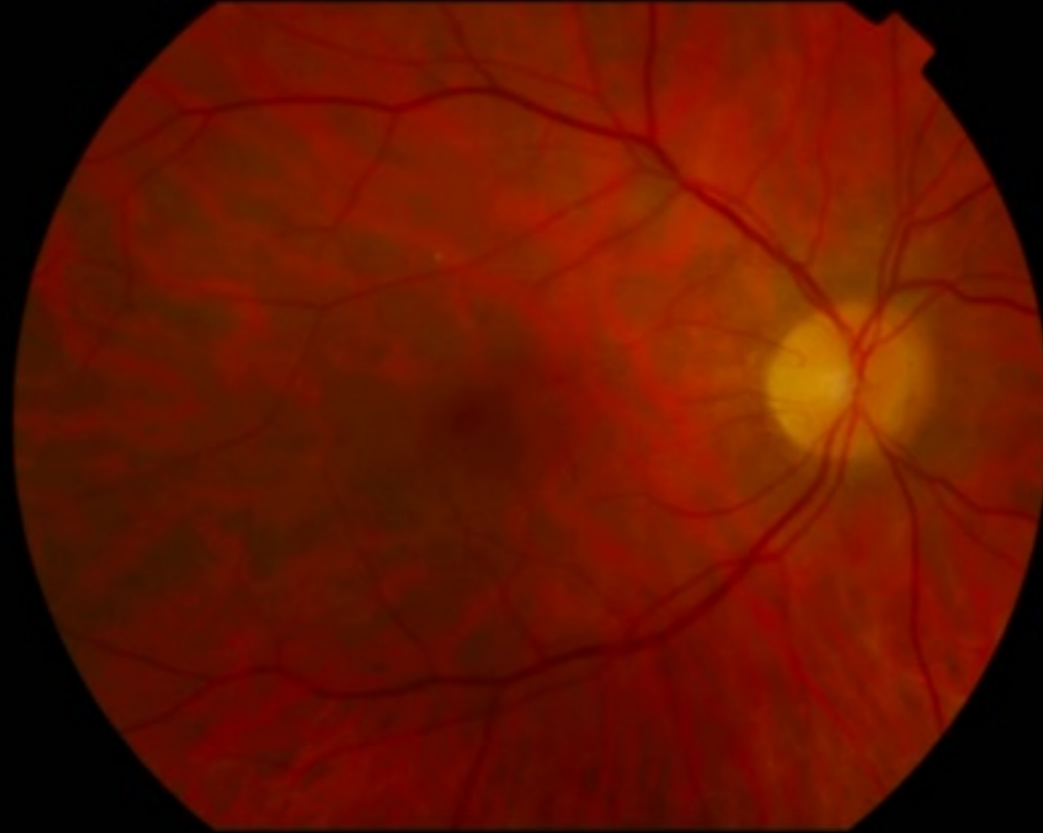
Fundus can be normal



F, 41 years.

Nyctalopia and loss of peripheral vision

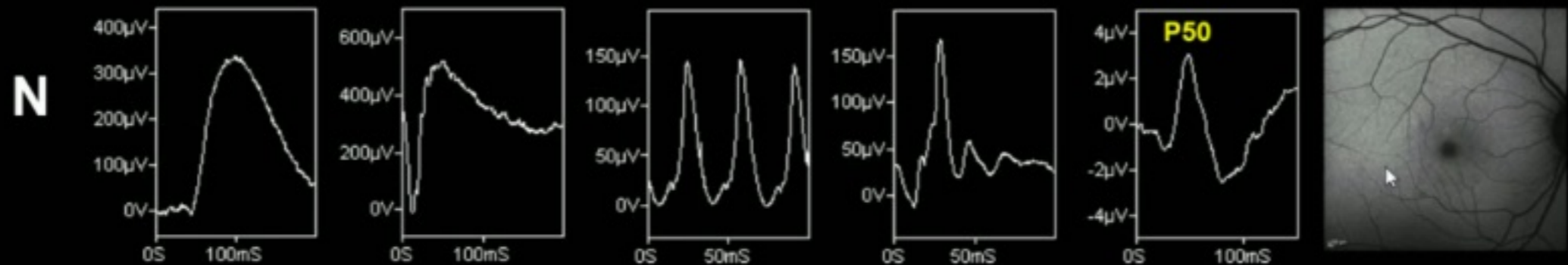
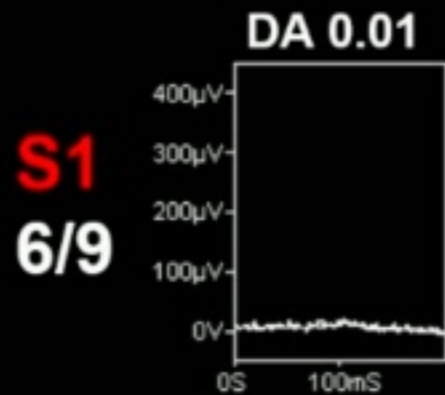
6/9



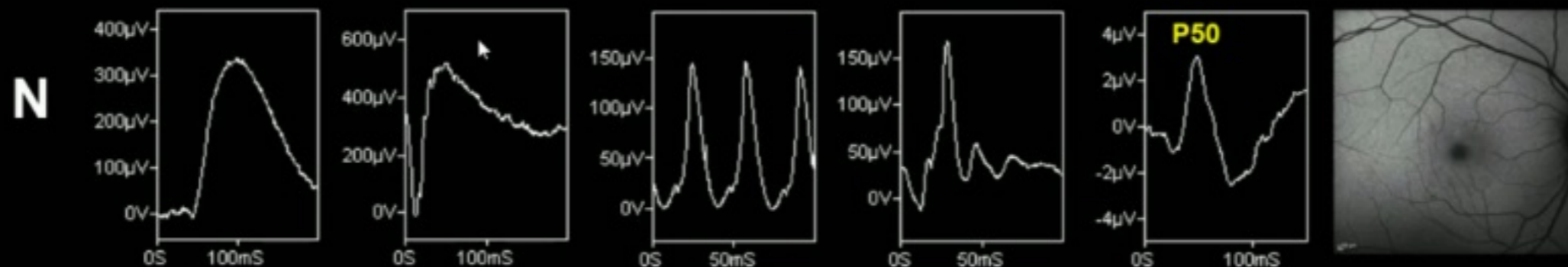
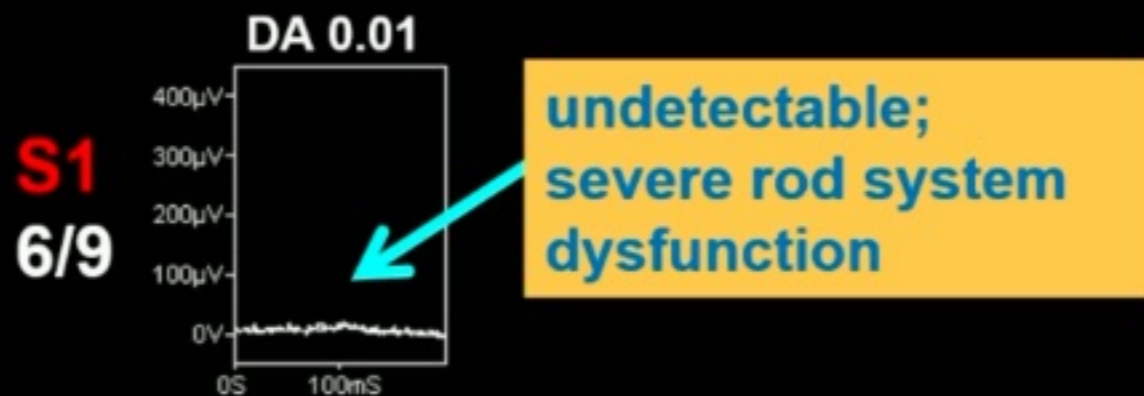
6/12



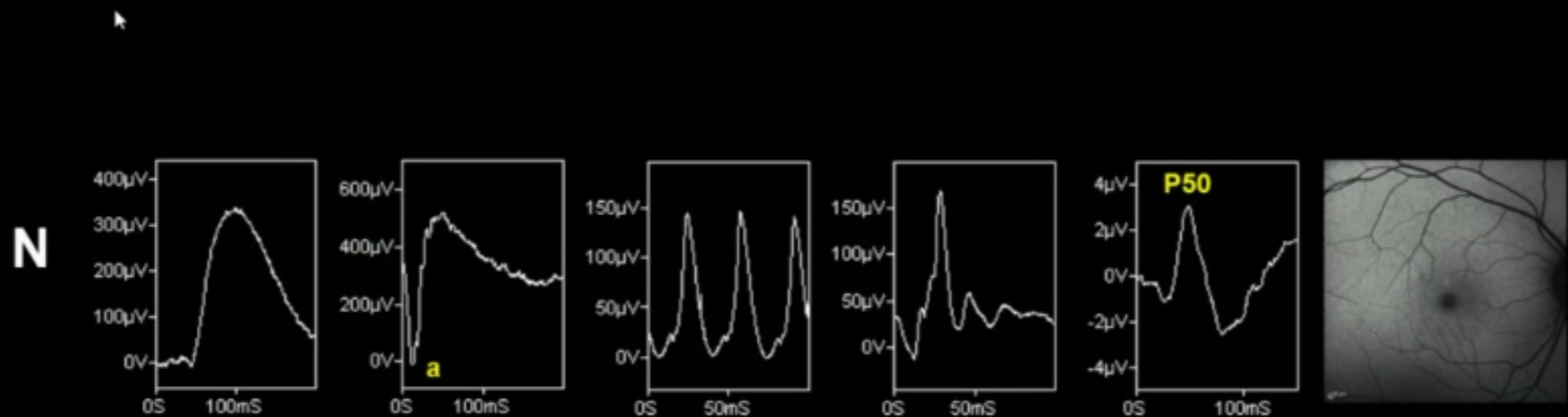
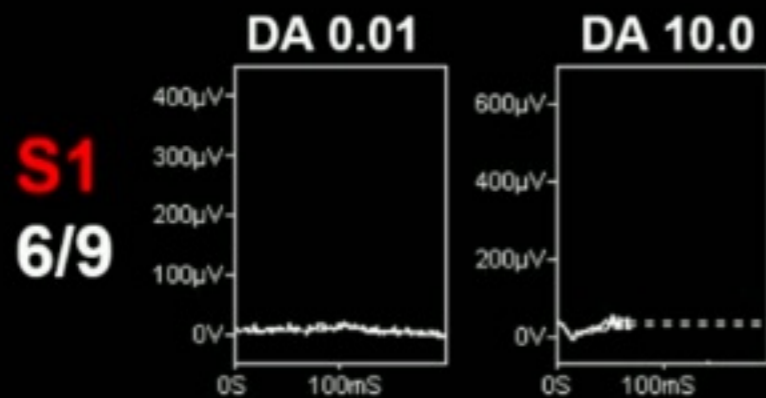
ERG, PERG and autofluorescence in retinitis pigmentosa



