

# **Perception of collisions while walking in a virtual environment with simulated peripheral vision loss.**

*James Barabas, Russell L. Woods,  
Robert B. Goldstein, Eli Peli*

*Schepens Eye Research Institute,  
Harvard Medical School*

Vision Sciences Society 2004 Poster G113

# Abstract:

While walking, people rely on visual judgments to avoid collisions. People with severe peripheral vision loss (tunnel vision) report frequent collisions with obstacles. We used a virtual environment to examine how normally-sighted subjects performed with and without simulated tunnel vision in a collision-detection task. The virtual environment consisted of a treadmill situated in front of a large rear-projected screen (about 95 degrees wide). Subjects walked down a simulated shopping mall corridor and were shown one-second glimpses of human-sized obstacles at eccentricities from zero to 12 degrees relative to their heading. Subjects were asked to judge whether continued walking in the same direction would have resulted in a collision with the obstacle. Head and eye tracking were used to dynamically adjust a dark mask restricting the subjects field of vision. Restrictions revealed only parts of the scene within circles 5, 10 or 20 degrees in diameter centered at the subjects' center of gaze. Not surprisingly, subjects failed to see obstacles more frequently as their vision was increasingly restricted. However, when subjects were allowed to repeat obstacle presentations that they failed to see, performance at discriminating collisions was unaffected by peripheral vision restriction.

Supported in part by NIH grant EY12890.

# Background:

Loss of peripheral vision makes navigating cluttered environments more difficult. Pelah et al., (2002) found an effect of vision restriction on decisions about obstacles in a virtual environment. Li, Peli & Warren (2002) found that simulated and disease-related peripheral vision loss impaired heading judgments in a virtual environment.

## Questions:

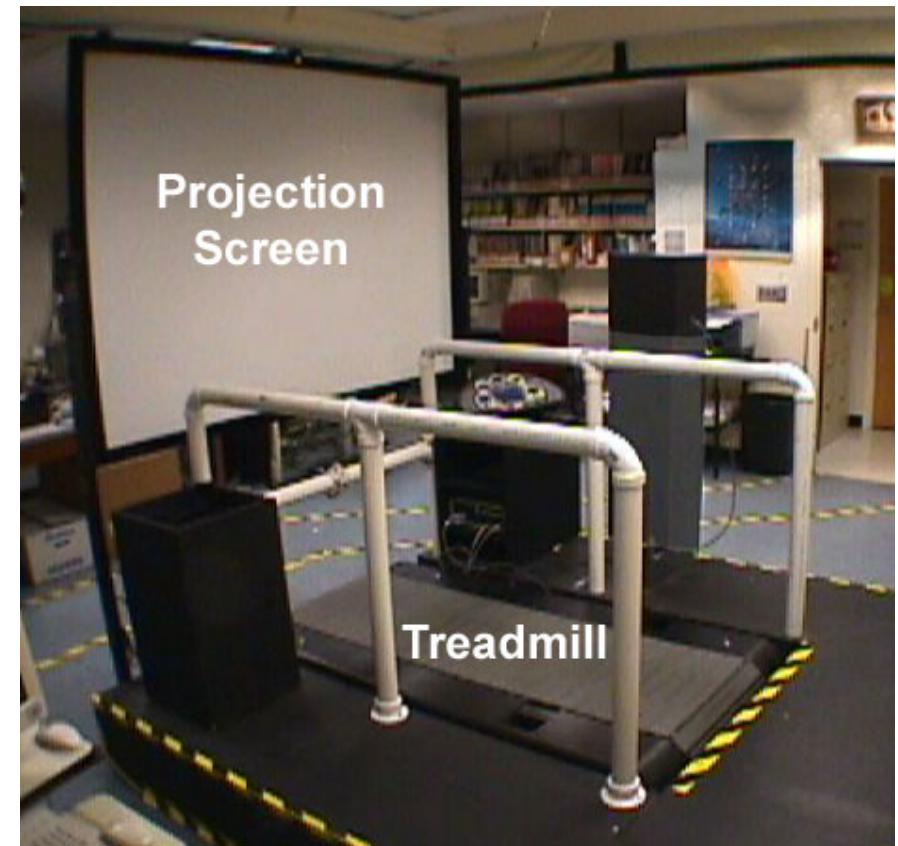
Does limited peripheral vision impair **detection** of potential obstacles?

Does limited peripheral vision impair **visual judgment** of potential collisions once obstacles are seen?

# Approach:

Evaluate collision perception of subjects walking in a computer-simulated corridor with and without simulated peripheral vision loss:

- Subject walks on treadmill in front of a rear-projection screen.
- Screen, viewed monocularly, shows simulated shopping mall corridor with obstacles.
- Track head and eye movements.
- For conditions with simulated vision loss, obscure virtual corridor except for a round window around point of gaze.



# Methods: Head and Eye Tracking

- Gaze tracked using ISCAN pupil tracker, Ascension Flock of Birds Head Tracker, custom head & eye tracking integration.
  - View of corridor is dynamically adjusted to match eye position in front of screen as subject moves while walking (Allows depth cues from self motion parallax).
- For restricted vision conditions, head and eye tracking used to dynamically place a virtual mask “in front of” subject’s eye along line of gaze (to our knowledge, a novel approach).

