A Guide to Rodent Electrophysiology: Biomarkers, Protocols, and Models

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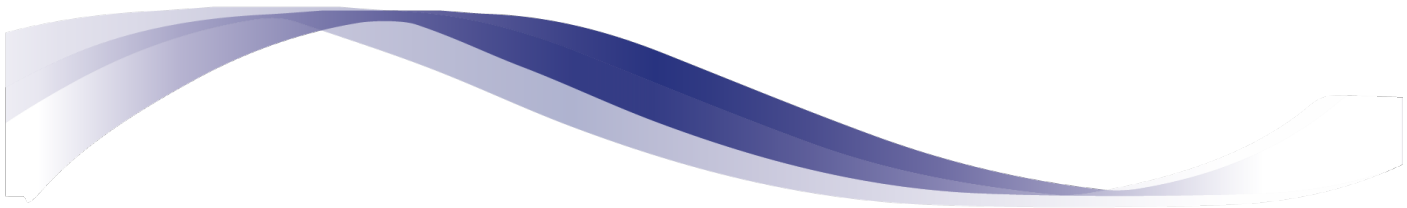
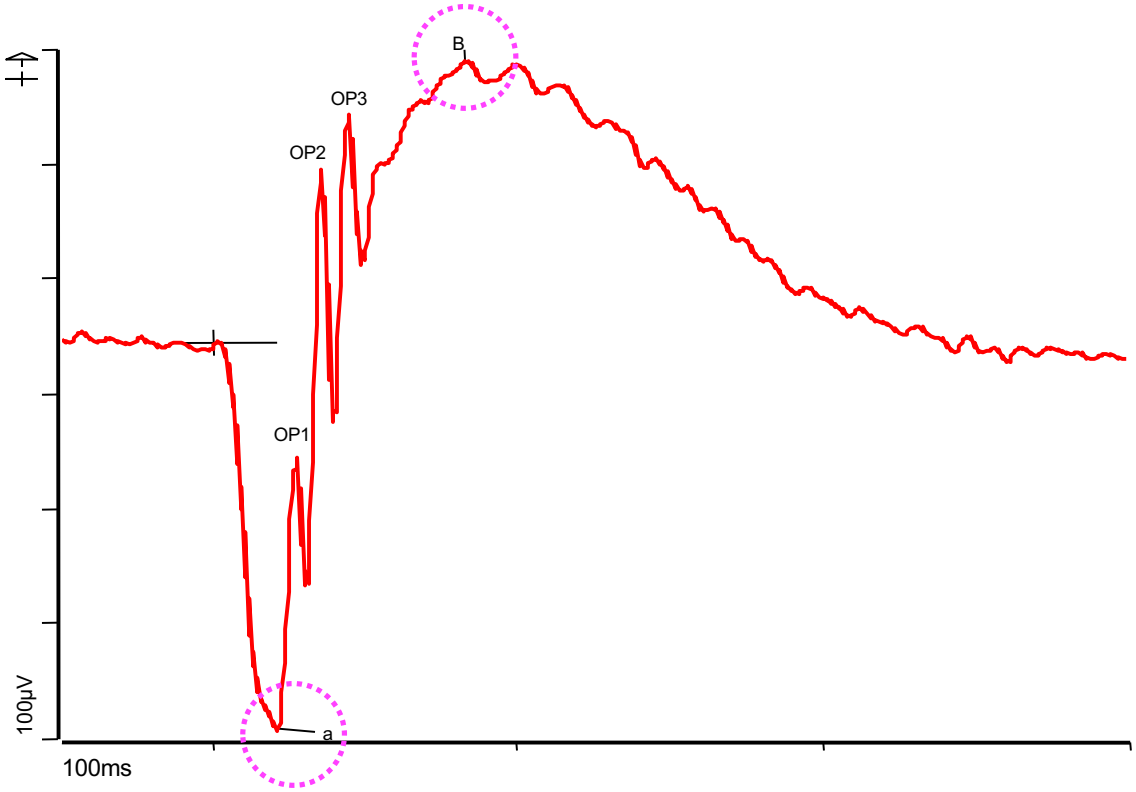


Biomarkers

Full Field Flash ERG

Celeris stimulators: Bright, Standard or Dim full-field



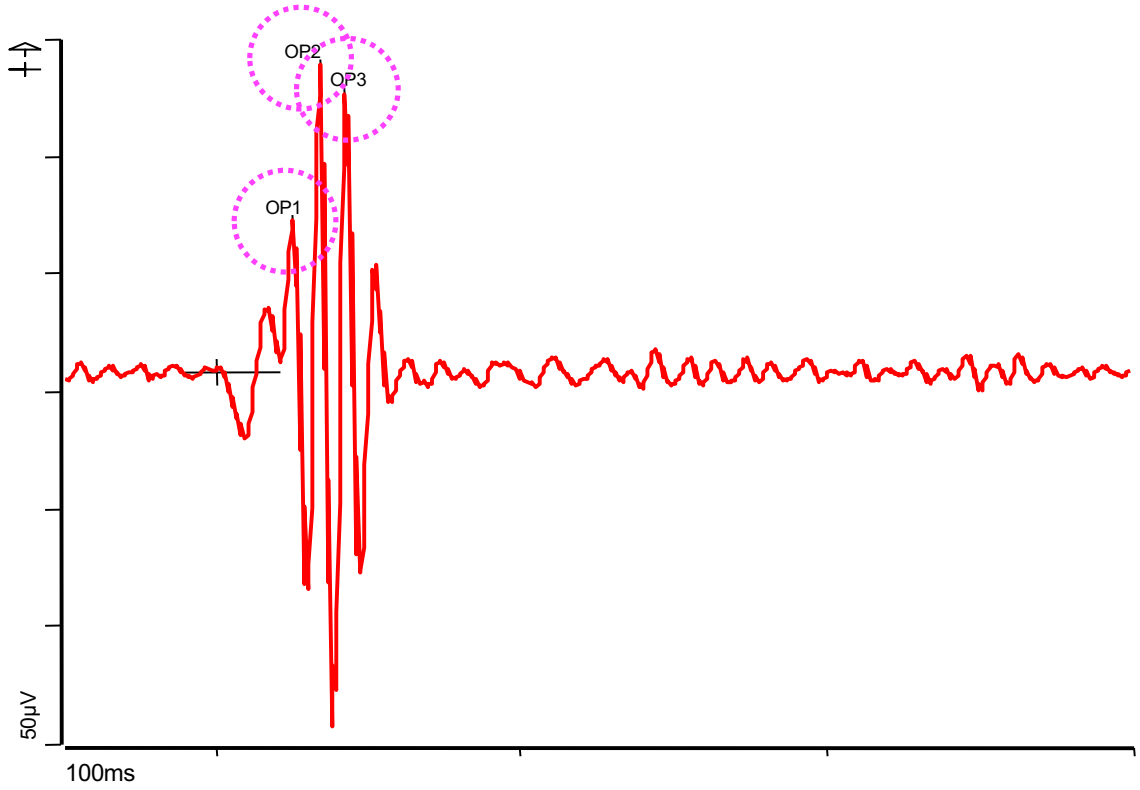
The a-wave and b-wave

1. The a-wave is derived from photoreceptors, rods and cones
2. The b-wave is derived primarily from Muller cells and ON-bipolar cells.

Key markers: A-wave and B-wave

Oscillatory Potentials

Celeris stimulators: Bright, Standard or Dim full-field



Oscillatory Potentials (OPs)

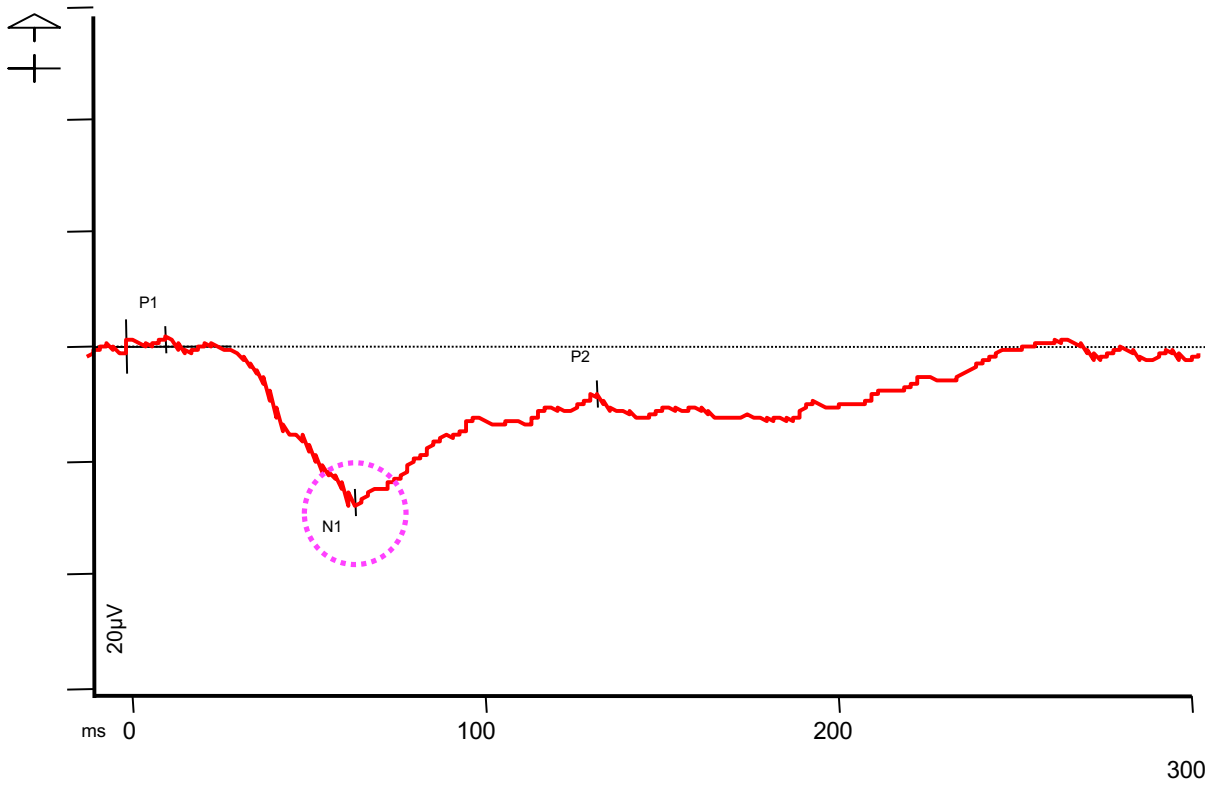
OPs are a subcomponent of the flash ERG shown above. Peaks observed on the ascending limb of the b-wave can be isolated and measured.

OP1, OP2, OP3 primarily from amacrine cells

Key markers: OP1, OP2, OP3

Flash Visually Evoked Potential (Flash VEP)

Celeris stimulators: Bright or Standard full-field



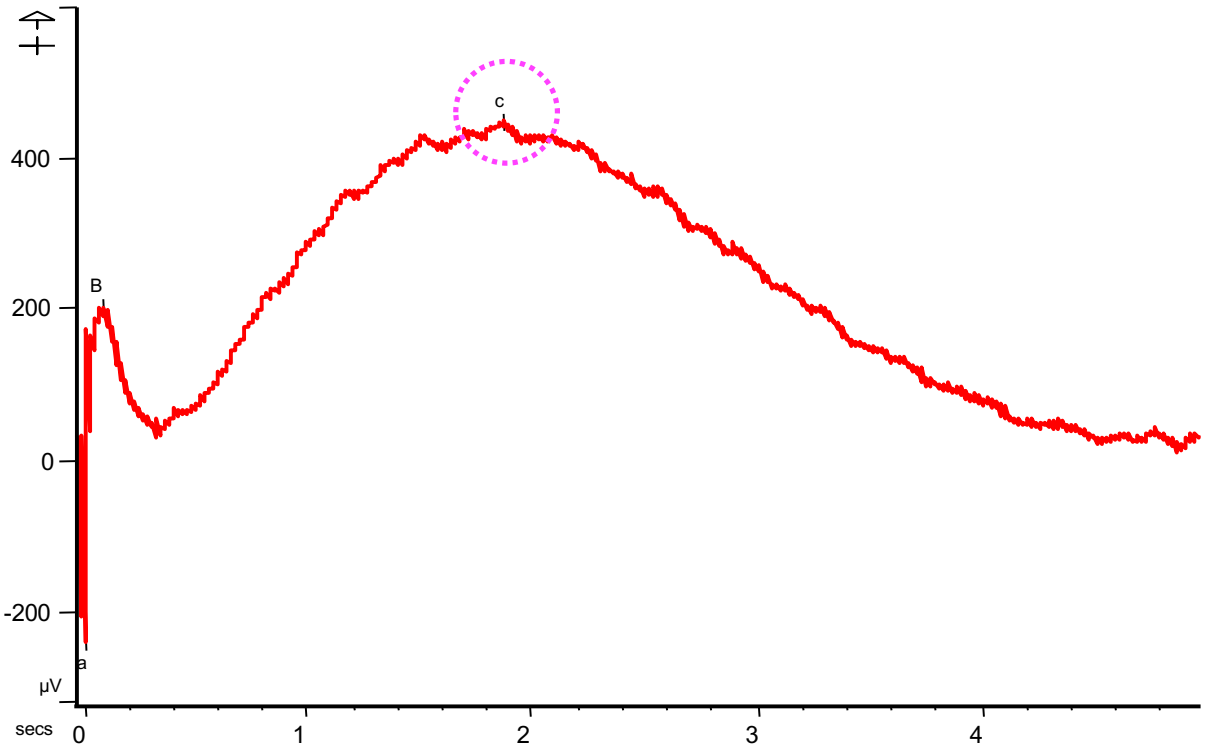
Flash Visually Evoked Potential (fVEP)

Originates in the visual cortex

Key marker: N1

C-wave ERG

Celeris stimulator: Bright or Standard full-field



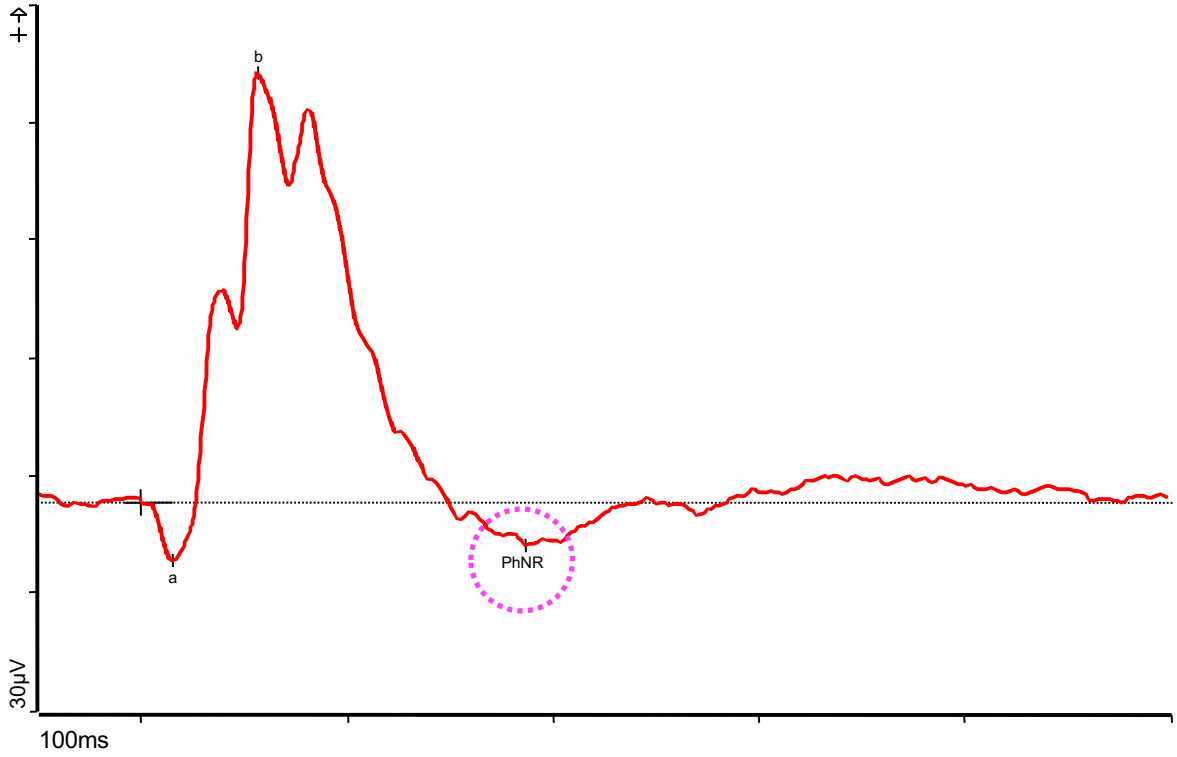
The C-Wave

The c-wave is derived from the pigmented epithelium (RPE).