ERG, PERG and autofluorescence in retinitis pigmentosa

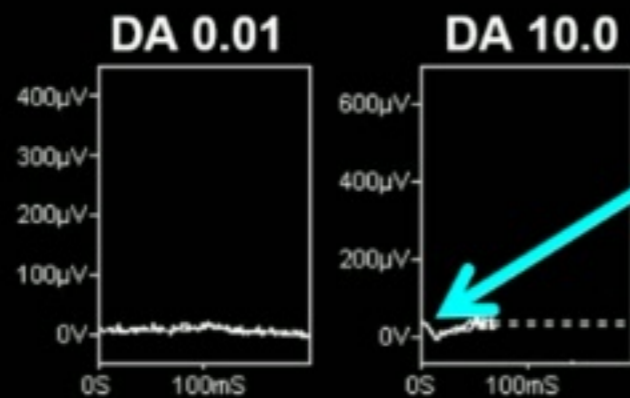


ERG, PERG and autofluorescence in retinitis pigmentosa



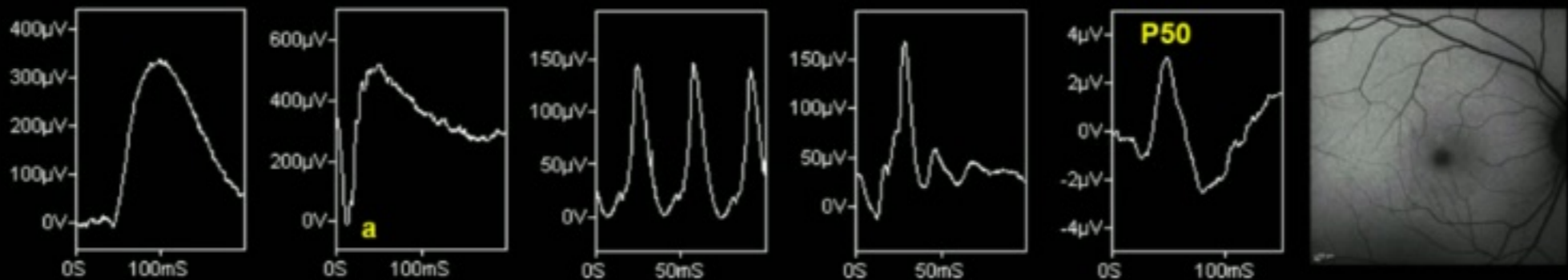
ERG, PERG and autofluorescence in retinitis pigmentosa

S1
6/9



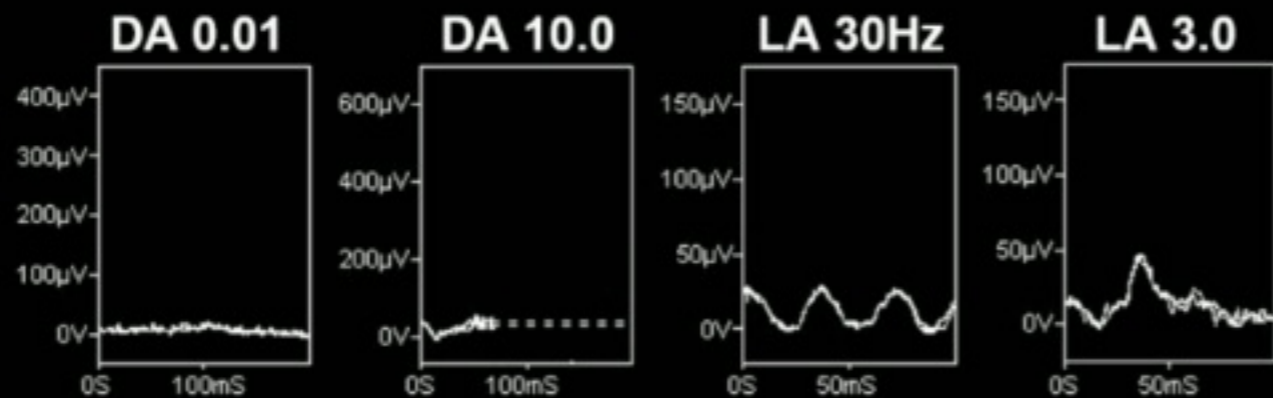
a-wave reduction;
rod photoreceptor dysfunction

N



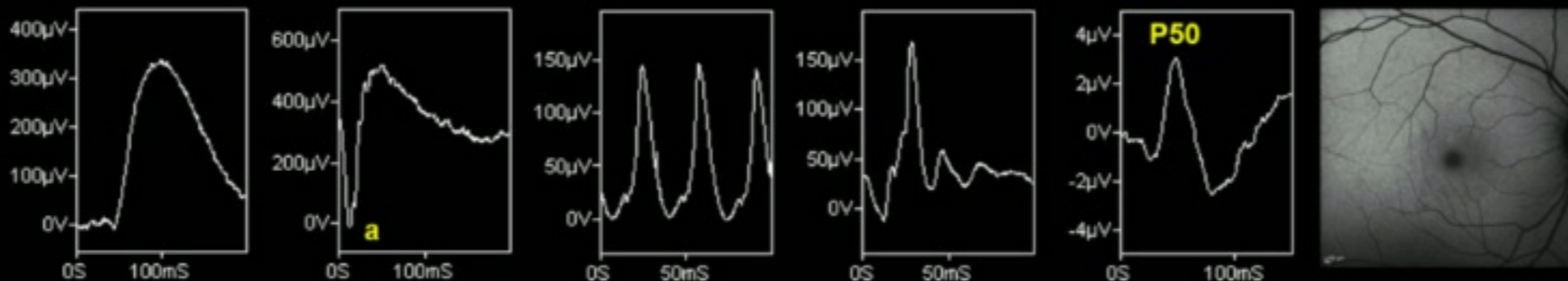
ERG, PERG and autofluorescence in retinitis pigmentosa

S1
6/9



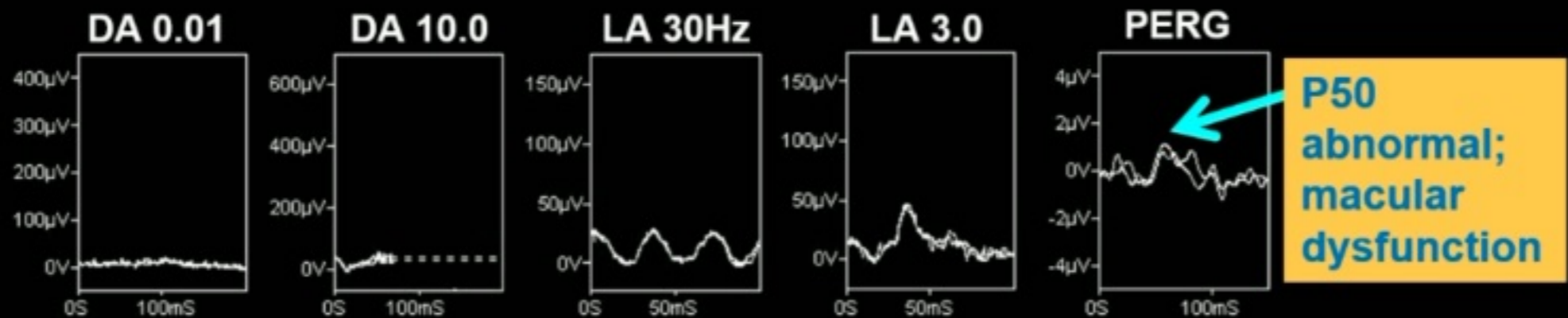
LA ERGs less severely abnormal; rod-cone dystrophy