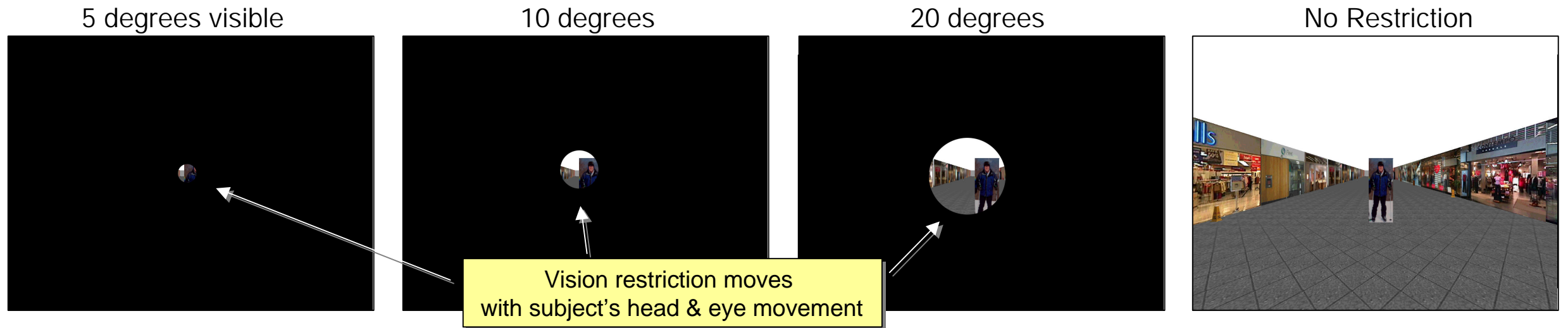


Example of view change for subject shifting position on treadmill

# Experimental Methods: Walking Task

Subjects: 6 normally-sighted adults

4 conditions: No peripheral vision restriction (about 90 degrees of corridor visible on screen independent of gaze), vision restricted to 5, 10, and 20 degrees around point of gaze.



Obstacles appear adjacent to point 5m or 15m down walking path.

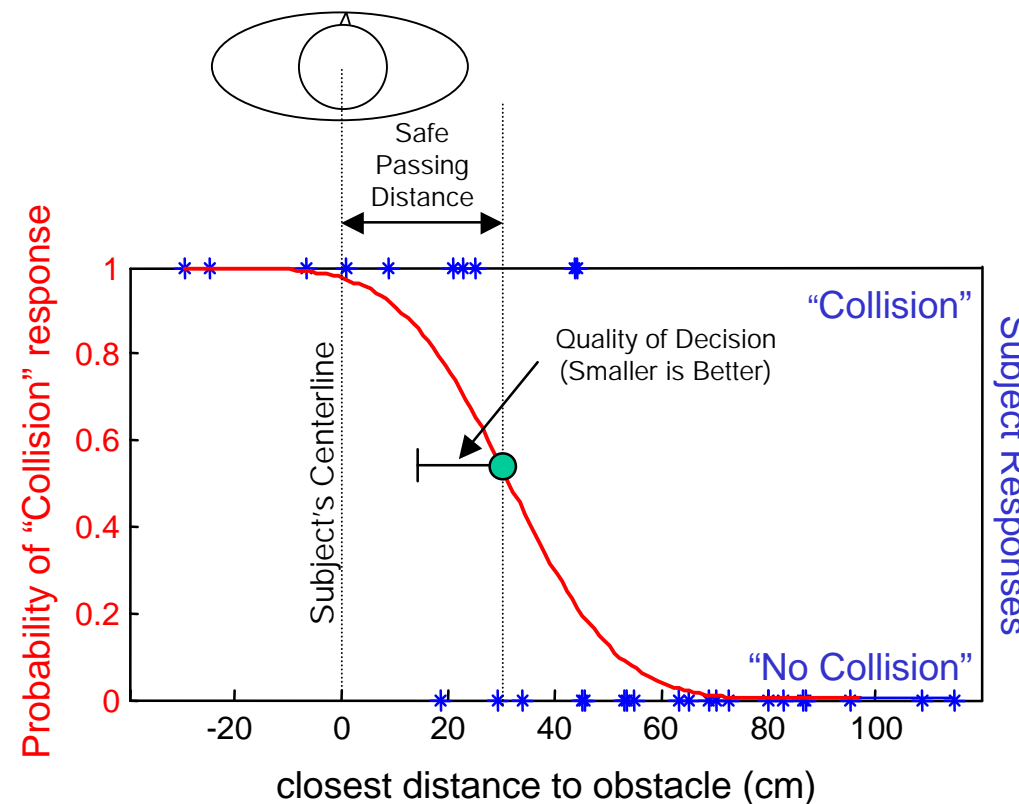
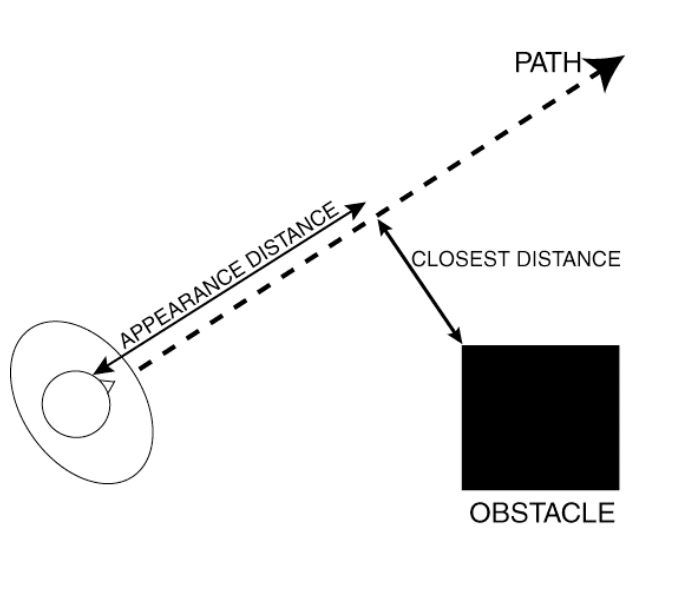
Closest distance between obstacle and path ranged from negative 10 cm to 100 cm.