Key marker: C-wave

Photopic Negative Response (PhNR)

Celeris stimulator: Bright or Standard full-field



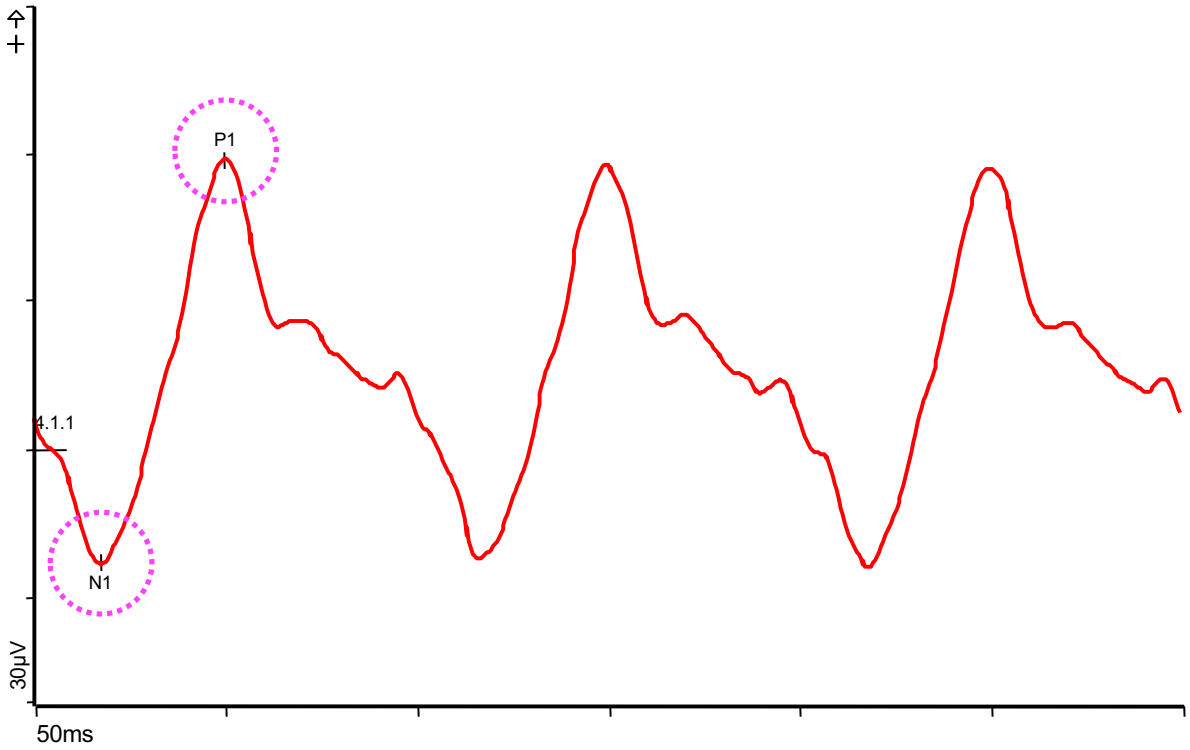
The Photopic Negative Response (PhNR)

A component of the photopic flash ERG measuring ganglion cell activity.

Key marker: PhNR

Flicker ERG

Celeris stimulator: Bright or Standard full-field



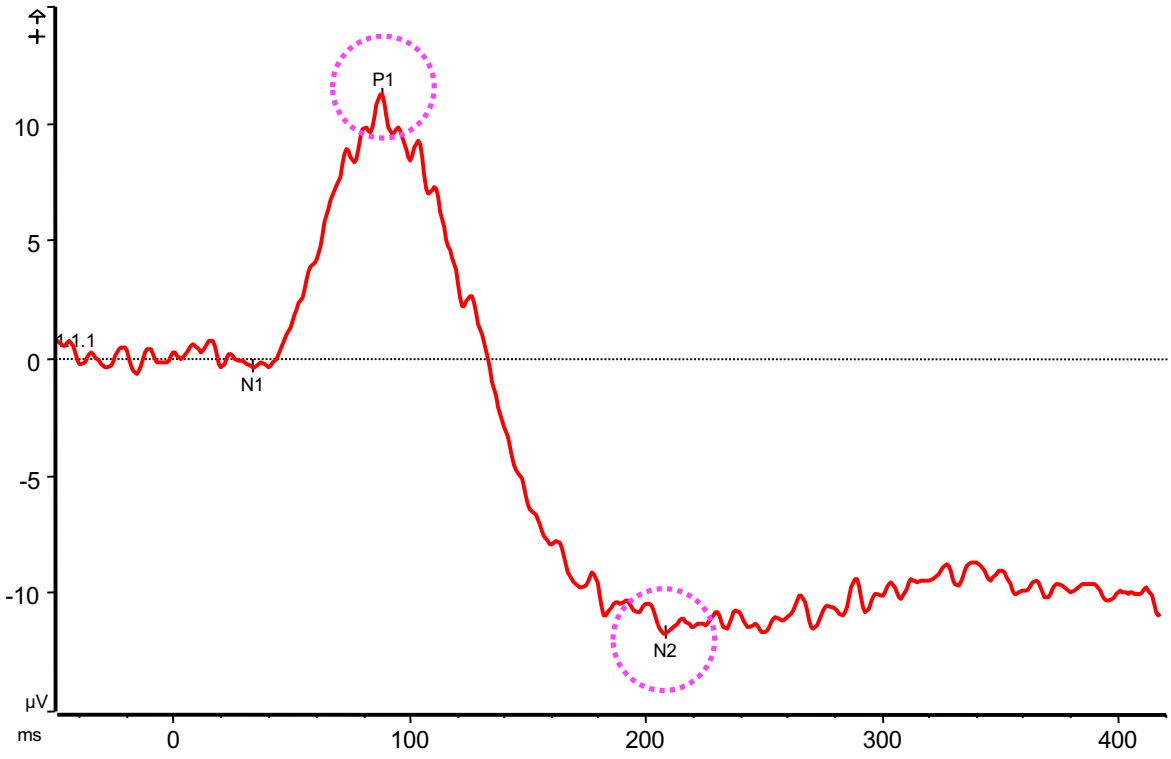
Flicker ERG

Measurement of cone opsin regeneration rate.

Key markers: N1, P1

Pattern ERG (PERG)

Celeris stimulator: Pattern



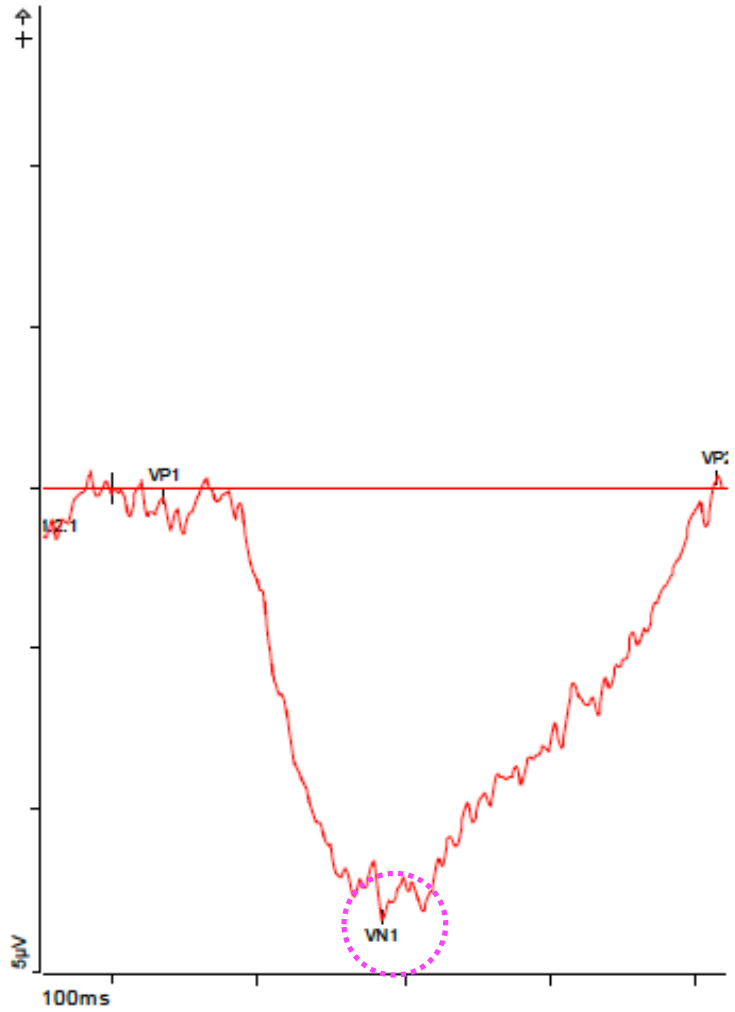
The Pattern ERG (pERG)

Measurement of ganglion cell function.

Key markers: P1 and N2

Pattern Visually Evoked Potential (pVEP)

Celeris stimulator: Pattern



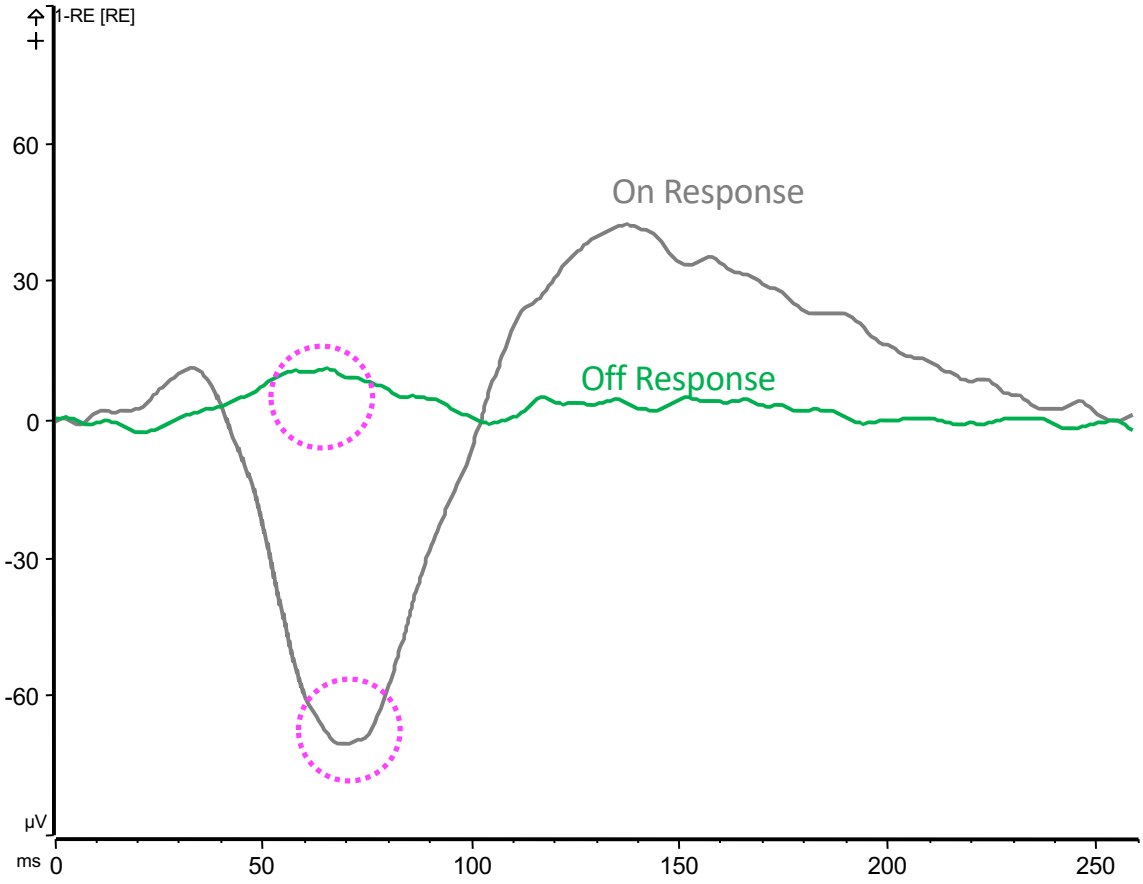
The Pattern VEP (pVEP)

Originates in the visual cortex

Key marker: VN1

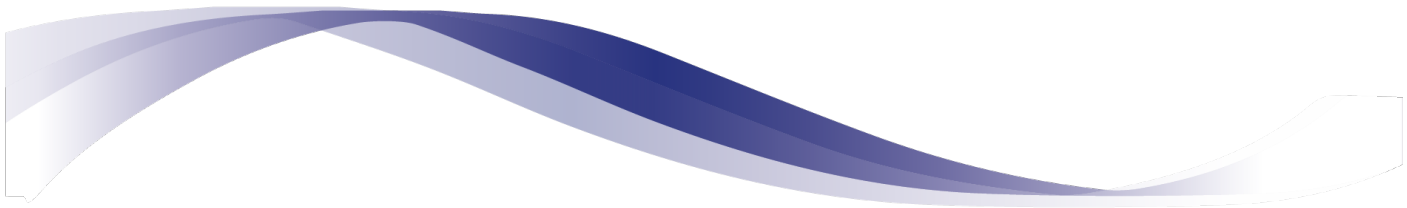
Full Field On-Off ERG

Celeris stimulator: Pattern



On-Off (Uniform Field) ERG

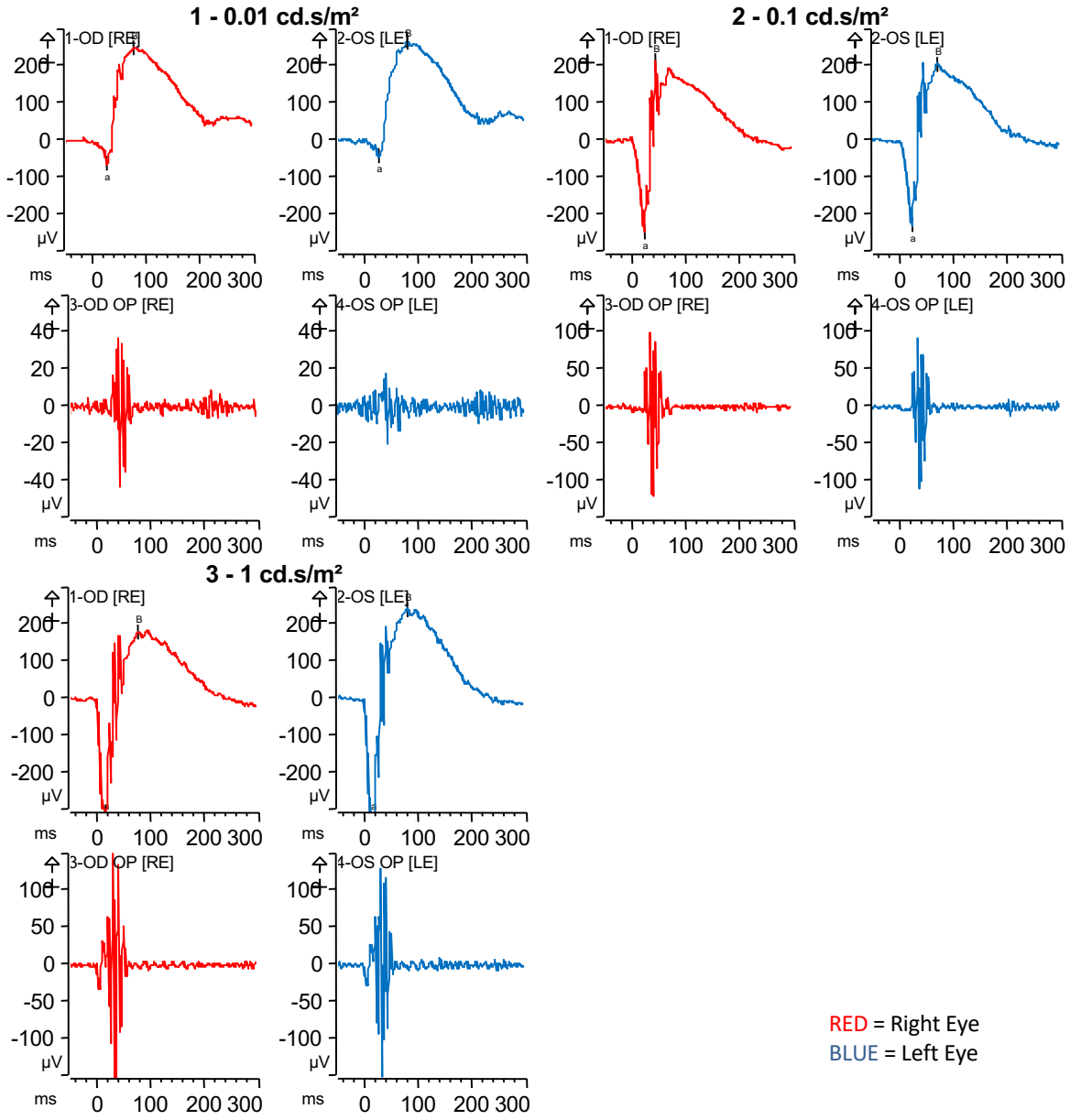
Key marker: first major peaks of each response



The Protocols

Protocol 1: Dark Adapted ERG + Ops

Celeris stimulator: Bright or Standard full-field



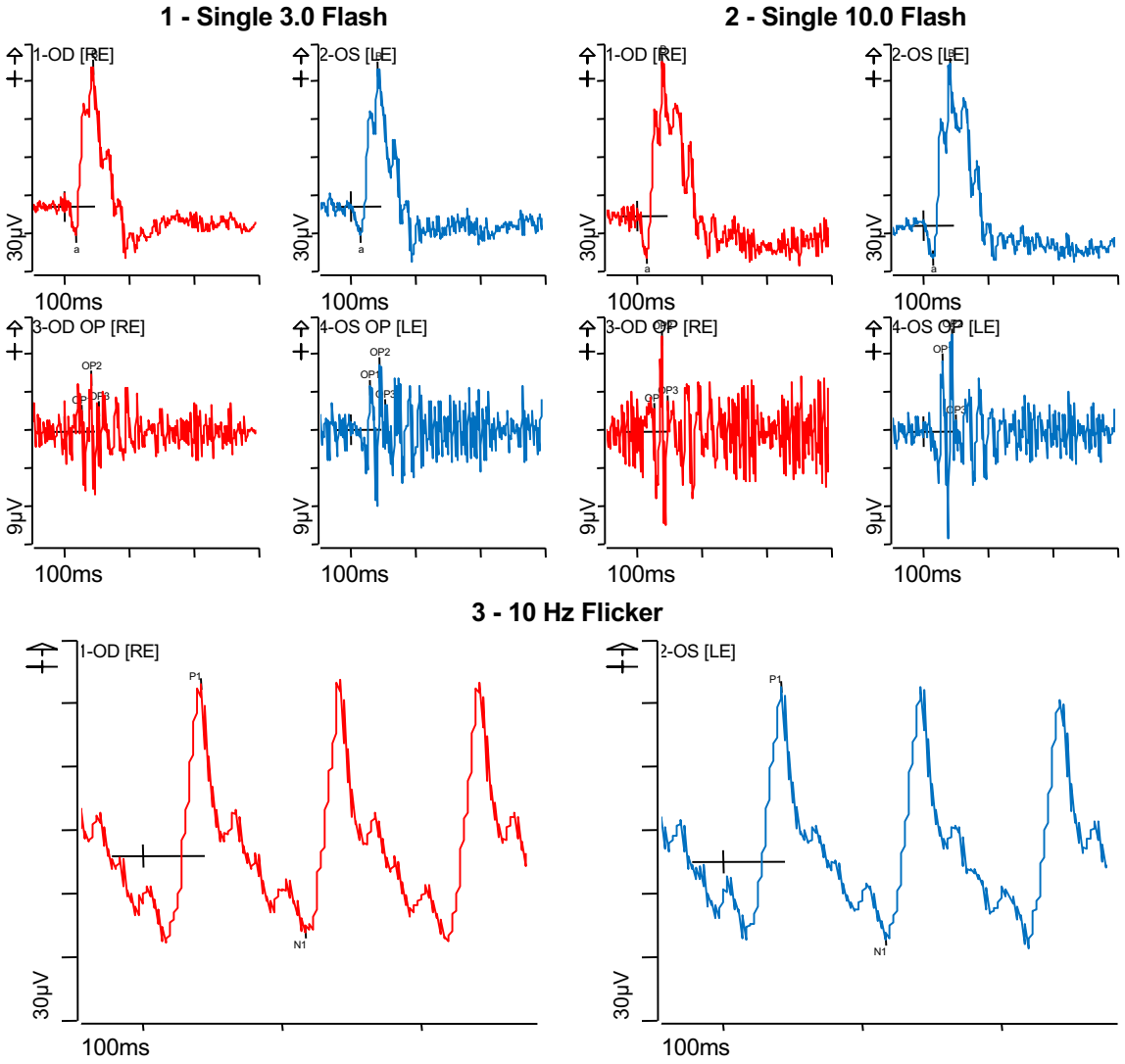
RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

An intensity series of single white flashes at 0.01, 0.1, and 1.0 cd.s/m^2.