N

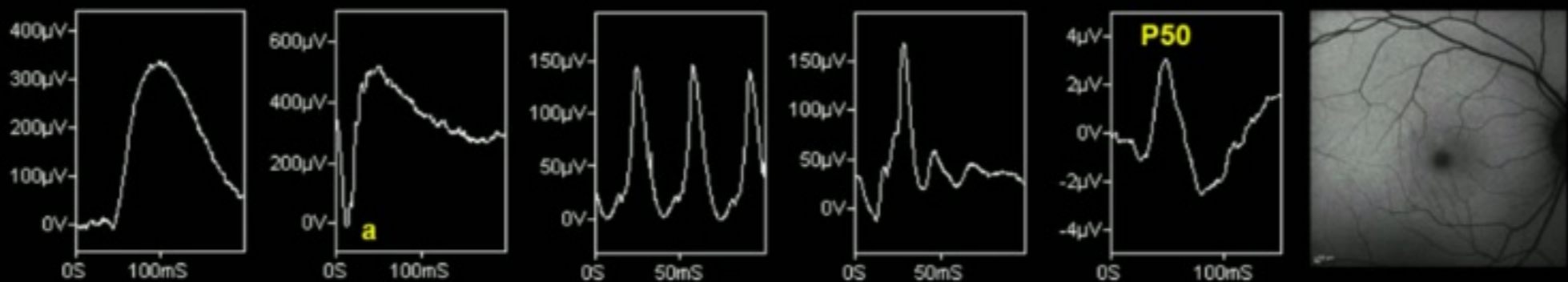


ERG, PERG and autofluorescence in retinitis pigmentosa

S1
6/9

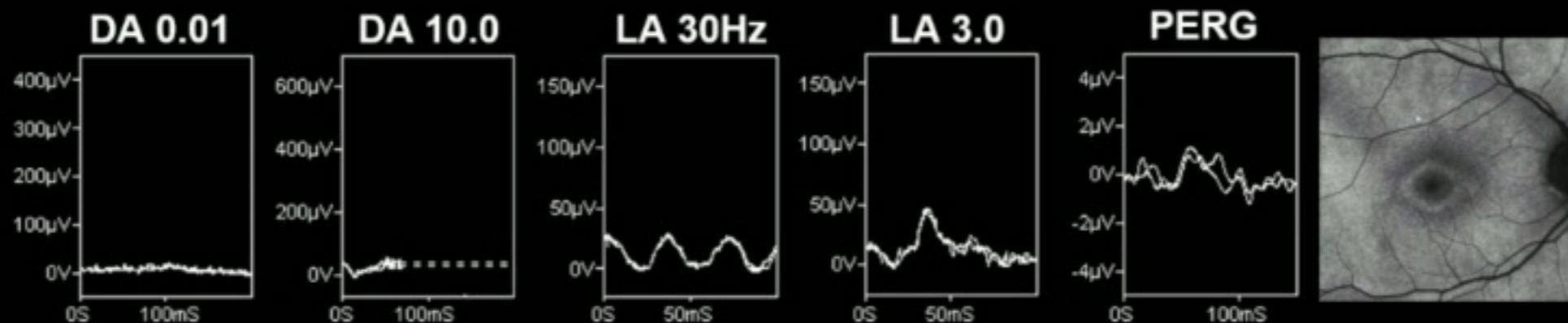


N

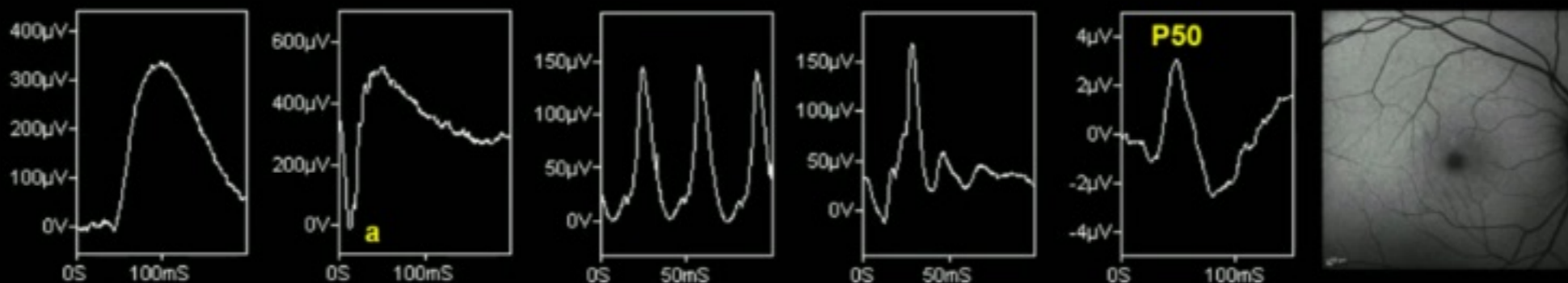


ERG, PERG and autofluorescence in retinitis pigmentosa

S1
6/9

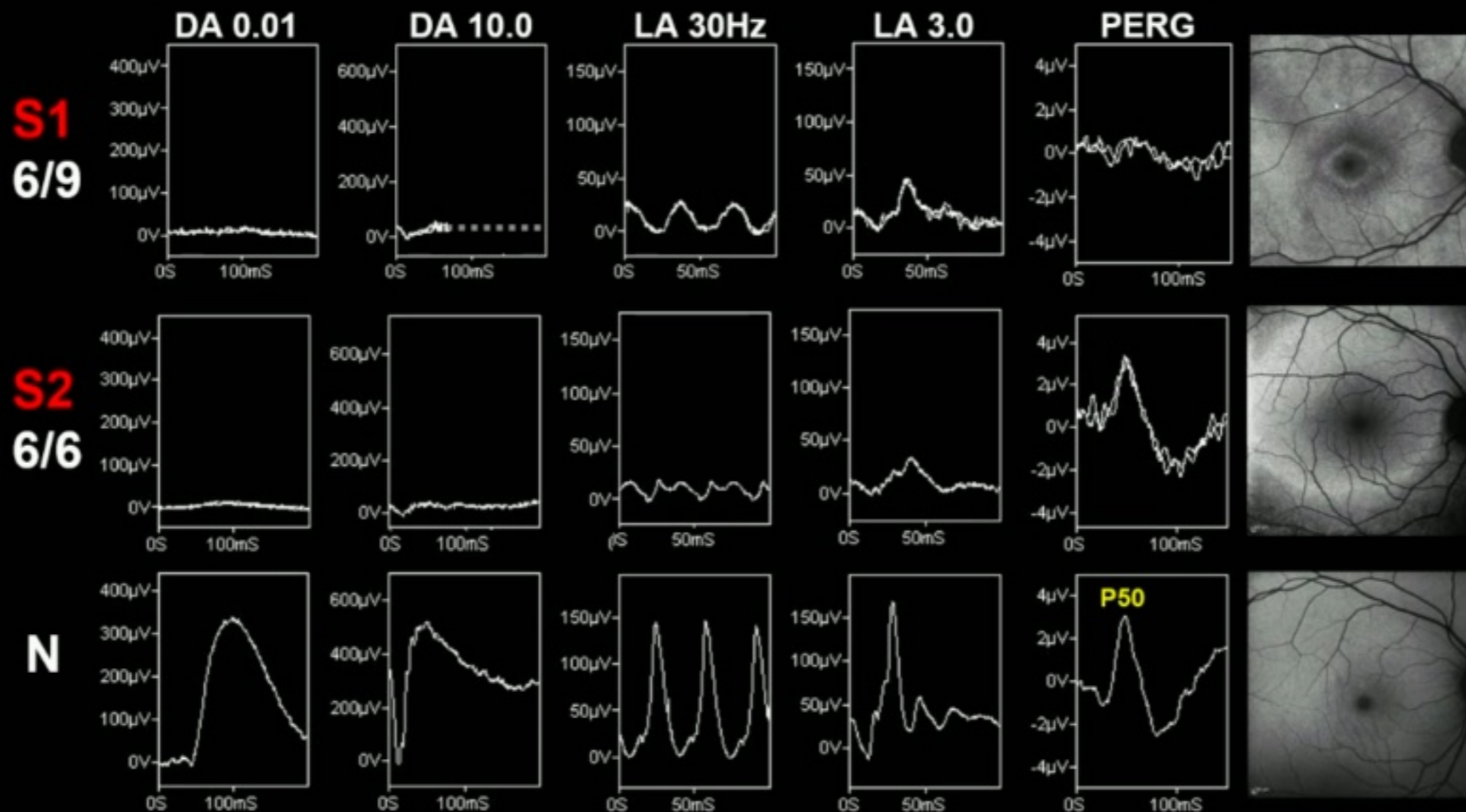


N



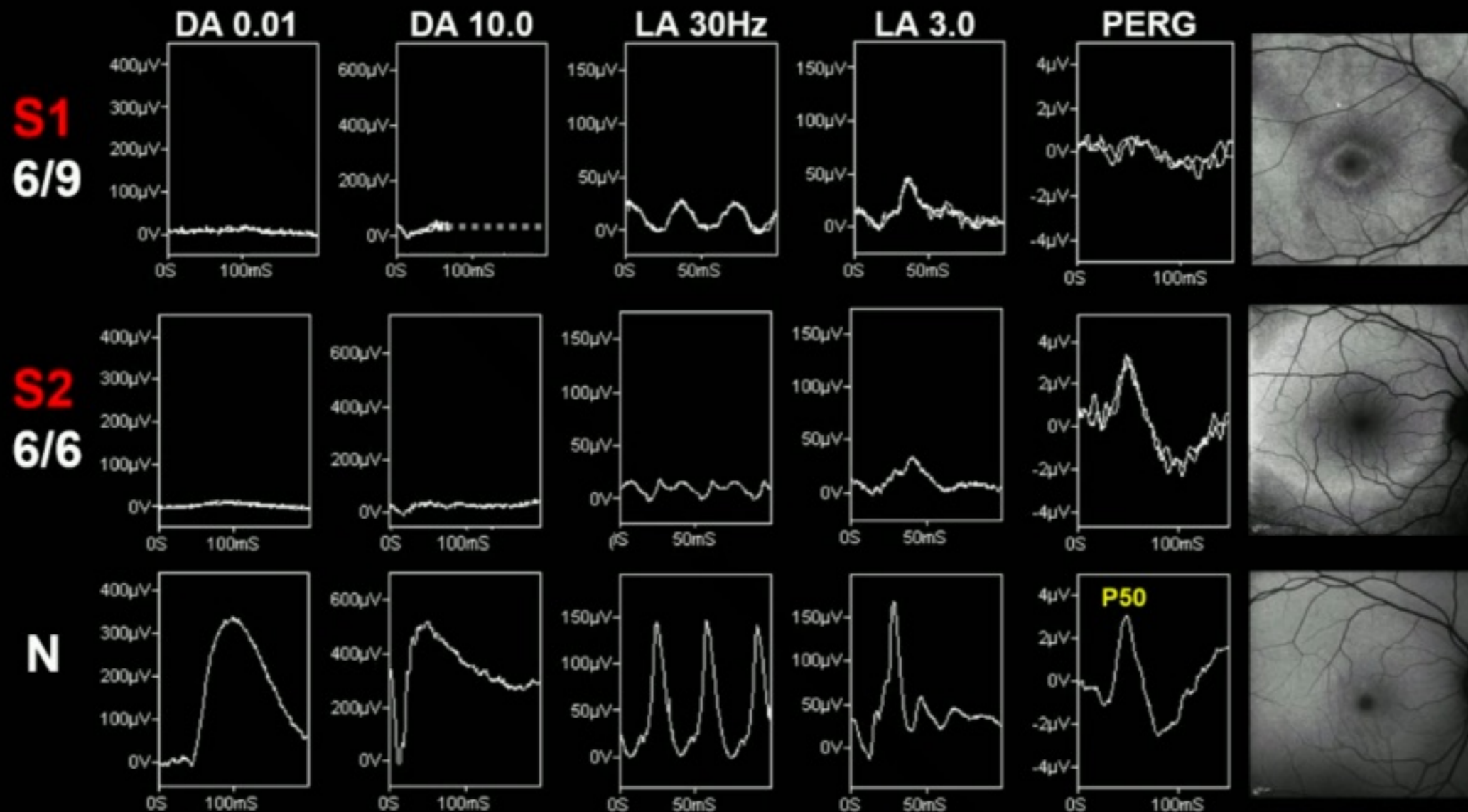
Generalised rod > cone dysfunction
Rod-cone dystrophy (RP)

