

**Biopic Telescopic Spectacles and Driving Rehabilitation for People with Age-Related
Macular Degeneration: A Pilot Project**

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Statement of Contributions

Chapter 2, Licensing Requirements across Canada, was prepared for submission to the Canadian Journal of Optometry. Sahar Khakneshin was the first author and was responsible for data updates, data interpretation, and drafting of the manuscript. Dr. Shamrozé Khan led the conceptualization and supervision of the work and contributed through critical review and editorial revisions. Dr. Tammy Labreche contributed through critical review and editorial revisions. Mariam Bhatti contributed to data collection related to provincial and territorial licensing requirements for Chapter 2.

Abstract

Introduction

Driving is a multifactorial task of which vision is a component. A person's ability to meet requirements to gain or maintain a driver's license may be compromised by visual impairments (VI) caused by ocular diseases such as Age-related Macular Degeneration (AMD). However, vision is only one component of safe driving. Programs aimed at permitting and individually assessing a person's ability to drive are important for improving the quality of life of Canadians living with VI whose ability to safely drive may be in question.

Purpose

In Ontario in October 2020, the Highway Traffic Act was amended to allow the use of [bioptic] telescopes to meet provincial visual acuity requirements for Class G licensure for the first time. pending successful completion of an on-road driving assessment while using the telescope (MTO Bioptic Telescope Program).

The George & Judy Woo Centre for Sight Enhancement (CSE) in Waterloo, Ontario has formulated a training protocol involving both fitting and training with a bioptic telescope for driving. The aim of this study aim was to determine whether the program sufficiently prepares individuals with AMD to effectively use their bioptic telescope, as determined by success in a simulated in-car evaluation.

Methods

The study aimed to recruit up to 10 participants with AMD who had lost their driver's license within the last 5 years, met MTO Bioptic Telescope Program visual requirements and did not suffer from motion sickness or cognitive impairment (by self-report). Visual function and visual perceptual testing as well as bioptic telescope fitting were administered. Participants also proceeded into the CSE training program which included 3-5 training sessions and a counselling session. Participants' driving skills and use of bioptic telescope(s) were then assessed in a virtual reality SUV driving simulator both with and without the telescope.

Results

Three participants (mean age of 74 years, male) were enrolled and completed the study. Visual parameters met the eligibility criteria (corrected visual acuity ranged from 0.35logMAR (20/50) to 0.77logMAR (20/126), contrast sensitivity ranged from 1.00-1.45logCS units and visual fields were full peripherally). All three participants had binocular central scotomas identified on Humphrey monocular full field tests and Nidek microperimetry. However, no central scotoma was evident on the Humphrey Estermann binocular field assessment. Each participant was fit with a bioptic telescope (2.2-3x magnification) and completed three training sessions. All participants passed the Scan Course but failed the other visual perceptual tests (Useful Field of View, Trail Making, Motor Free Visual Perceptual Test-4). Participant 3 failed the Montreal Cognitive Assessment for the Blind and Visually Impaired. In the final assessment, Participant 1 successfully completed the driving simulation with and without the telescope with no critical driving errors. Participant 2 passed only with the telescope which

was used appropriately to identify traffic and speed signs. Participant 3, despite having the best visual acuity, failed under both conditions with critical errors.

Conclusion

Although further research is required, several important findings to date have been identified. First, the Esterman binocular visual field test cannot be solely used to determine the full field of those with a potential central deficit. Second, the visual perceptual tests conducted with the cut-offs provided, did not definitively identify those individuals that may not be suitable for driving with bioptics; a functional assessment appears to continue to be the gold standard. Third, full medical evaluation should be conducted prior to the visual function evaluation to help identify those that are not safe driving due to non-visual reasons. Finally, it appears that the CSE Bioptic Fitting and Training Protocol may effectively enable participants to learn to apply the fundamental skills required for using a bioptic telescope in a driving situation.

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List of Abbreviations

1. Visual Acuity (VA)
2. Visual Field (VF)
3. Contrast Sensitivity (CS)
4. Age-related Macular Degeneration (AMD)
5. Retinal Pigment Epithelium (RPE)
6. Choroidal Neovascularization Membranes (CNVM)
7. Anti-Vascular Endothelial Growth Factor (anti-VEGF)
8. Useful Field Of View (UFOV)
9. Trail Making Test (TMT)
10. Motor-Free Visual Perception test (MVPT)
11. Motor Vehicle Collision (MVC)
12. Ministry of Transportation of Ontario (MTO)
13. The George & Judy Woo Centre for Sight Enhancement (CSE)
14. Canadian Journal of Optometry (CJO)
15. The Canadian Council of Motor Transport Administrators (CCMTA)
16. Motion Sickness Susceptibility Questionnaire (MSSQ)
17. Autonomous Vehicle Research Intelligence Lab (AVRIL)
18. Early Treatment Diabetic Retinopathy Study (ETDRS)
19. Just Noticeable Difference (JND)
20. Montreal Cognitive Assessment (MoCA)

21. American Medical Association (AMA)

22. Visual Field Score (VFS)

23. decibels (dB)

Chapter 1

Introduction

1.1 Visual Impairment

The prevalence of visual impairment increases with age. In Canada, a longitudinal study conducted in 2018 indicated that on average, 5.7% of Canadian adults aged 45-85 years, experience visual impairments varying from 2.7% among individuals aged 45-54 years to 15.6% among people aged 75-85 years.¹ The prevalence of visual impairments varies considerably across Canadian provinces, with Manitoba demonstrating the lowest rate at 2.4% and Newfoundland and Labrador showing the highest at 10.9 %.¹ Overall risk factors for visual impairment include aging, lower income, lifestyle (e.g. smoking), diabetes, cognitive problems, and irregular access to eye care).¹

Age-related ocular diseases such as cataract, glaucoma, age-related macular degeneration (AMD), stroke, and diabetes result in visual impairment. Leading causes of visual impairment in high –income countries differ than those countries with emerging economies. For example, according to recent studies, 78.8 million people with visual impairment are affected by cataract which accounts for 39% of visually impaired cases across the world, which is not as prevalent in higher income countries.² Glaucoma affects approximately 76 million people worldwide which includes about 4.5 million with low vision and 3.2 million who are blind.³ The global prevalence of diabetic retinopathy is approximately 103 million people which is predicted to increase.⁴ It is estimated that 8.69% of the world’s population has AMD, impacting 196 million individuals in 2020. It is predicted that this prevalence will rise to 288 million by 2040^{5,6} and

is one of the most common causes of vision loss in Canada. A recent study showed that 2.5 million Canadians have AMD.⁷ This number represents a high proportion (> 6%) of Canada's population of almost 40 million⁸, and is expected to increase due to the aging population.

1.1.1 Age-related Macular Degeneration (AMD)

AMD is a disease arising from multifactorial causes, involving a complex interaction between aging, genetic and environmental risk factors.

AMD impacts the complex structure of ocular photoreceptors, retinal pigment epithelium (RPE), Bruch's membrane, and the choroid, significantly affecting the macula, the area of the eye responsible for clear central vision. A key feature of AMD is the accumulation of drusen (i.e. focal deposits of lipid-rich extracellular debris made up of RPE cell fragments, lipids, minerals, and immune-related components) which accumulate between the RPE basal lamina and Bruch's membrane, contributing to the gradual degeneration of photoreceptors and RPE, and ultimately leading to the loss of central vision and visual function.^{9,10}

AMD is classified into two types including non-exudative (dry) AMD and exudative (wet) AMD. Dry AMD is marked by the gradual atrophy of the RPE and photoreceptors.⁵ Over time, these areas of atrophy progress and lead to further gradual loss of central vision. In wet AMD, abnormal blood vessels develop in the outer retina and beneath it, specifically beneath the RPE, resulting in choroidal neovascularization membranes (CNVM). These new blood vessels may leak or rupture, leading to fluid collection, bleeding, and a rapid reduction in vision.^{9,11,12} For management of AMD, healthy lifestyle habits such as smoking cessation, a balanced diet, and regular physical activity are essential. Both types of AMD cause irreversible vision loss, even

though treatments such as intraocular anti-vascular endothelial growth factor (anti-VEGF) injections, occasionally laser therapy, and nutritional supplements may slow its progression.⁹

In addition to central visual field changes such as scotoma or distortion (metamorphopsia), AMD causes significant reduction in other visual functions such as visual acuity, contrast sensitivity, glare sensitivity, and colour vision.¹³ In fact, AMD is the primary cause of severe vision loss in people over 55 years of age in high-income countries.^{9,10} This ocular disease can have a significant impact on tasks such as reading, recognizing faces, completing daily visual activities, and driving.⁵

1.2 Driving

1.2.1 Importance for Quality of Life and Impact of Loss

Driving is a key element of independence for many individuals and supports access to daily necessities. Having a driver's license enables individuals to attend necessary services, manage household responsibilities, and participate in community and social activities and as a result, contributes to activity, personal identity, and life satisfaction.¹⁴ Driver's licenses of individuals, especially older adults, can be restricted or revoked for a variety of reasons such as affected visual or cognitive function, and other aspects of medical conditions. Therefore, sudden driving cessation can result in depression, isolation,^{14,15} loss of independence, mobility, and even employment¹⁶ and can also reduce overall quality of life.

1.2.2 Multifactorial Nature of Driving

Driving is a multifactorial task.¹⁵ Physical abilities, general health, aging and individual driving preference may impact driving performance.¹⁷ Even depressive symptoms can reduce engagement in driving.¹⁷ A variety of visual functions such as visual acuity, visual field, contrast sensitivity, and colour vision may have an effect, as well as cognitive abilities such as visual processing speed and accurate judgment.¹⁸

1.3 Visual Functions Related to Driving

Multiple aspects of visual function are involved in driving.¹⁸ Much of the discussion here is captured in the paper by Owsley et al.¹⁸

1.3.1 Visual Acuity

Visual acuity refers to the capability of the eyes to distinguish fine details in the environment. Visual acuity is vital in recognizing and detecting road signs and hazards.¹⁸ Although reduced visual acuity can affect tasks such as road sign detection, the relationship between visual acuity and driving performance and safety is weak since visual acuity testing does not assess all visual abilities required for safe driving and other visual factors may also play important roles in driving performance and crash involvement.¹⁸ Nonetheless, in many countries, a specific visual acuity is required to meet eligibility for a driver's license as well as to obtain or regain a driver's license.¹⁸

1.3.2 Visual Field

Visual field is the total viewing area including central and peripheral regions that can be seen while maintaining stable fixation and is considered another crucial factor impacting driving performance.¹⁸ An adequate visual field allows drivers to detect hazards in their peripheral vision, which is important for safe driving. Although the minimum amount of visual field required for optimal driving performance remains unknown, many jurisdictions require individuals to meet a minimum visual field extent for driving.¹⁸ Visual acuity along with peripheral visual field minima form the most common combination of vision requirements for driving licensure in many jurisdictions.

1.3.3 Contrast Sensitivity

Contrast sensitivity refers to the ability to detect differences in luminance and distinguish objects from their background. This is another visual factor that affects the task of driving.¹⁸ Some studies showed that drivers with better contrast sensitivity demonstrate better driving performance.^{19,20} Furthermore, contrast sensitivity could be a stronger predictor of ability to detect road signs and obstacles at night compared to visual acuity.¹⁸ This has relevance in terms of drivers' ability to distinguish road signs and other markers¹⁸ while driving in variable lighting conditions or inclement weather .

1.3.4 Colour Vision

Colour vision is the ability of the visual system to distinguish and perceive variations in the spectral composition of light. In some countries, such as several states in the USA colour vision

can be a visual requirement for licensing,¹⁸ while there is no legislation regarding colour vision in Canada.²¹ Colour vision helps in the differentiation of traffic signals and possible hazards.¹⁸ Colour vision assessment is not based on evidence that colour vision defects significantly raise collision risk.¹⁸ Rather, screening confirms drivers can follow and correctly interpret colour traffic signals such as traffic lights and brake lights.¹⁸ Some studies indicate that individuals with colour vision defects generally respond more slowly to colour signals and experience more colour-based confusions than those with normal colour vision.¹⁸

1.3.5 Binocular Vision

Binocular vision defines when two eyes together are used to see one object. The brain combines two different images from the two eyes into one, which provides depth perception.²² Stereopsis (i.e. binocular capability to perceive depth and spatial position by comparison of the slightly different images received by each eye) is a controversial topic in the driving literature.²³ Monocular drivers, who do not have binocular vision, are generally allowed to drive. In Canada, there is no legislation to exclude people who are monocular from licensure.²¹ While binocular vision may not be as critical as other visual parameters in determining driving performance¹⁸, it can have an important role in depth perception and the ability of judging gaps and distances during driving.¹⁸ Some studies indicate that stereopsis has a positive influence on driving performance in dynamic conditions and also improves drivers' self-confidence, and the ability of target detection at distance.^{24,25} But most research shows that limited stereopsis does not compromise regular daily safe driving for private (non-commercial) drivers, with no relationship found between decreased stereopsis and collision rate.²²

1.4 Cognitive Function and Motor Skills Related to Driving

Cognitive functions such as memory, attention, reaction time, decision-making ability, thinking, precise judgment, and cognitive processing affect driving performance.^{18,19} Cognitive abilities enable people to quickly detect and react to various targets and potential hazards at the same time as doing tasks such as driving¹⁷ and are related to visual perception. Visual perception refers to higher order visual functions involved in the ability to understand, process and interpret visual information received from environmental stimuli such as people, objects, etc.²⁶

Several studies indicate that poor cognitive functions are associated with an increased likelihood of driving cessation or driving restrictions.¹⁷ Tests such as the Useful Field Of View test, Trail Making test, Scan Course test, and Motor-free Visual Perception Test are utilized to evaluate visual perceptual cognitive functions and may be used by functional assessment centers when assessing candidacy for driving.²⁷⁻²⁹

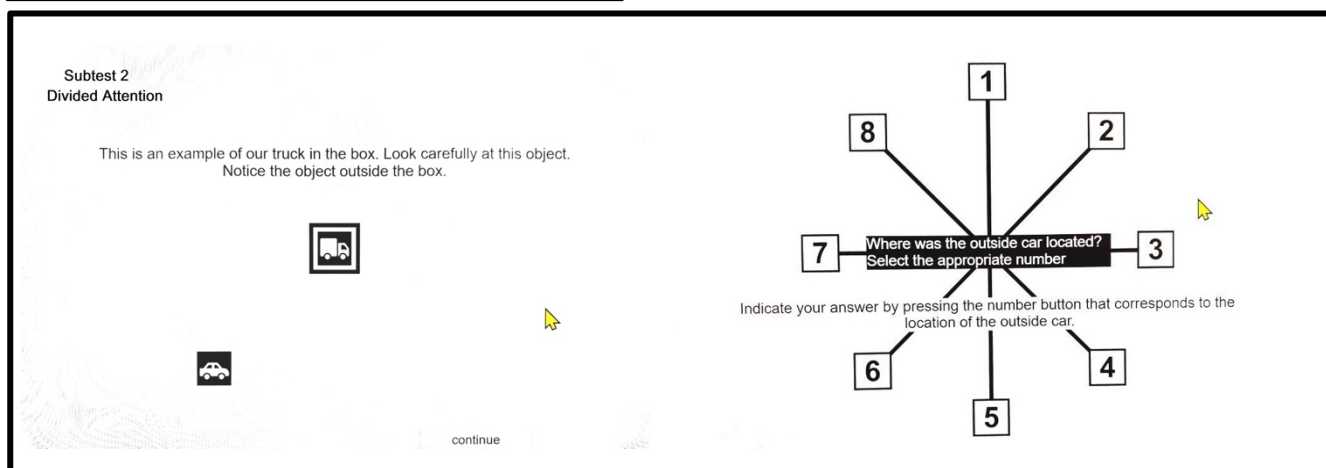
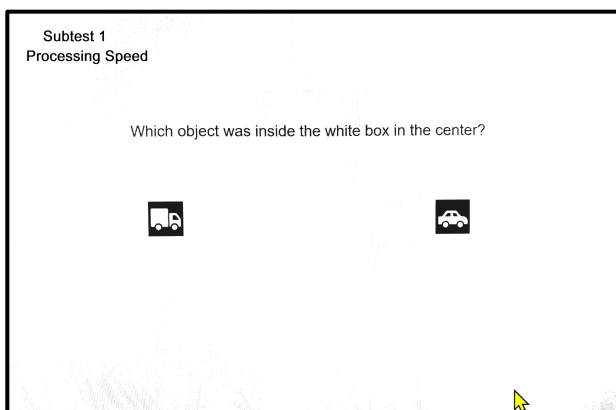
1.4.1 Useful Field of View Test

The Useful Field Of View (UFOV) test is a computer-administered evaluation which assesses visual processing to give a sense of higher order cognitive abilities. Participants are ultimately required to quickly identify and react to the simultaneous presentation of central and peripheral stimuli in a set viewing area under cluttered conditions.³⁰ This test is mostly utilized in driving research and in clinical screening settings to identify high-risk drivers and to predict motor vehicle collision risk particularly in older adults.³¹

In a study conducted in 2006, UFOV performance was examined in relation to age, gender, and education.³⁰ It indicated that people with less education and older ages performed more poorly on the UFOV test.³⁰ These poorer scores in senior individuals were attributed to a greater occurrence of age-related declines in cognitive processing speed among older people. Gender was not found to have a notable effect on the UFOV scores.³⁰

Subtests of the UFOV evaluate processing speed, divided attention and selective attention.³²

On a 17-inch display, a central target is shown within a 3 x 3 cm fixation box and 2 x 1.5 cm peripheral targets are shown at fixed eccentricities along eight radial locations.³³



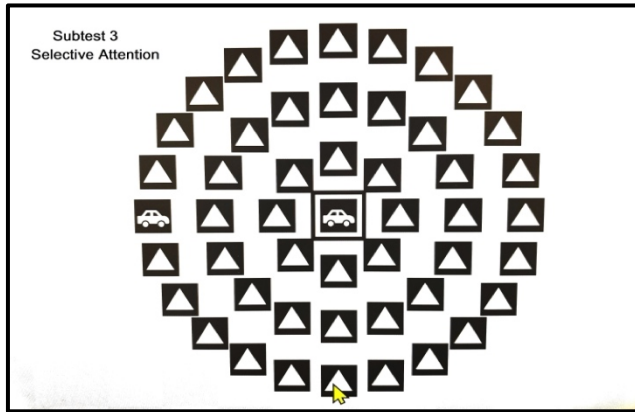


Figure 1- 1: The three subtests of the UFOV test.

The procedure for the subtests is described as follows:

In subtest 1, a picture of a car or a truck briefly appears in a central box. Display time differs from 16.67ms to 500ms in 16.67ms steps. Then, the screen is covered by a random dot mask, and participants identify whether the central picture was a car or a truck.³²

In subtest 2, along with the central picture (car or truck), a picture of a second car appears simultaneously at one of eight radial positions. Participants report the location of the peripheral car as well as identifying the central picture. If both selections are correct, this step is considered as accurate.³²

In subtest 3, participants need to identify the central image as well as the location of the peripheral car, this time among the presence of forty-seven triangle-shaped distractors which

are identical in size, brightness and contrast and displayed in three circles around the central target.³²

An initial version of the UFOV involved a fourth subtest, but is no longer used since it had limited predictive value for driving performance.³²

In all steps, as the trial progresses, the presentation time of the targets is reduced until a threshold can be determined.³² The shortest display presentation time with correct responses is scored and considered the threshold. As a result, threshold scores of each subtest may range from 16.67 to 500ms.³² The speed with which the participant enters their response does not affect scoring.³²

The results of the three subtests are often considered in aggregate in order to determine an overall crash risk profile of the test-taker.³⁴ A study conducted by Bedard et.al in 2008³⁵ which evaluated the utility of Subtest 2 of the UFOV (divided attention) as the best predictor of driving performance and crash risk determined that the optimal cutoff point was approximately 300ms to achieve optimal sensitivity (0.722) and specificity (0.795) for the test. The calculated area under the curve for the receiver operating characteristic curves was 0.82, indicating a good overall predictive use for this test.³⁵ Those achieving thresholds less than 300ms of stimulus duration would be unlikely to be involved in a car crash. Other research conducted by Ball et.al. in 2006³¹ showed that individuals who scored 353ms or more on UFOV subtest 2 were around two times more likely to be involved in an at-fault motor vehicle collision compared to those with better scores.³¹

As mentioned, the UFOV measures the minimum time required to detect or differentiate central targets while identifying peripheral targets simultaneously. Poor UFOV results among older drivers has been linked to a higher rate of collisions in recent years.^{15,18} Therefore, one may say that both visual functions as well as cognitive functions are important to be assessed for driving eligibility.

1.4.2 Trail Making Test

The trail making test is a neuropsychological assessment used in general practice and in research settings and is designed to evaluate cognitive functions such as processing speed, divided attention, and mental flexibility, as well as basic visual-motor abilities such as scanning.³³ The trail making test consists of two paper-and-pencil subtests which are usually utilized in driving research due to their simplicity of administration and association with driving performance.³⁶ This test may be useful to screen older drivers in terms of driving impairment and risk.³³

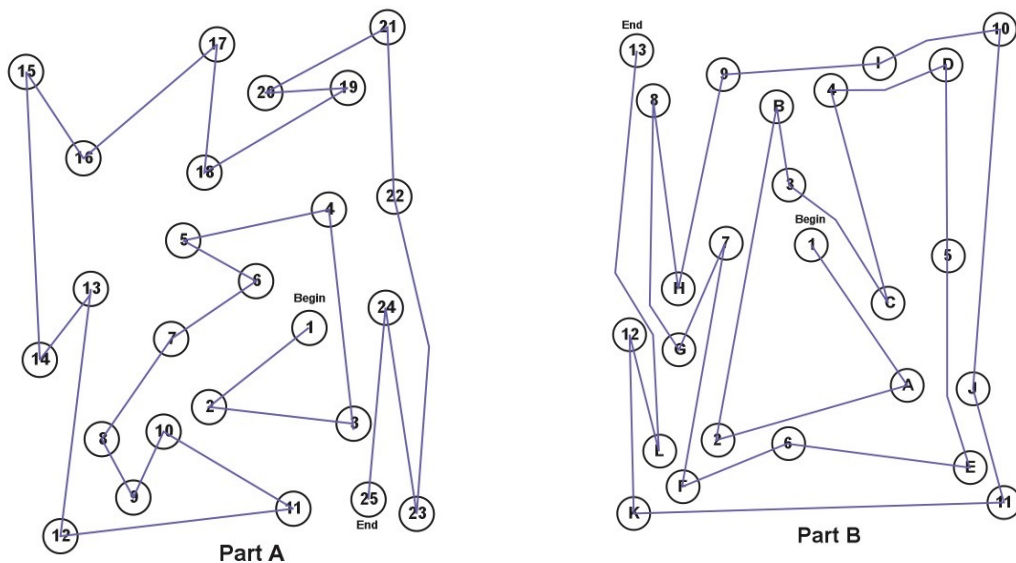


Figure 1- 2: Trail Making test (Part A and Part B): participants connect numbers in sequential order in Part A, and must alternate between numbers and letters in sequential order in Part B.

Part A assesses visual search/scan, attention and speed of motor ability and requires individuals to connect a sequence of randomly organized circles numbered 1 through 25 in numerical order. Part B assesses mental flexibility by requiring the participant to alternate between numbers and letters in sequential order (1 through 13 and A through L) making it a more complex task. The test is scored according to the amount of time required to complete each task in seconds.³⁶ According to the testing protocols, TMT-A is stopped at 180 seconds and TMT-B at 300 seconds. These cutoffs do not predict driving performance and inability to complete TMT-A and TMT-B within 180 and 300 seconds respectively may lead to restricted test utility.³⁶ According to a study conducted in 2013, TMT-B had stronger evidence than

TMT-A.³⁷ To predict driving performance and separate safe from unsafe, cutoff point of 180 seconds or three errors on TMT-B were recommended.³⁷

Completion times for both TMT-A and TMT-B increases among older adults despite the absence of motor or sensory impairments, which can be interpreted as sensitivity of the trail making test to age-related reduction in attention and visual skills.³⁸

It should be noted that visual impairments could impact test performance in older adults. 2019 research found that participants with simulated low visual acuity (20/100) performed significantly worse and received low scores on both the TMT-A and TMT-B, in comparison with those with normal visual acuity.³⁹

1.4.3 Scan Course

As previously mentioned, driving is a complex task that requires the combination of visual, cognitive, and motor abilities to quickly interpret information derived from a constantly changing environment in order to make safe decisions while driving.⁴⁰ The Scan Course is an informal, observational test used in occupational therapy in different settings and designed to evaluate visual scanning ability and attention while the examinee is motion. It was originally described by Warren⁴¹ and later adapted through an instruction developed by Kristalovich and Mortenson.⁴² The evaluation of the skills of visual scanning while in motion may reflect functional driving requirements.



Figure 1- 3: The Scan Course test, twenty numbered cards are positioned on either side of a hallway at different heights. Participants identify the numbers as they pass them.

The Scan Course as a clinical test is easy to administer, requires minimal training and time, and the results can be easily interpreted. Twenty numbered cards (3.25 inches × 4.25 inches) are positioned on either side of a hallway at standardized heights.⁴² Participants identify the numbers as they pass them. According to a recent study ⁴⁰, the ideal cutoff score on the Scan Course is 18 out of 20. Individuals who score 18 or above are more likely to be safe drivers while scores under this cutoff suggest increased risk of unsafe driving and need for further on-road assessment.⁴⁰

1.4.4 Motor-Free Visual Perception Test

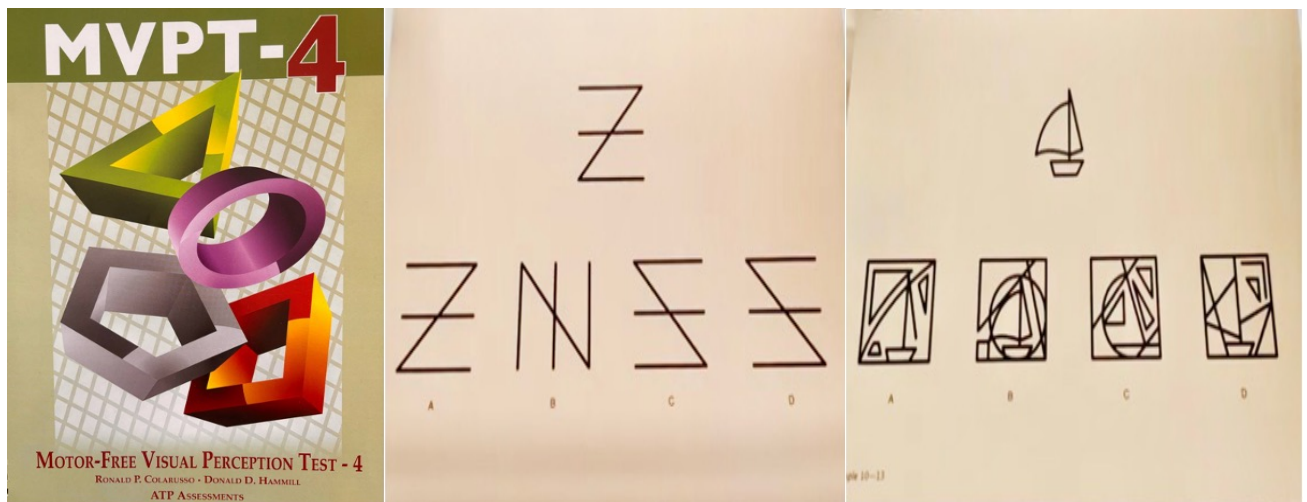


Figure 1- 4: Cover page of MVPT-4 testing booklet. The participant views 45 two-dimensional black and white drawings and selects the appropriate answer from four choices provided in multiple-choice format below.

The Motor-Free Visual Perception test (MVPT) is one of the common non-motor visual perception evaluations. It is a standardized test used for screening and research purposes.⁴³ This test evaluates various domains of visual perception relevant to driving and other daily activities such as visual discrimination, spatial relationships, visual memory, and figure-ground perception.⁴⁰ The MVPT-4, a modified version, evaluates visual perception abilities in individuals aged from 4 to 80+ years using a set of visual perceptual tasks which do not involve motor abilities such as drawing or following.⁴⁴ The test presents the examinee with 45 visual stimuli. The raw score is the total number of correct answers achieved out of 45. There is no

specified cutoff score for people with visual impairments on the MVPT-4 but the Heart and Stroke Foundation of Canada (2019) suggests that raw scores below 18 may indicate unfitness to drive, raw scores above 38 may indicate acceptable fitness to drive, and raw scores between 19-37 may illustrate a gray zone which needs further assessments to predict driving performance.⁴⁵

It is suggested that the raw score, or visual perception capacity, will increase with age then decrease in older adulthood.⁴⁴

Despite the many parameters or indicators of driving function in Canada, the Ministries of Transportation normally only evaluate a person's visual eligibility to obtain or retain a driver's license based on whether or not they meet specific visual acuity and visual field requirements.^{46,47} See Chapter 2 for a review of current province-specific vision requirements in Canada.

1.5 Changes to driving legislation in Canada

1.5.1 Individualized Assessments

It is noteworthy to outline the shift in Canada away from basing licensing decisions on inflexible vision standards and instead towards functional case-by-case evaluations to determine whether a person remains capable of performing driving tasks despite visual impairment. Grismer, the claimant in a 1999 court case against the British Columbia (B.C) Superintendent of Motor Vehicles, had a homonymous hemianopia (loss of half of the peripheral visual field) following a stroke.⁴⁸ The B.C. Motor Vehicle Branch revoked his

license because he did not meet their required 120° visual field standard. Despite passing driving tests, he was repeatedly denied from regaining his driver's license and subsequently documented a complaint with the B.C. Council of Human Rights. The case resulted in a Supreme Court ruling that the Superintendent should have provided Grismer with an individual road safety evaluation before making a blanket determination that he could not be licensed to drive due to his vision loss.⁴⁸ The decision was a turning point in Canada and set a precedent for licensing decisions to be established on functional and individual assessments, not vision standards alone. Individualized functional driving assessments to determine whether a person can compensate for peripheral vision loss (visual field loss) now exist widely across Canada (Chapter 2). The option for a functional assessment in the case of visual field loss has been part of the Ministry of Transportation of Ontario guidelines since 2005 and is known as the MTO Vision Waiver Program.^{21,49} Drivers demonstrate their driving skills via a specialized road test to a trained occupational therapist. Visual assessments to monitor for any further changes in visual function are conducted annually.