Obstacles presented on left or right side.

Subjects presented with **64 obstacles** per viewing condition, each repeated until seen.

Measure perception of potential collisions to define the subjects' "Safe Passing Distance."

Perceived safe passing distance (Woods et al., 2003) is the path-obstacle distance where subject responds "Collision" about half of the time.



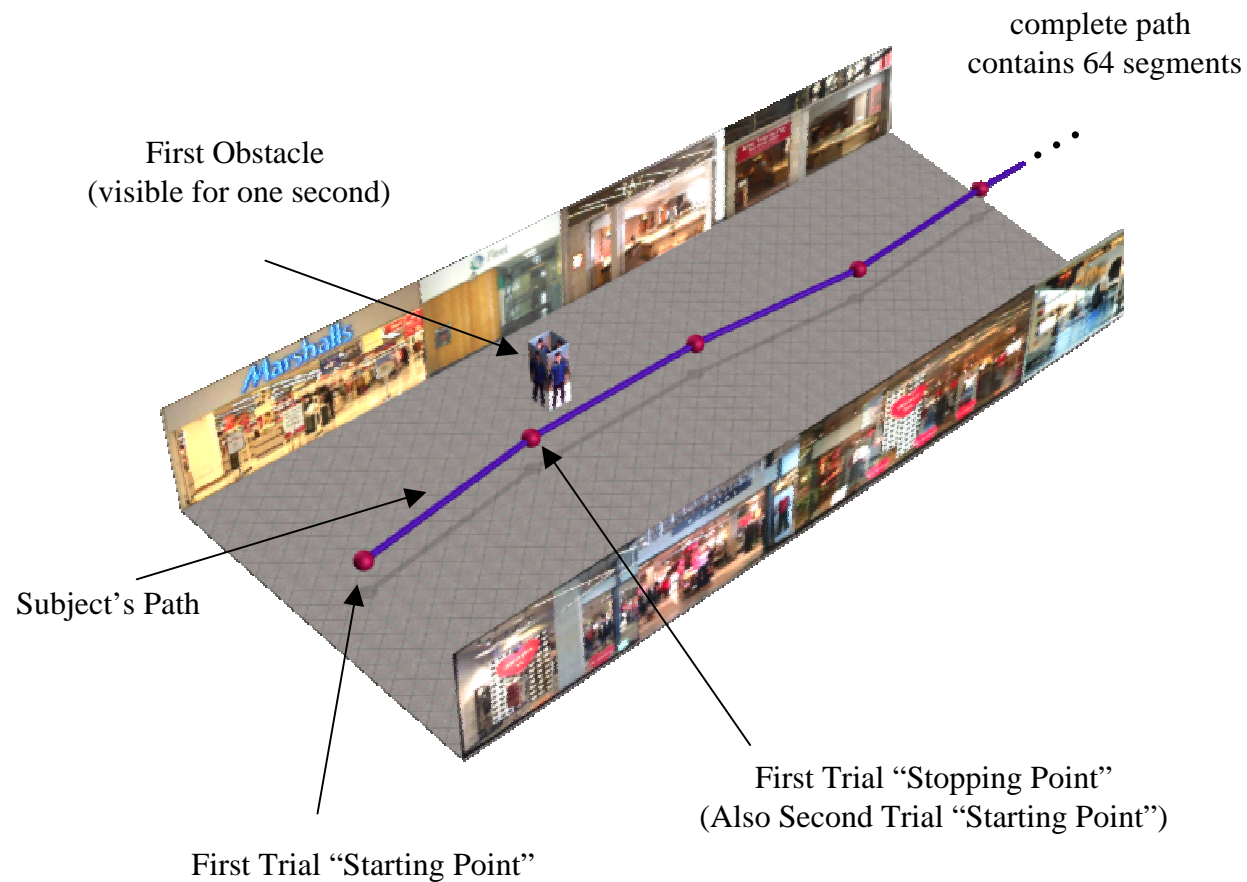
Cumulative Gaussian fitted to subject responses:

Mean: "Safe Passing Distance"