Protocol 2: Light Adapted ERG + Ops

Celeris stimulator: Bright or Standard full-field



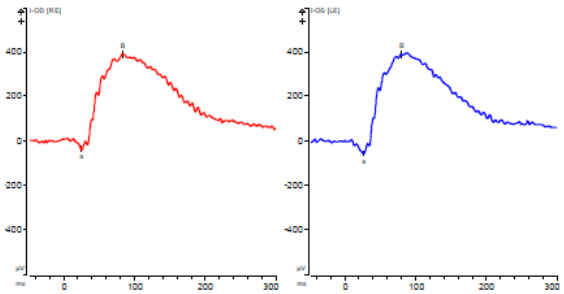
Animal tested: Mouse

Photopic ERG presents a 3 and 10 cd.s/m^2 flash paired with a 10Hz Flicker to demonstrate ERG, Oscillatory Potentials, and Cone Regeneration.

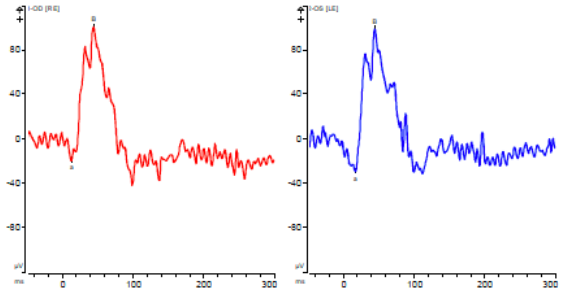
Protocol 3: Combined Light & Dark Adapted ERG

Celeris stimulator: Bright or Standard full-field

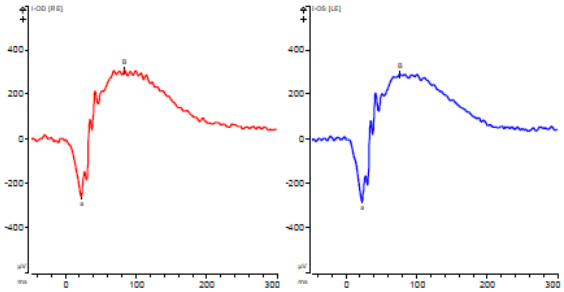
1 – DA 0.01 cd.s/m^2



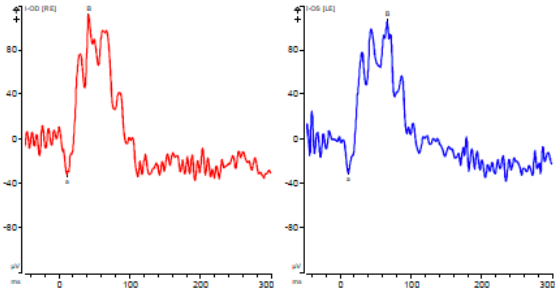
4 – LA 3.0 cd.s/m^2



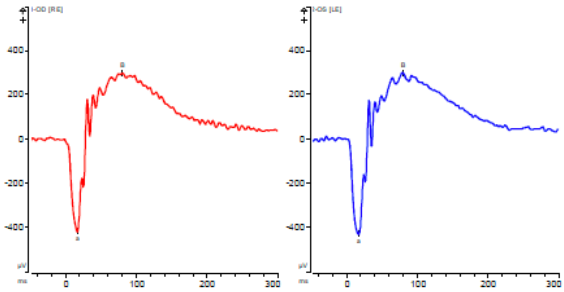
2 – DA 0.1 cd.s/m^2



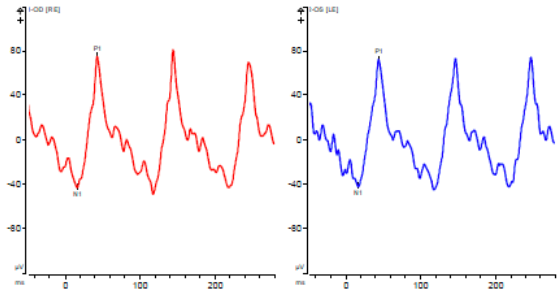
5 – LA 10.0 cd.s/m^2



3 – DA 1.0 cd.s/m^2



6 – LA 10 Hz Flicker

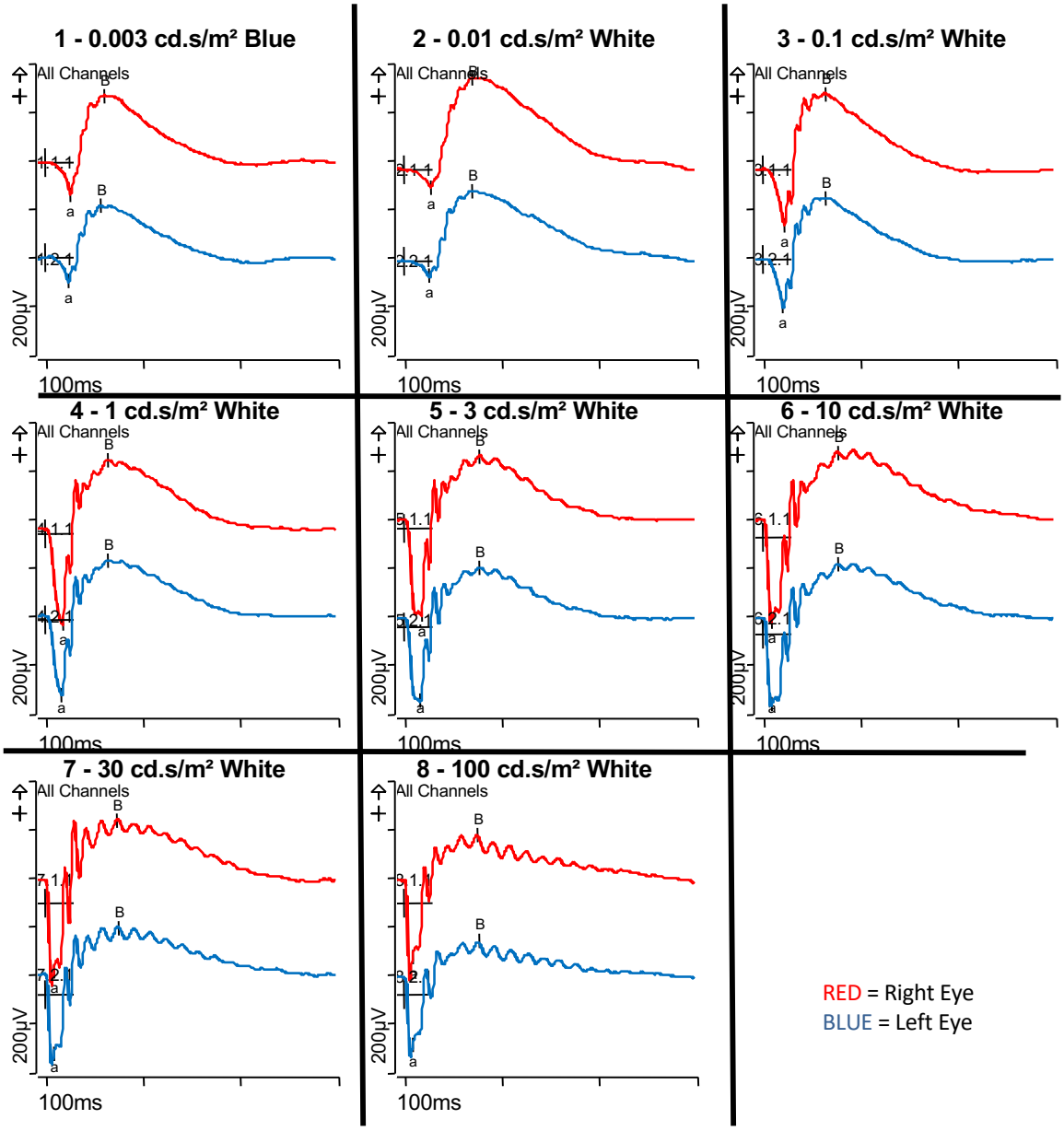


RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

Protocol 4: Dark Adapted Intensity Series

Celeris stimulator: Bright or Standard full-field

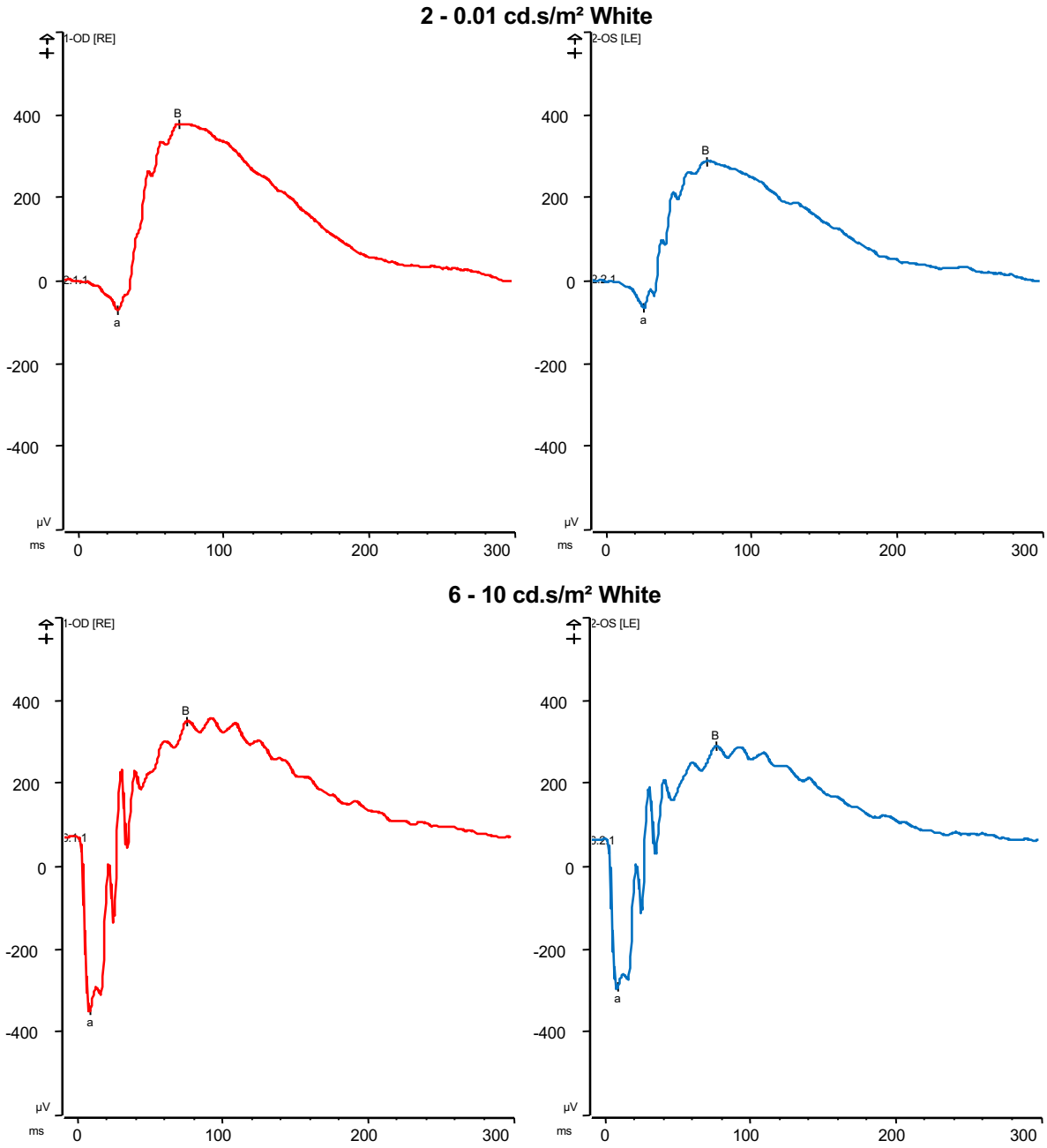


Animal tested: Mouse

An intensity series of single white flashes ranging from .003 – 100 cd.s/m^2.

