

Hazard detection by drivers with para-central visual field loss

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Abstract

We studied how para-central visual field loss (pCFL) affects pedestrian detection in a driving simulator.

Participants with pCFL had relatively good visual acuity (20/15 – 20/60) and 3 of 5 met local vision requirements for unrestricted drivers license; however, they had lower detection rates and longer reaction times to pedestrians likely to appear within the blind area than in their seeing areas.

They were at collision risk for 7% to 30% of pedestrians, whereas controls were at a collision risk for 0 to 4% of pedestrians.

Background

In the US, visual acuity is the primary vision measure determining driver eligibility. More than half the states have some visual field measure.

We have showed that drivers with central field loss (CFL) *and poor visual acuity* detected pedestrian hazards with difficulty in a driving simulator (Bronstad *et al.*, 2009), as do drivers with complete homonymous hemianopia to the vertical midline (Bowers *et al.*, 2009).

Such drivers would not be eligible to drive in many states. Drivers with **para-central field loss (pCFL)**, with binocular blind areas but good visual acuity, may easily pass even the most restrictive vision requirements.

In the present study participants with pCFL drove in a simulator and we measured their hazard detection abilities.

Methods

Simulator sessions

Participants drove 3 city (30mph) and 2 highway (60mph) test drives (each 10-12 minutes long) per session after simulator acclimation. During test drives they responded as quickly as possible to pedestrian appearances by honking the horn. Reaction time and detection rates were measured.

Pedestrians appeared at one of four offset locations (-14° , -4° , 4° , 14°) relative to vehicle heading (see Figure). They appeared approximately 5 seconds down the road, and walked or ran towards the participant's travel lane, keeping a fairly constant eccentricity as they did so (i.e. remaining on a collision course), but stopped before collision.

Participants

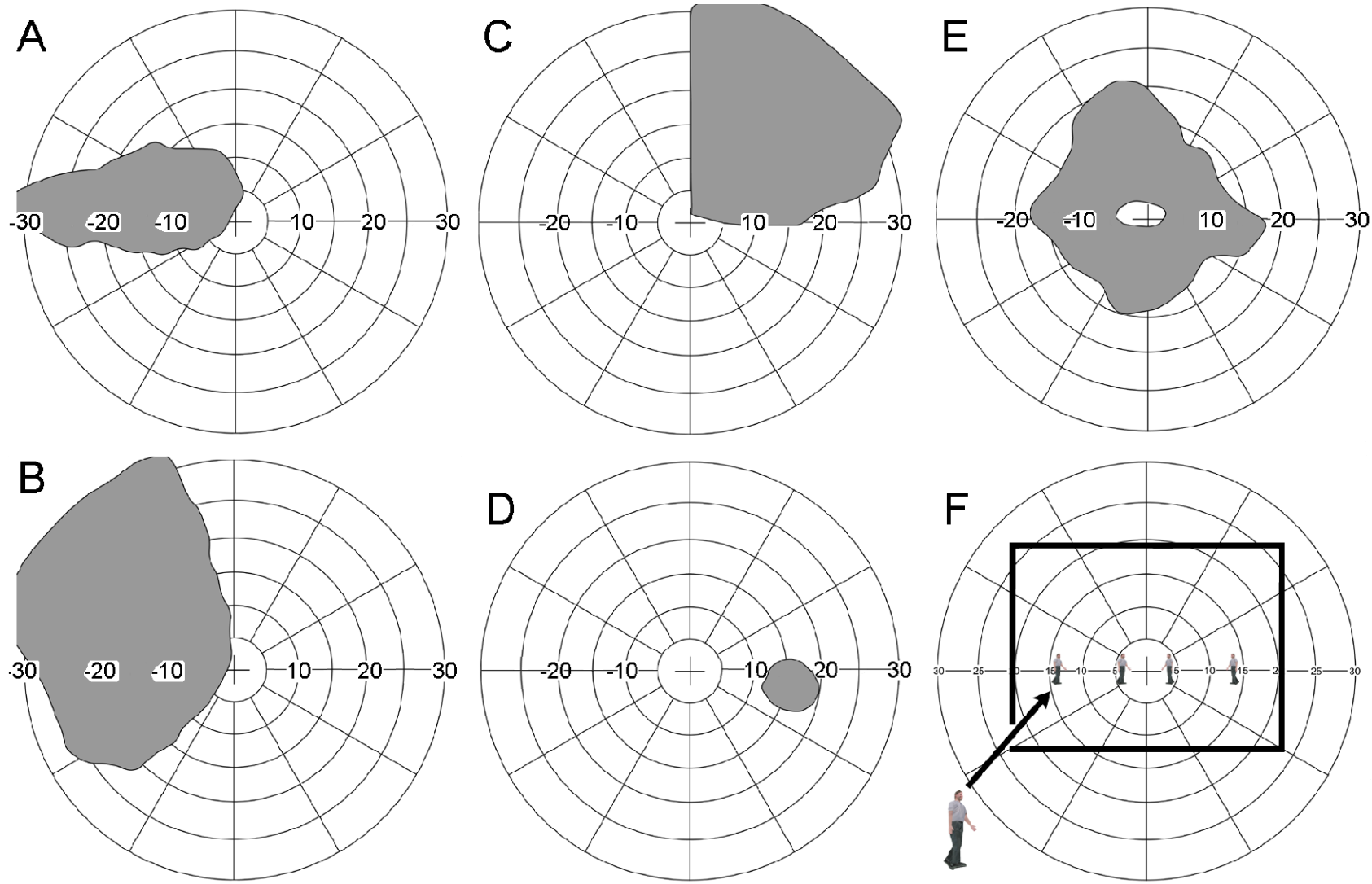
Five people with binocular visual field loss and five age- and sex-matched normally-sighted controls. Participants with hemianopia (n=3) showed no evidence of neglect.

