Schepens Eye Research Institute
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# Driving simulators in hemianopia rehabilitation research

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No disclosures

# Hemianopia

Loss of half the field on the same side in both eyes

Ranges from partial to complete loss

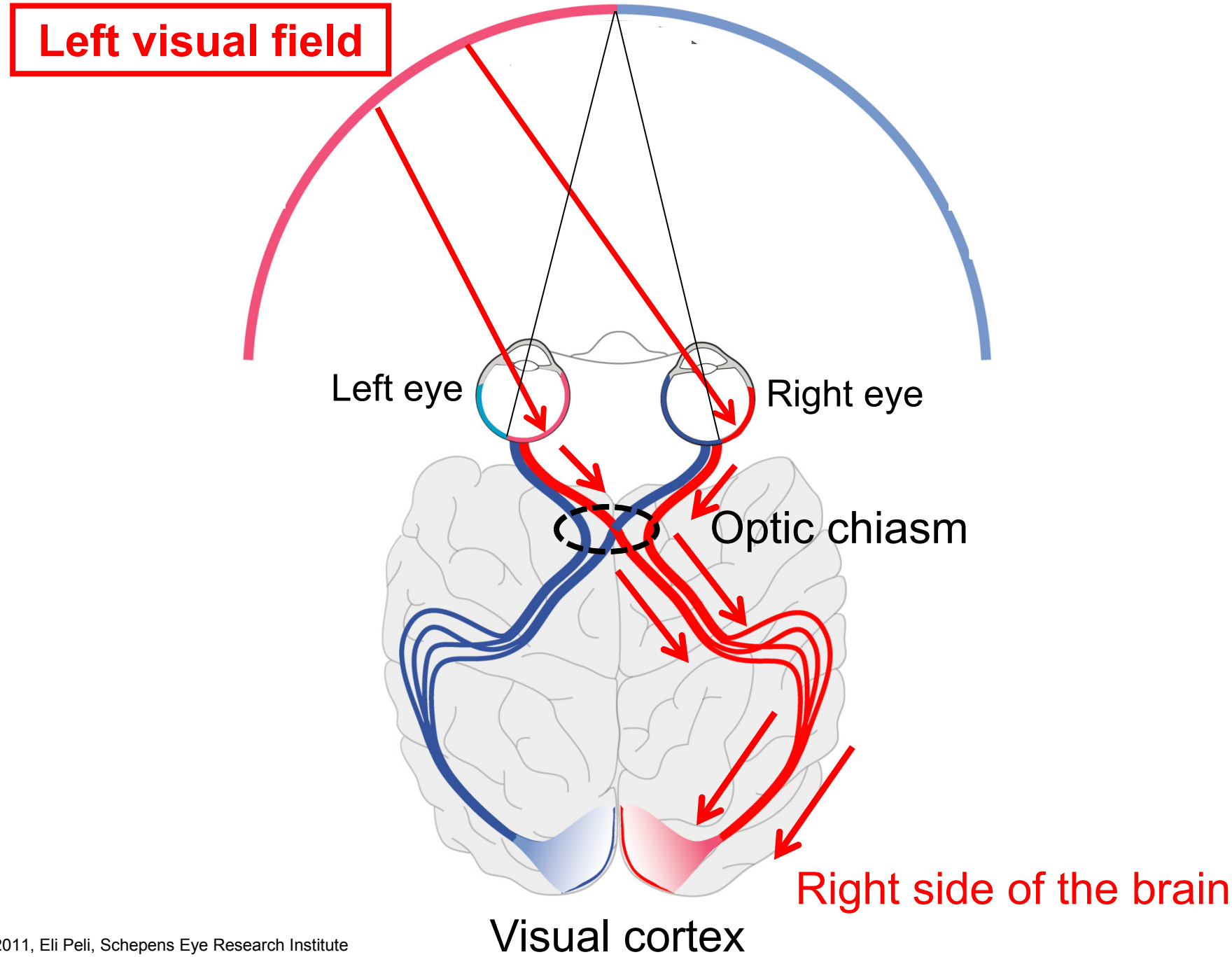
Simulation left hemianopia

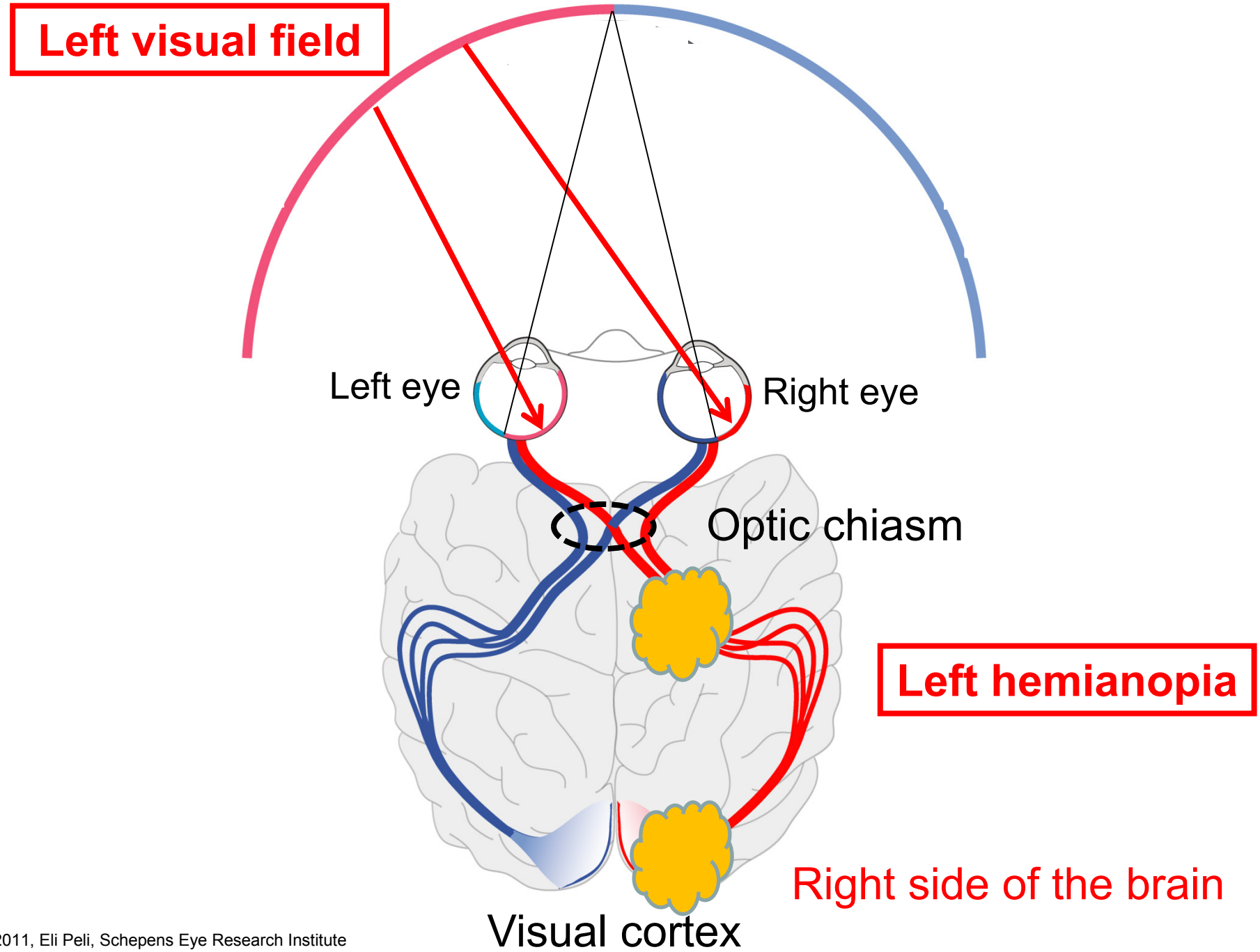

Normal vision

- Vision missing on <u>left</u> side (“blind” side)
- Vision is “normal” on the right side (“seeing” side)