ERG, PERG and autofluorescence in retinitis pigmentosa



Generalised rod > cone dysfunction
Rod-cone dystrophy (RP)

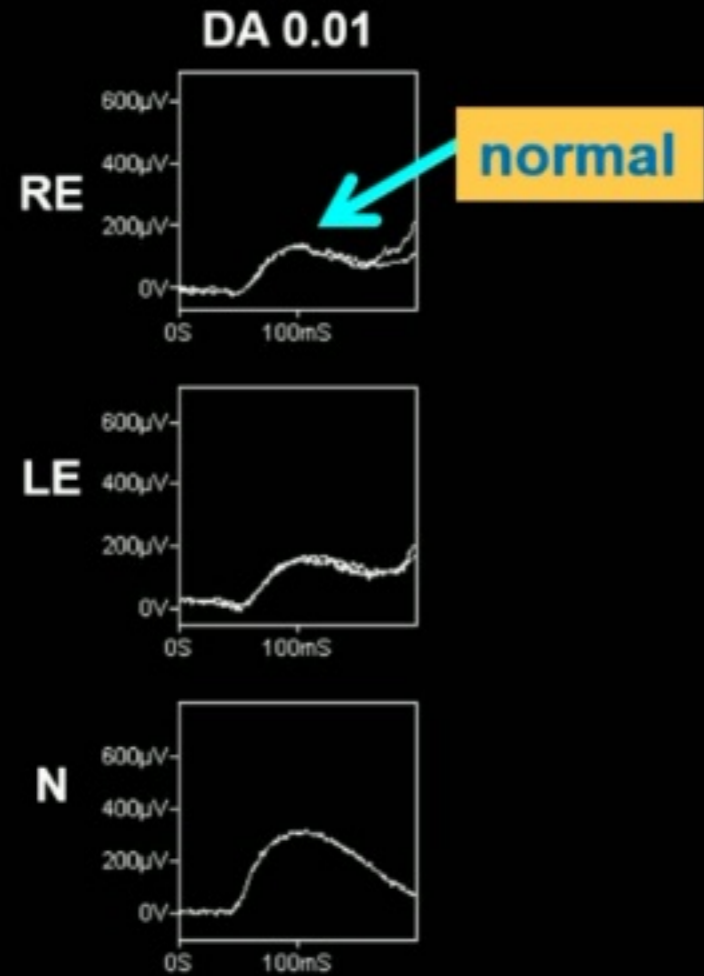
ERG, PERG and autofluorescence in retinitis pigmentosa



Generalised rod > cone dysfunction
Rod-cone dystrophy (RP)

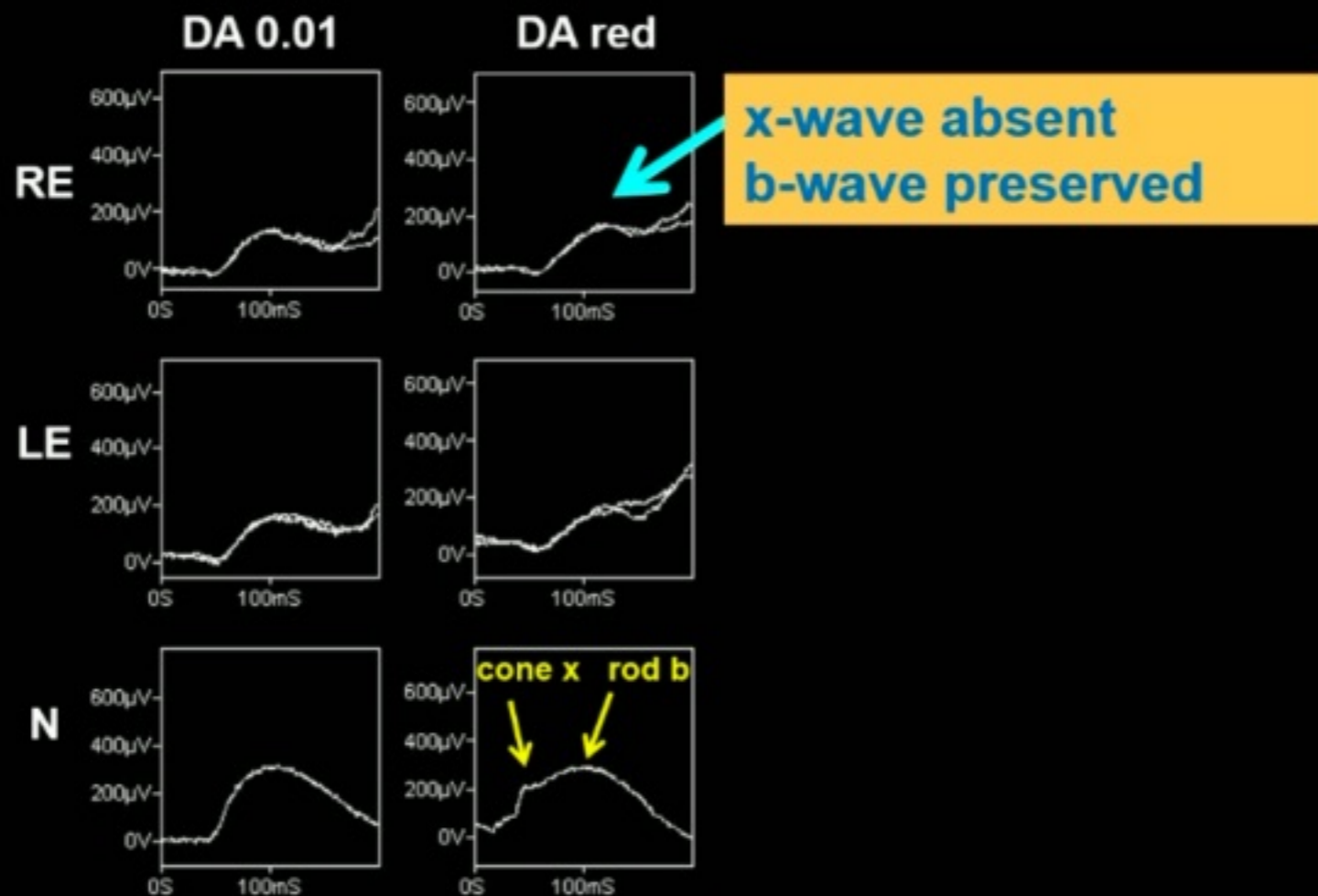
24yrs F.

Lifelong poor VA & poor colour vision, photophobia & nystagmus.



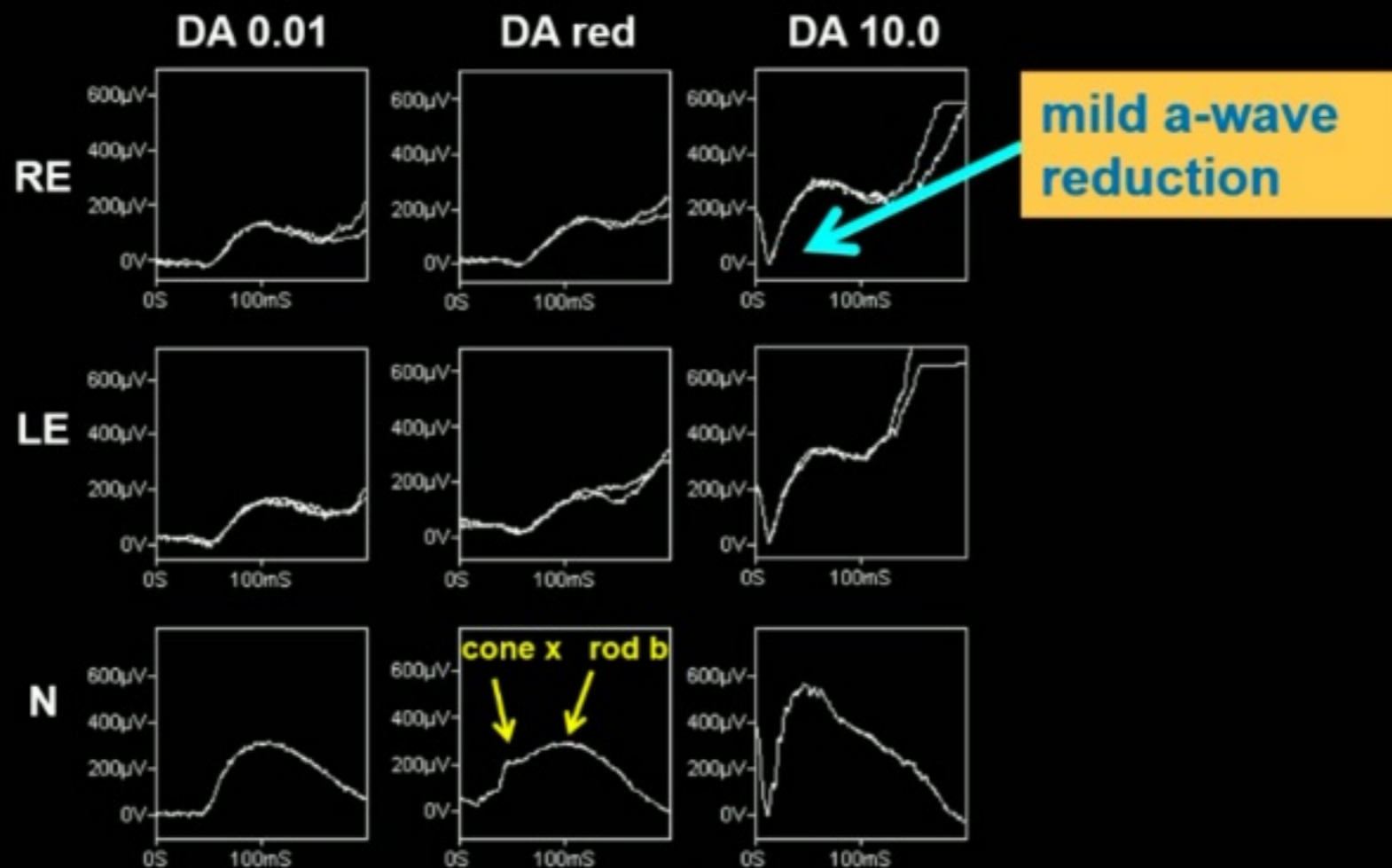
24yrs F.