Screening visit – Goldmann peripheral visual field measurement, central 60 degrees of visual field also measured with custom kinetic perimetry system (Woods, Apfelbaum, & Peli, 2010). Other measures included Small Portable Mental Status Questionnaire (SPMSQ, Pfeiffer, 1975).

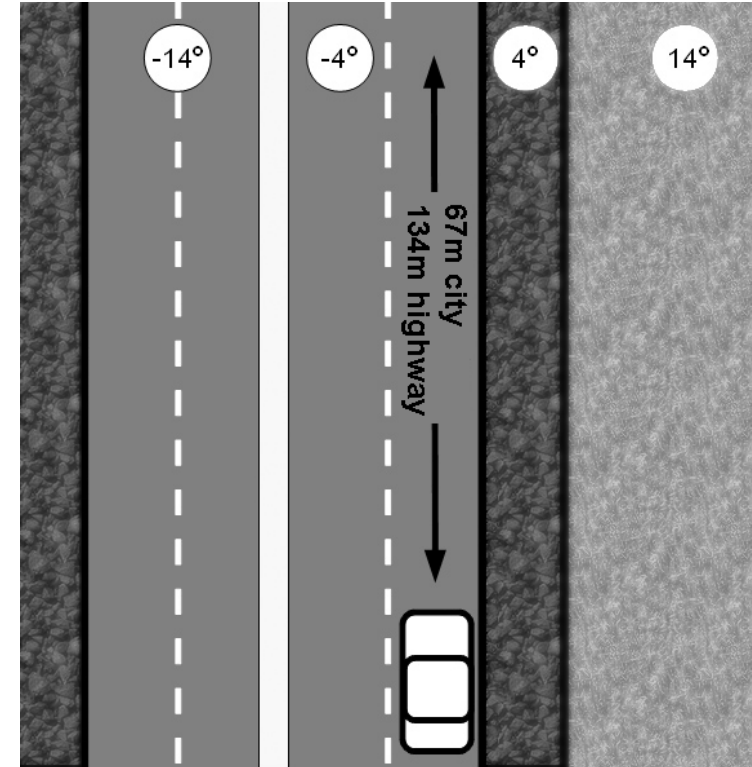
Table 1. Participant visual characteristics and demographic information.

| | <i>YOB – Sex</i> | <i>Diagnosis</i> | <i>Side of Loss</i> | <i>Visual acuity (Binocular)</i> | <i>Driving years</i> |
|--------------|------------------|------------------|---------------------|----------------------------------|----------------------|
| A | 1933 – F | Sectoranopia | Left | 20/30 | 1954-present |
| B | 1949 – M | Hemianopia | Left | 20/15 | 1965-present |
| C | 1972 - M | Quadrantanopia | Right | 20/20 | 1987-present |
| D | 1934 – M | AMD* | Right | 20/25 | 1950-present |
| E | 1931 – M | AMD | “Ring” | 20/60 | 1947-2002 |
| Matched to A | 1931 – F | n/a | n/a | 20/25 | 1947-present |
| “ “ B | 1951 – M | n/a | n/a | 20/25 | 1970-present |
| “ “ C | 1964 – M | n/a | n/a | 20/20 | 1981-present |
| “ “ D | 1937 – M | n/a | n/a | 20/15 | 1951-present |
| “ “ E | 1931 – M | n/a | n/a | 20/25 | 1949-present |

*AMD with large CFL in left eye, and physiological scotoma in the right visual field (Fig 1d).



