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

Normal vision
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
Left visual field

Optic chiasm

Left eye

Right eye

Optic chiasm

Right side of the brain

Visual cortex

©2011, Eli Peli, Schepens Eye Research Institute
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

- Seen
- Not seen
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

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

5 sec
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

<table>
<thead>
<tr>
<th>Detection rate</th>
<th>Mean reaction time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seeing side</strong></td>
<td>100%</td>
</tr>
<tr>
<td>(As good as normally sighted)</td>
<td></td>
</tr>
<tr>
<td><strong>Blind side</strong></td>
<td>&lt;10% - 100%</td>
</tr>
</tbody>
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12 subjects with hemianopia
12 age-similar controls with normal sight

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)

Blind side

Percent pedestrian appearances

40% potential collisions

60% timely

Did not see
Too late
Timely
Potential collisions
(Data pooled across participants)

- 0%
- 20%
- 40%
- 60%
- 80%
- 100%

Blind side
Seeing side

Percent pedestrian appearances

- 95% timely
- Did not see
- Too late
- Timely

95% timely
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

Relatively little scanning
Low detection rates

Time From Start (Seconds)

Lateral gaze position (°)

Gaze (eye) position

Left

Right

0  2  4  6  8  10

-60  -30  0  30  60
Scanning and blind side detection

Left hemianope 2: good detection rates

Frequent scans
More to left than right

Large scans (30°)
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
(Goldmann V4e target)

Without prisms

30° peripheral prisms

Windshield (driving on right)
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

With prisms (%)

Without prisms (%)

Better with prisms

Better without prisms
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
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