# Multifocal Pupillographic Perimetry in Unilateral Exudative Macular Degeneration

Faran Sabeti[1,2], Ted Maddess[1,2], Rohan Essex[3,4], Andrew James[1,2]
(1) ARC Centre of Excellence in Vision Science, (2) Centre for Visual Science, The Australian National University, Canberra, ACT.
(3) College of Medicine, Biology and Environment, ANU, Canberra. (4) Department of Ophthalmology, Canberra Hospital, Canberra, Australia

## INTRODUCTION

In Australia age-related macular degeneration (AMD) is the number one cause of blindness[1], affecting one in seven people above the age of fifty[2]. The debilitating effects of the disease during the exudative stage, coupled with the limited number of treatments, encourages the discovery of new detection methods. Early detection may assist in improved outcomes through lifestyle changes and supplement intervention. A new method of perimetry using multifocal pupillographic stimuli is an objective and fast method of determining the functionality of the macula. Our aim is to investigate the sensitivity and specificity of 4 stimulus variations in unilateral exudative MD.

## METHODS

### Subjects

- 29 normal (10 male, 19 female, aged 70.0 ± 6.0 ) 20 unilateral exudative AMD (8 male, 12 female, aged 78.0 ± 5.3)
- Subjects were recruited from patients undergoing treatment for AMD at The Canberra Hospital. Exudative AMD subjects were diagnosed by fluorescein angiography, OCT and funduscopy. Patients were required to have one eye with normal retinal status or non-exudative AMD.
- Controls were determined by normal FDT perimetry, and fundoscopy results. Subjects were required to have best corrected visual acuity no worse than 6/12.
- Subjects in both groups were required to have spherical refractive error within the range ±6 D, cylindrical refractive error < 3D, have no significant ocular disorders (other than exudative AMD), no systemic conditions known to affect the eye and not be using medications that affect pupil size.

### Stimuli and Recording

- Stimulus presentation and recording was conducted using the Truefield Analyzer[3].
- Stimuli were presented dichoptically to each eye on two LCD screens. Pupil responses were measured concurrently from both direct and consensual responses.
- Focal length was set at optical infinity with plano concave lenses and refractive error corrections were made using corrective trial lenses.
- Pupils were illuminated with infrared light emitting diodes and monitored separately by infrared video cameras.
- All protocols presented multifocal stimulus arrays subtending ±15˚ of visual field. Each subject was tested on 4 separate 4 min stimulus protocol divided into 8 segments of 30 s. Differences in protocols included:
- number of independent test regions/eye
- mean presentation interval/region

Figure 1. TrueField Apparatus

Table 1. Stimulus Parameters

| Stimulus Protocol | Maximum Luminance (cd/m²) | Minimum Luminance (cd/m²) | Mean Stimulus Interval (mi) (s/reg) | Number of regions/eye (Figure 2) |
|---|---|---|---|---|
| 1 | 250 | 10 | 1 | 44 |
| 2 | 250 | 10 | 4 | 44 |
| 3 | 250 | 10 | 1 | 24 |
| 4 | 250 | 10 | 4 | 24 |

### Data Analysis

- Multiple linear regression was used to extract responses.
- Responses were fitted with a lognormal function estimating amplitude, time-to-peak and width for each region.
- A linear disriminant model incorporating contraction amplitude and time to peak was used to assess pupil responses.
- ROC plots were used to determine sensitivity and specificity values for both exudative and non-exudative stages of the disease.