Protocol 4: Dark Adapted Intensity Series (close up of 0.01 and 10 cd.s/m²

Celeris stimulator: Bright or Standard full-field

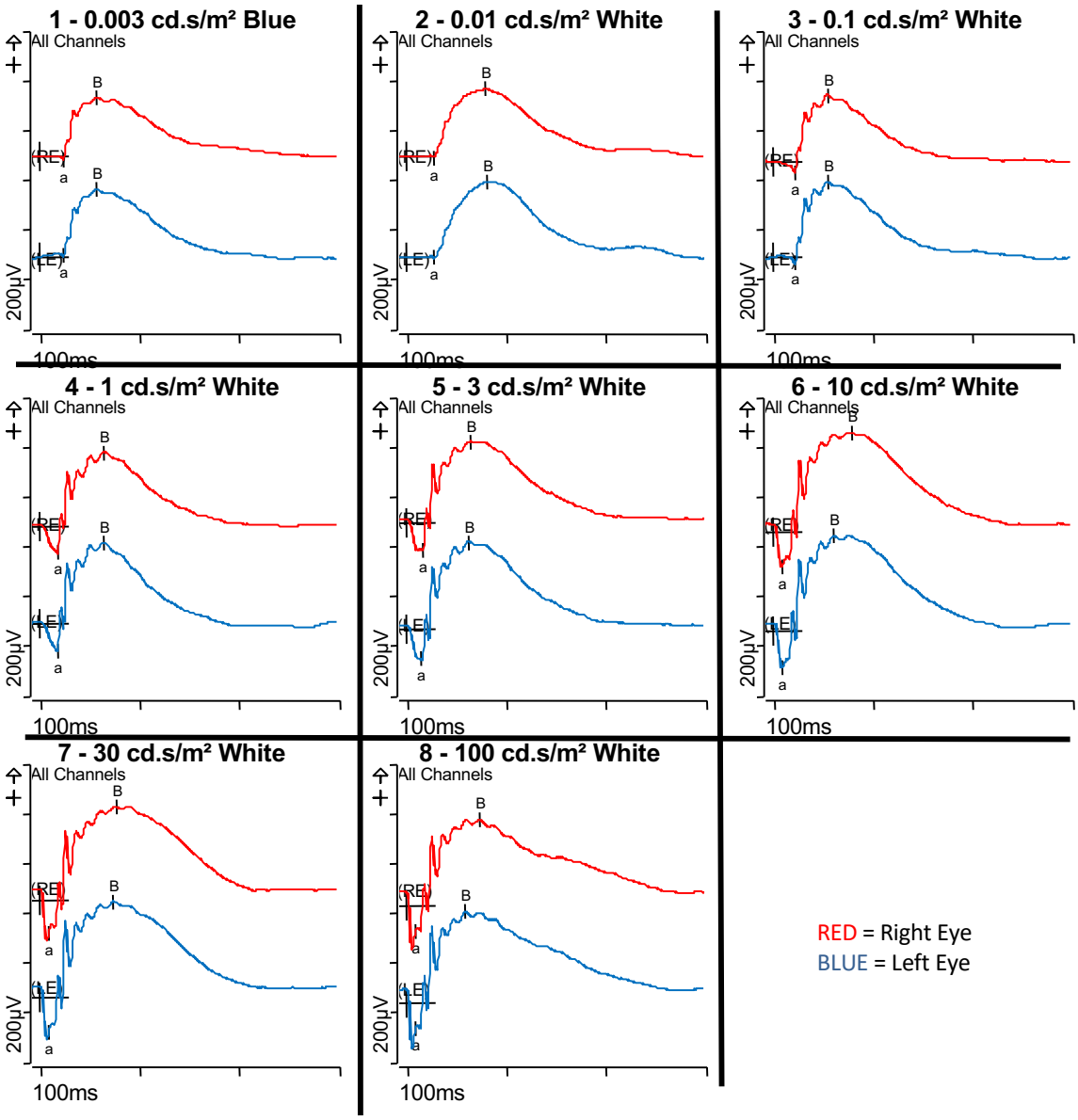


RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

Protocol 4: Dark Adapted Intensity Series

Celeris stimulator: Bright or Standard full-field

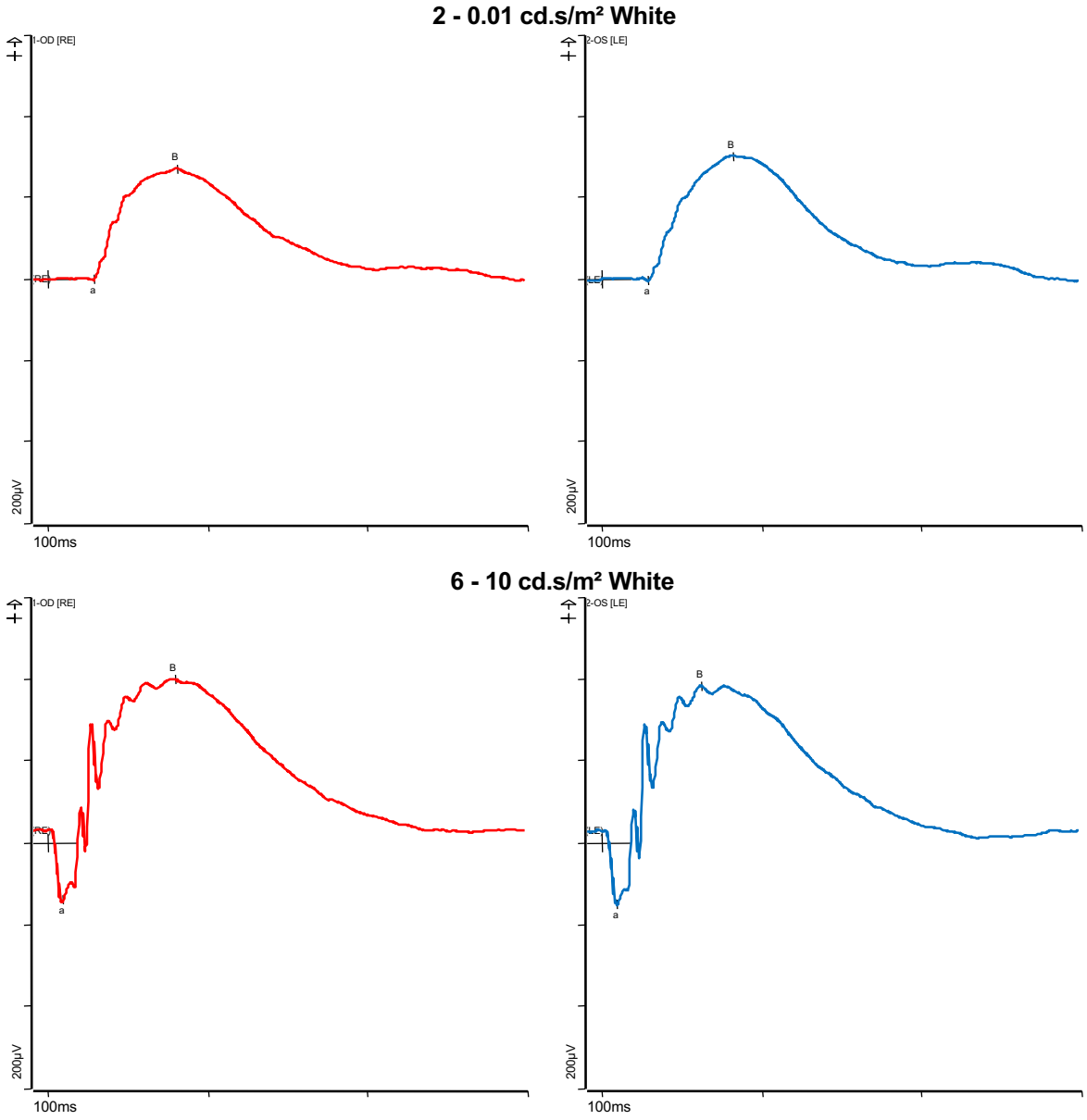


Animal tested: Rat

An intensity series of single white flashes ranging from .003 – 100 cd.s/m^2.

Protocol 4: Dark Adapted Intensity Series (close up of 0.01 and 10 cd.s/m²

Celeris stimulator: Bright or Standard full-field

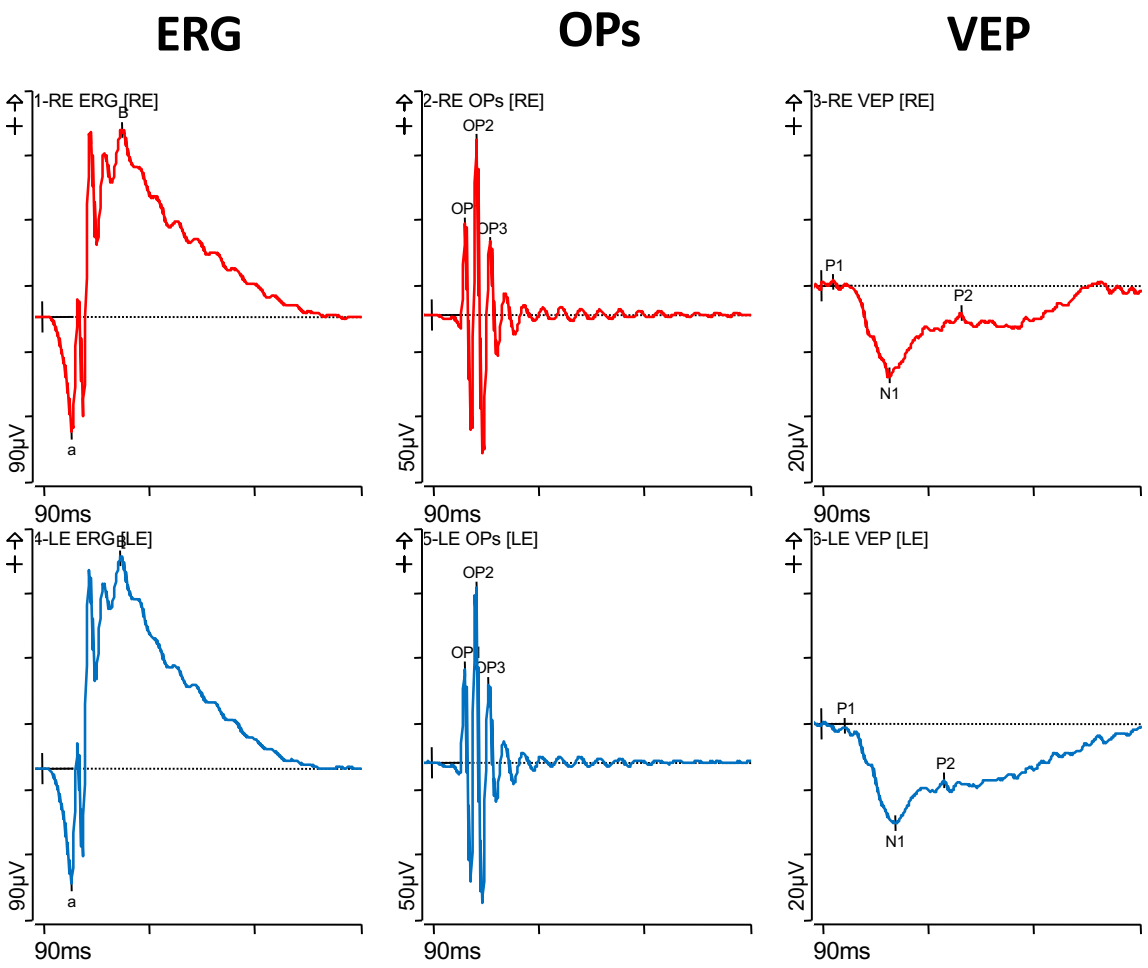


RED = Right Eye
BLUE = Left Eye

Animal tested: Rat

Protocol 5: Simultaneous ERG and VEP

Celeris stimulator: Bright or Standard full-field



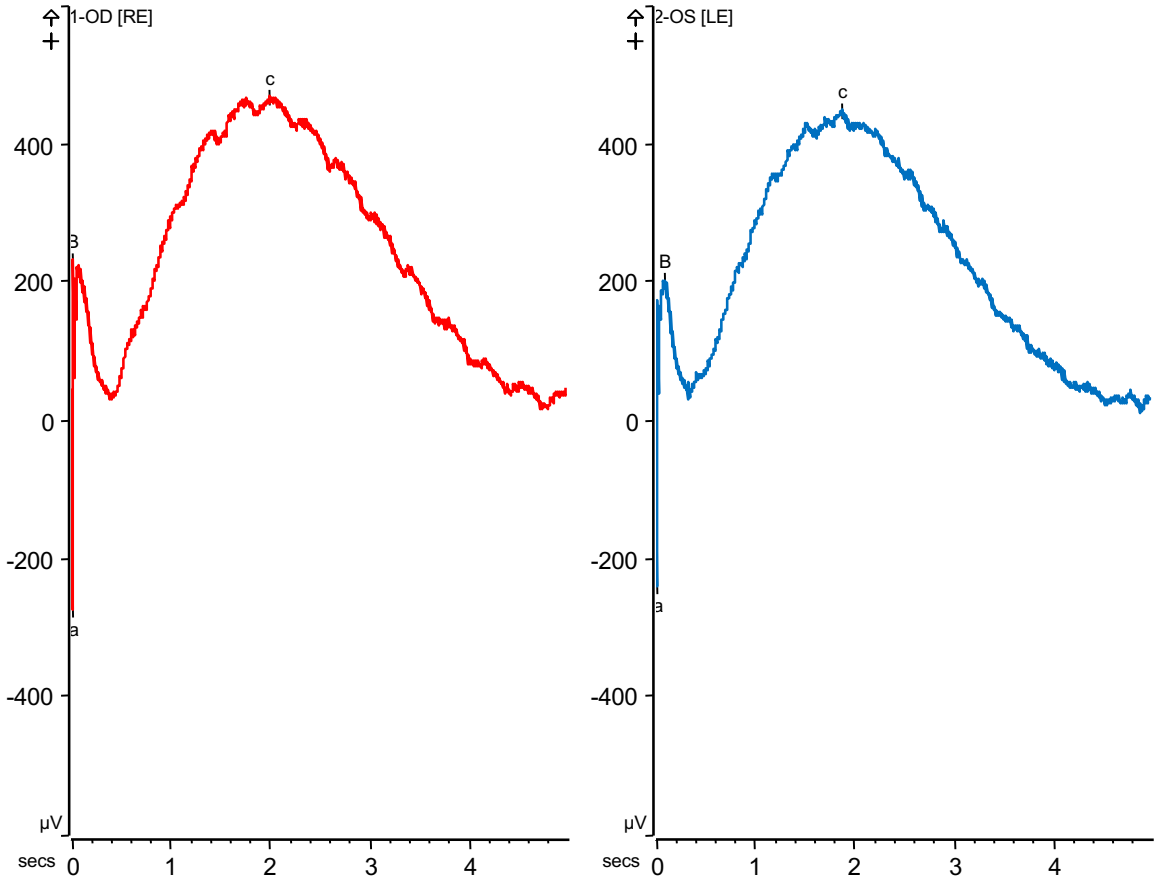
RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

Simultaneous flash ERG and VEP response pulls information from the retina and visual cortex simultaneously after presenting a 0.5 cd.s/m ^{2} flash of white light.

Protocol 6: C-Wave ERG

Celeris stimulator: Bright or Standard full-field



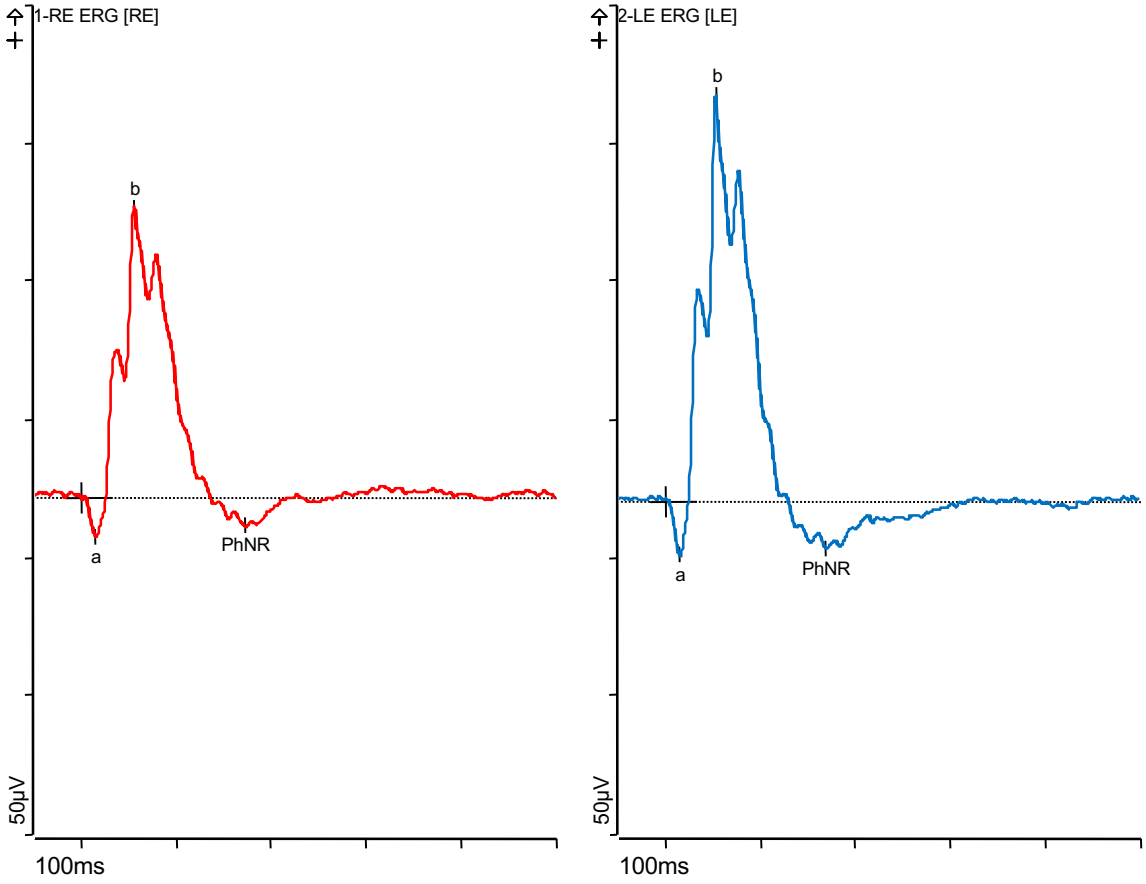
RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

Long exposure ERG used to detect RPE activity. 150 cd/m^2 for 100 ms

Protocol 7: Photopic Negative (PhNR) ERG

Celeris stimulator: Bright or Standard full-field



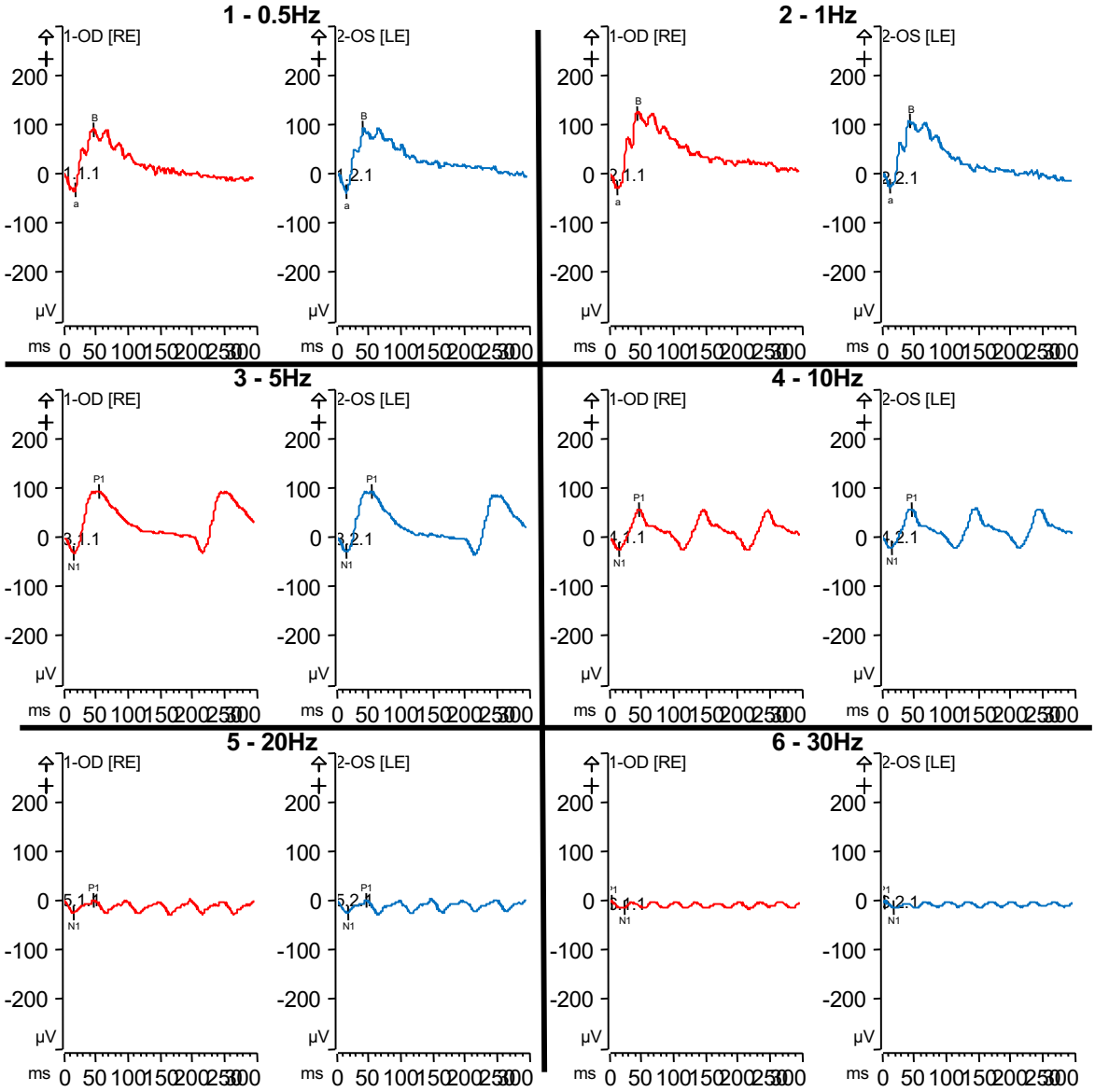
RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

White flash on green background to elicit ganglion cell response.