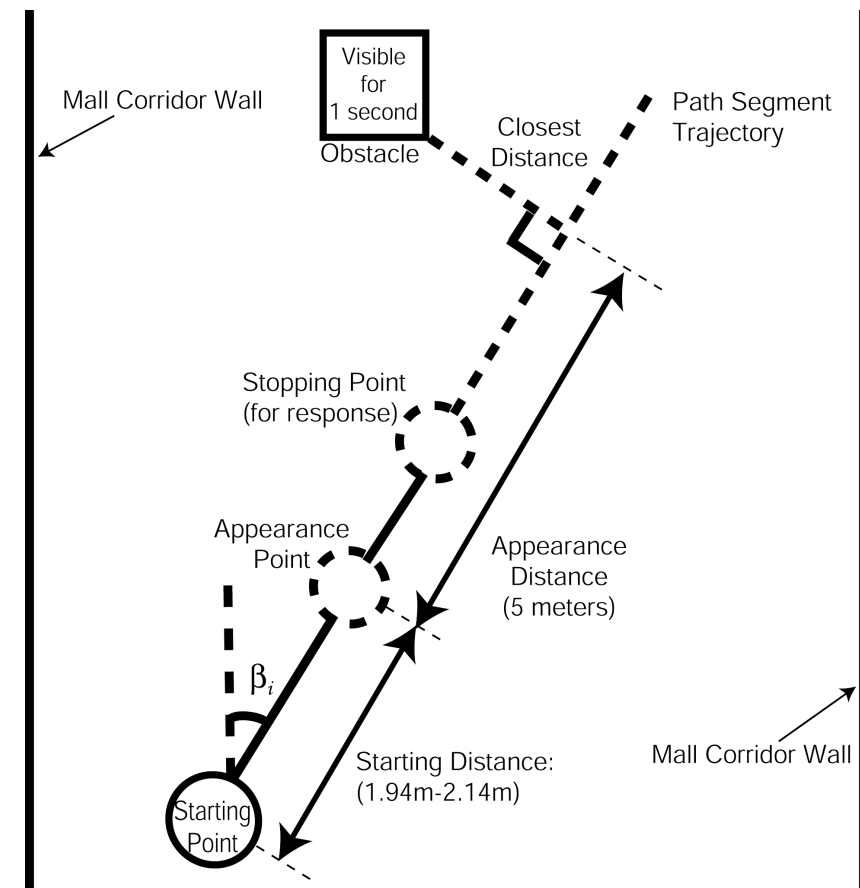
Standard Deviation: "Quality of Decision"

# Methods: Computer Simulation

Subjects walk “through” 3D model of shopping mall corridor along predefined path.