1.5.2 Individualized Assessments for Central Visual Impairment

With the consideration for functional assessments, the focus shifted to those who did not meet driving vision standards based on visual *acuity* loss (central visual impairment). Required visual acuity standards can be achieved with a specialized device called a “bioptic telescope,” the use of which had been commonplace in several countries including the United States of America since the 1970s.⁵⁰ In Canada, Quebec began a bioptic driving program in 2012. In Ontario in October 2020, the Highway Traffic Act was amended ⁴⁶ to allow for the use of

“telescopic lenses,” reportedly in response to a case filed by a driver claiming that a blanket ban on the use of telescopic lenses to meet visual acuity standards was unconstitutional since it violated the Canadian Charter of Rights and Freedoms.⁵¹ The Ontario Highway Traffic Act vision requirement for driving (with the amended portion in bold print) now includes:

“(a) a visual acuity as measured by Snellen Rating that is not poorer than 20/50 with both eyes open and examined together with or without the aid of corrective lenses **and with or without the aid of telescopic lenses**; and

(b) a horizontal visual field of at least 120 continuous degrees along the horizontal meridian and at least 15 continuous degrees above and below fixation, with both eyes open and examined together. O. Reg. 83/05, s. 10; O. Reg. 535/20, s.⁴⁶

1.6 Telescopes

1.6.1 Bioptic Telescopes

A telescope is a magnifying assistive device that can allow people with visual impairments to meet their goals for “distance” vision. Telescopes include an objective lens that focuses incoming light to a focal point and an eyepiece that further contributes to magnifying the image of a viewed distant object (e.g. a face or a street sign). The total amount of magnification depends on the focal length of the telescope and the power of the eyepiece.⁵² There are two types of telescopes: Galilean and Keplerian. Galilean telescopes consist of a convex (+) objective lens and concave (-) eyepiece lens.⁵² This combination creates an erect image at the eye.⁵² Galilean designs are typically lighter and cheaper than a Keplerian. A Keplerian

telescope has two convex lenses. This combination creates a real, inverted image which is erected with prisms that make the instrument longer and heavier.⁴⁴ In comparison to a Galilean, Keplerians offer a larger field of view particularly at higher powers as well as better optical quality, but are more expensive.⁵²

Telescopes can be classified based on how they are used, as handheld (literally held in the hand and up to the eye as needed) or spectacle-mounted. Spectacle-mounted telescopes involve the integration of the telescope into the lenses of a pair of glasses (described as “carrier lenses”). Spectacle-mounted telescopes can be Galilean or Keplerian, fixed-focus or focusable, and monocular or binocular according to the patient’s needs (visual function, rehabilitation goals, and preference).⁵³ There are two ways to mount a telescope into a pair of spectacles: centrally-mounted (full-field), or bioptic. A centrally-mounted telescope is placed in the centre of the spectacle carrier lenses (centred over the pupil/visual axis) such that the wearer is looking through the telescope at all times while wearing the system. This mount of telescope cannot be used while mobile since the world seen through the telescope appears closer, larger, and narrower, compromising judgment about where objects may truly be located. When telescopes are instead mounted into the carrier lenses above the line of sight, they are referred to as a “bioptic”. The user is able to ambulate by viewing through the carrier lenses most of the time, and then using the telescope intermittently as needed for viewing a distant object. Dr. William Feinbloom, a pioneer in the field of low vision rehabilitation in the United States, introduced the bioptic telescopic system in 1958.⁵⁰ Bioptic telescopes are the telescopic device of choice for driving for people with visual acuity impairment.^{52,53} Drivers use their conventional

refractive corrections in the spectacle carrier of the bioptic system during most of driving time (90-95%) but, when they intend to view a distant object, dip their chin down to view through the telescope briefly during 5-10% of driving time.⁵⁴ The bioptic telescope provides a magnified view of objects, signs, other drivers and pedestrians for faster detection of hazards and decision-making.⁵⁵

Prolonged viewing through the telescope is not feasible due to the challenges posed by magnification, restricted visual field, reduction in reaction time and trouble in use with vehicle mirrors.^{15,56}



A

B

C

Figure 1- 5: A) A person wearing a bioptic telescope. B) Viewing through the spectacle portion (carrier lenses) of the device C) Dipping chin down to view a distant object through the telescope.

There are some additional limitations to bioptic telescope use: ring scotomas and the ‘Jack in the box’ effect. Ring scotomas refer to a ring-shaped loss of visual field that is experienced when a user dips into the telescope - the new visual information is superimposed on top of the current visual scene and so some information is lost. Some studies demonstrate that the ring scotoma created by the bioptic telescope can be compensated by the fellow non-telescope wearing eye when fit with a monocular bioptic telescope for driving.^{57,58} The “Jack in the box” effect refers to the experience of having objects appear to jump in size and location because of the sudden transition between carrier lens and telescope.⁵⁹

1.7 Driving with Bioptics Literature

1.7.1 General

The topic of driving safety with bioptic telescopes has long been a subject of debate, therefore it is worth reviewing some studies regarding the use of a bioptic telescope during driving.

The majority of drivers who use bioptic telescopes while driving state that the telescope is a beneficial device which helps them read road signs and detect traffic light status.^{58,60}

According to some studies^{61,62}, the use of bioptic telescopes does not increase the risk of collisions during driving and there is no significant relationship between bioptic driving and increased rate of near-collisions.⁶³ However, Zhou et al in 2022 presented that poorer visual acuity and field of view are related to higher number of collisions even after accounting for age and driving exposure, and lower documented rates of collisions may be an artefact of self-imposed lower driving exposure.⁶⁴

In correcting for miles driven, Zhou et al propose that annual collision rates for bioptic drivers are slightly increased relative to non-biopic drivers with normal vision (1.3x to 3x) however collisions are typically minor (non-fatal and well under collision rates that are otherwise generally accepted by society e.g. teenagers whose crash risk is 8x greater compared to middle-aged drivers).⁵⁸ It may be reasonable to apply this grace to visually impaired individuals who demonstrate compensatory skills and meet training and licensing criteria. Debates about biopic driver safety should be addressed through risk management strategies such as training, restrictions (e.g. daytime driving only), conditional licensing, and monitoring rather than through risk-free operation.

1.7.2 AMD Literature

As mentioned earlier, driving is one of the important tasks which can be affected by visual impairment caused by AMD. There are several research studies that have investigated the impacts of AMD on driving ability.

Wood et al. in a study conducted in 2018 demonstrated that drivers with AMD tended to make more errors related to observation, maintaining lane position, and selecting safe gaps in traffic.⁶⁶ These mistakes show troubles and challenges in scanning and monitoring their surroundings, collecting crucial information from road signs and other road users, and making decisions about whether to proceed or yield, change lanes, or merge into traffic.⁶⁶ Another study conducted in 2018 indicated that drivers with AMD are significantly more prone to experiencing driving difficulties when their regular visual acuity is less than 20/50.⁶⁷

Bowers et al. illustrated that bioptic telescopes reduce driving limitations and can satisfy the visual requirements of drivers with AMD.⁶⁸ Allowing individuals with AMD to drive with a bioptic telescope lessens driving limitations which they impose on themselves. Bioptic drivers with AMD generally indicated less restricted driving patterns, lower perceived visual difficulty, and less avoidance of challenging driving circumstances compared to non-bioptic AMD drivers with similar visual acuity. They reported using the bioptic for a larger part of their driving time particularly for tasks like reading road signs and street names, and they tended to drive more frequently and more miles per week.⁶⁸ Bioptic AMD drivers also found their driving quality more positive and were less likely to drive under the general traffic speed. However, in comparison with normally sighted, age-matched drivers, bioptic AMD drivers were less likely to travel long distances and they also tried to avoid night driving more often.⁶⁹ Although telescopes meet this population's visual demands and increase quality of life by enabling driving, specific limitations such as decreased overall mileage and higher avoidance of night driving remain.⁶¹

Another study reported that the rate of motor vehicle collision among people with AMD might depend on the severity of AMD.¹³ Drivers with intermediate AMD have a lower risk of being involved in crashes compared to those with normal vision.¹³ This suggests that drivers with AMD are more cautious about driving behaviors and habits. They tend not to drive in unfamiliar areas in addition to avoiding night driving and long trips, as a result, the risk of collision decreases.¹³ The same study also implied that drivers with early age-related macular degeneration did not indicate a significantly higher rate of motor vehicle collisions in

comparison to those with normal vision. This could be because their visual impairment hasn't reached a level that affects driving ability.¹³

Subjects with ocular diseases such as cataracts, glaucoma, and AMD demonstrate slower hazard reaction times.⁶² Slower danger response times were linked to reduced visual acuity, lower contrast sensitivity, poorer binocular visual field, and greater self-reported troubles during difficult driving circumstances.⁷⁰ A recent study conducted in 2024 indicated that bioptic drivers with central vision impairments, such as AMD, improved their response times in situations with hazards.⁶² However, their speed of detection of road hazards is less than that of drivers with normal vision.

1.8 Bioptic Driving – International

Bioptic telescope use enables people with visual impairments to demonstrate their ability to compensate for their decreased central vision with a telescopic visual aid device. There are several countries that have permitted bioptic driving for many years.

Individuals with moderate visual impairment are permitted to drive with a bioptic telescope in 48 states in the United States^{15,71}, the Netherlands⁷², Australia⁷³, and now in some Canadian provinces including Ontario and Quebec.^{15,74} However, there is a range in protocols with respect to the visual functions assessed, acceptable visual function limits, and training requirements.

In the United States, bioptic driving began in 1971 when California issued the first driver's license to a bioptic driver⁵⁰ and is now permitted in all states except Iowa and Utah. In most

states, the minimum visual acuity required for an unrestricted driver's license is 20/40. For restricted or bioptic driving, minimum visual acuity requirements using spectacle lenses range from 20/40 to 20/400 with 20/100 to 20/200 being the most common.⁵⁰ The required visual acuity through the bioptic telescope varies by state and falls between 20/40 and 20/70. Visual field standards also differ across states. Some have no specified requirement, while others specify a binocular visual field of 105 to 140 degrees and some states outline specific regulations for people who are monocular.⁵⁰ Training requirements for bioptic drivers are different as well. Seventeen states provide clear guidelines, ranging between 10 to 60 hours of expected training.⁵⁰ Experienced drivers may need to complete fewer hours. Restrictions on how the license is to be used may also be imposed. The most common is to limit bioptic driving to daylight hours only. Some states consider a person's vision with the bioptic when considering eligibility for night driving.⁵⁰ Others permit nighttime driving only after one to three years of safe daytime experience or a night driving assessment.⁵⁰ In terms of the magnifying power of the telescope, some states do not impose a limit, while for others a telescope powered at no more than 3-4x is the most common limitation.⁵⁰ For further details, please refer to the original article.⁵⁰

In the Netherlands, a project was conducted to train eligible participants to use a bioptic telescope while driving and the results reported to the Minister of Traffic to request a revision of the country's visual requirements for driving at the time.⁶⁴ The Ministry permitted bioptic driving in 2007.⁷² Vision requirements in the Netherlands include a visual acuity of 20/40 or better while using a bioptic telescope and a visual field of at least 140 degrees horizontally.⁶⁴

A study conducted in 2016 familiarized Australian optometrists with conditional driving licenses and was considered a turning point in that country.⁷³ Australian conditional licenses allow visually impaired individuals to obtain a driver's license under specific conditions such as driving during the day, in familiar and local areas, at restricted and specified speed, or with the use of visual aids.⁷³ The visual acuity requirement for unconditional driving is at least 20/40 and for conditional driving is 20/50.⁶⁵ The visual field requirement is at least 110 degrees and 10 degrees above and below central fixation for regular driving. The Australian driving guidelines asked for further research on the practical application of bioptic telescopes for driving. In 2017, the National Transport Commission allowed bioptic use on a case-by-case basis.^{73,75,76}

Although visual acuity and visual field limits are commonly specified in licensing requirements for different states and countries, there are no empirically validated cutoffs for bioptic drivers that predict a safe driving performance. Bioptic licensing criteria differ substantially across various jurisdictions and minimum visual acuity, required visual field, permitted telescope magnification, permission for night or expressway driving, and even other factors such as cognitive and physical functions all vary. In the absence of studies which validate existing requirements, none of these criteria can be currently judged over the other for driving performance and safety. Moreover, studies in this field are limited and vary in terms of device types, requirements and training protocols examined, and indicate inconsistent relationships between clinical measurements and real-world driving operation.⁷⁷ These conditions restrict the ability to define reliable VA and VF cutoff points and a specific

guideline. For example, while 20/40 is the most common adopted VA in the US, there is no empirical evidence that drivers with visual acuity less than 20/40 have a higher risk of accident. In addition, in studies reporting higher collision risk among bioptic drivers, the specific contributors to the elevated risk are unclear.⁷⁷ As a result, it can be suggested that there are no clear cutoff points for VA and VF, further supporting the need for individualized functional and driving assessments of those with visual impairment. This subject is also a key gap that warrants further research.

1.9 Training with the Bioptic Telescope

1.9.1 The Importance of Training

In addition to proper assessment and telescope fit, sufficient training plays an important role in preparing individuals with visual impairments to use a bioptic telescope to optimize performance.⁶⁹

In studies that identify a higher risk of motor vehicle collision (MVC) among bioptic drivers, the specific factor(s) responsible for this increased risk usually remains unknown.⁶⁹ Owsley notes that some of these studies have design limitations, and did not include training programs.⁷⁷ Wood et al. showed that most drivers with moderate central vision loss who have received training demonstrate proficient on-road driving skills while wearing a bioptic telescope comparable to drivers with normal vision.⁷⁸ Other studies have shown that individuals without previous driving experience perform more poorly with driving and require more training with the bioptic.^{62,79} Training can also impact hazard detection in bioptic

drivers.⁷⁰ A recent study conducted in 2024 indicated that no correlation was found between driving mileage and bioptic drivers' hazard perception test scores.⁶² Since hazard perception can be improved with training, a training protocol focused on educating the driver on how common roadway features can become hazardous, and by teaching the “spotting technique” (described later in this thesis), can be helpful for bioptic drivers and enhances their hazard detection and driving performance.⁷⁰

Wood et.al in a study conducted in the state of Alabama, illustrated that for drivers with visual impairment with driving experience, training includes on-road instruction that combines bioptic use with work on existing driving skills.⁸⁰ The training program concentrates on telescope operation such as focusing, head tilting or dipping to look through the telescope, locating targets while viewing through the bioptic, and tracking objects, first in non-driving settings then in real driving conditions as a passenger and then as a driver.⁷² Trainees can progress from multiple sessions in the passenger seat to practicing and learning vehicle controls and other basic skills in a parking lot.⁷² After success in handling a car in the parking lot, they can advance to more complex traffic conditions where intermediate skills such as lane changes are required.⁷² There is no specific and fixed training duration, but new bioptic drivers commonly require at least one year involving approximately 10 to 50 hours of supervised training. Experienced drivers generally need less time depending on individual factors and their background.⁸⁰

Owsley in a study conducted in 2012 stated that participants who received three months of telescope training improved more on tasks such as mobility, scanning, and driving simulator and on-road driving performance than participants with no training.⁷⁷

In aggregate these studies suggest that the quality of bioptic driving, and road safety may improve with previous driving experience and proper training in the use of the bioptic device.

1.9.2 Sample Biopic Training Programs

Jose, Carter and Carter in 1983 outlined a staged bioptic driving program which included supervised telescope use, bioptic training at home (pre-driver training), structured behind-the-wheel instruction for driving, and practicing special driving tasks with proper use of the rearview and side mirrors.⁸¹ They offered a training program including a brief screening of traffic safety knowledge, in-office device training and on-road lessons in a dual-control car focusing on basic skills for people with visual impairment, to help them become licensed with a bioptic telescope.⁸²

Forty-eight states in the United States allow individuals with moderate central vision loss to utilize a bioptic telescope system for driving licenses, at least half of these states mandate involvement and successful fulfillment of a structured low vision driver training program as a prerequisite for obtaining a driver's license.⁸³ Here it is very important to talk about the comprehensive training program provided by Chuck Huss, certified orientation and mobility specialist and driving rehabilitation specialist who has pioneered formalized training for bioptic driving in the United States for forty-plus years. Mr. Huss's training for novice bioptic drivers involves 44 hours of behind the wheel training.⁸³ The program begins with

confirmation of basic survival orientation and mobility skills by a certified orientation and mobility instructor. It continues with information and activities through both in-class and in-vehicle training to address:

1. Distance Viewing skills
 - a. Forward scanning
 - b. Head and eye scanning
 - c. Following distance
 - d. Collision avoidance
 - e. Communication with other drivers
2. Critical Object and Condition Awareness Skills
 - a. Roadway characteristics
 - b. Traffic control devices
 - c. Roadway Users
3. Basic Bioptic Usage Skills
4. Hazard Perception Skills⁸³

Vogel et al stated that drivers with visual impairments need to be trained how to use a bioptic telescope in both in-office and home training sessions before their driver's license assessment.⁵⁹ The in-office training program includes five sessions (60 mins), two weeks apart. The at-home training includes 25 mins per day, 5 days of week in addition to 4-5 hours a week of training as a passenger in a car. Individuals need to record their experiences and difficulties during home training.⁵⁹

There are eight skills reviewed in the training program provided by Vogel.⁵⁹

1. Identifying stationary targets in a size of minimum acuity required for driving in static position.
2. Localizing, tracking and identifying moving targets while wearing the bioptic telescope in a static position.
3. Localizing and tracking static objects with carrier lens and identifying with telescopic lens while moving.
4. Tracking and scanning moving targets while moving.
5. Locating, scanning and tracking methods in different weather and lighting circumstances such as cloudy, rainy, and sunny days while walking and a passenger in a car.
6. Identifying and recalling data seen through the telescope before switching the view to carrier lenses
7. Use of the bioptic telescope in conjunction with rearview and side mirrors
8. Use of bioptic telescopes while driving

Although there is much variety in bioptic training programs, they are quite involved and extend across multiple sessions of both in-office/class and in-car evaluation.

1.10 The Ministry of Transportation of Ontario (MTO) Bioptic Telescope Driving Program

Table 1-1 indicates the visual requirements of the Ministry of Transportation of Ontario bioptic driving program.

Table 1-1: A summary of visual requirements of bioptic driving regulated by the Ministry of Transportation of Ontario

Parameter	MTO requirement	Notes
Best visual acuity (better eye)	20/160 or better	Visual acuity without telescope.
Telescopic visual acuity (potential)	Ability to reach 20/50 using a bioptic telescope	The examinee must be able to achieve 20/50 or better with the bioptic.
Telescope magnification limit	< 4 x	Maximum permitted magnification.
Binocular visual field	Continuous 120° horizontal, extending 15° above and below central fixation	Exception: a central scotoma is permitted; otherwise, the visual field should be uninterrupted.
Contrast sensitivity (better eye)	≥ 1.35 log units ideal (i.e. ≤ 4.5% contrast)	≥1.00 log units is acceptable in some cases but the prognosis is considered guarded
Training with the bioptic	3-5 bioptic training sessions	

If a driver would like to pursue the bioptic driving program, then following an assessment, fit and training on bioptic use with a low vision practitioner (optometrist or ophthalmologist), an individual's information is reported to the MTO where it is determined whether or not they may proceed to an in-car assessment (performed while using the bioptic). For those who are eligible and have recently had their driver's license suspended on account of visual impairment, an in-car assessment is arranged and a temporary driver's license issued only for the in-car assessment. In the case where the person either has not previously had a license or has not had a license for >3 years, they are instructed to first obtain their class G1 license. This is a written assessment which then usually allows for driving with another fully licensed (class G) driver. For those in the bioptic driving program, the only person they are permitted to drive with is a driving rehabilitation instructor.

At the initial evaluation, the driving/rehabilitation instructor will assess visual perceptual skills by conducting the UFOV, scan course, MVPT-4, and TMT. This is followed by an in-car evaluation while wearing the bioptic of the ability to:

- Avoid vehicles in adjacent lanes during lane changes and highway merges.
- Avoid various hazards such as pedestrians, cyclists, vehicles entering traffic, and movements in parking lots.
- Attend to vehicles approaching at intersections.
- Recognize road signs and traffic lights and respond appropriately.
- Maintain proper lane position while navigating curves.

- Deal with intersections at awkward, non-90-degree angles.
- Perform at least one parking maneuver in a parking lot.

If the initial in-car evaluation with the driving rehabilitation instructor is successful or shows potential, an additional 0-30 in-car training sessions are recommended. The training serves to enhance driving skill and/or integrate use of the bioptic. For new drivers, once determined to have successfully completed the in-car training portion, the individual is instructed to attend regular driver training which involves 10 hours of in-class instruction and 10 hours of in-car instruction with a regular driving instructor who has no rehabilitation training, prior to attempting their class G2 license. This license allows the individual to drive independently with some limitations (no alcohol, no 400-highway series, etc). After at least 12 months with the G2 license, they may attempt their full class G license in-car evaluation which allows the individual to drive independently with no limitation.

1.11 The George & Judy Woo Centre for Sight Enhancement (CSE) Bioptic Training Protocol

Although the MTO Bioptic Telescope Program specified 3-5 training sessions with a bioptic device before the in-car evaluation with a driving specialist, the specific requirements of the bioptic training were not outlined. The George & Judy Woo Centre for Sight Enhancement (CSE) has formulated a training protocol involving both prescription (fit) and training with a bioptic telescope with the intent to be used for driving, known as the CSE Bioptic Telescope Fitting and Training Protocol. Following the selection and fit of the appropriate telescope, the individual completes three to five hours of training with the bioptic over the course of three

months. During the training the individual is made aware of the limitations of a bioptic telescope, and its appropriate use while the individual is seated and moving. A PowerPoint presentation containing 134 slides is used to teach the concepts of localization, scanning, and tracking an object with a telescope, identification of objects and signs, recognition of safe bioptic driving conditions and to assess visual memory of a scene. The PowerPoint slides are projected on a screen placed at a distance of 4.5m (15 feet) from the trainee, with targets sized at greater than or equal to 13.5M (equivalent to 6/18M or 20/60). Targets include letters, numbers, words, shapes and street signs. At the end of training visits, “homework” assignments are given to encourage the trainee to use and practice with the bioptic outside the clinic in order to build comfort and efficiency with the device. These range from locating and identifying letters on provided charts or identifying objects with the telescope while walking or while a passenger in a car or while moving on a bike. Finally, a counselling session is added to manage expectations and address any anxiety the individual may have with the MTO process, the functional assessment or potential outcomes of the program.

1.12 Aims and Objectives

The purpose of this pilot project is to determine whether the CSE Bioptic Telescope Fitting and Training Protocol is sufficient in preparing individuals with AMD to effectively use their bioptic telescope, as determined by success in a simulated in-car evaluation. It is hypothesized that success in the simulator will extend to reduced in-car training sessions with the driving rehabilitation instructor and overall success in the actual MTO Bioptic Telescope Driving Protocol.

Chapter 2

Licensing Requirements across Canada

Prepared for submission to the Canadian Journal of Optometry (CJO)

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2-1 Introduction

Remaining a licensed driver despite living with visual impairment is a well-established concept in many parts of the world but a relatively new concept in Canada. While longstanding tropes present driving as a privilege and not a right, in Canada in particular, where the population is spread across the second largest land mass in the world, not being able to drive can have major impact on easy access to basic services that are the right of all Canadians – from purchasing groceries to attending medical visits, to name a few.⁸⁴⁻⁸⁶ The inability to drive can also impact mental well-being^{15,87} and employment.¹⁶ The landscape of understanding the experience of disability has also increased, with greater understanding that blanket assumptions about what a person living with impairment can and cannot do (including tasks such as driving) are outdated and better determined on a case-by-case basis. These conversations are important in light of the fact that visual impairment is on the rise across Canada.⁸⁸

A study conducted in 2018⁸⁸ demonstrated that on average, the prevalence of visual impairments among Canadian adults (45-85 years) is 5.7%. The prevalence of visual

impairments across provinces of Canada illustrates significant diversity, with Manitoba exhibiting the lowest rate at 2.4%, and Newfoundland and Labrador the highest at 10.9%.⁸⁸ According to the CNIB foundation, 1.5 million Canadians are identified as having sight loss.⁸⁹

In a sense, eyecare providers have long been part of the driving conversation since visual requirements, namely minimum visual acuity standards, have been an essential prerequisite for driving licensure across many jurisdictions including the United States of America, Canada, Australia and countries of the European Union.^{86,90-92} Some jurisdictions also include a minimum visual field requirement. This lends to the misconception that there are known standards of visual acuity and visual field for safe driving, when in fact, driving is a multifactorial task. Safe driving depends not only on visual functions such as visual acuity, visual field, colour vision, and contrast sensitivity, but also on other factors such as physical ability, visual perception and cognitive function.^{15,86} Although the minimum common visual acuity accepted for driving is 20/40, there is no indication that individuals with visual acuity lower than 20/40 are more likely to be involved in motor vehicle collisions.^{77,86} Studies conducted by Burg and Hills revealed no relationship between reduced visual acuity and motor vehicle collision rate in adults, with a small relationship demonstrated in older drivers.⁹³⁻⁹⁶ There are different opinions about the effect of visual field loss on driving. Johnson and Keltner in a study with large sample size observed that the rate of driving collision increased in drivers with greater loss of visual field^{86,97} while several studies did not confirm this finding.^{86,94,95,98-100} Some previous studies demonstrated that monocular drivers encounter some limitations, however significant variations were not observed in driving performance between monocular

and binocular drivers.^{18,101,102} Colour vision deficiency may cause difficulty with traffic light detection and consequent accidents but is also not often evaluated.

Visual function parameters that are not typically measured at driver evaluations or eye examinations such as contrast sensitivity may be more closely related to driving ability.^{90–93}

Visuperceptual ability, which has an association with higher order cognitive function, also appears to play a role. Multiple studies agree that individuals with cognitive or neural impairments are more likely to fail an on-road driving exam if they perform poorly on the Useful Field Of View (UFOV) test, a test which ultimately assesses a person's ability to pay simultaneous attention to central and peripheral stimuli within a set area in both cluttered and uncluttered environments.^{29,86,109–111} The UFOV test is beneficial in predicting increased risk of motor vehicle collision.^{105,112}

Driving behavior tends to change with visual impairments. People with visual impairments drive less than others and prefer to drive in places that they are familiar with, as a result, the frequency of collisions might decrease.^{86,93,113–115} Numerous studies indicate that drivers who drive with visual field loss try to compensate for their reduced field of view by slowing down or moving their eyes and head to change their viewing direction.^{105,116–118} Therefore, it is argued that individuals with visual field impairments attempt to apply adaptation methods to adjust for visual field defects to improve their driving performance.¹¹⁹ It is good to point out that driving rehabilitation training plays an important role in improvement of driving performance, influencing safety.¹⁸

In summary, physical, visuoperceptual and cognitive function in addition to basic visual function and driving habits may affect driving performance. All these factors are complementary components and should be considered in tandem to identify eligibility for driving.

As a result, several jurisdictions have embraced the concept of case-by-case evaluations to prevent individuals with visual impairments from being unfairly prevented from driving.⁸⁶ Driving performance of people with visual impairments can be assessed using driving simulators in research and laboratory conditions or natural driving with an evaluator in an on-road test.

Biopic telescopes are one tool that can be used to help individuals with visual acuity impairment to meet minimum visual acuity requirements for driving.¹⁵ This assistive device is a legal choice for driving in several countries including in 48 states of the United States of America, the Netherlands, Australia, and most recently, Canada.^{15,74,86} In some jurisdictions, e.g. in Canada, an established process also exists for persons with visual field loss to potentially demonstrate that they can compensate for their loss with eye and head movements and still drive safely.²¹

The allowance of biopic telescopes to drive in some provinces in Canada appears to have stemmed from Human Rights and Charter challenges initiated by members of the general public living with visual impairment.⁴⁶ As a result, it is expected that there may be wider inquiry across provinces about the possibility of returning to driving after visual impairment, and eyecare providers should be prepared for this.

In this light, the authors of this paper have noted that a central and complete repository regarding driver's license vision requirements across the provinces and territories of Canada does not exist. This paper provides a central resource to address this issue. In addition, it outlines the provinces and territories that currently have programs that allow for case-by-case evaluation of individuals with vision that falls outside listed requirements, and additional details regarding those waiver programs where known.

2-2 Methods

The information related to vision standards to acquire a class 5 driving license (Ontario equivalent G license) was collected for 10 provinces and 3 territories across Canada over a period from May to August 2023. Some updates were made in September 2025. In the first step, the Ministry of Transportation (or equivalent) website was visited for each territory or province to find the Class 5 driving requirements for non-commercial vehicles and any waiver requirements. This was followed by direct inquiry to ministry personnel if the information was not retrieved through online access or if clarification of the information was necessary. Finally, the online links to access this information that would be available to members of the public was determined for each applicable province and territory. Information was compiled into provincial vision driving requirements and limitations in terms of visual acuity and visual fields and other aspects for driving licenses of non-commercial transportation vehicles.²¹

2-3 Results

The information retrieved for each province and territory was collated into Table 2-1.

Table 2-1: Visual requirements and vision waiver programs for class 5 or equivalent G license for driving with non-commercial vehicles across Canada (10 provinces and 3 territories).

Province	Regular driving requirements	Vision waiver options
Newfoundland & Labrador	VA No less than 20/50 (6/15) in the better eye VF 120 degrees continuous and 15 continuous degrees above below fixation	VA N/A VF N/A CCMTA https://www.ccmta.ca/web/default/files/PDF/National%20Safety%20Code%20Standard%206%20-%20Determining%20Fitness%20to%20Drive%20in%20Canada%20-%20MAY%202025.pdf There are no special formalized programs for assessing people with vision impairments.
Nova Scotia	VA Not less than 20/40 in the better eye	VA/VF N/A Referred to ophthalmologist or CNIB for possible assistance because there are no programs or resources for driving impairment.

