Visual field loss and driving

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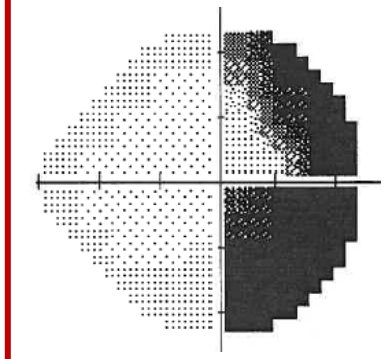
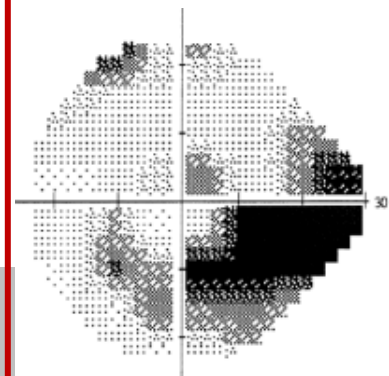
Presentation overview

- Visual field requirements for driver licensing
  - Private vehicles
  - Unconditional and conditional licensing
- Summary of evidence linking visual field loss and driving outcomes
  - Stroke
  - Glaucoma
- Summary



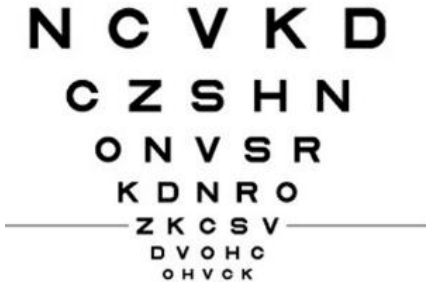


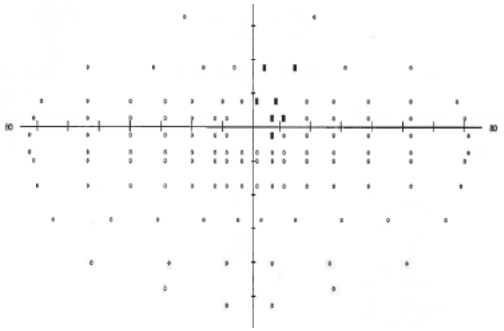
Vision and driving

- Driving requires coordination of visual, motor and cognitive skills
  - Identify hazards and respond rapidly to changes in driving environment
- Driving environment is visually complex and requires drivers to rapidly process dynamic visual information
  - Guide steering direction, lane position and detect potential hazards

Vision and driving

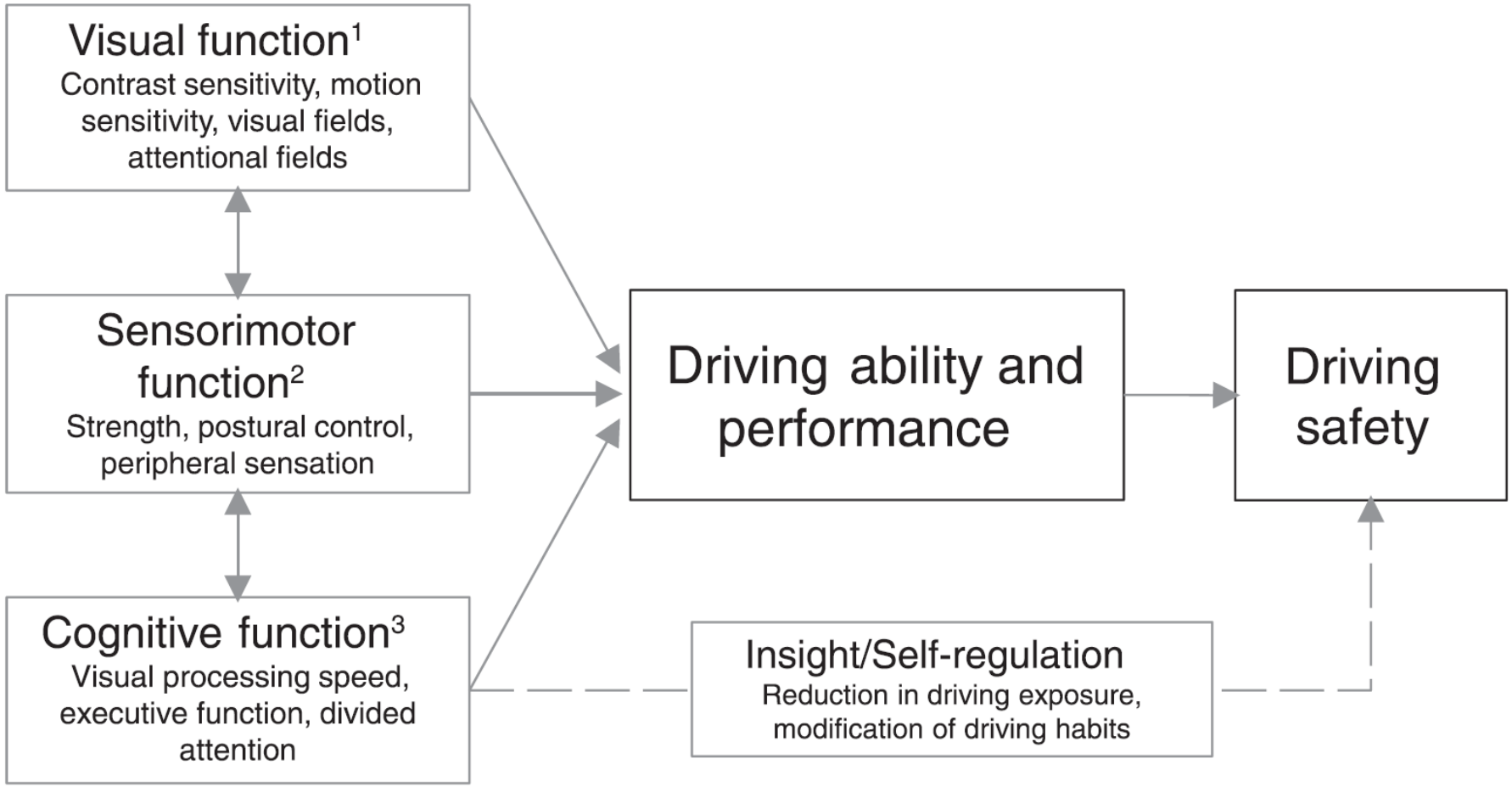
- Adequate visual function required for safe driving
  - Licensing authorities typically set standards for central vision (visual acuity) and peripheral vision (visual fields)
  - However, minimum levels of visual function required for safe driving are unclear - ongoing focus of research
- Loss of driving privileges has important consequences as driving is important for maintaining independence
- Driving cessation linked with[1,2]
  - Feelings of isolation and depression
  - Associated functional impairment





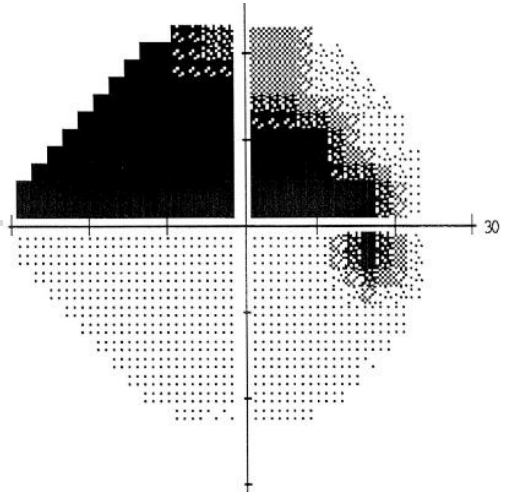
1. Marottoli et al (1997); 2. Windsor et al (2007)

Visual function and driving



1. Owsley & McGwin (2010); 2. Lacherez et al (2014); 3. Anstey & Wood (2011); Figure from Wood & Black (2016)

Visual fields and driving

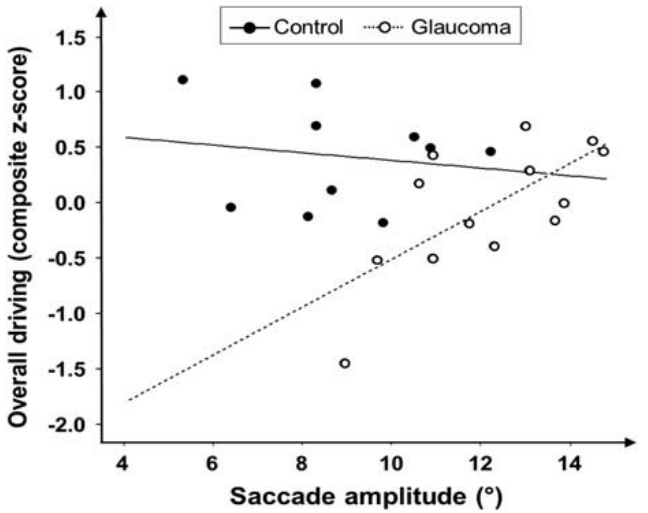


- Visual fields are important for safe driving
  - Included in most driving standards worldwide
  - Minimum field extent required varies between countries and across states within countries (USA)
  - Determining extent of visual fields required for safe driving is challenging
- Association between visual field loss and crash risk is inconclusive[1]
  - Many studies failed to find an association between visual field loss and state-recorded crash risk[2-4]
  - Johnson and Keltner (n=10,000)[5] reported that crash risk 2x for drivers with severe binocular field loss
    - Half of the drivers were unaware of their field loss
    - Monocular field loss did not increase crash risk

1. Wood et al (2021); 2. Burg (1968); 3. Council & Allen (1974); 4. Decina & Stalin (1993); 5. Johnson & Keltner (1983)

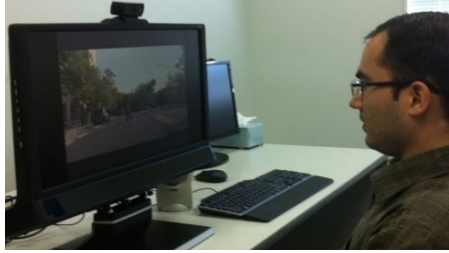
Visual fields and driving

- Large population (n~2000)[1,2] and data linkage (n=31,296)[3] studies
  - Severe field loss associated with increased crash risk
- Naturalistic study (n=659)[4]
  - Binocular peripheral field loss associated with ~2x increase in crash risk (all, major and at-fault)
- Closed and on-road studies demonstrated potential for compensation for visual field loss through head and eye movements
  - Glaucoma[5]
  - Hemianopia[6,7]



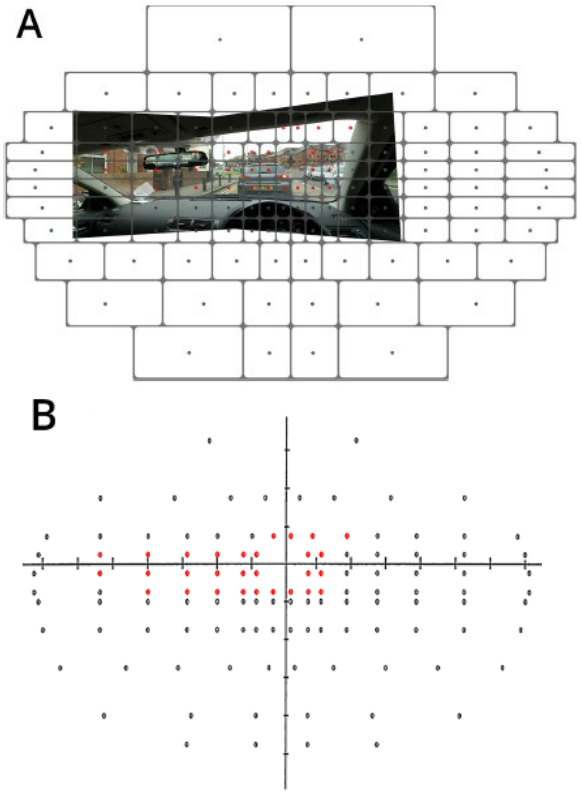
1. Rubin et al (2007); 2. Huisingh et al (2015); 3. Manners et al (2024); 4. Huisingh et al (2017); 5. Lee et al (2018); 6.Wood et al (2011); 7. Kasneci et al (2015)

Location of field loss



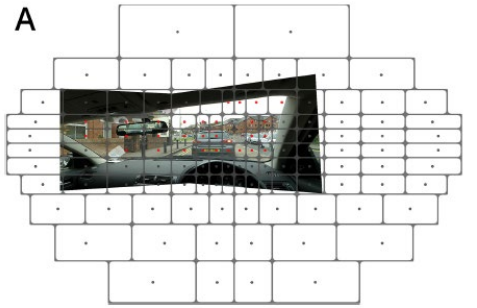
- Simulated field loss in young adults: superior loss delayed Hazard Perception Test (HPT) times more than inferior loss[1]
  - HPT assesses only one aspect of driving
- Inferior field loss associated with unsafe on-road driving performance in older adults[2]
- Severe superior and inferior field loss associated with increased crash risk (data linkage study), but superior fields more important when field loss mild or moderate[3]

Figure 1 The Esterman Visual Field Test (EVFT) grid superimposed over a road scene as seen from the driver's perspective (A), and an example of a clinical EVFT output (B). Test locations within the region covered by the car windscreen are coloured red: it can be seen that many points on the EVFT, especially in the inferior visual field, are irrelevant to the driving scene.



1. Glen et al (2014); 2. Black et al (2015); 3. Manners et al (2024)

Location of field loss



- Many points on Esterman test (widely included in driving standards worldwide) are not relevant to driving[1]
  - Not developed for this purpose, no central points and a lack of standardisation of test point positions in Esterman programs on different perimeters[2]
- Custom binocular “Driving Visual Field”[3]

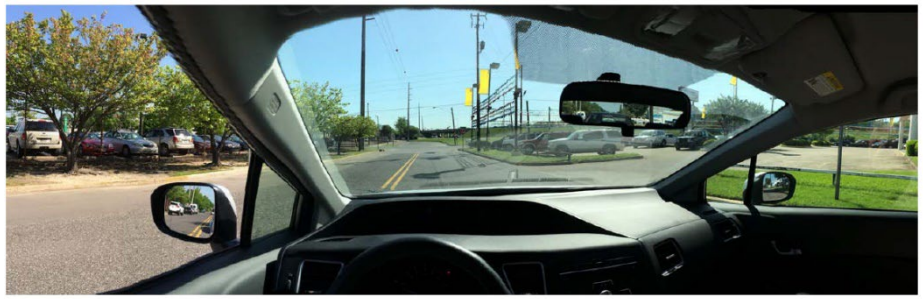
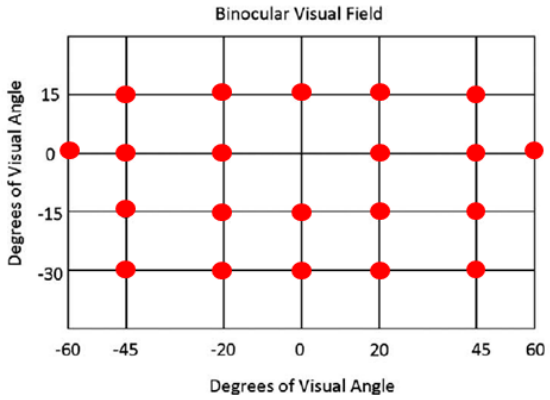


FIGURE 1. Driver's view through the windshield and side windows of a vehicle; this view is the widest possible panoramic view from the driver's vantage point as the driver's head turns from one side of the roadway to the other.