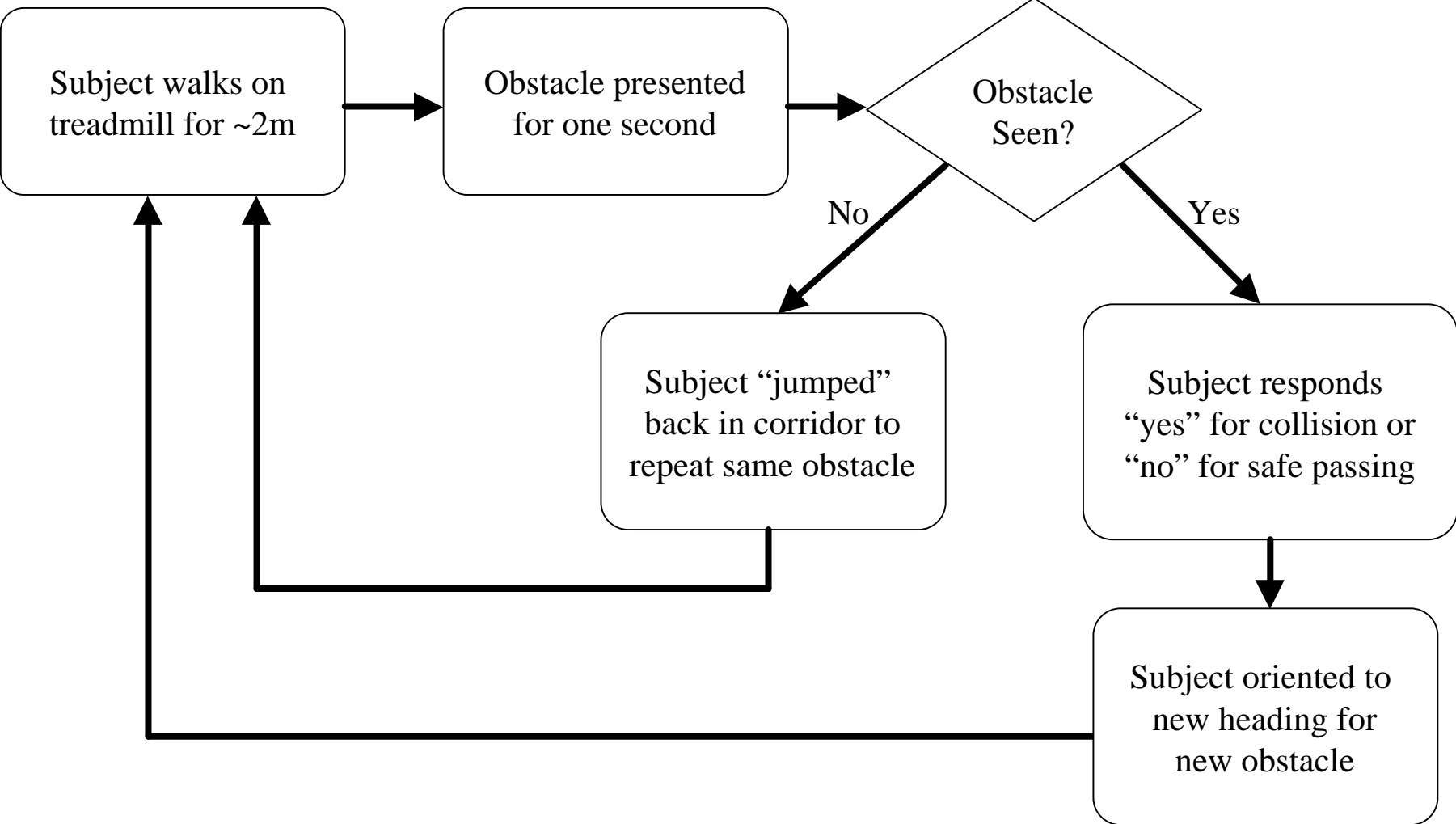


Along each path segment, an obstacle appears, and then vanishes.





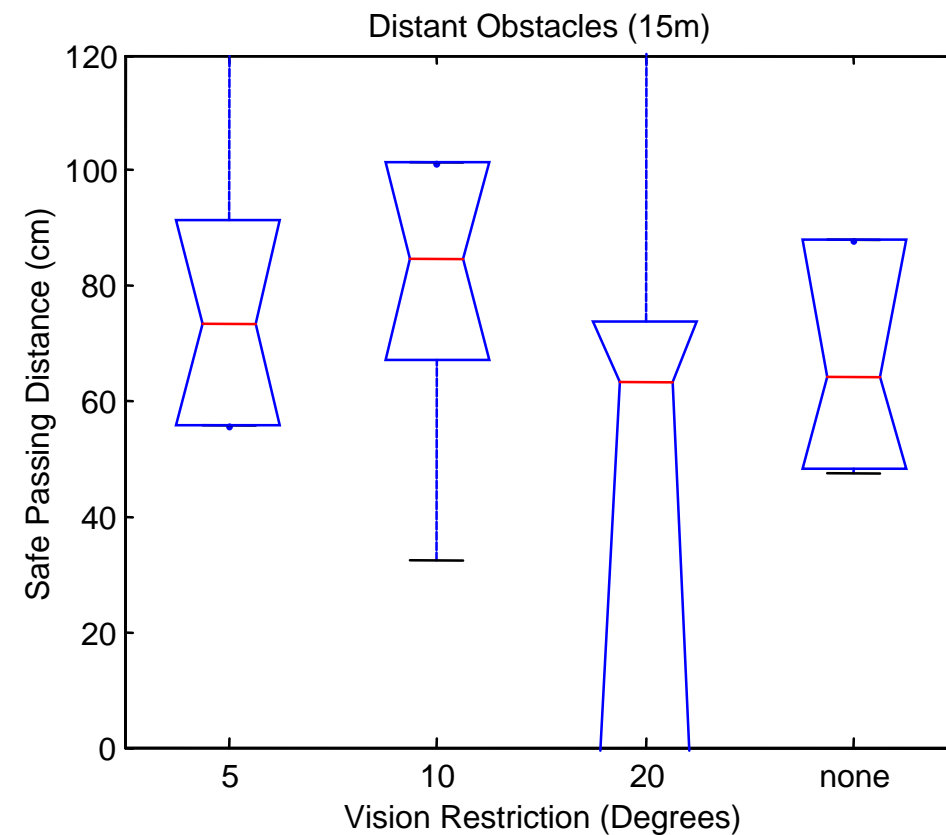
