


**THE SCHEPENS  
EYE RESEARCH INSTITUTE**  
 An Affiliate of Harvard Medical School
 

**Driving with Impaired Vision:  
who can drive, where, and why?**

***Eli Peli***  
 Professor of Ophthalmology  
 Moakley Scholar in Aging Eye Research

 Supported in part by NIH grant # EY12890

**Driving with Low-Vision?**

Boston Globe 4/25/99

**World Briefs**

**Argentina**  
**Blind man arrested behind the wheel**

BUENOS AIRES - Argentine police arrested a blind man driving a pickup truck with the help of his 13-year-old daughter and charged him with dangerous conduct, a police spokesman said yesterday. "The blind man was driving fairly well, although he made some pretty abrupt maneuvers which attracted the attention of a patrol car," the spokesman told the official Telam news agency in the southern Argentine city of Trelew. "The officers were amazed to discover that the man's daughter was sitting in a grade. She was turning the steering wheel while he changed gears, accelerated and braked according to her instructions," the spokesman said. (Reuters)

**Driving is Critical for Independence**

- Particularly in the USA
  - Minimal public transportation
  - Critical issue for the elderly

**Elder Transportation in Solution?**



**Impact of Losing the License**

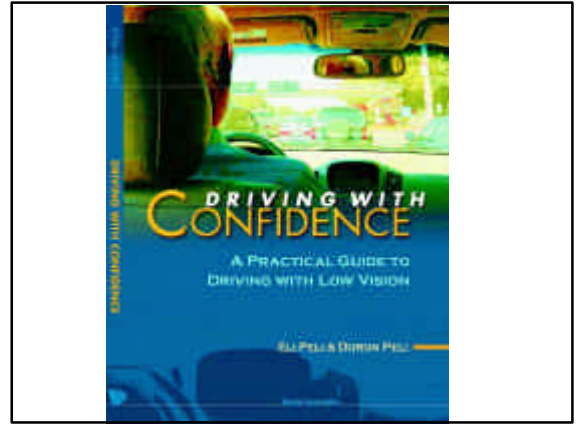
- Driving is an important skill in society
  - Right of passage for teenagers
- Consequences for self-esteem, financial security, quality-of-life
  - Dependence on others to travel to work or social activities and shopping
  - Need to live near public transport
- Do not want to withhold the privilege needlessly

**Driving with Low Vision**

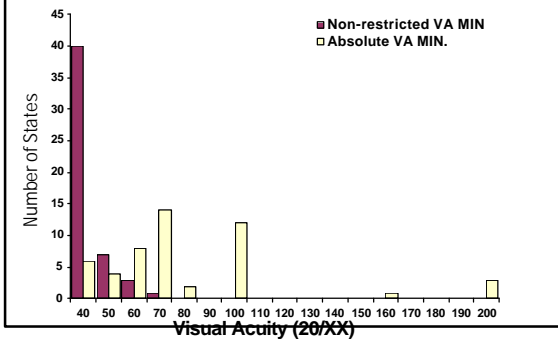
- **Driving is critical for independence**
  - Particularly in the USA
    - Minimal public transportation
    - Critical issue for the elderly
- **Who can drive and where?**
- **Regulations are very uneven across states**
  - What are these based on?

## Data Collection-Regulations

- Questionnaire to all 51 jurisdictions
  - Responses received from all
    - Many included detailed regulations
- Results tabulated in uniform format (almost)
- Tables were sent back for confirmation
  - Responses received from 45 states
- Published as appendix in a book



## VA Requirements



## Is VA an Appropriate Test?

- VA is only weakly correlated with accident record (Burg 1967) and many others
- Some would like to dispute these findings:
  - **It has to be related!!!**
  - Correlation is low because no low vision drivers
    - Many drive until removed, and many states don't retests
  - Accidents are rare, multi-factorial, discreet events
    - So?