A-E: Binocular visual field plots for pCFL subjects. Shading indicates blind areas.
 F: Positions of pedestrian hazards at the four offset locations.
 Size of figures approximates visual size 3 seconds after appearance.



The FAAC simulator has 5 screens for 225° field of view, automatic transmission, controls typical of automobiles, and a motion seat with 3 degrees of freedom.

Overhead view, pedestrian placement with respect to participant's vehicle.

Results

Detection Performance

pCFL participants detected 92.5% of pedestrians in their blind areas, 100% in seeing areas. Controls detected 100% of pedestrians.

Reaction Times

pCFL participants had significantly delayed responses to their blind areas, compared to seeing areas, $\chi^2 = 7.21$, $p=0.007$, (see reaction times figure).

At non-scotoma locations, reaction times only slightly elevated relative to controls (effect was not significant, $Z = 1.54$, $p=.13$).

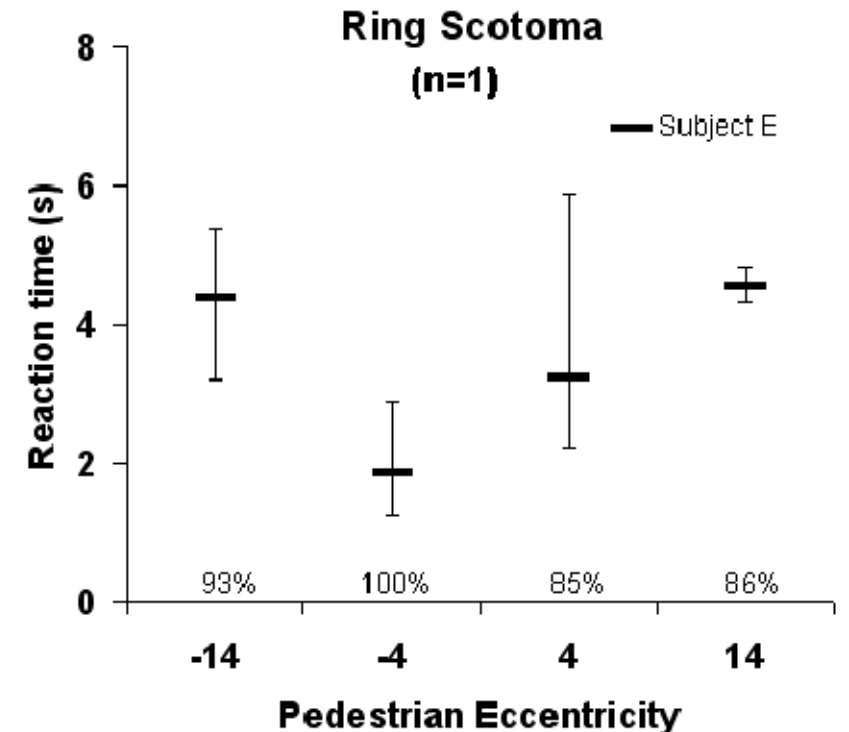
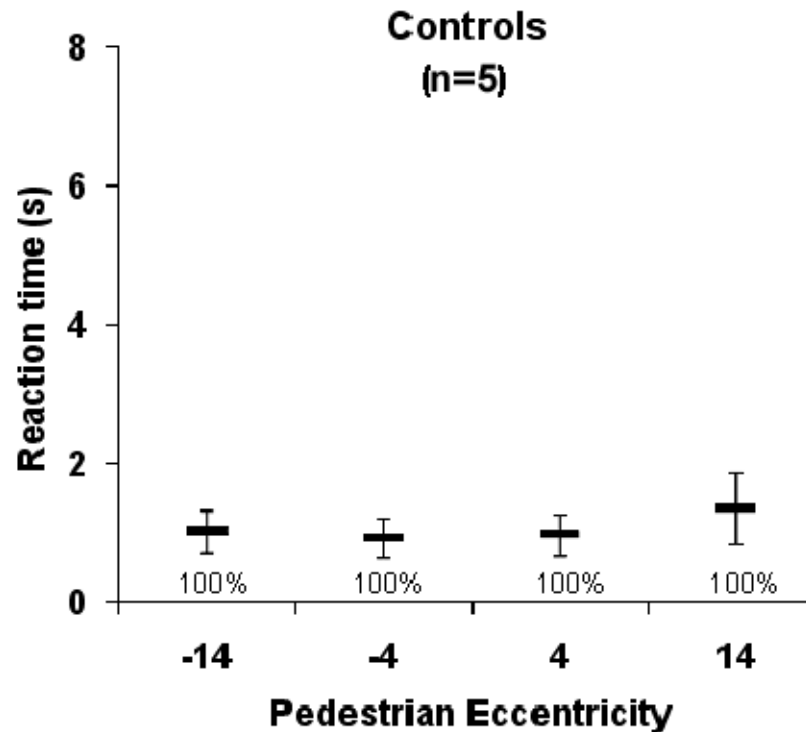
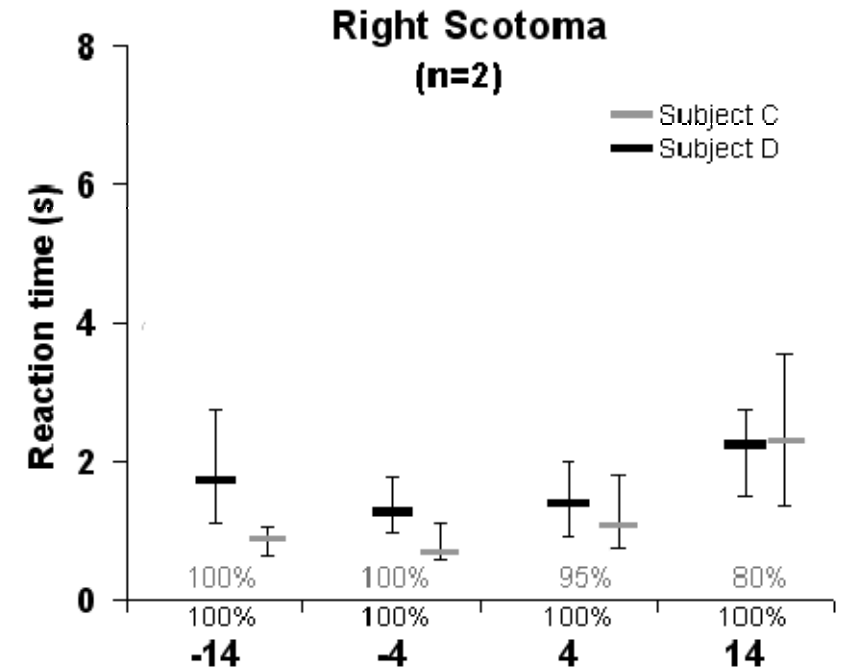
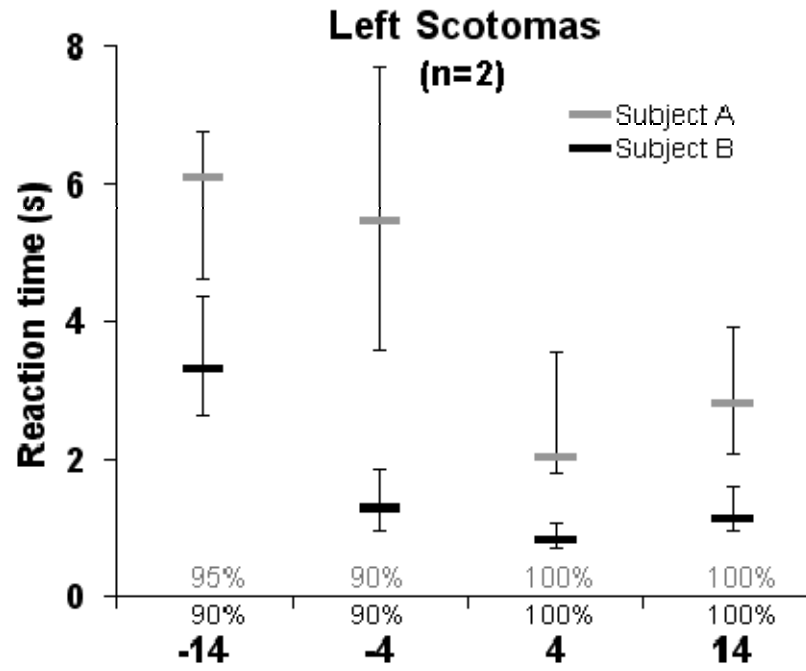
Projected Collisions

