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Publication date:
2001

Permanent link:
https://doi.org/10.3929/ethz-a-004266484

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Saccades & Pursuit Eye Movements of Cats
- Induced with artificial and natural stimuli

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Introduction

Eye movements have a crucial influence on analysis and perception of our visual environment. They are normally classified into stabilizing and target searching movements, considered to be controlled by different systems. Here we investigate the interaction of the systems mediating the optokinetic nystagmus (OKN), scanning movements and the vestibulo-ocular reflex using natural visual stimuli. In particular, we test the hypothesis that eye movements elicited by the former two systems are linearly superposed, and investigate the compensation of missing vestibular information by the optokinetic system.

Methods

Eye movements of 3 head fixed cats were recorded using a non contact method (Dual Purkinje Imaging). For details see poster "*Non contact eye tracking on cats*".
The stimuli consisted of: 1) A natural movie (3 minutes) recorded from a camera mounted to a cats head. 2) A sequence of 10 alternating still images taken from natural videos. 3) Gratings (5 ° width) oriented orthogonal to the direction of movement. To induce stabilizing eye movements, these stirmuli were superimposed with slow (6.25 °/sec), middle (12.5 °/sec) and fast (25 °/sec) motion in both horizontal and both vertical directions.

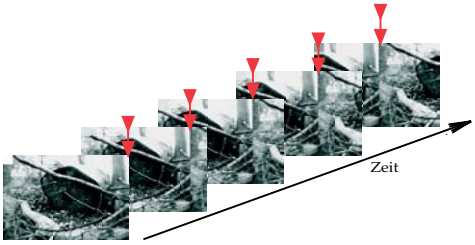


Fig.1.:Artificial motion overlaid to a still image from a cat-cam video.

Eye movements were discriminated into saccades and drifts, depending on their maximal velocity: movements faster than 50/sec were defined as saccades.

Characteristics of Cats' Saccades

In contrary to primates cats make relatively few saccades (about every 2 sec) and their amplitude range is much more restricted. This points to a more prominent role of slow drifts of the eyes and head movements in analyzing visual scenes.

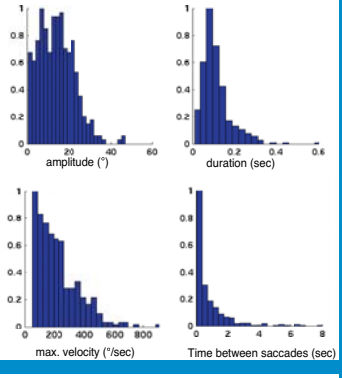


Fig.2: shows the distribution of amplitudes, durations, maximal velocities and time spans between two saccades when the animal was watching a natural movie sequence.

Eye movements for horizontally moving stimuli

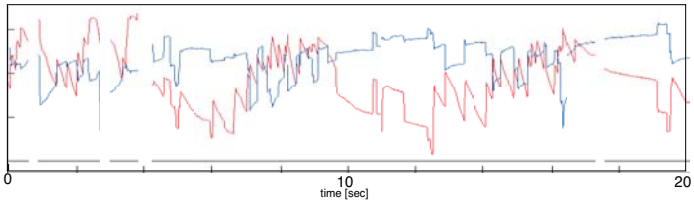


Fig.3: displays the raw data of horizontal (red) and vertical (blue) eye movements for drifting stills. One can clearly recognize an optokinetic nystagmus like effect on the horizontal movement.

Drifting gratings are a classical stimulus for inducing an optokinetic nystagmus (OKN). A similliar effect can be elicited using drifting still images of natural scenes (Fig.3). A direct comparison of saccades and drifts between these stimuli shows that the natural stills have an even stronger effect on the OKN than gratings (Fig.4).

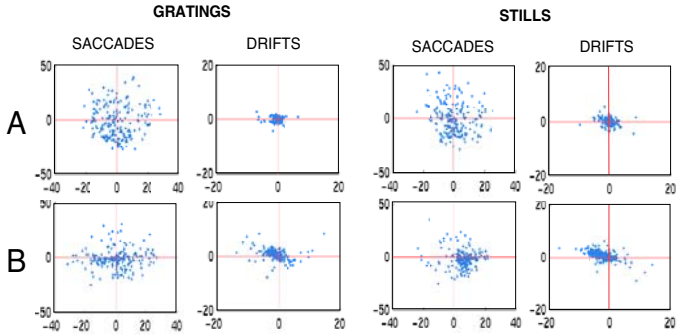
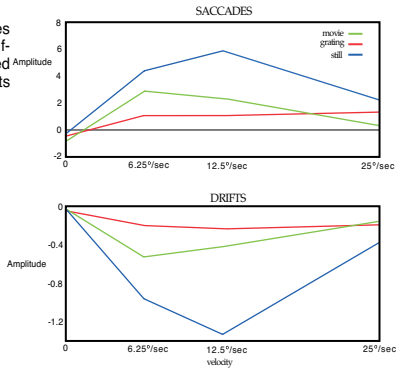


Fig.4: Distribution of saccades and drifts between saccades for still images and gratings, stationary (row A) and moving at 12.5 °/ sec to the left (row B). Axis are in deg.

No clear difference in eye movement patterns can be seen for stationary gratings and stills. For moving stills on the other hand nearly all drifts follow the motion of the stimulis and their amplitude is much larger than for gratings of the same speed. Comparing the distribution of saccades shows that stills evoke more stereotyped pattern of eye movements.

Fig.5 shows the median of the saccades and drifts for leftward moving stimuli of different speeds. The median was computed over about 1000 eye movements of 3 cats for each stimulus.

Still images of natural scenes have the largest effect on both drifts and saccades. Furthermore their maximal effect occurs at a faster velocity than for gratings (12 compared to 6 /sec).



Eye movements for vertically moving stimuli

Comparing upward and downward shifted stills shows a clear asymmetry: downward motion does not elicit an OKN like effect (Fig.6) which might be linked to a neglect of flow fields during walking of the animal. The difference between gratings and stills is less expressed than for horizontally moving stimuli.

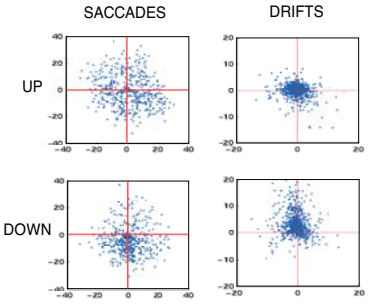


Fig.6: Distribution of saccades and drifts for vertical moving stills (16 °/sec).

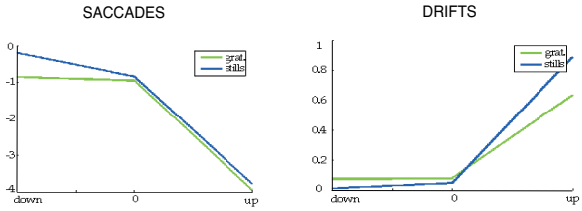


Fig.7: Median of the distribution of saccades and drifts for up- and downwards shifted stills.

Conclusion

- The interaction of the systems mediating the OKN and scanning movements is synergistic, in so far as compared to classical gratings the richer image structure stimulating scanning movements supports the OKN with a gain closer to 1 and up to higher image velocities.
- When the visual stimulus matches natural conditions (movie) the OKN can not compensate a missing vestibular information and pursuit movements are far less than elicited by globally moved still images.