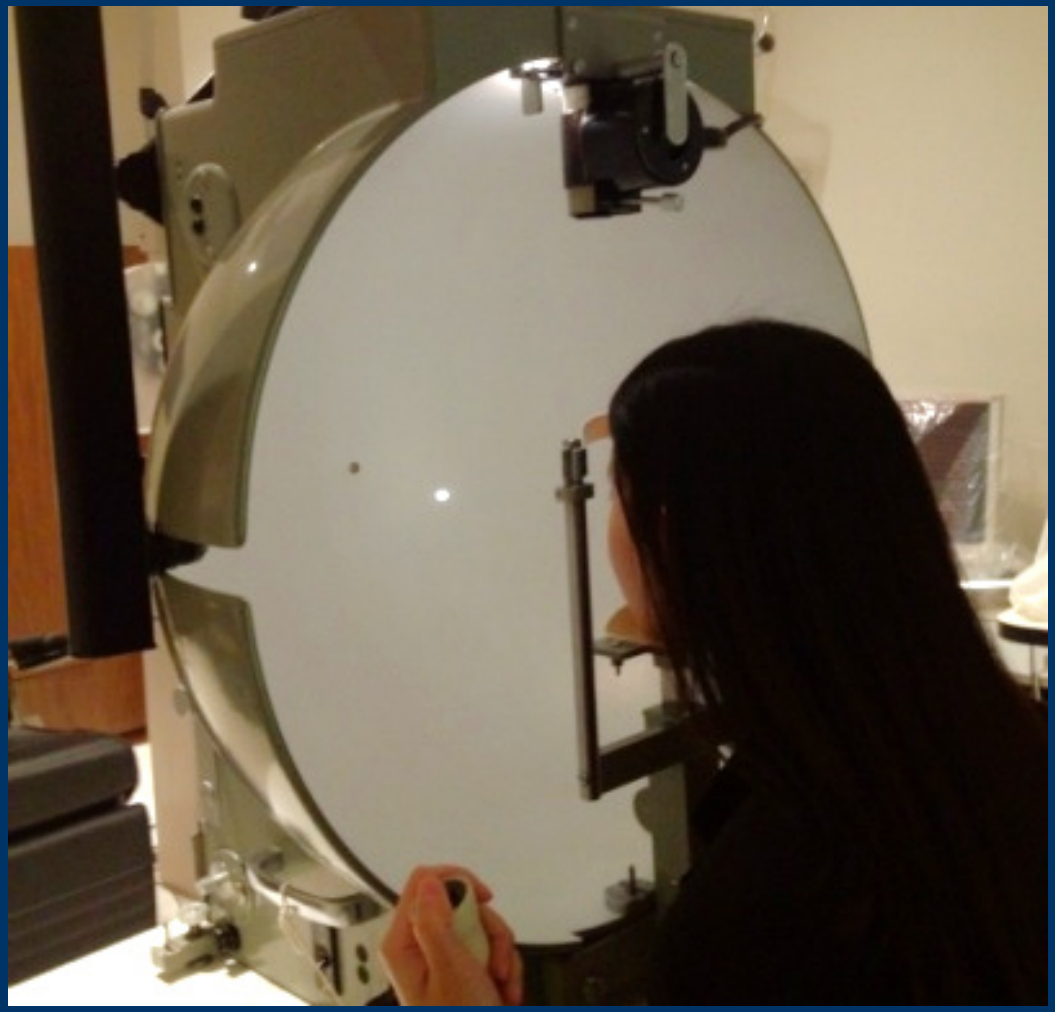
# Hemianopia

- Common after brain injury
- Stroke
  - About 80,000 veterans are stroke survivors
  - About 6 million stroke survivors in the USA in 2010
  - 30% to 50% of stroke survivors have visual field loss
- Traumatic brain injury (TBI)
  - About 30% of veterans with moderate-to-severe TBI have visual field loss





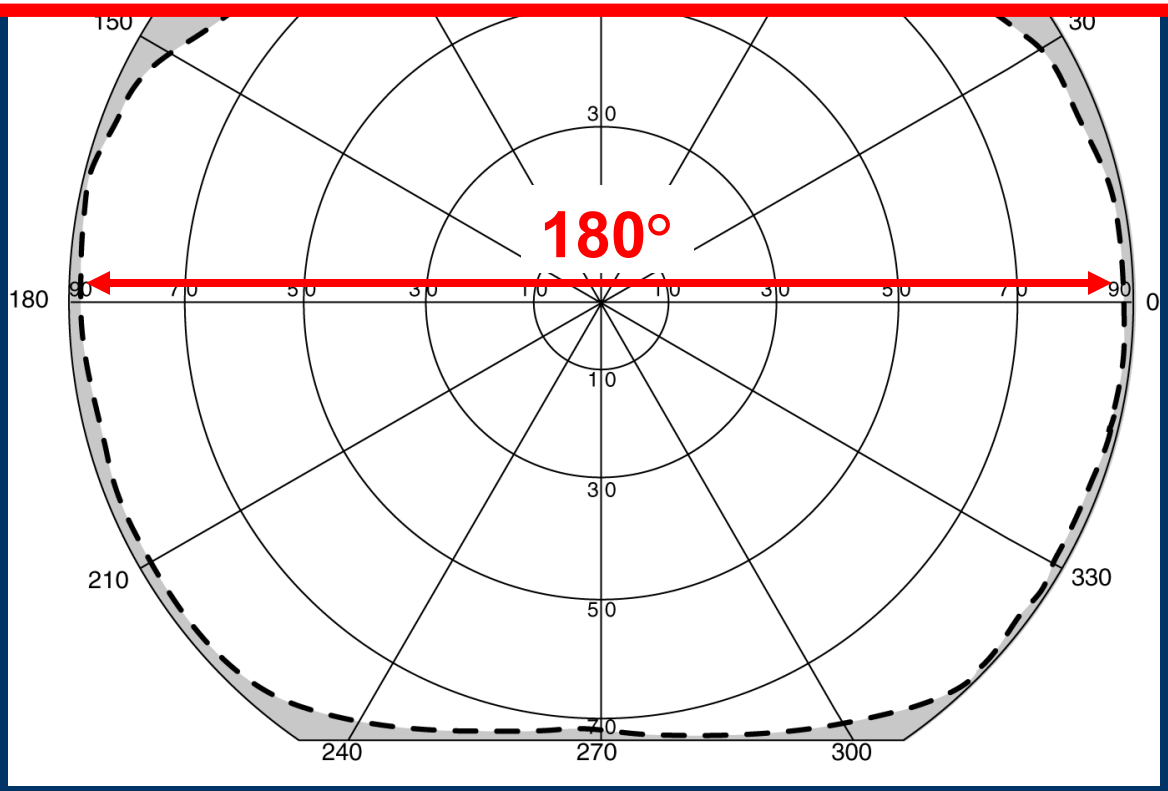
# Measuring visual fields in the clinic



Goldmann Perimeter

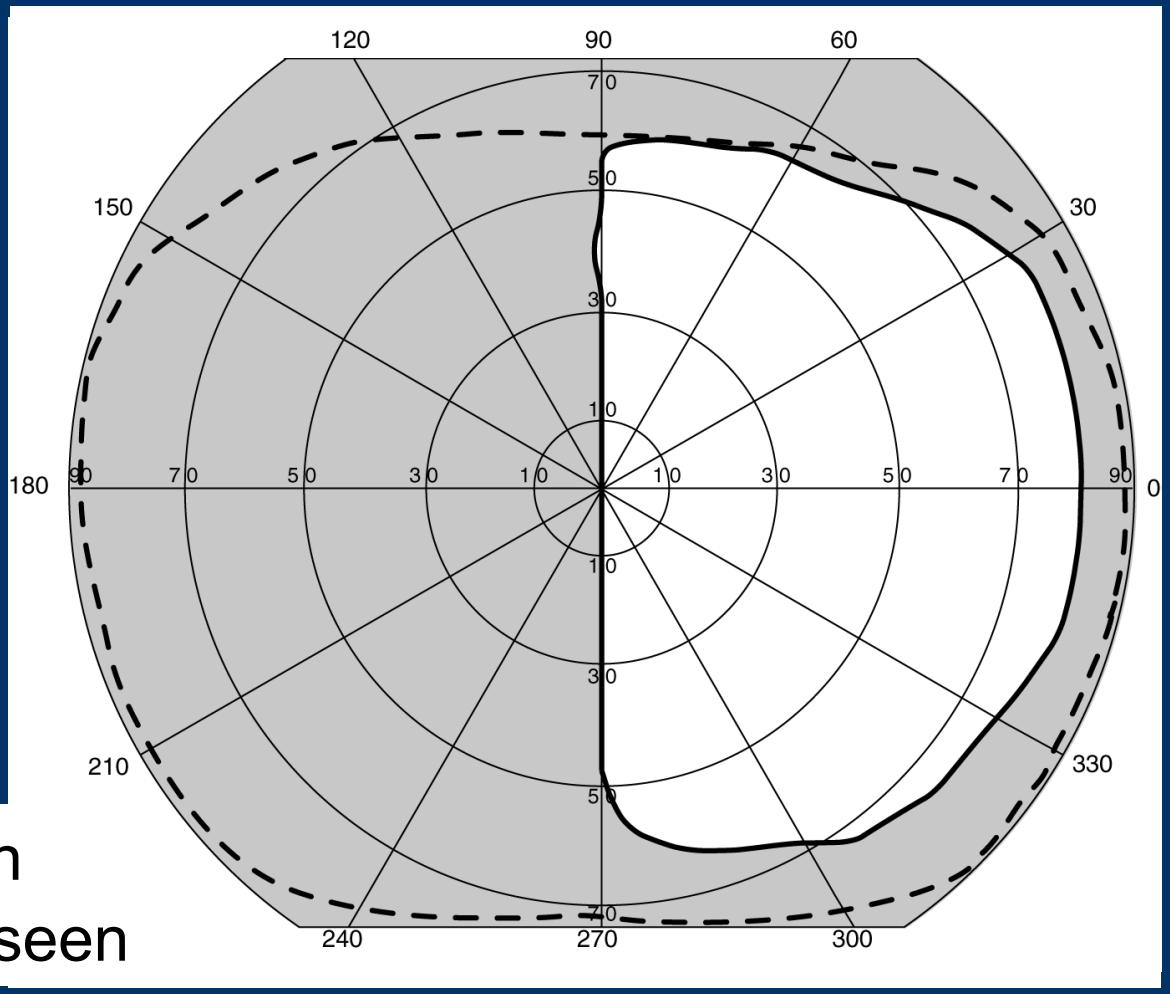
# Normal binocular visual field
## (Goldmann V4e)

**BINOCULAR VISUAL FIELD**
**Both eyes open**



# Patient with left hemianopia

## Maximum 90° field extent



# Hemianopia

- Difficulties detecting objects on blind side
- Bumping into obstacles when walking
- Failing to detect hazards when driving?