## Is High Acuity Needed for Driving?

- To read road signs
- Distinguish traffic lights
- Few other occasional tasks
- Can be achieved with bioptic telescopes



## Importance of Reading Road Signs?



Malaysian Sign

## Importance of Reading Road Signs?



Israeli Signs

## Bioptic Telescopes



## Using Bioptic Telescope



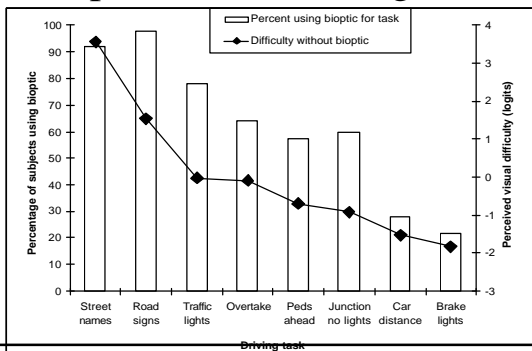
## Data Collection-Bioptic Drivers

- Driving Habits Questionnaire (DHQ)<sup>1</sup>
- Driving with Bioptic questionnaire
  - Telephone interview (~1 Hour)
- 58 bioptic drivers from 12 states

	Median	Range
Age (yrs)	47	17 - 86
Bioptic driving (yrs)	8	0.25 - 32
Impairment Duration (yrs)	34	2 - 81
VA without bioptic	20/100	20/50 - 20/240

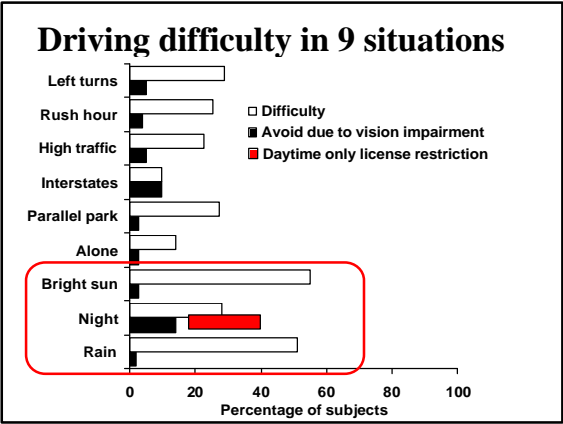
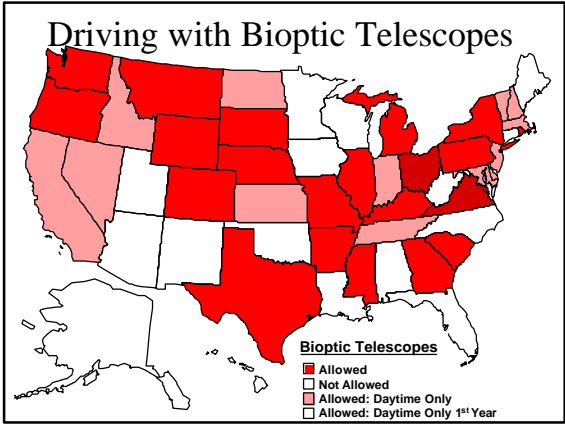
<sup>1</sup> Owsley et al (1999) J. Gerontol A Biol Sci Med Sci; 54:M203-211

## Bioptic use for driving tasks



## 95% of the Time Bioptic Drivers Use Unaided Vision

- Steering the car in the lane
- Keeping distance from lead car
- Detecting pedestrians stepping off sidewalk
- Note other cars approaching the intersection
- Watching for lead car brakes light
- Check rear view mirrors before lane change
- Etc.



### Bioptic Driving

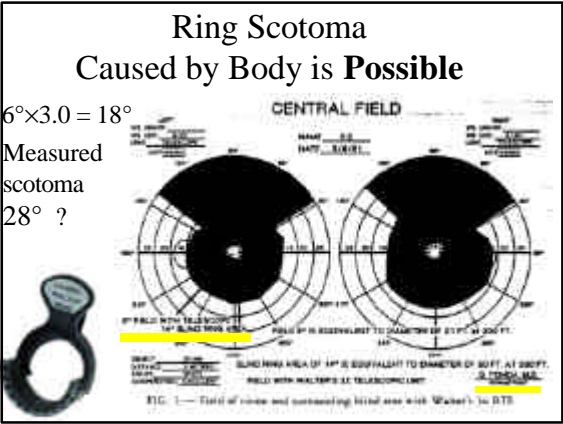
<h4>Requirements</h4> <ul style="list-style-type: none"> <li>• Special training – 12 states – (Michigan recommends)</li> <li>• Road test – 18 states</li> <li>• Annual vision screening</li> <li>• Mirrors (?)</li> </ul>	<h4>Restrictions</h4> <ul style="list-style-type: none"> <li>• Day light driving only</li> <li>• Radius from home</li> <li>• No highway driving</li> <li>• Speed limitation</li> </ul>
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### Main Objection to Bioptic Driving