Lifelong poor VA & poor colour vision, photophobia & nystagmus.



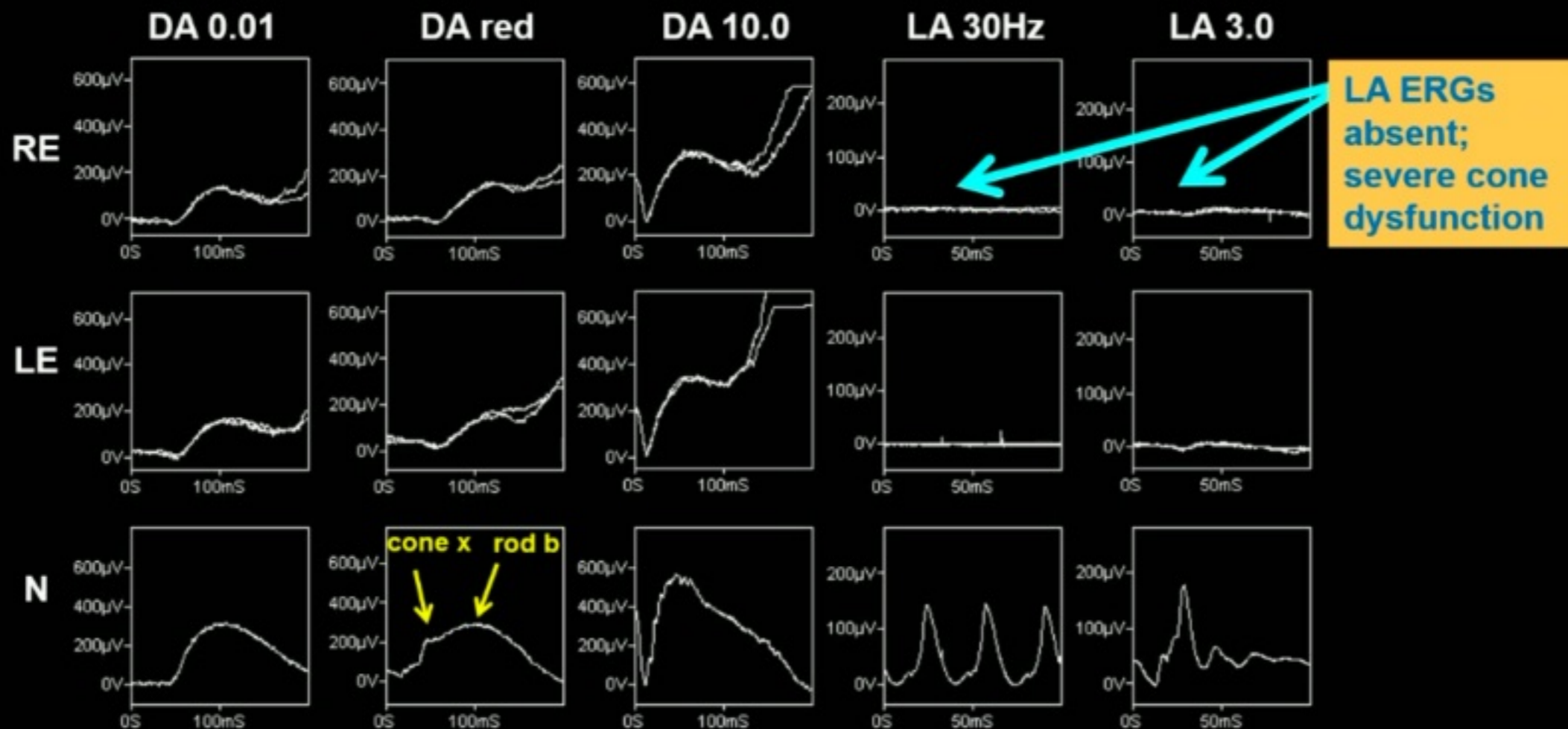
24yrs F.

Lifelong poor VA & poor colour vision, photophobia & nystagmus.



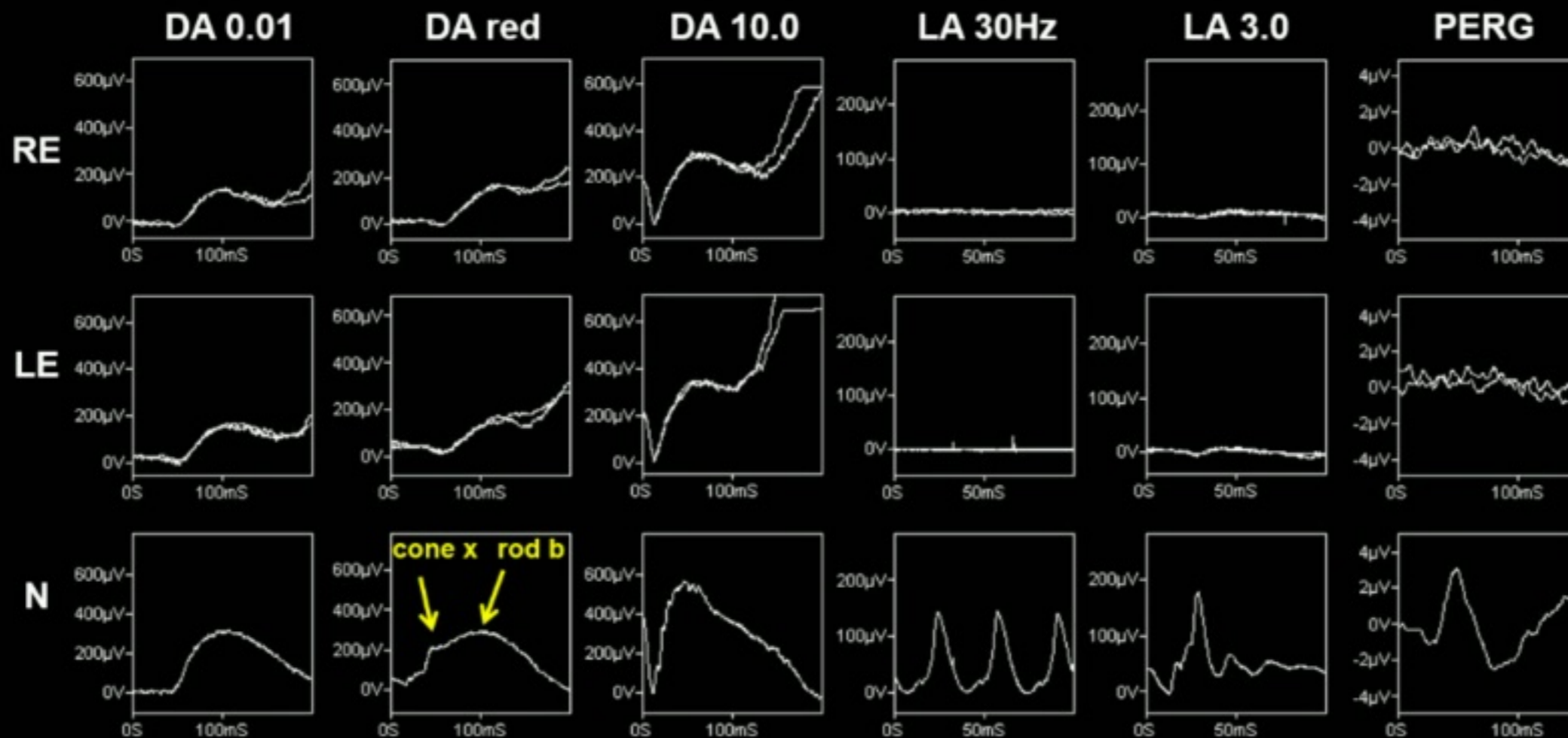
24yrs F.

Lifelong poor VA & poor colour vision, photophobia & nystagmus.