# Why driving?

- Important rehabilitation goal for many patients
- Cessation of driving:
  - Decreased quality of life and independence
  - Increased risk of depression and social isolation
- People with hemianopia are permitted to drive:
  - In about half of the states
  - In other countries following a specialized on-road test (Canada, UK, Netherlands, Belgium)

# Driving simulator

**Horizontal field of view 225°**

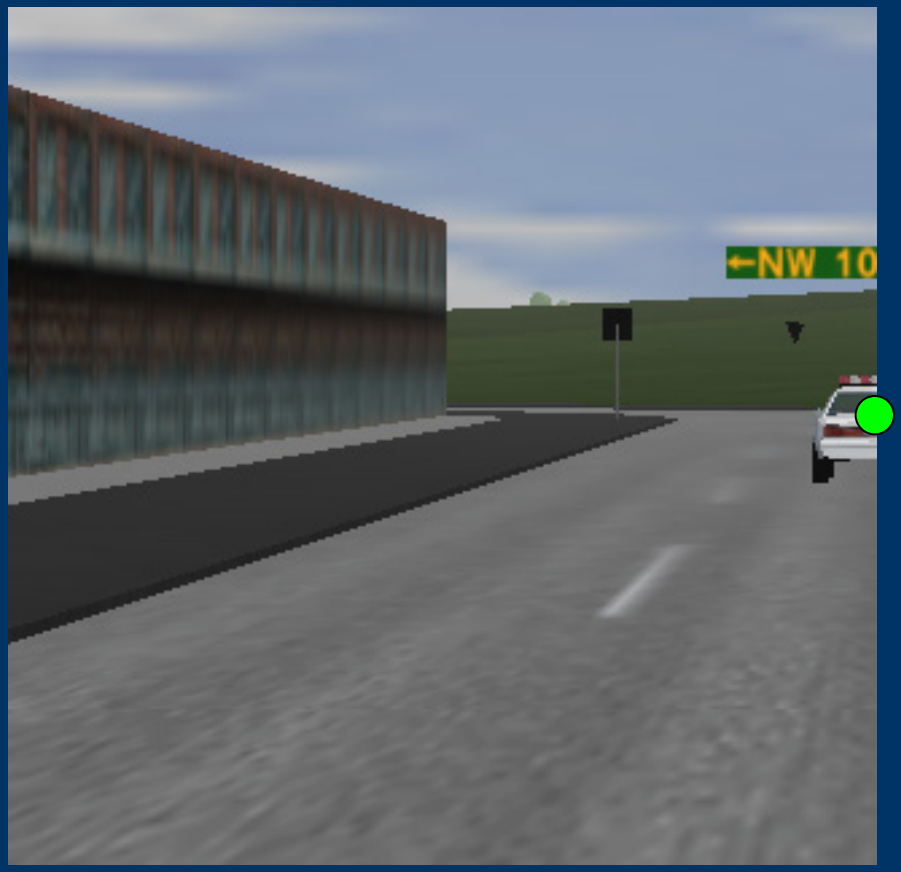
# Driving simulator

# View for a driver with normal vision


Central screen of driving simulator

# Simulation of right hemianopia

## Looking straight ahead




Central screen of driving simulator

# Simulation of right hemianopia

## Looking slightly to the right


Central screen of driving simulator

# Simulation of right hemianopia

## Looking further to the right


Central screen of driving simulator

- How well do people with hemianopia compensate by scanning when driving?
- Do they detect and respond to potential hazards in a timely fashion?

# Pedestrian detection task

- Press the horn button when a pedestrian is detected
- At least 104 pedestrian events in about 2 hours of driving

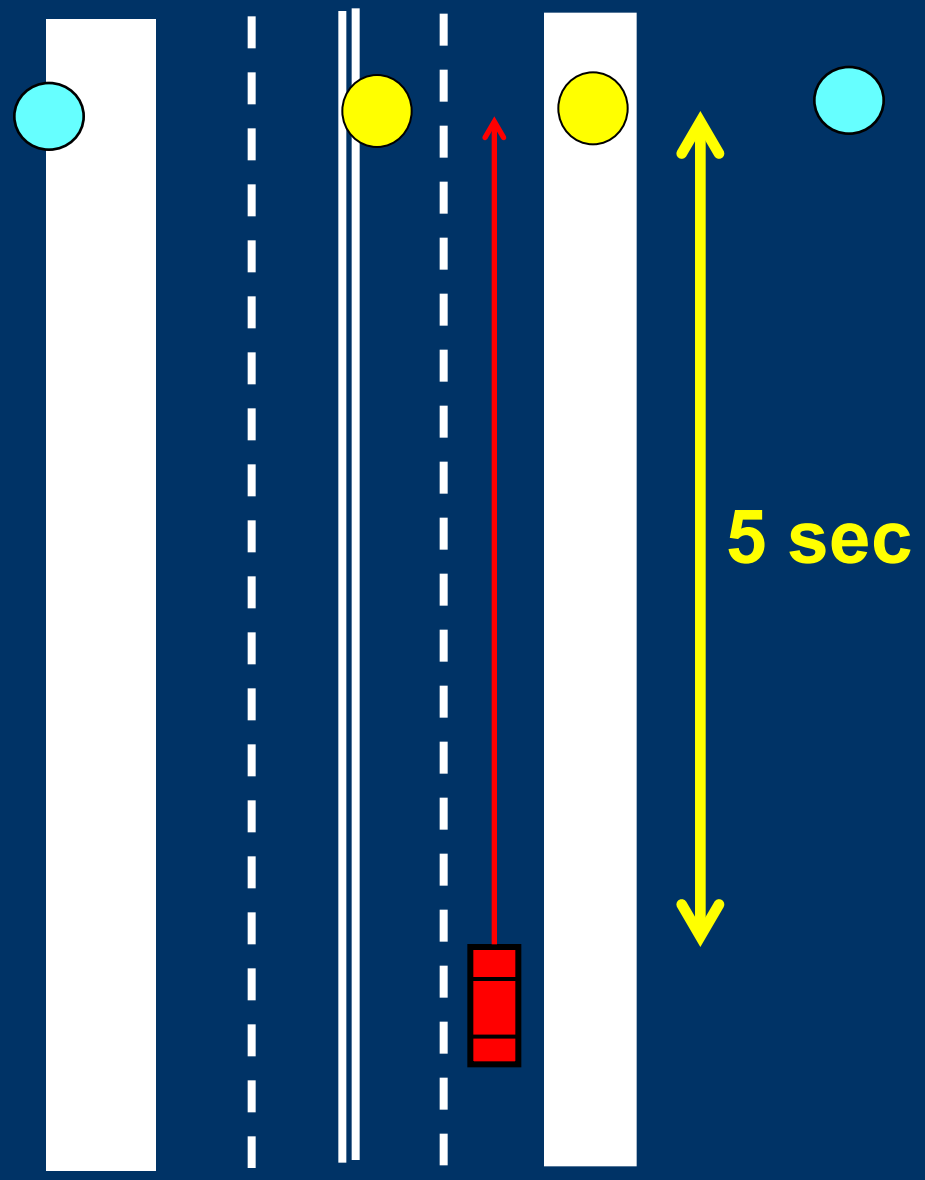
Bowers et al. (2009) Invest. Ophthalmol. Vis. Sci. 50; 5137-5147
Bronstad, Bowers, Albu, Goldstein and Peli (2013) JAMA Ophthalmol