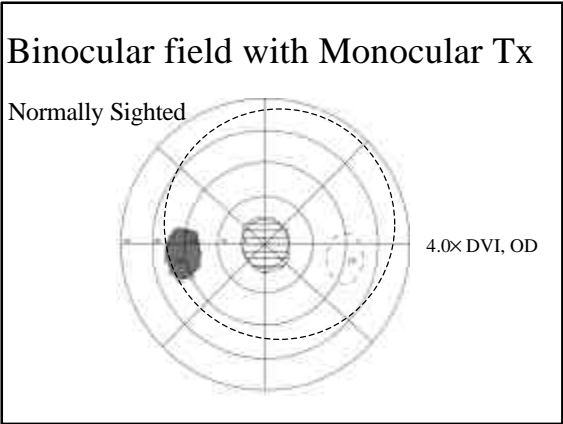
- **Ring scotoma**
- Effect of magnification not of mechanics (body)
- Note, shift of physiological scotoma and asymmetric ring scotoma





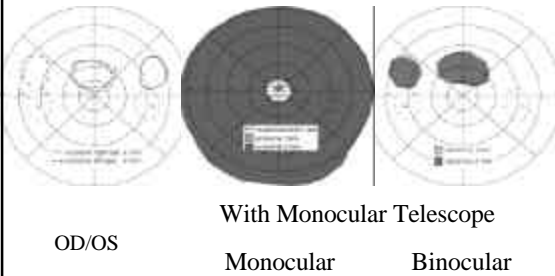
Binocular fields with monocular Tx

- “Drivers with a bioptic telescope before only one eye have no significant loss of functional visual field.” (Feinbloom, 1977)
- “Simple confrontation experiment, however, verify that objects obscured by BTS ring scotoma can be perceived within the field of the naked eye while the BTS- fitted eye fixates.” (Lippmann, et al, 1988)
- “When tested on a Goldman Perimeter with both eyes open a scotoma of any kind can not be plotted.” (Jose & Ousley, 1984)



## Impact of central field loss

Subject RP (JMD, right: 20/175, left: 20/225)



## Is Driving with Bioptics Safe?

Comparing accident rates and traffic violations rates

- 1.2× more accidents
  - California, (Janke, 1983)
- 1.34× more accidents
  - Texas (Lippmann et al 1988)
- 1.2× more accidents (16 yrs old 22 ×)
  - Illinois (Taylor 1990)
- 2.2× more accidents
  - Californian 1996 (Clarke)

## Is Driving with Bioptics Safe?

- General findings
  - Higher accident rate (slightly)
  - Lower citation rate for violations
  - Other groups have higher accidents rate
    - Physical Handicap
    - Mentally impaired
    - Young drivers (59% first license with bioptic)
- Half of Americans are below average on almost any measure.

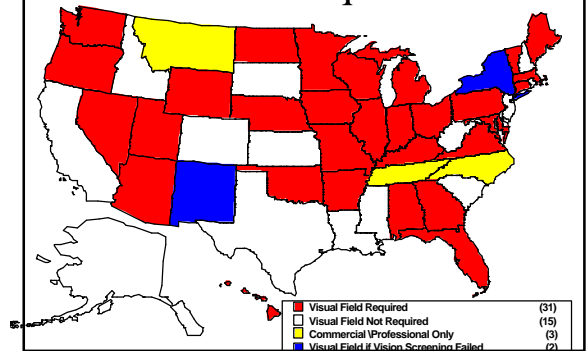
## Peripheral Visual Fields Loss

- Most commonly from RP or Glaucoma
- Gradual concentric loss
- May be modest at first and then becomes severe
- **Impact on driving of moderate field loss is unknown**

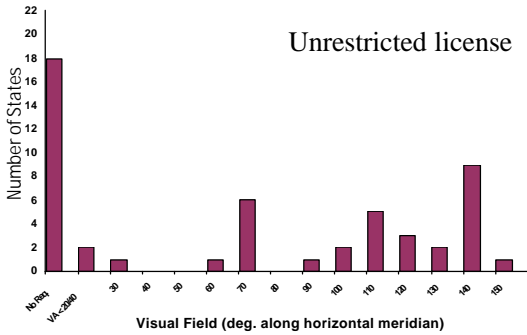
## Impact of Field Loss?



