Study design
We will employ a mixed cross-sectional/longitudinal design. (Group 1) Throughout Years 1-3 we will recruit patients from a clinic waiting room to engage in a short (15-30min) reading task. This large group (n=100) will provide "snapshots" of normal reading performance in a mixed control group and will provide feasibility and usability information that will inform the task design going forward. (Group 2,3) From the middle of year 1 we will begin recruiting into a control (Group 2: n=40) and test group (Group 3: n=40). The test group consists of patients with wet AMD patients undergoing anti-VEGF treatment. The test and control groups will be age-matched (45 to 80 years old).

Our study design will conform to the Declaration of Helsinki and we will obtain ethics approval for our protocol and study documents (consent forms, participant information sheets etc) via The University of Auckland Human Participants Ethics Committee (UAHPEC) and by the New Zealand Lower South Regional Ethics Committee. Consent will grant our team access to both remote visual assessment data and to patient records of e.g. retinal fundus imagery.

Participants
Group 1 will be recruited opportunistically and will comprise patients in the waiting rooms of the Tony Han Optometrist clinic in Bethlehem, Tauranga. We will ask whether the patient is happy to read some information about our research study while waiting for their eye appointment. This information will be presented on the iPad device: the research study will be explained briefly and potential participants will be asked to read and sign a digital consent form (which will e.g. give access to acuity information for that patient which is held on file).

Group 2 participants will be identified from routine eye examinations at the same clinic. They will be patients with good ocular health, and their ocular media will be sufficiently clear to allow fundus assessment.

Group 3 participants will be identified from eye consultations at an ophthalmology clinic in Auckland. They will be patients currently undergoing anti-VEGF treatment for wet AMD. Their ocular media will need to be sufficiently clear to allow fundus assessment.

In terms of recruitment of group two and three, a question will be asked at the end of their eye examination to find out whether the patient will be interested in receiving some information regarding an upcoming age-related macular degeneration research study. An digital invitation letter, participant information sheet and consent form will be sent to those patients who agrees to be contacted.

Patients who consent to participate will be contacted via telephone to make an appointment for their initial visit.

Baseline data
Participants in Groups 2 and 3 will go through a series of baseline clinical measurements of visual function at their initial visit (30min) and the subsequent follow-up visits (30min).

1. ETDRS logMAR distant visual acuity test
2. ETDRS logMAR near visual acuity test
3. Pelli-Robson contrast sensitivity test
4. Cognition test (the type of test to be confirmed)
5. MNRead-Speed test (http://legge.psych.umn.edu/mnread-speed)

Inclusion criteria
1. Age between 50 and 89 years
2. Group One: at least one eye has visual acuity better than 6/12 TBD from records at the clinic. Group two: at least one eye has visual acuity 6/6; Group three: at least one eye being treated for wet AMD.
3. Clear ocular media
4. No other ocular disease
5. Not taking any retinotoxic drugs
6. Passing the cognition test

Exclusion criteria
1. Cataract or other media opacity
2. Glaucoma or ocular hypertension

3. Diabetes or diabetic retinopathy
4. History of venous/arterial occlusion
5. Requiring full-time professional health care
6. Failing the cognition test

Device used
Apple iPad Pro 11 inch tablet computer (20 units) will be the device used to administer all tests. These devices are lightweight (471g), have book-like portability (11 inch screen), and a high-resolution contrast-accurate display (2388-by-1668 at 264 PPI). Uniquely these devices have imaging technology built in - an IR sensitive camera, IR illuminator and time-to-flight imaging device - that is designed to support Apple's Augmented Reality technology. This technology allows one to measure the users head position (tilt and distance from the a screen) with high levels of precision. In practice Professor Steven Dakin's group have also successfully used this technology to track gaze position while people read text without the need for dedicated eye-tracking hardware. Demonstration from their group showing real-time gaze tracking during reading using an unmodified iPad pro is here: https://www.dropbox.com/s/09cypxjd21uvowo/RPReplay_Final1592265409.mov?dl=0

We will implement a simple eReader app in the *Swift* programming language that will allow the patient to read content of their choice and make a series of measurements during its use.

Outcome measurements
The iPad reading app will yield measures of:
1. Reading speed
2. Eye fixation positions (e.g. landing accuracy)
3. Frequency of regressive eye scans
4. Reading distance
5. Frequency and extent of device tilting
6. Font size chosen by the patient
7. Display brightness chosen by the patient

Task
Years 1-3: Group one patients will be given an iPad to read in the waiting room for 15-30 minutes. Reading distance, font size, iPad brightness can be changed at a calibration page to suit the patient. The iPad will be held in a normal reading position and can be moved and/or tilted to assist reading. Data collected will be normative and will provide us valuable feedback to refine the app.

Year 1 onwards: after initial assessment of baseline data, a selection of groups 2 and 3 participants will be invited to take an iPad home. Simple instructions will be given to read an article on the iPad for 30 minutes daily at their preferred time and location. Reading distance, font size, iPad brightness can be changed at a calibration page to suit the patient. The iPad will be held in a normal reading position and can be moved and/or tilted to assist reading.

At any one time we would anticipate having up to 15 iPads in the field with iPads being with participants for a period of up to 4 months. Each participant will have a follow-up visit every 2 months for 4 months in total (3 data sets per head). We will conduct visual assessment battery each time. This will guarantee to complete data collection from all 80 participants over the course of 22 months

Data collected from the test and control groups will be compared to conventional clinical assessment of visual function. We will also conduct exploratory machine learning (ML) based analysis of our results in Years 3-4. This will consist of inclusion of our dataset in a multimodal diagnostic system (including automated analysis of retinal imagery) under the supervision of Dr Vaghefi, who has published a proof of principle of this approach earlier this year.[9] Early efforts at automated identification of AMD biomarkers using machine learning (ML) show promise (87% identification)[10] but similar approaches have yet to be applied to either (a) behavioural data or (b) multi-modal combined behavioural/imaging data. This is largely because behavioural data tends to be *sparse* – isolated measures made infrequently during visits to the clinic. In contrast, effective ML training requires large, dense datasets. We propose that the behavioural datasets we will develop are more suitable for ML training and hold the promise of training systems to predict AMD-progression based on combined structure-function deficits.