- Friday, April 3, 1998
  Seeing Variable Stars

1.0 These are the minutes of the YORKVIS meeting held on Friday April 3rd 1.1 There are three YORKVIS events currently planned for you to look forward to:

1.1.1 Thursday April 30th; ARVO rehearsal talks in 061 BSB as follows: 10.00 INDEPENDENT ENCODING OF SPEED AND DISPLACEMENT FOR A MOVING CYCLOPEAN GRATING. Authors: R.P. KOHLY, D. REGAN

10:30 THE RELEVANCE OF HEADING AND MOTION-IN-DEPTH DATA COLLECTED WITH CONSTANT-SIZED DOT DISPLAYS. Authors: R. GRAY, D. REGAN

11:00 DEPTH FROM MOVING UNCORRELATED RANDOM-DOT DISPLAYS. Authors: I.P. HOWARD, R.S. ALLISON, A. HOWARD

1.1.2 Tuesday May 5th; ARVO posters rehearsal in 061 and corridor(!)

1.1.3 Friday May 22th, 1998 Stephen Palmisano (post-doc with Ian Howard) "Perceiving self-motion in depth: the roles of stereoscopic, changing-size, ground plane and jitter information" (abstract) 10am 061 BSB

1.2 Please feel free to offer to give a YORKVIS yourself (as you see from the above, we do not intend to break for the summer) or to invite anyone. There are no funds at the moment to invite speakers but if they are visiting anyway, and you would like them to give a seminar...

1.3 Let me take this opportunity to remind them as are interested that the deadline for Neuroscience Abstracts is Monday April 27th.

2.0 The YORKVIS that was given on April 3rd was by Peter Hallett of the Physiology Dept., U of Toronto. He talked about 'seeing variable stars'. 2.1 Peter started off with an atmosphere-evoking description of the requirements of amateur star-gazing. I think it was the cut-off mitts that got me out there.

2.2 There are a number of tasks that variable star watchers indulge in. Such as looking for new stars, stellar eclipses etc.. They have their own society (AAVSO, the American Association of Variable Star Observers). The task Peter concentrated on was estimating the magnitude of variable stars.

2.3 The magnitude of a star is defined (after Hipparchus) as a relative measure. One magnitude of brightness difference between two stars is defined as a brightness ratio of 2.5 times. Thus a star of magnitude -1 is 2.5 times as bright as a star of magnitude 0 and 2.25*2.5=6.25 times as bright as one of magnitude 1 etc. A magnitude can be expressed as a logarithmic DIFFERENCE of log (2.5) = 0.4 log units. The scale is anchored to some standard reference stars such that the brightest star (Sirius, the dog star) has a magnitude of -1.42 for example.

2.4 The basic strategy of variable star observers is to find a star of known magnitude nearby and compare the brightness of the variable star to this reference. The data thus collected forms part of a massive database. Apart from AAVSO members, another major contributor to this database is from photoelectric measurements.

2.5 The problem is that since brightness is a perceptual measure, its judgement can be affected by a number of things. Can we apply modern visual science to help correct for such factors?

3.0 There are three main factors, spectral content, area, and dark adaptation state. 3.1 Spectral content. Starlight, even from a coloured star, is essentially broadband, that is it contains energy at all wavelengths. We can measure sensitivity (thresholds) across the spectral range for four things: (i) rods, (ii) foveal cones, (iii) parafoveal cones and (iv) the photoelectric measuring devices. These are all slightly different. So you will obtain different brightness estimates from each system. In particular, at the shorter wavelengths (blue end of the spectrum), rods and cones are more sensitive than the photoelectric measures. Rods are especially sensitive in the short range. Thus people using rods and cones might integrate short wavelengths into their response and judge starlight as brighter than a system not sensitive to those wavelengths. Older people, with yellowing lenses, will have less short wavelengths because of the colour filtering properties of the lens which might alter their judgements.

3.2 Area. The visual system integrates over AREA too, with the thresholds of both rods and cones falling proportional to the area stimulated. For larger areas, the slope of the area versus threshold function changes, but from the data from small areas, we can extrapolate back to predict the sensitivity to star-sized patches of light. It turns out the rod and cone curves make predictions that fit nicely with the observed measurements.

3.3 Dark adaptation. Dark adaptation will reduce the sensitivity of the rods by an amount proportional to the background luminance level (above a certain minimum called the "dark light"). The luminance level of the night sky is certainly well above this "dark light level" so we might expect rods to be disadvantaged by this and cones to play a proportionally larger role.

3.4 Thus brightness judgements will depend on background luminance, spectral content, size of the particular image and on which part of the retina the image falls (whether it is the rod-rich periphery, or the cone-rich fovea, for example). These in turn will depend on the age of the viewer and their viewing strategy.

4 When looking at stars, even deep red stars have enough short wavelengths to stimulate the rods which will be the photoreceptors underlying at-threshold detections (corresponding to unaided eye magnitude about 6). However, for stars that are 2-4 magnitudes above detection threshold (which will depend on the properties of the instrument being used), the cones will certainly be involved and may well dominate, (see: Doma& Hallett (1988) Vision Research, 28, 915-924). Knowing all these factors, it might well be possible to "correct" the historic data base of umpteen million amateur observations to match the more objective photoelectric measures: an example of applied visual science.

5 Discussion focused on the use of threshold measures to explain suprathreshold judgements and the relative contributions of rod and cone vision when both were active.

Peter Hallet