## Visual Field Requirements



## Visual Field Requirements



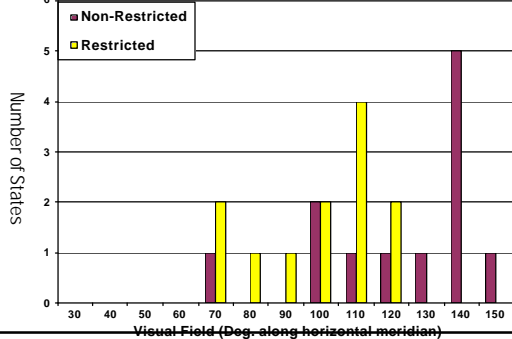
Driving performance of retinitis pigmentosa patients

British J. of Ophthalmology, 1981, **65**, 122-126

**Table 2:** Total horizontal meridian degrees for peripheral field in 42 patients with retinitis pigmentosa

Patient no.	Right eye	Left eye	Both eyes
1	30	15	45
2	15	10	25
19	15	35	50
39	105	50	155
41	70	70	140

## Restricted License Permitted with Restricted Fields



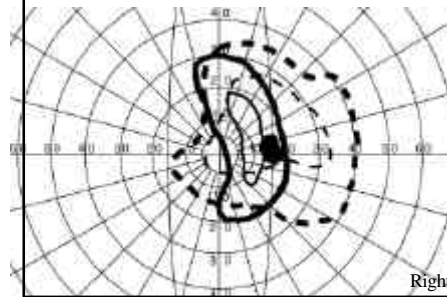
## License Restrictions with Visual Field Loss

- Left outside mirror
  - Washington, DC (District of Columbia)
- Both outside mirrors
  - Illinois, Iowa, Maine, Maryland, Nebraska

## Field Expansion Aids

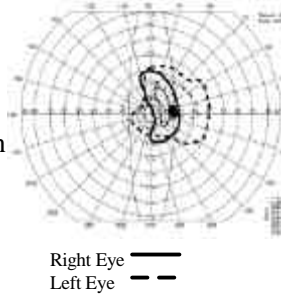
- None approved
- In some states explicitly prohibited!

## Case: Severe field loss following 3 brain surgeries



## Case: Severe field loss following 3 brain surgeries

- Lives in New Jersey
- Visual acuity 20/50
- Qualifies for driving in New Jersey and many other states
- **Not driving**

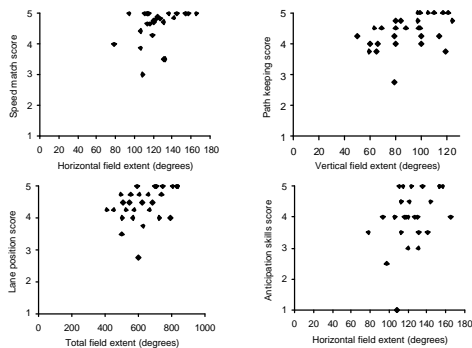


## Driving with Moderate Field Loss

LMS department of ophthalmology  
driving assessment clinic

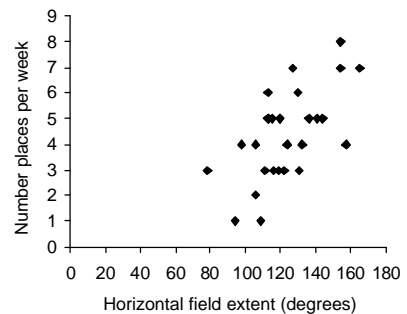
- 14 miles course in Birmingham AL
- 28 Current drivers, age 67 (33-84), 2 to 348 mi/week
- Horizontal binocular field 120° (78 - 165°),
  - Glaucoma
- Smaller fields associated with poorer performance
- Horizontal field associated more than vertical field
- Reduced vertical field associated with poorer performance when taking a curve
  - Lane positioning and in keeping on a path

## Results



Relationship between horizontal field extent and driving performance

## Patients Obviously Know their Limitation



## Driving with One Eye



- Slightly restricted field on one side
- Fairly common: 1/500 monocular
- Driving permitted in all states
- In many countries 6 months adaptation

## Monocular Truck Drivers Study

- 40 monocular and 40 binocular tractor-trailer drivers
  - Visual fields 145° vs 173°
- Monocular deficient on some visual functions
  - CS, VA in low light and glare, stereo
- Not deficient on others
  - Static VA, dynamic VA, glare recovery
- Not deficient on driving skills
  - Search, lane keeping, clearance and gap judgment, hazard detection, and information recognition
- Deficient only on sign reading distance