Protocol 8: Flicker Frequency Series

Celeris stimulator: Bright or Standard full-field



RED = Right Eye
BLUE = Left Eye

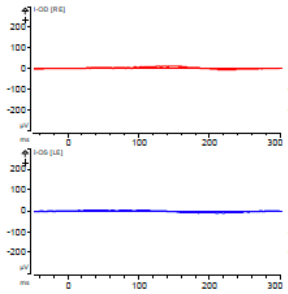
Animal tested: Mouse

Flicker stimulus increases frequency progressing 0.5, 1, 5, 10, 20, and 30 Hz.

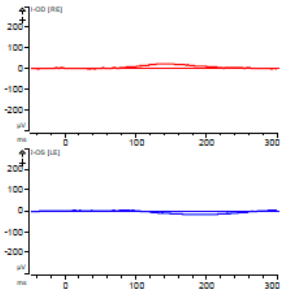
Protocol 9: Scotopic Threshold Response

Celeris stimulator: Dim full-field

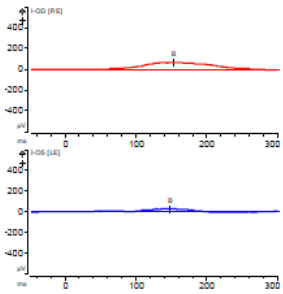
1: 1x10^{-7} cd.s/m^2 blue



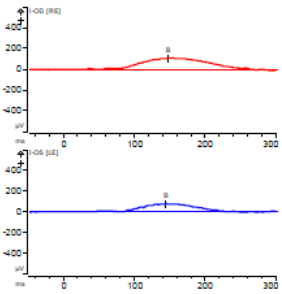
2: 5x10^{-6} blue cd.s/m^2



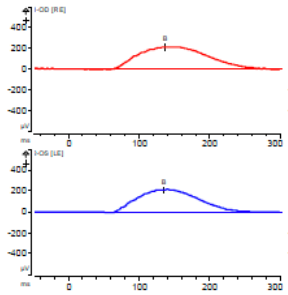
3: 1x10^{-6} cd.s/m^2 blue



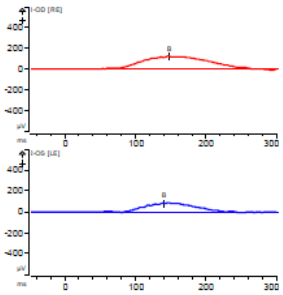
4: 5x10^{-5} blue cd.s/m^2



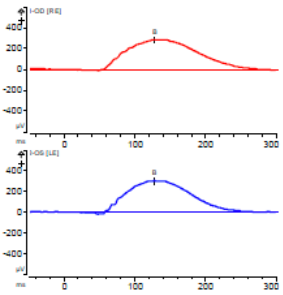
5: 1x10^{-5} cd.s/m^2 blue



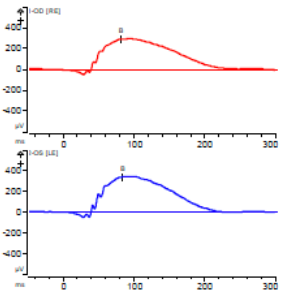
6: 1x10^{-4} white cd.s/m^2



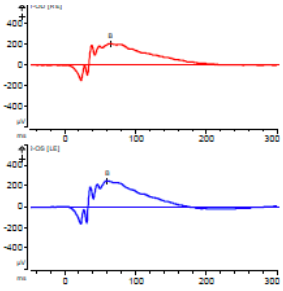
7: 1x10^{-3} cd.s/m^2 white



8: 1x10^{-2} white cd.s/m^2



9: 1x10^{-1} cd.s/m^2 white



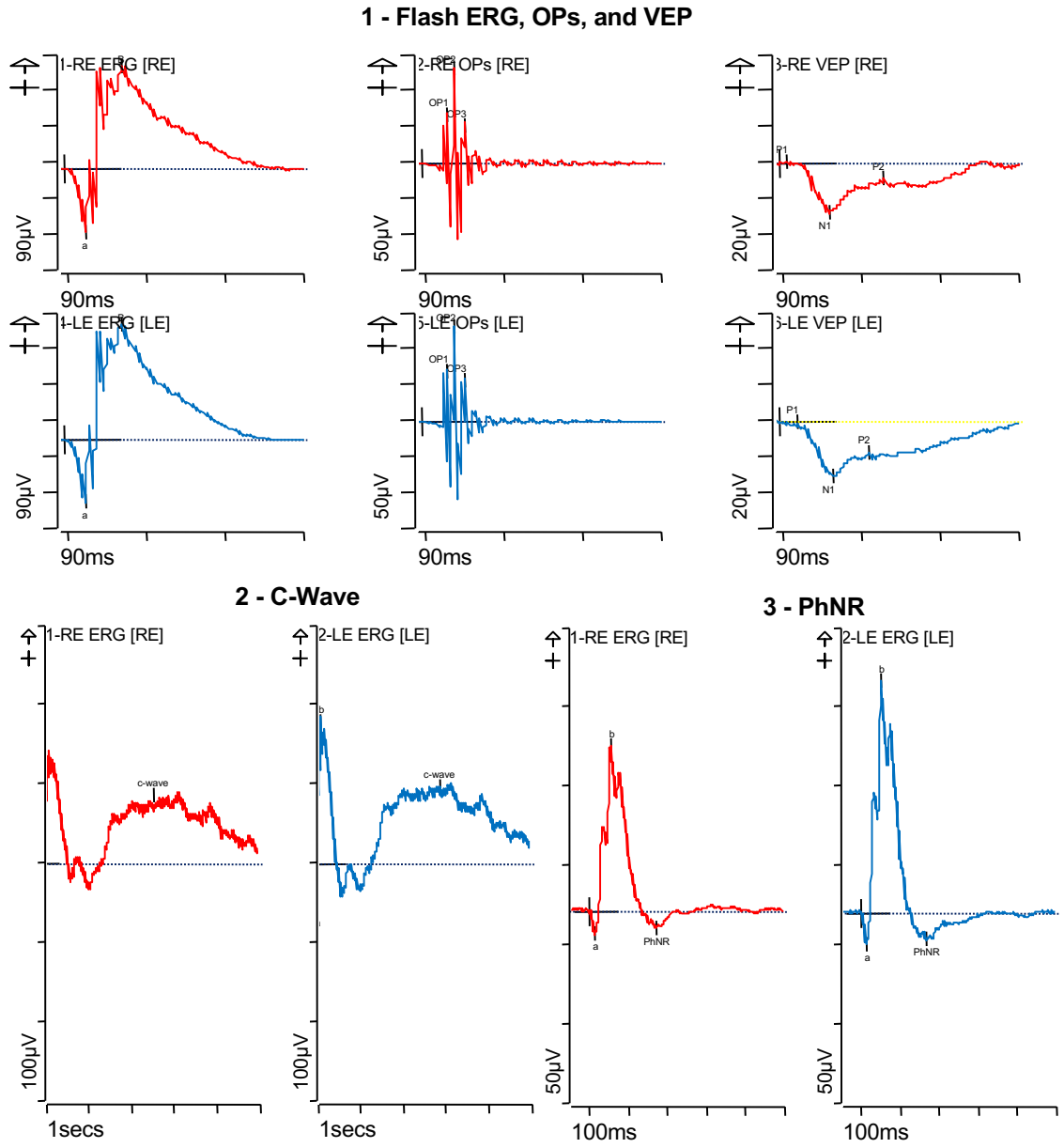
RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

Determine the scotopic threshold, when B-wave first detected.

Protocol 10: Viz Pathway

Celeris stimulator: Bright or Standard full-field



Animal tested: Mouse

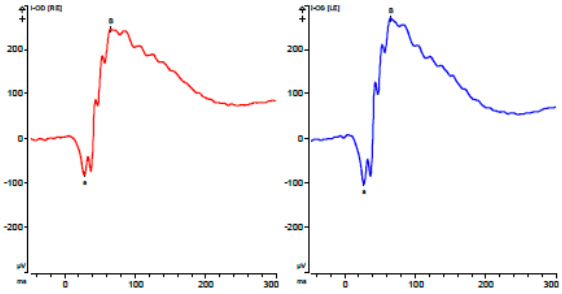
RED = Right Eye
BLUE = Left Eye

A test of the entire visual system starting with a single white flash that elicits ERG, OP, VEP response. Then a long exposure RPE, C-wave step. Followed by a ganglion cell, PhNR.

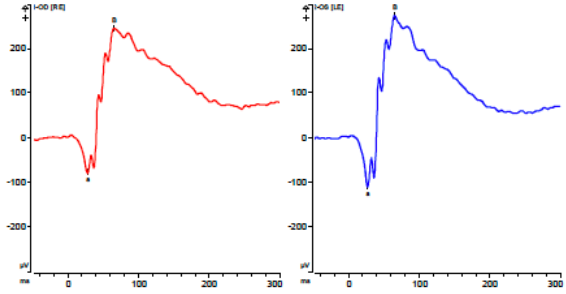
Protocol 11: Bleach Recovery (page 1 of 2)

Celeris stimulator: Bright or Standard full-field

Pre Bleach Probe #1

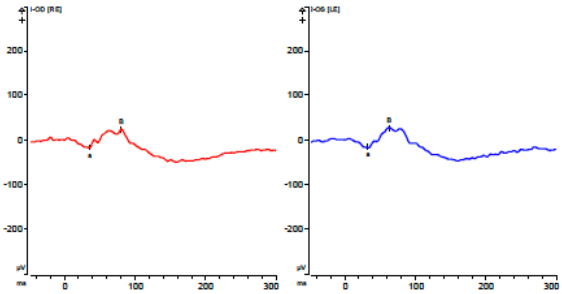


Pre-Bleach Probe #2

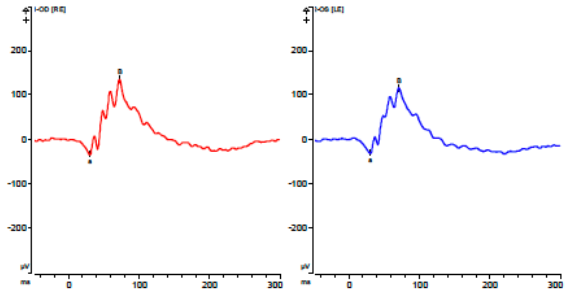


BLEACH

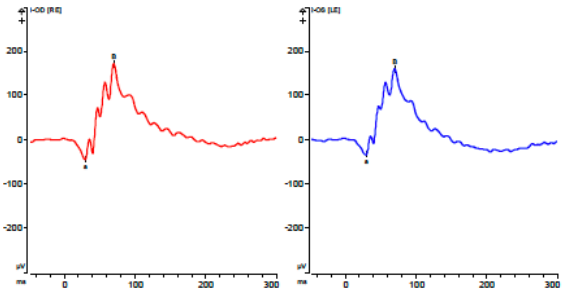
1 minute after bleach: 12% recovery



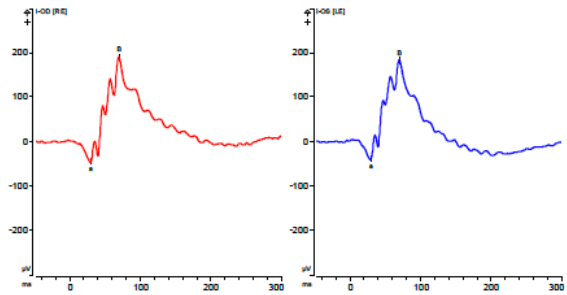
2 minutes after bleach: 45% recovery



3 minutes after bleach: 58% recovery



4 minutes after bleach: 65% recovery



RED = Right Eye
BLUE = Left Eye

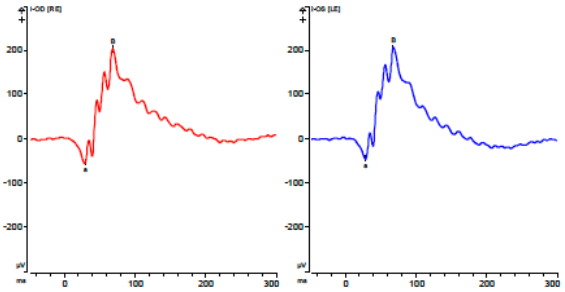
Animal tested: Mouse

Determine time to recover from a mild bleach by using pre- and post-bleach ‘probe’ flashes.

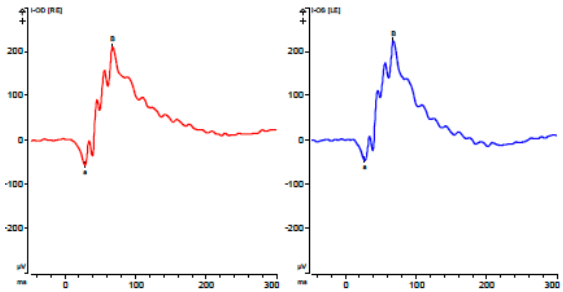
Protocol 11: Bleach Recovery (page 2 of 2)

Celeris stimulator: Bright or Standard full-field

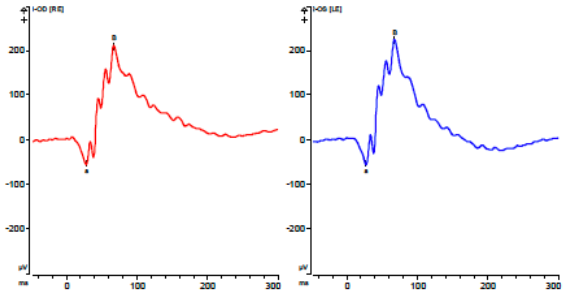
5 minutes after bleach: 73% recovery



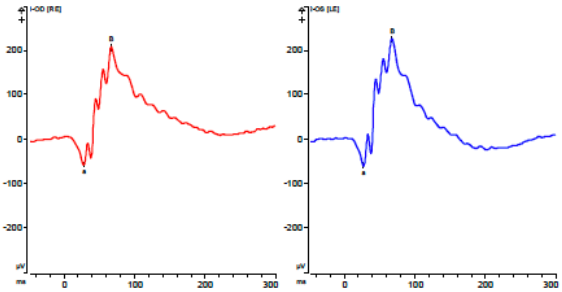
6 minutes after bleach: 76% recovery



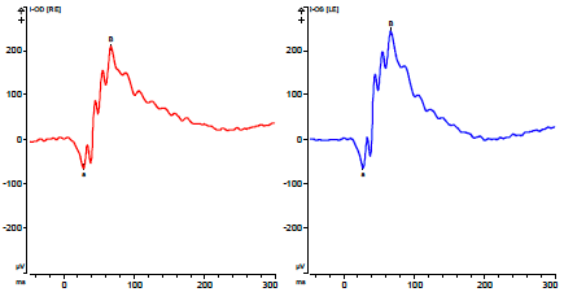
7 minutes after bleach: 78% recovery



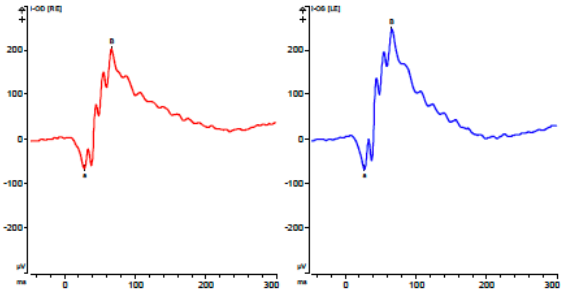
8 minutes after bleach: 79% recovery



9 minutes after bleach: 83% recovery



10 minutes after bleach: 83% recovery



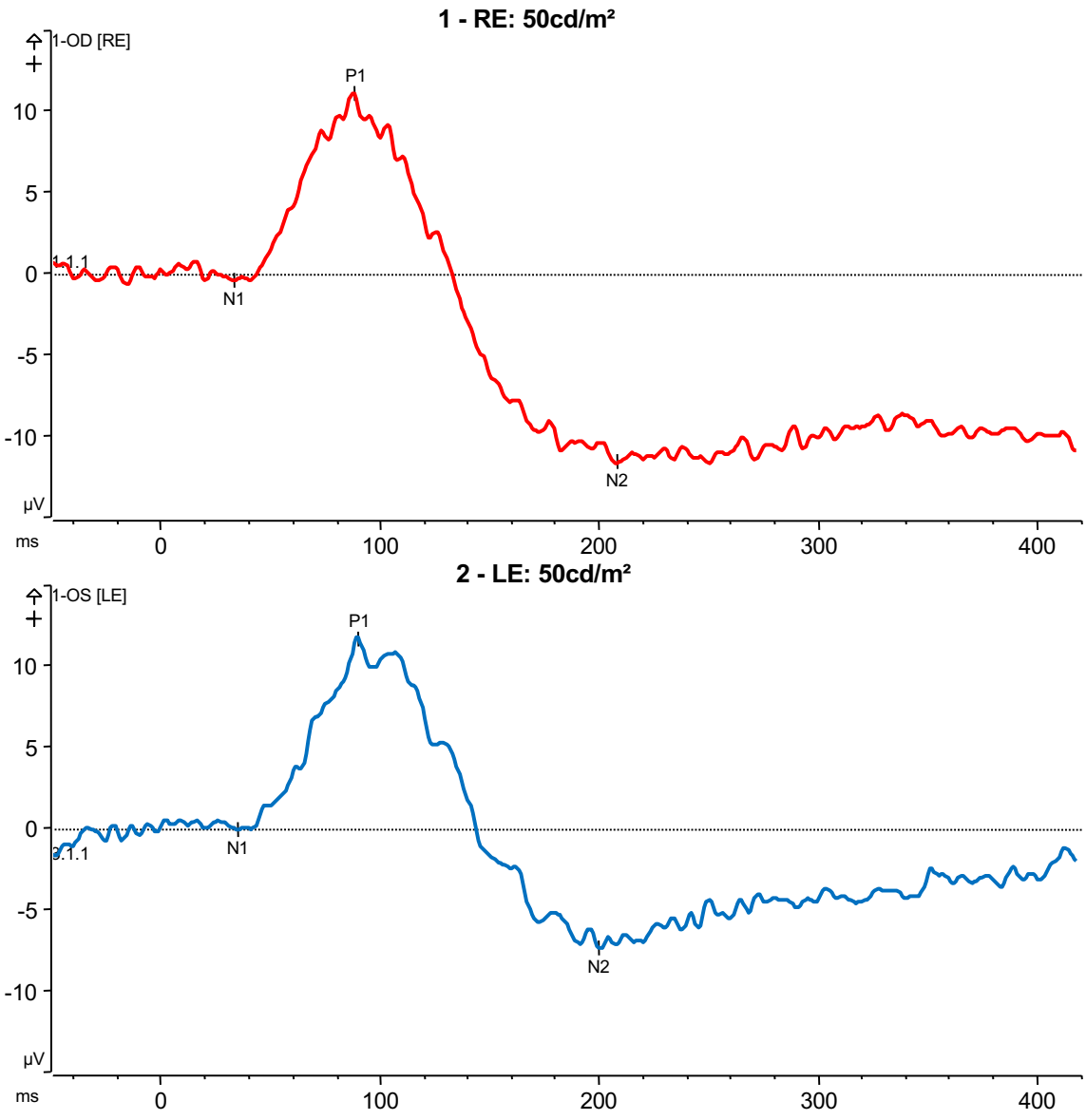
RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

Determine time to recover from a mild bleach by using pre- and post-bleach ‘probe’ flashes.