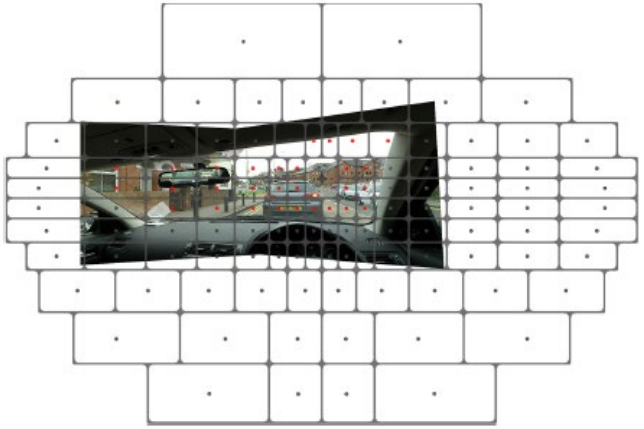


  - Severe binocular field loss (lowest quartile for population) associated with 40% increase in at-fault retrospective crashes in drivers >70 years (n=2000)
  - Severe field loss in inferior or left field associated with higher crash risk (USA)

1. Glen et al (2014); 2. Bro (2022); 3. Huisingh et al (2015)

Location of field loss

- In summary, no specific location of field loss has been shown to be more important for driving safety
- Hazards can appear from any direction
- Eye movements can shift gaze around and defects will shift with eye movements



Driver licencing

- Vision testing across Australia guided by NTC guidelines
  - Visual acuity and visual fields
- Renewal varies between states/territories
  - Always check with websites of state-based licensing authorities

	QLD	VIC	NSW	SA	WA	TAS	ACT	NT
Vision test (VT) and/or medical examination at renewal	≥75 yrs: current medical certificate (with vision results) (maximum validity 1 yr)	If a concern is declared/ reported	<45 yrs: VT every 10yrs 45-74 yrs: VT every 5 yrs ≥75 yrs: annual medical certificate (with VT) ≥85 yrs road test every 2 yrs	≥70 yrs current medical certificate and VT	≥80 yrs: annual VT and medical certificate	If a concern is declared/ reported	VT: 50, 60, 65, 70 and 75 yrs ≥75 yrs: annual VT and medical certificate	No VT, medical assessment or road test only when condition notified by health professional

- Mandatory reporting in South Australia and Northern Territory
  - But many jurisdictions allow discretionary reporting by practitioners if the patient continues to drive against your advice

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Unconditional and conditional licences

- Unconditional licence: an individual meets the standards for licensure
  - In the case of vision, this typically means the visual acuity and visual field requirements
  - This is not related to refractive error correction if patient meets the visual acuity requirements with correction
- Conditional licence: enables individual case-based decision making
  - "..final decision rests with the driver licensing authority and will be issued on the basis that any additional road safety risk posed by the person driving is acceptable"

Conditional licensing

- Provides a means of optimising driver and public safety while maintaining independence
  - When patient has a long-term health condition/injury that affects their ability to drive safely
- Permits driving in conditions that suit patient's capability
  - No night driving - a good option as vision always worse at night[1]
  - Only in familiar areas (local area restriction)
    - Commonly expressed as km radius restriction based on home address
    - Should be capable of managing usual driving demands (intersections, giving way to pedestrians) in local area
    - Consideration of ability to respond appropriately to unexpected occurrences (e.g. roadworks) that require problem-solving
    - BUT most crashes occur nearer to home[2,3] and lower driving exposure is related to increased crash risk[4-6]

4.4. Conditional licences

4.4.1. What is a conditional licence?

A conditional licence provides a mechanism for optimising driver and public safety while maintaining driver independence when a driver has a long-term or progressive health condition or injury that may affect their ability to drive safely. A conditional licence permits the driver to drive in conditions that suit their capability – for example, no night driving, only driving in familiar areas (local area restriction) or having to wear corrective lenses. A conditional licence identifies the need for medical treatments, vehicle modifications or driving restrictions that would enable the person to drive safely. It may also specify a review period, after which the person must undertake a medical review to establish the status of their condition and their continued fitness to drive. A conditional licence therefore offers an alternative to withdrawing a licence and enables individual case-based decision making.

1. Wood (2020); 2. Janke (1991); 3. Langford & Koppel (2005); 4. Hakamies-Blomqvist et al (2002); 5. Langford et al (2006); 6. Langford et al (2013)

Conditional licensing

- The role of the health professional is to provide information to licensing authority
  - Which medical requirements have not been met
  - Adequacy of treatments
  - Plan for monitoring driver's performance and condition, including timeframes –frequency can be determined by the health professional
  - Information relating to the appropriate type of restriction, e.g. no night driving, local area restriction,
  - Final decision rests with the driver licensing authority

4.4.3. What is the role of the health professional?

While the driver licensing authority makes the final decision about whether a driver is eligible for a conditional licence, the health professional provides information to assist the authority in its decision making. The health professional should advise the driver licensing authority of:

- which medical requirements (for an unconditional licence) have not been met (referring to medical criteria/thresholds outlined in this document)
- the likely adequacy of treatments, driver aides or vehicle modifications in optimising driver capacity
- the plan to monitor the driver's performance and the medical condition, including timeframes for review
- if appropriate, information relating to possible licence conditions – for example, vehicle type or licence restrictions such as no night driving, radius restriction or downgrading to a lower class of licence
- any other medical information that may be relevant to the driving task.

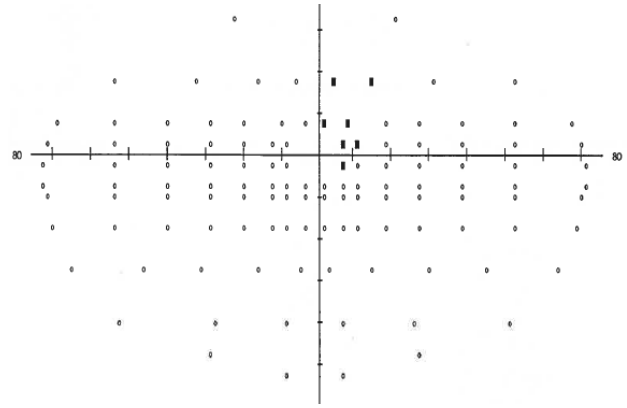
This information is needed so the driver licensing authority can make an informed decision and determine what conditions will be endorsed on the licence.

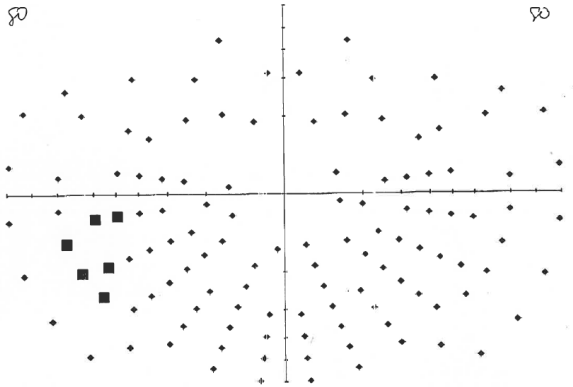
Visual fields: licensing requirements

- If no clinical indication of visual field impairment or progressive eye condition
  - Satisfactory to screen for field defect by confrontation
- If a person has, or is suspected of having, a field defect, should have an automated perimetry assessment
  - If monocular automated perimetry shows no visual field defect, standard is met (but I would recommend binocular Esterman testing)
  - If there is a significant field defect or a progressive eye condition a binocular Esterman is required

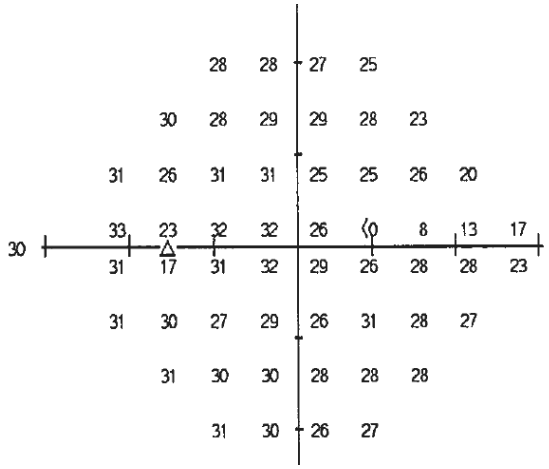
Visual fields: licensing requirements

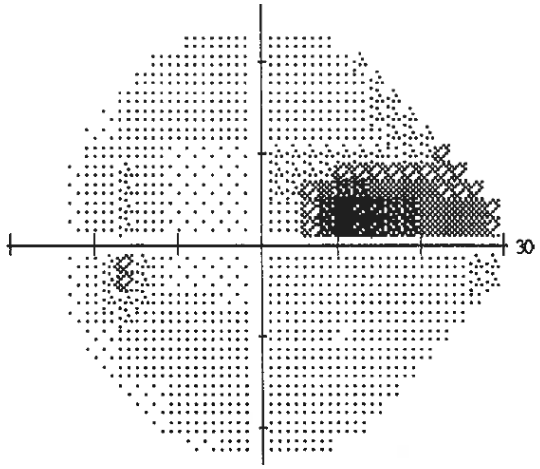
- Individuals with a significant field defect or a progressive eye conditions require a binocular Esterman field assessment on Humphrey Field Analyser or equivalent
  - Fixation monitoring must be performed and recorded
  - Alternative devices are acceptable if they monitor fixation and stimulate the same locations as the standard binocular Esterman
  - False positive score should be 20% or less for an Esterman binocular field to be considered reliable for licensing