# Pedestrian locations

Close to driving lane

Far from driving lane

**On blind side:**
Lower detection rates
for pedestrians
far from driving lane



# Pedestrian starts close to driving lane walks toward road

Video example

# Pedestrian starts further away runs toward road on a collision course

Video example

# Results

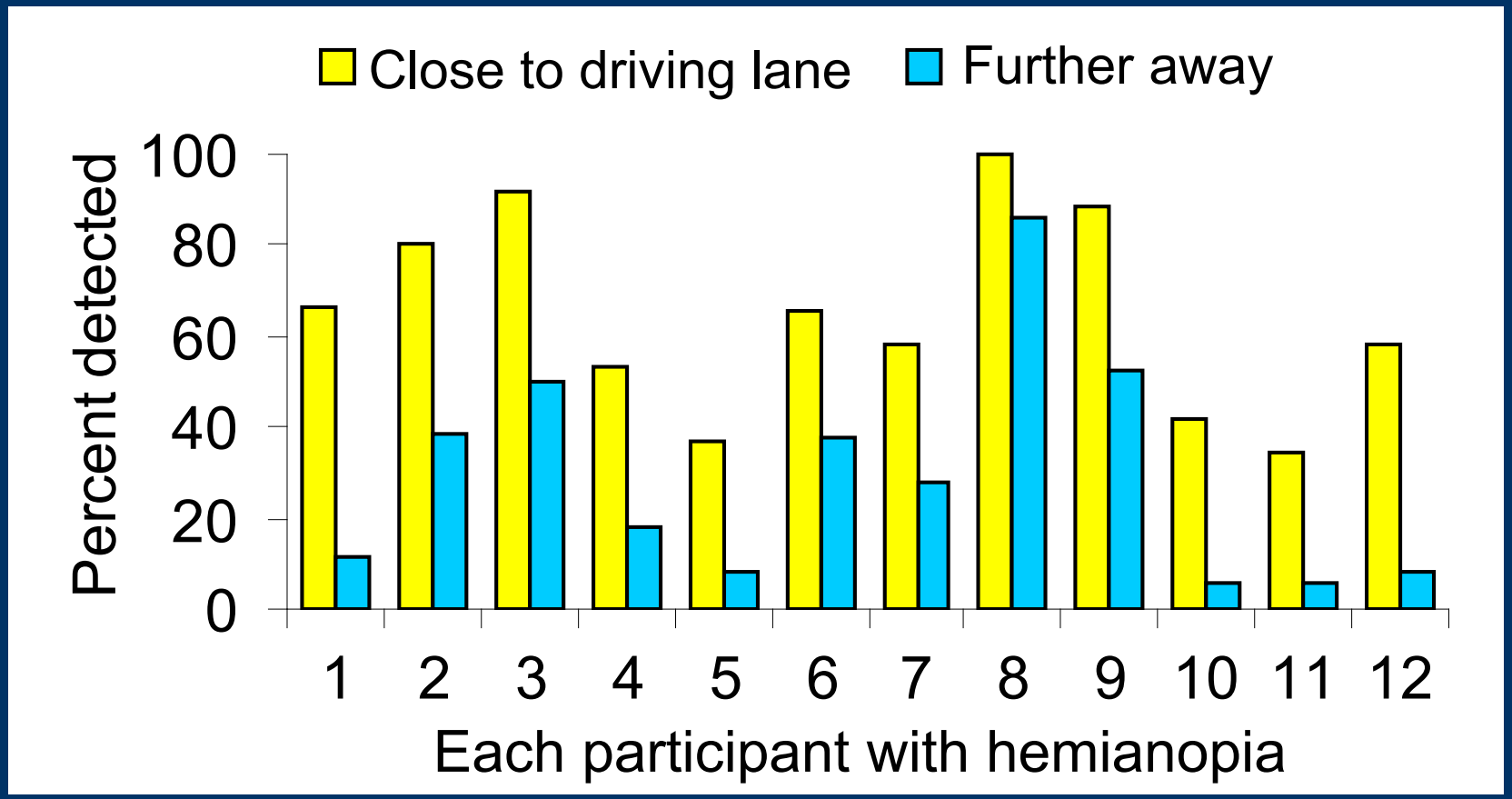
| | Detection rate | Mean reaction time |
|---|---|---|
| **Seeing side** | 100% | 0.8 s |
| | (As good as normally sighted) | |
| **Blind side** | <10% - 100% | 1.6 s |

12 subjects with hemianopia
12 age-similar controls with normal sight

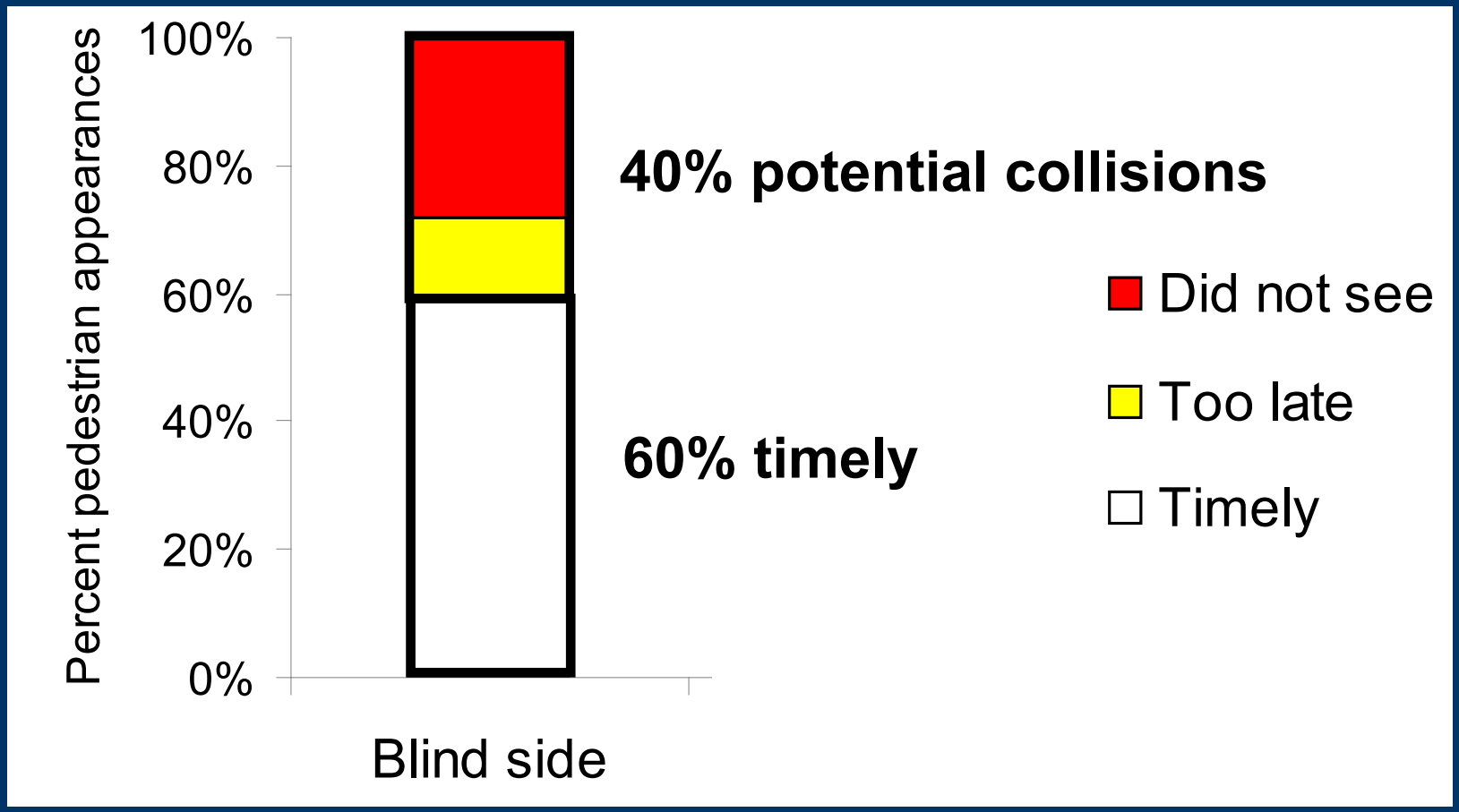
Bowers et al. (2009) Invest. Ophthalmol. Vis. Sci. 50; 5137-5147

# Detection rates on the blind side for each participant with hemianopia

Wide range in blind side detection
Yet all have exactly the same visual field loss



