Eye Movement Patterns of Walking Hemianopic Patients

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Abstract

Purpose: To measure and analyze the pattern of eye movements of patients with homonymous hemianopia while walking for an extended period. This information should help in the design of mobility visual aids for these patients.

Method: We measured the eye position of people while they walked in unfamiliar environments. Three homonymous hemianopia patients (CH1 and CH2 complete, and IH3 with partial recovery of 20°×10° in the lower hemianopic field) were tested indoors and outdoors (city street) and were compared with three normally sighted observers. A head mounted eye-tracking device (ISCAN) was used to record eye position with reference to the head. Spatial histograms of eye angular position were calculated. Kinetic perimetry and fixation stability during static perimetry were measured in patients with a Scanning Laser Ophthalmoscope (SLO).

Results: Patient CH1 demonstrated steady fixation in the SLO. The other two patients showed dynamic horizontal scanning displacements of the point of regard when they were asked to fixate in the SLO. Eye position distributions while walking appeared to be shifted slightly towards the seeing side for patients with complete hemianopia.

Conclusions: Preliminary data indicate that field enhancement devices should allow for an essentially normal range of eye scanning (± 15 degrees).

Introduction

Patients with homonymous hemianopia may have difficulties with reading, detection of stimuli and finding objects. Mobility may be affected because they are unaware of objects, persons and hazards on their blind side, and they may need more time to perceive the whole scene.

Due to the lack of awareness of visual stimuli on the affected side, hemianopic patients may have difficulty directing their gaze into the blind hemi-field. This may manifest as an asymmetry of scanning eye movement behavior, such as has been reported for reading and fixation tasks.

Several optical aids (prisms, mirrors, peripheral prisms) have been proposed for hemianopia, bringing information from the blind hemi-field onto the seeing retina. In addition, training of (horizontal) visual scanning to improve visual search performance has been suggested. The idea of training is to force large saccades towards the affected side, thus increasing the effective visual field. This strategy would have significance for daily mobility tasks, however eye movement behaviors of hemianopic patients during walking have never been investigated.

Knowledge of eye movement patterns during walking is of importance in the design and correct adaptation of visual aids for patients with hemianopia. We report preliminary data on the scanning patterns of hemianopic patients while walking in unfamiliar surroundings.

Methods

Subjects
- **Three patients with homonymous hemianopia:**
  - CH1 (male-72 years) and CH2 (female-52 years) had complete hemianopia
  - IH3 (male-73 years) had partial recovery of 20°×10° in the lower hemianopic field
  - Visual acuity was normal; No macular sparing; Unaided mobility.

- **Three normally sighted subjects (**males 65 – 72 years**) used as controls**

Visual fields
- Kinetic and static perimetry performed using a Scanning Laser Ophthalmoscope (SLO).
- **Figures 1a, 2a and 3a**

Fixation behaviour
- Fixation behavior of hemianopic subjects assessed during static perimetry with the SLO.
- Fixation behaviors illustrated by the distribution of black crosses in **Figures 1b, 2b and 3b**
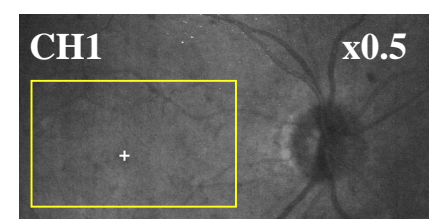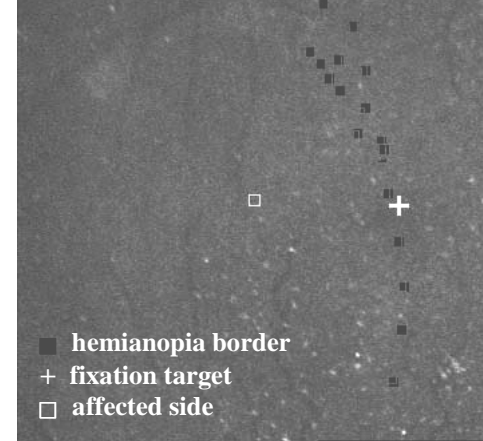
Eye movements recording:

- Eye position of patients and controls measured while they walked in unfamiliar environments (indoors and outdoors on a city street) for an extended period (30 min. approx.).
- Head mounted video eye-tracking device (ISCAN) modified to be portable and used to record eye position with reference to the head.
- Signal recorded into a palm-size digital camcorder.
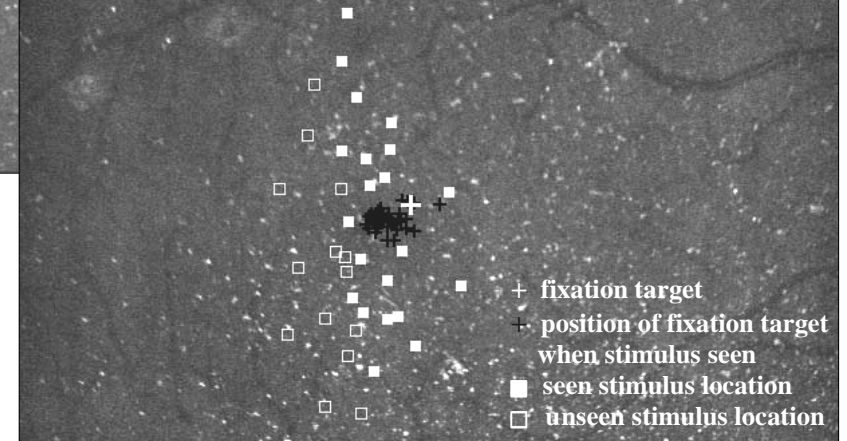
Data analysis:

- Eye image data processed using a dark pupil tracking algorithm (ISCAN) that provided pupil center positions and pupil diameter.
- Some false measurement values (blinks, lack of or too much illumination, corneal reflex, and erratic values) resulted from the uncontrolled environment and the duration of the experiment.
- False position data were discarded based on criteria of pupil diameter (absolute limits and difference from the average diameter of the surrounding 1000 frames @60Hz) and anatomical limits of eye position.
- Conversion to angular position was derived from a 9-point fixation calibration procedure performed in the lab and repeated during the walk.
- Spatial histograms of eye angular position calculated using 2°×2° binning, presented as 3D mesh and horizontal frequency representations in **Figures 4-7**
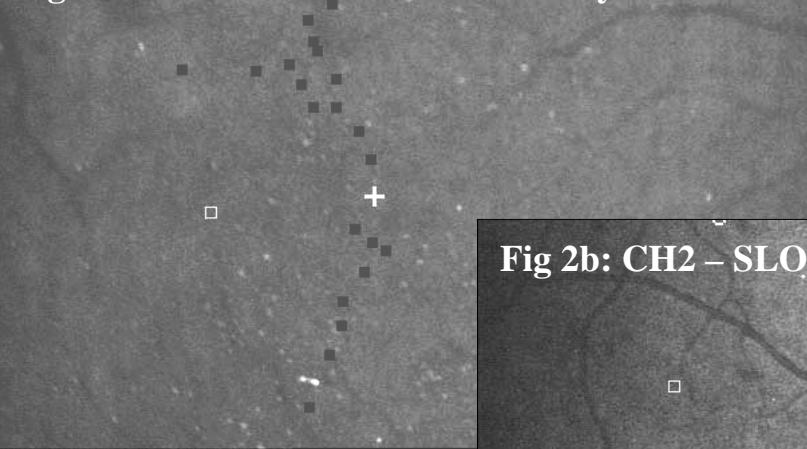