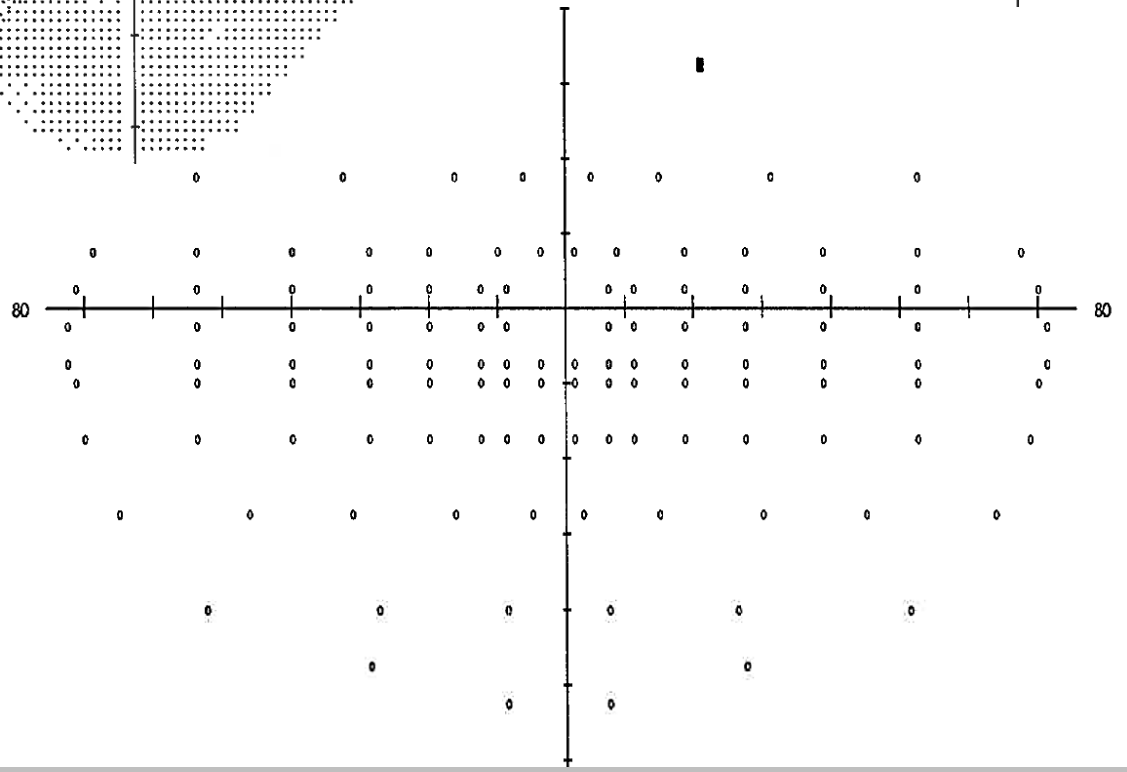


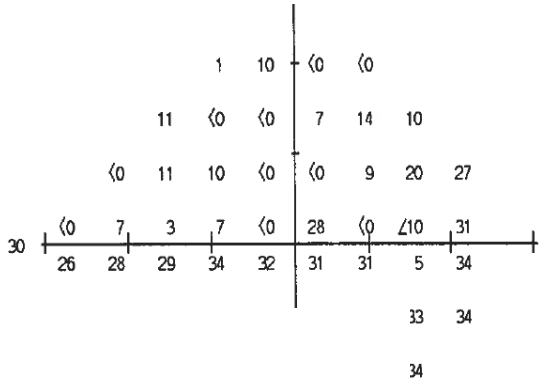


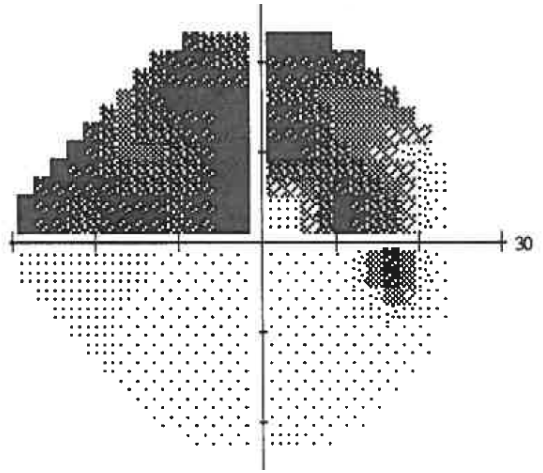
Visual fields: licensing requirements



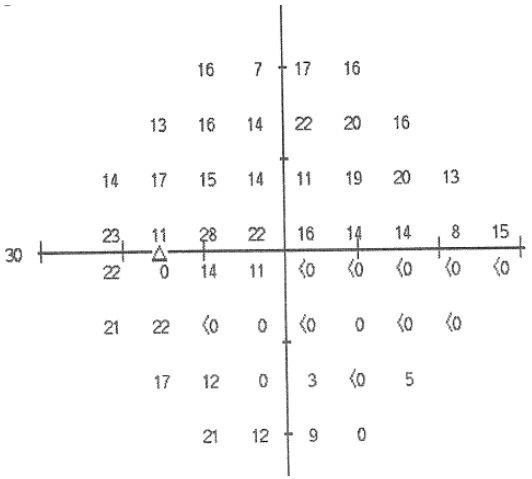


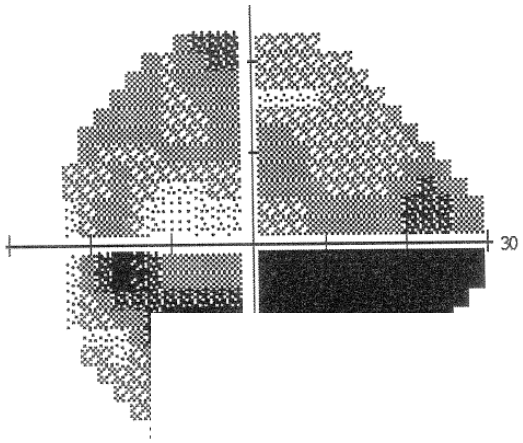


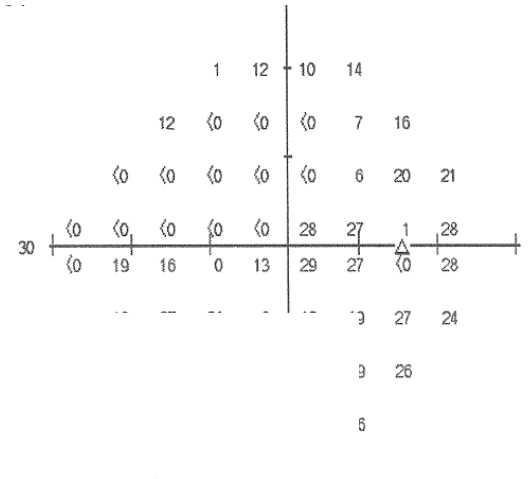


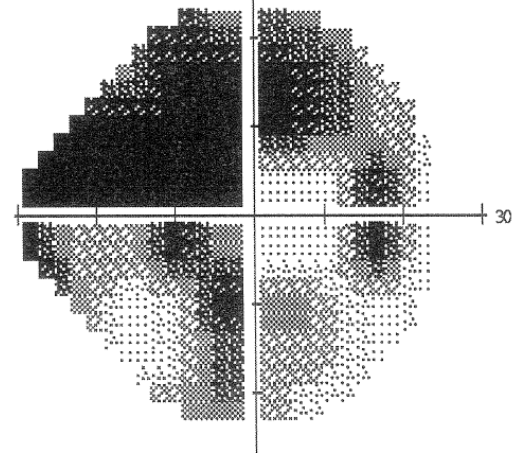


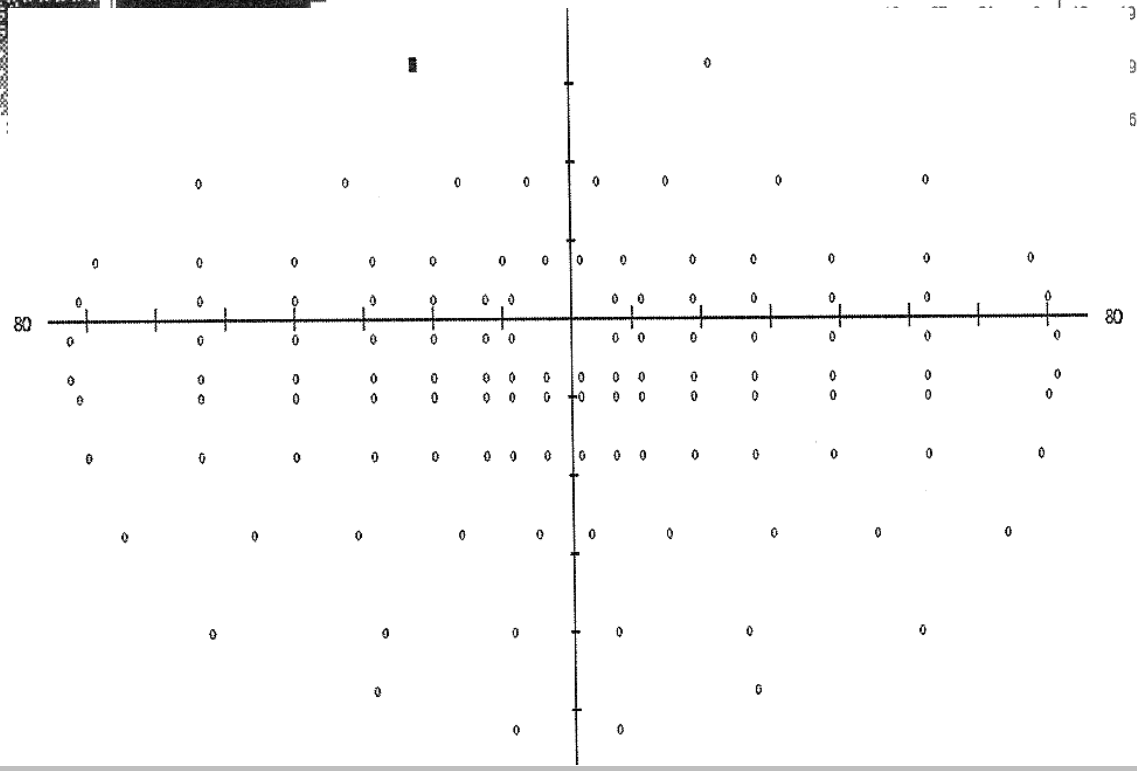
Visual fields: licensing requirements



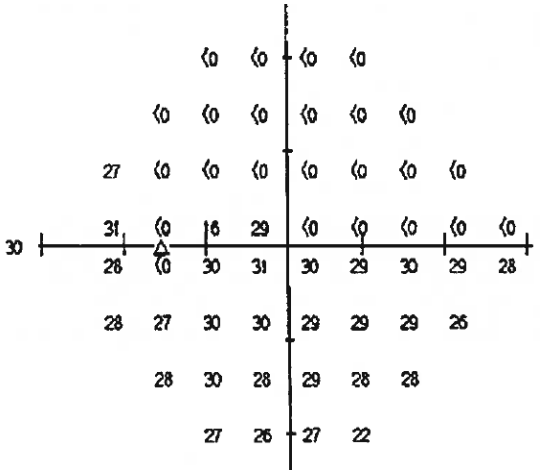


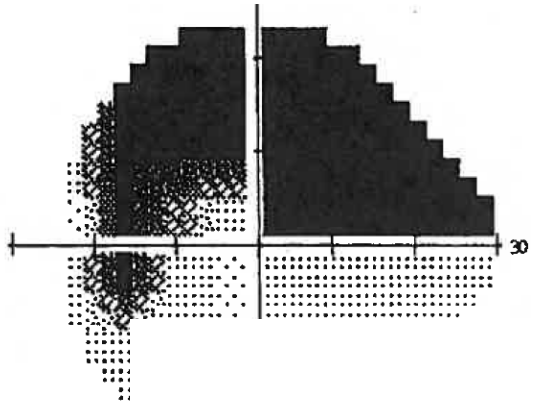


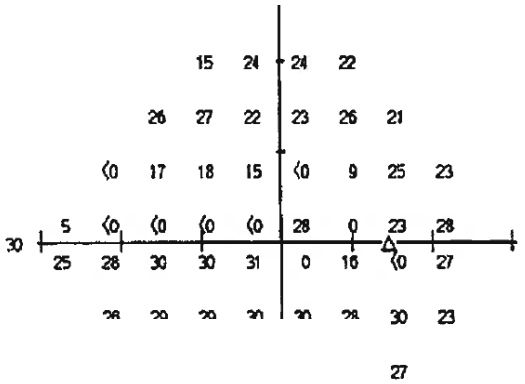


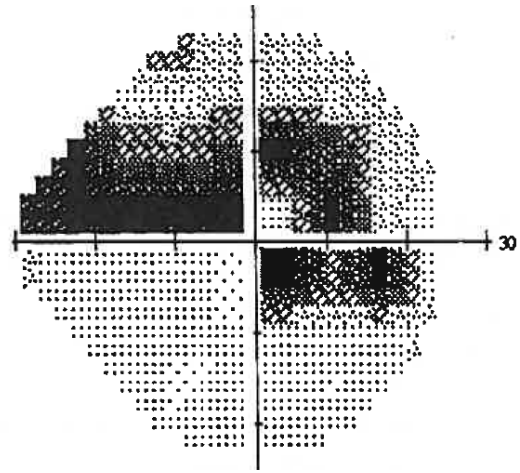


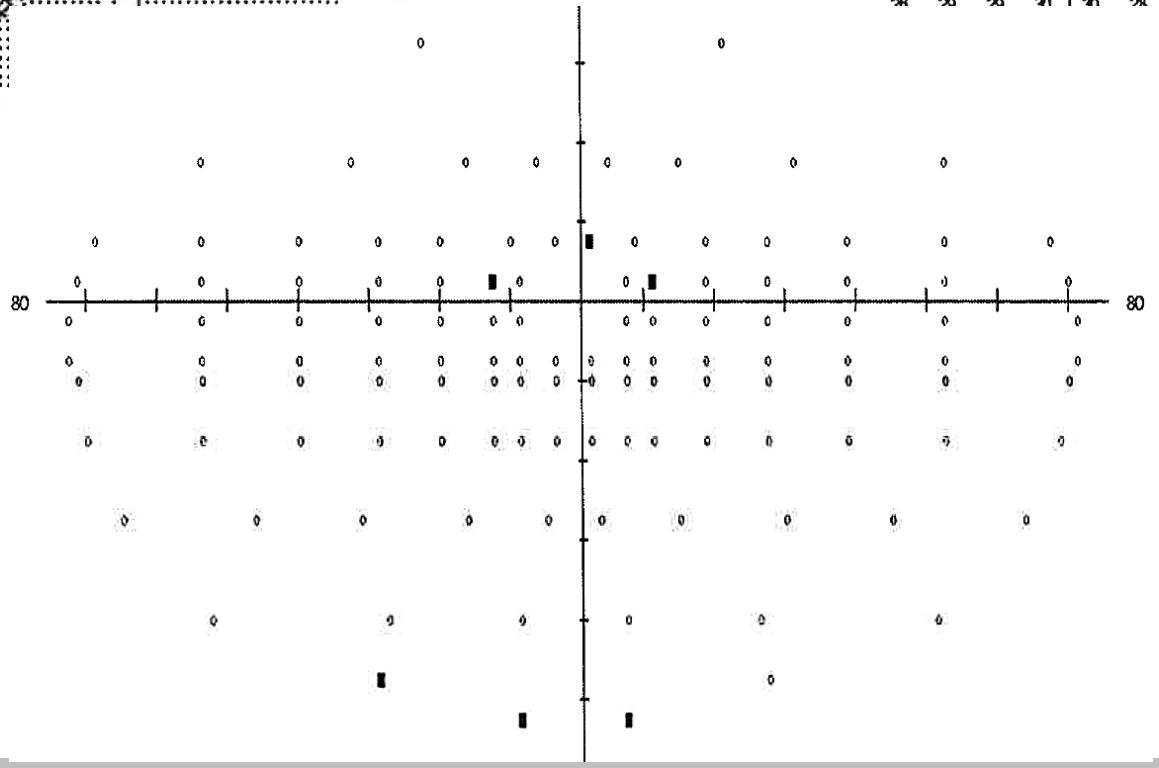
Visual fields: licensing requirements





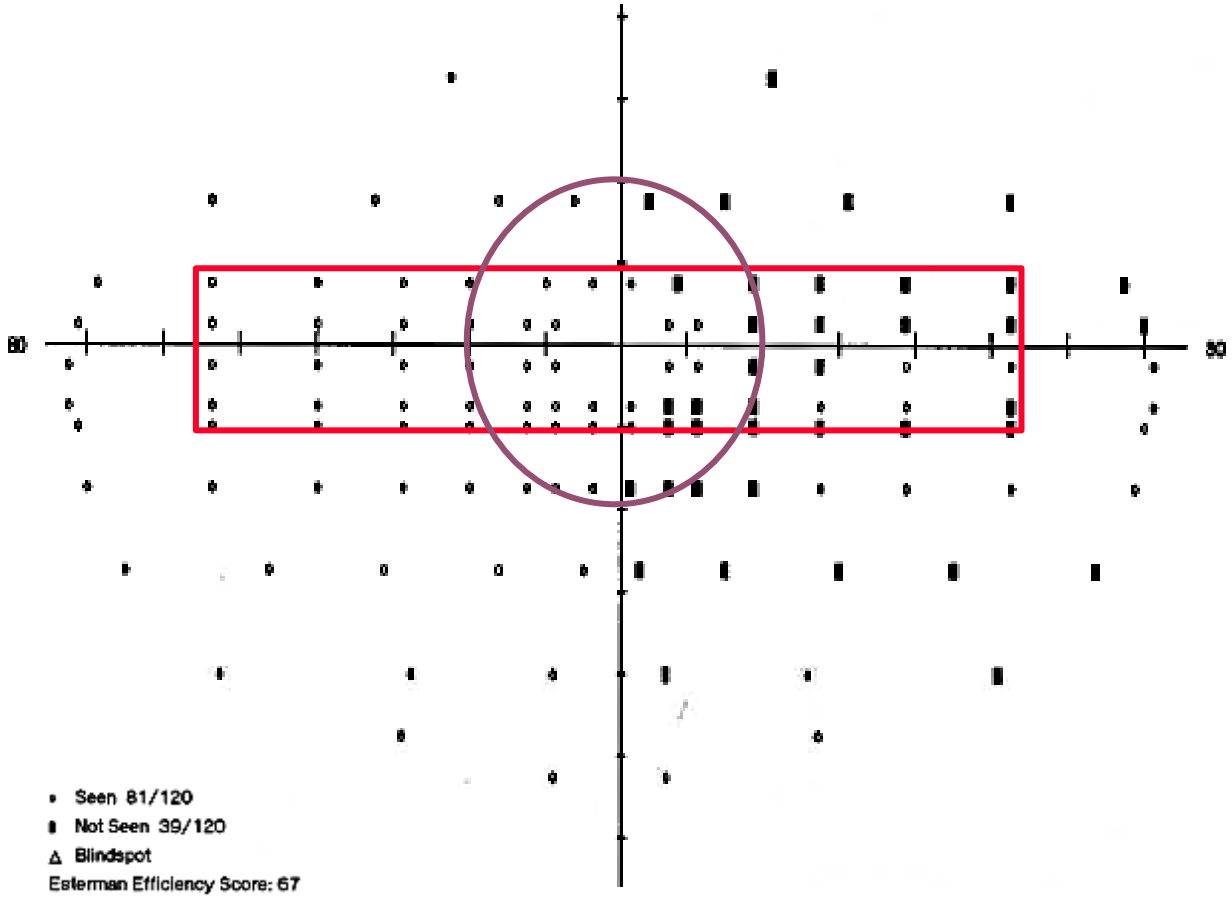






Visual fields: licensing requirements

- Visual fields for an <u>unconditional</u> licence for a private vehicle must meet two criteria:
  - Horizontal binocular visual field extent
    - 110° horizontally,10° above and below horizontal midline
  - Central visual fields
    - No significant field loss within central 20°



Visual fields: licensing requirements

Horizontal extent of the visual field

In the case of a private vehicle driver, if the horizontal extension of a person's visual fields are less than 110 degrees but greater or equal to 90 degrees, an optometrist or ophthalmologist may support the granting of a conditional licence by the driver licensing authority. The extent is measured on the Esterman from the last seen point to the next seen point. There is no flexibility in this regard for commercial vehicle drivers.

A single cluster of up to three adjoining missed points, unattached to any other area of defect, lying on or across the horizontal meridian will be disregarded when assessing the horizontal extension of the visual field. A vertical defect of only a single point width but of any length, unattached to any other area of defect, that touches or cuts through the horizontal meridian may be disregarded. There should be no significant defect in the binocular field that encroaches within 20 degrees of fixation above or below the horizontal meridian. This means that homonymous or bitemporal defects that come close to fixation, whether hemianopic or quadrantanopic, are not normally accepted as safe for driving.