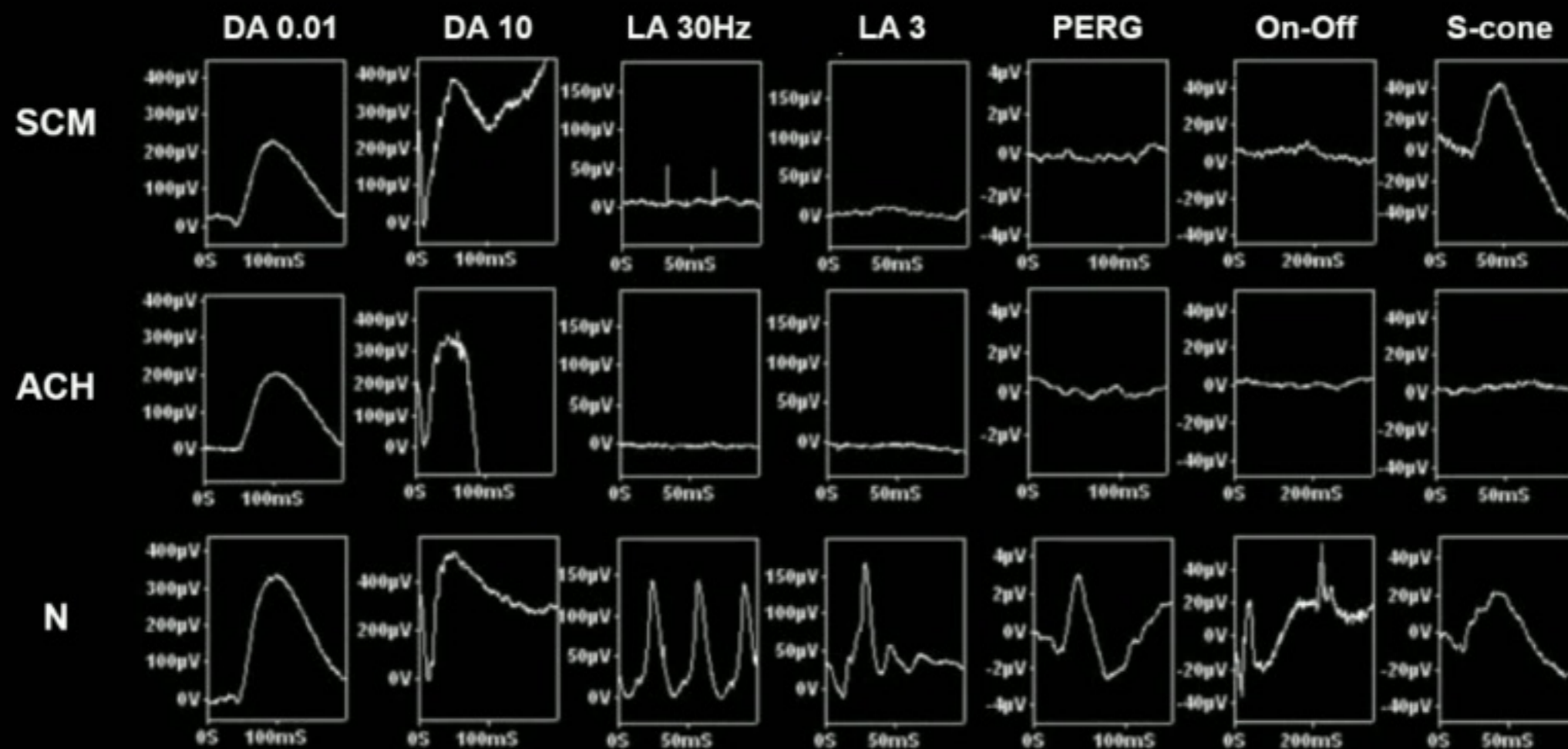
24yrs F.

Lifelong poor VA & poor colour vision, photophobia & nystagmus.