Fig 1a: CH1- SLO Kinetic Perimetry x2

CH1 x0.5

OD - Left complete hemianopia

■ hemianopia border
+ fixation target
□ affected side

Fig 1b: CH1 – SLO Static Perimetry x2

CH1 demonstrated steady fixation during perimetry

+ fixation target
+ position of fixation target when stimulus seen
■ seen stimulus location
□ unseen stimulus location
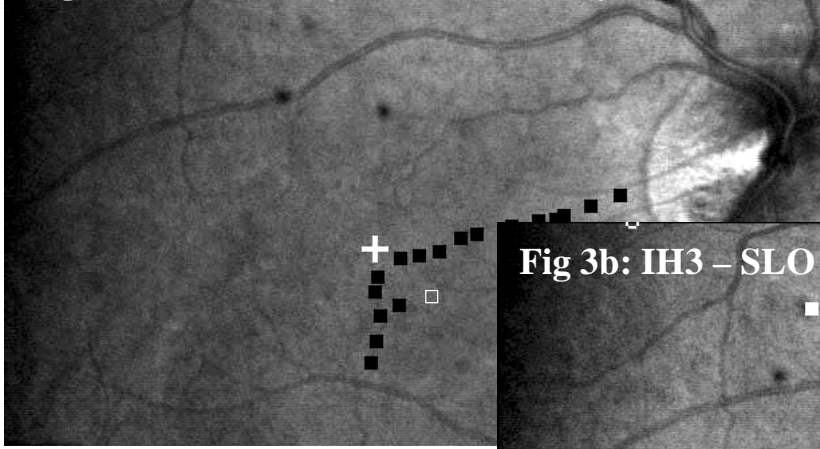
Fig 2a: CH2 – SLO Kinetic Perimetry x2

OD - Left complete hemianopia

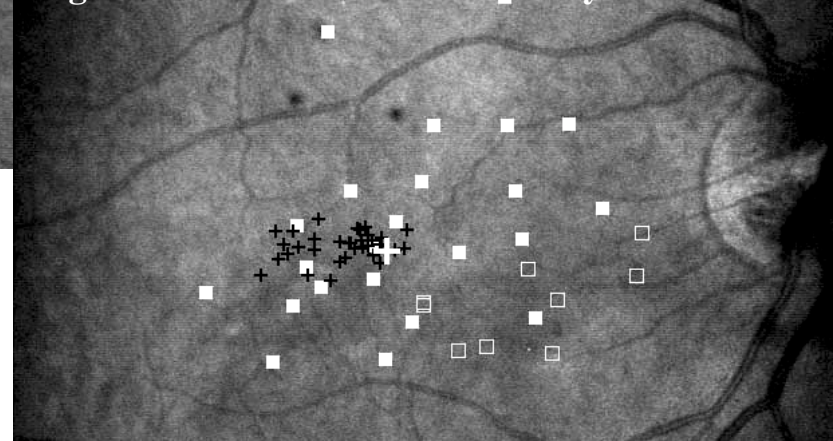Fig 2b: CH2 – SLO Static Perimetry x1
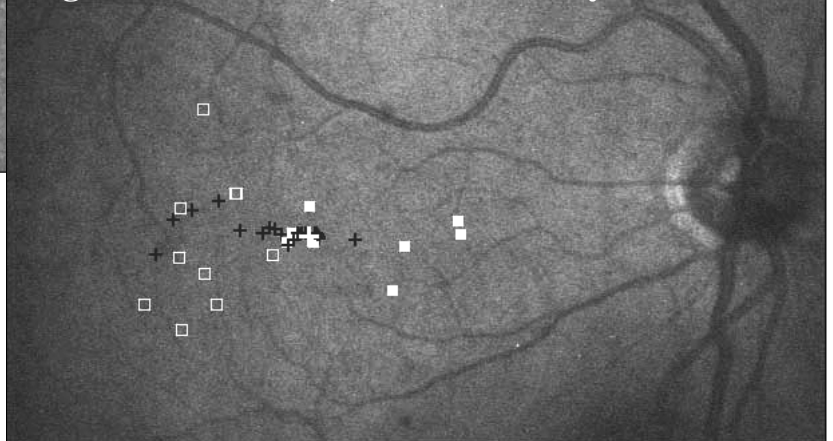
CH2 demonstrated a horizontal scanning pattern (note spread of black crosses along horizontal meridian) when asked to fixate the bright cross in the SLO.