	VF 120 degrees horizontally	They are working on developing a vision waiver (as in ON) medicalfitness@novascotia.ca, access the CCMTA and NS Driver's Medical Examination files
Prince Edward Island	VA Not less than 20/50 in the better eye VF120 degrees continuous and 15 continuous degrees above below fixation	VA Case-by-case basis for relicensing - Medical recommendation, Individual review for additional driving test. VF Restricted to using equipped vehicles with mirrors. https://www.princeedwardisland.ca/sites/default/files/publications/drivers_handbook_eng_feb_2022_dh.pdf CCMTA Standard 6 https://www.ccmta.ca/web/default/files/PDF/NSC-FULL/NSC%20-

		<u>%20FULL%20SET%20ENGLISH%20MARCH%202022.pdf</u> Page 450 <u>https://www.princeedwardisland.ca/en/information/transportation-and-infrastructure/medical-fitness-to-drive</u> Information is not available online, required to contact the department directly (transportation and infrastructure/highway safety department)
New Brunswick	VA Not less than 20/40 in at least one eye VF 120 degrees horizontally	VA Minister may waive the vision requirements for a special class if an applicant illustrates their ability to compensate for decreased vision, undertakes a road test, regularly update their vision status VF N/A For more information, please contact the Motor Vehicle Branch office at 506-453-2410.
Quebec	VA Not less than 20/50 in the better eye VF Not less than 100 degrees	VA INLB (Institut Nazareth et Louis-Braille) program help individuals develop compensatory skills for safe driving by bioptic telescopic spectacles up to 4x magnification -

	continuous and Not less than 10 continuous degrees above fixation and 20 continuous degrees below fixation. Not less than 30 degrees on each side of the vertical meridian	Will be eligible for this program if VA is not less than 6/15 with an eligible VF and stable vision by usage of bioptic telescopic spectacles. VF (Diplopia) usage of eye patch and prismatic spectacles permitted. https://www.legisquebec.gouv.qc.ca/en/document/cr/C-24.2,%20r.%2040.1%20/ https://santemonteregie.qc.ca/en/services/visual-impairment-car-driving
Ontario	VA No less than 20/50 with both eyes open and examined together with or without the aid of corrective lenses and with or without the aid of telescopic lenses	VA Reaching a VA of 20/50 or better using a bioptic telescope with up to 4x magnification https://www.ontario.ca/laws/regulation/940340 https://www.drlowvision.com/pages/bioptic-driving#:~:text=Bioptic%20Driving%20Program,traditional%20glasses%20or%20contact%20lenses

	VF 120 degrees continuous, with 60 degrees on each side of the midline. A vertical visual field of at least 15 continuous degrees above and below fixation	VF Vision waiver offered by the minister based on some conditions about driving behavior, need to provide satisfactory medical report and vision assessment from an OD/OMD Regaining driver's license by submitting request and medical history https://www.ontario.ca/page/medical-review-ontario-drivers
Manitoba	VA No less than 20/50 in the better eye VF 120 degrees continuous and 15 continuous degrees above below fixation	Manitoba follows the vision requirements outlined in the CCMTA Medical Standards for Drivers: https://www.ccmta.ca/web/default/files/PDF/National%20Safety%20Code%20Standard%206%20-%20Determining%20Fitness%20to%20Drive%20in%20Canada%20-%20MAY%202025.pdf Page 282 VA/VF – Individual assessment - need to submit a visual report and visual field diagrams and medical examination reported from health care personnel,

		occupational therapy evaluation at DAMP and on-road evaluation Details about driving evaluation: https://www.mpi.mb.ca/Pages/medical-assessments-evaluations.aspx
Saskatchewan	VA Not less than 20/50 in the better eye VF 120 degrees continuous and not less than 15 degrees above and below fixation	VA Case-by-case examination, road test with a trained SGI evaluator or an occupational therapist-based driver's evaluation (an in-house and on-road evaluation) by a driver rehabilitation specialist and a driver instructor VF (Diplopia) corrected by prismatic glasses and eye patch permitted. Same as the CCMTA For detailed information, please visit sgi.sk.ca - medical tab under licensing.
Alberta	VA 20/50 both eyes open	VA Referred to Driver Fitness, Alberta Transportation to indicate good driving record, stable condition,

	Worse eye not less than 20/200 VF120 degrees continuous horizontally and 15 degrees above and below fixation vertically	absence of other significant medical issues, and a functional evaluation. VF Additional tests and individual evaluation https://www.optometrists.ab.ca//web/AAO/Patients/Drivers_License_Vision_Requirements.aspx For new diplopia: Temporary eye patch permitted. https://collegeofoptometrists.ab.ca/wp-content/uploads/2020/04/Vision-Standards-Drivers-License.pdf
British Columbia	VA Not less than 20/50 in the better eye VF120 degrees continuous and 15 continuous degrees above below fixation	VA N/A VF On-road evaluation and individual evaluation conducted by an occupational therapist or driver rehabilitation professional More information needed: Examination of visual functions (EVF), Binocular visual field test (VFT), or Vision screening at ICBC Point of Service

		https://www2.gov.bc.ca/gov/content/transportation/driving-and-cycling/roadsafetybc/medical-fitness/medical-prof/med-standards/22-vision For diplopia: corrected by prismatic glasses
Nunavut		
Northwest Territories	VA Not less than 20/50 (6/15) in the better eye VF 120 degrees continuous and 15 continuous degrees above below fixation	VA N/A VF N/A CCMTA Standard 6 https://www.ccmta.ca/web/default/files/PDF/NSC-FULL/NSC%20-%20FULL%20SET%20ENGLISH%20MARCH%202022.pdf Page 450 There is no program or resources for people with visual impairments to drive https://www.ccmta.ca/en/national-safety-code

Yukon	VA Not less than 20/50 in the better eye VF 120 degrees continuous and 15 continuous degrees above below fixation	VA N/A VF Road test CCMTA Medical requirements for Drivers If license is cancelled or suspended due to medical conditions: regaining license by a letter from doctor Need additional information by doctor: Functional occupational therapist's report, Road test, Medical specialist report, driveABLE assessment https://yukon.ca/en/driving-and-transportation/driver-licensing/how-get-medical-approval-drive%E2%80%8B%E2%80%8Bwhat-can-i-do-if-my-licence-gets-cancelled-for-medical-reasons
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2-4 Discussion

This paper reviews the driving requirements for individuals with and without vision impairment across Canadian provinces and territories. To the authors' knowledge, it serves as the first centralized repository of this information in the country.

Many provinces and territories align with Canadian Council of Motor Transport Administrators (CCMTA) guidelines. The CCMTA is a national organization in which

Canadian provinces and territories come together to follow minimum consistent medical standards including vision standards for motor vehicle and traffic safety and driver licensing.⁴⁷

Most provinces and territories adopt a VA limitation of ‘no worse than 20/50’ aside from New Brunswick and Nova Scotia where the VA limit is ‘no worse than 20/40”. Interestingly, this varied between applying this VA to the measurement of the better eye only or to both eyes assessed together/binocularly. Typical visual field requirements across Canada are 120 degrees horizontally and 15 degrees above and below fixation aside from Quebec, New Brunswick and Nova Scotia. Ontario is specific in that this field must be centred at midline.

Most provinces and territories allow for individual consideration and assessment of people with visual impairments to allow for demonstration of their ability to compensate for their reduced vision prior to determining licensure. Newfoundland & Labrador, Prince Edward Island, Manitoba, Saskatchewan, Alberta, Nova scotia, Ontario, British Colombia, Quebec, Yukon, and New Brunswick apply case by case assessment in-car evaluation to proceed with driving. Despite this, only Ontario and Quebec have a bioptic driving program, and how safe driving is then demonstrated in cases of visual acuity losses in other provinces is not clearly outlined.

The accessibility of driving requirements varies by province and territory. Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Colombia, and Yukon have published their requirements online as presented in Table 2-1.

2-5 Conclusion

The variation of driving requirements for individuals with visual impairments across provinces and territories of Canada indicates the need for a consolidated and accessible repository of information to prevent confusion for providers and patients who seek the related criteria. The paper provided centralized information about driving requirements in Canada. Still, information is challenging to find and somewhat difficult to interpret online. Clarity, in particular, regarding the availability of individualized functional assessments for particular license categories, as well as the specific steps required to obtain a vision waiver, would be well-received for many Canadian provinces and territories.

Chapter 3

Methods

3-1 Study Design and Sample Size

A prospective interventional study design was implemented as the intent was to follow driving performance of a group of drivers with age-related macular degeneration post-biopic training. The study received ethics clearance through the University of Waterloo Research Ethics Board and adheres to the principles of the Declaration of Helsinki. A formal sample size calculation was not conducted as this was a pilot project and it was expected that up to 10 participants would be adequate to estimate the effectiveness of the CSE Biopic Telescope Fitting and Training Protocol.

3-2 Inclusion and Exclusion Criteria

Participants were recruited from the Waterloo Eye Institute, George & Judy Woo Centre for Sight Enhancement Low Vision Clinic. Participants with an established diagnosis of AMD but meeting the minimum visual requirements (see Table 1-1) of the MTO Biopic Telescope Driving Program (best visual acuity no worse than 20/160 in the better eye with the potential to obtain at least 20/50 acuity with no greater than a 4x telescope, an uninterrupted binocular (except for central scotoma) 120-degree horizontal visual field extending 15 degrees above and below central fixation, and contrast sensitivity no less than 1.00 log unit in the better eye) were invited. These requirements needed to be maintained at the time of the first visit in order to continue with participation. Participants were included if they were older than 50 years old with previous G license driving experience and had their driver's license revoked due to visual

impairments within the last five years. Participants also needed to not be susceptible to motion sickness, and free of a known diagnosis of dementia or cognitive impairment to participate.

3-3 Recruitment

Potential participants were sent an invitation to participate in the study with an accompanying consent/information form (Appendix A) either by email or by mail for those without an email address (Appendix B). A telephone appointment (see Appendix C for script) was arranged with those who expressed interest in the study. During this call, any questions the participant had were addressed. If the participant was still interested, the Motion Sickness Susceptibility Questionnaire (MSSQ, Appendix D) was conducted to assess for risk of motion sickness while in the driving simulator, which could prevent completion of that portion of the study. [In the MSSQ, participants are asked how often they felt sick or nauseated while using different modes of transportation or entertainment (e.g. funfair ride). Answers can include any one of not applicable/never traveled, never, rarely, sometimes, or frequently. Answers are scored as follows: 0 for never, 1 for rarely, 2 for sometimes, and 3 for frequently]. In addition, at the time of the phone call, potential participants were asked if they had been diagnosed with any cognitive impairment such as dementia. Participants were excluded at this stage if they reported a diagnosis of cognitive impairment or dementia or if they were deemed to suffer from motion sickness as evidenced by a score of over '23' on the MSSQ screener. Those who passed both screeners proceeded with the CSE Bioptic Fitting and Training Program Study.

3-4 Study Visits

The research project consisted of at least 9 visits, each an hour long except for the initial two which were estimated to take 120 minutes. See Appendix E for data Recording Sheets for all visits. The clinical examination and training visits were administered at the clinic of the University of Waterloo School of Optometry and Vision Science, as well as the main administrative building. The last two visits were devoted to in-car virtual reality simulations with and without the telescope in the fully immersive AVRIL SUV virtual reality simulator located at the Autonomous Vehicle Research Intelligence Lab on the University of Waterloo main campus.

Visits 1 through 8 emulated the CSE Bioptic Training Protocol. The visits for the study are summarized as follows:

3-4.1 Visit 1

The first visit included a review of general and ocular health history, driving history, and diagnostic clinical tests including:

1. Visual acuity measured using the Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Visual acuities were measured initially at a distance of 3m. If the participant could not identify the letters at the top of the chart at that distance, the working distance was reduced in 1m increments until they were able to fully read the top row of letters. Visual acuities were measured both unaided (no distance glasses) and aided (habitual distance prescription if applicable).
2. Autolensometry

3. Autorefraction
4. Trial frame refraction: A presbyopic trial frame refraction technique was used. The just noticeable difference (JND) was determined from the participant's aided visual acuity unless a substantial change was discovered from the autorefraction.
5. Binocularity assessment: assessment of ocular alignment by the Hirschberg test, a light was directed at the participant's eyes from 50cm and the corneal light reflex position observed relative to the pupil center to estimate the presence of strabismus.
6. Colour vision testing by Jumbo D-15: The Jumbo D15 color vision test with larger-sized (10-degree) stimuli was used. The participant was assessed binocularly under normal illumination (no additional task illumination). The participant was asked to arrange the colour caps in order of closest colour similarity.
7. Central field test (Amsler grid): The test consists of a square grid of horizontal and vertical lines with a central fixation point that was used to assess the integrity of the central 20 degrees of visual field. The Amsler grid used for this visit consisted of a white grid on a black background with diagonal lines forming an 'X' through the central fixation point to aid with the participant's fixation. The chart was held at a distance of 28cm. Participants were assessed monocularly and asked to report any blurry, faded, wavy, distorted or missing areas on the grid.
8. Contrast sensitivity: The Pelli-Robson chart at 1m was used. The participant was asked to view through their habitual intermediate prescription (or distance prescription if an intermediate was not available). Participants were assessed monocularly and binocularly and asked to start reading at the top of the chart until they could no longer

see the letters. The last letter read in the trial where two letters were missed was the endpoint.

9. Automated Peripheral field assessment: The Humphrey visual field test is an automated perimeter designed to evaluate sensitivity across the visual field using a variety of stimuli. In this study, the Full Field 120-Point Suprathreshold monocular test was administered, which offered a quick assessment of both central and peripheral field of view of each eye across two zones of the field. The extent of the binocular field was determined using the binocular Esterman test, which included 120 white points presented at a fixed suprathreshold brightness of 10 dB, and evaluated over 130 degrees of the visual field.¹²⁰ A Goldman size III white stimulus, demonstrated against a standard white background, was used in this test. In the monocular tests, the appropriate prescription was placed in the lens holder and the fellow eye was patched. The participant placed their chin on the chin rest and fixated on a central target. Stimuli in different locations were presented, and the participant pressed a response button whenever a stimulus was seen. The test was repeated for the fellow eye. The binocular Esterman was then conducted. The patient was not patched and was uncorrected for the binocular tests. The tests were monitored manually for fixation losses.
10. Telescope fit: The required magnification to achieve at least 20/50 (using no more than 4x as specified by the MTO), the appropriate eye to fit and the telescope model were determined from the information retrieved from this visit. The 1.7x and 2.2x Designs for Vision Telescope and the 3 and 4x Ocutech VES Explorer were options used for the study. Telescopes were fit monocularly unless the individual could not suppress the

image from the eye without the telescope, in which case the telescope was fit binocularly. This applied only to the DVI telescope options as the Ocutech VES telescopes are only monocular.

3-4.2 Visit 2

Participants with no previous telescope experience were trained to focus, spot and scan with a handheld telescope. At this visit, an appropriate spectacle frame was selected to house the bioptic telescope design from Visit 1 and the carrier lenses. Optional selective transmission filters to accompany the bioptic were reviewed and the participant's customized bioptic was ordered.

Visual perception skills of participants were examined at this visit:

1. Trail Making Test- each test was placed in front of the participant at a distance of ~ 40cm. The participant was permitted to use reading aids if necessary to see the target. For Part A the participant was asked to connect a sequence of random circles numbered (1-25) in numerical order. For Part B the participant was asked to alternate between numbers and letters in sequential order.³⁶ The participant was timed while completing each task. The number of errors made was recorded.
2. Scan Course - The scan course was conducted in a hallway where twenty numbered cards were positioned on both sides of the hallway at different heights ranging from knee to head level. 50% of the numbers were placed on the left side of the hallway and 50% on the right.⁴⁰ The participant was asked to walk while calling out the numbers on

the cards. The total number of cards the participant correctly identified was documented.

3. Motor Free Vision Perception Test version 4. The participant was asked to view 45 two-dimensional black and white drawings, and for each, select an appropriate answer from four choices provided in multiple-choice format. Participants were permitted to use reading aids as required to see the target. Each correct identification received a score of one.

Additional clinical tests including tonometry, direct and consensual pupillary light responses, anterior chamber angle measurement and a dilated ocular health evaluation followed by Nidek MP3 microperimetry were conducted at this visit.

Nidek MP3 microperimetry, which provides a detailed assessment of the central visual field, was conducted on the eye(s) fit with the bioptic. To conduct a measurement on the Nidek MP3, the participant sat in front of the device with one eye patched, placed their chin on the chin rest and fixated on a central target. Stimuli of light were projected on specific retinal locations and the participant pressed a response button when the stimulus was perceived while fixation was monitored. The microperimetry test was performed using the following parameters: exam type: static microperimetry, background: 31.4 asb (white), fixation target: single cross (red, max,1.0°), pattern: automatic MP1 Normal 20°, stimulus: Goldman III (200ms, white), dynamic range: 34dB, strategy: 4-2 (fast).

The scan course, microperimetry and fundus evaluation were conducted at the main optometry building. The remaining tests were completed at the optometry field clinic.

3-4.3 Visit 3

First, the ordered bioptic telescope was dispensed. The remainder of the visit consisted of the first session of training from the CSE Bioptic Telescope Fitting and Training Protocol including bioptic education, specific activities and assignment of homework. The UFOV was also conducted at this visit.

Training: The details of the initial CSE training protocol are outlined below. The training is supported by presentation slides projected at 4.5m (15 feet)

- a. Overview of how to use the bioptic telescope (90-95% with carrier lens and 5-10% of driving time with bioptic telescope)
- b. Education about changes in perception while looking through a telescope: objects appear larger, field of view is smaller, objects appear closer, and objects appear to move faster
- c. Practice of vertical spotting technique (eye-head movement) to scan and localize targets; alternating vision from the carrier lens to bioptic telescope to spot and identify them. Targets include letters, numbers, shapes, and letters within shapes. These are located on slides 1-12.
- d. Timed activities: location and identification of 22 targets from a slide (slides 13-15).
The goal is to achieve this within 40 seconds in 3 attempts while wearing the bioptic telescope. The first slide includes the combination of 22 numbers and letters, the second slide includes 22 numbers, and the third one includes 22 letters.

Assigned homework: locating and identifying letters of a 4-corner Hart chart, identifying shapes in the Tell Me 2 shapes activity, and determining the direction of arrows in the Directional Arrows task (see Appendix F). All tasks are conducted at 3metres (10feet). Participants are also told to practice the vertical spotting technique while walking and wearing the bioptic telescope.

For the Useful Field Of View test, the participant was positioned in front of the monitor at an approximately 50-66cm distance and wore appropriate glasses for that distance (intermediate or near). For each subtest, the test appeared on the screen and was then replaced with a screen instructing the participant to report their answers. For subtest one, the participant was asked to select whether the central image was a truck or car. In subtests two and three, the participant was instructed to identify the central image as a truck or car plus the location of the additional vehicle presented in the periphery.

3-4.4 Visit 4

The fourth visit was a counselling session. Exploration of advantages and disadvantages of returning to driving, mental readiness for driving, techniques for managing driving anxiety and the Montreal Cognitive Assessment (MoCA-Blind) were conducted by the CSE psychotherapist on the phone or in a virtual meeting. The Montreal Cognitive Assessment (MoCA) is a screening tool designed to detect mild cognitive impairment and dementia (although as a screening tool it cannot be used independently to clinically diagnose cognitive impairment).¹²¹ The MoCA includes assessment of cognitive domains such as memory, attention, language, abstraction, delayed recall, and orientation.¹²² Factors such as fatigue,

depression, and anxiety may impact the results.¹²¹ The CSE psychotherapist is trained on the accurate administration of the test. The MoCA-Blind was used as it has been adapted from the original MoCA by removing visual components to be a suitable version for individuals with visual impairments, relying instead on verbal responses.¹²¹ Once the test was conducted, a score out of 22 was calculated.

3-4.5 Visit 5, 6.

These visits consisted of the second and third training sessions of the CSE Bioptic Fitting and Training Protocol including assigned homework (see Visit 3 for description of the first training session).

The details of the second and third training sessions of the CSE Protocol are outlined below:

Second training session (using slides 16-45 of the PowerPoint training presentation):

- a. Practicing vertical spotting technique to locate and identify shapes, letters in shapes, colour shapes, and 2, 3 and 4-letter words with the carrier lens and bioptic telescope.
- b. Ambulating while wearing the bioptic telescope; locating and scanning with the carrier lens and identifying targets and pictures with the bioptic telescope
- c. Timed activities: locating and identifying 22 targets from a slide within 40 seconds in 3 attempts while wearing the bioptic telescope. The first slide includes the combination of 22 numbers and letters, the second slide- 22 numbers, and the third- 22 letters.

Assigned homework: locating and identifying different targets such as cars and pedestrians and stating these aloud both as a passenger in a car and while walking.

Third training session:

- a. Review of vertical spotting technique (slides 47-49; includes single letters, 3 letter- and 4 letter words)
- b. Location and identification of street signs with and without distractors (slides 50-61).
- c. Visual memory activities: location and identification of 3-letter words within a 2-3 second window, progression to 4-letter words and continuing to phrases presented for 3-4 seconds to acquire the skills of identification as quickly as possible with a bioptic telescope (slides 62-98). Answering questions related to a presented scene (i.e. direction of exit, distance to next town) located on slides 99-117. A question is initially presented on a slide, followed by a picture of a scene which is presented for 2-3 seconds. Participants need to recall and answer the question based on the presented scene.
- d. Detailed recall of pictures: describing pictures presented within 3 seconds of disappearing (slides 119-126)
- e. Identifying if the scene is one in which bioptic use would be safe (slides 127-130).
- f. Timed activity: locating and identifying 22 targets within 40 seconds in 3 attempts while wearing the bioptic telescope (slides 131-132).

Assigned homework: locating and identifying different targets as a passenger in a car and then while moving while operating a bike or scooter.

3-4.6 Visit 7,8

Visits 7 and 8 were reserved for additional sessions if it was felt that the participant was not progressing well or had not completed the previous 3 sessions.

1.12.1 Visit 9

Driving simulation: an in-car virtual reality simulation using the fully immersive AVRIL SUV driving simulator with its original components (modified car positioned in front of a projection screen) was employed to examine participants' use of bioptic and driving abilities after completion of the bioptic training.

A driving course including roads, pedestrians, cyclists, other motor vehicles, intersections, buildings and road signs was designed by the AVRIL/CSE team and projected on the screen.



Figure 3-1: The AVRIL SUV simulator presents users with a driving course projected on a screen and which contains elements (intersections, road signs) commonly encountered during a driving task

Visit 9 was divided into two sub visits. At the first, participants attended to be trained on the use of the virtual reality driving simulation without the bioptic telescope. At the second, which occurred the following day, participants attempted the simulated driving course first while wearing the bioptic telescope within an approximately 10-minute driving scenario, and then once again without wearing the telescope within an approximately 10-minute driving scenario. A web camera directed towards the participants recorded their bioptic telescope use. A member of the AVRIL team sat as a passenger in the vehicle and provided consistent turning, parking and lane change instructions (Appendix G).

The driving scenario included the following components:

- Initiating movement from a parked position
- Right and left turns
- Encountering pedestrians, intersections with traffic lights (albeit not active and treated as a four-way stop), stop signs, road signs, roundabouts and other vehicles
- Performing a parking maneuver and a lane change

After the simulation, the recordings were evaluated to extract information such as response to obstacles and hazards, frequency of bioptic use, and abilities in identifying road signs and following traffic regulations including speed control.

Chapter 4

Results

4-1 Analysis

A descriptive analysis of the data was conducted for this pilot project to describe each of the measurements and parameters recorded for each participant. Most plots were generated using Jamovi (version 2.7.2), and some were created using Microsoft Excel.

4-2 Results

Three male participants with a diagnosis of AMD were recruited to date with ages ranging between 68-82 years old. In addition, at the beginning of the recruitment, two more individuals as potential participants did not respond to phone calls after follow-up attempts, and one other person declined to participate in the study.

4-3 Motion Sickness Analysis

4-3.1 Visual Impairment and Motion Sickness

1.12.1.1 MSSQ and Self-Reported Cognitive Function Question

To screen participants at risk of motion sickness in the simulator at the beginning of the study, the Motion Sickness Susceptibility Questionnaire short-form (MSSQ-Short) - a shortened and modified version of the MSSQ-Long – was applied.¹²³ Motion sickness susceptibility was evaluated by rating the experience of symptoms using different forms of transport and entertainment such as car, bus, train, airplane, small boat, ship, playground swing, roundabout,

and amusement park rides in childhood experiences up to age 12 (MSA score) and adult experiences over the past 10 years (MSB score).

The MSA and MSB scores were calculated following the equations described by Golding.¹²³

The overall MSSQ score was obtained by summing the MSA and MSB scores together.¹²⁴

$MSA = (\text{total sickness score child}) \times (9) / (9 - \text{number of types not experienced as a child})$

$MSB = (\text{total sickness score adult}) \times (9) / (9 - \text{number of types not experienced as an adult})$

$MSSQ \text{ raw score} = MSA + MSB$

The individual MSSQ scores for all participants are presented in Table 4-1. The MSSQ scores of all participants were under 23 (cutoff point).

All participants also self-reported no diagnosis of cognitive impairment.

As such, all participants were eligible to participate in the research.

Table 4-1: Individual MSSQ scores for each participant. The cut-off score is 23.

Participants #	Age	MSSQ score	Eligibility status
1	74	0	Eligible
2	68	3	Eligible
3	82	0	Eligible

4-4 Demographic and Visual Clinical Results

As part of study eligibility in terms of meeting MTO requirements, and to assess visual function, a visual examination was conducted for all participants. The results of these assessments are presented in Table 4-2 along with the participant demographic information.

Table 4-2: First visit assessment results for each participant

Participant #	1	2	3
Age	74	68	82
Gender	Male	Male	Male
Duration of driving experience/when a driver's license revoked	More than 20 years/ Feb 2024	30 years/ 2023	More than 30 years/ Dec 2023
Unaided VA (logMAR)	OD: 0.64 (20/80) OS: 0.75 (20/126) OU: 0.48 (20/64)	OD: 0.96 (20/200) OS: 0.86 (20/160) OU: 0.83 (20/126)	OD: 0.48 (20/64) OS: 0.50 (20/64) OU: 0.58 (20/80)
Aided VA after trial frame refraction	OD: 0.48 (20/64) OS: 0.64 (20/80)	OD: 0.64 (20/80) OS: 0.77 (20/126)	OD: 0.35 (20/50) OS: 0.58 (20/80)

(logMAR)	OU: 0.46 (20/64)	OU: 0.65 (20/100)	OU: 0.46 (20/64)
Bioptic telescope VA (logMAR)	0.28 (20/40)	0.28 (20/40)	0.22 (20/32)
Pelli-Robson contrast sensitivity	OD:1.45 OS:1.45 OU:1.15	OD:1.30 OS:1.00 OU:1.25	OD:1.15 OS:1.30 OU:1.30
Colour vision	Non-specific colour vision defect	No defect	Tritan-like colour vision defect
Hirschberg test	Ortho	Ortho	Ortho
Amsler grid	OD: no defect OS: no defect	OD: no defect OS: blurry defect superior-nasal	OD: no defect OS: no defect

120 pt Humphrey Visual Field	OD: central scotoma OS: central scotoma	OD: central scotoma OS: central scotoma	OD: central scotoma OS: central scotoma
Telescope Fit, type and mag	Binocular, Galilean 2.2X (DVI)	Monocular (right eye), Keplerian 3X (Ocutech)	Binocular, Galilean 2.2X (DVI)

4-5 Visual Acuity Analysis

All participants met the MTO eligibility criteria for bioptic driving which requires a minimum best-corrected visual acuity of 20/160 (0.90 logMAR) to participate in the program and at least 20/50 (0.39 logMAR) using the bioptic telescope. Across all participants, unaided visual acuity of the right eye (OD) ranged from 0.48 (20/64) to 0.96 (20/200) in logMAR, and for the left eye (OS) from 0.50 (20/64) to 0.86 (20/160) in logMAR, and OU from 0.48 (20/64) to 0.83 (20/126) in logMAR. Aided visual acuity with updated correction in right eyes ranged from 0.35 (20/50) to 0.64 (20/80) in logMAR, in left eyes from 0.58 (20/80) to 0.77 (20/126), and with both eyes open, from 0.46 (20/64) to 0.65 (200/100) in logMAR. Bioptic telescope visual acuity ranged from 0.22 (20/32) to 0.28 (20/40) in logMAR.

A series of scatter plots were created to indicate visual acuity measurements across all participants. These plots include unaided visual acuity (VA) (Figure 4-1), aided trial frame refraction visual acuity (TFR VA) (Figure 4-2), and VA through the bioptic telescope (Bioptic Telescope VA) (Figure 4-3).