achromatopsia

S-cone monochromacy vs achromatopsia

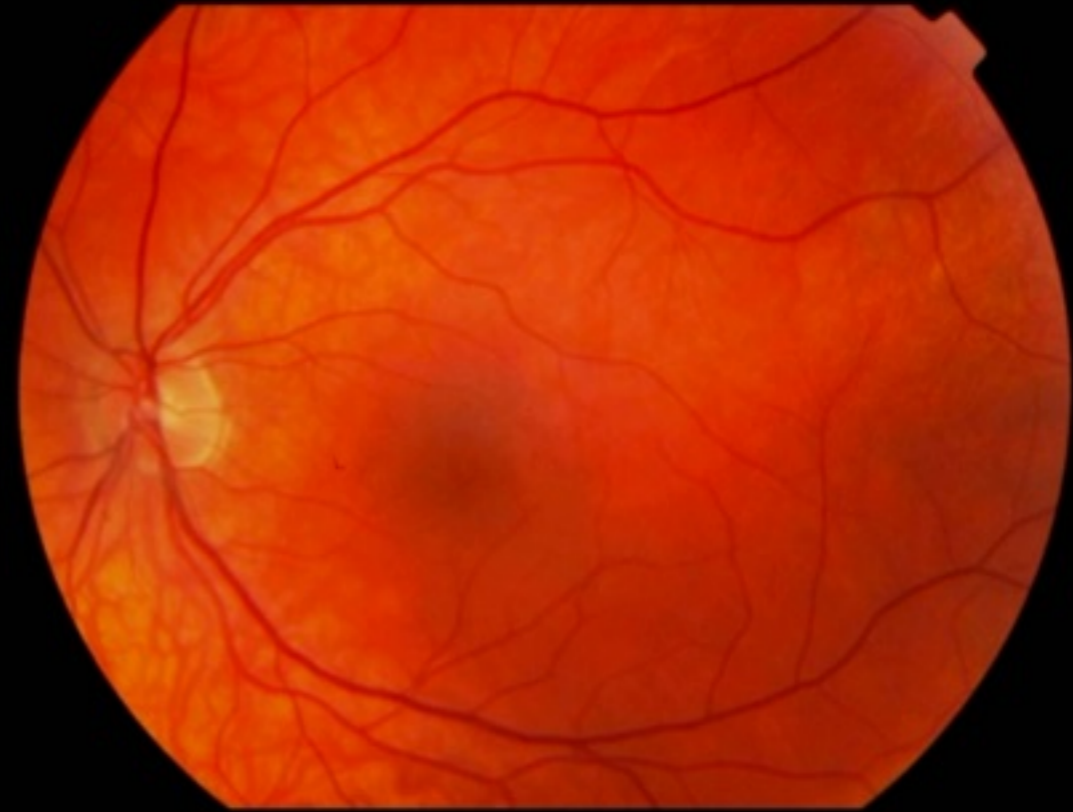


M. 30 yrs. Gradual reduction in vision since age of 15

20/80



20/80



M. 30 yrs. Gradual reduction in vision since age of 15

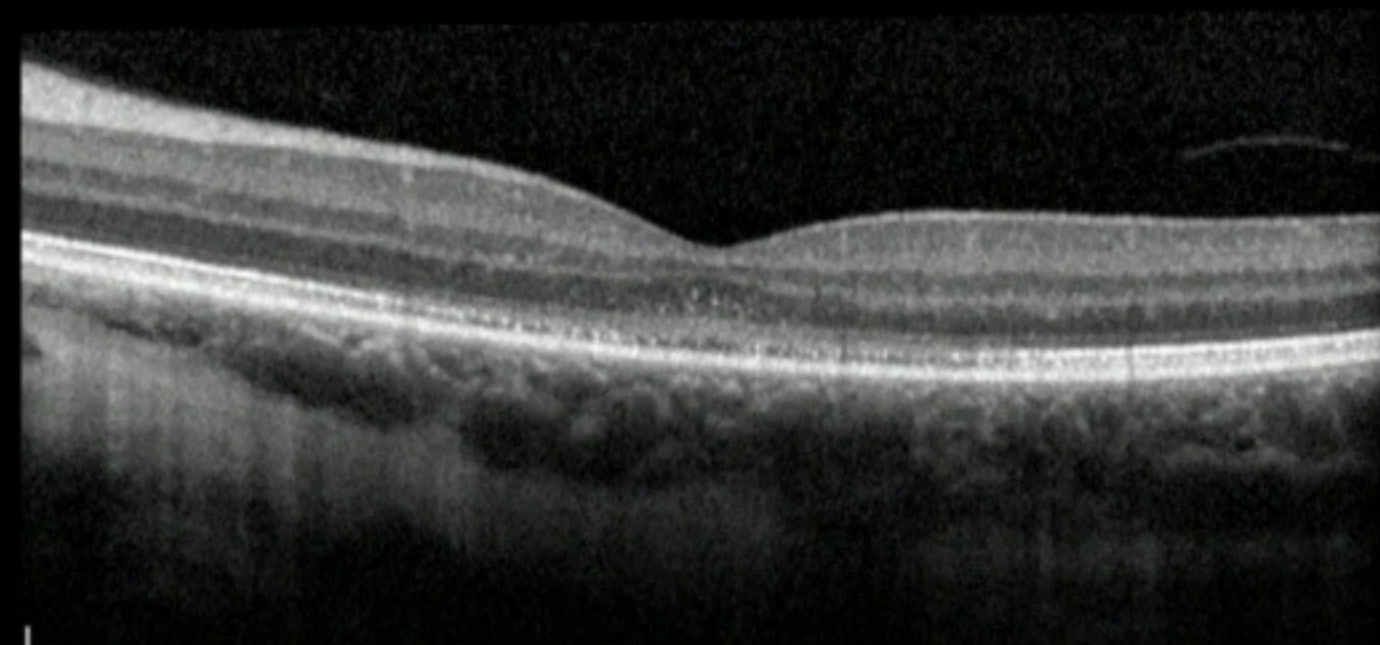
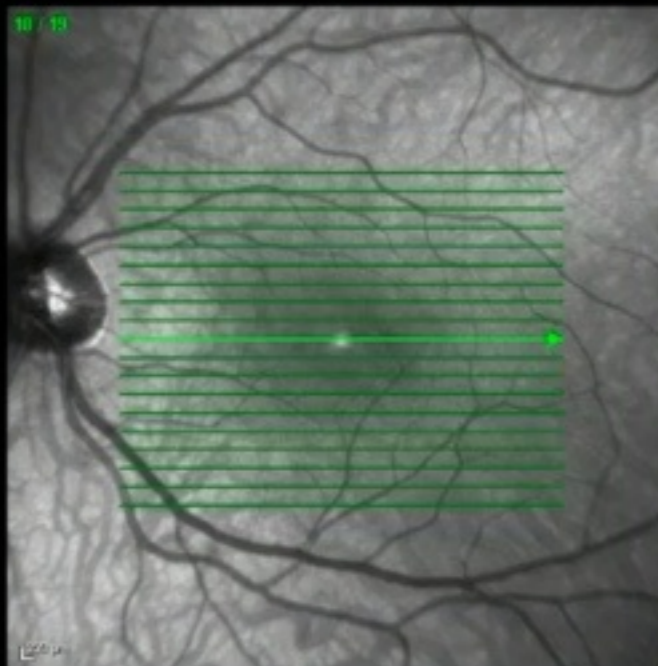
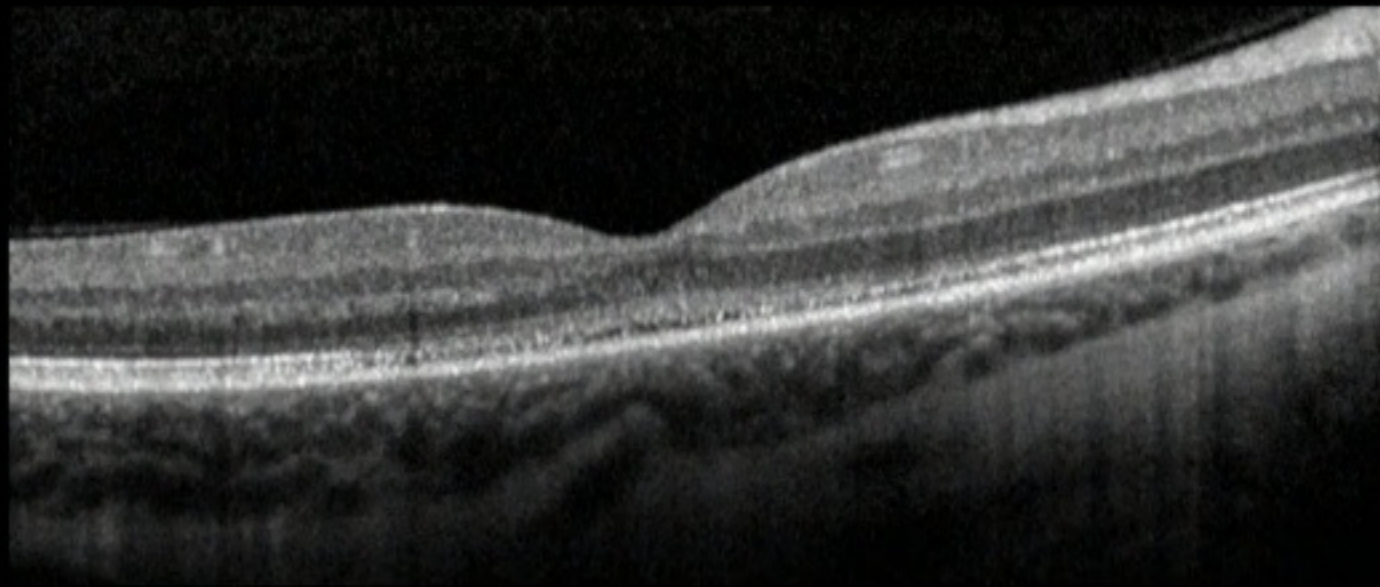
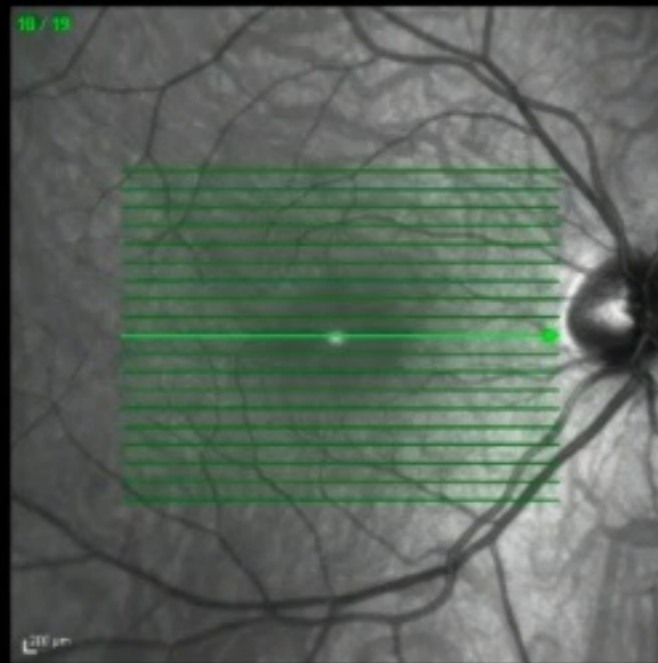
20/80



