RETINAL GANGLION CELL PARAMETERS PREDICTING HUMAN PERFORMANCE IN A TWO-STAGE NEURAL SPIKING MODEL OF LUMINANCE INCREMENT DETECTION

Jonathan Denniss[1,2], Allison M. McKendrick[1], Andrew Turpin[2]
[1] Optometry & Vision Sciences, [2] Computing & Information Systems,
The University of Melbourne. jdenniss@unimelb.edu.au

Introduction

Perimetry is a clinical test that measures non-central vision loss using circular luminance increment stimuli. Gardiner et al (Vision Res, 2008) developed a two-stage neural spiking model of perimetric stimulus detection that used parameters from animal neurophysiology to model signal propagation through the retina and visual cortex. Signal detection was based on firing rates in the visual cortex.

Aims

To determine parameters for modelled retinal ganglion cells (RGCs) that allow the model to predict human psychometric functions at two retinal eccentricities, accounting for changing size of perimetric stimuli.

Methods

Psychometric functions for stimulus detection were measured for two observers, at eight visual field locations (±9, ±9 and ±15, ±15) in a temporal two-alternative forced choice task. Stimuli were circular luminance increments of 0.43° and 1.70° diameter. Model psychometric functions were also computed using the same stimuli and task. RGC receptive field characteristics (difference-of-Gaussians model), maximum firing rate and centre-to-centre spacing were varied, and the psychometric functions produced were compared to the empirical data. The effect of RGC dysfunction was also modelled, and compared to data from glaucoma patients in the literature.

Results

Model RGC parameters were found that matched empirical detection thresholds across locations and stimulus sizes (mean difference [95% CI] for smaller stimulus -0.1dB [-0.5 to +0.3], for larger stimulus +0.3dB [0 to +0.6]). Similar to the study of Gardiner et al, empirical psychometric functions were steeper than those of the model, possibly due to unmodelled feedback factors (mean difference [95% CI] for smaller stimulus 1.0dB [0.9 to 1.1], for larger stimulus 1.9dB [1.7 to 2.1]). The RGC parameters were within the range found in electrophysiological studies of monkeys. Increasing RGC dysfunction caused modelled psychometric functions to flatten and thresholds to increase, consistent with the literature on glaucoma patients. The model will be useful in predicting the effects of RGC disease on perimetric thresholds.