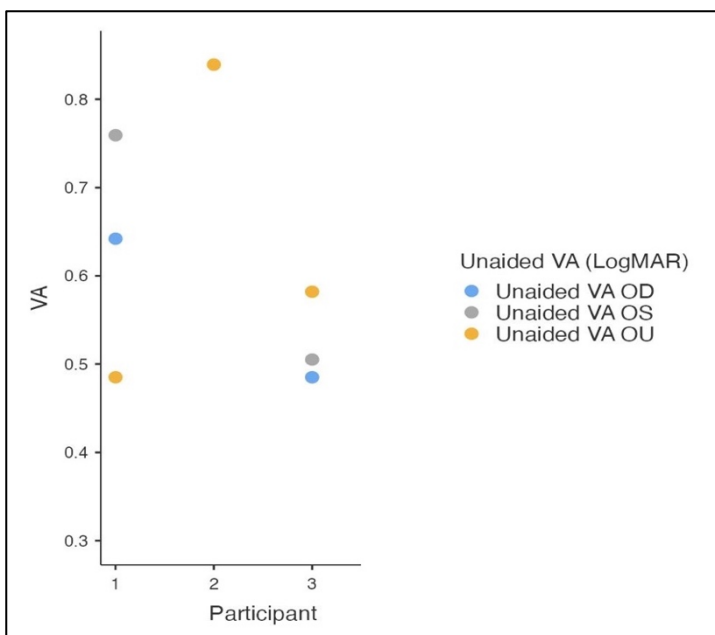


Figure 4-1: Monocular and binocular unaided visual acuity per participant

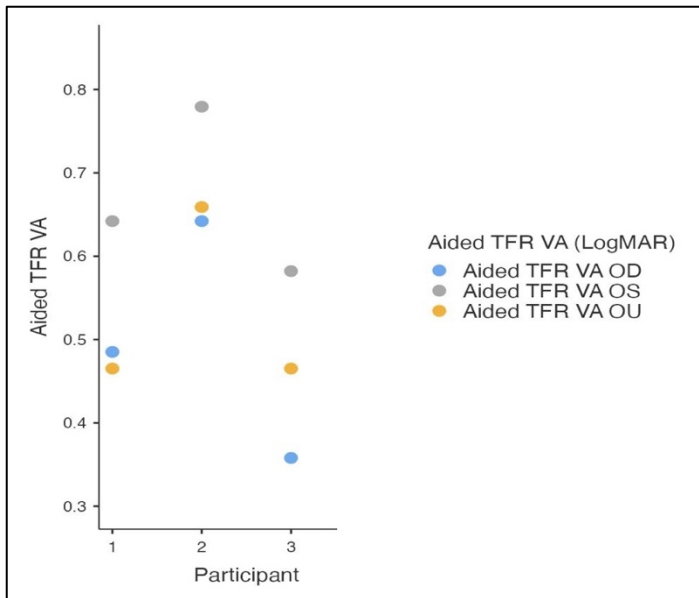


Figure 4-2: Monocular and binocular aided Trial Frame Refraction (TFR) visual acuity for each participant

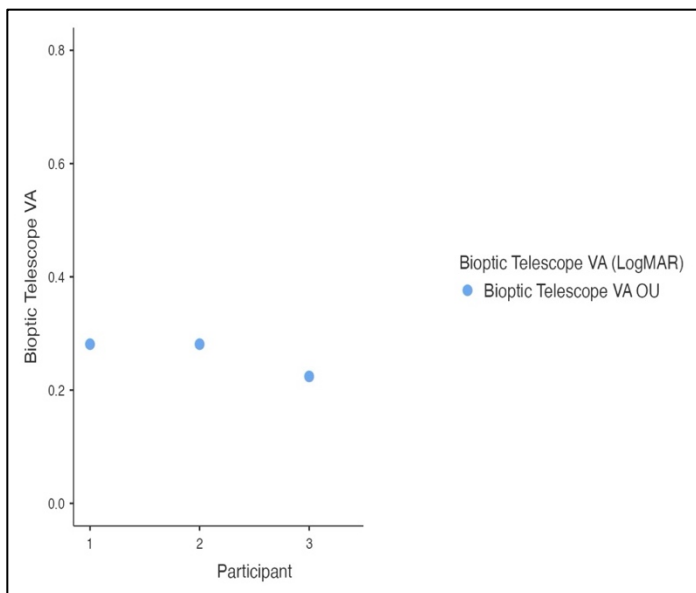


Figure 4-3: VA through the bioptic telescope for each participant

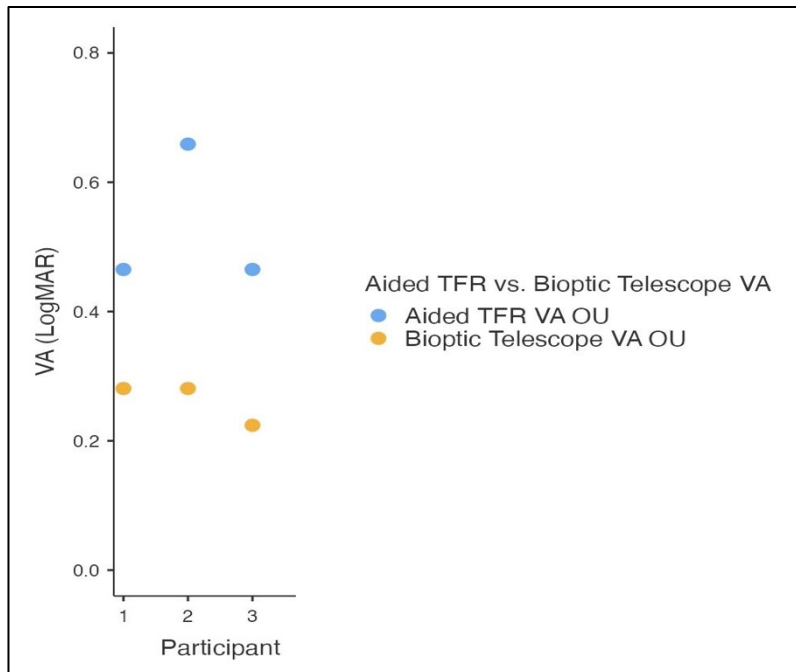


Figure 4-4: Aided Trial Frame Refraction Visual Acuity vs. Bioptic Telescope Visual Acuity

A scatter plot was drawn to visually indicate the difference in visual acuity between aided status with correction and bioptic telescope vision across all participants (Figure 4-4). The plotted results highlight the variation in baseline VA among participants. Figure 4-4 illustrates a consistent improvement in visual acuity using the bioptic telescope from a range of 0.46 (20/64)-0.65 (20/100) (aided) to 0.22 (20/32)-0.28 (20/40) (bioptic).

4-6 Contrast Sensitivity Analysis

In this study, contrast sensitivity (CS) was measured monocularly and binocularly for each participant using the Pelli-Robson chart. The MTO requires a minimum CS score of 1.00 log units (with 1.35 log units preferred) as part of visual requirements for driver licensing

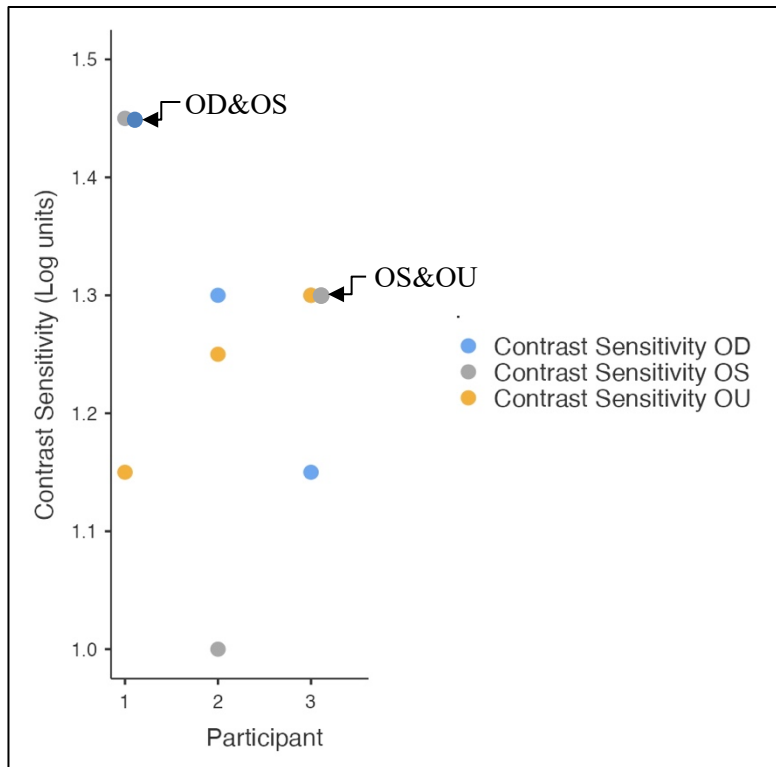


Figure 4-5: Monocular and Binocular Contrast Sensitivity for each participant

Across all participants, monocular contrast sensitivity ranged from 1.00 log units to 1.45 log units (normal range 1.65-1.8 log units). Binocular contrast sensitivity ranged from 1.15 log units to 1.30 log units. All participants met the CS cutoff score needed for MTO requirements.

Figure 4-6 examines the relationship between CS scores and aided VA with correction.

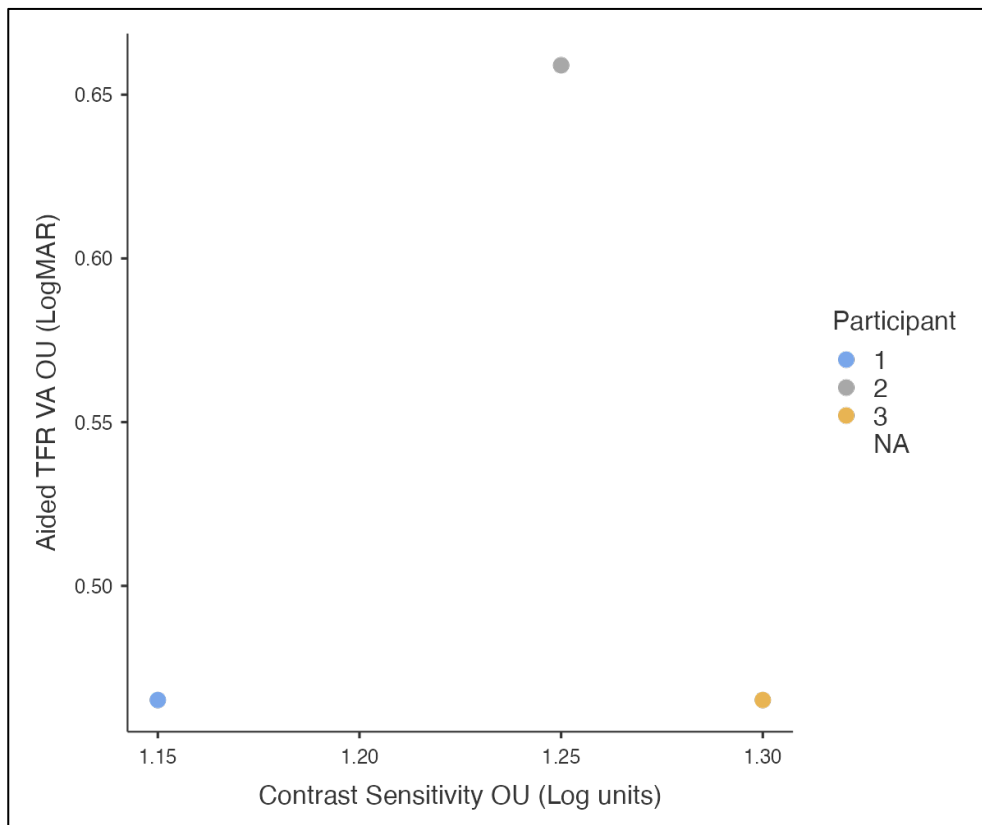


Figure 4-6: Aided Trial Frame Refraction Visual Acuity vs. Contrast Sensitivity for each participant

4-7 Refraction

In this study, habitual correction, autorefraction, and subjective trial frame refraction results were collected to evaluate participants' refractive status.

Due to the small number of participants, raw prescription data and descriptive analysis are reported here.

Refractive errors in spherocylindrical notation are presented for each participant. Table 4-3 indicates participants' habitual correction versus trial frame refraction results.

Table 4-3: The actual prescriptions of current correction and trial frame refraction for each participant

Participant	Habitual correction (cc)/Trial frame refraction (TFR)	Eye	Sphere (D)	Cylinder (D)	Axis	Prescription incorporated into the bioptic (Yes/No); Bioptic type
1	CC	OD	-0.50	-0.50	98	Yes; Galilean 2.2X (DVI) - OU
	TFR	OD	-0.25	-0.75	95	
	CC	OS	+0.25	-0.50	79	
	TFR	OS	+0.25			
	CC	OD	-1.50	-3.25	170	

2	TFR	OD	-1.00	-3.75	150	Yes; Keplerian 3X (Ocutech) - OD
	CC	OS	+1.50	-3.75	179	
	TFR	OS	Plano	-6.50	179	
3	CC	OD	+1.00	-1.00	87	Yes; Galilean 2.2X (DVI) - OU
	TFR	OD	+1.00	-1.00	90	
	CC	OS	+0.75	-0.25	115	
	TFR	OS	+0.50	-0.25	105	

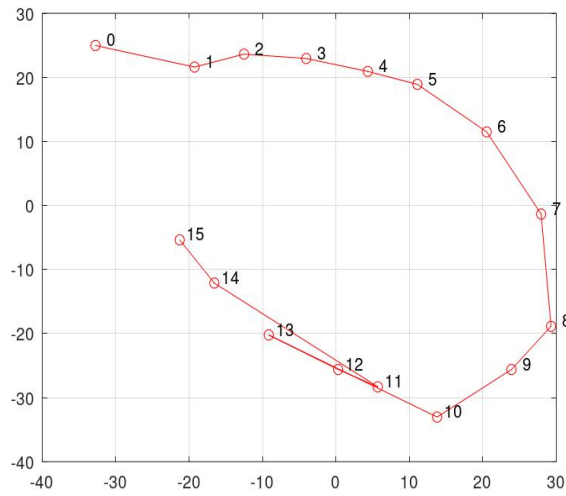
The final prescriptions were incorporated into the eyepiece of each telescope for all three participants. The findings reflect notable differences in refractive error across participants: one was a low myope, the other anisometropic and the other a low hyperope.

4-8 Colour Vision Analysis

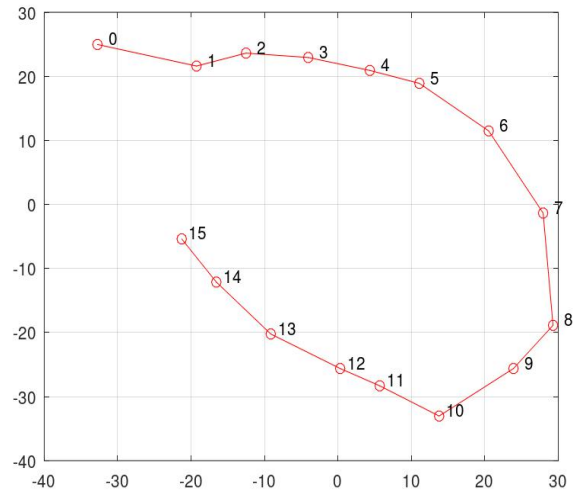
To analyse the colour vision data, the Vingrys and King-Smith colour difference vector method¹²⁵ was used, which calculates colour difference vectors between adjacent caps based on the pattern in which they were arranged. The method can provide a quantitative assessment of colour vision defects in age-related macular degeneration.¹²⁵

The GNU Octave program was used to calculate several parameters including confusion angle, Confusion index (C-index), and Selectivity index (S-index) from the D15 cap arrangement data for each participant. The confusion angle identifies the affected axis and the type of colour defect (protan, deutan, tritan). The Confusion index (C-index) quantifies the severity of colour loss compared to a perfect cap sequence with larger values reflecting greater deviation from the ideal ordering. The Selectivity index (S-index) quantifies the extent of polarity or lack of randomness of a cap arrangement.¹²⁶

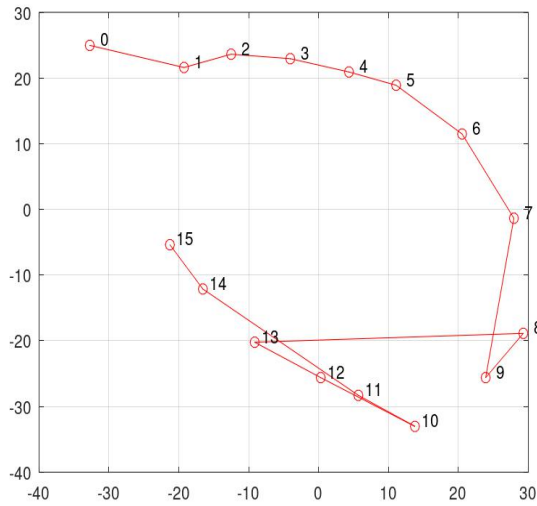
Angles between -25° and $+25^{\circ}$ indicate a red-green defect. Typically, in deutan defects, the angle is less than 0, and in protan defects, greater than 0. Angles between -70 and -100 and $+70$ and $+100$ indicate a blue-yellow defect while angles outside these regions represent a non-specific colour vision deficit. In terms of Confusion index, C-index of 1.00 indicates a perfect ordering, whereas C-index >1.78 reflects a colour vision deficit. An S-index for a normal value is around 1.38.¹²⁷ Higher values of S-index reflect errors that are aligned along a single axis (selective or polar) rather than random. The following figures indicate the Jumbo D-15 arrangement plots (created with the Octave program) for each participant.



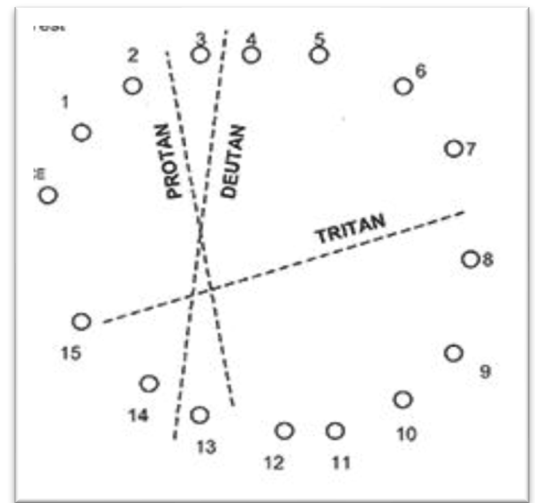
Participant 1



Participant 2



Participant 3



Color vision defects diagram

Figure4-7: Jumbo D-15 arrangement patterns for participants 1-3. These numbered points are the D-15 caps, and the connecting lines show the order in which the caps were arranged.

Table 4-4 illustrates the confusion angle, Confusion index (C-index), Selectivity index (S-index) and colour vision status for all 3 participants.

Table 4-4: Colour vision parameters and patterns

Participant Number	Angle	C- index	S- index	Colour vision Pattern
1	55.591	1.41	2.12	Selective, non-specific axis, colour vision defect with normal severity
2	50.504	1.00	1.51	Near-random, non-specific, perfect colour vision
3	71.297	1.59	1.70	Selective blue-yellow (tritan-like) axis, colour vision defect with normal severity

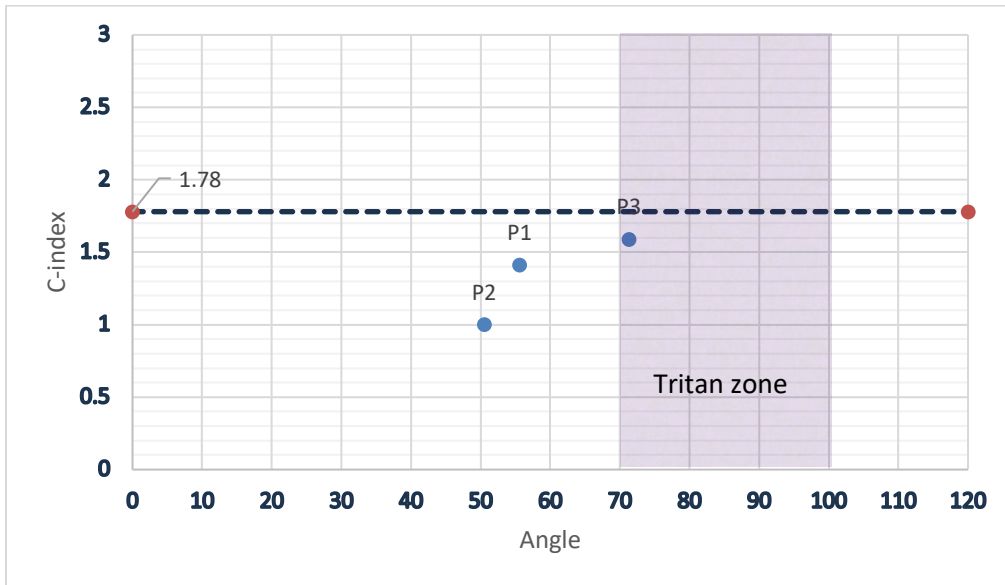


Figure 4-8: C-index vs. Angle

Figure 4-8 indicates angle vs. C-index. The dashed line marks the C-index cutoff and the highlighted region shows the tritan zone. Participant 1 ($\approx 56^\circ$, $C=1.41$) and participant 2 ($\approx 51^\circ$, $C=1.00$) lie outside the tritan zone and below the cutoff. P3 ($\approx 71^\circ$, $C=1.59$) lies at the edge of the tritan zone with borderline colour loss.

4-9 Driving-related Cognitive and Perceptual Functions Analysis

A series of cognitive evaluations relevant to driving performance were conducted with habitual correction to assess participants' visual processing speed, attention, and cognitive flexibility. These assessments included the Trail Making test, Scan Course test, Motor-Free Visual Perception test, and Useful Field of View test. Each participant's results were analyzed individually based on age-related normative data or determined cutoff scores. The outcomes

of each test for all participants are presented in the following table (Table 4-5). Cells indicating values outside the normative range have been shaded for clarity.

Table 4-5: Scores of perceptual functions tests

Participant Number	TMT-B >180 s ³⁷ >3 errors (unsafe)	Scan Course >18 ⁴⁰ (safe)	MVPT-4 >38 (fit to drive) 19-37 (need further assessment) <18 (unfit to drive) ⁴⁵	UFOV Guideline categories/ Subtest 2 (>300ms)- Crash risk	
				Subtest 2 (>300ms) based on Bedard ³⁵	Risk statement based on UFOV guideline³⁴
1	195	20	21	T2: 331.75	T1: 320.63

	0 errors				T2:331.75 T3: 500.41 Moderate to high risk
2	111 0 errors	19	35	T2: 131.59	T1: 35.21 T2: 131.59 T3: 408.56 Moderate to high risk
3	207 0 errors	19	16	T2: 500.41	T1: 233.52 T2: 500.41 T3: not determined High risk

Considering Bedard's work with the UFOV subtest 2, participant 2 would be at lower risk of a crash due to perceptual limitations.

In the UFOV subtests, subtest 1 (T1) measures processing speed, subtest 2 (T2) reflects divided attention and subtest 3 (T3) indicates selective attention. Results of each UFOV subtest for

each participant are presented in the last column of Table 4-5. Those above a score of 300ms on subtest 2 are considered as requiring further driving assessments. In addition, these were compared against established UFOV categories in the UFOV User's Guide Version 6.0.6 relating thresholds to collision risk³⁴ which include very low, low, low to moderate, moderate to high, high, and very high risk.³⁴ Only two of these categories were applicable to the participants' scores in this study.

4-10 Visual Field Analysis

In this study, three complementary assessment methods were employed to evaluate the central visual field of the participants - Humphrey automated perimetry, microperimetry, and Amsler grid testing- to evaluate the visual fields.

4-10.1 Visual Field Scoring

To precisely analyze and compare visual field results across the mentioned methods, a specific VF scoring system was used. For the Humphrey full field 120-point tests, scoring was based on the American Medical Association (AMA) functional visual field scoring system which will be explained in next paragraphs.

For consistency in visual field analysis, the AMA Visual Field scoring system was also used for the Microperimetry results.

For the Amsler grid test, scoring was qualitative and subjective and based on participant report. The scoring procedures together prepared both quantitative and qualitative comparisons of functional visual field in participants with AMD.

4-10.1.1 AMA Visual Field Scoring System

The AMA functional visual field scoring system uses a standardized grid with ten meridians positioned at intervals of 25, 65, 115, 155, 195, 225, 255, 285, 315, and 345. Along each meridian, ten eccentricities are evaluated; five eccentricities located within the central 10 degree of the visual field at 1, 3, 5, 7, and 9, and the remaining five are positioned within the peripheral visual field at 15, 25, 35, 45, and 55 eccentricities.¹²⁸

Visual field scoring is based on whether the stimulus was detected (seen) or not detected (not seen) by the participant.

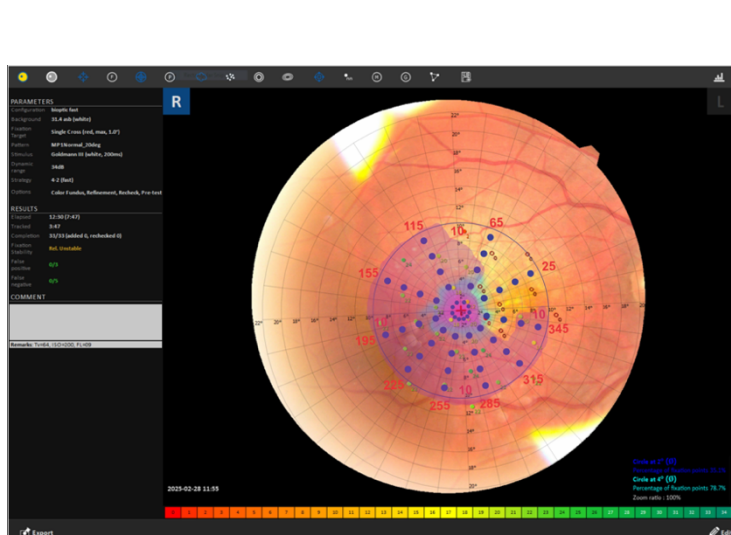
To score the visual field, an overlay grid with the specifications as described is created using CorelDRAW software and digitally positioned over the Humphrey visual field plot image and an image of the final result was captured for documentation. The area seen which falls within the grid is then highlighted. Then all grid points that fall within the highlighted areas are counted as points seen and any grid points that lie within scotomas are excluded from the count. The total number of points seen represents the Visual Field Score (VFS).

In this study, the investigators focused only on the central 10 degrees of visual field both because of the clinical importance of the central visual field in AMD and for consistency when trying to compare across the Humphrey, microperimeter and Amsler grid. Microperimetry also provides detailed retinal sensitivity mapping within the central 10-degree area.

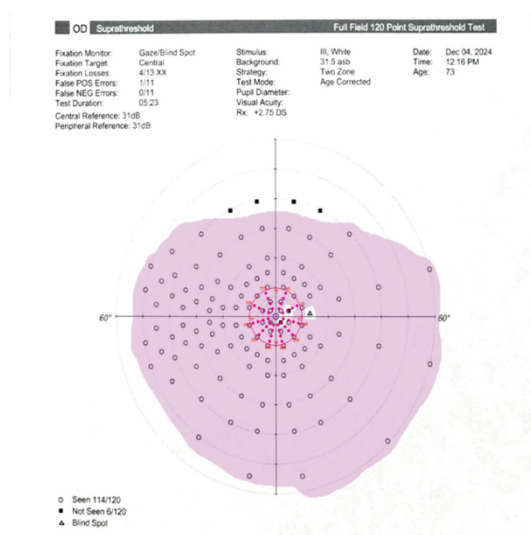
It is noteworthy to point out that in microperimetry, retinal sensitivity is recorded in decibels (dB) at each point. Moreover, fixation stability was evaluated to map functional visual field. For microperimetry, test points with a retinal sensitivity of 10 dB or greater were classified as

seen, while those with retinal sensitivity under 10 dB were considered not seen to be consistent with the two-zone Humphrey visual field assessment delineation of seen and unseen. The remaining steps of the scoring process followed the same procedure which was used for the Humphrey visual field. The number of “seen” points within the central 10 degrees of retina were counted. In the AMA scoring system, the central grid consists of 50 test points at 1,3,5,7, and 9 eccentricities within 10 meridians. The percentage of visual field score is calculated by multiplying the number of detected points by 100 and dividing by 50. For each participant, both Humphrey and microperimetry plots were analyzed and compared. These comparisons allowed to examine the consistency between microperimetry and Humphrey evaluations of central field of view. The following section presents a comparative interpretation of these visual field tests participant by participant.

4-10.2 Visual Field Assessment – Right Eye – Participant #1



(A) Humphrey map



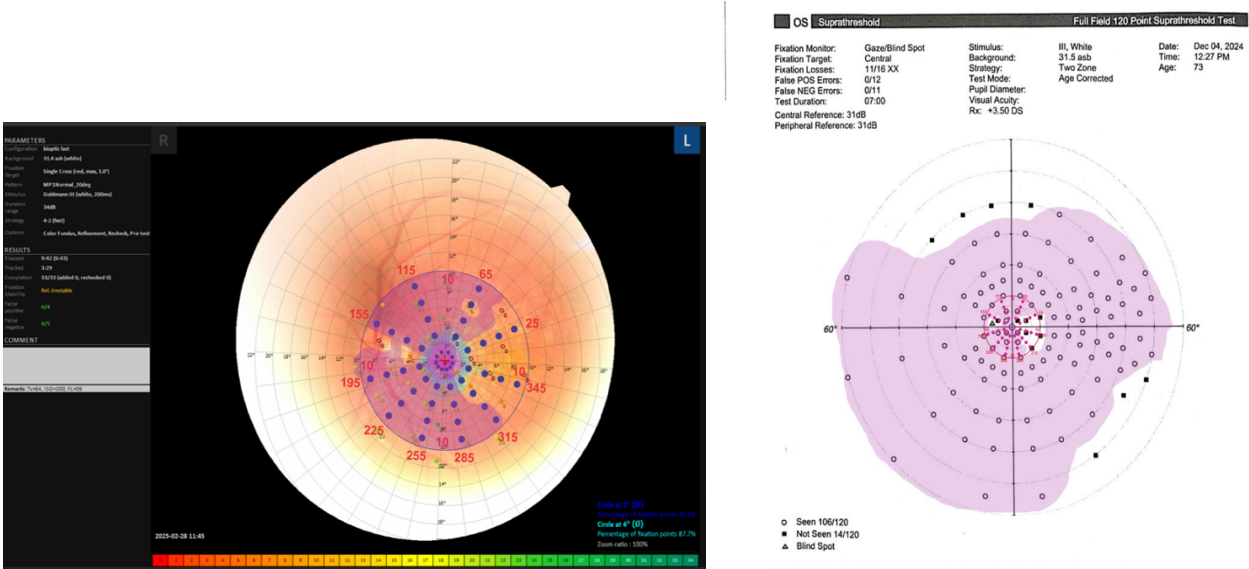
(B) Humphrey map

Figure 4-9 shows two plots which correspond to (A) OD microperimetry sensitivity map, (B) the OD Humphrey 120-point visual field for Participant 1.