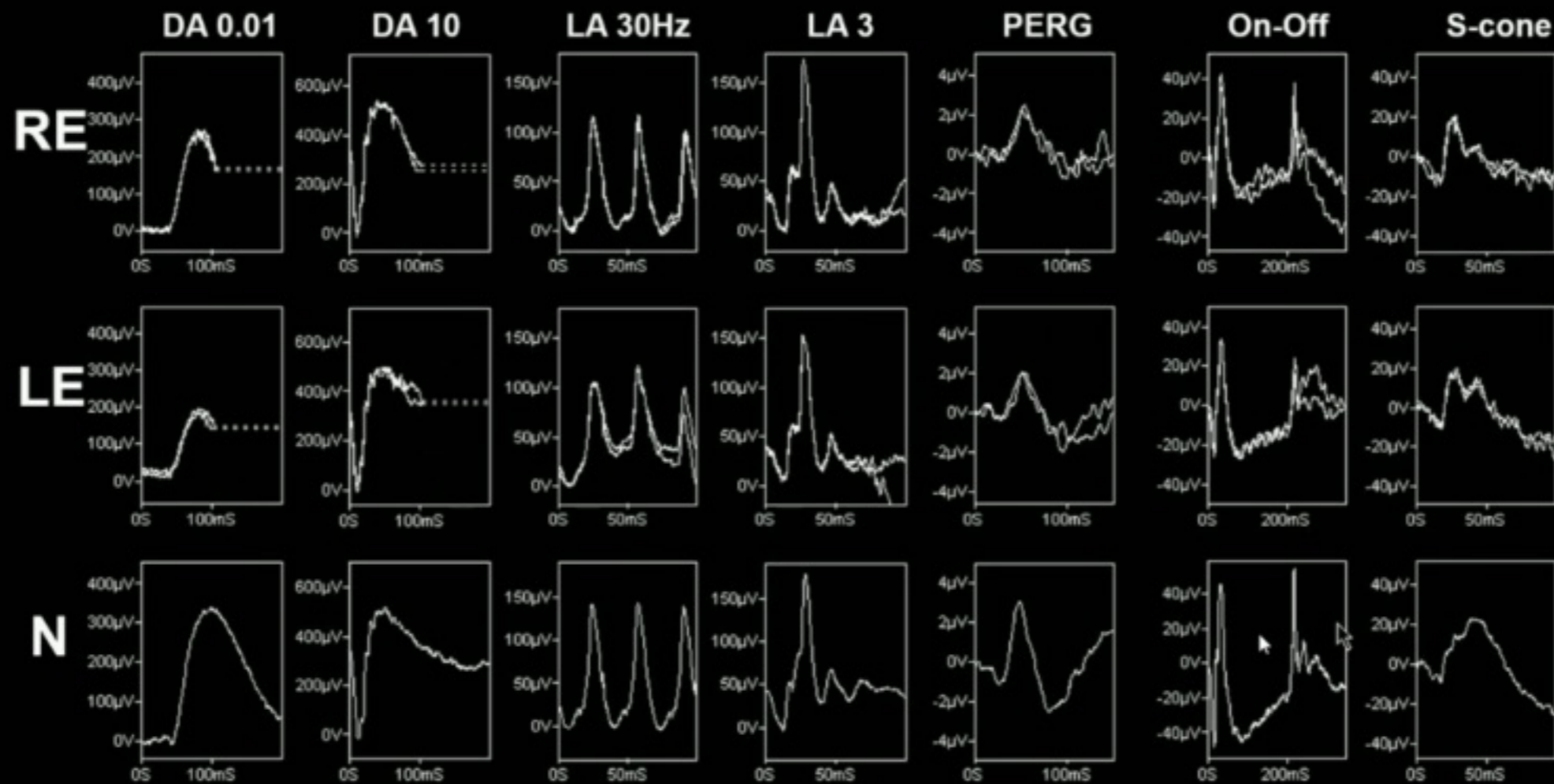
20/80



M. 30 yrs. Gradual reduction in vision since age of 15

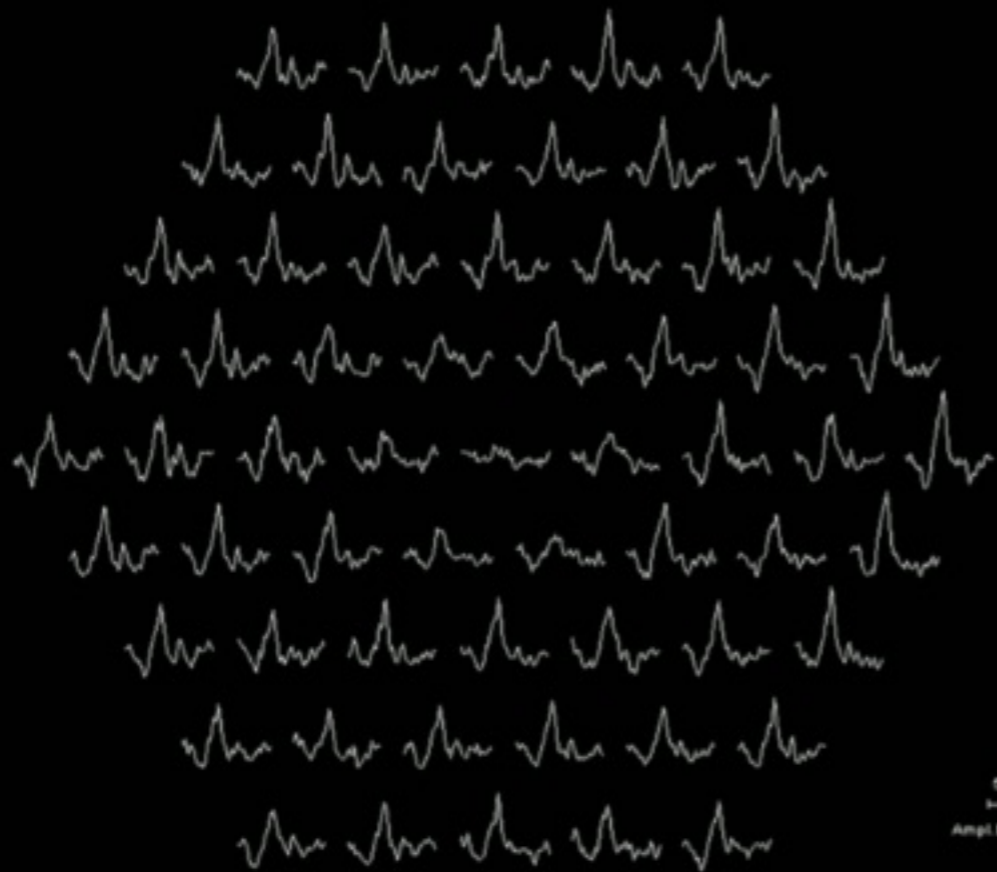


M. 30 yrs. Gradual reduction in vision since age of 15

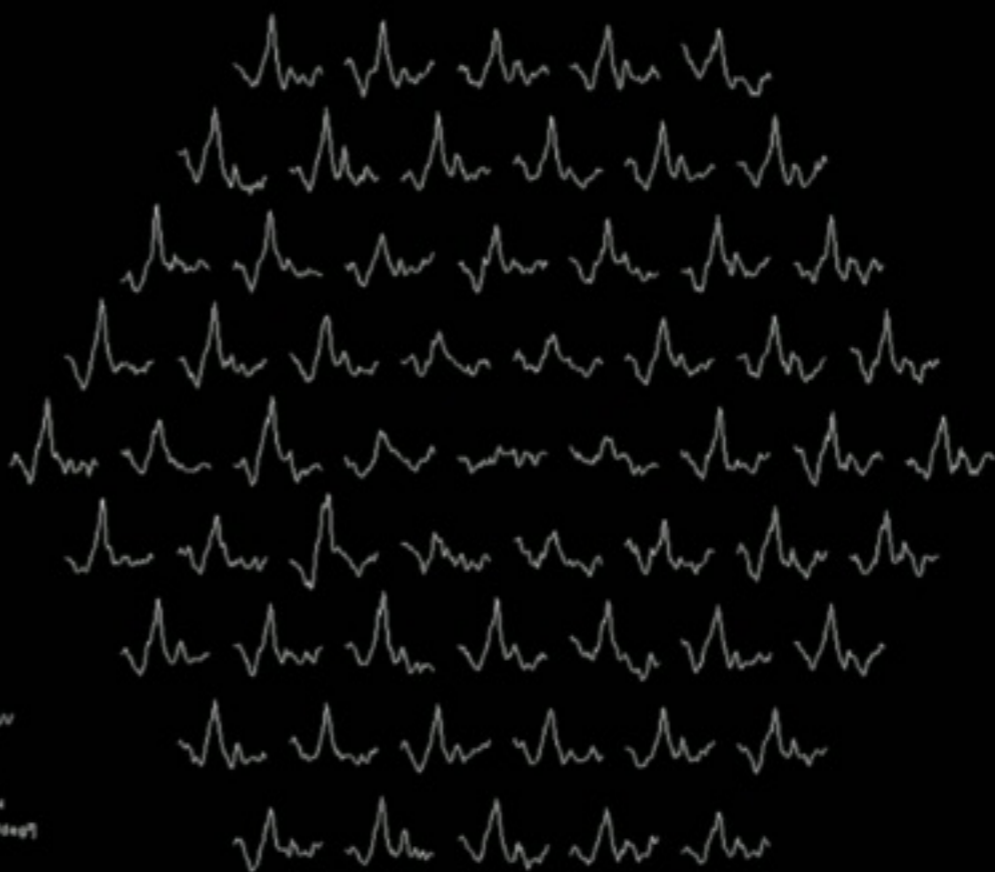


M, 30 yrs

RE 20/80



LE 20/80

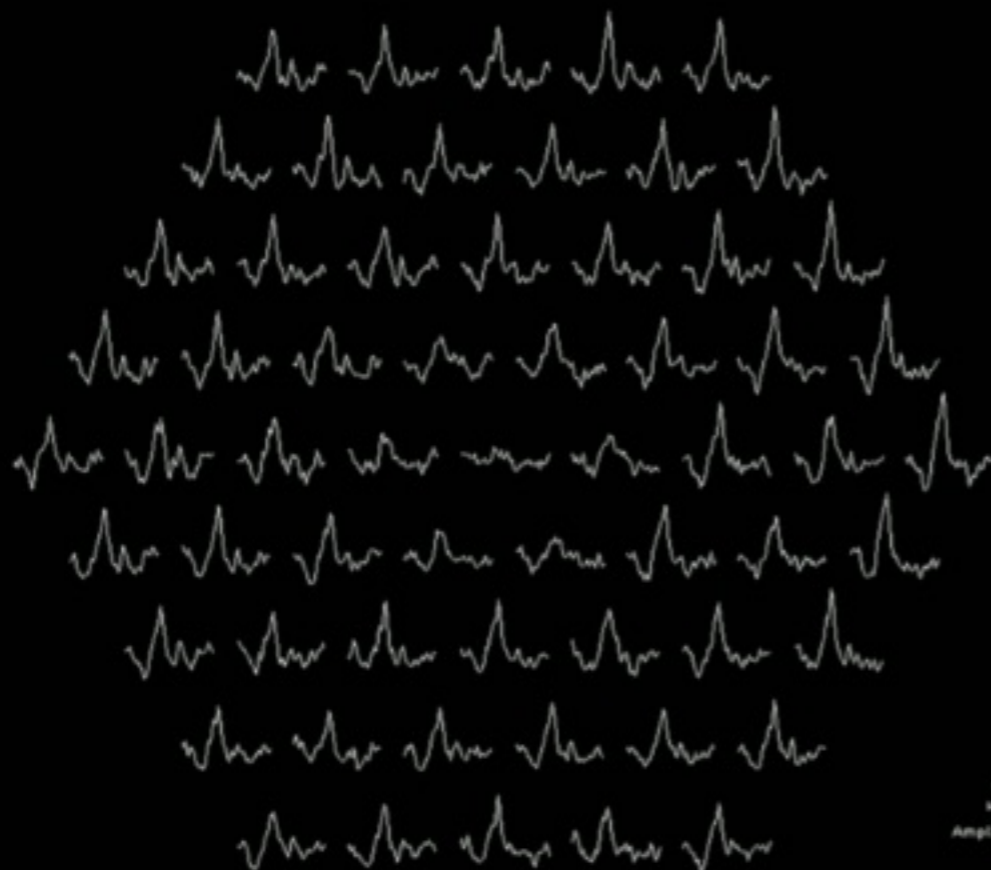


20V
50ms
Ampl 5 (mV/deg)

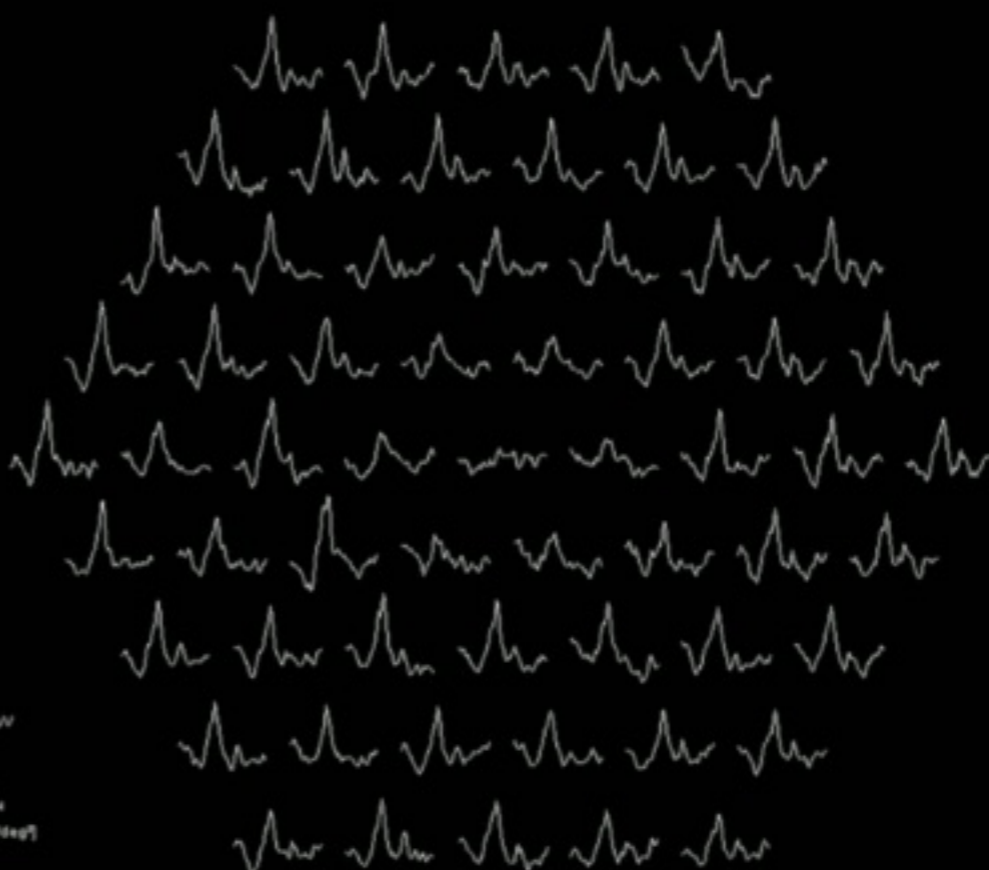
M, 30 yrs.

Occult macular dystrophy

RE 20/80



LE 20/80



20V
50ms
Amplitude (mV/deg)

RP1L1; p.Arg45Trp heterozygous

After: Davidson et al., 2012

ISCEV STANDARDS

ISCEV guide to visual electrodiagnostic procedures

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