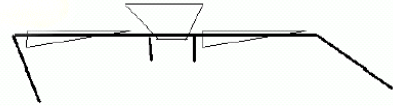
**Not worse in safety of most driving functions**

– McNight et al 1991. Accid Anal & Prev. 23: 225-237

## Visual Aid for Driving with One Eye



## CROS-VISION Glasses for Monocular Patients



“Installed with the prism bases toward the user’s blind side for 3 to 7 degrees expanded central vision”

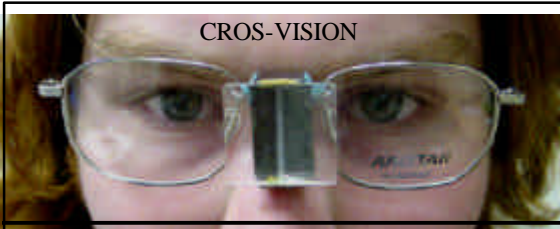
**NIRE**

National Institute of Rehabilitation Engineering

Butler, NJ. Operated 1967 - 1997

“Do not use Fresnel prisms”

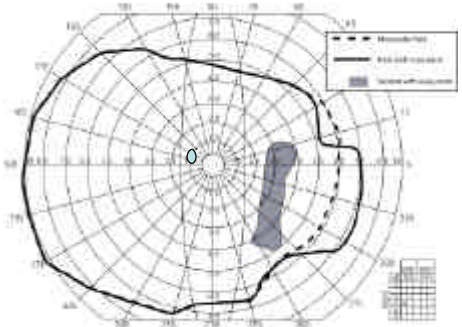
CROS-VISION



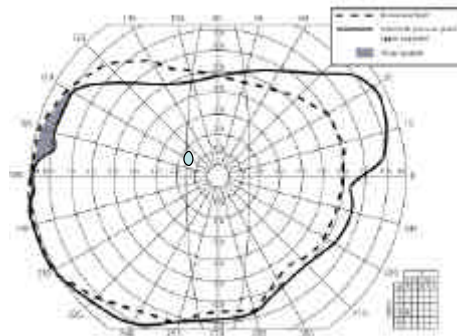
Fresnel Prisms



## Left Monocular with NIRE Nose Prism



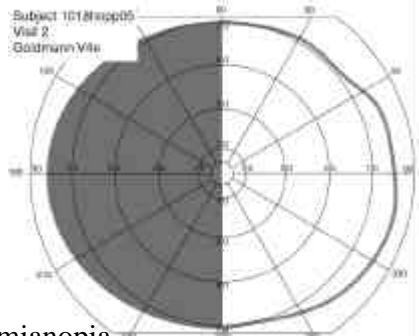
## Left Monocular with Fresnel Prism



## Driving with Hemianopia

- Hemianopia - loss of half the visual field on one side in both eyes
  - Result of brain injury
    - Stroke, trauma, surgery
- Visual field usually 90 degrees or less
  - Fail to qualify in 22 states (Utah – special evaluation)
- **Impact of hemianopia on driving not clear**
  - With or without prism

## Binocular Visual Fields



Left Hemianopia

## Driver with L. Hemianopia Hits Pedestrian at a Left Turn

### Woman Struck By Motor Vehicle Severely Injured Driver Suffered Vision Problem, Possibly Due To Earlier Stroke

#### \$1.6 Million Settlement

On 11/14 on or about 6/2002, the defendant drove the plaintiff's vehicle on the road and struck the plaintiff's child. The child was severely injured and the plaintiff's child was hospitalized in the hospital for several weeks. The plaintiff has filed a lawsuit against the defendant for the amount of \$1,600,000. The plaintiff has filed a lawsuit for the amount of \$1,600,000.



Massachusetts Lawyers Weekly 8/9/04.

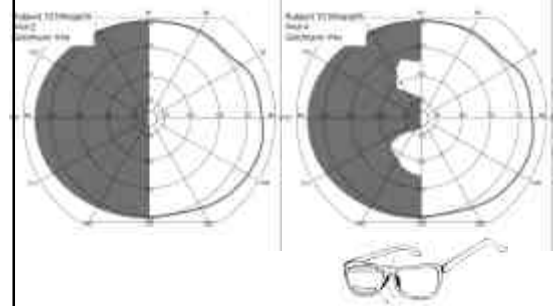
\$1.6M settlement

## Peripheral Prism for Hemianopia



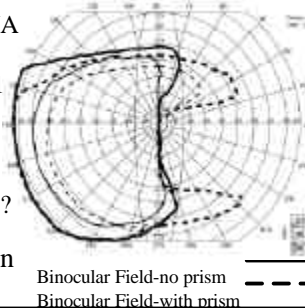
Expands visual field by 20 deg  
Does it help in driving?