The Humphrey 120-point VF plot illustrates relatively good central sensitivity such that 92% of test points are seen within the central 10 degrees of the overlay grid based on the AMA method. The only points unseen are located temporally (inferior-temporal side) within 10 degrees.

In comparison, the microperimetry plot demonstrates a slightly decreased level of sensitivity, with a Visual Field Score (VFS) of 84% within the same central 10 degrees. Although this still shows a functional visual field, microperimetry showed additional regions of reduced sensitivity specifically in the superior-nasal quadrant of the retina relative to the highlighted

4-10.3 Visual Field Assessment – Left Eye – Participant #1



(C) Microperimetry map

(D) Humphrey map

Figure 4-10 demonstrates two plots which belonged to (C) microperimetry sensitivity map, (D) the Humphrey visual field of the left eye of Participant 1.

The Humphrey VF plot for the left eye shows a central field impairment compared to the right eye, with a Visual Field Score of 74% within the central 10 degrees based on AMA grid. Deficits are mostly seen beyond 10 degrees in the superior-temporal and inferior- nasal quadrants and slightly in central and paracentral region (inferior-nasal) near the fixation.

The microperimetry plot reveals a relatively comparable Visual Field Score of 72% in comparison with the Humphrey plot. The scattered points of reduced sensitivity are particularly seen within superior and inferior-temporal area of the retina which aligns with the area of points unseen in the Humphrey plot.

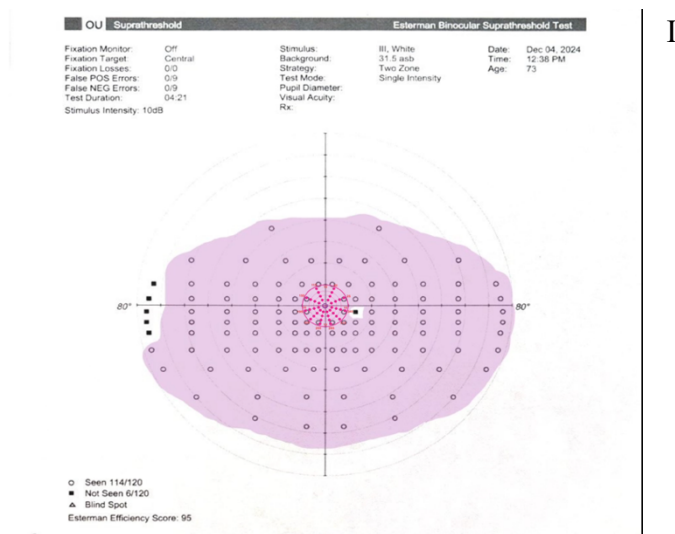
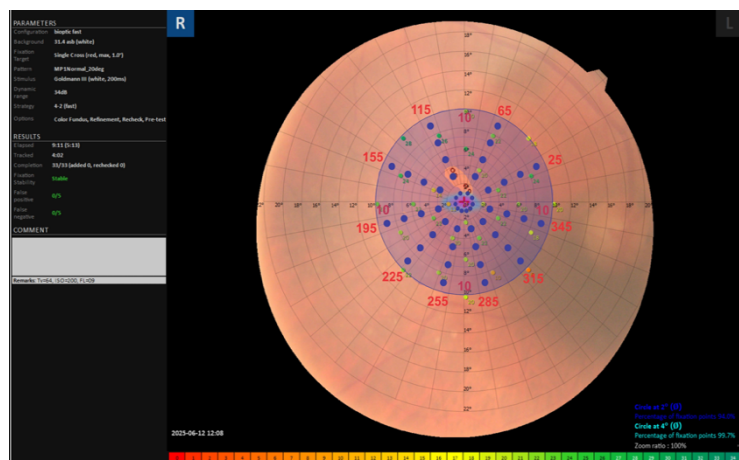


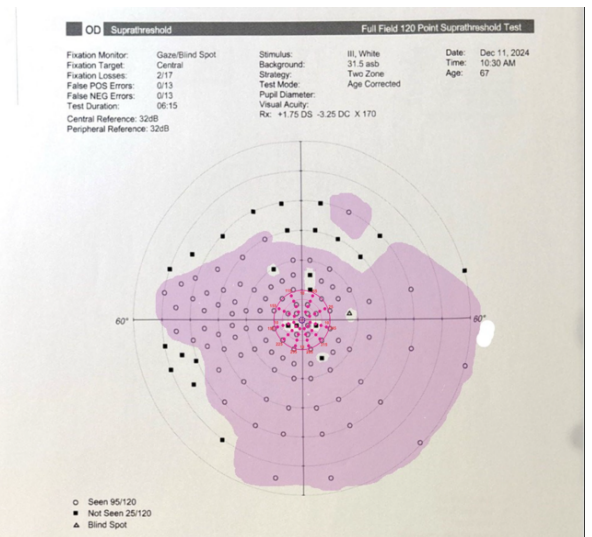
Figure 4-11: Binocular Esterman visual field plot for participant 1

Figure 4-11 presents the binocular Esterman visual field plot for the first participant with a Visual Field Score (VFS) of 100% within the central 10-degree field of view based on the AMA scoring system. All points in this area are seen. As a result, under binocular conditions, the central 10 degrees field, which is important for bioptic telescope use, is misleadingly indicated as intact.

4-10.4 Visual Field Assessment – Right Eye – Participant #2



(F) Microperimetry map



(G) Humphrey map

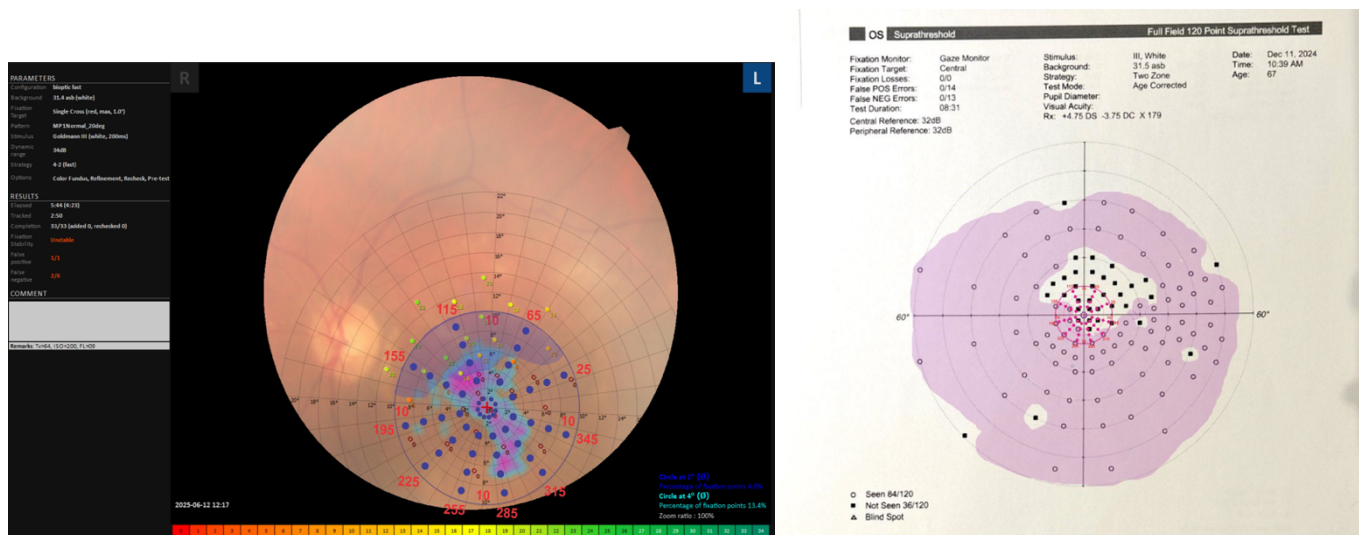
Figure 4-12 shows two plots which correspond to (F) microperimetry sensitivity map, (G) the Humphrey visual field of the right eye of Participant 2.

The Humphrey VF plot indicated good central field sensitivity with a visual field score (VFS) of 90 % within the central 10 degrees of field of view according to AMA scoring. A few missed

points were seen in the inferior-nasal and superior-temporal quadrants of the peripheral VF. In addition, some points are missed on the nasal side of the central VF within 10 degrees.

The microperimetry plot presented a good central field sensitivity with a VFS of 94% within the central 10 degrees of visual field. Points unseen were found in the superior -temporal regions of the retina within the central 10 degrees.

4-10.5 Visual Field Assessment – Left Eye – Participant #2



(H) Microperimetry map

(I)Humphrey map

Figure 4-13 indicates two plots which correspond to (H) microperimetry sensitivity map, and (I) the Humphrey visual field of the left eye of Participant 2.

The Humphrey VF plot showed a visual field impairment with visual field score of 32% within the central 10 degrees of the field based on the AMA grid. A large area of decreased sensitivity

or points unseen were observed specifically in the superior and nasal sections of the visual field within the central 10 degrees.

In comparison, microperimetry test illustrated a lower VFS of 14% within the central 10 degrees of the field of view that confirms central visual field loss. The sensitivity map indicated areas of deficits within the inferior- temporal, and nasal of the retina which aligns with the Humphrey results deficit location.

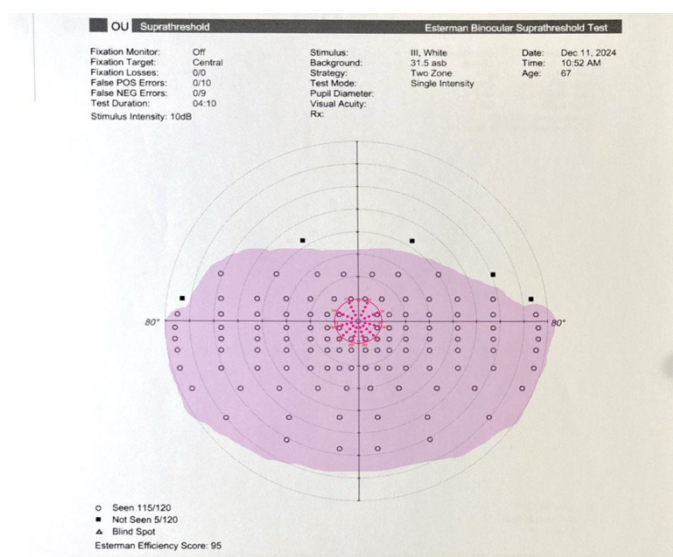
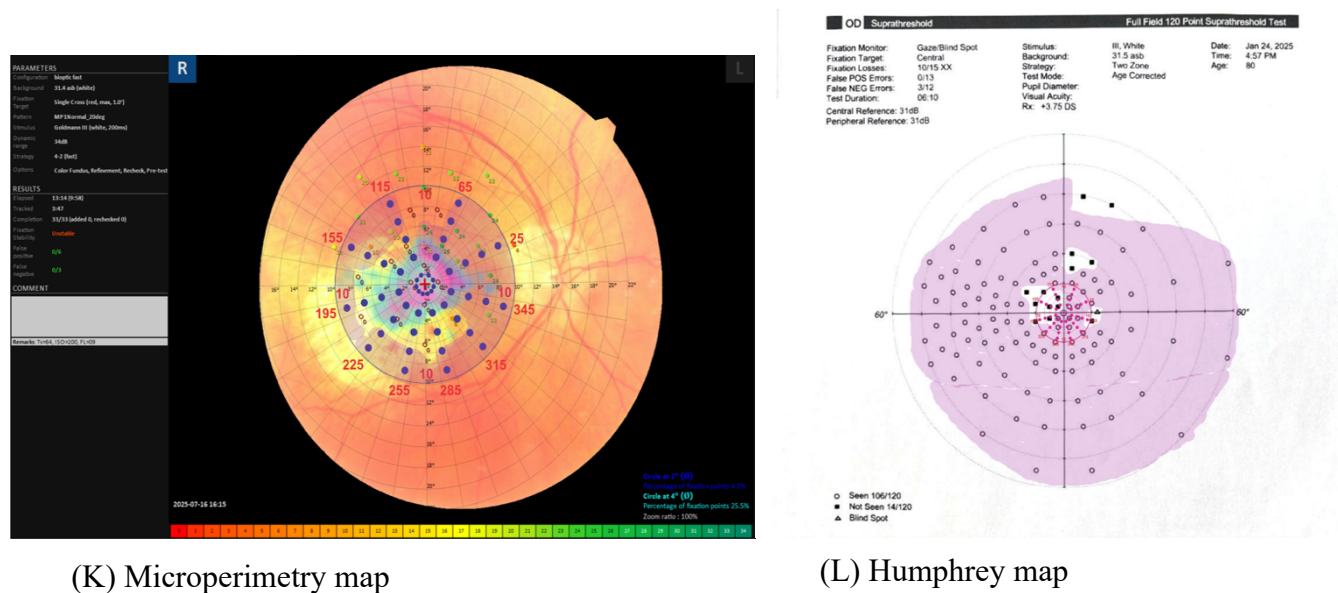


Figure 4-14: Binocular Esterman visual field plot for participant 2

Figure 4-14 presents the binocular Esterman visual field plot for the second participant with a visual field score (VFS) of 100% within the central 10 degrees visual field based on the AMA scoring system. Under binocular condition, it reflects that the central 10 degrees VF was misleadingly indicated as intact. Overall, both VF methods confirm significant central visual field loss in the left eye and good central visual field in the right eye.

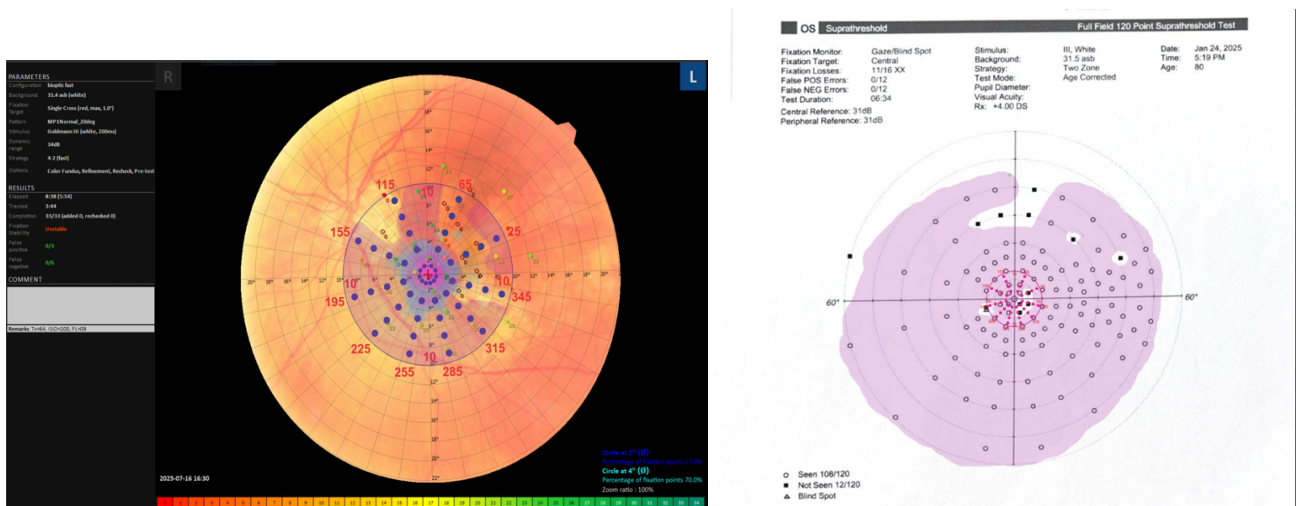
4-10.6 Visual Field Assessment – Right Eye – Participant #3



The Humphrey VF plot revealed a visual field score of 76% within the central 10 degrees based on AMA system. Missed points were scattered in the superior-nasal and inferior-temporal quadrants of VF within central 10 degrees.

Microperimetry test indicated a lower VFS of 52% that may suggest more central visual field impairment compared to the Humphrey plot. This map indicated reduced sensitivity in the superior and inferior temporal areas of the retina within the central 10 degrees.

4-10.7 Visual Field Assessment – Left Eye – Participant #3



(M) Microperimetry map

(N) Humphrey map

Figure 4-16 shows two plots which correspond to (M) microperimetry sensitivity map, and (N) the Humphrey visual field of the left eye of Participant 3.

The Humphrey plot presented a good central visual field with a VFS of 84% which indicated that most of the central points were seen. The points unseen were observed in the inferior-nasal side of central VF.

In comparison, microperimetry demonstrated a VFS of 82% which supported the Humphrey findings. The sensitivity map indicated good central VF with some areas of reduced sensitivity in the superior-temporal and superior-nasal retinal regions within the central 10 degrees.

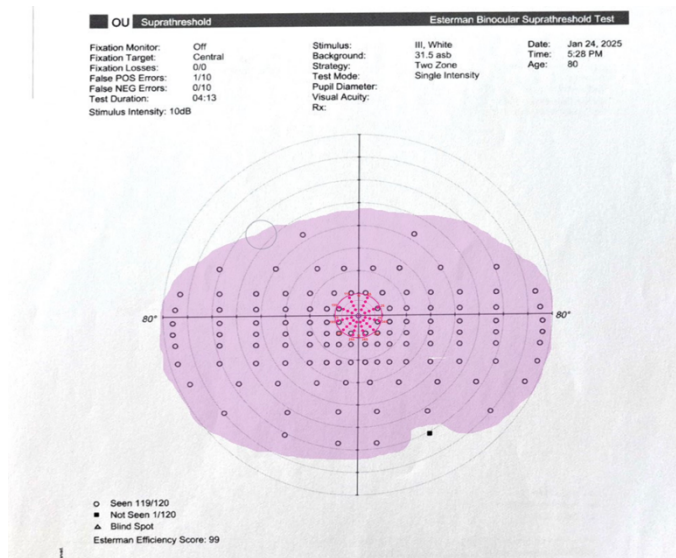


Figure 4-17: Binocular Esterman visual field plot for participant 3

Figure 4-17 indicates the binocular Esterman visual field plot for the third participant with a visual field score (VFS) of 100% within the central 10 degrees visual field according to the AMA grid. Under binocular condition, it reflects that the central 10 degrees VF was misleadingly indicated as intact. Overall, both tests suggest a moderate central visual field deficit in the right eye and good central visual field in the left eye.

Microperimetry also measures an individual's fixation stability (Table 4-7). Fixation stability was evaluated by the method developed by Fujii et al. The percentage of fixation locations that fall within a 2 or 4-degree circle is calculated. Thresholds are described in the table below.^{129,130}

Table 4- 6: Classification of fixation stability developed by Fujii et al.

Stable	>75% of fixation points (FP) fall within a 2-degree circle
Relatively Unstable	<75% FP fall within a 2-degree circle but >75% in a 4-degree circle
Unstable	<75% FP fall within a 4-degree circle

Table 4-7: Participant fixation stability as measured by microperimetry

Participant	Eye examined	Fixation points within 2-degree circle (%)	Fixation points within 4-degree circle (%)	Stability
1	OD	35.1	78.7	Relatively Unstable
	OS	45.1	87.7	Relatively Unstable
2	OD	94	99.7	Stable
	OS	4	13.4	Unstable
3	OD	4.2	25.5	Unstable

	OS	27	79	Relatively Unstable
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Table 4-8 illustrates VA, Amsler grid, monocular and binocular VF, fixation stability, and the selected telescope fitting type for each participant.

Table 4-8: A summary of visual functions, fixation stability and telescope fitting type

	VA (TFR) (LogMAR)	Pelli- Robson contrast sensitivity	Amsler Grid	Humphrey VFS (Visual Field Score) (%)	Microperime try VFS (Visual Field Score) (%)	Fixation Stability	Telesco pe Fitting type
1	OD: 0.48(20/64) OS: 0.64(20/80) OU: 0.46(20/64)	OD:1.45 OS:1.45 OU:1.15	OD: no defect OS: no defect	OD: 92% OS: 74% OU: 100%	OD: 84% OS: 72%	OD: Relativel y unstable OS: Relativel	Binocul ar

						y unstable	
2	OD: 0.64(20/80) OS: 0.77(20/126) OU: 0.65(20/100)	OD:1.3 OS:1.00 OU:1.25	OD: no defect OS: blurry defect in superior- nasal	OD: 90% OS: 32% OU: 100%	OD: 94% OS: 14%	OD: Stable OS: Unstable	Monoc ular (Right eye)
3	OD: 0.35(20/50) OS: 0.58(20/80) OU: 0.46(20/64)	OD:1.15 OS:1.30 OU:1.30	OD: no defect OS: no defect	OD: 76% OS: 84% OU: 100%	OD: 52% OS: 82%	OD: Unstable OS: Unstable	Binocul ar

Figure 4-18 compares the visual field score for each eye of all participants, provided by Humphrey visual field and microperimetry tests. Across eyes, microperimetry showed slightly lower VFS than Humphrey, which is consistent with its higher sensitivity to small central defects due to the retinal and eye movement tracking function.

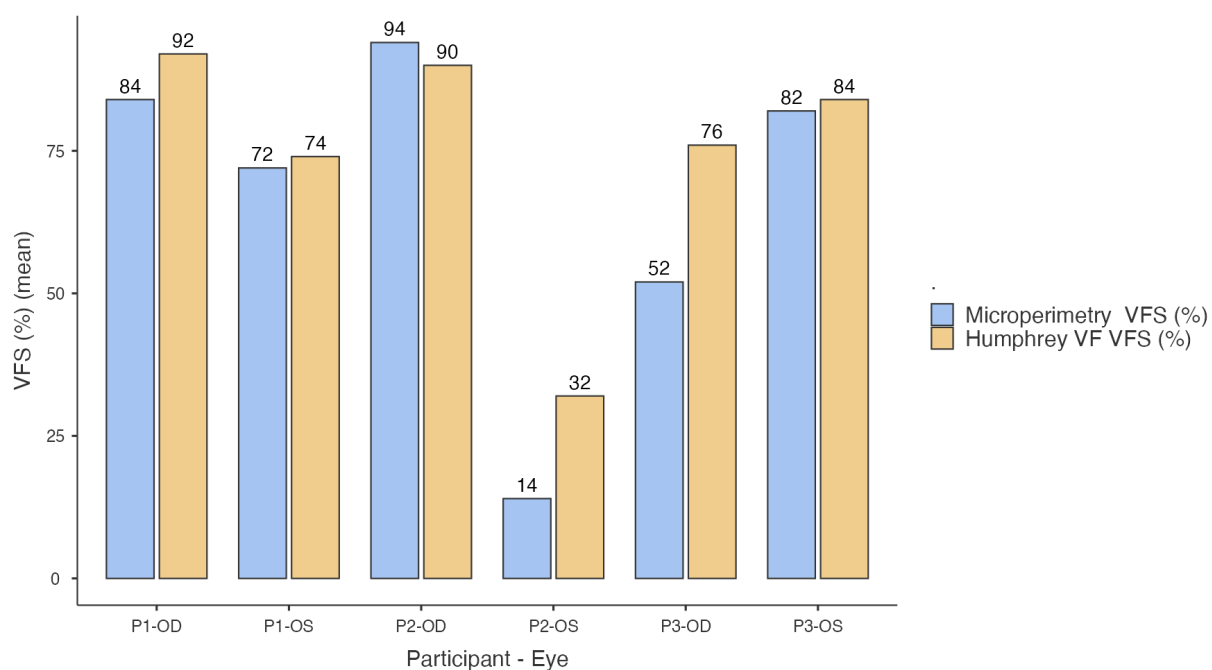


Figure 4-18: Central 10° Visual Field Score (VFS): Microperimetry vs. Humphrey

Figure 4-19 compares each participant's best monocular Humphrey VFS with their binocular Esterman VFS. Across all participants, binocular Esterman scores reach 100% indicating a normal field.

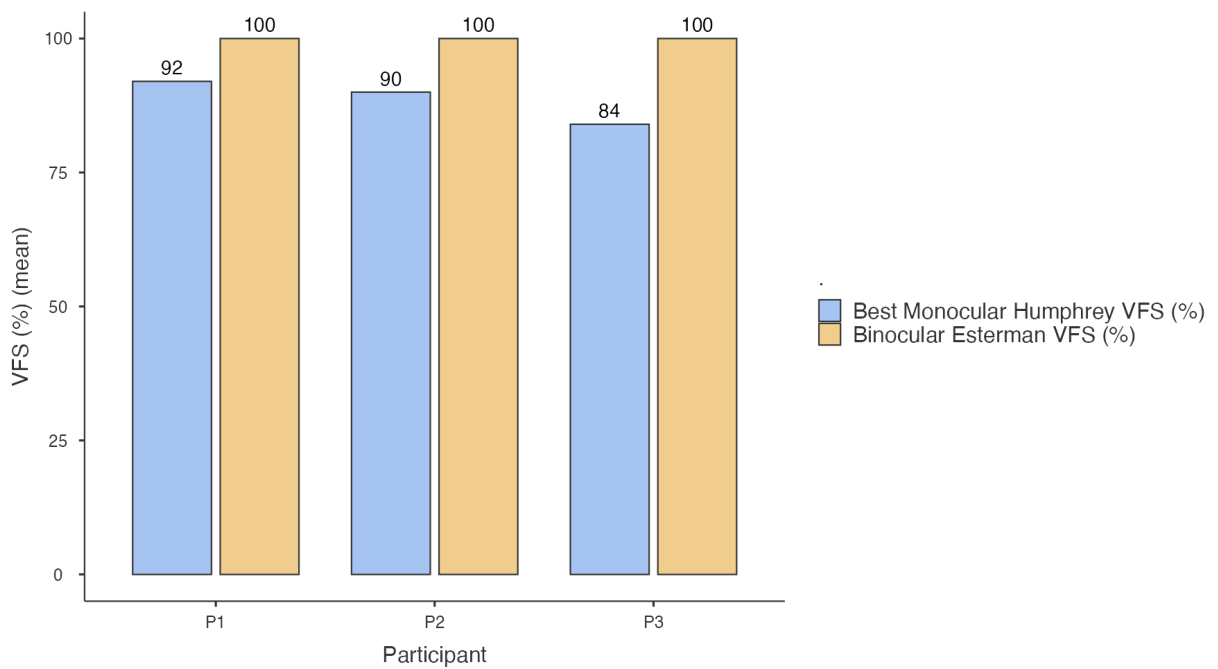


Figure 4-19: Best Monocular Humphrey VFS vs. Binocular Esterman VFS

4-11 Counselling Visit and MoCA

Table 4-9 indicates the presence or absence of anxiety experience about driving and the bioptic driving program and Montreal Cognitive Assessment results for all participants. The total possible score is 22 points; a score of 19 or above is considered normal. The cells indicating value outside the normative range has been shaded for clarity.

Table 4-9: Anxiety experience about driving and Montreal Cognitive Assessment result

Participant number	Anxiety experience about driving (Yes or No)	Anxiety experience about the bioptic driving program (Yes or No)	MoCA result (Normal ³ 19)
1	No	No	21 (Normal)
2	Yes	Yes	21(Normal)
3	No	No	16 (Abnormal)

4-12 Training

Three bioptic training sessions were completed for all three participants. No additional sessions were required to complete the training tasks. The results of the timed activities were recorded

for each participant at the end of each training session. The results indicate the number of targets out of 22 targets that the participants were able to identify with their bioptics in three attempts within 40 seconds each which is consistent with the need to identify targets within two seconds while driving and with Vogel's training program.⁵⁹

The table 4-10 below illustrates the timed activities outcomes for each participant which reflect their progression trend with training.

Table 4-10: Timed activities (training) results

Participant number	First Training Session (Out of 22)	Second Training Session (Out of 22)	Third Training Session (Out of 22)
1	Attempt 1: 13 Attempt 2: 14 Attempt 3: 14	Attempt 1: 10 Attempt 2: 14 Attempt 3: 15	Attempt 1: 18 Attempt 2: 17 Attempt 3: 18
2	Attempt 1: 9 Attempt 2: 11 Attempt 3: 11	Attempt 1: 5 Attempt 2: 5 Attempt 3: 6	Attempt 1: 9 Attempt 2: 12 Attempt 3: 17
3	Attempt 1: 5 Attempt 2: 10 Attempt 3: 10	Attempt 1: 8 Attempt 2: 14 Attempt 3: 14	Attempt 1: 18 Attempt 2: 18 Attempt 3: 18

4-13 Driving Simulation

During a driving course in the AVRIL simulation, some specific driving tasks under two conditions (with/out bioptic telescope) were monitored and recorded in the table below (Table 4-12). The simulation included 5 stop signs, 3 pedestrians, 2 right hand turns (one at a roundabout), four left hand turns. They were asked to make one lane change, park in front of a parked vehicle and verbally identify one road sign for each simulation task. The lane changing was considered a pass if they used a signal light and maintained proper position while changing lanes. The parking task was considered a pass if they used a signal light and were able to park within the lines of the space. Critical driving errors are defined as safety errors including failure to detect or respond to pedestrians and hazards, collision involvement, over-speeding, or disregarding traffic controls such as stop signs or red lights. The presence or absence of critical errors determine the participant's overall pass or failure status in the simulation. Bioptic telescope use was reviewed. The number of times the bioptic was engaged is also specified in table 4-11. We accepted up to 10 km/h over the speed limit.

Table 4- 11: Simulation driving course results

Participant		1		2		3	
Condition		With telescope	Without telescope	With telescope	Without telescope	With telescope	Without telescope

Stop Signs/4 way stops (correct/total)		4/5	5/5	5/5	3/5	4/5	3/5
Hazard detection		3/3	3/3	3/3	3/3	3/3	3/3
Turns	R	2/2	2/2	2/2	1/2	1/2	1/2
	L	2/4	3/4	2/4	1/4	1/4	0/4
Speed (60km/h)		35 - 60 km/h	45 - 70 km/h	38 - 65 km/h	42 - 65 km/h	47 - 87 km/h	48 - 87 km/h
Lane changing		Pass	Pass	Pass	Pass	Pass	Fail
Parking		Pass	Pass	Pass	Pass	Fail	Fail
Road sign detection		Pass	Fail	Pass	Pass	Pass	Pass
Staying in lane		1	1	4	3	9	7
BTS engagement		9		5		1	

Number of collisions		0	0	0	0	0	0
Total additional driving errors		3	2	2	1	1	2
Fail or Pass		PASS	PASS	PASS	FAIL	FAIL	FAIL

Participant 1: With the telescope, one stop sign was considered a failure as he stopped in the middle of the roadway, before the designated stop line. Two left-turns were also failed, as the participant turned initially into the oncoming traffic lane and did not maintain the car within the lane boundaries. On one occasion, the participant failed to keep to the proper lane and committed three additional driving errors including stopping in the middle of the street, neglecting to use the turn signal, and entering the opposite lane. Despite these errors, the participant did not commit any critical errors. Therefore, the overall performance was considered as a pass status for this test.