Central field loss

Scattered single missed points or a single cluster of up to three adjoining points is acceptable central field loss for a person to hold an unconditional licence. **A significant or unacceptable central field loss is defined as any of the following:**

- a cluster of four or more adjoining points that is either completely or partly within the central 20-degree area
- loss consisting of both a single cluster of three adjoining missed points up to and including 20 degrees from fixation, and any additional separate missed point(s) within the central 20-degree area
- any central loss that is an extension of a hemianopia or quadrantanopia of size greater than three missed points.

Additional factors to be considered by the driver licensing authority in assessing patients with defects in visual fields therefore include, but are not limited to, the following:

- kinetic fields conducted on a Goldman
- binocular Esterman visual fields conducted without fixation monitoring, often referred to as a roving Esterman (two consecutive tests must be performed with no more than one false-positive allowed) – the test should be in the numeric field format when it is printed out or sent for an opinion
- contrast sensitivity and glare susceptibility
- medical history; duration and prognosis; if the condition is progressive; rate of progression/deterioration; effectiveness of treatment/management
- driving record before and since the occurrence of the defect
- the nature of the driving task – for example, type of vehicle (truck, bus, etc.), roads and distances to be travelled concomitant medical conditions such as cognitive impairment or impaired rotation of the neck.

There is no flexibility in this regard for commercial vehicle drivers.

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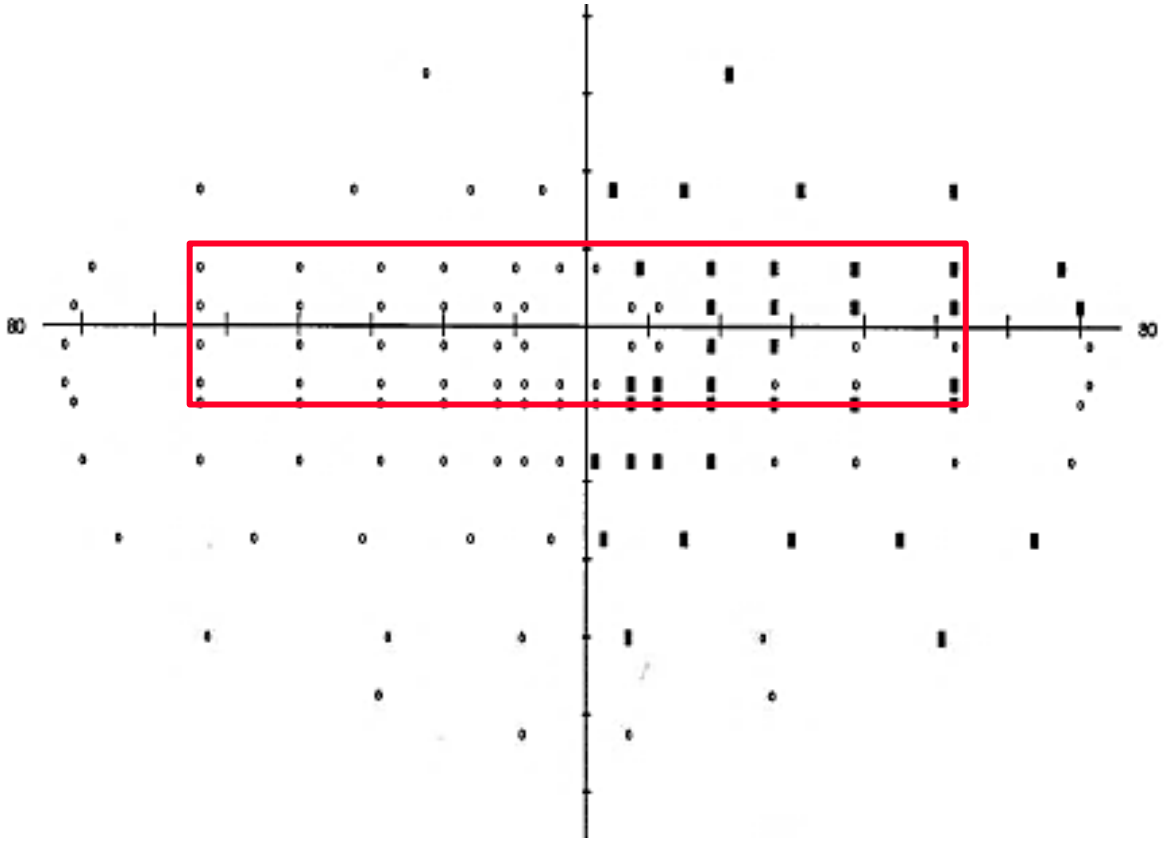
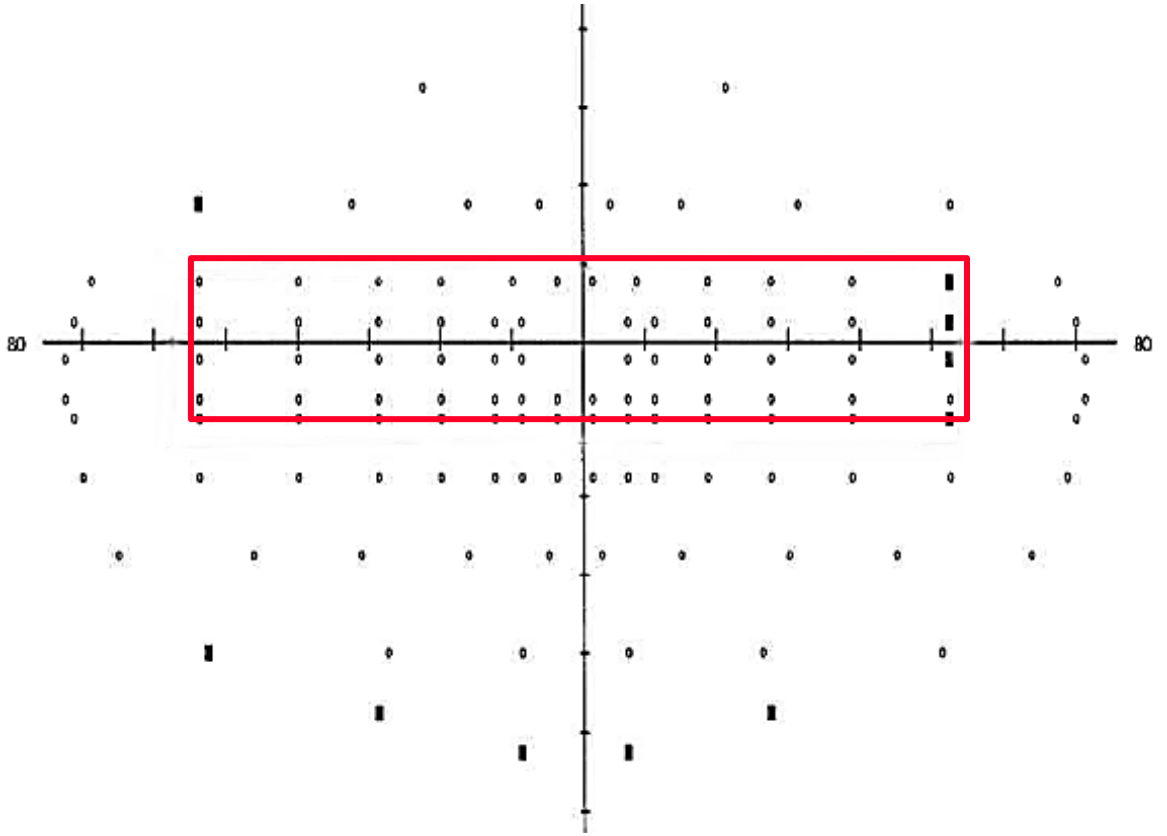
Visual fields: conditional licence

- Horizontal binocular visual field extent
  - 110° horizontally, 10° above and below midline
  - <110 ≥ 90° conditional licence may be granted
    - Extent measured from last seen to next seen point
  - Single cluster of up to 3 adjoining missed points not attached to any other field defect will be disregarded
  - Vertical defect of single point width of any length, that is unattached to any other area of defect, which touches or cuts through horizontal meridian may be disregarded



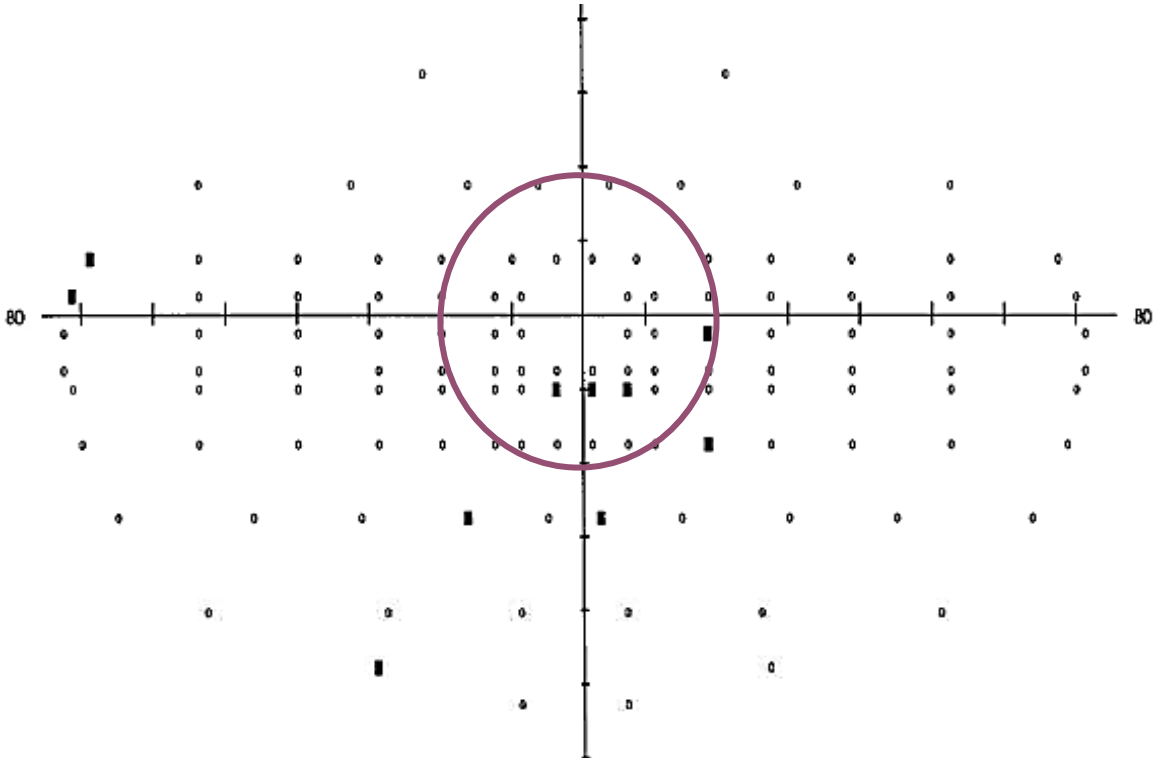
Visual fields: conditional licence

- Horizontal binocular visual field extent
  - 110° horizontally, 10° above and below midline
  - <110 ≥ 90° conditional licence may be granted
    - Extent measured from last seen to next seen point
  - Single cluster of up to 3 adjoining missed points not attached to any other field defect will be disregarded
  - Vertical defect of single point width of any length, that is unattached to any other area of defect, which touches or cuts through horizontal meridian may be disregarded



Visual fields: conditional licence

- Significant loss within central 20°:
  - Cluster of **four (4)** or more contiguous (adjacent) points (includes extension of hemianopia or quadrantanopia)
  - Cluster of **three (3)** contiguous points and **one (1)** or more unconnected point
  - Central loss greater than 3 missed points that is an extension of a hemianopia or quadrantanopia
    - "homonymous or bitemporal defects that come close to fixation – whether hemianopic or quadrantanopic - not normally accepted as safe for driving"



Visual fields and driving: conditional licence

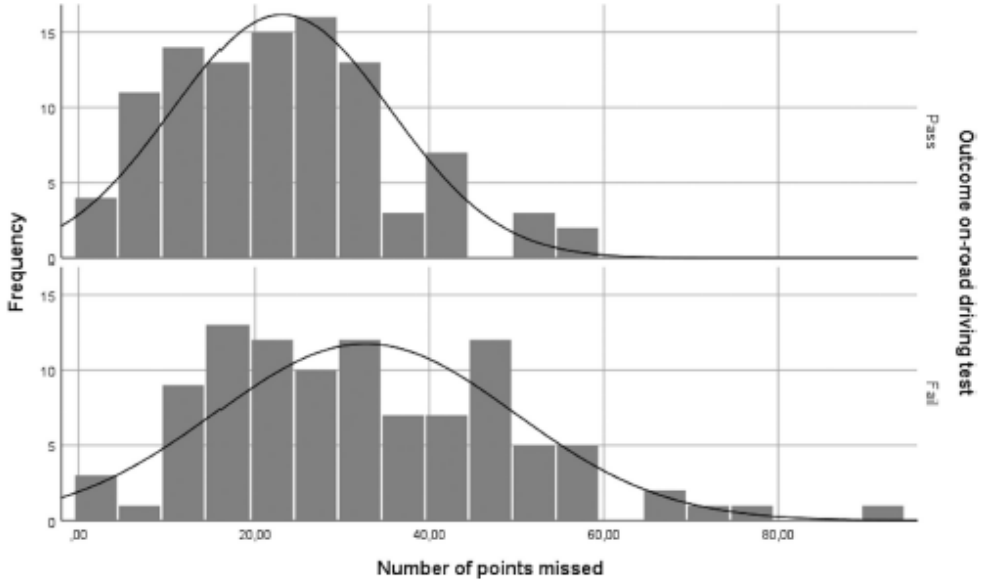
- Other factors to be considered when assessing patients with visual field defects:
  - Goldman kinetic fields
  - Roving Esterman – two consecutive tests must be performed with ≤1 false positive
  - Contrast sensitivity and glare susceptibility
  - Medical history duration, prognosis and progression
  - Driving record before or since onset of condition
  - Nature of driving task
    - Type of vehicle driven
    - Roads and distances travelled
    - Concomitant medical conditions: cognitive impairment or impaired neck rotation

Methods of measuring visual fields are limited in their ability to resemble the demands of the real-world driving environment where drivers are free to move their eyes as required and must sustain their visual function in variable conditions. Additional factors to be considered by the driver licensing authority in assessing patients with defects in visual fields therefore include, but are not limited to, the following:

- kinetic fields conducted on a Goldman
- binocular Esterman visual fields conducted without fixation monitoring, often referred to as a roving Esterman (two consecutive tests must be performed with no more than one false-positive allowed) – the test should be in the numeric field format when it is printed out or sent for an opinion
- contrast sensitivity and glare susceptibility
- medical history; duration and prognosis; if the condition is progressive; rate of progression/deterioration; effectiveness of treatment/management
- driving record before and since the occurrence of the defect
- the nature of the driving task – for example, type of vehicle (truck, bus, etc.), roads and distances to be travelled concomitant medical conditions such as cognitive impairment or impaired rotation of the neck.

