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Melanopsin pathway control in the human retina and the relationship with traumatic photalgia

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Introduction: The melanopsin light-signaling pathway is a recently-discovered addition to the light-processing capabilities of the vertebrate eye. Human melanopsin responses have been measured largely through pupillometric responses. Spectral analysis of electroretinographic (ERG) responses provides a further capability of assessing the functionality of the melanopsin pathway in human. Our results suggest that there is a fast melanopic response contributing to the ERG at high intensities.

Methods: To gain insight into the process of visual information in photalgic eyes, we recorded electroretinographic (ERG) from facial electrodes. High-quality ERG responses for full-field stimulation as a function of wavelength and intensity were obtainable with the approach of recording wavelength-specific ERG responses to whole-field chromatic stimuli under a full range of light-adaptation conditions. Stimulation conditions were full-field R (610 nm), G (540 nm), B (480 nm) and W (R+G+B) stimulation of 2.5 Hz square-wave modulation (200 ms on/ 200 ms off) with a maximum intensity of 265 cd/m^2 (W). Signals were recorded from controls and a population of individuals with photalgia subsequent to mild traumatic brain injury.

Results: Light-adapted ERGs in controls exhibit similar properties to dark-adapted ERGs as a function of flash intensity; with the b-wave speeding up from a peak time of ~250 ms when dark-adapted to ~40 ms when maximally light-adapted with a compressive reduction in the amplitude function at the higher intensities. The results at all test wavelengths conform to a single pair of functions (amplitude and time-to-peak) of melanopic intensity under most conditions, which we term the "main sequence" for ERG amplitude and times-to-peak as a function of intensity. These functional properties were significantly different across the population of photalgic individuals, who showed markedly reduced amplitudes and delayed b-wave peaks relative to the controls.

Conclusion: To extend the measurement of human melanopsin responses beyond pupillometric responses, we have developed an approach for spectral analysis of ERG responses to expand the capability of assessing the functional role of the melanopic pathway in humans. Our results suggest that there is a fast melanopic response contributing to the light-adapted ERG, with a peak time comparable with the rod and cone responses under these conditions. This melanopic response showed marked amplitude reductions and delays in the photalgic patients, potentially providing the first objective biomarker for photalgia.

Biography

Christopher W Tyler is a visual neuroscientist specializing in visual and oculomotor function and disorders who joined City University London in 2013. He previously worked at several universities in the United States and has been a long-established researcher at the Smith-Kettlewell Eye Research Institute, San Francisco, where he established its Brain Imaging Center. Christopher Tyler received his training in Experimental Psychology at the Universities of Leicester, Aston and Keele before taking postdoctoral fellowships at Northeastern University, Boston, University of Bristol and Bell Laboratories. He then took up a position at the Smith-Kettlewell Eye Research Institute, where he retains an affiliation, and has taught courses at Northeastern, UCLA, UC Santa Barbara, UC Berkeley and the University of Paris along the way. He has had widespread collaborations across the globe and has given numerous keynote addresses to scientific meetings across many disciplines, from microscopy to Renaissance art.

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