The participant engaged the telescope a total of 9x. He used the telescope 3x to look at a stop sign, viewed a speed sign on another occasion and viewed his surroundings 5x when no obstacle/sign was present.

Without the telescope, one left-turn was failed, as the participant initially turned into the oncoming traffic lane and crossed the opposite lane. On one occasion, the participant failed to keep to the proper lane and committed two additional driving errors including stopping in the middle of the street and entering the cyclist lane. On one occasion, the participant did not detect the road sign. Despite these errors, the participant did not commit any critical errors. Therefore, the overall performance was considered as a pass status for this test as well.

Participant 2: With the telescope, two left-turns were failed, as the participant started turning into oncoming traffic lane and entered the farthest lane. On four occasions, the participant failed to keep to the proper lane and committed two additional driving errors including reversing at an intersection, neglecting to use the turn signal. Despite these errors, the participant did not commit any critical errors. Therefore, the overall performance was considered as a pass status for this test.

He used the telescope a total of 5x. He viewed 3 speed signs through the telescope and then viewed and reviewed a 'curve in the road' sign.

Without the telescope, two stop signs were failed due to stopping in the middle of the roadway, before the designated stop line and neglecting to stop at a stop sign. Three left-turns were also failed, as the participant started the turns into the oncoming traffic lane and did not maintain the car within the lane boundaries. One right-turn was also failed due to contacting with the curb. On three occasions, the participant failed to keep to the proper lane and committed one additional driving error including stopping in the middle of the street. As the participant

committed critical errors such as missing a stop sign, the overall performance was considered as a failure status for this test.

This participant struggled with motion sickness particularly during the training session.

Participant 3: With the telescope, one stop sign was failed due to failure to stop at a stop sign. Three left-turns were also failed, as the participant started the turns into the oncoming traffic lane and did not maintain the car within the lane boundaries and entered cyclist lane. One right-turn was also failed because the participant didn't let the pedestrian completely cross the street prior to commencing the turn. Parking performance was also failed as the vehicle was not positioned between lines. On nine occasions, the participant failed to keep to the proper lane and committed one additional driving error. As the participant committed critical errors including failing to stop at a stop sign, not letting a pedestrian completely cross, and speeding over 15km over the limit, the overall performance was considered as a failure status for this test.

He used the bioptic only once to view a 'curve in the road ahead' sign.

Without telescope condition, two stop sign tasks were considered failed due to stopping in the middle of the roadway, before the designated stop line and failure to stop at a stop sign. Four left-turns were also failed, as the participant started the turns into the oncoming traffic lane, did not maintain the car within the lane boundaries and entered the cyclist lane. One right-turn was also failed because the participant didn't let pedestrian completely cross the street. Parking performance was also failed as the vehicle was not positioned between the lines and two parking spaces were used. Lane changing maneuver was also failed as the participant went

completely across the line. On seven occasions, the participant failed to keep to the proper lane and committed two additional driving errors including stopping in the middle of the street and neglecting to use the turn signal. As the participant committed critical errors including failing to stop at a stop sign, not letting pedestrian completely cross the intersection, and over speeding, the overall performance was considered as a failure status for this test.

Chapter 5

Discussion

The works described are a sample of an ongoing pilot project to determine the effectiveness of the CSE Bioptic Telescope Fitting and Training Protocol in preparing individuals with visual impairment from AMD to effectively use their bioptic telescope while driving. Although only three participants have completed the research to date, the findings prove to be valuable.

At the onset of the project, individuals were asked to complete a questionnaire regarding susceptibility to motion sickness. Motion sickness is a common phenomenon that may impact people during travel by airplane, ship or boat, and while riding a car, train, entertainment ride, swing (physical motion), or even virtual reality (visual motion). It is characterized by feelings of sickness such as nausea, dizziness, and vomiting.¹²⁴ Susceptibility to motion sickness varies depending on environmental conditions, type of transportation, and individual traits such as age, sex, and genetics.¹²⁴ It is indicated that susceptibility increases in childhood and declines during adolescence and adulthood.¹²³

Motion sickness might arise when various sensory systems such as visual, vestibular, and somatosensory send inconsistent and conflicting signals to the brain about movement, such as during virtual simulations.¹²⁴ One of the most important factors which contributes to motion sickness is vision. A recent 2024 study demonstrated that motion sickness susceptibility decreases in people who are totally blind, in comparison with those who are partially sighted or fully sighted.¹²⁴ These results align with the sensory conflict theory which suggests that motion sickness is caused by conflicting signals between various sensory systems, especially

between visual and vestibular inputs. In the absence of visual input while moving, the conflict between vision and other sensory signals is reduced or eliminated.¹²⁴ A driving simulator, as a form of virtual reality which is used in our research settings, can induce motion sickness because of sensory conflicts. Therefore, understanding and assessing motion sickness becomes essential for participant convenience and study validity. The MSSQ results corresponded, for the most part, with participants' driving simulation experience, as participants who all achieved normal scores were able to complete the driving course simulation. Although all participants successfully passed the screener and completed the simulation, one participant did experience symptoms of motion sickness particularly during the initial training session. Interestingly, this was also the participant with the worse acuities (Participant 2).

The oculo-visual assessment to determine visual eligibility for driving with a bioptic telescope is largely focused on visual acuity, visual fields, and contrast sensitivity as guided by the Ministry of Transportation of Ontario (MTO) requirements. All individuals met the visual requirements as outlined to proceed with the program. As was expected, some adjustments from habitual corrections in trial frame refraction were warranted for all participants, emphasizing the importance of updated refraction prior to bioptic fitting and training.

Also, as anticipated, the relationship between visual acuity and contrast sensitivity did not indicate a consistent trend in this sample size. One participant had a better contrast sensitivity with poorer VA while some participants with better contrast sensitivity also had better visual acuity. These findings suggest that while both visual acuity and contrast sensitivity are important factors of visual function, they may not directly predict one another which might

illustrate that these factors could contribute independently to visual performance in people using bioptic telescopes.

The colour vision impairment in AMD is most often the blue-yellow (tritan) deficit. Research presented that under low illumination, individuals with AMD indicated significant defect in colour vision and the severity and extent of this color vision loss is linked with reduced visual acuity.¹²⁶ It is therefore, not surprising that one participant had a tritan deficit. However, while trends are important to know, individual testing is still important as not all will follow the trend. Participant 2 had the worst acuity, but the best colour vision.

For the purpose of the research, additional testing was conducted to help determine if there were other tests that might help eyecare providers better predict or define an individual's success with a driving program. One such addition was microperimetry. Microperimetry is another form of perimetry often used in clinical research. It offers valuable information in terms of diagnosis and prognosis of functional and structural alterations in the macula among patients with AMD. Stimulus intensity ranges from 0dB, maximum stimulus luminance, to 34 dB, minimum stimulus luminance. The size of the stimulus can also be changed using standard Goldmann sizes, from I to V.¹³¹ Microperimetry is unique in that it uses real time tracking of eye movements to eliminate some of the limitations of static perimetry with respect to repeatability and reliability of assessment of fields with a central scotoma. Microperimetry enables correlation between the sensitivity threshold at each specific retinal point and its clinical appearance, which is seen through biomicroscopy, for example. It also provides an output that combines the test of static perimetry and a map of the fundus. In addition, it

provides information on both the position and stability of fixation.¹³¹ This instrument provides practical data on fixation and scotomata characteristics particularly in people with AMD as their visual acuity could be poor, and their fixation can be unstable and eccentric.

It is noteworthy to mention that while both the Humphrey perimetry and Nidek MP3 microperimetry evaluations reflected functional central visual field, microperimetry demonstrated greater reductions in retinal sensitivity. This difference may be caused by the fundus and eye movement tracking method used in microperimetry, which reduces the impact of poor fixation and enables more precise correlation and measurements including more accurate detection and definition of any retinal defects. Microperimetry also offers an additional feature of evaluating the individual's fixation stability which, in addition to the other assessments, helped validate the positioning of the bioptic telescope over Participant 2's right eye. Of note, Participant 3 was the only participant who was considered as having unstable fixation in both eyes. While the microperimeter may be a useful adjunct test to include, there are significant barriers to microperimetry use, with the cost of the instrument being the predominant barrier for access by practicing vision care providers at this time.¹³²

It is also important to mention that Esterman binocular visual field assessments did not effectively detect any of the central scotomas. This is a valuable point to bring forward, as the MTO lists a full field as one of the main visual requirements for obtaining and maintaining a driver's license. The binocular Esterman test does not evaluate the central 7-8 degrees of the visual field. The result from this study proves that binocular Esterman assessments miss small central visual field deficits. Greater emphasis should be placed on monocular visual fields than

on binocular field tests which do assess the central visual field (e.g Goldmann perimeter) when evaluating individuals that have the potential for a central visual field deficit.

Assessment of higher order visual perceptual skills was also added to the research protocol, although it is not required by the MTO as part of the optometric/ophthalmologic visual assessment protocol. These particular tests are tests that the driver rehabilitation occupational therapist conducts as part of their assessment. It was questioned by this research team if there would be benefit to conducting the tests earlier in the process to help with the selection of an appropriate candidate for the bioptic telescope program.

Aside from the scan course, no participant instantly met “fit to drive” criteria across the board. Even Participant 2, who arguably performed the best across the visuoperceptual tests, was categorized as having an increased crash risk. While distinguishing between those identified as likely being fit or unfit to drive or having higher crash risk compared to those identified as requiring additional testing is interesting information, it is uncertain how this information could be used to further select appropriateness for bioptic driving. For one, two of three participants did still pass in the driving simulator. Second, there are limitations to the testing. It should be noted that most neuropsychological tests do not adjust for visual impairment.³⁹ For example, according to Bioptic Driving of USA, the UFoV test is generally considered most useful and informative for individuals with mild visual loss (20/20 – 20/100) and less applicable for people with more severe vision impairment (20/120 – 20/200 or worse).¹³⁴ Since it is not obvious how much visual impairment affects the ability to see test materials, low scores can be misinterpreted. It indicates that the clinicians may mistakenly attribute low test scores to

cognitive impairment in individuals with visual impairments or, underestimate cognitive impairment by mistakenly considering low scores during poor performance as visual impairments.³² As a result, the validity of such evaluations in older adults with visual impairment may be compromised, since most parts of these kinds of tests depend significantly on visual tasks.³⁹ The tests in this study were not modified beyond allowing the participants to use preferred working distances.

Furthermore, many studies indicate that none of the visual perceptual assessment tools can accurately predict safe or unsafe drivers as stand-alone tests.³⁵ For example, a specified cutoff may incorrectly detect many safe drivers as unsafe, while increasing the cutoff point may miss unsafe drivers.²⁹ The participants also took longer on the Trails but didn't make any errors which could be attribute to their impairment. As a result, relying on a single test to predict crash risk would not be possible.²⁹ These limitations mean such tests are not solely suitable for medical decision making and relying on the results of several tests together related to driving performance status seems more logical and reliable. This approach is supported by the outcome of this work, in which two participants still passed the driving simulation despite cautionary performance and risk classification on the visuoperceptual testing. While it could be argued that the driving simulation is a relatively short assessment, this is an additional reason to prioritize individualized functional assessments as the gold standard, and to recall that driving training can increase risk mitigation to improve safe driving.⁵⁷

The scan course helped confirm that the visual deficit was not peripheral and that the skills required to identify and state the targets while moving were intact. However, it did not help

identify which individuals were more likely to fail the driving simulation at this time. Nonetheless, an argument may be made that there is an over-focus on central vision in driving conversations, considering that people with vision impairment often restrict driving to short, local and familiar routes, where peripheral vision may actually be a more relevant factor. The fact that all participants passed the Scan Course is interesting in this light.

Considering the evaluation of the training program, the results showed that all three participants progressed throughout the three training sessions within a 3-visit period and were able to identify more targets in their third sessions within 40 seconds compared to the initial training session. Therefore, the results indicate the positive impact of bioptic training and practice.

The final assessment conducted in the study was the evaluation of the in-car driving simulation in the AVRIL fully immersible SUV. Participant 1 successfully completed the driving simulation course (no critical errors) both with and without the telescope as outlined in the results section. Success even without the telescope is not shocking as his binocular acuity was just one line away from the acuity standards for driving (20/60 vs 20/50). Bioptic telescopes predominantly help mitigate visual acuity loss. This result may simply indicate that the visual acuity limits for driving are not reflective of the best limit to predict safe driving as highlighted previously. It is this researcher's opinion, however, that the use of the telescope when identifying a road sign may demonstrate the effectiveness of the training program.

Participant 2 did not pass the simulation driving course evaluation without the telescope but did when using the telescope. This was the participant with the worst acuities and contrast

levels. Participant 2 engaged the telescope at the appropriate times, including for speed signs which appears to have helped with limiting speed appropriately. This can be attributed to an appropriate fit and training program.

The third participant had the best visual acuity, both with and without the telescopes, however, failed the driving simulation evaluation under both conditions, with and without the telescopes. On closer evaluation of the findings, Participant 3's fixation was unstable in both eyes, and he had the worse scores for the trail-making, MVPT-4 and UFOV subtest 2. He was also the only participant classified as 'high risk' by the UFOV. However, as all participants were highlighted as not being a safe driver, it is impossible to use this information with the current cut-offs alone to accurately exclude him from the program over the other two participants. He also was the only participant to fail the MOCA test, indicating the possibility of a mild cognitive impairment. This could also potentially contribute to poorer visual perceptual tests of cognitive function scores. This highlights the need for a full medical evaluation in addition to a visual evaluation for those wishing to take part in the MTO bioptic driving program, a key component that is lacking.

5-1 Limitations

One limitation of the data presented to date is the small sample size. The time for recruitment, assessment, and training sessions in addition to the simulations spanned across an entire year. The study is ongoing to help further strengthen the data that will inform a more comprehensive project.

Another limitation was the gender composition of the sample. All participants were men. This was not due to exclusion criteria but may reflect self-selection and gender differences in driving exposure and patterns. A study conducted by Keay et al.¹⁷ indicated that compared with men, women had a 4 times higher likelihood of stopping or restricting driving with similar visual and cognitive deficits. In another study, women with vision impairment were twice as likely as male drivers with equal visual functions to limit driving to daytime.¹³³ It has been mentioned that sex differences arise from unequal driving exposure which reflects that men tend to begin driving earlier with more annual mileage and stronger driving habits, and therefore they are more likely to continue driving longer.¹⁷ Men are more likely to take risk and engage in high risk driving behaviors like fast or night driving in comparison with women. Owsley et al. also reported that a higher proportion of bioptic drivers were men in their sample.⁷⁴ As a result, future research should consider barriers and motivations for women to ensure the bioptic driving program is equitably serving both genders.

Yet another limitation was the dB extent used to compare the Humphrey monocular fields and microperimetry results for the AMA analysis. The binocular Humphrey limits were used instead. This represents a 4dB difference. While this likely would not significantly alter outcomes, it should be adjusted for future studies.

Another limitation was the absence of a control group. As a pilot project, the priority was to first establish the feasibility and potential of the program before introducing a comparative design with a control group. Future studies should consider including a control group such as people who do not undergo training or who are not fit with a bioptic telescope. The other issue

with including a control group in a study of this nature is that finding a true age and in particular vision matched control group (in terms of diagnosis, acuity, field, contrast etc) poses significant challenges. A deliberate decision was made not to use the participants as their own controls (i.e. participants were not tested on the simulator before the training and/or without the telescope in order to serve as a basis for comparison). It was felt that repeated simulator exposure would likely introduce learning effects which might not only come from the training program but also from becoming more familiar with the simulator. Such effects make it difficult to isolate the impact of the intervention.

The final simulation course used to assess participants' driving did not include all requested parameters, such as traffic lights and moving vehicles in adjacent lanes to the driver, as the engineering team struggled to determine how to include these within the timeframe of the project. Also, two simulations with similar obstacles but different courses were requested but not possible due to the time restraints of a Masters project. This would have contributed to a more accurate evaluation of the effectiveness (or lack thereof) of use of the bioptic telescope. As a result of the delay in the creation of the driving simulation, there was insufficient time to include evaluation by the driver rehabilitation specialist team member, which would have provided additional valuable feedback on each participant's driving performance and the professional opinion they would have provided (e.g. pass versus fail, additional training sessions required and how many, etc).

Chapter 6

Conclusion

Although further research is required, several important findings from the data to date have been identified. First, the Esterman binocular visual field test cannot be solely used to determine a full field for those that have the potential for a central deficit, and therefore, should not be the only test conducted by eyecare providers when determining a full field in this population. However, automated monocular visual field assessments capture the field loss. The addition of microperimetry is not necessary. Second, the visual perceptual tests conducted with the cut-offs provided, did provide some additional information, however, cannot be used in isolation to further assist with identifying individuals that may not be suitable for driving with bioptic telescopes. Given that these are also conducted at the time of the driving evaluation, it is not necessary to be included in the MTO protocol for optometrists. Third, full medical evaluation should be conducted prior to the visual function evaluation to help identify those that are not safe driving due to non-visual reasons. Finally, it appears that the George & Judy Woo Centre for Sight Enhancement Biopic Fitting and Training Protocol is on the right track for effectively enabling participants to learn to apply the fundamental skills required for using a bioptic telescope in a driving situation.

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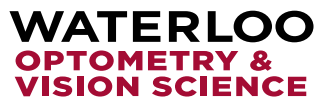
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Appendix A, Participant Information Sheet and Consent Form



Participant Information Sheet and Consent Form

Title of Project: Bioptic Telescopic Spectacles and Driving Rehabilitation for People with Age -Related Macular Degeneration (AMD) Pilot Project

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Introduction

We invite you to take part in a research study which is being undertaken at the School of Optometry and Vision Science. We have provided an overview here and will discuss it with you if you are interested. Please read this information carefully and feel free to ask questions about anything that you want to know more about.

Why is this research being done?

Individuals with visual impairments, specifically central vision loss, have difficulties obtaining a driver's license. The inability to drive may take away independence and lead to isolation and depression. Utilizing specific visual aids such as bioptic telescopes gives people a chance to drive again. Telescopes provide a magnified view of street signs, objects, and pedestrians to help visually impaired drivers see road hazards.

The Ministry of Transportations (MTO) Highway Traffic Act was recently amended to allow for use of bioptic telescopes for driving.

The information gathered from this study will be used to examine if the training program developed at the George & Judy Woo Centre for Sight Enhancement (CSE) will sufficiently prepare individuals to safely navigate a simulated driving course using a bioptic telescope. The training will hopefully assist people to get a driver's license and drive safely.

Who can participate in the study?

We are currently recruiting adults 18 years and older with Age-Related Macular Degeneration (AMD) whose driver's license was revoked because of their visual impairment. Potential participants are those who have a diagnosis of age-related macular degeneration and have had their license revoked because of their vision yet meet the visual requirements for bioptic driving at their last clinical assessment. Those that report a diagnosis of cognitive impairment or are significantly affected by motion sickness will be also excluded. Once you have agreed to participate, you will be asked questions about motion sickness or any diagnosis of cognitive impairment to determine eligibility. You will then be invited to participate in the research. It is good to point out that motion sickness is considered as the last step of the research includes SUV in-car simulator that the participant may experience motion sickness.

What is the purpose of the study?

The objective of this study is to evaluate the CSE protocols in preparing individuals with AMD for further in-car training. We hypothesize that the protocol developed will successfully prepare individuals to proceed with the MTO requirements for the Bioptic Telescope Driving Program.

What will your responsibilities be if you decide to take part in the study?

You will be asked questions about motion sickness and cognitive function at the first step. If you qualify, you will then be invited for 8-9 visits.

The first visit includes general and ocular health, driving history, various visual assessments (acuity, refraction, binocularity, contrast sensitivity, color vision, visual field), and characterizing central field loss. Should your vision be sufficient for proceeding with the MTO bioptics telescope program, you will be invited for subsequent visits. In the next visit, training with a monocular telescope (focusing, spotting, scanning, tracking) and frame selection for telescope will be done. In addition, visual perception testing (Trails making), tonometry, dilated health ocular evaluation and microperimetry will be conducted. In the third visit, the bioptic will be dispensed and the first bioptic training session will be conducted. A session for mental preparedness for driving and anxiety management will be conducted by a Psychotherapist in the counseling visit during visit four. Training with bioptic telescope (focusing, spotting, scanning, tracking, reaction time) will continue for at least 3 visits. If not successful in completing the training successfully in three sessions, the participant will be invited for an additional 1-2 sessions. A Useful Field Of View assessment will also be done in visit 3. After three months of bioptic telescope use, the final visits will include in-car simulation driving.

Please bring your most recent eyeglasses when you come for the study visits.

This is a list of locations where study visits will be conducted:

Visit 1&2: The School of Optometry & Vision Science Low Vision clinic of the university of Waterloo - 419 Phillip St., Unit C.

Visit 3: The School of Optometry & Vision Science Low Vision clinic of the university of Waterloo - 419 Phillip St., Unit C and The University of Waterloo School of Optometry and Vision Science, main campus – 200 Columbia St W.

Visit 4 will be conducted virtually.

Visits 5,6 and potentially 7&8: The School of Optometry & Vision Science Low Vision clinic of the university of Waterloo - 419 Phillip St., Unit C.

Last 2 visits (Simulation vehicle): The University of Waterloo campus at

the Autonomous Vehicle Research and Intelligence Lab – BEG Test Hut

For visit 3 if you have not attended the session with a driver,
transportation by taxi will be provided between the two locations.

Study assessments during study visit:

The following clinical assessments will be done:

Visit 1 (2 hours):

1. Ocular, general health and driving history: you will be asked ocular and systemic medical history, your current low vision device use, and your driving history.
2. Visual acuity: You will be asked to read the letters of the chart with each eye.
3. Autorefractometer: You will be seated behind a device and asked to focus on a target. The device will generate a prescription.
4. Trial Frame Refraction: You will wear a spectacle frame and lenses will be demonstrated. You will indicate which lens is clearer.
5. Binocularity (Hirschberg, presence of nystagmus): You will be instructed to sit at a distance of 50 cm from the examiner and look at the light source that is directed toward the middle of your eyes and the examiner will examine the corneal light reflects from both eyes.
6. Jumbo D-15 colour vision: You will be asked to arrange the color caps in order.
7. Amsler grid: the person looks at a grid and identifies if there is an area missing, blurry or distorted.
8. Pelli-Robson contrast sensitivity: You will be asked to read the letter test with each eye and both eyes.
9. Humphrey monocular and binocular Esterman visual field: You will be asked to sit in front of a machine wearing your corrective lenses if needed and you will need to respond to the stimuli in different locations by pressing a button while looking at a central target.
10. Response to magnification and bioptic fitting: Several types of telescopes will be demonstrated to determine if your visual acuity improves with the telescope magnification. We will determine a power, type of telescope and which eye the telescope will be mounted.

Visit 2 (2 hours):

1. If you have no previous telescope experience, you will receive training with a monocular handheld telescope (no greater than 4x magnification): You will be trained on how to focus, spot and scan with a handheld telescope. Furthermore, frame selection for telescopes will be conducted for all participants.

2. Visual perception skills:

- a. Trail Making Test: You will be instructed to connect a set of 25 dots as quickly as possible in numerical order. In the second part, 13 of the dots are numbered from 1 to 13 and 12 are given the letters from A to L; you must connect the dots in order while alternating letters and numbers (1-A-2-B...) as fast as possible without lifting the pen from the paper.
 - b. Scan Course: You will walk along a hallway and identify numbers located on either wall.
 - c. Motor-Free Vision Perception Test: You will be asked to describe or identify specific elements on plates based on the test's requirements.
1. Tonometry. Non-contact tonometry: You will be seated behind a device and asked to view a target. Once alignment is achieved, a puff of air will be dispensed towards your eye and the intraocular pressure measurement will be generated.
 2. Anatomical angle measure: You will be seated behind a fundus biomicroscope, and a light will be shone in your eyes to determine if your angle is open and if it is safe to dilate you.
 3. Dilated ocular health evaluation: pupil-dilating eye drops will be administered to ensure a clear view of the retina during the test. You will be asked if you have been dilated in a recent eye examination and if you had any complications/adverse reactions.
 4. Nidek MP3 microperimetry to characterize central field loss and take a photo of the posterior pole: You will be asked to sit in front of a machine possibly wearing your corrective lenses if you have

them and you should respond to the stimuli/targets in different locations by pressing a button while looking at a central target.

Visit 3 (1 hour):

1. Dispensing bioptic: ensuring the bioptic telescope accurately fits.
2. Initial training with bioptic: You will be trained on use of the telescope (Focusing, spotting, and tracking). You will be predominantly viewing a PowerPoint presentation projected at a distance of 15 feet/4.5m and asked to identify targets. Some activities are timed.
3. UFOV: The UFOV Assessment is a short (5-10 minute) online test. You will be asked to sit in front of a computer with your corrective lenses if needed and you should respond the stimuli in different locations or identify targets on a screen by pressing a button or clicking a mouse.

Visit 4 (1 hour)

1. Counselling session

a. Exploration of pros/cons of driving

b. Mental preparedness for driving

c. Anxiety management strategies

d. MoCA administration- In this study, we use the Montreal Cognitive Assessment (MoCA) to screen for mild cognitive changes. Although we are not qualified to diagnose cognitive impairment and do not intend to assess participants for such issues with this test, we want to offer you the option to be informed if your MoCA score is lower than typical for your age. If you prefer to be notified of a low score, we suggest discussing it with your physician to determine if further testing or examinations are needed to assess your cognition more accurately. You can indicate your preference in the MoCA Consent section of this document.

Visit 5, 6 (potentially visit 7, 8 to complete on training tasks if needed) (1 hour)

1. Bioptic training: continuation of visit 3.

Last 2 visits

1. Two in-car virtual reality simulations using the fully immersive AVRIL SUV located at the Autonomous Vehicle Research Intelligence Lab on the University of Waterloo campus. You will attend one visit to be trained on use of the VR fully immersive SUV simulation. You will attend a second visit one-two weeks later to attempt to drive through the simulated driving course while wearing the bioptic telescope.

Here are the items that will need to at least be successfully accomplished for considering success in the simulator:

1. Avoid vehicles in adjacent lanes during lane change and highway merge
2. Avoiding hazards (pedestrians, cyclist, drivers emerging from parked vehicles, vehicles entering traffic, parking lot movements- for example)
3. Attend to vehicles approaching at intersections
4. Respond to road signs/traffic lights to determine if they see the sign/light and follow through with the appropriate action
5. Navigate curves - to ensure maintaining proper lane position
6. Navigate awkward angles (non-90 degree intersection)
7. Parking lot - one backing maneuver required.

All data will be recorded using REDcap versions of recording forms submitted. The driving simulations will be recorded.

What are the possible benefits of the study for me and/or society?

In this study we are evaluating the George & Judy Woo Centre for Sight Enhancement (CSE) protocols for preparing individuals with AMD for further in-car training. We hypothesize that the protocol developed will provide sufficient preparation to successfully proceed with MTO requirements for the Bioptic Telescope Driving Program. If you are interested in regaining your driver's license, completion of this study will provide you the necessary tools and training to proceed to the Ministry's Bioptic Telescope Driving Program. This study will also inform policymakers regarding adequate training protocols. In addition, you will be given a

custom bioptic telescope (~\$1500-2000). At the conclusion of the research, if you wish to proceed to the MTO bioptic telescope program, a summary letter of the research can be written to upload into your clinical file at the University of Waterloo Optometry Clinics with your approval. This will eliminate the need for a repeat of some assessments in the clinic and you will only be required to complete 1-2 clinical visits at an additional cost of 200-300 dollars. This is a cost savings of approximately \$450.

What are the possible risks and discomforts?

1. Dilation will cause the participant to be more sensitive to light for 3-6 hours and they may have some trouble focusing even with their glasses on.
2. Participants may experience motion sickness (nausea, vertigo, vomiting) in the simulator. The initial screener will hopefully help us understand if you will likely suffer from this experience.
3. If an individual scores low on the MoCa cognitive assessment, they may be emotionally affected. The MoCA cognitive assessment will be conducted only during the fourth visit, by the psychotherapist. If participants indicate their consent to be notified, they would be informed if we find that their MoCA score is below what is considered typical for a person of their age. This has clinical implications because a low cognitive assessment score may be indicative or predictive of cognitive impairment or dementia in the older population. Because we are unqualified to make any real judgments about their results, we will not share any specifics about the results.

What information will be kept private and confidential?

Your data will not be shared with anyone outside the research team except with your consent or as required by law. All personal information will be removed from the data and will be replaced with a number code. Your information will be stored at the study site. Paper and electronic records will be retained for a minimum of 10 years after the study is complete. All anonymized forms and study data will be stored in a locked office or on an online database. Only the research team will have access to the data. Your name or other identifying

information will not appear with the data. Data stored at the University of Waterloo study site will be secured in accordance with University of Waterloo policies available at <http://ist.uwaterloo.ca/security/policy/>.

Any information obtained during the research project is subject to inspection (for the purpose of verifying the procedures and the data) by the relevant authorities and authorized representatives of the University of Waterloo or as required by law. By signing the Consent Form, you authorize release of, or access to, this confidential information to the relevant regulatory authorities.

It is anticipated that the results of this research project will be published or presented in a variety of forums. The results will be presented in such a way that you cannot be identified.

Can I end my participation early?