Visual fields and driving: conditional licence

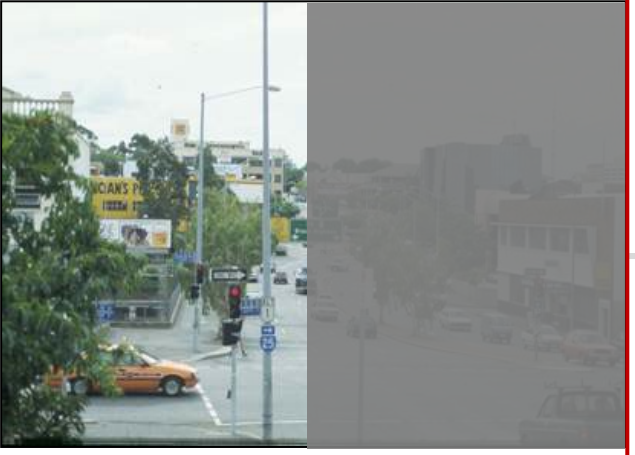
- Binocular field extent is less than 110 degrees but greater or equal to 90 degrees
- Significant defect in central 20°
  - A conditional licence may be granted subject to annual review by treating optometrist/ophthalmologist
- Retrospective review of driver license applicants (n=202)[1]
  - More missed points on the Esterman more likely to fail on-road test
  - But large overlap in number of points missed and safe/unsafe outcomes

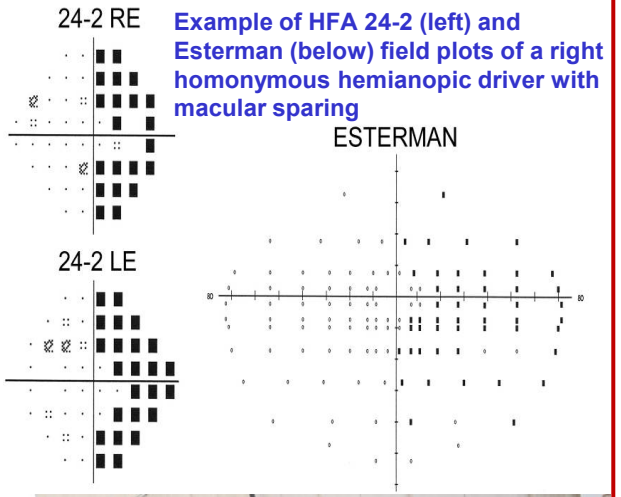


1. Faraji et al (2022)

Visual fields and driving: conditional licence

- Medical review panel in Victoria
  - 57% of drivers who had their licences revoked because of field loss were allowed to continue driving [1]
    - Key factors: age, crash history, cause of VF loss, 25% of cases had on-road test data available
  - Option not currently available in Queensland
- Current Australian guidelines state that a practical driving assessment is <u>not</u> safe or reliable to assess the effects of vision disorders on driving
  - On-road testing permitted for other medical conditions (e.g. cognitive impairment)
  - Naturalistic driving study[2] demonstrated that on-road testing outcomes were significantly associated with at-fault and at-fault near crashes over a 6-month period
- Need a process for drivers to demonstrate capacity for safe/unsafe driving





Example of HFA 24-2 (left) and Esterman (below) field plots of a right homonymous hemianopic driver with macular sparing

Hemianopia and driving

- Individuals with hemianopic or quadrantanopic field defects prohibited from driving or allowed a conditional licence in most jurisdictions
  - Yet limited research to evaluate driving performance and safety in this population
- No evidence that all persons with hemianopia or quadrantanopia are unsafe to drive

Hemianopia and driving

- Studies on drivers with hemianopic or quadrantanopic loss more common in simulators than on-road assessments
- Studies often limited to small samples of participants
  - Many simulator studies include individuals who are not current drivers

FIGURE 3. Picture of Sim III at VTI with the motion platform and the interior used in the test.

Hemianopia: driving simulators

- Studies including sample sizes demonstrate poorer performance than controls[1-4]
  - Difficulties with lane keeping (n=6-12)[1,2]
  - Impaired pedestrian detection and longer response times when pedestrians appeared in blind field, particularly peripherally (n=12)[3,4]
- Compensatory head and eye movements allowed detection of hazards in the blind field[5-7]

FIGURE 3. Picture of Sim III at VTI with the motion platform and the interior used in the test.

1. Szlyk et al (1993) 2. Bowers et al (2010); 3. Bowers et al (2009); 4. Alberti et al (2014); 5. Bowers et al (2014); 6. Papageorgiou et al (2012); 7. Kubler et al (2015)

Hemianopia: driving simulators

- Recent study[1] included 153 individuals with field loss from stroke whose licence had been withdrawn, and 83 healthy individuals with normal fields
  - 65% of stroke participants passed simulator test
    - Likely to be younger
    - Not related to extent of homonymous visual field loss nor side of visual field loss
    - Lateral lane position was displaced towards the seeing field for stroke patients
    - Drivers who regained license were NOT involved in a crashe 3 - 6 years following the simulator assessment

FIGURE 3. Picture of Sim III at VTI with the motion platform and the interior used in the test.

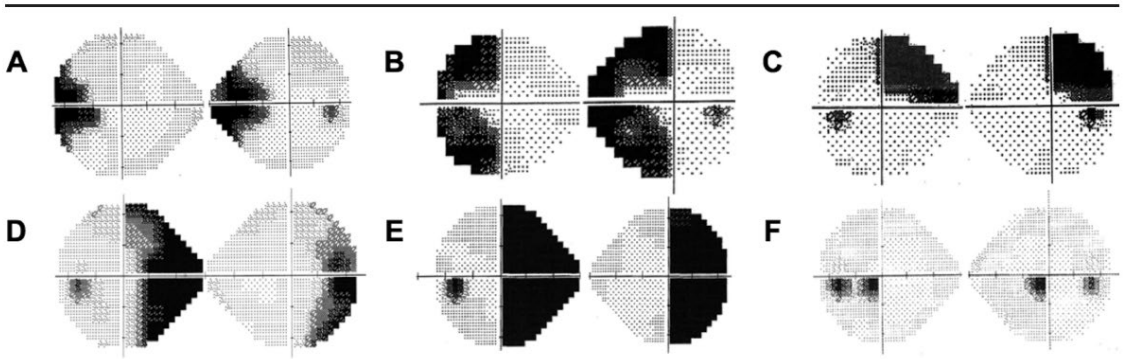


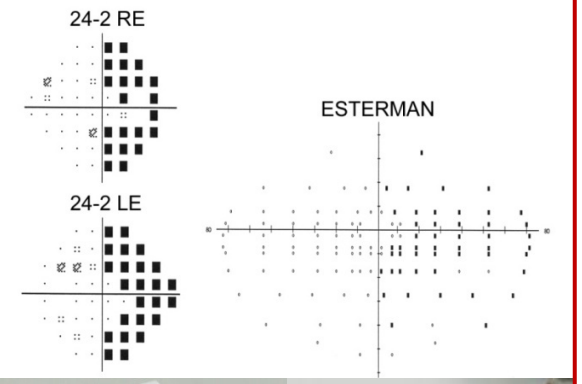
FIGURE 1. Classification of visual field defects (the right eye is on the right, and the left eye is on the left; all examinations with Humphrey perimetry 24-2). (A) Homonymous sectoranopia. (B) Homonymous hemianopia sparing the macula. (C) Quadrantanopia. (D) Partial or incongruous homonymous hemianopia. (E) Complete homonymous hemianopia. (F) Homonymous scotomatous defect.

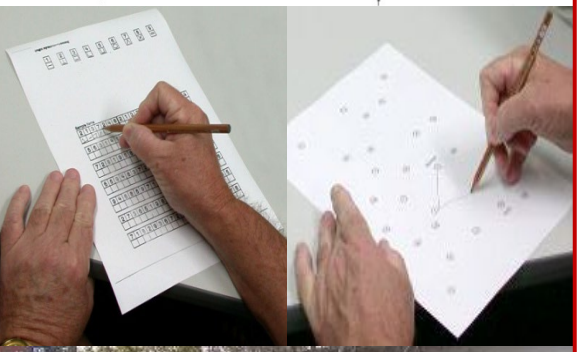
1. Bro & Andersson (2022)

Hemianopia: on-road driving performance

- On-road driving assessment
  - Useful to evaluate real-world driving performance, using standardised protocols and can explore which aspects of performance are impaired
- On-road driving performance
  - Only 14% hemianopes passed driving assessment, problems with on-road steering ability (n=28)[1]
    - Participants recruited whose driving was considered unsafe by carers or patients themselves
  - Retrospective chart review of on-road driving assessments: 73% rated as safe or having potential for safe driving (n=20)[2]
- Driving and eye movement recorded in hemianopic drivers (n=10)[3]
  - 40% failed assessment due to poor lane keeping and gap judgement
  - Extent of visual field loss was not related to driving ability
    - Those who passed had higher % of glances into their field defect areas

1. Tant et al (2002); 2. Racette & Casson (2005); 3. Kasneci et al (2015)





Hemianopia study: on-road driving

- 60 licensed participants[1-4]
  - 22 with hemianopic; 8 quadrantanopic field loss (M age=52.7 yrs)
  - 30 persons with normal visual fields (M age=52.5 yrs)
  - No lateral spatial neglect (Stars test)
- Vision and cognitive testing battery
  - Visual acuity
  - Visual fields
  - Contrast sensitivity
  - Mini-Mental State Examination
  - Digit Symbol Substitution Test
  - Trail Making A and B tests
  - Driving Habits Questionnaire

1. Wood et al (2009); 2. Wood et al (2011); 3. Parker et al (2011); 4. Vaphiades et al (2014)

Hemianopia study: on-road driving

- In-traffic course of 23 km (14.1 miles: 6.3 miles non-interstate; 7.8 miles interstate)
- Dual brake instrumented vehicle
  - Certified Driving Rehabilitation Specialist (CDRS) in front seat Performance scored by 2 backseat raters (masked)
  - Agreement between backseat raters was high (r=0.96)
  - Overall safety rating (scale 1-5)
  - Types of driving errors (scale 1-3):
    - Scanning, lane position, steering steadiness, speed, gap selection, braking, directional indicator use, obeying traffic signs and signals

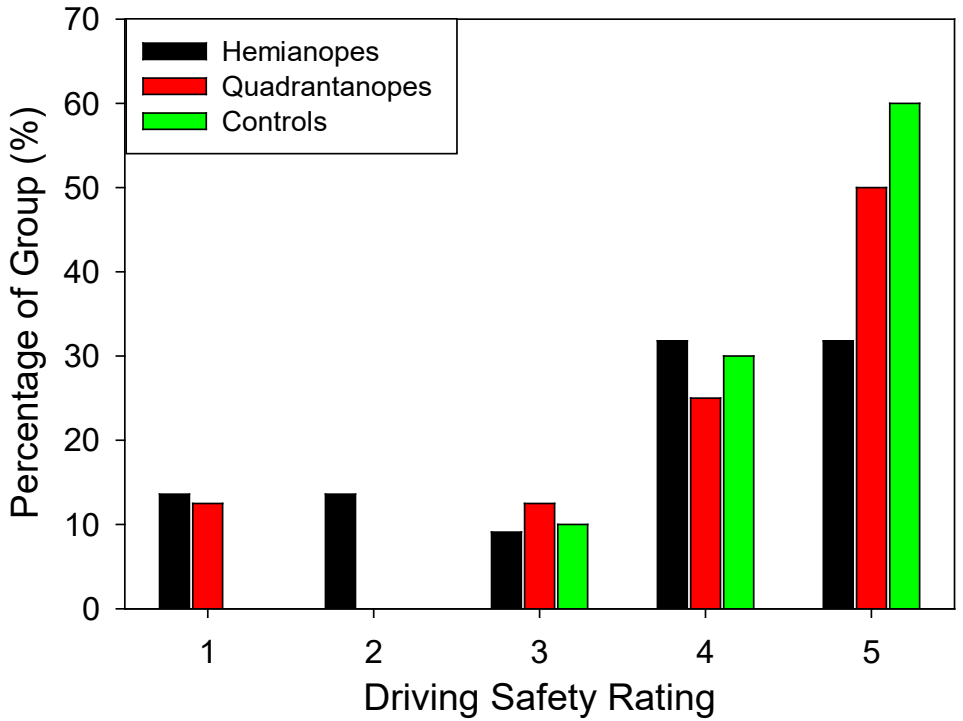
Hemianopia study: on-road driving

- Vigil Vanguard System
  - Accelerometers and inertial sensors
  - GPS samples speed and position
  - 4 vehicle-mounted cameras
  - Data exported as text or graphical files assessed using Vigil software
  - Video footage scored post-testing by 2 independent masked raters
    - Head movement counts, ratings of lane position, head and eye movements

Results: on-road driving

- Percentage of drivers who were rated as safe to drive
  - 73% (16/22) hemianopes
  - 88% (7/8) quadrantanopes
  - 100% (30/30) controls

Backseat Evaluator Driving Rating Scale:
1 = Driver is unsafe and the drive was, or should have been terminated
2 = Driver is unsafe but did not judge drive should be terminated
3 = Driver's performance was unsatisfactory but not unsafe
4 = Driver was safe but demonstrated minor flaws
5 = Driver was safe and demonstrated either flawless or near flawless driving

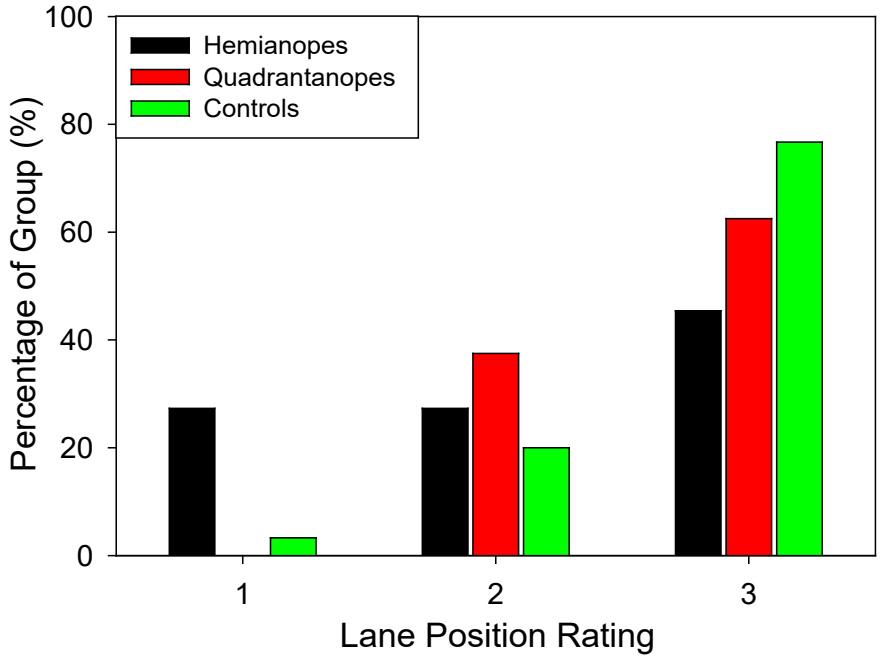


Wood et al (2009)

Results: on-road driving

- Significant differences for hemianopes and quadrantanopes vs controls
  - Lane position
  - Steering steadiness
  - Gap selection
- No significant differences
  - Scanning
  - Speed
  - Braking
  - Indicator use
  - Obeying signs/signals