## Peripheral Prisms - visual fields




## Case: Hemianopia at childhood Surgery for seizures at age 13

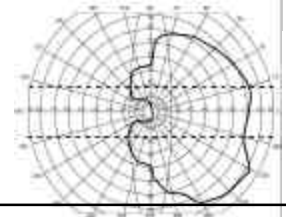
- Met qualification in MA with prism only
- Awarded License 2001
  - A case in Montreal
  - A case in Israel
  - 2 cases in Arizona
- Should they be driving?
- Should it be based on that field?



 B  
**With  
Horizontal Prisms**



 B  
**With  
Oblique Prisms**



# Permanent Prism (Oblique)

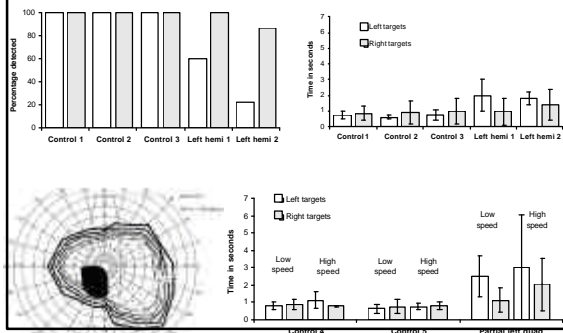


Improved Cosmetics

Driving Simulator at the Boston VA Center for Innovative Vision Rehab.



## Pilot Results



## On-Road Studies

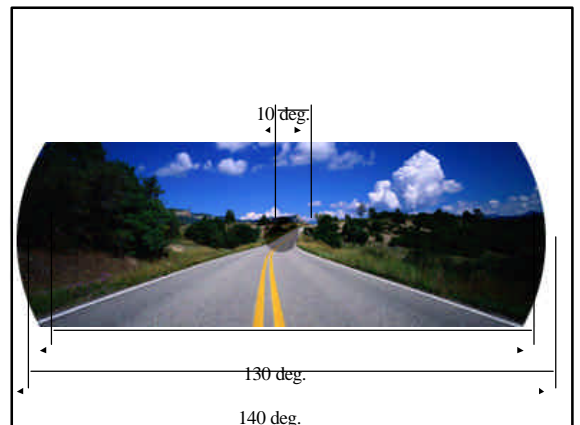
- Driving with hemianopic prisms
  - Groningen, Holland
    - Horizontal Prism- Completed
  - Gent, Belgium
    - Oblique Prism- Starting
  - Birmingham, Alabama
    - Binocular, include training- Planning

## Cross Requirements

- Some states require:
  - Larger visual fields for drivers with reduced VA
  - Better VA for drivers with slightly restricted field

## Examples

- DC – If  $20/40 < VA < 20/70$ , a 140 deg field is required for a restricted license
  - Otherwise 130 deg.
- Maryland – If  $VA < 20/40$  in one eye, a 100 deg is sufficient for a restricted license
  - Unrestricted 140 deg.
- New York – If VA is worse than  $20/40$ , a visual field of 140 deg is required.
  - Otherwise no requirements



## Possible Explanation

- Computation of disability for insurance or social security frequently takes the form:
- **Disability =  $K \times (\text{fractional VA}) + C \times (\text{percent field})$**
- This suggests that one can compensate for the other

## Conclusions

- Wide variations in requirements reflect:
  - Severe lack of scientific basis
  - Improper application of medical-legal rules
  - Must be either unfair or unsafe
- Need studies of driving and visual aids
- We have embarked on such studies

# Thank You!

## Traffic Light Recognition with Color Deficiency

- 10% of men and 0.5% of women are color deficient
- Mostly red-green deficient
- Some difficulty with traffic light
- More impact on visually impaired
- Very Few states test non CDL

## Multiplexing Spectacles for Red-Green Color Deficiency

- When traffic-light is noted, slight head tilt brings it into the red-tinted zone
- Red light shines through
- Green light is blocked