# Potential collisions
## (Data pooled across participants)



# Potential collisions
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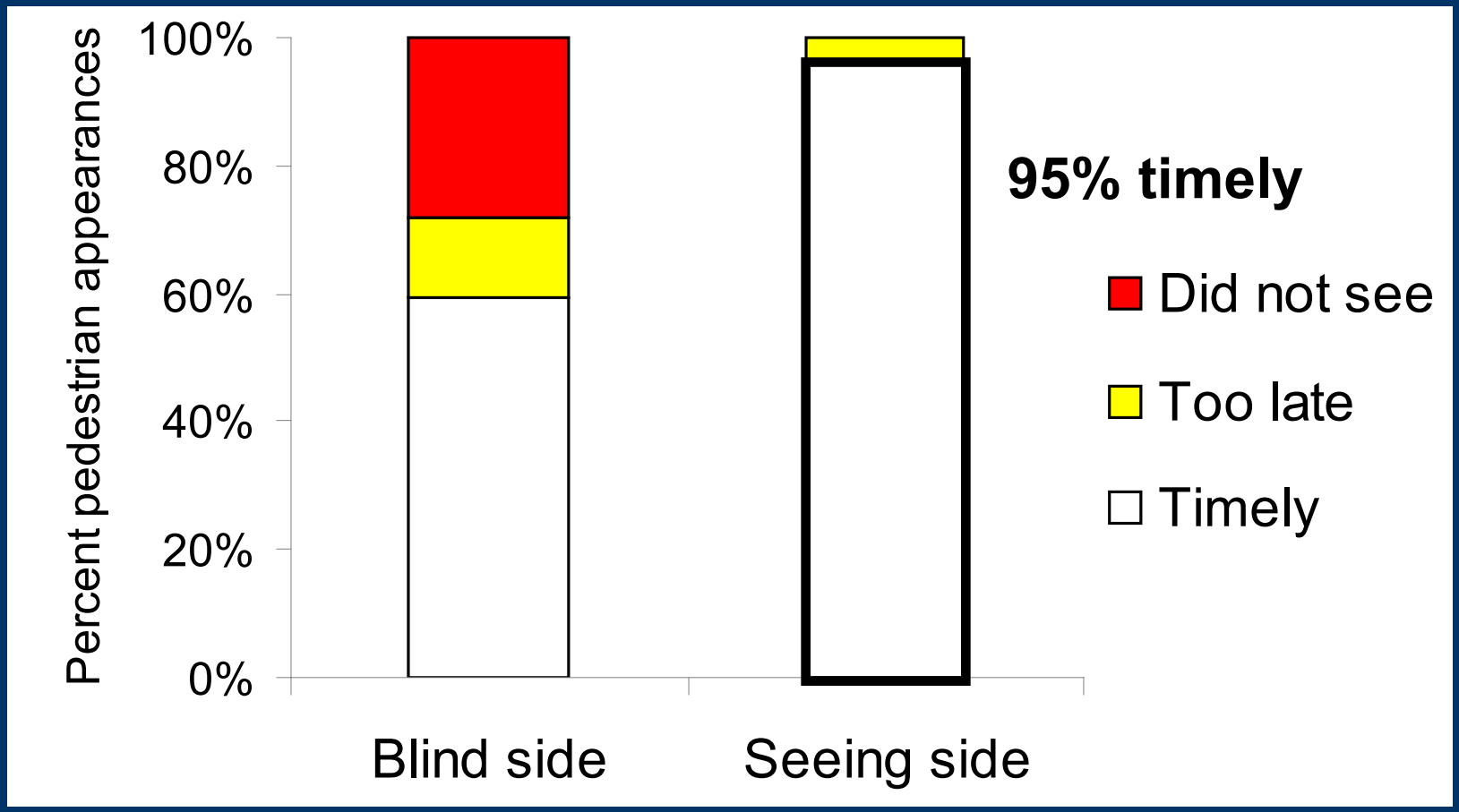
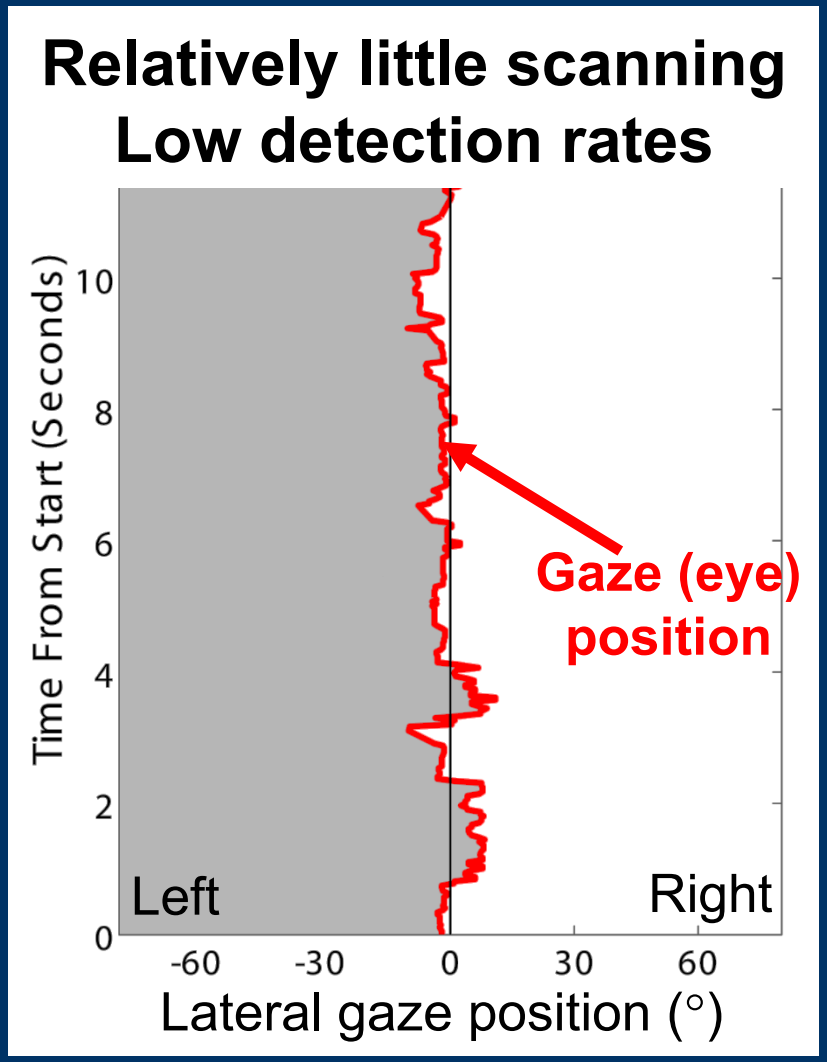


# Wide range in blind side detection rates

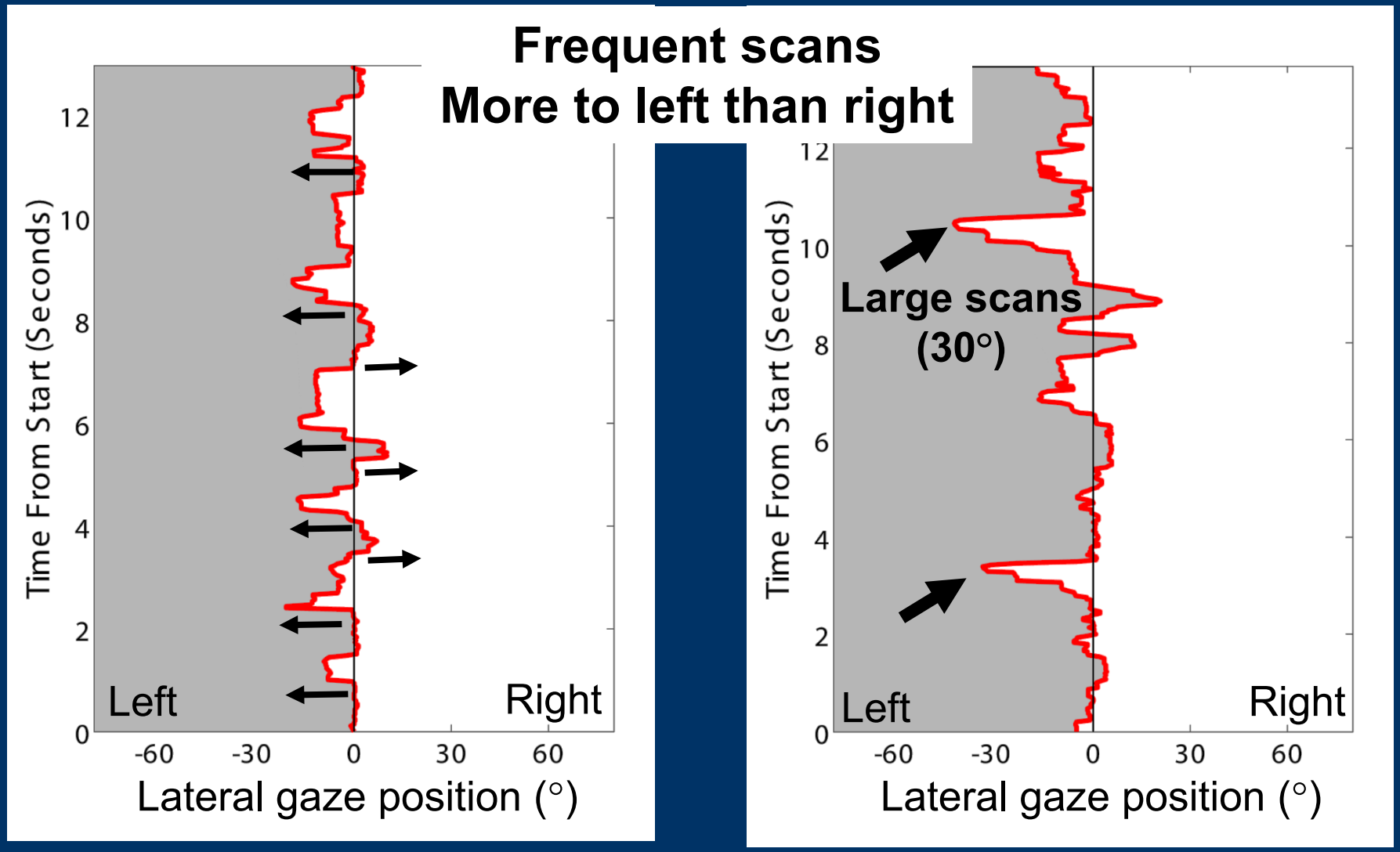
- Ranged from <10% to 100%
- Replicated in two more recent studies in our lab
  (Alberti, Peli & Bowers, 2014; Houston, Goldstein, Peli & Bowers, 2017)
- Similar findings in recent studies by other groups using other detection tasks in virtual environments
  (Iorizzo 2011; Papageorgiou 2012; Bahnemann 2014; Smith 2015)
- Similar findings in pilot on-road study
  (Bowers et al., 2012)