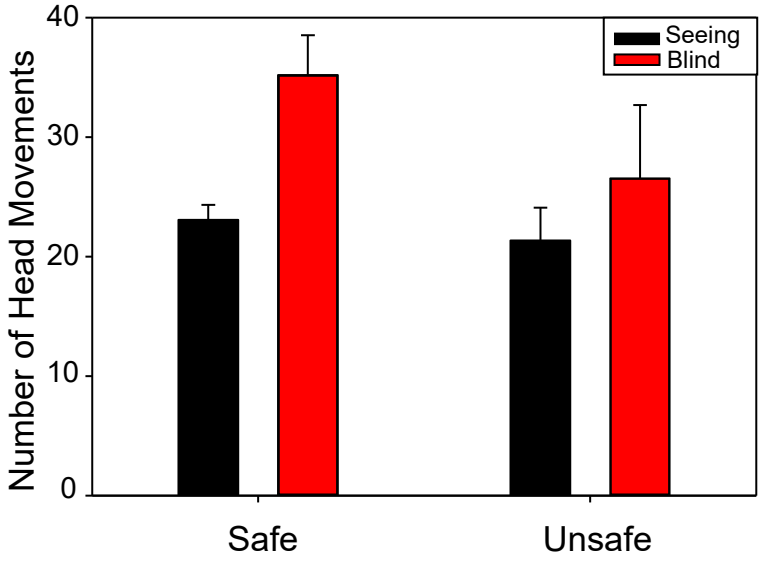
Backseat Evaluator Rating Scale for Specific Driving Skills/Behaviors:
1 = Failure to execute skill/behavior
2 = Some problems with executing skill/behavior but not complete failure
3 = Good execution of skill/behavior



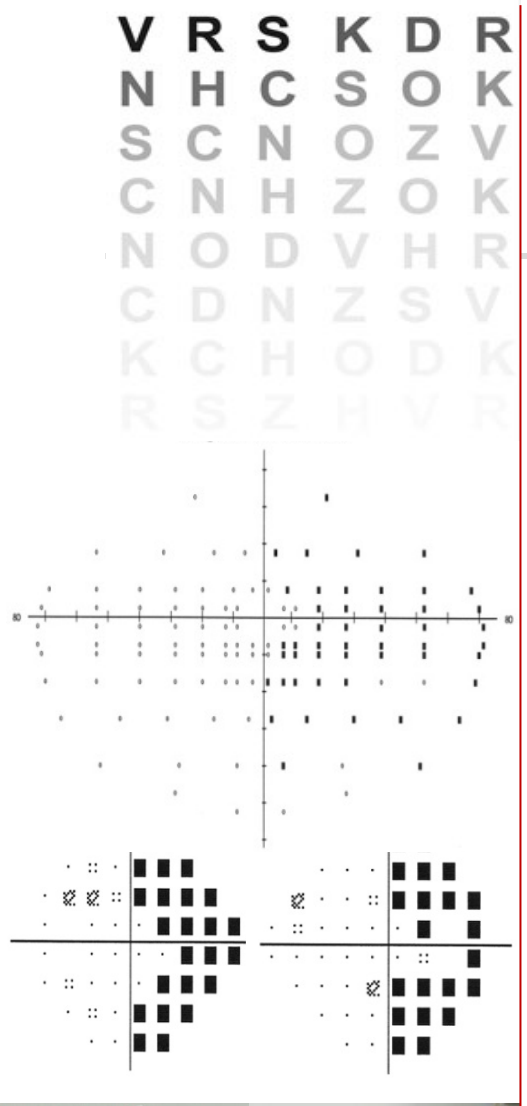
Wood et al (2009)

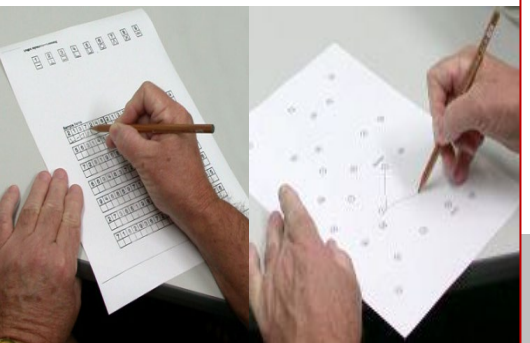
Results: on-road driving

- Hemianopes and quadrantanopes made more head, shoulder and eye movements than controls[1]
- Compared to safe drivers, drivers with hemianopia rated as unsafe[1]
  - Made less head movements into their blind field
  - Drove more slowly but had >2x as many sudden braking events than safe drivers (3.9 vs 1.6)
  - Steered into their seeing field
- Drivers rated as unsafe were no more likely to report driving difficulty than those rated as safe[2]



1. Wood et al (2011); 2. Parker et al (2011)





Results: predictors of driving

- Driving safety associated with visual and cognitive function[1]
  - Reduced contrast sensitivity
  - Visual field defects: Esterman, binocular field sensitivity
  - Slower visual processing speed and executive function
- Driving safety poorly predicted by neuro-ophthalmologists based on neuroimaging reports based on CT/MRI reports[2]

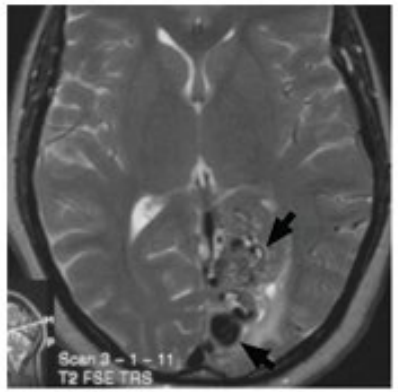


FIGURE 1: Axial T2 MRI demonstrates a large left parietooccipital arteriovenous malformation yet the patient was found to be a safe driver.

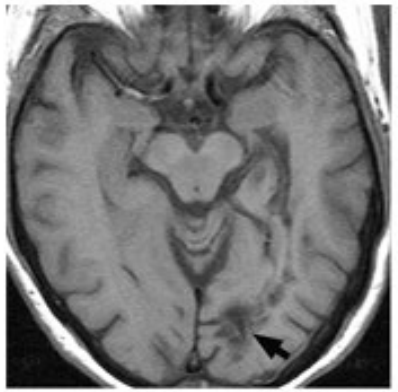


FIGURE 2: Axial T1 MRI shows evidence of a small left parietooccipital infarction yet the patient was determined to be an unsafe driver.

1. Wood et al (2009); 2. Vaphiades et al (2014)

Summary: hemianopia and driving

- Some drivers with hemianopia or quadrantanopia are safe to drive when compared to controls
  - 73% hemianopes, 88% quadrantanopes rated as safe to drive[1]
- Problem areas for unsafe drivers include
  - Lane position (tended to steer into their seeing field), steering steadiness and gap judgments
- Potential for safe driving through compensatory eye and head movements into blind field[2]
- However, current visual standards in Australia unlikely to allow either an unconditional or conditional licence
  - Less than 90º horizontal extent and significant central clusters

Exceptional case provisions (UK)

- 62 yr old man, field loss secondary to R occipital lobe stroke
  - Significant defect in central 20°, surrendered licence
  - 2 yrs post-stroke failed on-road driving assessment
  - 4 yrs post-stroke passed on-road assessment
    - Field loss non-progressive
    - VA=6/6 R & L
    - Pelli-Robson CS = 1.80 logCS
  - Licence restored

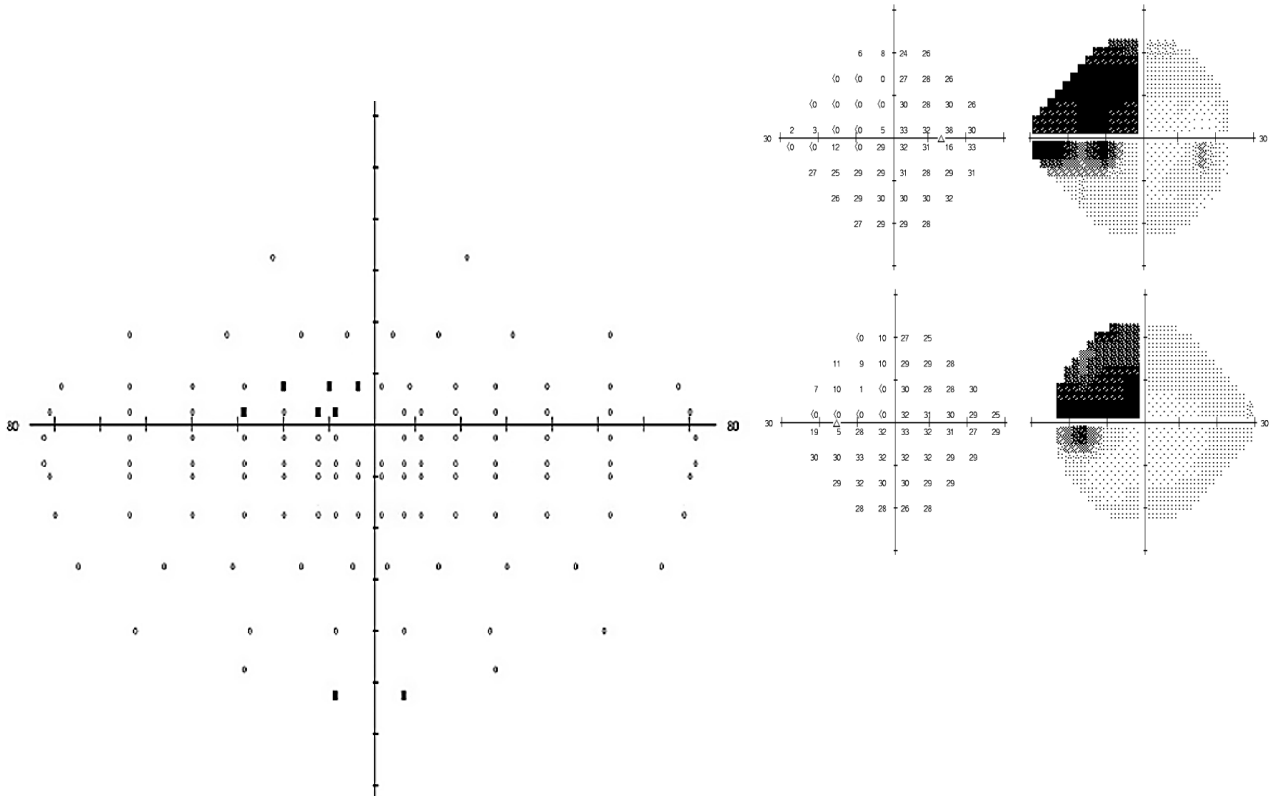
The criteria to be considered as an exceptional case is:

- Defect must have been present for at least 12 months
- Caused by an isolated event or a non-progressive condition
- There must be no other condition or pathology regarded as progressive and likely to be affecting the visual fields
- Sight in both eyes
- No uncontrolled diplopia
- No other impairment of visual function, including no glare sensitivity, contrast sensitivity or impairment of twilight vision
- Clinical confirmation of full functional adaptation.

Any application where an applicant is applying under the agreed exceptional criteria process will need to include evidence showing each point listed above can be meet.

If an applicant meets all the required exceptional criteria, DVLA will issue a provisional licence valid for one year, provided the applicant agrees to accept certain conditions.

Applicants will be advised that they must, at all times, be accompanied by a qualified driver, who, in an emergency will be able to take control of the steering and braking functions.



1. Harper et al (2022)

Exceptional case provisions (UK)

- 48 yr old woman, unaware of field loss
  - Neurological investigation indicated L middle cerebral artery stroke (perinatal intracranial haemorrhage)
  - Significant defect, licence revoked
  - 1 yr following
    - Field loss non-progressive
    - VA=6/4.8 R & L
    - Pelli-Robson CS = 1.92 logCS
    - Passed on-road assessment
  - Licence restored

The criteria to be considered as an exceptional case is:

- Defect must have been present for at least 12 months
- Caused by an isolated event or a non-progressive condition
- There must be no other condition or pathology regarded as progressive and likely to be affecting the visual fields
- Sight in both eyes
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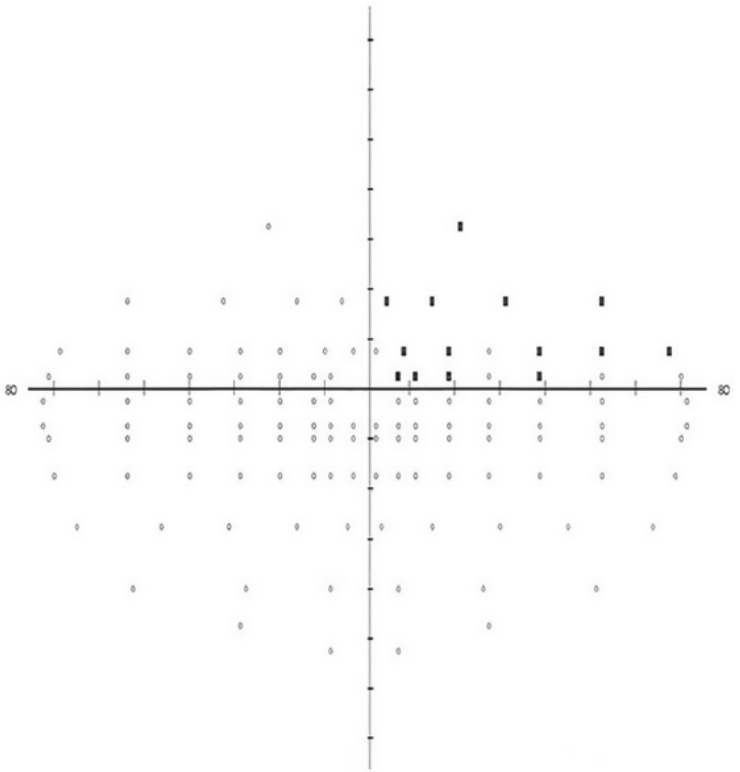
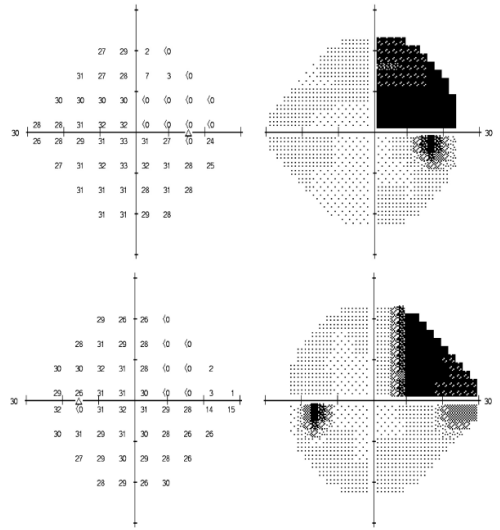
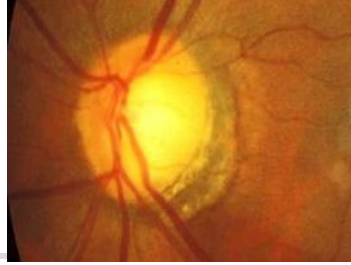




1. Harper et al (2022)

Glaucoma and driving



- Glaucoma characterised by visual field defects and contrast sensitivity loss
  - Complain of a combination of blurred vision and missing areas of visual field; 26% unaware of their field loss[1]
- Drivers with glaucoma regularly assessed to ensure that they meet the visual standards for driving
  - Conflicting evidence regarding the impact of glaucoma on driving ability and safety
  - Unclear whether visual field licensing requirements predict the capacity for safe/unsafe driving in those with glaucoma

1. Crabb et al (2013)

Glaucoma: driving difficulties and crash risk

- Glaucoma associated with self-reported driving difficulties[1]
  - Common reason that older drivers cease driving[1]
  - Self-reported difficulties often not related to driving performance[2]
- Self-reported crashes
  - Drivers with severe glaucomatous field loss reported more motor vehicle crashes (MVC) in previous 10 yrs than controls (n=144 G; 157 C)[3]
    - 25% of those with severe field loss (MD ≥-10 dB in worse eye) reported an MVC in past 10 years

> Have you been involved in one or more traffic accident in the past ten years? yes/no

  - No association between integrated binocular field loss and MVCs in previous 5 yrs (n=247)[4]

Glaucoma: crash risk

FIGURE 1. Driver's view through the windshield and side windows of a vehicle; this view is the widest possible panoramic view from the driver's vantage point as the driver's head turns from one side of the roadway to the other.