Based on participant's speed at honk time and assumed deceleration of 4m/s^2 (Evans, 2004), projected collisions were more numerous at scotoma than non-scotoma locations for pCFL participants ($\chi^2 = 9.98$, $p < .01$), ranging from 0-12% (median=2%) at non-scotoma locations and 8-47% (median=30%) for scotoma locations.

Overall, pCFL participants had collision risk for 7% to 30% (median= 10%) of pedestrian appearances. Controls were at risk for 0-4% (median=2%) of all pedestrian appearances.

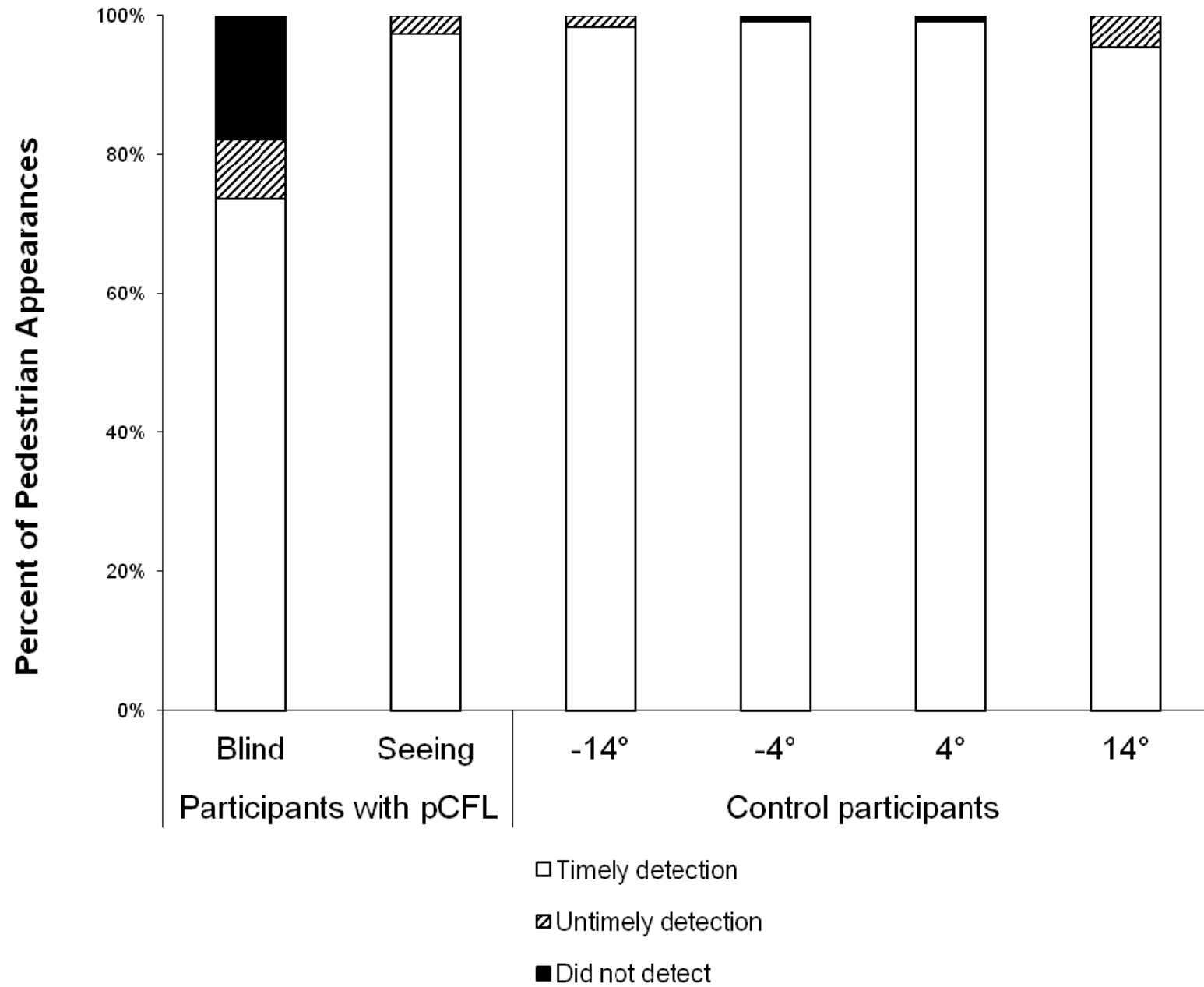
Reaction Times

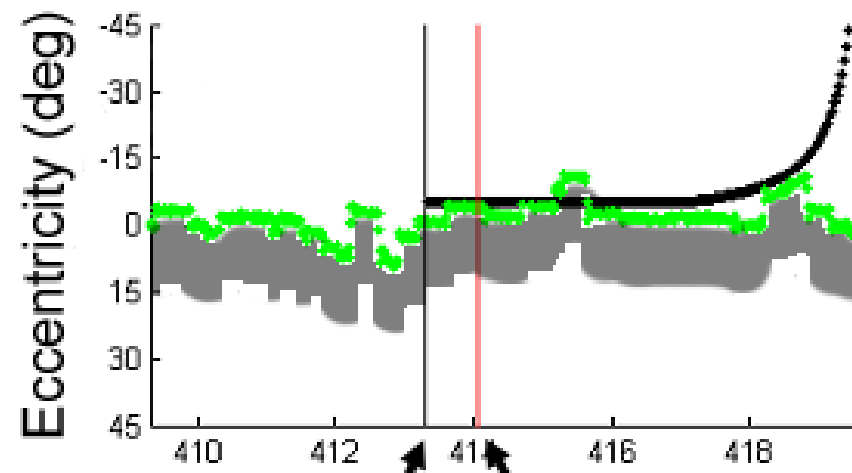
Participants with pCFL show clear deficits in scotoma areas.



Potential Collisions

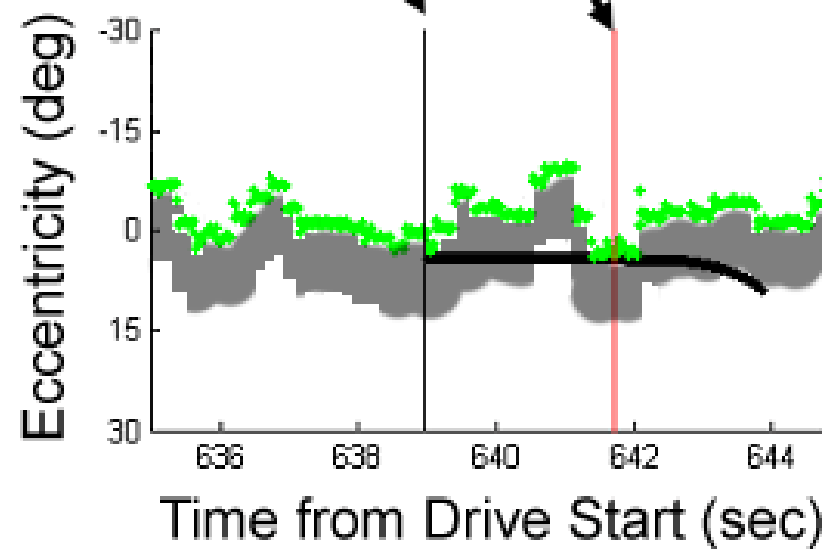
Participants with pCFL show clear deficits in scotoma/ blind areas.





Pedestrian
Appeared

Participant
Honked



Time from Drive Start (sec)

Discussion

Results are in agreement with hypotheses; central visual field loss increases reaction time to potential hazards. Participants did not adequately compensate for field loss enough to reduce this deficit.

This is not without precedent; visually-impaired people primarily attend straight ahead while walking (Vargas-Martín & Peli, 2006), normally sighted drivers tend to stare straight down the road while driving (Underwood, 2007).

Potential collision analysis illustrates the potential real-world significance of the reaction time deficit, but makes several assumptions: 1) 4m/s^2 deceleration is conservative; 2) participants might steer around the hazard; and 3) pedestrian intrusions more frequent than in the real world.

Results are further evidence that visual field deficits should be considered in fitness to drive.

References

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