Protocol 12: PERG

Celeris stimulator: Pattern



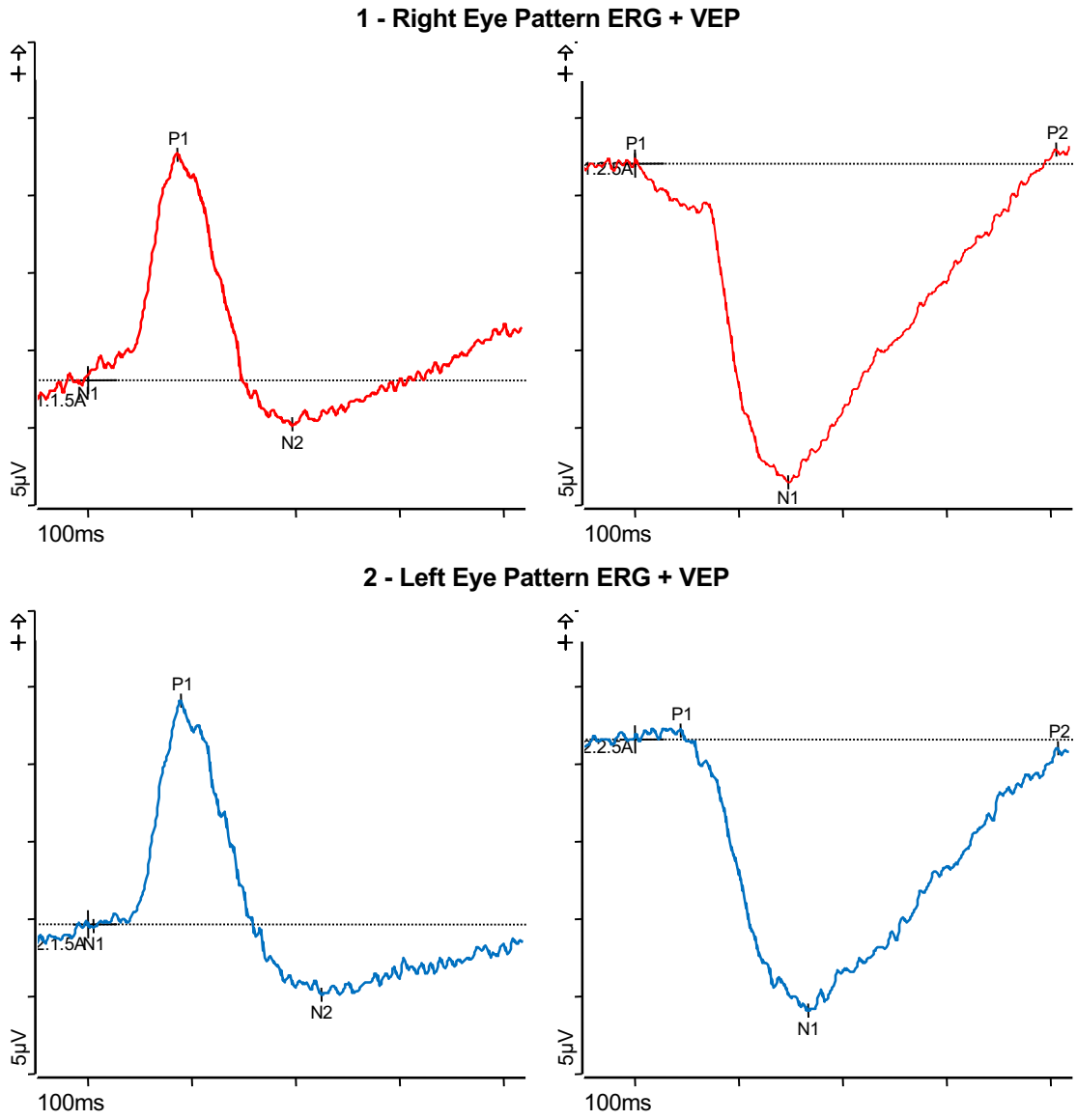
RED = Right Eye
BLUE = Left Eye

Animal tested: Mouse

Pattern Stimulus presents black and white gratings at spatial frequency to elicit ERG from a dark adapted mouse.

Protocol 13: PERG and pVEP

Celeris stimulator: Pattern



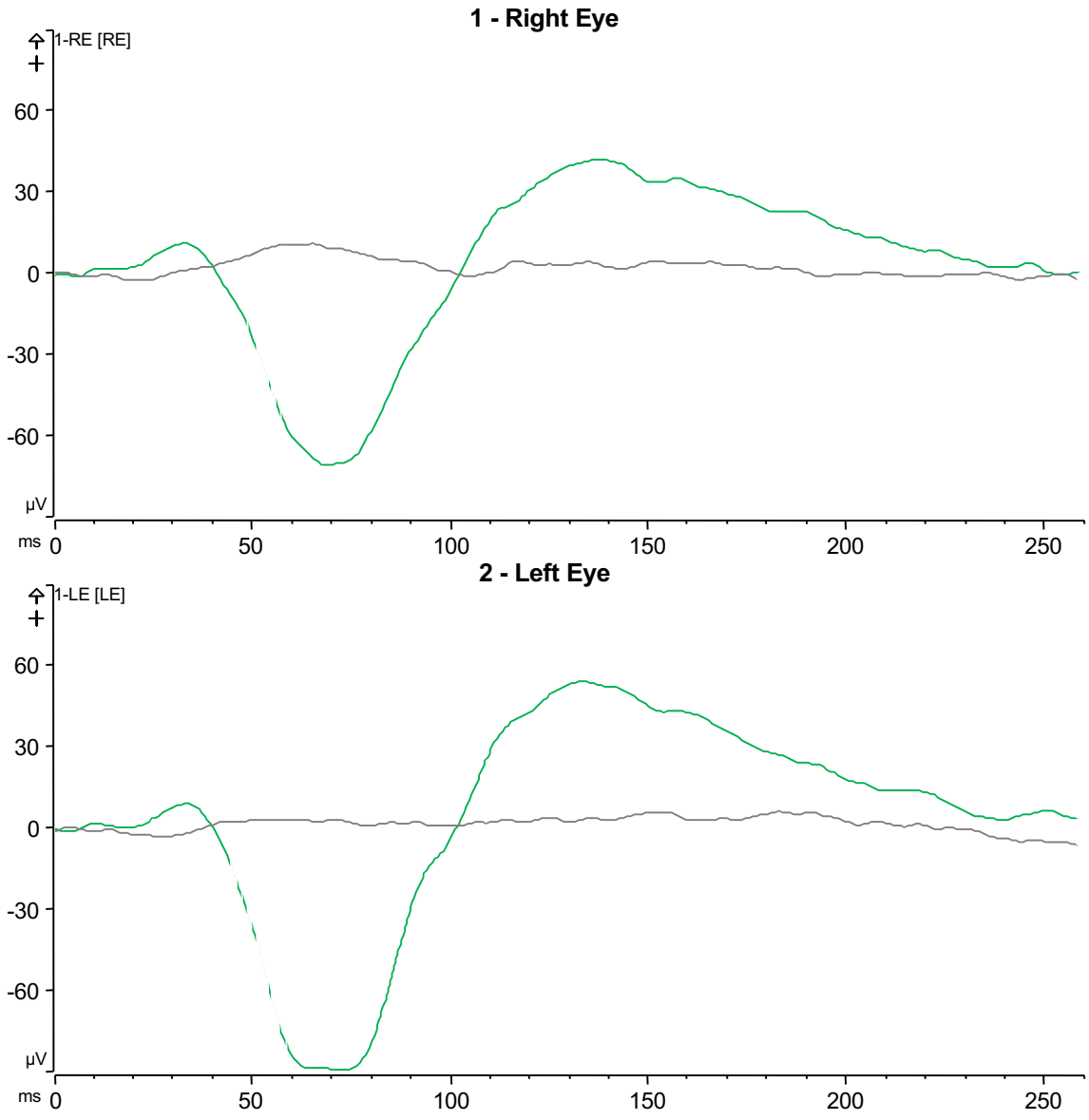
RED = Right Eye
BLUE = Left Eye

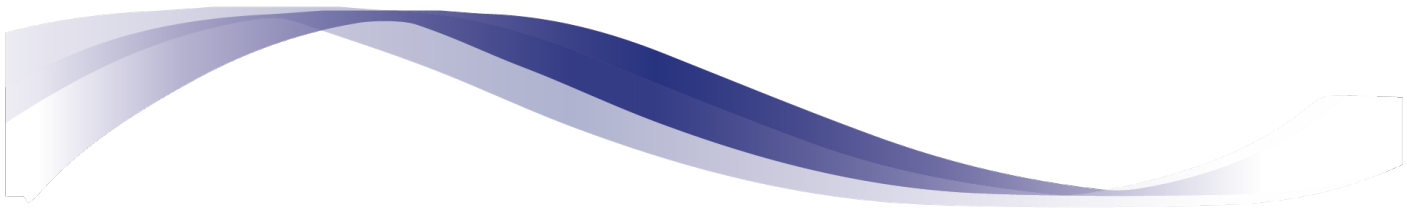
Animal tested: Mouse

Pattern stimulus simultaneously stimulates a response from retina and visual cortex using globe and subdermal electrode locations.

