- Friday, July 24, 1998
  Electroretinogram, Spectral Sensitivity and Glaucoma

  6.0 Harry Sperling gave us a talk on his research on cones, especially the short-wavelength cones, and his more recent work on creating an animal model for glaucoma. The following notes have now (Oct 7th, 1998) been altered slightly to task into account Harry's comments.

  6.1.1 Sperling introduced us to some of the fancy optical equipment he had designed and built for presenting monochromatic lights of precisely known luminance and duration to human and monkey subjects.

  6.1.2 The detection threshold curve for monochromatic light show three little peaks at around 440, 510 and 610 nanometers. This threshold curve fits the spectrophotometric curve for the photopigments of the cones for the short wavelength cone type, but is quite different from the photoabsorption properties of the other two cones. The behavioural and spectrophometric data could be reconciled by a model, published by Sperling and Herworth in 1971 postulating weighted opponency between the medium and long wavelength cones in two independent channels and an independent short wavelength mechanism.

  6.1.3 This model stood up to more rigorous testing involving measuring increment detection thresholds against monochromatic backgrounds. This technique allowed the cone mechanisms to be seen in isolation and supported the weighted opponency model.

  6.2 Comparison of the detection of a monochromatic flash coming on with the detection of its offset (ie. a steady background suddenly dimming) suggested that the short wavelength mechanism is predominantly 'on-type' and does not respond (and thus does not contribute to the response to) offset of a monochromatic light. (This claim has been disputed eg. by Porcini and Smith, but Sperling gave reasons for not being convinced by the opposing data)

  6.3 The electroretinogram (ERG) measures the voltage between the front and back of the eye from which information about the retina (a major contributor to this electrical activity) can be deduced. It is similar to the electroencephalogram (EEG) in this regard which measures voltages over the skull from which information about brain activity can be deduced.

  6.3.1 In response to the onset of a monochromatic light the ERG shows an initial -ve response within the first 10-20 msecs (called the 'a' wave and attributed to the activity of the photoreceptors directly), followed by a +ve peak at about 50 msecs (called the 'b' wave and attributed to the bipolar and Muller cells). Then there is a -ve plateaux (called the 'c' wave which reflects retinal ganglion cell (RGC) activity).

  6.3.2 The variation in the amplitude of the 'a' wave with wavelength matches the scalar sum of the medium+long cones whereas the amplitude of the 'b' component shows a notch indicating a subtractive interaction between these systems.

  6.3.3 Application of strychnine which blocks glycine (an inhibitory retinal neurotransmitter) has no effect on these waves but application of bicuculline which blocks GABA (another inhibitory retinal neurotransmitter) changes the 'b' wave pattern into an 'a' wave pattern. This indicates that the medium/long interaction has an inhibitory component, but does not isolate it to a particular retinal layer since both horizontal and amacrine cells use GABA.

  6.3.4 The 'c' wave depends on the presence of a visual pattern. By constructing a checkerboard out of alternating spectral and white areas, the spectral properties of the 'c' wave could be ascertained. The curve seems to match the behavioural detection thresholds (cf 6.1.2).

  6.4 Glaucoma is an important disease which is a leading cause of blindness. It is often (but not always) associated with a raised intra-ocular pressure. By the time it is detected by conventional perimetry it is usually too late, with up to 50% of the retinal ganglion cells already dead. Blue/yellow confusion is amongst the earliest signs known suggesting that the short wavelength mechanism goes first.

  6.4.1 Sperling is trying to make an animal model for glaucoma by artificially raising the intra-ocular pressure of monkeys. Preliminary data suggests that in these animals sensitivity to short wavelength light, as measured with the pattern ERG, was was selectively impaired, giving hope that his is a successful model and that there might be a successful early detection method using the pattern ERG on patients.

  Harry G. Sperling