Participation in this research is voluntary. The training program we are assessing is offered at the George & Judy Woo Centre for Sight Enhancement if you do not want to participate in the research but would still like to benefit from the program. If you don't wish to take part, you don't have to. You will receive the best possible clinical care at the School of Optometry clinics whether or not you take part. If you volunteer to be in this study, you may withdraw at any time, up until data analysis has commenced as it is not possible to withdraw your data once this step has been completed. You may keep the telescope if you decide to withdraw after the telescope has been given to you. We anticipate that this will occur by January 31, 2025. If you decide to withdraw from the project, please notify a member of the research team.

Will I receive anything for participating in the study?

If you are found to be ineligible for the study during the first visit you will receive remuneration of \$60 in consideration for your time plus the cost of parking, or cost of public transportation, or taxi if you required. If you are eligible to continue on in the study, you will be given a custom bioptic telescope (~\$1500-2000) plus the cost of parking if you require it, or the cost of public transportation or we can arrange to cover your taxi fare.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB). If you have questions for the Board, contact the Office of Research Ethics at 1-519-888-4567

ext. 36005 or reb@uwaterloo.ca. For all other questions contact Dr. Tammy Labreche at 519-888-4567x47742, tammy.labreche@uwaterloo.ca , Dr. Shamroze Khan, zay.khan@uwaterloo.ca , Dr. Stan Woo, stan.woo@uwaterloo.ca or Sahar Khakneshin, skhaknes@uwaterloo.ca.

Consent of Participant

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about the study, **Biopic Telescopic Spectacles and Driving Rehabilitation for People with AMD Pilot Project**, being conducted by Drs. Tammy Labreche, Shamroze Khan and Stan Woo and Sahar Khakneshin or I have had it read to me in a language that I understand. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions and any additional details I requested. I understand the purposes, procedures and risks of the research described in the project.

I am aware that I may withdraw from the study without penalty at any time by advising the researchers of this decision.

With full knowledge of all foregoing, I agree, of my own free will to participate in this study. I have been advised that I will receive a signed copy of this form.

MoCA Cognitive Assessment

- ☐ Yes, I want to be informed of any incidental findings from the cognitive assessment used in this study.
- ☐ No, I do NOT want to be informed of any incidental findings from the cognitive assessment used in this study.

Name of Participant _____

Signature of Participant

Date

Person obtaining consent:

I have discussed this study in detail with the participant. I believe the participant understands what is involved in this study.

Name, Role in Study	Signature	Date
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Name of Translator if applicable *Language translated into*

<i>Signature of Translator</i>	<i>Date</i>
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Appendix B, E-mail script for recruiting participants, to go to clinic patients who have an email address available in VisualEyes:

Hello,

My name is Sahar Khakneshin and I am currently conducting research with Drs. Tammy Labreche, Shamroze Khan and Stan Woo on **“Bioptic Telescopic Spectacles and Driving Rehabilitation for People with Age - Related Macular Degeneration (AMD)- a Pilot Project”**. We are currently recruiting **ten adults over 18 years of age, with AMD whose driver’s license was revoked because of their visual impairment**. We are contacting you as you indicated that you may be willing to participate in research.

Individuals with visual impairments, specifically central vision loss have until recently, not had an opportunity to have their driving skill tested to regain their license as those with peripheral vision loss have. Using a visual aid called a bioptic telescope gives people a chance to drive again. Telescopes provide a magnified view of street signs, objects, and pedestrians to help visually impaired drivers more quickly see road hazards. The Ministry of Transportations (MTO) Highway Traffic Act was recently amended to allow for use of bioptic telescopes for driving.

The objective of this study is to evaluate the George & Judy Woo Centre for Sight Enhancement (CSE) training protocols for preparing individuals with AMD for further in-car training. We hypothesize that the protocol developed will successfully prepare individuals to proceed with MTO requirements for the Bioptic Telescope Driving Program.

We are recruiting individuals to participate for **at least nine study visits** at the **University of Waterloo School of Optometry and Vision Science**. Potential participants are those who have a diagnosis of age-related macular degeneration, have had their license revoked because of their vision yet meet the visual requirements for bioptic driving at their last clinical assessment. Those that have a diagnosis of cognitive impairment or are significantly affected by motion sickness will be excluded.

Once you have agreed to participate, you will be asked questions about motion sickness or any diagnosis of cognitive impairment during a telephone appointment to determine eligibility. You will then be invited to participate in the research which includes 8-9 visits. It is good to point out that motion sickness is considered as the last step of the research includes SUV in-car simulator that the participant may experience motion sickness.

The first visit includes questions about your general and ocular health, driving history, as well as various visual assessments (for example, checking your vision, your glasses prescription, how your eyes work together, your ability to see poor contrast letters, colour vision and extent of your side vision)., Should your vision be sufficient for proceeding with the MTO bioptics telescope program, you will be invited for subsequent visits. In the next visit, training with monocular telescope (focusing, spotting, scanning, tracking) and frame selection for telescope will be done. In addition, visual perception testing, tonometry (eye pressure testing), dilated health ocular evaluation and microperimetry (a different form of side vision) will be conducted. In the third visit, the bioptic will be dispensed and the first bioptic training session will be conducted. A session for mental preparedness for driving, anxiety management and cognitive health in visually impaired individuals will be conducted by a Psychotherapist in the counseling visit during visit four. Training with the bioptic telescope (focusing, spotting, scanning, tracking, reaction time) will continue for at least 3 visits. If not successful in completing training in three sessions, the participant will be invited for an additional 1-2 sessions. A Useful Field Of View assessment (divided attention side vision test) will also be done in visit 3. After three months of bioptic telescope use, the final visits will include a virtual reality in-car driving simulation.

The training sessions will be conducted in the School of Optometry & Vision Science Low Vision clinic of the university of Waterloo while virtual reality sessions will be completed on the University of Waterloo campus at the Autonomous Vehicle Research and Intelligence Lab.

The study visits will take **approximately 10 hours over all visits** to complete. The first two sessions will take approximately 2 hours and the remaining will be one hour each. You will be provided with a custom bioptic

telescope (~\$1500-2000) in appreciation for your time plus travel or parking costs. If you wish to proceed with acquiring your license, with your permission, we will access some of the research information and you only be required to complete 1-2 clinical visits at an additional cost of 200-300 dollars. This is a cost savings of approximately \$450 compared to completing all bioptic training in the clinic.

If you get tired, we will give you breaks or we can stop the testing and re-schedule, if you are willing. You will be able to withdraw from the study at any time without any influence on your current or future clinical care at the School of Optometry.

All identifying information collected during the study will be considered confidential. It will be kept locked in Dr. Labreche's office in the School of Optometry & Vision Science building for a minimum of ten years. When we enter data electronically or in publications, we will use numbers rather than names to support anonymity.

I would like to assure you that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board.

If you are interested, we can send a full information letter that can be reviewed before deciding to take part. For more information please contact:

Dr. Tammy Labreche, 519-888-4567 x47742,

tammy.labreche@uwaterloo.ca OR

Dr. Shamrozé Khan, zay.khan@uwaterloo.ca OR

Dr. Stan Woo, stan.woo@uwaterloo.ca

Appendix C, Telephone script for recruiting participants from clinic (for those without an email address in VisualEyes)

“Hello, my name is Sahar Khakneshin, and I am a researcher working at the School of Optometry and Vision Science at the University of Waterloo. I am following up on the letter that I mailed out to you last week regarding research being conducted with bioptic telescopes as you indicated when you came for an appointment at our Optometry Clinic that you are willing to be contacted about research projects that are currently happening at UW.

If you have a few minutes right now, may I tell you more about the project? If **No**: “Is there a better time to call you OR do you prefer email?” If they prefer email, collect the email address and follow the recruitment procedure for participants who have their email id in VisualEyes.

If **Yes**:

- I am currently conducting research with Dr. Tammy Labreche, Dr. Shamrozé Khan and Dr. Stan Woo at the School of Optometry on Bioptic Telescopic Spectacles and Driving Rehabilitation for People with Age - Related Macular Degeneration.
- We are currently recruiting adults 18 years and older with Age -Related Macular Degeneration (AMD) whose driver’s license was revoked because of their visual impairment.
- Individuals with visual impairments, specifically central vision loss have until recently, not had an opportunity to have their driving skill tested to regain their license as those with peripheral vision loss have. Using a visual aid called a bioptic telescope gives people a chance to drive again. Telescopes provide a magnified view of street signs, objects, and pedestrians to help visually impaired drivers more quickly see road hazards. The Ministry of Transportations (MTO) Highway Traffic Act was recently amended to allow for use of bioptic telescopes for driving.

- The objective of this study is to evaluate the George & Judy Woo Centre for Sight Enhancement (CSE) protocols in preparing individuals with AMD for further in-car training. We hypothesize that the protocol developed and currently utilized at the CSE will successfully prepare individuals to proceed with MTO requirements for the Bioptic Telescope Driving Program.

- Participation is voluntary. If you are interested in participating in the study or knowing more details about it, we would be happy to send you the detailed letter of information of the study if you can provide us with your email address. Your decision regarding whether you would like to learn more about the study will not impact your clinical care at the school of optometry.

- The study involves 8-9 visits. The study visits will take **approximately 10 hours over all visits** to complete. The first two sessions will take approximately 2 hours and the remaining will be one hour each. Please bring your most recent eyeglasses when you come for the study visit. You will be provided with a custom bioptic telescope (~1500-2000\$) in appreciation for your time plus travel or parking costs. If you wish to proceed with acquiring your license, with your permission, we will access some of the research information and you only be required to complete 1-2 clinical visits at an additional cost of 200-300 dollars. This is a cost savings of approximately 450\$ compared to completing all bioptic training in the clinic.

- Potential participants are those who have a diagnosis of age-related macular degeneration, have had their license revoked because of their vision yet meet the visual requirements for bioptic driving at their last clinical assessment. Those that have a diagnosis of cognitive impairment or are significantly affected by motion sickness will be excluded. Once you have agreed to participate, you will be asked questions about motion sickness or any diagnosis of cognitive impairment to determine eligibility. You will then be invited to participate in the research. It is good to point out that motion sickness is considered as the last step of the research includes SUV in-car simulator that the participant may experience motion sickness.

The first visit includes questions about your general and ocular health, driving history, as well as various visual assessments (for example, checking your vision, your glasses prescription, how your eyes work

together, your ability to see poor contrast letters, colour vision and extent of your side vision) Should your vision be sufficient for proceeding with the MTO bioptics telescope program, you will be invited for subsequent visits. In the next visit, training with monocular telescope (focusing, spotting, scanning, tracking) and frame selection for telescope will be done. In addition, visual perception testing, tonometry (eye pressure testing), dilated health ocular evaluation and microperimetry (a different form of side vision) will be conducted. In the third visit, the bioptic will be dispensed and the first bioptic training session will be conducted. A session for mental preparedness for driving and anxiety management in visually impaired individuals will be conducted by a Psychotherapist in the counseling visit during visit four. Training with the bioptic telescope (focusing, spotting, scanning, tracking, reaction time) will continue for at least 3 visits. If not successful in completing training in three sessions, the participant will be invited for an additional 1-2 sessions. A Useful Field Of View assessment will also be done in visit 3. After three months of bioptic telescope use, the final visits will include virtual reality in-car driving simulation.

The training sessions will be conducted in the School of Optometry & Vision Science Low Vision clinic of the university of Waterloo while virtual reality sessions will be completed on the University of Waterloo campus at the Autonomous Vehicle Research and Intelligence Lab.

- If you are interested in participating in the study after going through the information letter, please let us know your willingness by replying by email or by phone.
- Please be assured that all information collected during the study will be considered confidential and that your participation in the study is voluntary.
- This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board.
- Do you have any questions about the study? (answer questions)

Possible questions

a) **Question:** Is there a remuneration for taking part?

Answer: You will be provided with a custom bioptic telescope (~\$1500-2000) in appreciation for your time plus travel or parking costs. If you wish to proceed with acquiring your license, with your permission, we will access some of the research information and you only be required to complete 1-2 clinical visits. This is a cost savings of approximately \$450 compared to completing all bioptic training in the clinic.

Question: What measurements will you take? * Detailed responses if they have questions regarding a particular measure.

Answer:

Visit 1 (2 hours):

1. Ocular, general health and driving history: you will be asked ocular and systemic medical history, your current telescope low vision device use, and your driving history.
2. Visual acuity: you will be asked to read the letters of the ETDRS chart with each eye and with both eyes together.
3. Autorefraction: you will be seated behind a device and asked to focus on a target. The device will generate a prescription.
4. Trial Frame Refraction: you will wear a spectacle frame. Lenses will be demonstrated, and you will indicate which lens is clearer.
5. Binocularity (Hirschberg, presence of nystagmus): you will be instructed to sit at a distance of 50 cm from the examiner and look at the light source that is directed toward the middle of your eyes and examiner will examine the corneal light reflects from both eyes.
6. Jumbo D-15 colour vision: you will be asked to arrange the color caps in order.
7. Amsler grid: you will be asked to look at a grid with each eye and determine if there are any blurry, missing or distorted patches.

8. Peli-Robson contrast sensitivity: you will be asked to read the letter test with each eye and both eyes.
9. Humphrey monocular 120 pt and binocular Esterman visual field: you will be asked to sit in front of a machine with your corrective lenses if needed and you should respond to the stimuli in different locations by pressing a button while looking at a central target.
10. Response to magnification and bioptic fitting. Several types of telescopes will be demonstrated to determine if your visual acuity improves with the telescope magnification. We will determine a power, type of telescope and which eye the telescope will be mounted.

Visit 2 (2 hours):

1. If you have no previous telescope experience, you will receive training with monocular handheld telescope (no greater than 4x magnification). You will be trained on how to focus, spot and scan with a handheld telescope. Furthermore, frame selection for telescopes will be conducted for all participants.
2. Visual Perception Skills:
 - a. Trail Making Test: you will be instructed to connect a set of 25 dots as quickly as possible in numerical order. In the second part, 13 of the dots are numbered from 1 to 13 and 12 are given the letters from A to L; you must connect the dots in order while alternating letters and numbers (1-A-2-B...) as fast as possible without lifting the pen from the paper.
 - b. Scan Course: you will walk along a hallway and identify numbers located on either wall.
 - c. Motor-Free Vision Perception Test: you will be asked to describe or identify specific elements on the plates based on the test's requirements.
3. Tonometry. Non-contact tonometry. you will be seated behind a device and asked to view a target. Once alignment is achieved, a puff of air will be dispensed towards your eyes and the intraocular pressure measurement will be generated.

4. Anatomical angle measure: you will be seated behind a fundus biomicroscope, and a light will be shone in your eyes to determine if your angle is open and if it is safe to dilate you.

5. Dilated ocular health evaluation: pupil-dilating eye drops will be administered to ensure a clear view of the retina during the test. you will be asked if you have been dilated in a recent eye examination and if you had any complications/adverse reactions.

6. Nidek MP3 microperimetry to characterize central field loss and take a photo of the posterior pole: you will be asked to sit in front of a machine possibly with their corrective lenses and you should respond to the stimuli/targets in different locations by pressing a button while looking at a central target.

Visit 3 (1 hour):

1. Dispensing bioptic: ensuring the bioptic telescope accurately fits.

2. Initial training with bioptic: you will be trained on use of the telescope (Focusing, spotting and tracking). you will be predominantly viewing a PowerPoint presentation projected at a distance of 15 feet/4.5m and asked to identify targets. Some activities are timed.

3. UFOV: The UFOV Assessment is a short (5-10 minute) online test. you will be asked to sit in front of a computer with your corrective lenses if needed and you should respond to the stimuli in different locations or identify targets on a screen by pressing a button or clicking a mouse.

Visit 4 (1 hour)

1. Counselling session

a. Exploration of pros/cons of driving

b. Mental preparedness for driving

c. Anxiety management strategies

d. Screener for cognitive health (Montreal Cognitive Assessment for Blind)

Visit 5, 6 (potentially visit 7, 8 to complete on training tasks if needed) (1 hour)

1. Bioptic training: continuation of visit 3.

Last 2 visits

Two in-car virtual reality simulations using the fully immersive AVRIL SUV. You will attend one visit to be trained on use of the VR fully immersive SUV simulation. You will attend a second visit one-two weeks later to attempt to drive through the simulated driving course while wearing the bioptic telescope.

b) **Question:** Will eye drops be used in this study?

Answer: eye drops for dilation will be used.

• Would you be willing to take part in this study or to have more information about the study?

○ Yes

▪ Thank you. We do have a motion sickness questionnaire and a cognitive health question to confirm your eligibility before we proceed. We would like to ask you this now if this is a good time?

• Yes – Okay thank you! The first questionnaire I have is regarding your susceptibility to motion sickness as you recall a part of this research is conducted in a virtual reality simulator that is difficult for those that are prone to motion sickness. (MSSQ conducted). The next question is regarding your cognitive health as those that have certain diagnoses have difficulty with driving a vehicle. Have you been diagnosed with a cognitive impairment such as dementia?

○ If passes screener

- “You are eligible to participate, let’s schedule the visits!”
- If fails screeners
 - Unfortunately, you do not meet the eligibility criteria for participating in this study. This information will be destroyed.
Thank you for your time and interest in this research!
- No- let’s arrange a better time for me to call back
- / Unsure/would like more information/would like more time to think
 - Okay...can we arrange another time for me to call and follow up?
- No
 - Thank you for your time and consideration (hang up)

Appendix D, Motion Sickness Susceptibility Questionnaire Short-form (MSSQ-Short)

Please State Your Age Years.

This questionnaire is designed to find out how susceptible to motion sickness you are, and what sorts of motion are most effective in causing that sickness. Sickness here means feeling queasy or nauseated or actually vomiting.

Your CHILDHOOD Experience Only (before 12 years of age), for each of the following types of transport or entertainment please indicate:

3. As a **CHILD (before age 12)**, how often you **Felt Sick or Nauseated** (tick boxes):

	Not Applicable - Never Travelled	Never Felt Sick	Rarely Felt Sick	Sometimes Felt Sick	Frequently Felt Sick
Cars					
Buses					
Trains					
Aircraft					

Small Boats					
Ships					
Swings in playgrounds					
Roundabouts in playgrounds					
Funfair Rides					

Your Experience over the LAST 10 YEARS (approximately), for each of the following types of transport or entertainment please indicate:

4. Over the LAST 10 YEARS, how often you **Felt Sick or Nauseated** (tick boxes):

	Not Applicable - Never Travelled	Never Felt Sick	Rarely Felt Sick	Sometimes Felt Sick	Frequently Felt Sick
Cars					
Buses					
Trains					
Aircraft					

Small Boats					
Ships					
Swings in playgrounds					
Roundabouts in playgrounds					
Funfair Rides					

Appendix E, Recording Sheet

Visit 1

Date of assessment
Examiner
Background information
Participant ID
Age
Date of birth
Gender
General health
Last medical exam
Health conditions/investigations

Diabetes
Hypertension/heart disease/stroke
COPD/Asthma/Allergies
Current medications
Eye drops (Type, Eye, Freq, Time of day)
Other prescription medication
Other OTC medication
Ocular health history
Eye condition
How long have you had vision problems
Vision changes in last 6 months?

Last eye exam
Previous eye surgery
Low vision devices
Previous telescope use?
Type of telescope used?
Driving history
How long has your driver's license been revoked?
How many years have you been driving?
Class of driver's license (G, A, B, C, D, E, F, M)
How many hours approximately each week did you drive? 0-5, 6-10, 11-15, 16-20, >20 hrs
How far did you drive? Long distance or local areas?

Did you drive on the 400-series highway?

Visual assessment tests:

- 1. Unaided Distance Visual Acuity:** (check all letters correct. A matching card may be used if the participant has difficulty naming the letters)

ETDRS chart testing distance OD _____ OS _____ OU _____

logMAR for 4m*	M print	<u>OD</u>	<u>OS</u>	<u>OU</u>	
1.0	40	N__ C__ K__ Z__ O__	D__ S__ R__ K__ N__	N__ C__ K__ Z__ O__	D__ S__ R__ K__ N__
0.9	32	R__ H__ S__ D__ K__	C__ K__ Z__ O__ H__	R__ H__ S__ D__ K__	C__ K__ Z__ O__ H__
0.8	25	D__ O__ V__ H__ R__	O__ N__ R__ K__ D__	D__ O__ V__ H__ R__	O__ N__ R__ K__ D__
0.7	20	C__ Z__ R__ H__ S__	K__ Z__ V__ D__ C__	C__ Z__ R__ H__ S__	K__ Z__ V__ D__ C__
0.6	16	O__ N__ H__ R__ C__	V__ S__ H__ Z__ O__	O__ N__ H__ R__ C__	V__ S__ H__ Z__ O__

0.5	12	D__K__S__N__ V__	H__D__K__C__ R__	D__K__S__N__ V__	H__D__K__C__ R__
0.4	10	Z__S__O__K__ N__	C__S__R__H__ N__	Z__S__O__K__ N__	C__S__R__H__ N__
0.3	8	C__K__D__N__ R__	S__V__Z__D__ K__	C__K__D__N__ R__	S__V__Z__D__ K__
0.2	6	S__R__Z__K__ D__	N__C__V__O__ Z__	S__R__Z__K__ D__	N__C__V__O__ Z__
0.1	5	H__Z__O__V__ C__	R__H__S__D__ V__	H__Z__O__V__ C__	R__H__S__D__ V__
0.0	4	N__V__D__O__ K__	S__N__R__O__ H__	N__V__D__O__ K__	S__N__R__O__ H__
-0.1	3	V__H__C__N__ O__	O__D__H__K__ R__	V__H__C__N__ O__	O__D__H__K__ R__
-0.2	2.5	S__V__H__C__ Z__	Z__K__C__S__ N__	S__V__H__C__ Z__	Z__K__C__S__ N__
-0.3	2	O__Z__D__V__ K__	C__R__H__D__ V__	O__Z__D__V__ K__	C__R__H__D__ V__

logMAR last attempted line + (0.02x#errors) = logMAR VA

Final logMAR VA OD _____ OS _____ OU _____

2. Habitual (aided) Distance Visual Acuity: (check all letters correct. A matching card may be used if the participant has difficulty naming the letters)

ETDRS chart testing distance OD _____ OS _____ OU _____

logMAR for 4m*	M print	<u>OD</u>	<u>OS</u>	<u>OU</u>	
1.0	40	N__C__K__Z__ O__	D__S__R__K__ N__	N__C__K__Z__ O__	D__S__R__K__ N__
0.9	32	R__H__S__D__ K__	C__K__Z__O__ H__	R__H__S__D__ K__	C__K__Z__O__ H__
0.8	25	D__O__V__H__ R__	O__N__R__K__ D__	D__O__V__H__ R__	O__N__R__K__ D__
0.7	20	C__Z__R__H__ S__	K__Z__V__D__ C__	C__Z__R__H__ S__	K__Z__V__D__ C__
0.6	16	O__N__H__R__ C__	V__S__H__Z__ O__	O__N__H__R__ C__	V__S__H__Z__ O__
0.5	12	D__K__S__N__ V__	H__D__K__C__ R__	D__K__S__N__ V__	H__D__K__C__ R__
0.4	10	Z__S__O__K__ N__	C__S__R__H__ N__	Z__S__O__K__ N__	C__S__R__H__ N__
0.3	8	C__K__D__N__ R__	S__V__Z__D__ K__	C__K__D__N__ R__	S__V__Z__D__ K__
0.2	6	S__R__Z__K__ D__	N__C__V__O__ Z__	S__R__Z__K__ D__	N__C__V__O__ Z__
0.1	5	H__Z__O__V__ C__	R__H__S__D__ V__	H__Z__O__V__ C__	R__H__S__D__ V__

0.0	4	N__V__D__O__ K__	S__N__R__O__ H__	N__V__D__O__ K__	S__N__R__O__ H__
-0.1	3	V__H__C__N__ O__	O__D__H__K__ R__	V__H__C__N__ O__	O__D__H__K__ R__
-0.2	2.5	S__V__H__C__ Z__	Z__K__C__S__ N__	S__V__H__C__ Z__	Z__K__C__S__ N__
-0.3	2	O__Z__D__V__ K__	C__R__H__D__ V__	O__Z__D__V__ K__	C__R__H__D__ V__

logMAR last attempted line + (0.02x#errors) = logMAR VA

Final logMAR VA OD _____ OS _____ OU _____

3. Aided Near visual acuity (continuous text near vision card):

	VA
OD	
OS	
OU	

4. Autorefraction

	Sphere	Cyl	Axis
OD			
OS			

5. Current spectacles

	Sphere	Cyl	Axis	Add
OD				
OS				

6. Trial frame refraction

	Sphere	Cyl	Axis
OD			
OS			

- 7. Aided Distance Visual Acuity after trial frame refraction:** (check all letters correct. A matching card may be used if the participant has difficulty naming the letters)

ETDRS chart testing distance OD_____OS_____OU_____

logMAR for 4m*	M print	<u>OD</u>	<u>OS</u>	<u>OU</u>	
1.0	40	N__C__K__Z__ O__	D__S__R__K__ N__	N__C__K__Z__ O__	D__S__R__K__ N__
0.9	32	R__H__S__D__ K__	C__K__Z__O__ H__	R__H__S__D__ K__	C__K__Z__O__ H__
0.8	25	D__O__V__H__ R__	O__N__R__K__ D__	D__O__V__H__ R__	O__N__R__K__ D__
0.7	20	C__Z__R__H__ S__	K__Z__V__D__ C__	C__Z__R__H__ S__	K__Z__V__D__ C__
0.6	16	O__N__H__R__ C__	V__S__H__Z__ O__	O__N__H__R__ C__	V__S__H__Z__ O__
0.5	12	D__K__S__N__ V__	H__D__K__C__ R__	D__K__S__N__ V__	H__D__K__C__ R__
0.4	10	Z__S__O__K__ N__	C__S__R__H__ N__	Z__S__O__K__ N__	C__S__R__H__ N__
0.3	8	C__K__D__N__ R__	S__V__Z__D__ K__	C__K__D__N__ R__	S__V__Z__D__ K__
0.2	6	S__R__Z__K__ D__	N__C__V__O__ Z__	S__R__Z__K__ D__	N__C__V__O__ Z__
0.1	5	H__Z__O__V__ C__	R__H__S__D__ V__	H__Z__O__V__ C__	R__H__S__D__ V__

0.0	4	N__V__D__O__ K__	S__N__R__O__ H__	N__V__D__O__ K__	S__N__R__O__ H__
-0.1	3	V__H__C__N__ O__	O__D__H__K__ R__	V__H__C__N__ O__	O__D__H__K__ R__
-0.2	2.5	S__V__H__C__ Z__	Z__K__C__S__ N__	S__V__H__C__ Z__	Z__K__C__S__ N__
-0.3	2	O__Z__D__V__ K__	C__R__H__D__ V__	O__Z__D__V__ K__	C__R__H__D__ V__

logMAR last attempted line + (0.02x#errors) = logMAR VA

Final logMAR VA OD _____ OS _____ OU _____

8. Hirschberg test:

		Observation	Comments/deviating eye
Hirschberg	Near		

9. Jumbo D-15 Colour vision

Standard order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Order given by patient															

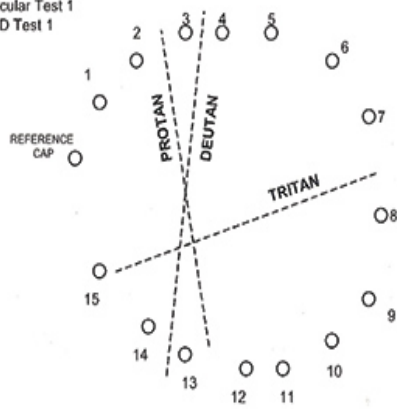
Score Sheet Template for 15 Disc Color Vision Test

Name: _____ DOB: _____ Test Date: _____

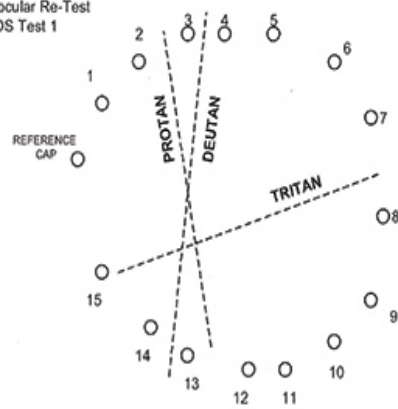
Mode: Binocular _____ or OD _____ OS _____ Tester: _____