- State-recorded crashes
  - Case-control study, drivers with glaucoma (n=48) were >6x more likely to crash than controls, strongest association with impaired selective attention (Useful Field of View)[1]
  - At-fault crash rates
    - 6x higher with moderate/severe loss (AGIS scores) in worse eye (n=240)[2]
    - 2x higher with severe binocular PD impairment (n=438)[3]
    - 1.65x higher with severe loss in novel 'driving visual field' (n=206)[4]

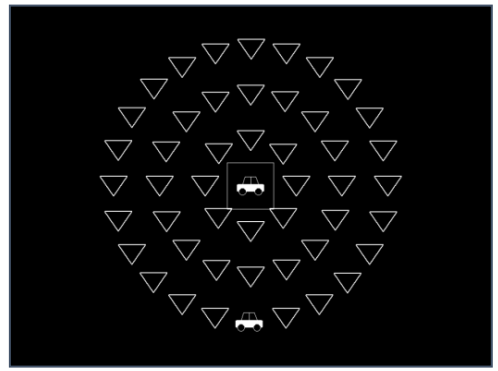
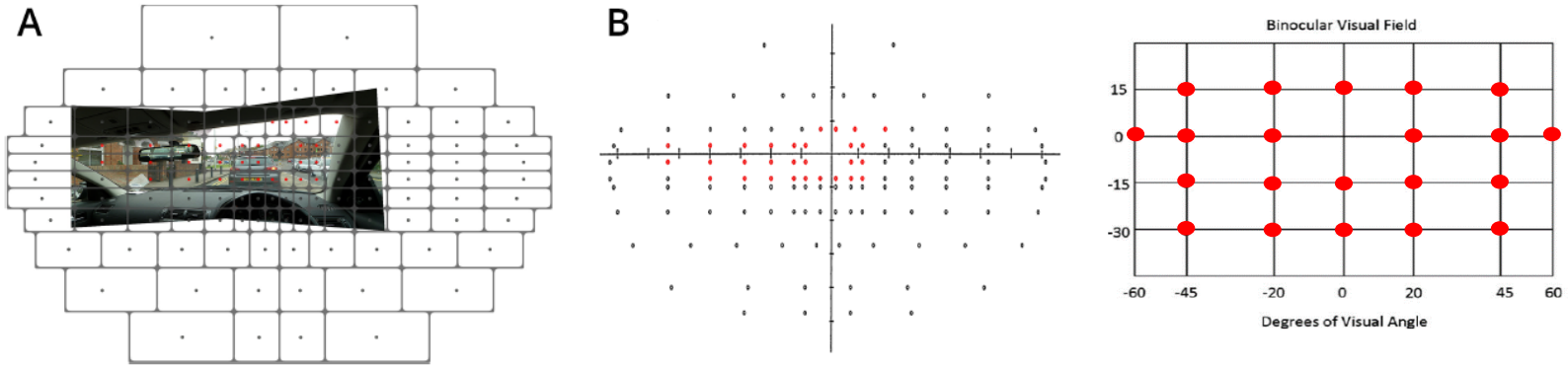


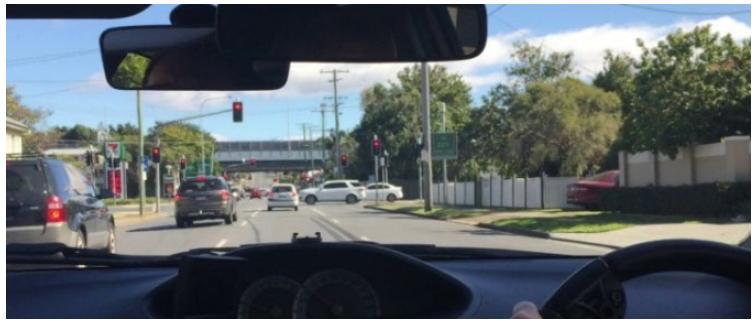
Figure 1 The Esterman Visual Field Test (EVFT) grid superimposed over a road scene as seen from the driver's perspective (A), and an example of a clinical EVFT output (B). Test locations within the region covered by the car windscreen are coloured red: it can be seen that many points on the EVFT, especially in the inferior visual field, are irrelevant to the driving scene.



1.Haymes et al (2007); 2.McGwin et al (2005); 3. McGwin et al (2015); 4. Kwon et al (2016)

Glaucoma: driving simulators

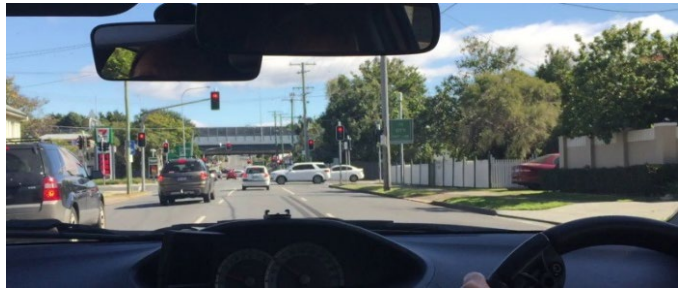
- Driving simulators – no between group differences
  - Drivers with mild/moderate glaucoma (n=25) not different from controls[1], increased sample (n=40) wider range of field loss, simulator and self-reported crashes not different to controls[2]
  - Drivers with glaucoma (n=23) more steering actions, worse on visual detection task but no other differences[3]
  - Performance on a divided attention reaction task predicts self-reported crash risk (n=18 of 153)[4]



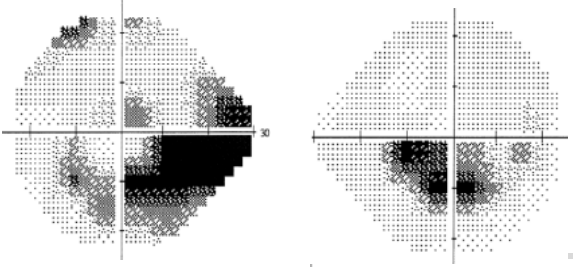
1. Szlyk et al (2002); 2. Szlyk et al (2005); 3. Vega et al (2013); 4. Tatham et al (2015)

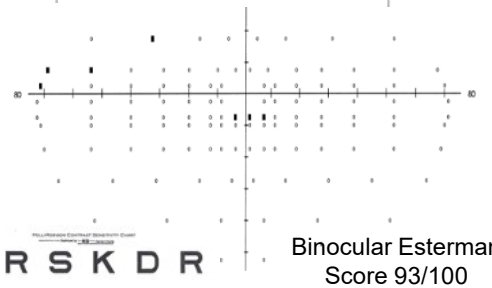
Glaucoma: on-road driving performance

- Previous on-road driving research: drivers with glaucoma demonstrate poorer performance:
  - Lane-keeping, scanning ability, anticipatory skills (n=10-27)[1,2]
  - More driving instructor interventions (n=20)[3,4]
- Underlying differences in performance poorly explained by standard clinical vision tests[2,4]
  - Standard tests unlikely to capture the relevant visual requirements of driving
  - Potential compensation by increased visual scanning

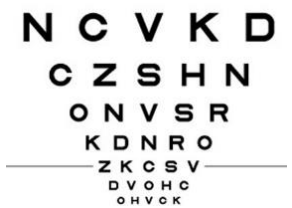


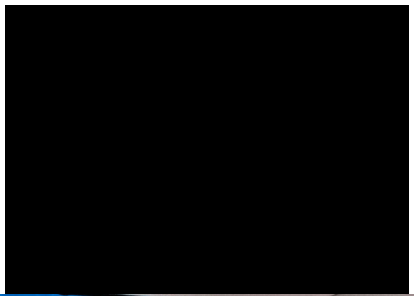
1. Bowers et al (2005); 2. Kasneci et al (2015); 3. Haymes et al (2008); 4. Bhorade et al (2016)





Binocular Esterman
Score 93/100

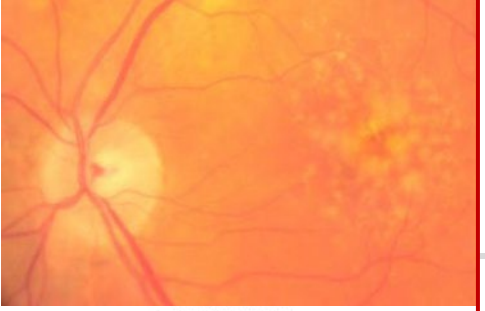


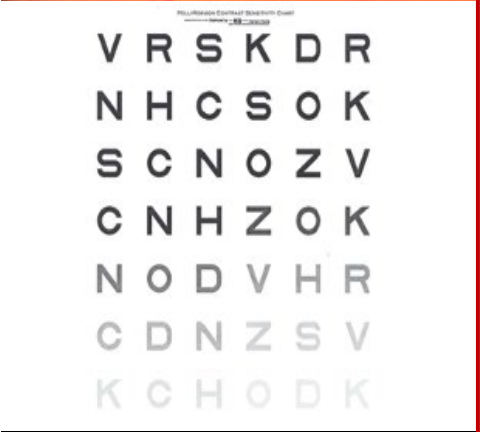


Glaucoma study: on-road driving

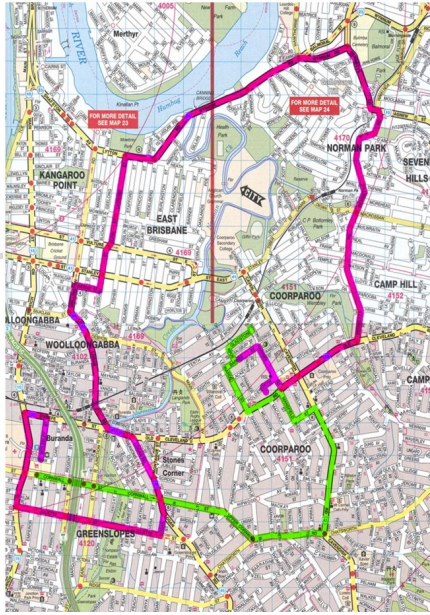
- 75 older adults aged 65+ with glaucoma and mild to moderate field loss (M=73 ± 6 yrs)[1]
  - HFA 24-2 Mean Defect:
    - Better eye: -1.2 dB ± 4.9 (-23.2 – 4.00 dB)
    - Worse eye: -7.8 dB ± 8.5 (-31.0 - 2.1 dB)
- 70 age-matched drivers without glaucoma (M=73 ± 5 yrs)
- Vision testing battery:
  - Visual acuity, visual fields (binocular Esterman, monocular 24-2), contrast sensitivity (Pelli-Robson), motion sensitivity (D_{min})

1. Wood et al (2016)

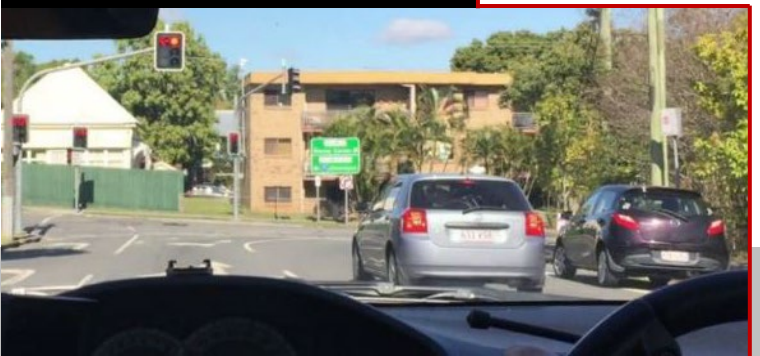




Glaucoma study: on-road driving



- Driving performance scored at 148 locations[1]
  - Global safety rating (scale 1-10)
    - 1 - 3: driver made a critical error so that driving instructor had to take action to avoid an incident or the driver hit a significant object
    - 4 - 5: poor driving and observation skills
    - 6 - 8: average driving skills but with some bad habits
    - 9 - 10: good to excellent driving and observational skills
  - Critical errors (CE) requiring an instructor intervention
    - Observation, vehicle control, speed, lane discipline
- Types of driving errors and driving situations where errors made

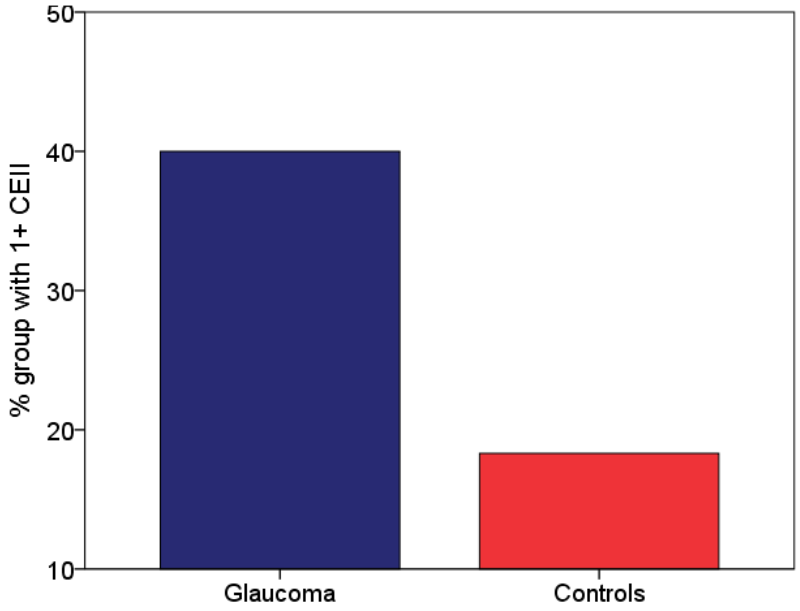


1. Wood et al (2016)

Results: on-road driving

- Drivers with glaucoma[1]
  - Rated significantly less safe than controls (5.2 vs 5.8)
  - 2x more critical errors (CE) requiring instructor intervention than controls
    - RR = 2.06 (95% CI 1.17 - 3.62)