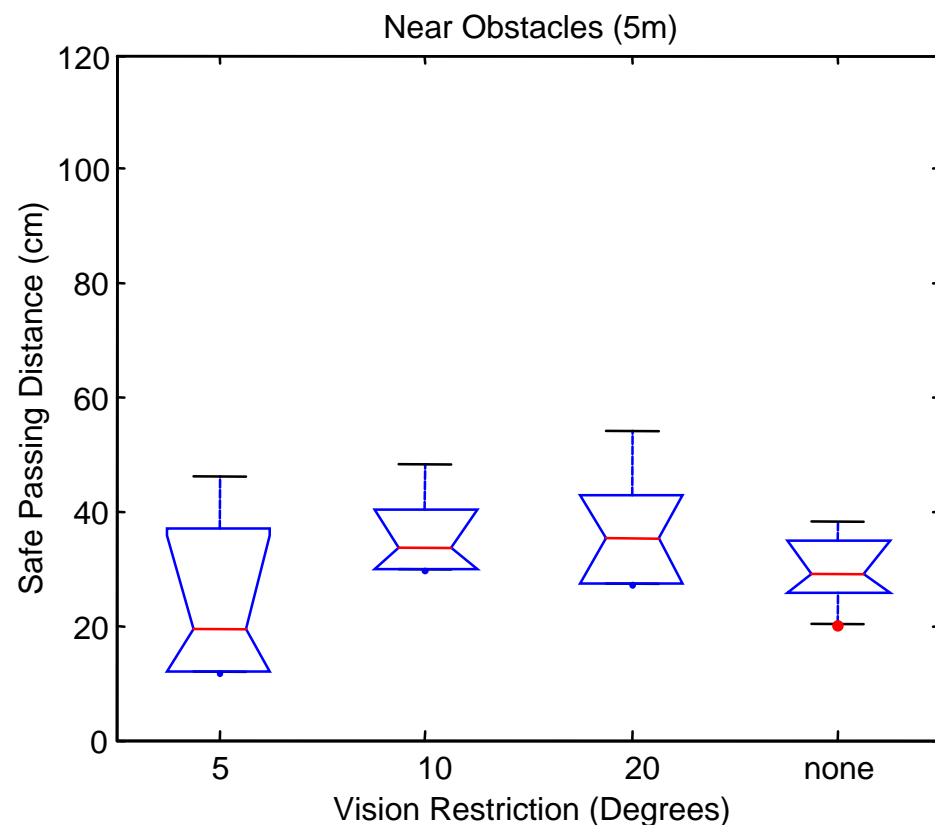
Obstacle Presentation Flowchart. Continues until all 64 obstacles are seen.



