# The Control of Gaze in Dynamic 1/f-Noise Displays

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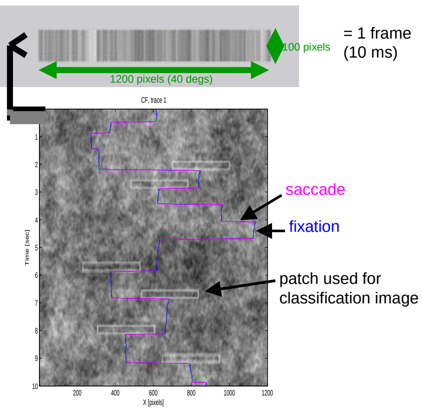
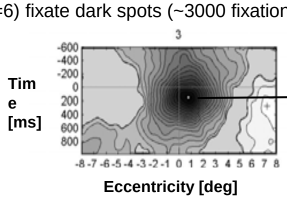
## Introduction

Gaze behavior has been investigated either in laboratory conditions (static, unnatural displays) yielding 'clean' data, or in natural environments (dynamic, uncontrollable input) yielding 'complex' data. In our study, we aim at stimuli mimicking dynamic (natural) input in laboratory conditions by using a dynamic noise display whose **1/f frequency spectrum** is similar to the one of natural images (Field 87, Simoncelli & Olshausen 01). Specifically, the dynamic noise consists of a flickering bar-code whose frames are taken row-wise from a 1/f-noise image (=1 trial=10secs):




## Free Viewing

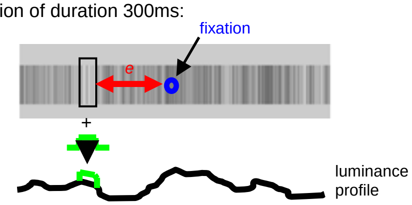
What are the patch characteristics for fixation selection during free viewing? Viewing instructions were: 'be inspired'. A **classification image** analysis (Ahumada 02) reveals that all observers (N=6) fixate dark spots (~3000 fixations):




Using support vector machines (Kienzle et al 06), we determined the **ROC** area values for a fixation/non-fixation analysis. They range from **0.54 to 0.62** and are almost as large as the ROC values determined for natural scenes (Peters et al 05, Tatler et al 05). Hence, the dynamic noise movie is a reasonable approximation to real-world conditions.

## Visual Search

We are particularly interested in markers (oddity target) which were **just-noticeable** and whose amplitude was **proportional to gaze eccentricity** to compensate for the peripheral, exponential decline in visual acuity. Markers are added as a finite-pulse function of duration 300ms:



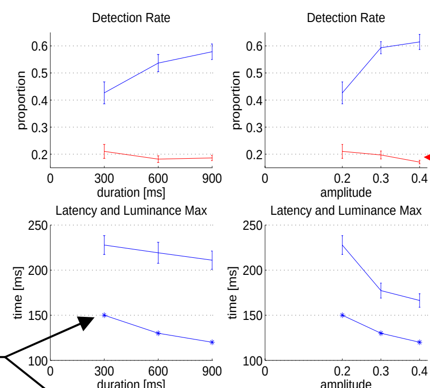

Marker amplitude: $a_{mrk} = a_{min} + a_{max} - exp(-e)$

$a_{min}$ : minimum amplitude

$a_{max}$ : maximum amplitude

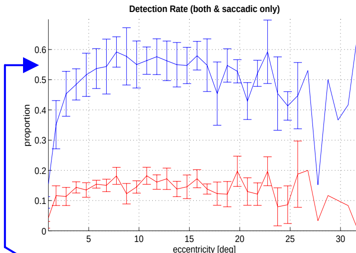
e : eccentricity

Subjects were asked to press a button when seeing such a marker. **Detection rate** is determined as proportion of foveation (eccentricity-dependent tolerance) including accompanying manual response. We systematically manipulated marker duration (300, 600, 900ms, left two graphs) and minimal amplitude (0.2, 0.3, 0.4, right two graphs):

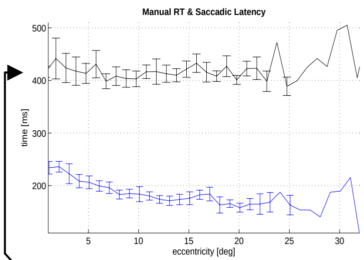



1) The luminance maximum of the classification image covarys with latency. Is saccadic decision time flexible?

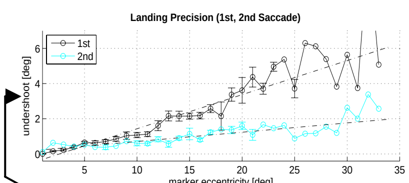
2) There were saccadic detections (foveation) without button press.



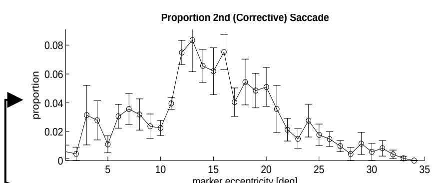

The detection rate (foveation & manual press) increases initially and later gradually decreases. There was again a number of saccadic hits only.




Manual RT remains constant, saccadic latency resembles the Bowl function (Kalesnykas, Hallett 94).




Undershoot linearly increases with marker eccentricity (m=0.20, c=-0.62).



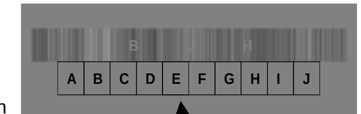

The proportion of corrective saccades is highest around 15 degrees eccentricity.

### Methods

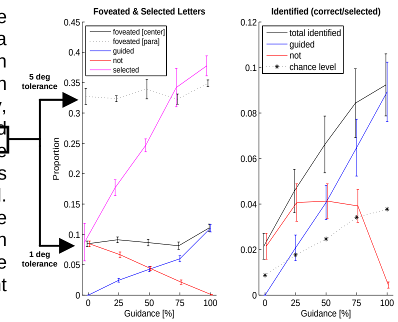
Eyelink II tracker; typically 3-5 subjects; all figures are subject averages (expect the classification image); visual search: 900 markers per subject; cued search: 300 markers per subject.

## Cued Search

Subjects performed a difficult letter detection and identification task with just-noticeable, **temporarily appearing letters (500ms, 0.6Hz).** [Imagine driving along the Autobahn in dense fog and trying to recognize road signs]. Letter selection occurred by mouse continuously (during the trial).




A spatial marker cued the appearance of a letter with a certain frequency per condition (0 to 100% guidance). With increasing cueing frequency, the total proportion of foveated letters hardly increased (!), the number of manual selections in turn strongly increased. Most correct judgments are made when the letter was in the parafovea (<5 deg). The total of identified letters (right graph) increased steadily.




## Summary

1) Dynamic 1/f noise is a reasonable approximation to real-world input (see lower left, free viewing)

2) Saccadic decision time may not be constant but depend on stimulus properties (see how luminance maximum varies with latency [lower left])

3) In a **visual search** task - for which target amplitude depended on gaze distance (eccentricity) - it was shown that detection rate was roughly equal with increasing eccentricity. Manual reaction times remained constant as well, but saccade latencies decreased slightly.

4) The **cued search** revealed that:

**a:** manual selections (identification responses) are encouraged by the presence of cueing (see identification increase for not-cued responses)

**b:** the majority of identification judgments are made when the letter was in the parafovea.

### References

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