Fig 3a: IH3 – SLO Kinetic Perimetry x1

OD - Right incomplete hemianopia with lower right field recovery

Fig 3b: IH3 – SLO Static Perimetry x1

IH3 demonstrated horizontal scanning when asked to fixate in the SLO

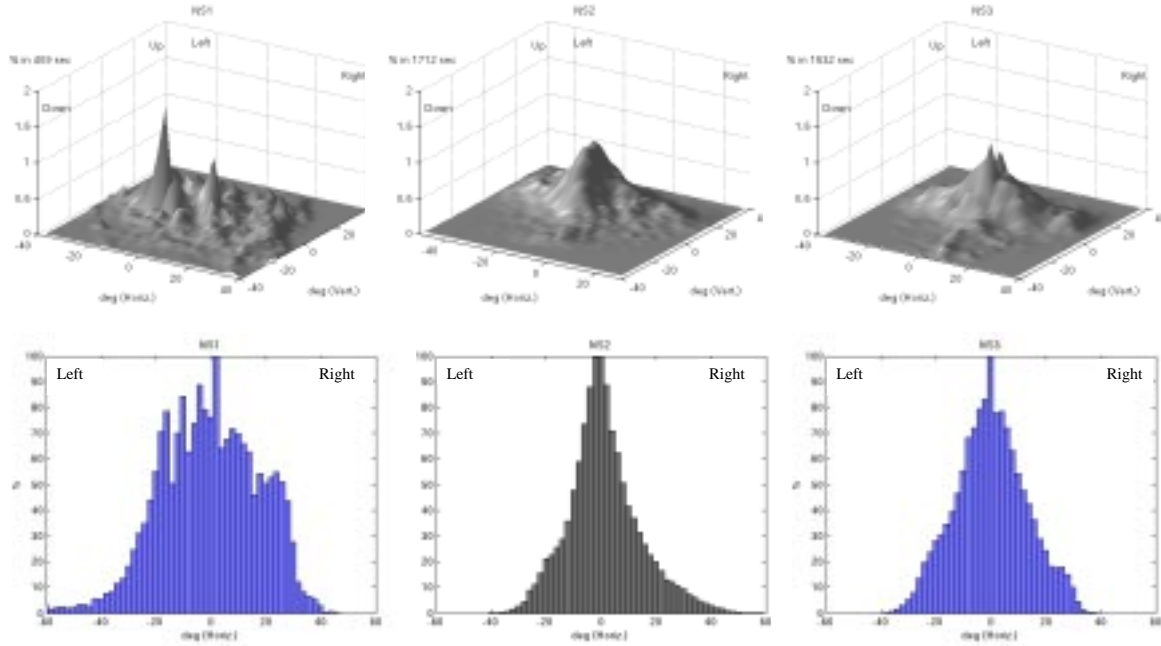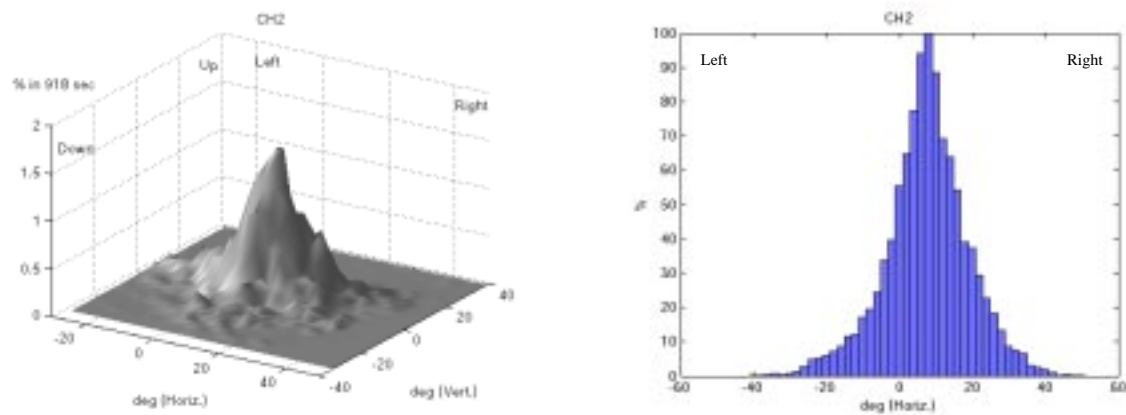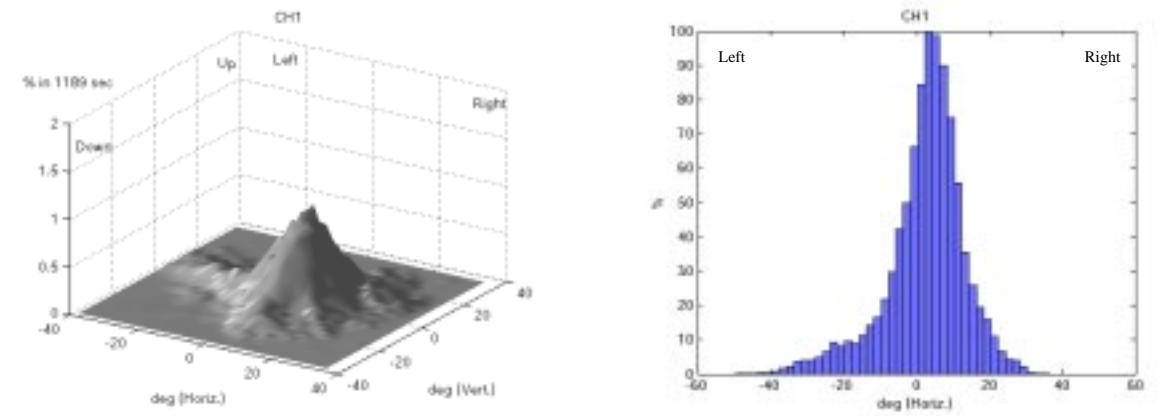**Fig 4: Spatial Histograms of Eye Angular Position - Normally-Sighted Subjects**