# Results:

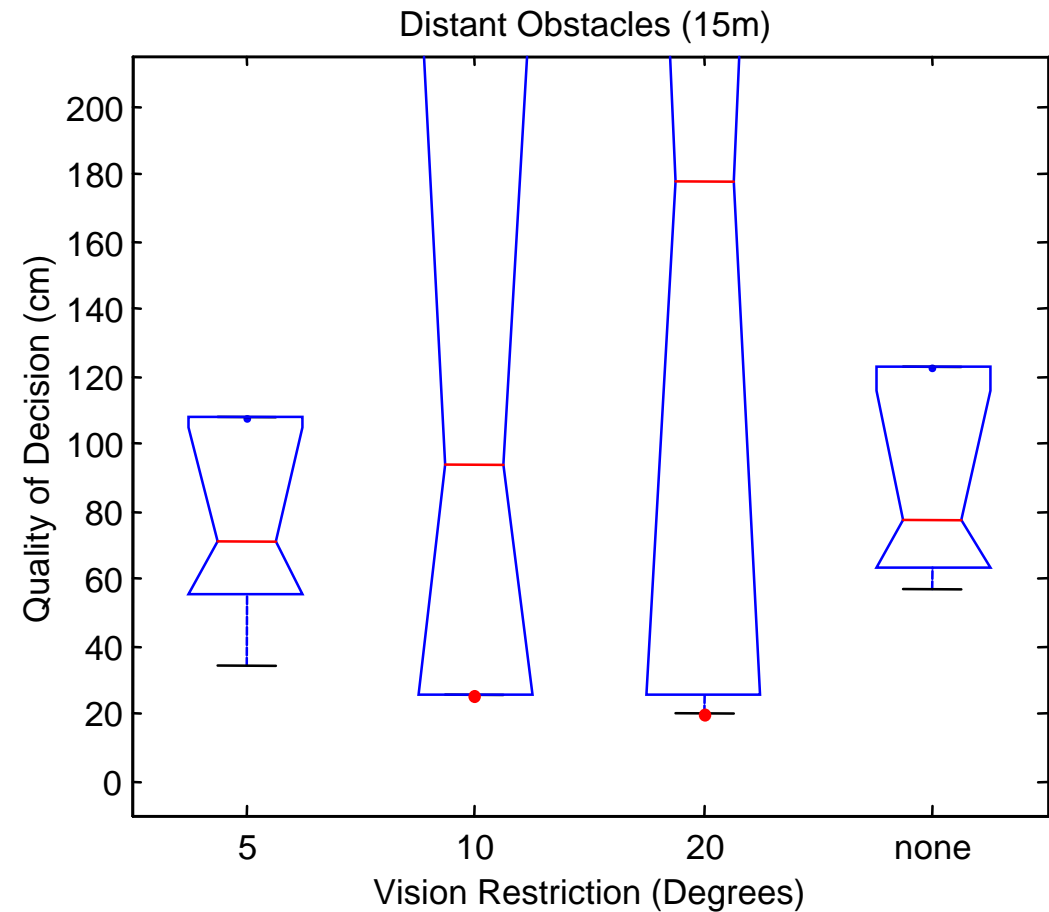
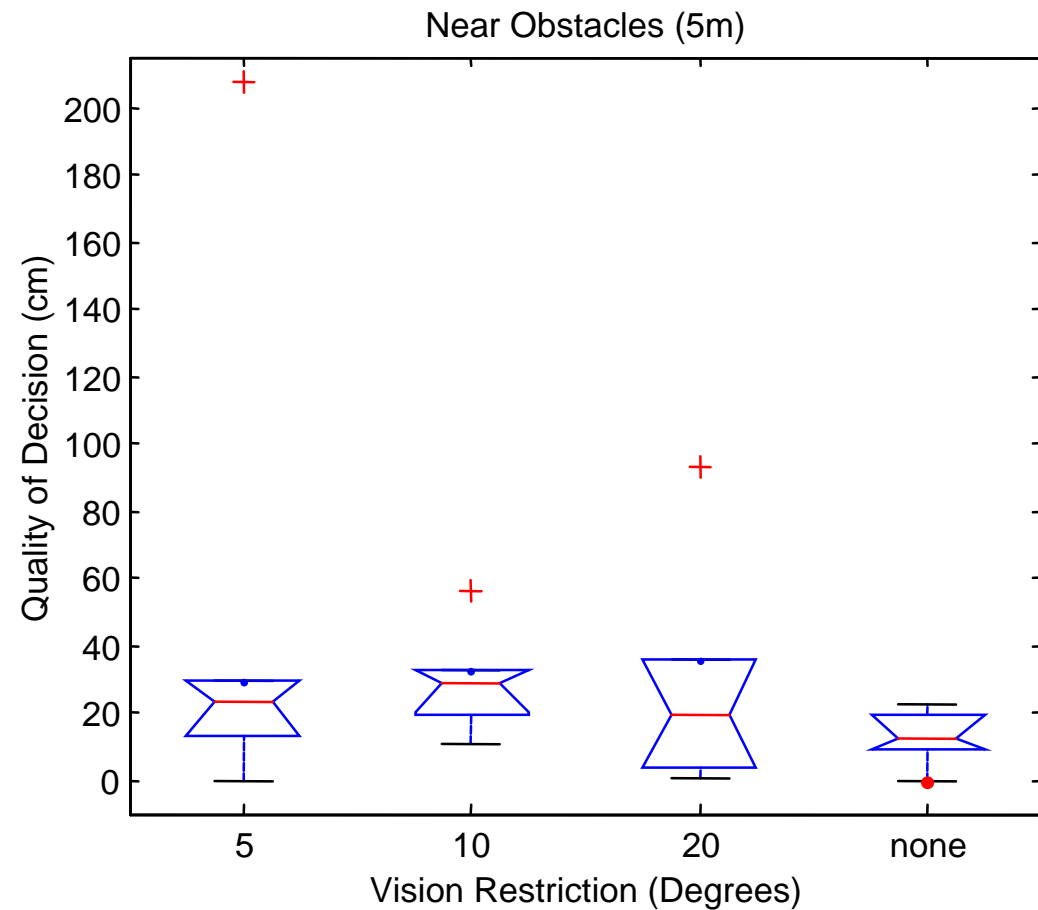
We did not find an effect of peripheral vision restriction on perceived safe passing distance.