Copy this template onto your medical history or plain paper

Binocular Test 1
or OD Test 1



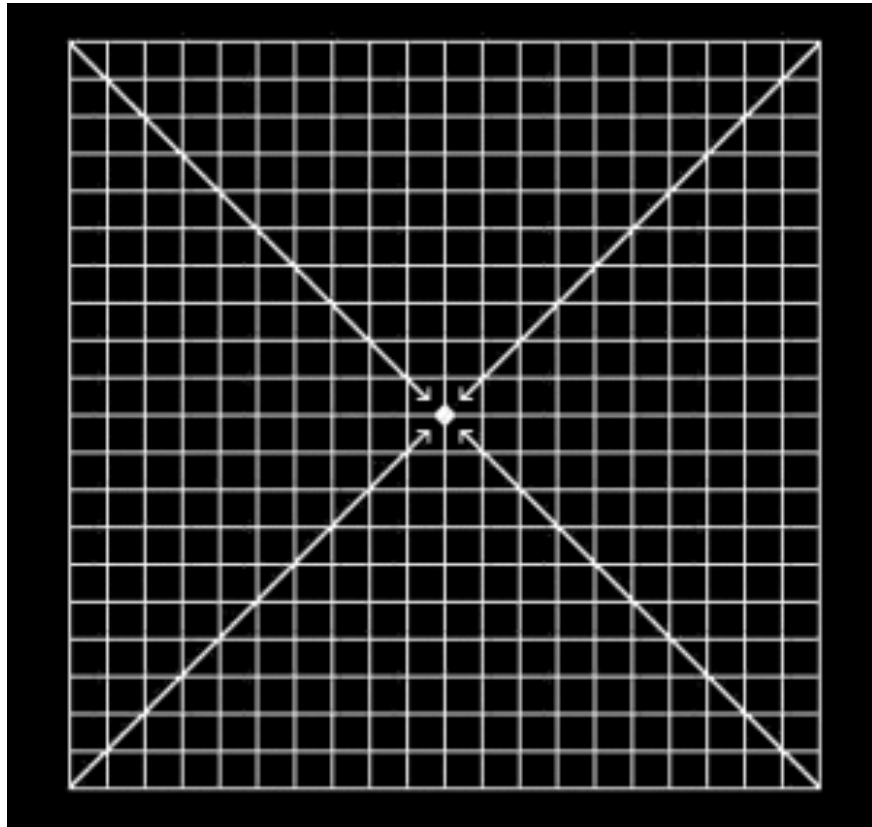
Binocular Re-Test
or OS Test 1



Richmond Products
4400 Silver Ave. SE Albuquerque NM 87108

Richmond Part Number 4428

10.Amsler grid



11. Pelli-Robson contrast sensitivity

PELLI-ROBSON CONTRAST SENSITIVITY TEST

0.00	V R S	K D R	0.15	0.00	V R S	K D R	0.15	0.00	V R S	K D R	0.15
0.30	N H C	S O K	0.45	0.30	N H C	S O K	0.45	0.30	N H C	S O K	0.45
0.60	S C N	O Z V	0.75	0.60	S C N	O Z V	0.75	0.60	S C N	O Z V	0.75
0.90	C N H	Z O K	1.05	0.90	C N H	Z O K	1.05	0.90	C N H	Z O K	1.05
1.20	N O D	V H R	1.35	1.20	N O D	V H R	1.35	1.20	N O D	V H R	1.35
1.50	C D N	Z S V	1.65	1.50	C D N	Z S V	1.65	1.50	C D N	Z S V	1.65
1.80	K C H	O D K	1.95	1.80	K C H	O D K	1.95	1.80	K C H	O D K	1.95
2.10	R S Z	H V R	2.25	2.10	R S Z	H V R	2.25	2.10	R S Z	H V R	2.25
Right Eye				Binocular				Left Eye			
Log Contrast Sensitivity: _____				Log Contrast Sensitivity: _____				Log Contrast Sensitivity: _____			
Acuity: _____				Acuity: _____				Acuity: _____			
Correction: _____				Correction: _____				Correction: _____			
Pupil Diameter: _____ mm				Pupil Diameter: _____ mm				Pupil Diameter: _____ mm			
Name: _____				Comments: _____							
Age, Sex: _____											
Diagnosis: _____											
Medications: _____											
Date: _____											
Examiner: _____											

Pelli-Robson Contrast Sensitivity Chart 4K. The above log contrast sensitivities are correct to within ± 0.05 at the time of calibration of the chart. Copyright © 1988 by Metrovia Ltd.
 Clement Clarke International Ltd, Edinburgh Way, Harlow, Essex, CM20 2TT UK. 01279 414969 or Haag-Streit Service, Inc., 5500 Courseview Drive, Mason, Ohio 45040, U.S.A. Tel: 513-336-7255 Fax: 513-336-7260
 REF: 7002252



10. Humphrey Esterman visual field - attach printed output

11. Telescope trial and bioptic fitting

Type of telescope	Magnification of telescope	OD or OS or OU	Final VA

--	--	--	--

12.Aided Distance Visual Acuity with telescope selected: (check all letters correct. A matching card may be used if the participant has difficulty naming the letters)

ETDRS chart testing distance OD ____ OS ____ OU ____

logMAR for 4m*	M print	<u>OD</u>	<u>OS</u>	<u>OU</u>	
1.0	40	N__ C__ K__ Z__ O__	D__ S__ R__ K__ N__	N__ C__ K__ Z__ O__	D__ S__ R__ K__ N__
0.9	32	R__ H__ S__ D__ K__	C__ K__ Z__ O__ H__	R__ H__ S__ D__ K__	C__ K__ Z__ O__ H__
0.8	25	D__ O__ V__ H__ R__	O__ N__ R__ K__ D__	D__ O__ V__ H__ R__	O__ N__ R__ K__ D__
0.7	20	C__ Z__ R__ H__ S__	K__ Z__ V__ D__ C__	C__ Z__ R__ H__ S__	K__ Z__ V__ D__ C__
0.6	16	O__ N__ H__ R__ C__	V__ S__ H__ Z__ O__	O__ N__ H__ R__ C__	V__ S__ H__ Z__ O__

0.5	12	D__K__S__N__ V__	H__D__K__C__ R__	D__K__S__N__ V__	H__D__K__ C__R__
0.4	10	Z__S__O__K__ N__	C__S__R__H__ N__	Z__S__O__K__ N__	C__S__R__ H__N__
0.3	8	C__K__D__N__ R__	S__V__Z__D__ K__	C__K__D__N__ R__	S__V__Z__ D__K__
0.2	6	S__R__Z__K__ D__	N__C__V__O__ Z__	S__R__Z__K__ D__	N__C__V__ O__Z__
0.1	5	H__Z__O__V__ C__	R__H__S__D__ V__	H__Z__O__V__ C__	R__H__S__ D__V__
0.0	4	N__V__D__O__ K__	S__N__R__O__ H__	N__V__D__O__ K__	S__N__R__ O__H__
-0.1	3	V__H__C__N__ O__	O__D__H__K__ R__	V__H__C__N__ O__	O__D__H__ K__R__
-0.2	2.5	S__V__H__C__ Z__	Z__K__C__S__ N__	S__V__H__C__ Z__	Z__K__C__ S__N__
-0.3	2	O__Z__D__V__ K__	C__R__H__D__ V__	O__Z__D__V__ K__	C__R__H__ D__V__

$\text{logMAR last attempted line} + (0.02 \times \text{\#errors}) = \text{logMAR VA}$

Final logMAR VA OD _____ OS _____ OU _____

Visit 2:

Previous Telescope User?

- ☐ NO
- ☐ YES (if YES, no monocular telescope training required)

1. Monocular Telescope Training

- ☐ Spotting – participant was able to spot distance target, unaided, and then with pre-focused monocular
- ☐ Focusing – participant was instructed on how to focus a monocular telescope
- ☐ Spotting & Focusing – participant was able to spot distance target, unaided, and then use monocular to focus on and identify target object
- ☐ Scanning & Tracking – with a monocular, participant was able to visually follow a connected pattern on a blackboard and identify different shapes/pictures

2. Visual Perception Testing – Trail Making

Spectacles Worn?

- ☐ YES (additional information _____)
- ☐ NO

Working Distance _____ cm

- ☐ Part A – Time to complete (max 2.5 min) _____
- ☐ Part B – Time to complete (max 5 min) _____

3. Visual Perception Testing – Motor-Free VP Test

Spectacles Worn?

- ☐ YES (additional information _____)
- ☐ NO

Working Distance _____ cm

- ☐ Raw Score: _____
- ☐ Standard Score: _____
- ☐ Percentile Rank: _____
- ☐ Age Equivalent: _____

4. Hallway Scan Course (target size 20/160)

Ambulatory Concerns (ie: uses walker, support cane, or wheelchair):

- ☐ NO
- ☐ YES – uses _____

Completed - WITH or WITHOUT concerns (circle one)

Identified ____/20

Percent Accuracy: ____

5. Telescope Frame Selection

- ☐ Bioptic Telescope System Selected
 - DVI
 - Ocutech
- ☐ Manufacturer's Form Completed
 - Frame Style/Colour/Size: _____
 - Distance PD: OD _____ OS _____
 - Exact PD of Telescope Position (Ocutech): OD _____ OS _____ (only one)
 - Sun Options: ____ selected ____ declined

6. Non-contact tonometry

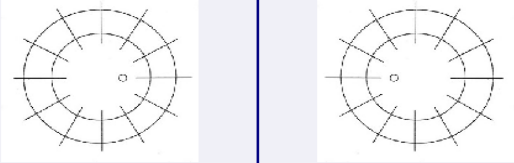
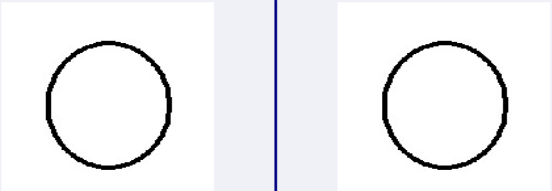
	Intraocular pressure
OD	
OS	

7. Anatomical angle measure (by fundus biomicroscopy - (Van Herick technique)

8. Dilated ocular health evaluation

Anterior segment evaluation	
------------------------------------	--

Cornea status	
OD:	OS:
Crystalline Lens status (Cataract)	
OD:	OS:

Diagnostic Drops Eye OU Drops Time		
CD Ratio OD: Vert Horiz OS: Vert Horiz Disc Size Disc Size		
Posterior Segment 		
		Optic Nerve Head Venous pulse Macula Vasculature Periphery Vitreous Pupils Post Dilation
		Lenses Used Lenses Used

9. Nidek MP3 microperimetry (Attached)

Recording Sheet 2

Visit 3:

1. Bioptic Device Dispense & First Training Session

- ☐ Reviewed Bioptic Telescope System (BTS) that was selected
- ☐ Overview of how BTS is used:
 - Carrier lens (Rx/no Rx; used 90-95% of time)
 - Telescope (power; how positioned; used 5-10% of time to spot signs, signals, distant road conditions; hazards)
 - If telescope is focusable – advise that when using for ‘driving’, the telescope needs to be focused for distance and then remain untouched
 - Introduce concept of Vertical Spotting Technique (user alternates vision from carrier to telescope)
- ☐ Educate on impact of telescope on:
 - Object Size (things appear larger than normal)
 - Field of View (when looking through TS vision is narrower/constricted)
 - Distance Perception (objects appear closer than they actually are)
 - Motion Perception (if looking through telescope, objects appear to move faster)
- ☐ Educated on care & cleaning of device
- ☐ Participant was instructed NOT to drive a vehicle unless licensed to do so by MTO

- ☐ Final fit/adjustment done by Optician

Training of Vertical Spotting Technique ('I' Head Movement)

- ☐ Basic head movement is straight up and down ('I') – localizing with carrier lens and spotting through telescope
- ☐ Slides #2-16 of BTS power point – practicing proper head movement
- ☐ Slides #13-15 – 'testing' of skill with timed activities – 40 seconds to identify 22 letters/numbers
 - First attempt - ____ / 22
 - Second attempt - ____ / 22
 - Third attempt - ____ / 22
- ☐ Participant was provided with homework and instructions

2. Useful Field of View (UFOV)

- ☐ Completed. Output to be attached.

Homework: (after first training session)

Homework is best done with a partner who can verify the User's accuracy. The User should be able to stand 10 feet from a chart, which should be located on a vertical surface at approximately eye level.

1. 4 corner Hart Chart – User hangs up the charts that are spaced approximately 2 feet apart in a ‘square’ pattern (two charts side by side and then two charts, side by side, underneath first two) and User stands 10 feet from charts.

□ (1) □ (2)

□ (3) □ (4)

Using the carrier lens, User locates chart 1 and identifies the letter on first line, using the telescope. User (putting their head back up) then locates chart 2 with carrier lens and identifies the first letter, of first line. User then locates chart 3 with carrier lens and identifies the letter, of first line. Lastly, User locates chart 4 with carrier lens and identifies the letter, of first line. User begins again by locating chart 1 through carrier lens and second letter of first line, chart 2 letter, chart 3 second letter and chart 4 second letter. Continue on, locating the third letter of each chart in same style. Scanning between charts must be done with carrier lens and identification of letter must be done with the telescope.

2. Tell Me 2 – Shape in Shape – User hangs up the chart and stands 10 feet away. Using the carrier lens, the User locates the larger shape and then looks through the telescope to identify the second shape (inside the first). Eg. “square/circle” The User then puts their head up and uses the carrier lens to repeat with the following shapes in the row. Note: Even though it is possible to see the consecutive shapes in the row while looking through the telescope, the User should make an effort to use the “I” head

movement (spotting with carrier and identifying with telescope). If the User finds the shapes too close, the paper can be cut in vertical strips, which can then be placed 1+ feet apart.

3. Directional Arrows – With the paper placed 10 feet away from the User, the User should spot the shape (arrow) through the carrier lens and then using the telescope, indicate the direction the arrow is pointing. Eg. Left, right, up or down. *when repeating this activity, the chart can be rotated so the User doesn't begin to memorize the direction of the arrows.
4. Begin to wear the BTS outside while walking. The object is to become comfortable wearing the device. Do not scan with the TS (only use carrier lens), but you can try stopping and then dropping chin to look through the telescope to try and identify different objects - traffic signs, etc. from varying distances.

Visit 5:

Biopic Telescope Training Second Session:

- ☐ Discussed first training homework and addressed any questions

- Ask if user has had any more ‘in-car’ opportunities or have they walked around outside Yes ☐ No ☐
- Have they tried using the bioptic @ various times of the day? (ie morning, evening, sunny, dull, etc.) Yes ☐ No ☐
- ☐ Confirm bioptic is fitting well – is user using the device with the head strap? Yes ☐ No ☐
- ☐ Outline objectives for second training – continuation of spotting activities with introduction of using device while moving
- ☐ Slides #18-20 - Quick colour spot activity
- ☐ Slides #21-28 – spotting with carrier and then identifying with the telescope
- ☐ Walk around clinic, focusing on using only carrier lens when scanning or looking around
 - Goal when walking
 - ‘Aim high’ - looking ahead (through carrier)
 - Keep eyes moving (scanning through carrier)
 - Get big picture (be aware of your surroundings)
- ☐ Slides #30-38 - three letter words
- ☐ Slides #39-45 - four letter words
- ☐ Slides #46-48 – ‘testing’ of skill with timed activities – 40 seconds to identify 22 letters/numbers
 - First attempt - _____ / 22

- Second attempt - ____ / 22
- Third attempt - ____ / 22
- Participant was provided with homework and instructions

Homework: (after second training session)

Focus is on your Functional Visual Acuity and getting to know where you notice your:

1. Awareness Acuity – “I notice something ahead but can’t identify what it is” (is there a considerable difference between the foreground & background)
2. Identification Acuity – “it is beginning to look like a red vehicle” (as you get closer to the object)
3. Sure Acuity – “I recognize the car as a red Ford” (what is the furthest yet optimal viewing distance you can do this?)

As a passenger in a car – state aloud or point out as quickly as possible the presence of other road users approaching or crossing your path – this is done with the carrier lens (eg, someone on a bike is ahead and on the right)

Going for a walk, practice looking ahead through the carrier lens, look for objects or people and then using the telescope, quickly provide some detail about what you see (eg. I see three figures walking towards me, when using the telescope I can see it is a two women and a man)

Visit 6:

Bioptic Telescope Training Third Session:

- ☐ Discussed second training homework and addressed any questions
 - Ask if user has had any ‘in-car’ opportunities or have they walked around outside Yes ☐ No ☐
 - Have they tried using the bioptic for anything else? Other activities stationary or moving Yes ☐ No ☐
- ☐ Confirm bioptic is fitting well – is user using the device with the headstrap? Yes ☐ No ☐
- ☐ Outline the objectives for Visit #3 – continuation of spotting activities with focus on more movement and expanding visual information/memory with timed exercises
- ☐ Slide #51 – reviewing the vertical spotting technique with single letters
- ☐ Slides #52 & #53 – three and four letter review
- ☐ Slides - #54-58 - Street sign identification
- ☐ Slides - #60-65 – scene pictures
- ☐ Slides - #67-102 - Timed visual memory activities
- ☐ Slides - #104-120 - Picture memory questions
- ☐ Slides - #124-130 - Detail recall pictures – “describe what you see” – open answers
- ☐ Slides - #132-134 – Three picture quiz – “where can you use the TS?”

- ❑ Slides #136-138 – ‘testing’ of skill with timed activities – 40 seconds to identify 22 letters/numbers
 - First attempt - _____ / 22
 - Second attempt - _____ / 22
 - Third attempt - _____/22
- ❑ Discuss ‘homework’ activities that user can continue to work on
 - Keep record of time in car as right-hand passenger
 - Practice verbalizing what is seen through the carrier lens while a passenger
 - Try to find opportunities to practice ‘while moving’ - bike/scooter/golf cart/ebike/rollerblades/etc.

Counselling Recording Sheet (Visit 4)



University of Waterloo School of Optometry & Vision Science, 200 University Ave. W.

Waterloo, ON CA N2L 3G1, Tel: 519-888-4567 x46763 Fax: 519-746-2337

Counselling Data Recording Sheet

GENERAL INFORMATION:	PARTICIPANT INFORMATION:
Research Session #:	Session Length:
In Person: By Telephone: TEAMS:	Unique Identifier:
	Ocular Condition: VAs: OD OS OU Contrast: OD OS OU Field Loss: OD OS OU
Therapist's signature:	Date of Session:
Introduction & Consent:	

Informed consent for initial contact: I provided a general introduction to my role in the bioptic driving program. Verbal consent was gained for the call/meeting by the participant.

Participant was informed and gave consent after being read the following: “In this single session I will ask certain questions and your responses will be written down and shared with the research team. Specifically, we will discuss your driving history, your perceived advantages/disadvantages to being able to drive, any concerns or anxiety that you might have about the process and about driving. I may suggest some strategies for preparation or addressing concerns you might express. I will also provide an overview of the bioptic driving process and you will have an opportunity to ask questions throughout our session.” Yes No

A. Mental Preparation for Driving

- I. I asked the participant if they have questions about the process for bioptic driving preparation or the functional driving assessment: Yes ☐ No ☐
- II. I gave an overview of the bioptic driving process/program: Yes ☐ No ☐
- III. I gave an overview of the bioptic driving functional driving assessment: Yes ☐ No ☐
- IV. I discussed the participant’s driving history: Yes ☐ No ☐

Any relevant information:

B. Exploration of the Participant’s pros and cons to driving

i. I asked the participant what they think the pros of being able to drive would be: Yes ☐ No ☐

ii. Pros listed:

iii. I asked the participant what they think the cons of going through the bioptic driving program might be:

Yes ☐ No ☐

iv. Cons listed:

C. Exploration of Anxiety

When I asked the participant if they are experiencing any anxiety about driving, they said: Yes ☐ No ☐

When I asked the participant if they are experiencing any anxiety about the bioptic driving program they said:

Yes ☐ No ☐

There were strategies outlined for working with anxious thoughts/feelings in the body: Yes ☐ No ☐

Strategies employed: CBT: ☐ Mindfulness: ☐ Externalization of anxiety (Narrative): ☐ Other: ☐

Suggestions/recommendations made for addressing anxiety: ☐

D. MoCa- Blind Administration

MoCA: There is one other assessment tool that I am responsible for completing with you today. Be assured that your results will not be reviewed with other members of the research team until after you conclude the Bioptic Driving Program. I can provide you with a copy at your request at the end of the assessment. “The time to administer the assessment is approximately 5-10 minutes.

The Montreal Cognitive Assessment (MoCA)- BLIND is an adapted version of the original MoCA, a rapid screening instrument for mild cognitive dysfunction.

The MoCA-BLIND assesses different cognitive domains: attention and concentration, memory, language, conceptual thinking, calculations, and orientation.

Complete assessment.

“The total possible score is 22 points; a score of 19 or above is considered normal. This cutoff score is suggestive, as it has not been validated thus far. Your score today was a _____. This is not a diagnostic test but for anyone scoring under 19 we are suggesting that they may want to discuss with their family physician or nurse practitioner. They can review and repeat or recommend further assessment. Communicating that to your

health care team is not required as I mentioned earlier, and it will not affect your ability to participate in the study.”

Any relevant information:

D: I asked the participant if they have any other questions: Yes ☐ No ☐

Any relevant information:

E: I made referrals for additional information or support: Yes ☐ No ☐

Any relevant information:

☐ ☐ I provided my contact information for future information or supports: Yes ☐ No ☐

Any relevant information:

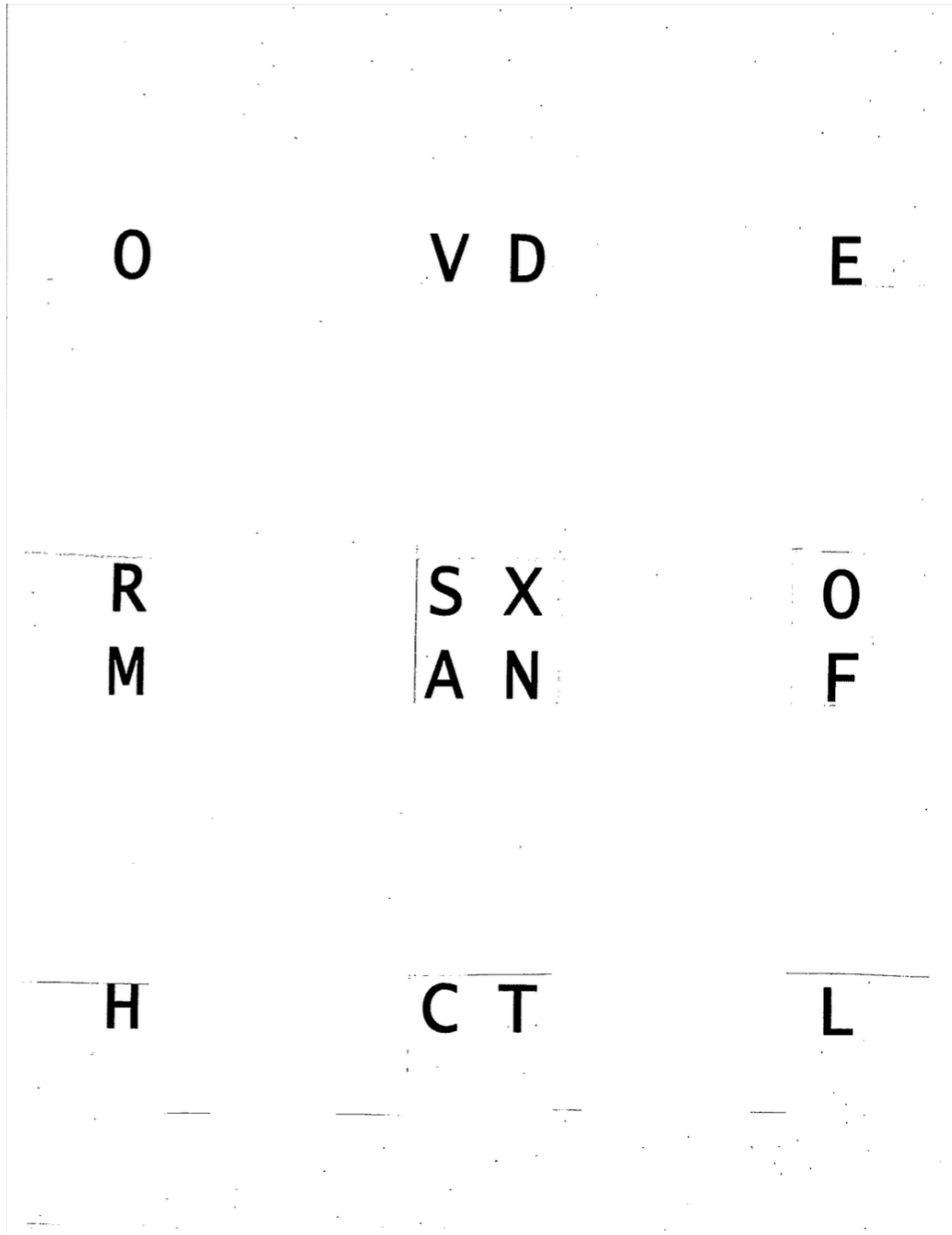
To be included on every page:

Participant ID #:

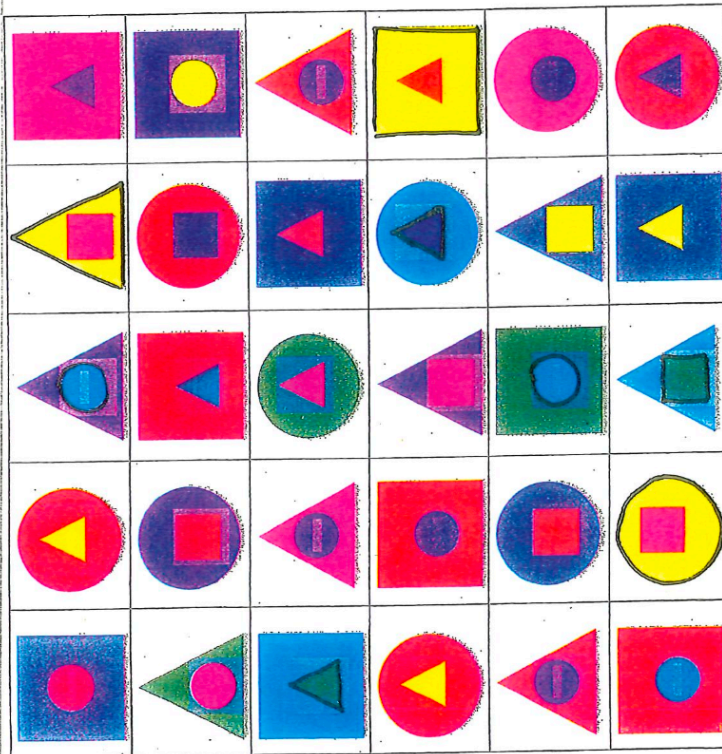
Therapist's Signature & Date of Session:

Appendix F, Training charts

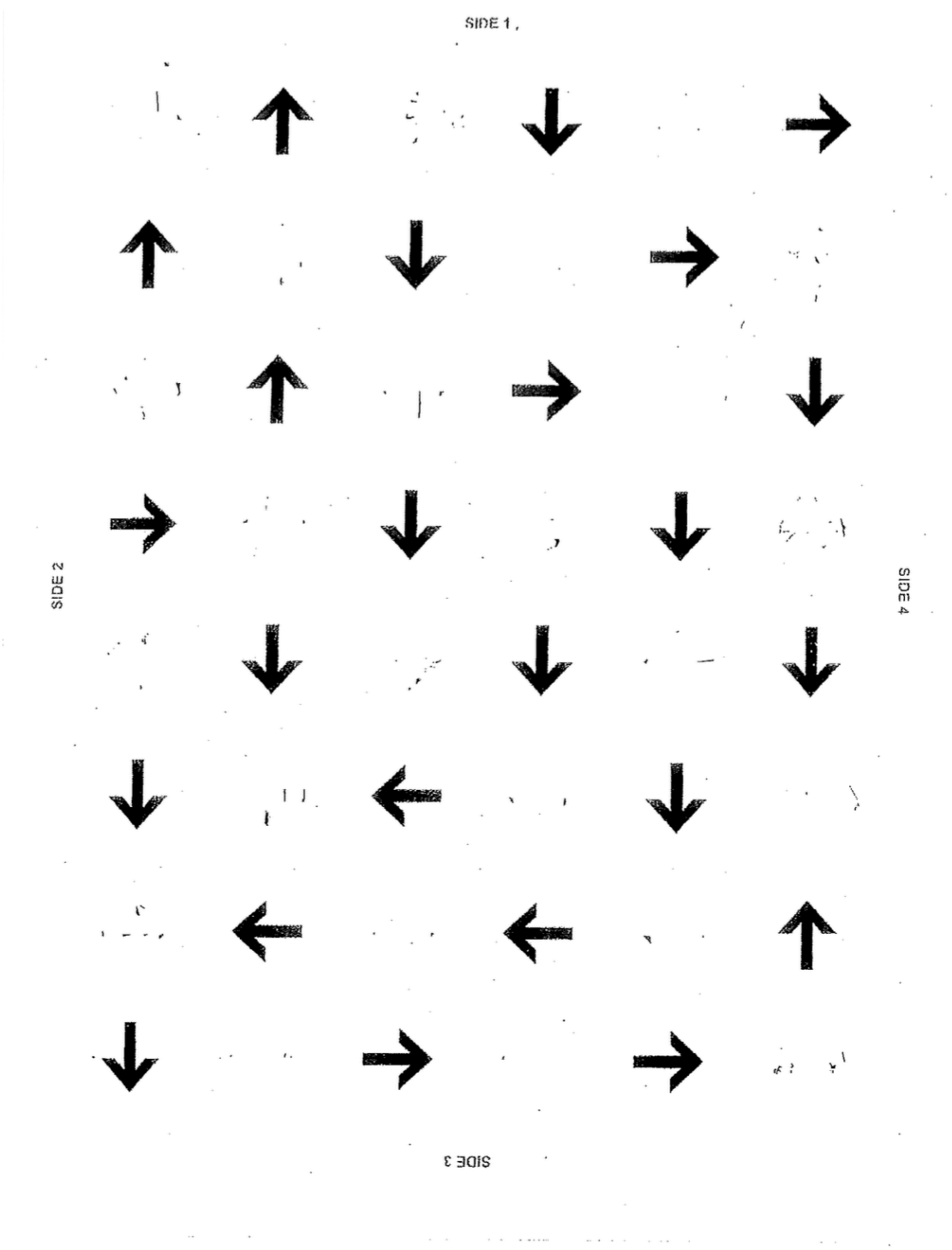
4-corner Hart chart



Tell me 2 (Shape in shape)



Directional arrows



Appendix G, Driving simulator instruction

Safety:

- Please enter and exit the vehicle carefully. When it's time to exit, please remain seated until you feel safe to do so.
- You may stop the simulation at any time.
- We have water available for you if you feel unwell. We also have bags available if you feel that you may be sick to your stomach.
- Chewing gum can help with motion sickness (offer gum).

Some major differences:

- The seatbelt fastens in a 5-point harness. (Demonstrate how to put in and how to unlock by turning the button. They can be adjusted if they need them adjusted. Only need to do 3 points.)
- You do not receive the same feedback about the speed of the vehicle in the SUV simulator as you would in a normal vehicle. The feedback you feel from the seat belt will be 65-75% of what you would feel when driving in a real car.

- You cannot check your blind spots as far back as you normally would for a regular driving experience. Do what you normally would do to start but just be aware that you will not be able to see as far back as you may want to.
- There is a camera recording inside the car (show where camera is).
- Brake pedal and gas pedal work the same. It may brake faster than you are used to. Start and stop are buttons on the steering wheel (show buttons). You change gears using buttons on top of gear shifter (show buttons).
- Steering wheel is very loose until you start the car and then it will start to give feedback.
- Side mirrors, review mirrors will show the virtual environment just as it would be if backing up.
- Turn signals will work and show on the dash but they are not loud as in your regular car.