# Scanning and detection
# Left hemianope 1

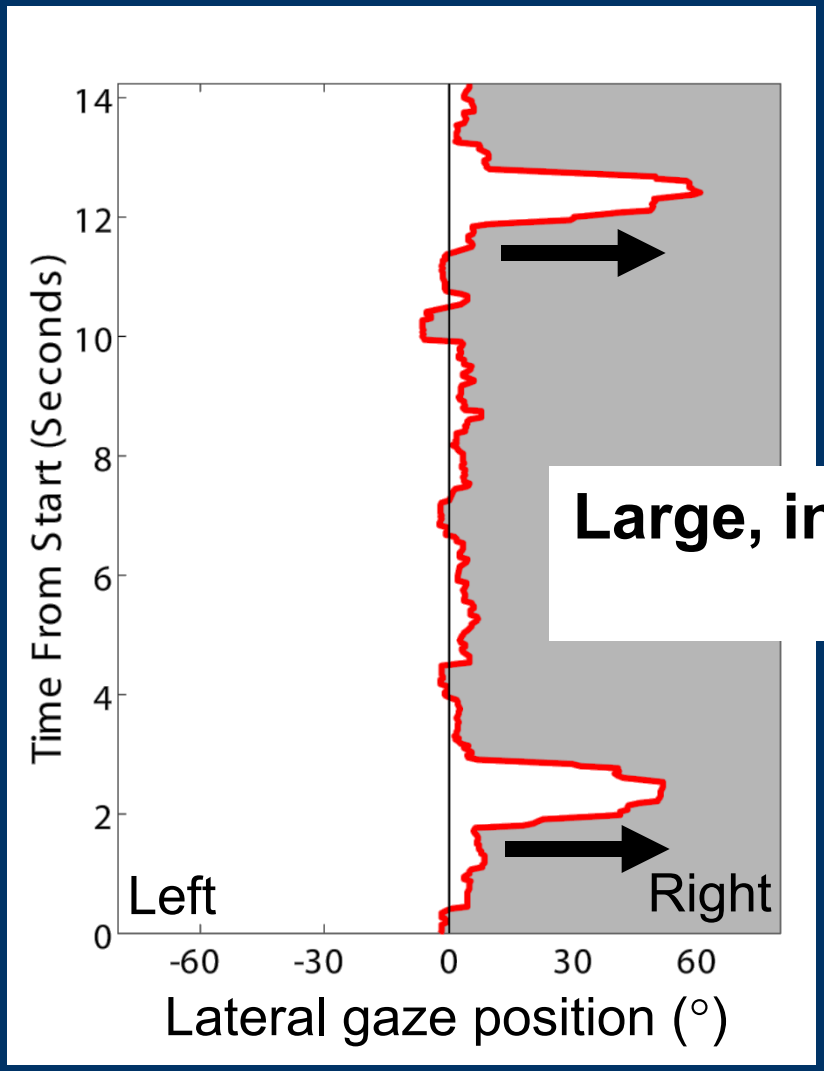


# Scanning and blind side detection

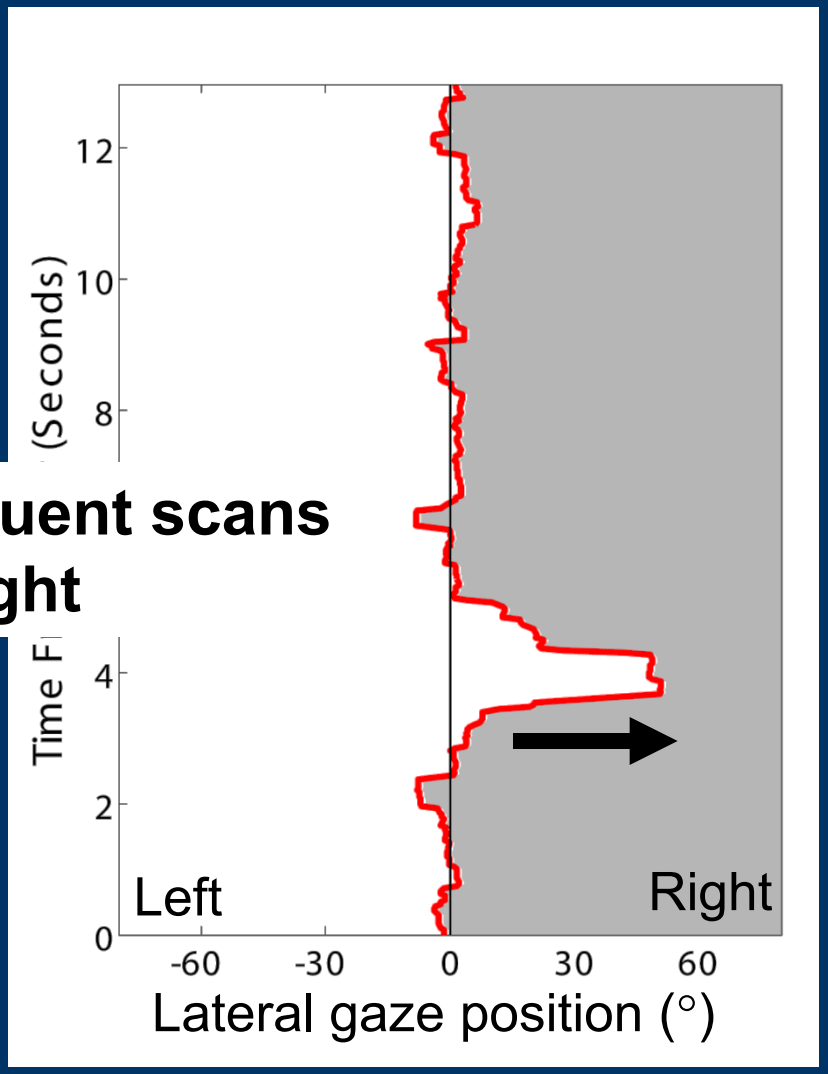
# Left hemianope 2 : good detection rates



# Scanning and blind side detection
# Right hemianope: moderate detection




**Large, infrequent scans to right**

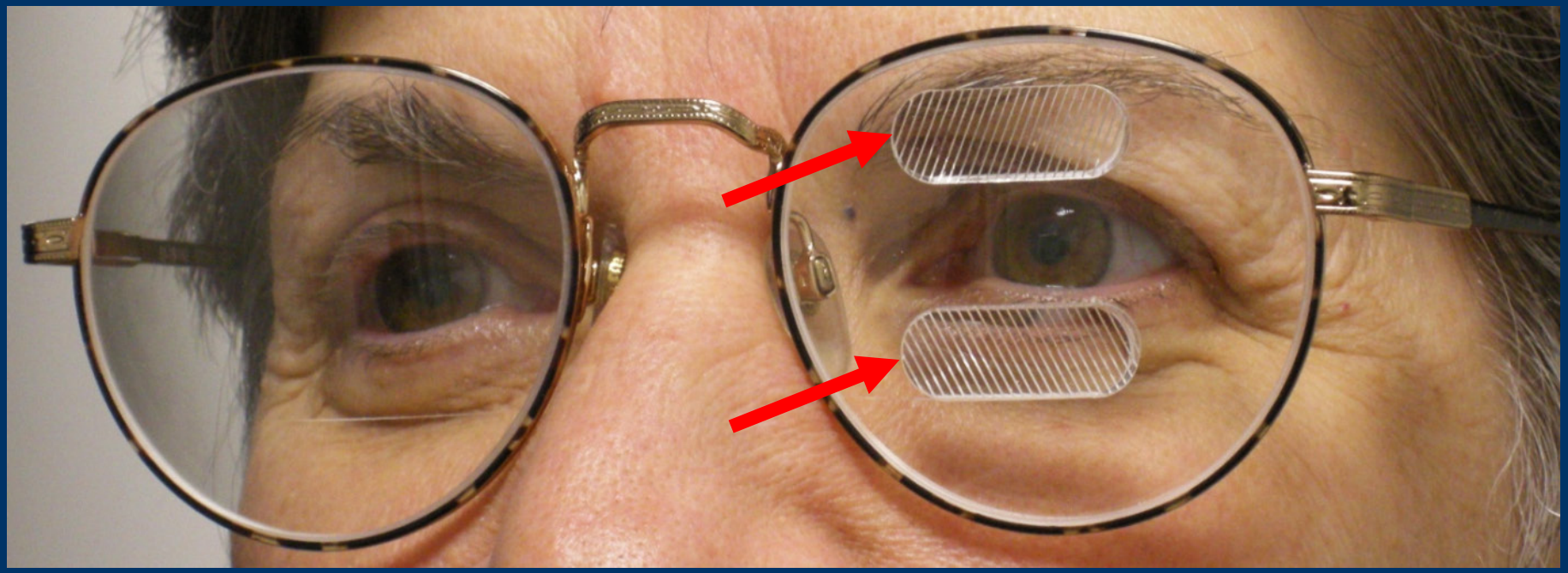


# Rehabilitation

Can we improve blind side detection?