Protocol 14: Uniform Field

Celeris stimulator: Pattern

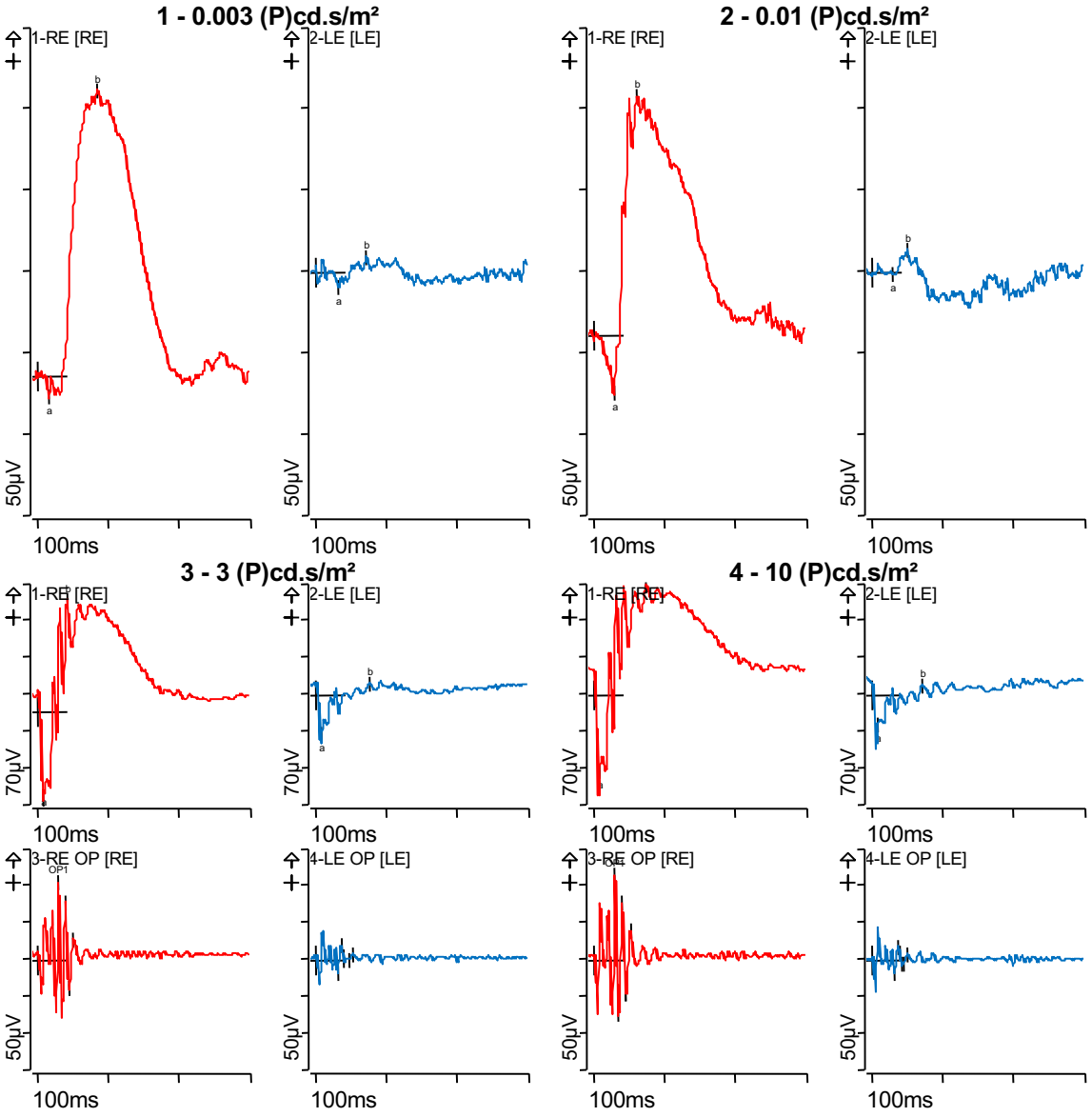




Animal Disease Models

Intravitreal Injection of Rotenone

Celeris stimulator: Bright or Standard full-field



RED = Right Eye
BLUE = Left Eye

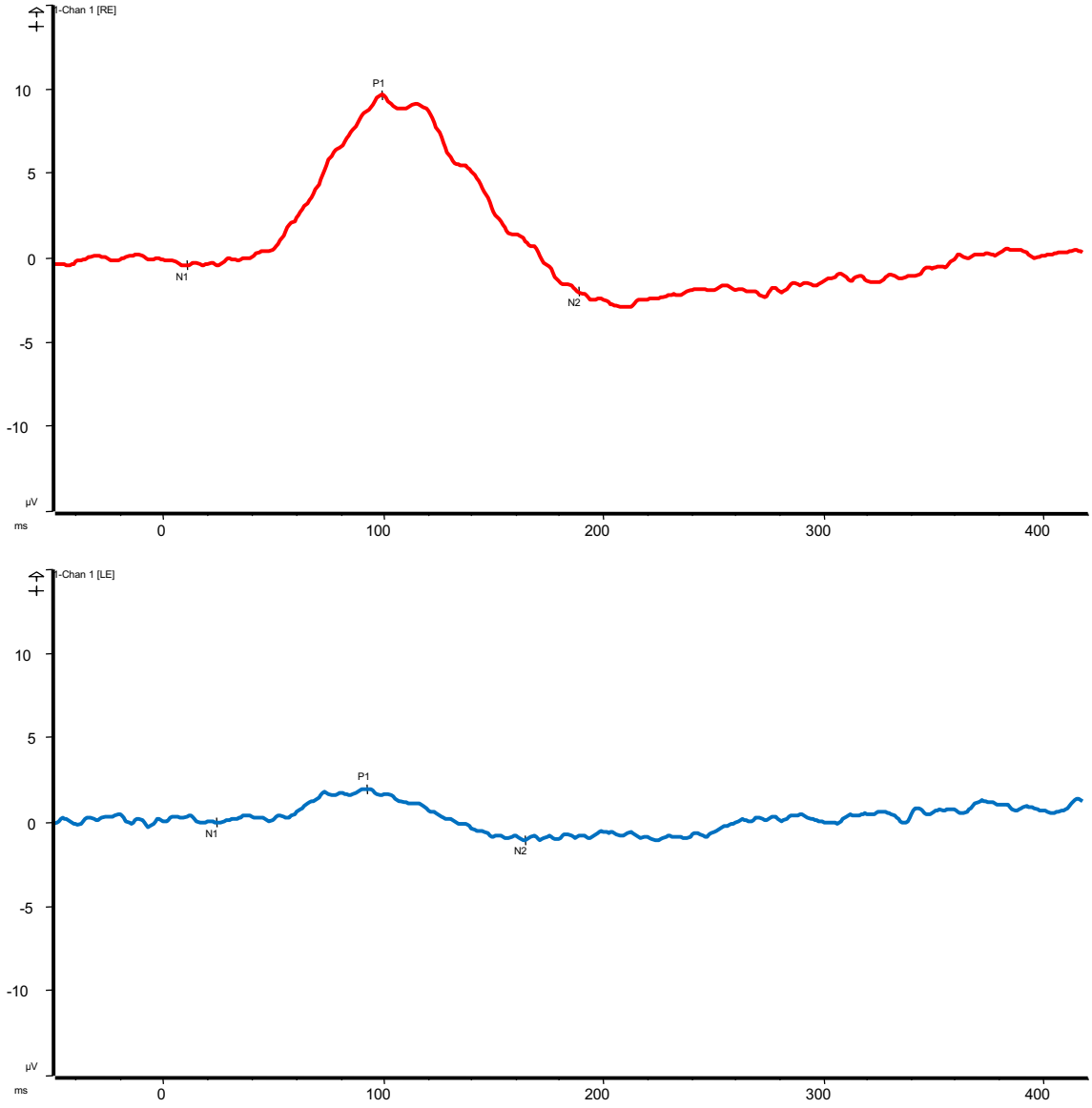
Dark Adapted Rodent with OPs

Intravitreal Injection of Rotenone-Left Eye

Observe: depressed a-wave, b-wave and OPs on Left Eye

Intravitreal Injection of Rotenone

Celeris stimulator: Pattern



RED = Right Eye
BLUE = Left Eye

Pattern ERG

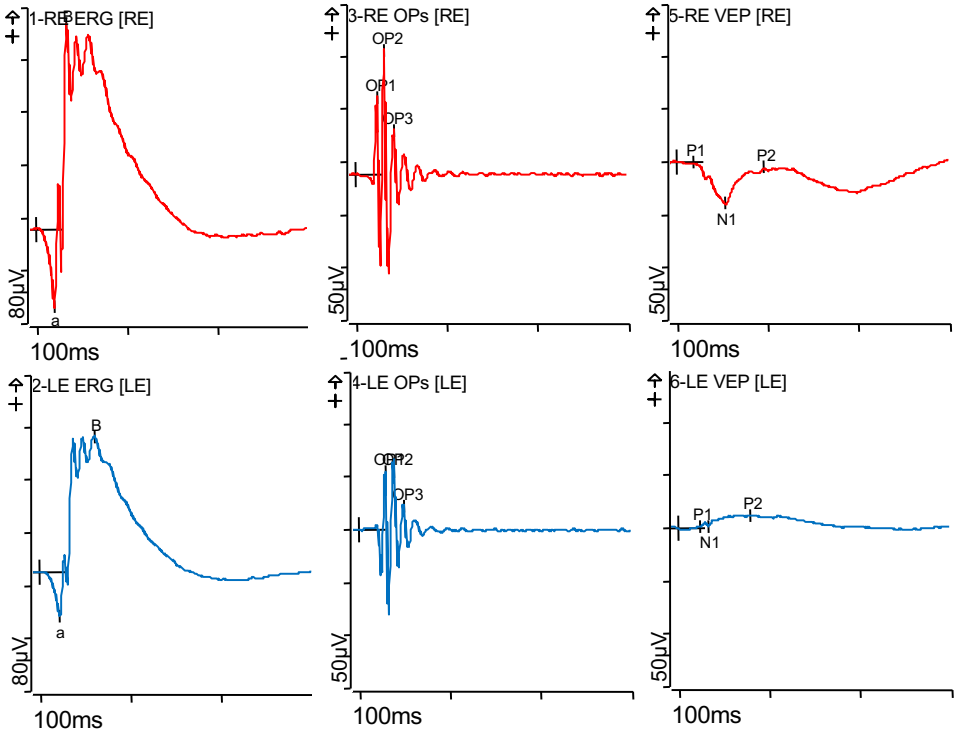
Intravitreal Injection of Rotenone-Left Eye

Observe: depressed P1 and N2 on Left Eye

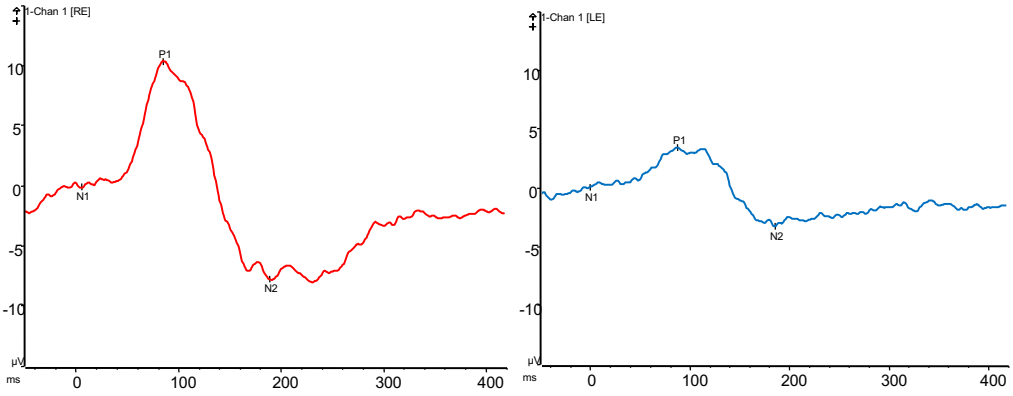
Optic Nerve Crush

Celeris stimulators: Bright or Standard full-field and Pattern

Simultaneous ERG and VEP: 12 weeks post optic nerve crush



Pattern ERG: 12 weeks post optic nerve crush



RED = Right Eye
BLUE = Left Eye

Optic Nerve Crush – Left Eye

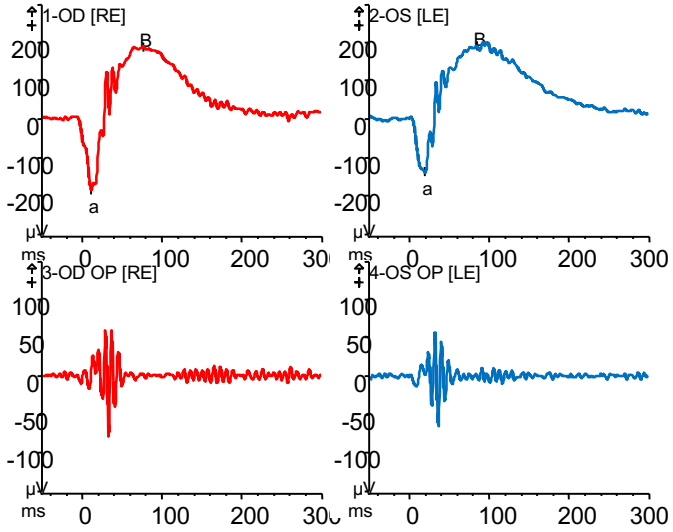
Observe: depressed fVEP N1 and pVEP P1/N2 with a healthy a- and b-wave ERG on Left Eye

Glaucoma

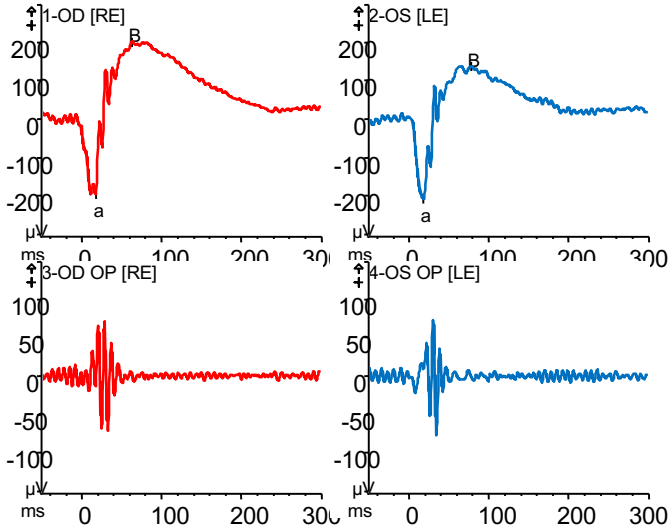
Celeris stimulators: Bright or Standard full-field and Pattern

Dark Adapted ERG + Ops: Magnetic Microbead Surgery Left Eye; 3weeks post surgery

Treated Mouse

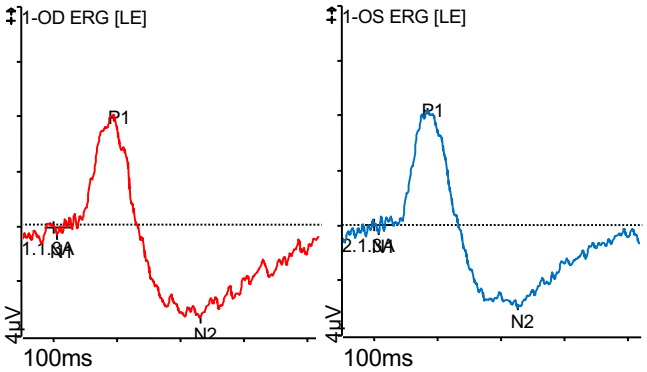


Untreated Mouse

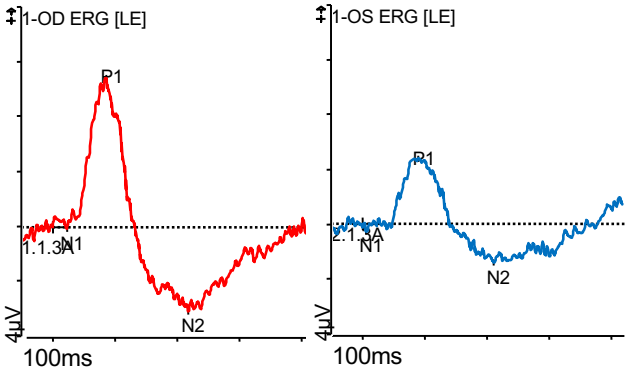


Pattern ERG: Magnetic Microbead Surgery Left Eye; 3weeks post surgery

Treated Mouse



Untreated Mouse



RED = Right Eye
BLUE = Left Eye

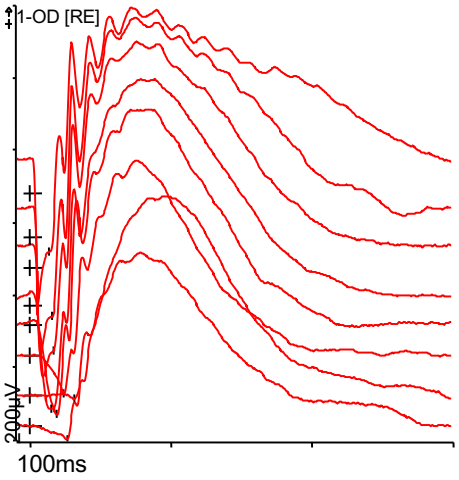
Observe: depressed pVEP P1/N2 on untreated Left Eye; all other waveforms normal

Retinitis Pigmentosa

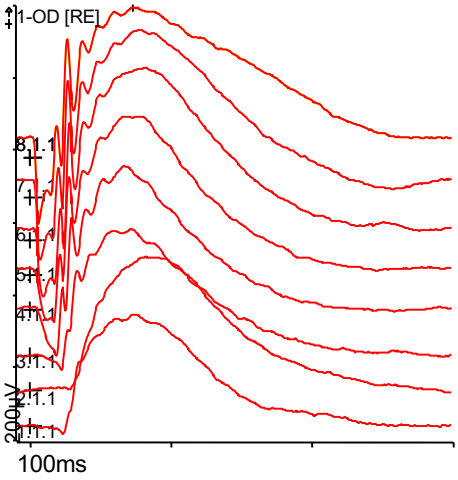
Celeris stimulators: Bright or Standard full-field and Pattern