Figure 2. 44 Region/eye layout subtending ±15˚ visual space

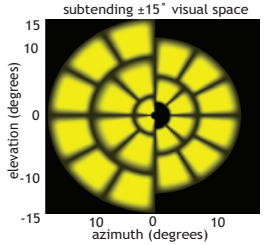



Figure 3. 24 Region/eye layout subtending ±15˚ visual space

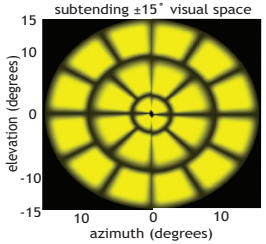
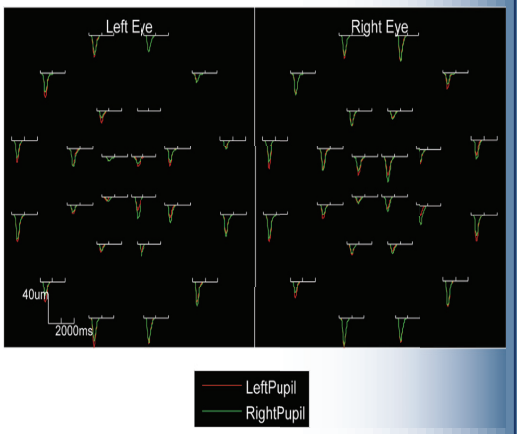



Figure 4. Direct and Consensual Pupil Responses of subject with left exudative AMD




## RESULTS

### Diagnosticity Asymmetric AMD

- Analysis of pupil responses were divided into subjects presenting with asymmetric pathology between eyes and exudative AMD only.
- Stimuli presented in a 24 region layout with a 4 s/region presentation rate achieved the largest responses ($b$ = 3.63 dB, $t$ = 3.57, p <.00001); however this was not found to be most diagnostic, achieving an area under the curve (AUC) of 83.31%. The most diagnostic was found to be a 44 region layout with 4 s/region presentation rate achieving a AUC of 89.51%.

Table 2.

| AUC n=10 worst | 44 region 250 cd/m² mi 1 s/reg 15˚ VF | 44 region 250 cd/m² mi 4 s/reg 15˚ VF | 24 region 250 cd/m² mi 1 s/reg 15˚ VF | 24 region 250 cd/m² mi 4 s/reg 15˚ VF |
|---|---|---|---|---|
| n=worst | 66.64 | 77.28 | 60.57 | 72.26 |
| Asymmetry | 87.19 | 89.51 | 83.20 | 83.31 |

### Diagnosticity Non-Exudative AMD and Exudative AMD

- Subsequent analysis of pupil responses were divided into exudative presentation and non-exudative due to the unilateral presence of AMD in subjects
- The best results were again obtained with a 44 region layout with 4 s/region presentation rate.
- A clinically significant result is the diagnosticity acheived discriminiating non-exudative AMD at 89.9%

Table 3.

| AUC n=10 worst Asymmetric | 44 region 250 cd/m² mi 1 s/reg 15˚ VF | 44 region 250 cd/m² mi 4 s/reg 15˚ VF | 24 region 250 cd/m² mi 1 s/reg 15˚ VF | 24 region 250 cd/m² mi 4 s/reg 15˚ VF |
|---|---|---|---|---|
| Non-Exudative | 86.10 | 89.90 | 85.51 | 84.50 |
| Exudative | 87.19 | 89.51 | 83.20 | 83.31 |

## CONCLUSION

The clinical application of multifocal pupillography utilizing a 44 region stimulus with a slow presentation rate can produce ROC AUC of 89.51% in the diagnosis of unilateral exudative AMD.
The appeal of pupil perimetry is that it assesses an objective reflex, producing results which do not have to rely on patient's judgement, increasing the reliability of the responses.
Further developments to stimuli will improve signal to noise ratios leading to more accurate diagnoses and increased sensitivity of non-exudative AMD which will facilitate early diagnosis and therapeutic intervention.

REFERENCES
1 Mitchell P, Taylor HR, Keeffe JE, Vu H, Wang JJ, Rochtchina E, Pezzullo LM. 2005. Vision Loss in Australia. Medical Journal of Australia 2005v12 (11):565-568.
2 VanNewkirk MR, Nanjan MD, Wang JJ, Mitchell P, Taylor MD, McCarty CA. 2000. The Prevalence of Age-related Maculopathy: The Visual Impairment Project. Ophthalmology 107:1593-1600.
3 Seeing Machines Ltd., Acton, ACT. http://www.truefield-analyzer.com