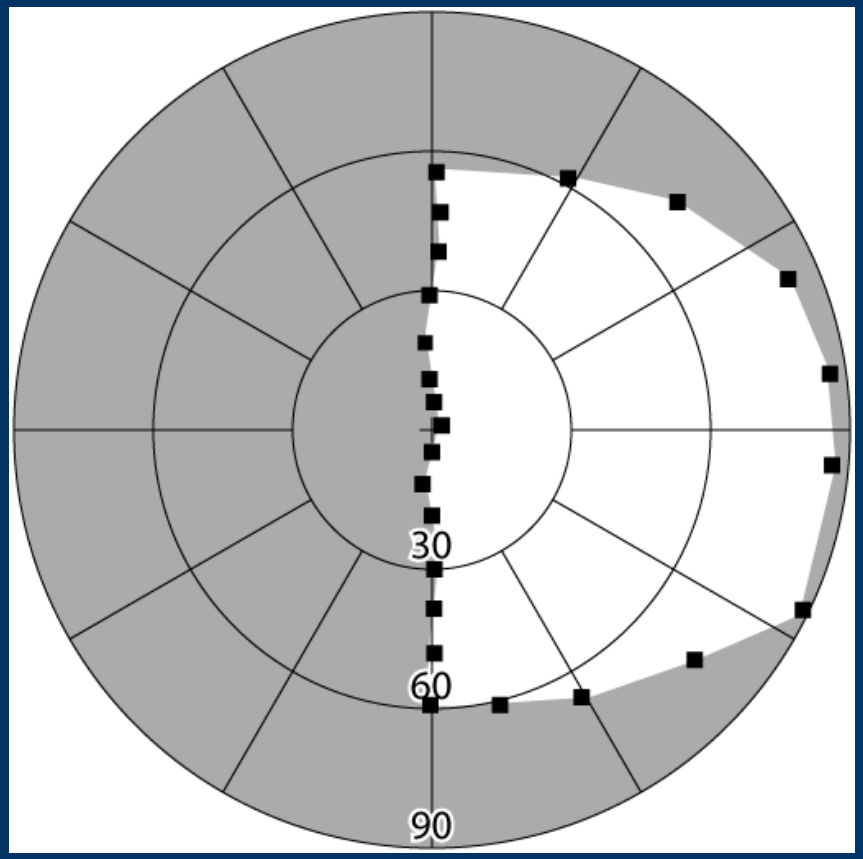
# Peripheral prism glasses
## (Peli, 2000 & 2008)

- High power (30°) prisms fitted on one lens (on side of hemianopia)
- Provide visual field expansion

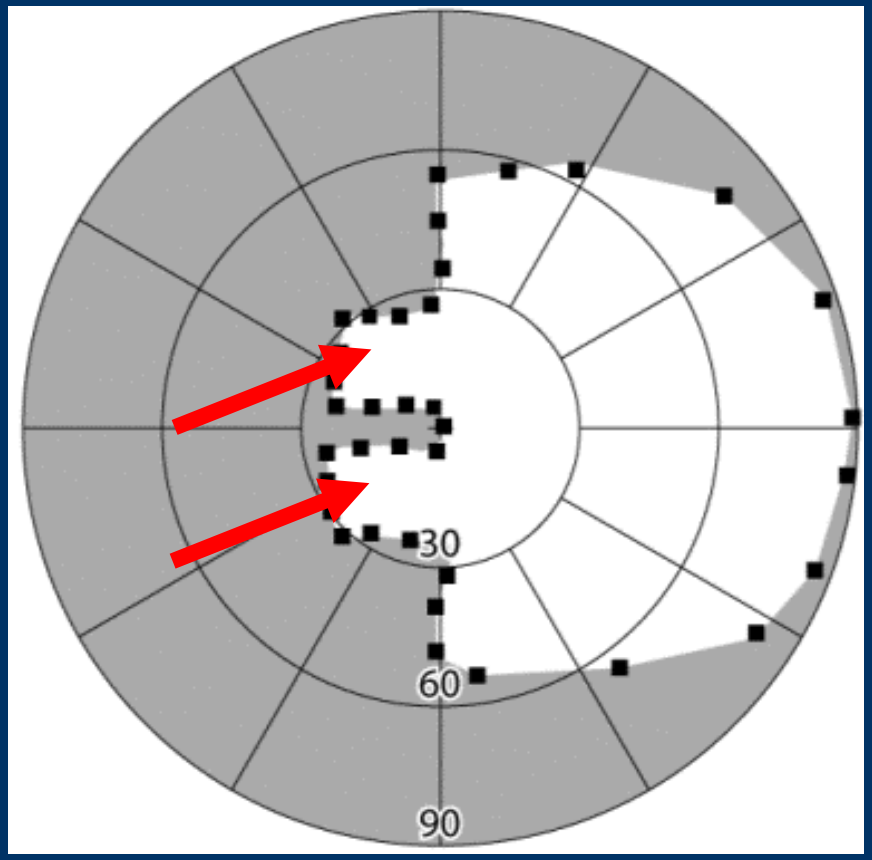


# Binocular visual fields - Left hemianopia

## (Goldmann V4e target)




Without prisms




30° peripheral prisms

# Binocular visual fields - Left hemianopia

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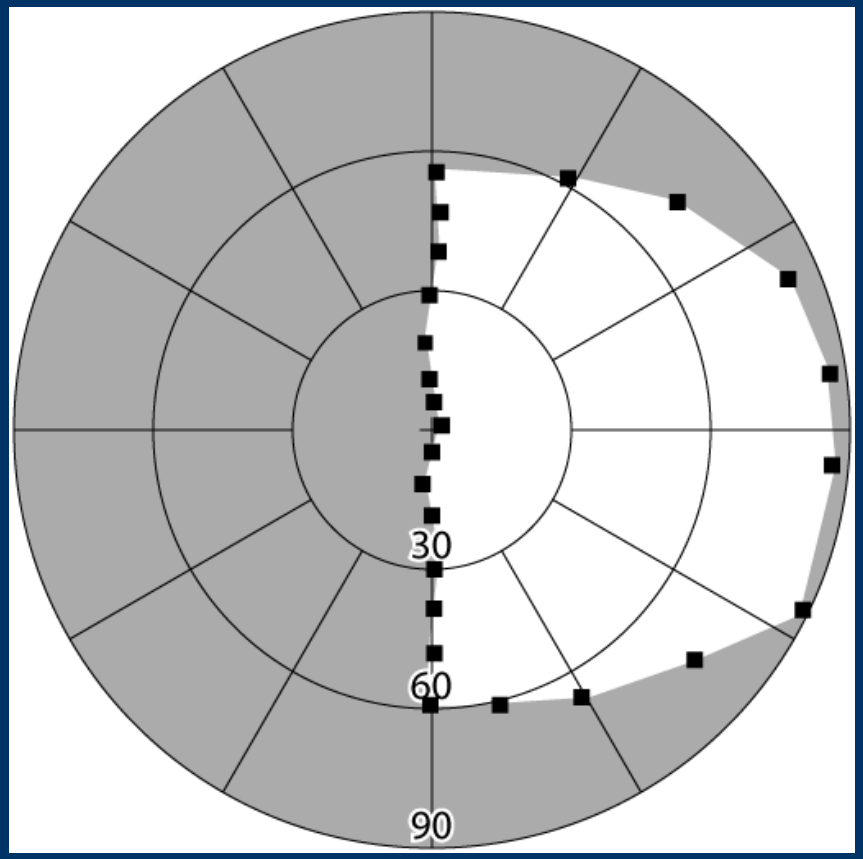
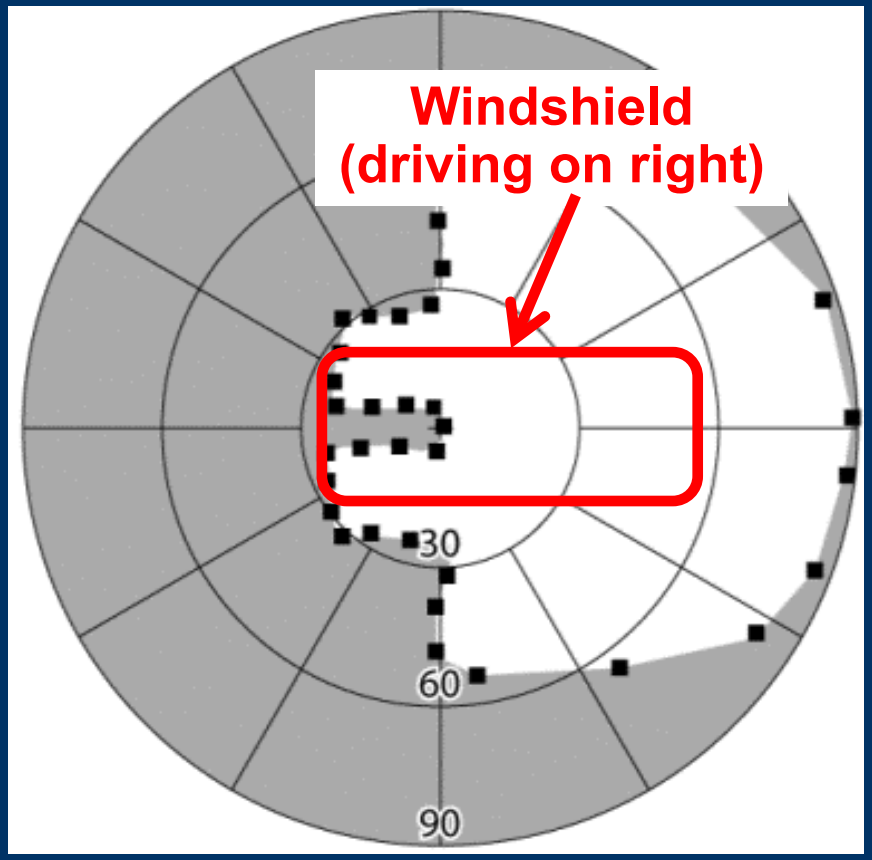