Subjects were able to make good judgments even when obstacles were seen through a 5° window. Responses were highly variable for distant (15m) obstacles, both with and without vision restriction.

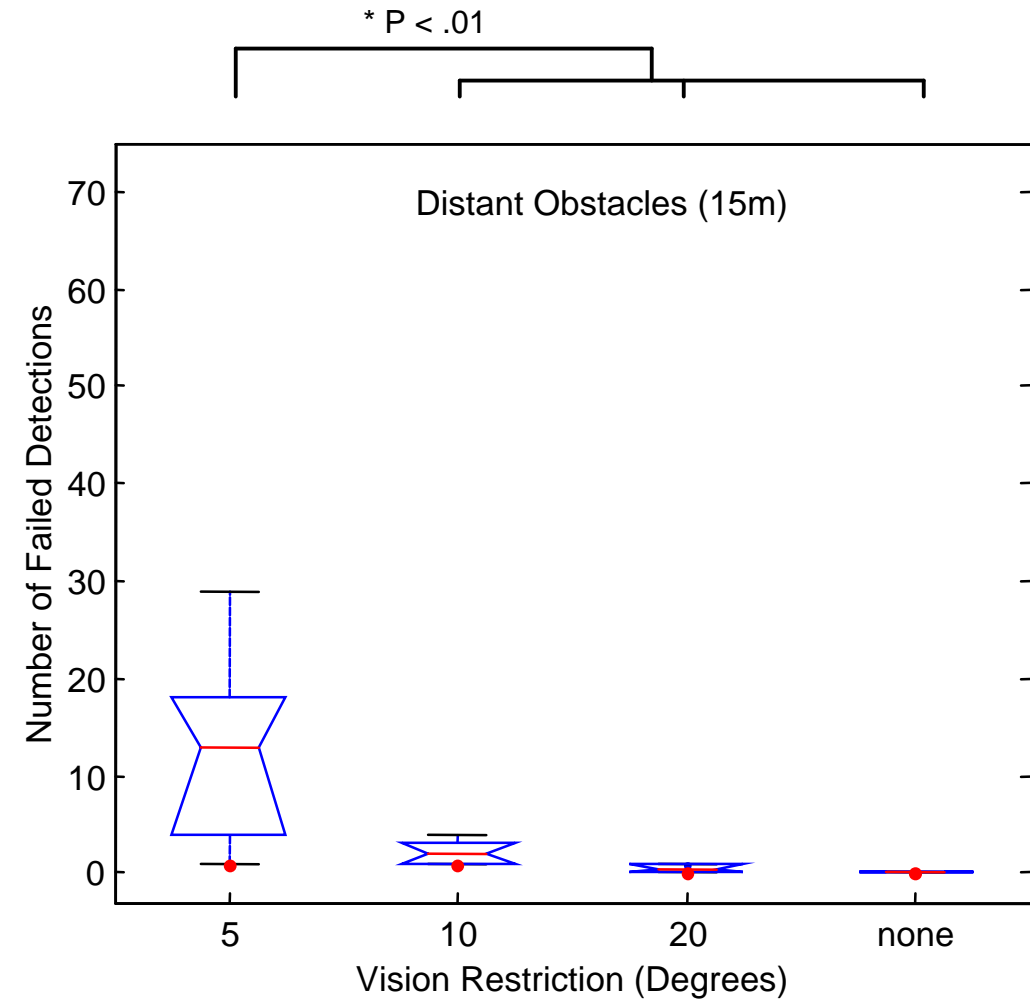
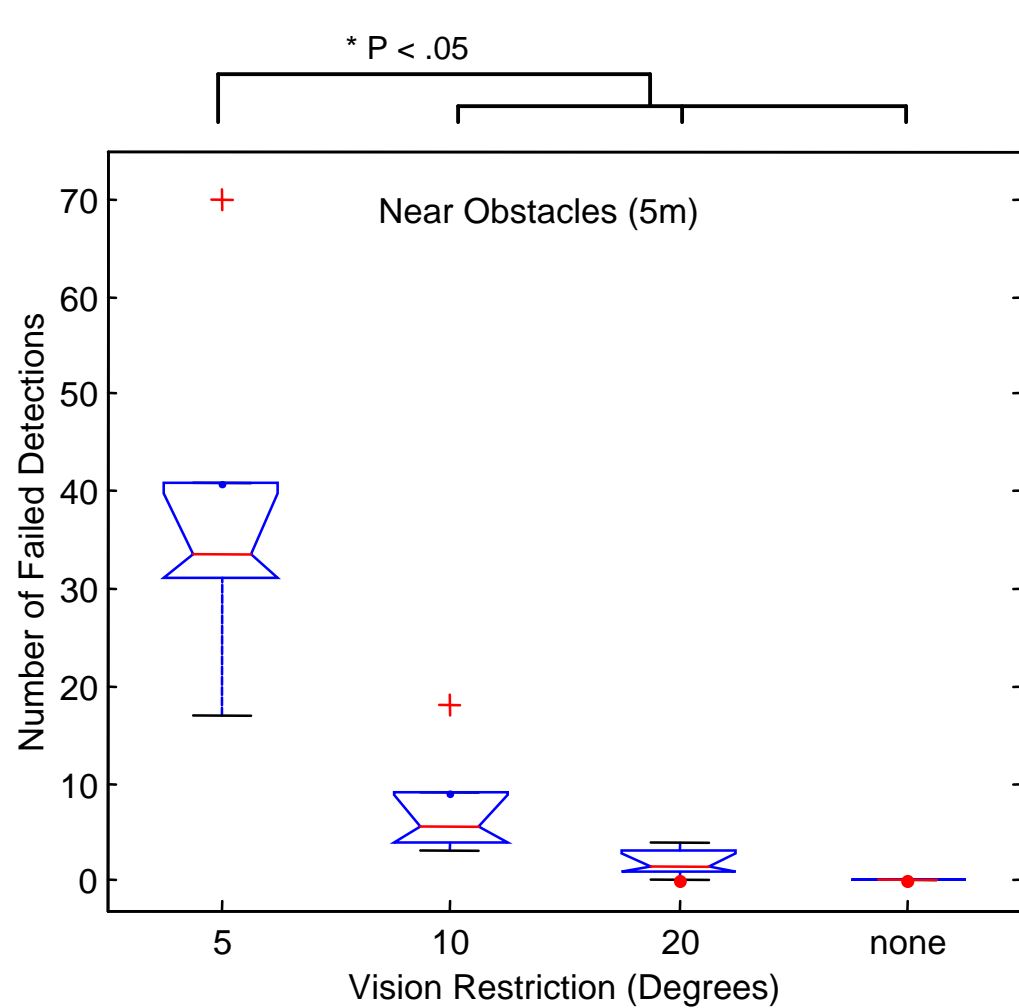


Boxes cover range from lower to upper quartile with median in red. Box sides are sloped inside confidence interval for mean ( $med \pm 1.57 \cdot (q3 - q1) / \sqrt{n}$ ).

We found no effect of peripheral vision restriction on the quality of subjects' judgments.



Subjects failed to see obstacles more often as vision was restricted.



# Conclusions:

We did not find an effect of peripheral vision restriction on perceived safe passing distance, or on quality of decision. This experiment lacked sufficient power to detect small changes ( $n = 6$ ).

Subjects seemed to make good judgments of a potential collision even when viewing small parts of obstacles for very brief periods.

This result suggests that collisions can be avoided if obstacles are detected. We are developing optical and electronic devices to aid collision detection for people with visual impairments.

# References:

Li L, Peli E, Warren WH. (2002) Heading perception in patients with advanced retinitis pigmentosa. *Optom Vision Sci*, 79: 581-589.

Pelah A, Hucknall R, Hedges R, Turner M, Shieh J, Apfelbaum H & Peli E. (2002). Measures of obstacle avoidance while walking in a virtual environment by patients with retinitis pigmentosa. *Assoc. Res. Vision Ophthalmol. 2002 Annual Meeting CD-ROM*: 3913.

Woods RL, Shieh JC, Bobrow L, Vora A, Goldstein RB & Peli E. (2003). Perceived collision with an obstacle in a virtual environment. *Assoc. Res. Vision Ophthalmol. 2003 Annual Meeting CD-ROM*: 4321.