Wild Type normal Long Evans Rat

4 weeks

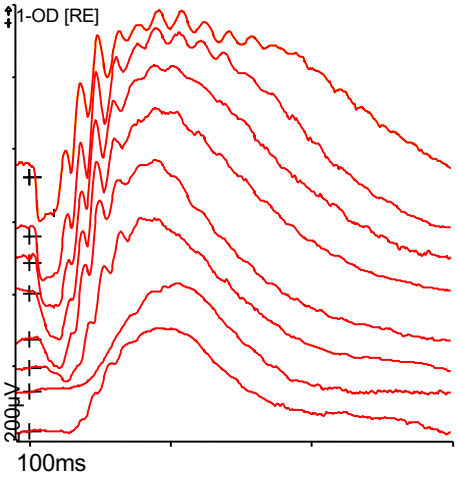


20 weeks

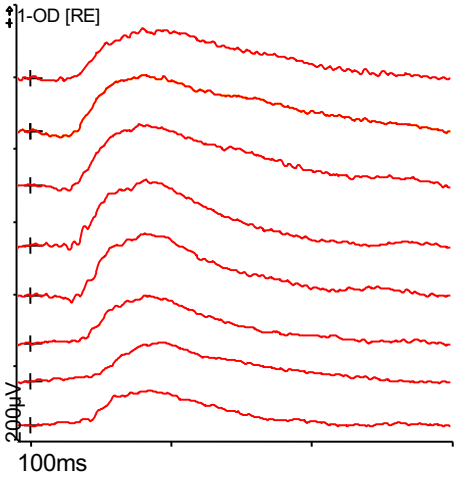


P23H Long Evans Rat Photoreceptor Degeneration

4 weeks



20 weeks



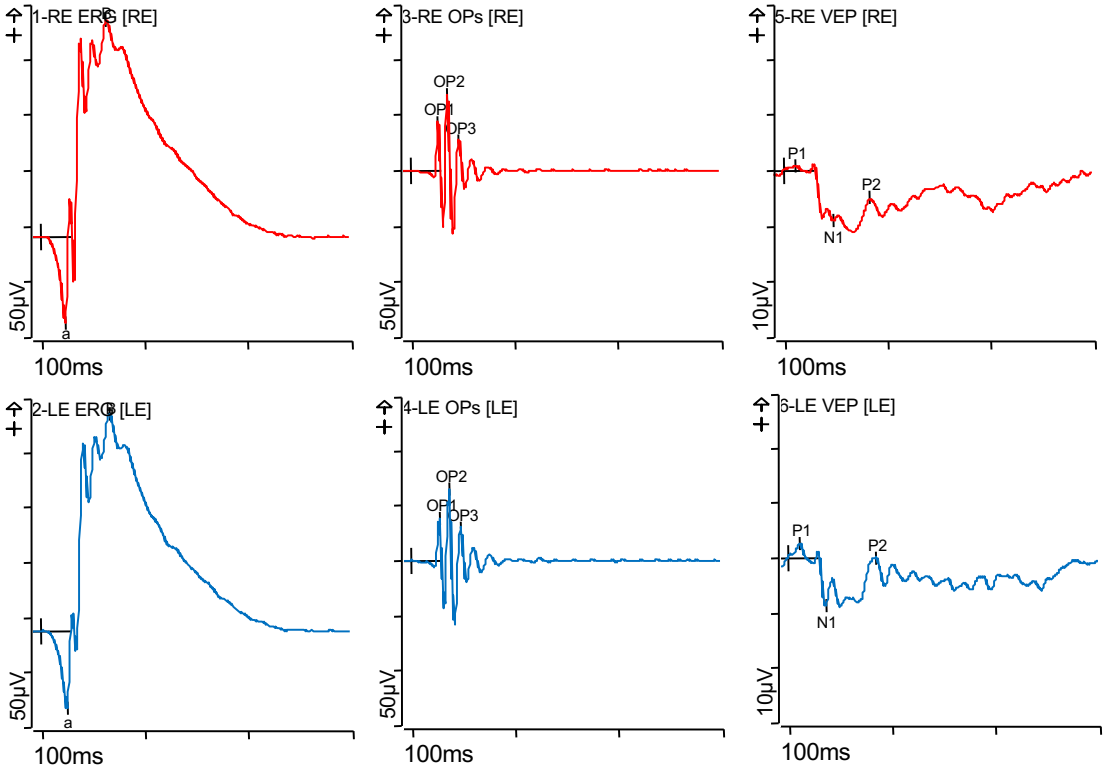
Dark adapted Intensity Series

Observe: ERG responses of P23H model animal, 20 weeks after treatment

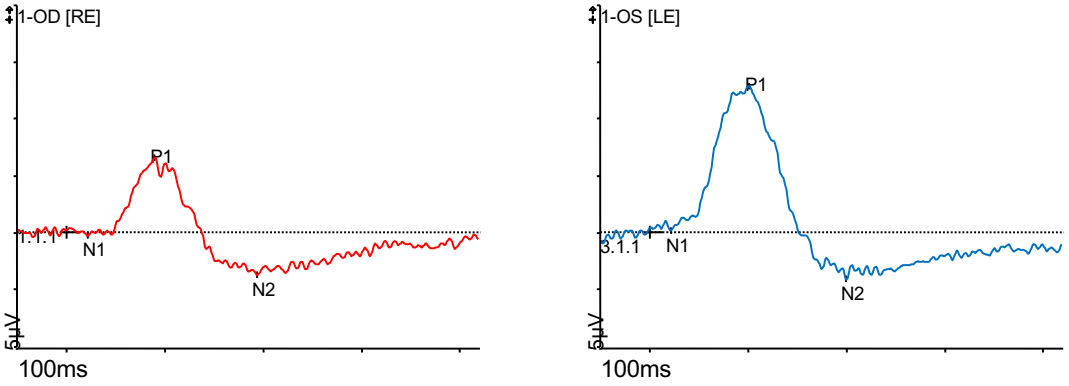
Leber's Hereditary Optic Neuropathy

Celeris stimulators: Bright or Standard full-field and Pattern

Simultaneous ERG and VEP: 6 months post LHON induction

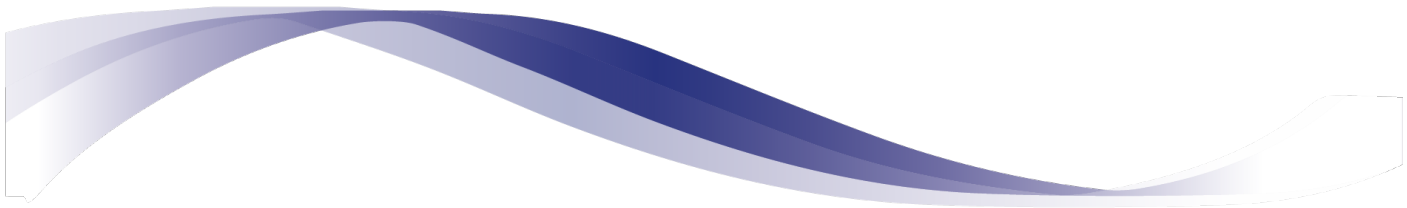


Pattern ERG: 6 months post LHON induction



RED = Right Eye
BLUE = Left Eye

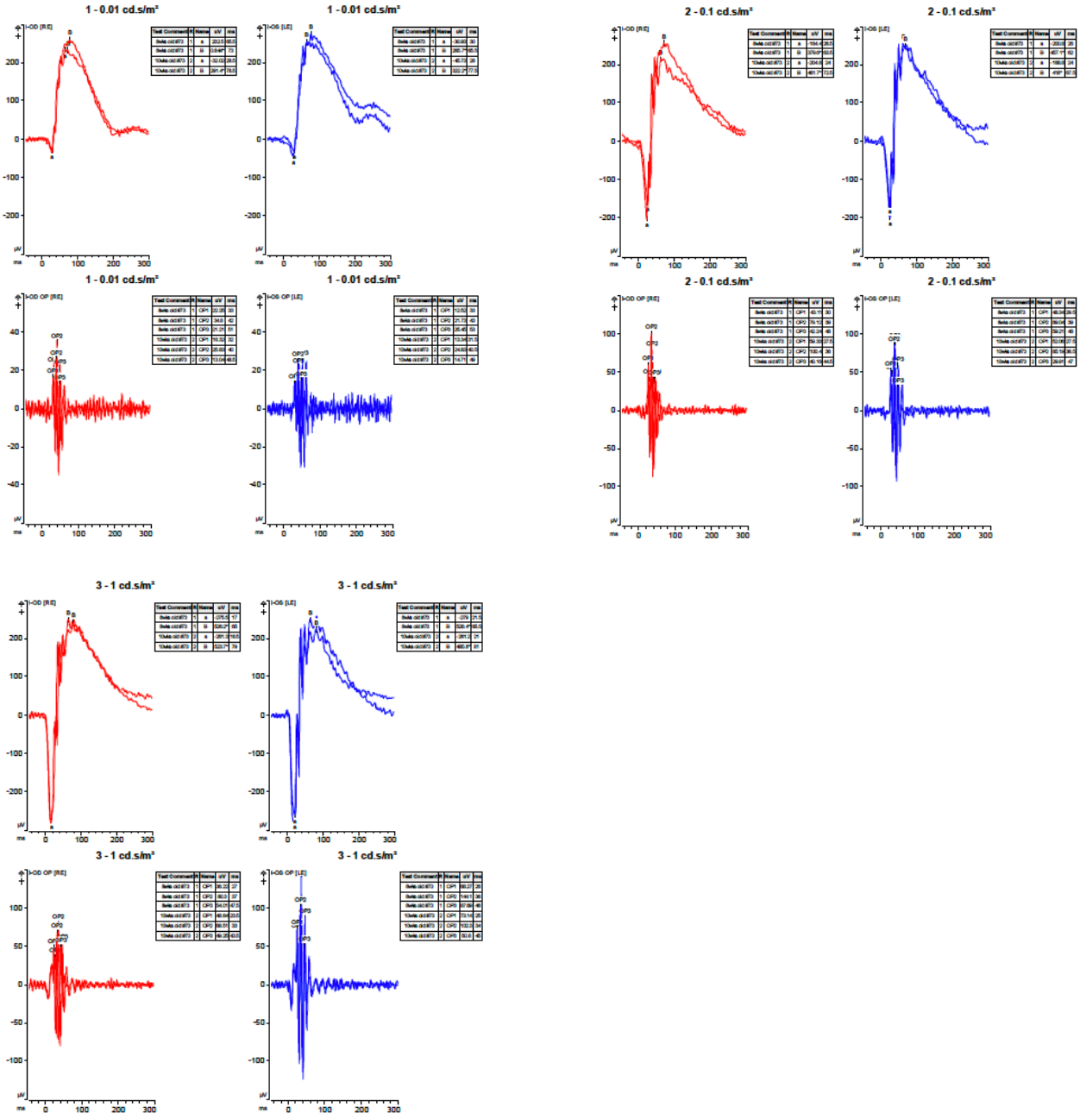
Observe: depressed pVEP P1/N2 on LHON model Right Eye; all other waveforms normal



Protocol Repeatability Examples

Protocol: Dark Adapted ERG + Ops

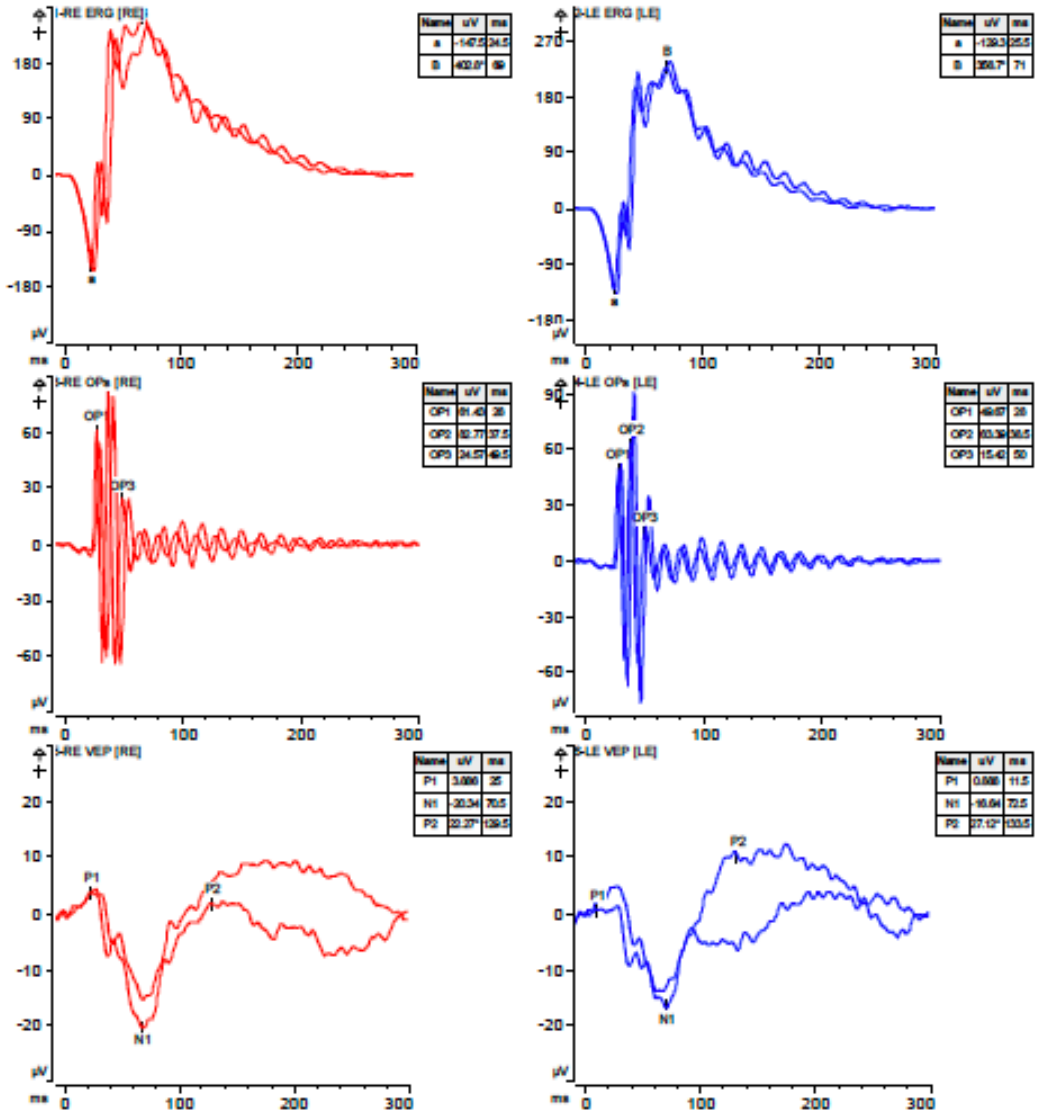
Celeris stimulator: Bright or Standard full-field



Observe: with good procedures, the ERG waveforms will be quite repeatable (test above: same mouse, tests are 2 weeks apart)

Protocol: Simultaneous ERG and VEP

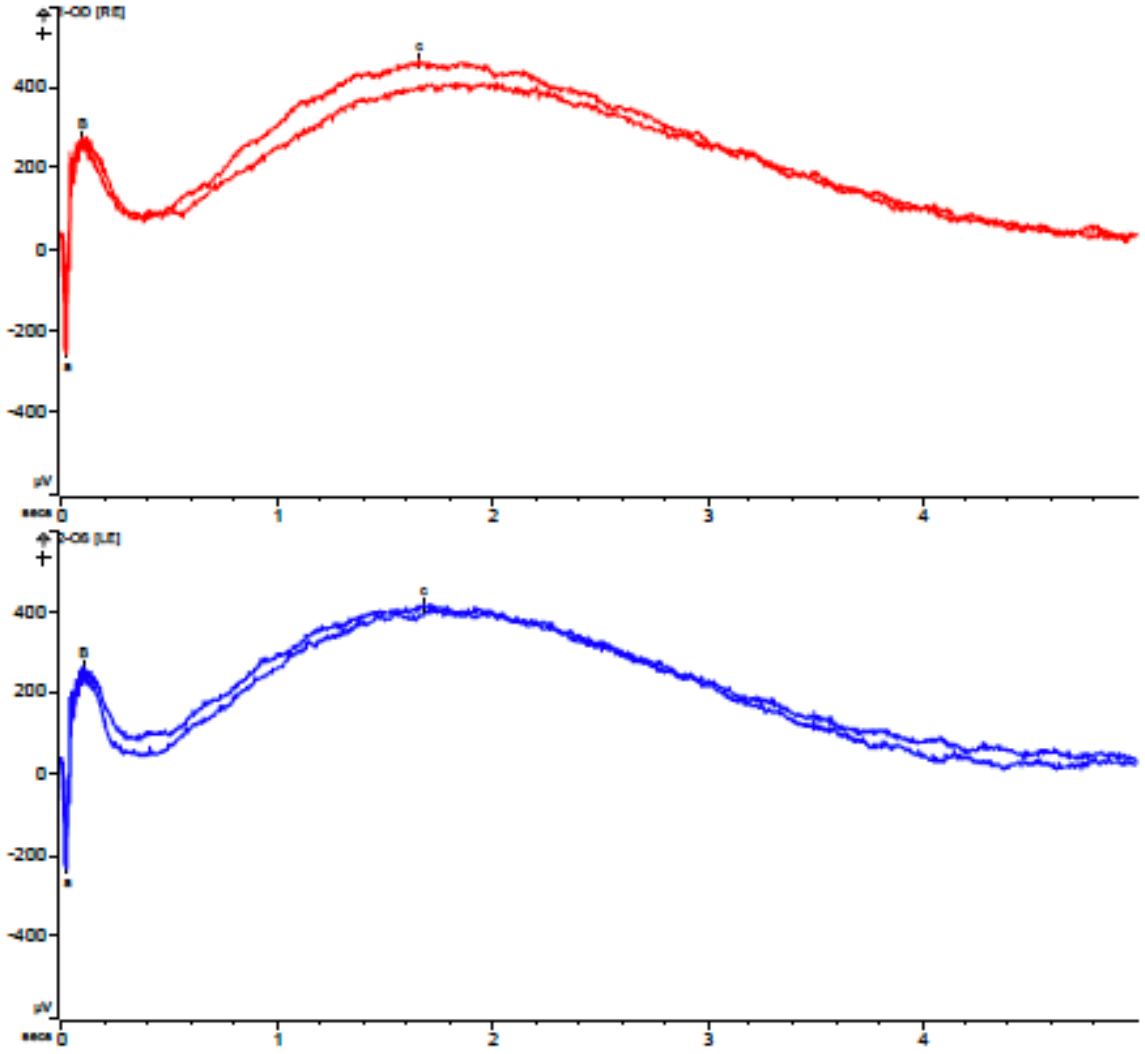
Celeris stimulator: Bright or Standard full-field



Observe: with good procedures, the ERG and flash VEP waveforms will be quite repeatable (test above: same mouse, tests are 2 weeks apart)

Protocol: C-Wave ERG

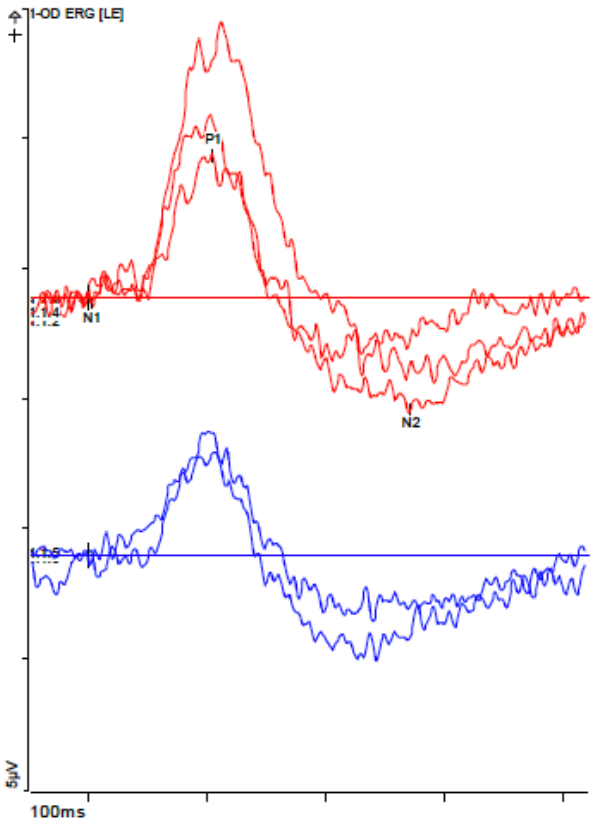
Celeris stimulator: Bright or Standard full-field

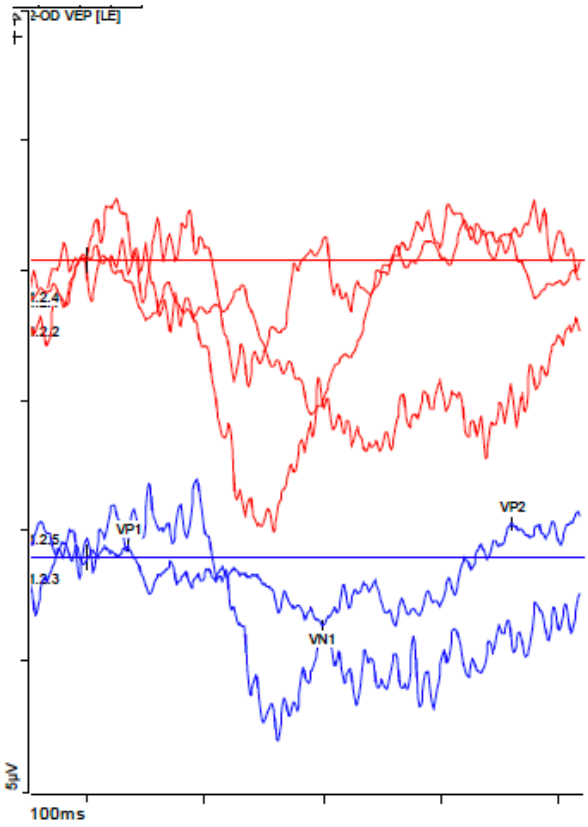


Observe: with good procedures, the C-wave ERG waveforms will be quite repeatable (test above: same mouse, tests are 2 weeks apart)

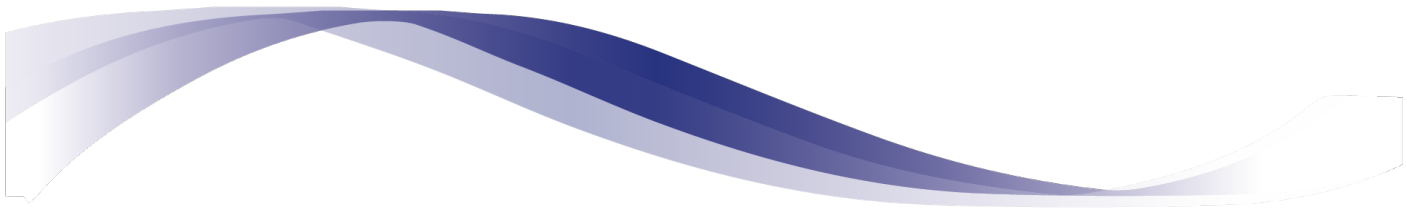
Protocol: PERG and pVEP

Celeris stimulator: Pattern





Observe: with good procedures, the PERG waveforms will be quite repeatable; pVEP waveforms will not be as repeatable (test above: same mouse, tests are 2 weeks apart)



Thank you!

Contact us at:
support@diagnosysllc.com