Without prisms



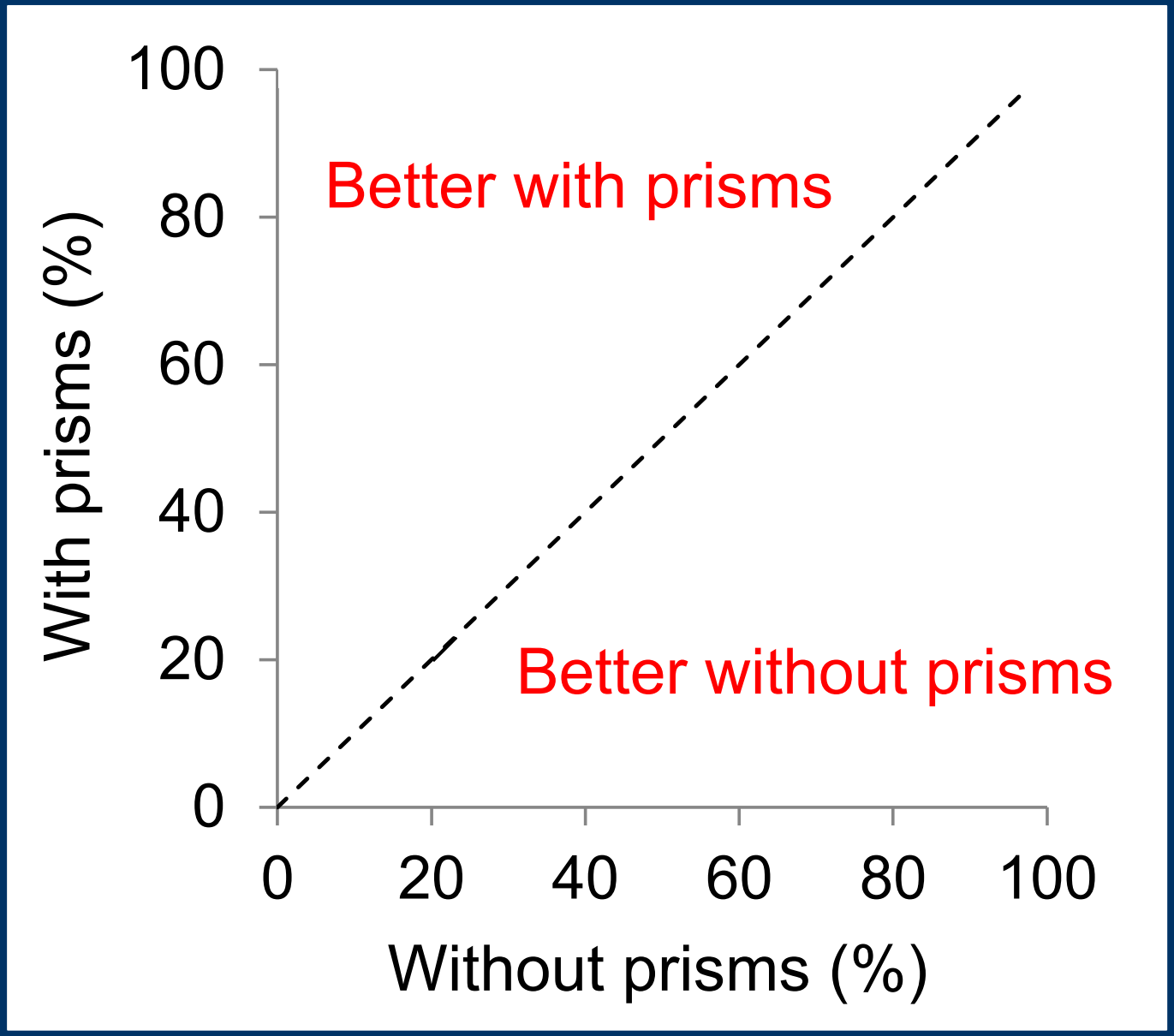

30° peripheral prisms

# Peripheral prism glasses

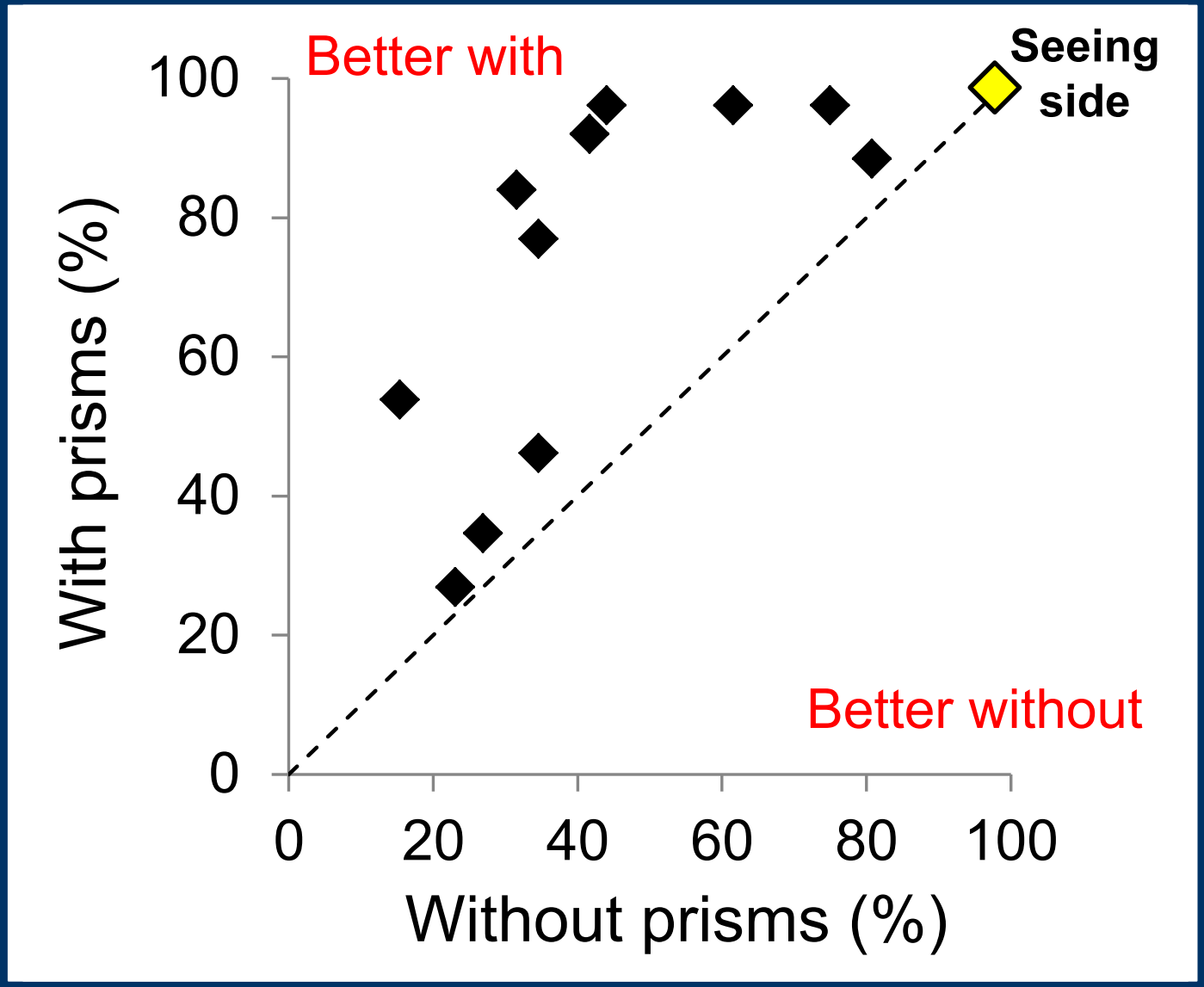
- Patients report helpful for obstacle detection when walking
  (Peli 2000, Bowers et al., 2008, O'Neill et al., 2011, Bowers et al., 2014)

- Need objective measure of performance …
  – Driving simulator pedestrian detection task!

# Blind side detection rates



# Blind side detection rates better with than without prisms



# Summary

- Some people with hemianopia compensate well by scanning but many do not
  - Despite similar amounts of visual field loss
- Those who do not compensate well
  - Fail to detect potential hazards in a timely fashion
- Preliminary evidence that peripheral prisms improve blind side responses
  - Similar results in pilot on-road study (Bowers et al, 2012)

# Driving simulators in hemianopia rehabilitation

- Objective measure of scanning and detection
- Quantify how well a patient is able to use their vision
  - In an interactive, realistic task
  - Safe, controlled, repeatable
  - More informative than clinical measures of visual field
- Quantify improvements with interventions

# Driving simulators in hemianopia rehabilitation

- As a training tool
- Individualized scanning training
- Training of other driving skills

# Acknowledgements

Concetta Alberti
Egor Ananev
Matt Bronstad
Robert Goldstein
Kevin Houston
Alex Hwang
Aaron Mandel
Lauren Spano
Steven Savage
Eli Peli
Mark Tant
Lily Zhang

**Supported in part by:**

DoD grant: DM090420
NIH grants: R00-EY018680, R01-EY025677, R01-EY12890, S10RR028122

# Thank You!

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