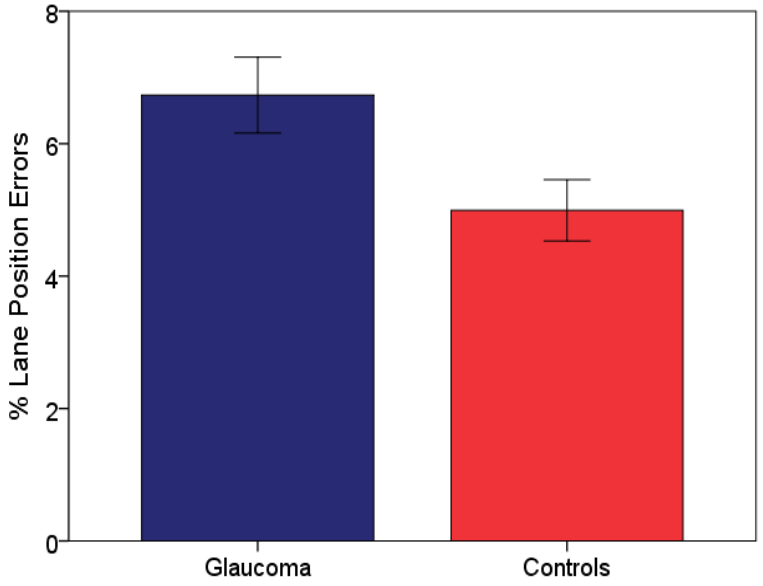
Driving Outcomes	Group Mean (SD)	
	Glaucoma	Controls
CE total#	**0.83 (1.16)**	**0.43 (0.73)***
CE observation#	**0.48 (0.76)**	**0.24 (0.52)***
CE vehicle control#	0.11 (0.35)	0.14 (0.39)
CE lane keeping#	0.19 (0.39)	0.16 (0.40)
CE speed#	0.15 (0.56)	0.06 (0.29)

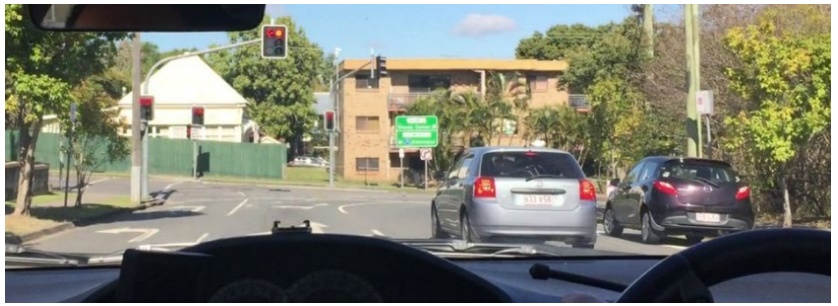


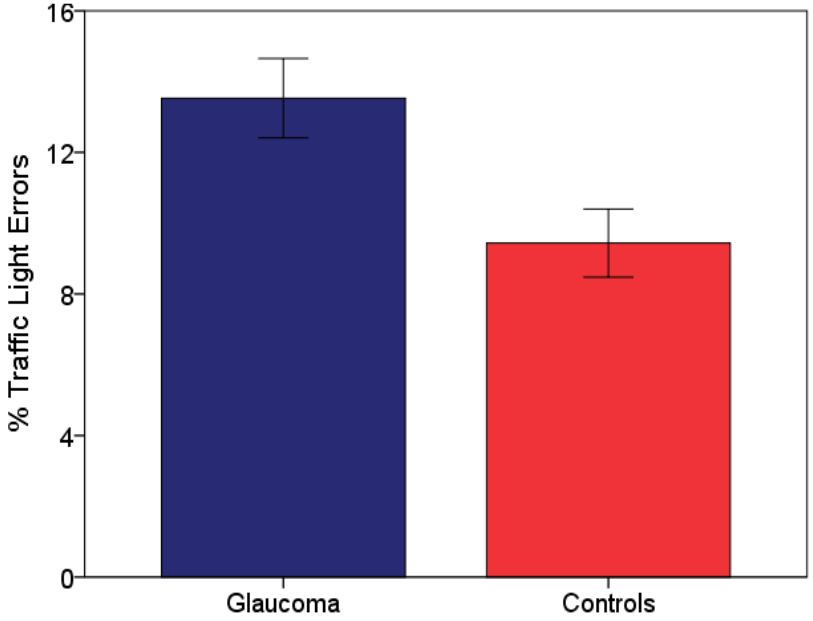
1. Wood et al (2016)

Results: on-road driving

- Types of errors[1]
  - Significant differences: lane keeping, observation and approach
- Location of errors[1]
  - Significant differences: traffic-light controlled intersections, give-way





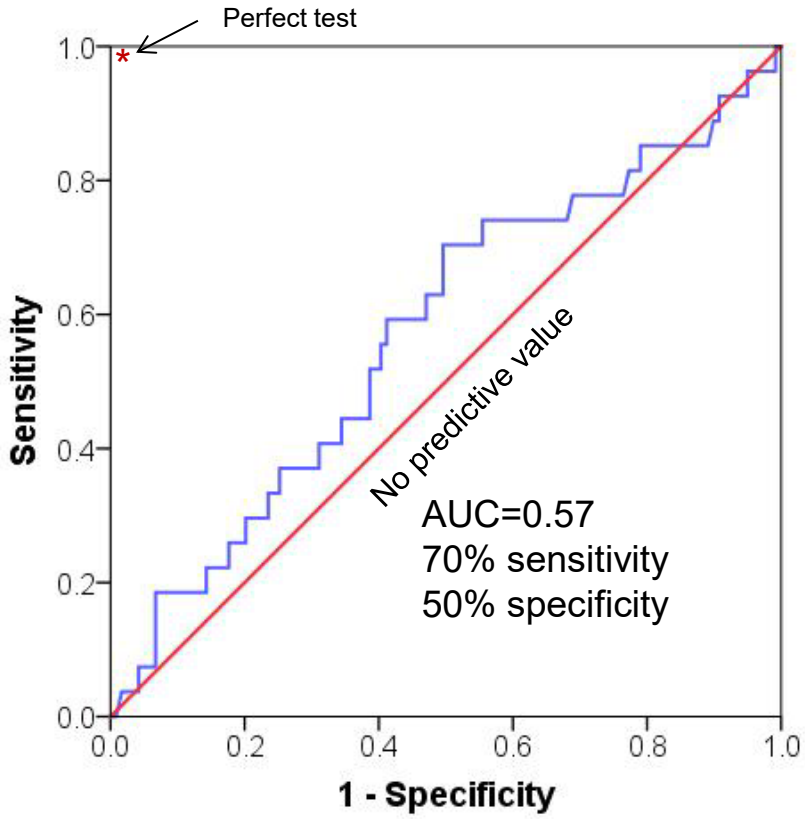


1. Wood et al (2016)

Results: visual predictors of driving

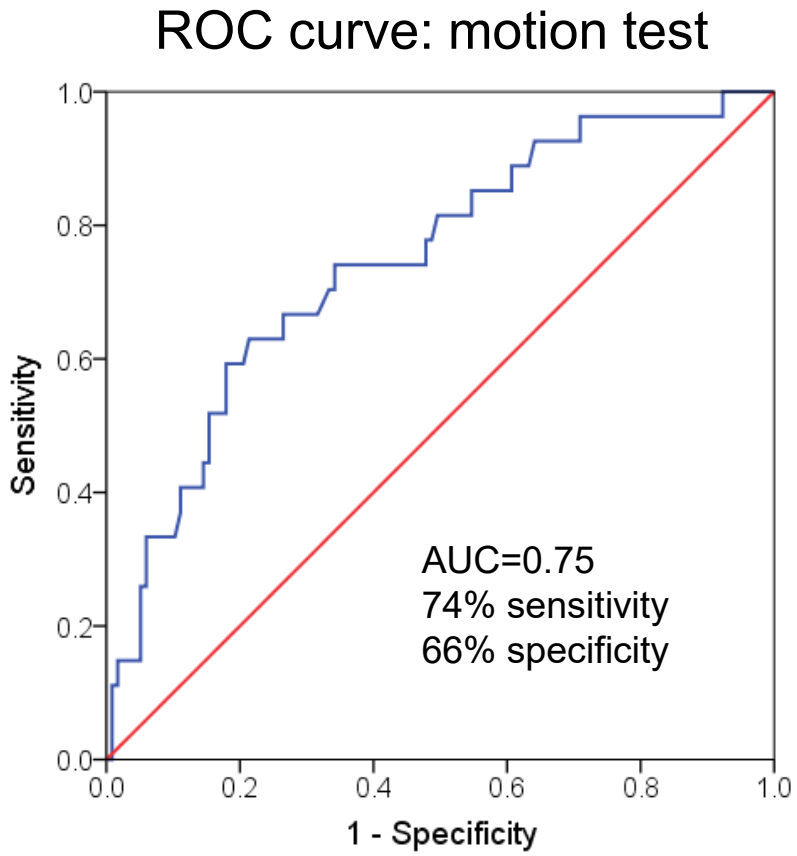
- None of the standard visual field measures were strongly associated with driving performance or safety ratings
  - Worse eye MD best of the visual field measures (including Esterman test)

ROC curve: worse eye MD



Results: visual predictors of driving

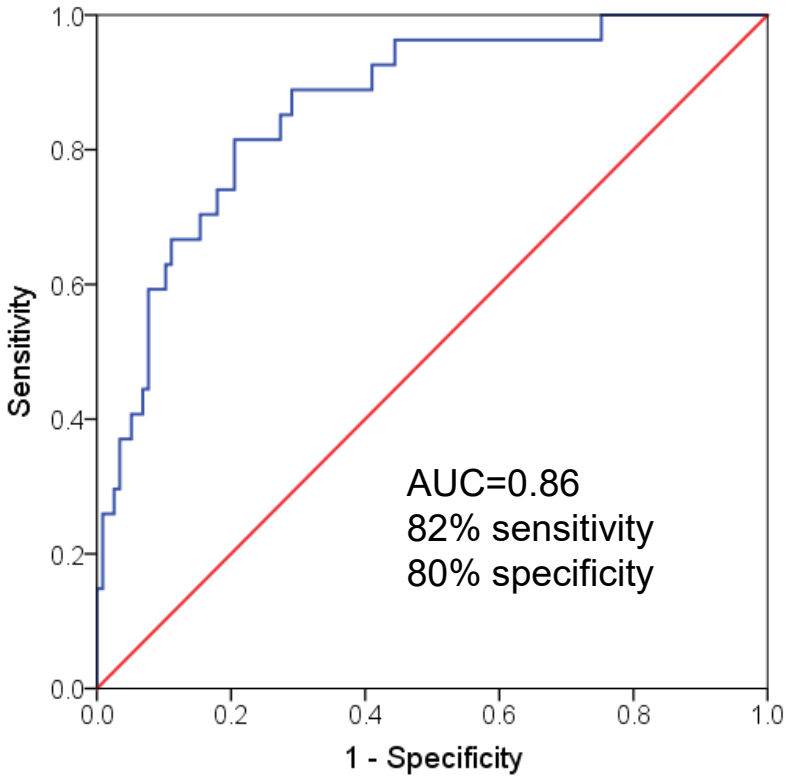
- None of the standard visual field measures were strongly associated with driving performance or safety ratings
  - Worse eye MD best of the visual field measures
- BUT motion sensitivity was significantly associated with a range of driving performance measures



Results: visual predictors of driving

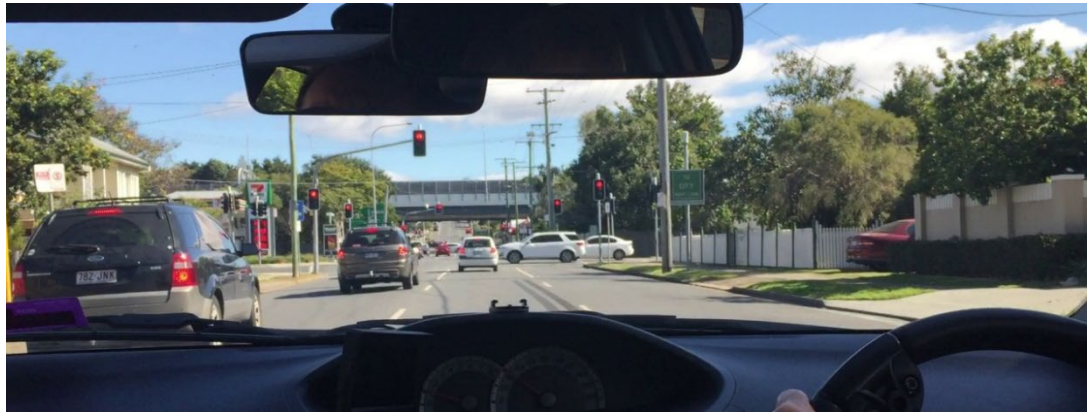
- None of the standard visual field measures were strongly associated with driving performance or safety ratings
  - Worse eye MD best of the visual field measures
- BUT motion sensitivity was significantly associated with a range of driving performance measures
  - High sensitivity and specificity when combined with measures of cognitive and motor performance and driving exposure

ROC curve: motion test combined with cognitive and motor measures



Summary: glaucoma and driving

- Small but significant differences in driving safety between groups[1]
  - Drivers with mild to moderate glaucoma were rated as less safe than controls
  - Errors included lane-positioning, approach and observation and were more common at give-way and traffic-light controlled intersections
  - Critical errors that involved an instructor intervention were higher - observation errors were the main problem



1. Wood et al (2016)

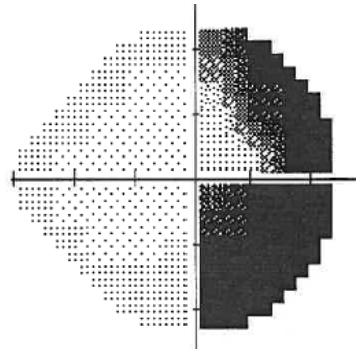
Summary: glaucoma and driving

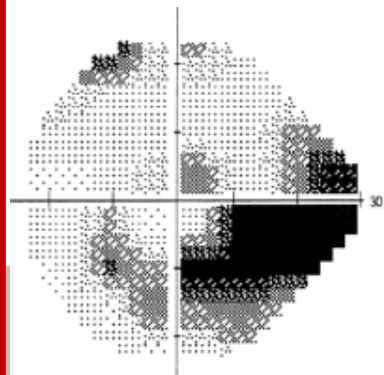
- Of the visual function tests assessed, motion sensitivity most strongly associated with driving performance[1]
  - Standard vision tests (including visual fields) poorly associated with driving ability and safety in drivers with mild to moderate glaucoma
- Some drivers may compensate for field loss through eye movements, which may explain lack of predictive ability of visual fields for driving[2-4]
  - Potential for training interventions to enhance scanning and search while driving
- Fitness to drive should be based on performance rather than age or disease status
  - Decisions must ensure fair outcomes for all drivers including those with glaucoma

1. Wood et al (2016); 2. Wood et al (2010); 3. Kasneci et al (2015); 4. Lee et al (2018)

What advice should we give to patients?

- Discuss whether vision meets the requirements for driver licensing
  - Depends on licence type
    - Private/commercial
    - Unconditional/conditional
- ALWAYS maintain good records of advice
- Even if visual standards are met, doesn't guarantee good vision for driving!!!!





Summary

- Criteria are complex
  - Careful consultation of the current guidelines essential, particularly given changes that occur between editions
- For patients with demonstrated field loss, the Esterman is the essential criteria
  - Consider repeat testing to confirm presence/absence of defects
  - Understand that total horizontal extent is from seen points to seen points (can be shifted laterally)
  - Be careful of rim defects that can add to existing defects
- Implications of recommendations
  - Balance between road safety and impact of loss of driving privileges on mobility and independence

Visual fields and driving

Thank you for your attention

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