Fig 5: Patient CH1 – Left Complete Hemianopia

Eye position distribution appears to be shifted slightly towards the seeing field (to the right). There appears to be a longer tail towards the blind side (to the left).

Fig 6: Patient CH2 - Left Complete Hemianopia

Eye position distribution appears to be shifted slightly towards the seeing field (to the right).

Fig 7: Patient IH1 - Right Incomplete Hemianopia with lower right field recovery
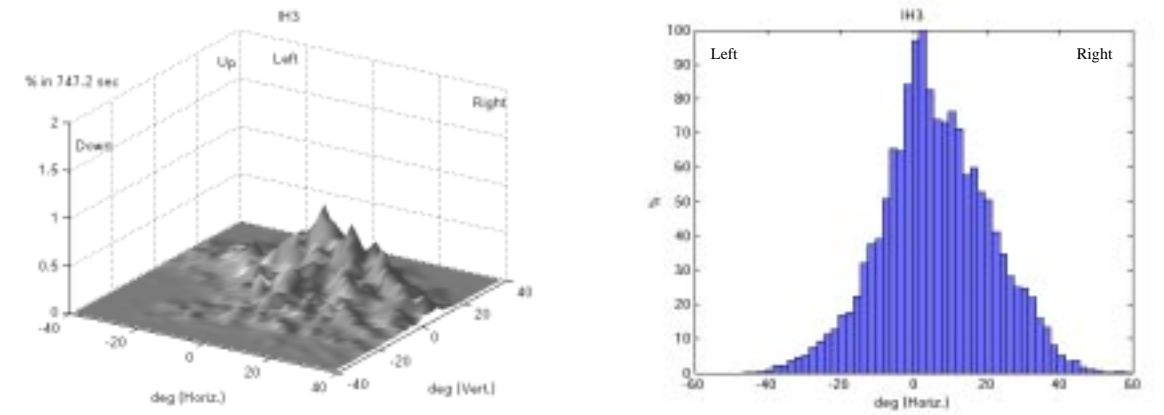
There does not appear to be any obvious shift in the eye position distribution for IH1

CONCLUSIONS

- Preliminary data suggest that, for subjects with complete hemianopia the peak of the eye position distribution is shifted towards the seeing field by a few degrees.
- Fixation stability does not seem to have any obvious effect on the eye position distribution.
- Field enhancement devices should allow essentially normal range of eye scanning (± 15 degrees).

ACKNOWLEDGEMENTS

References:

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