



# Oculoceptive fields for smooth pursuit eye movements

Kurt Debono, Alexander C. Schütz, & Karl R. Gegenfurtner

Justus-Liebig-University Giessen

Contact: kurt.debono@psychol.uni-giessen.de

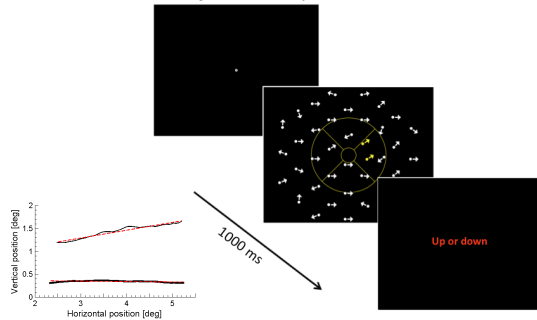


## Introduction

The smooth pursuit system can follow various motion signals by integrating them across a large field to compute direction for the eyes<sup>1</sup>. We wanted to map this integration by describing an 'oculoceptive field' for pursuit, akin to neuronal receptive fields, to shed light on integration properties of the system across space in the visual field.

## Methods

We asked observers to pursue a signal (moving horizontally or slightly upwards/downwards from the horizontal) consisting of coherently moving dots in a random dot kinematogram masked by 80% noise.



In each trial observers pursued the signal (that was converted to a binary up/down decision) then were asked to judge the perceived direction of motion (offset up or down away from the horizontal) in a 2AFC task, to see how closely related the pursuit and perceptual systems are in terms of direction discrimination.

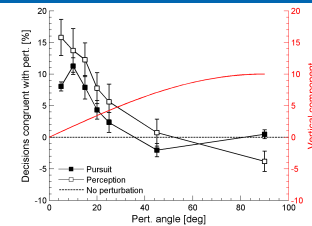
A perturbation (i.e. dots moving coherently in a direction offset from the signal) could be presented in a gaze-contingent region of the stimulus.

## Discussion

- 1) Perturbation angle:** Perturbations were integrated maximally up to a 10° angle offset from the signal. This indicates that the pursuit system takes into account the inertia of the target by assuming that vectors will keep moving along the same trajectory and will not make sharp trajectory changes. However, the system still takes into account small deviations in vector trajectories.
- 2) Perturbation position:** The system integrates best those vectors moving along the pursuit trajectory rather than above or below it as well as those close to the gaze position.
- 3) Pursuit vs Perception:** Both systems had similar integration properties for certain tasks but some differences were also found.

## 1 Perturbation angle

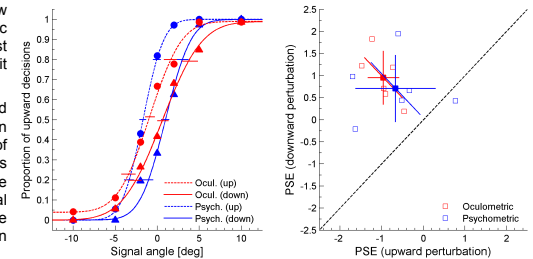
**Methods:** We presented different perturbation angles in front of the gaze position to measure their effect on direction decisions.



**Results:** The left fig. shows that the highest agreement between decisions and perturbation direction coincided with a perturbation angle close to the signal for all observers.

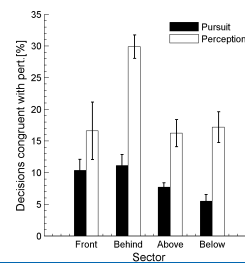
**Methods:** We investigated how psychometric and oculometric functions were affected by the most salient perturbation angle for pursuit (+/-10°).

**Results:** Oculometric and psychometric functions (shown in middle fig.) shifted in the direction of the perturbation. The shifted curves were parallel showing little change in precision for different signal angles. The effect of the perturbations on the PSE is shown for all observers (right fig.).



## 2 Perturbation position

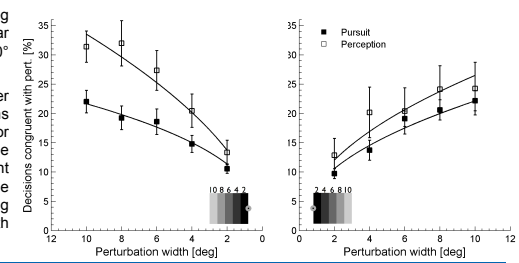
**Methods:** We presented a perturbation in front of, behind, above, or below the gaze position.



**Results:** Perturbation in front and behind gaze position had a stronger effect on pursuit direction discrimination. Perturbation behind gaze position had a much stronger effect on perceptual direction discrimination.

**Methods:** We varied the width (in 2 deg steps) and eccentricity of a rectangular perturbation region (with a +/-10° perturbation) along the pursuit trajectory.

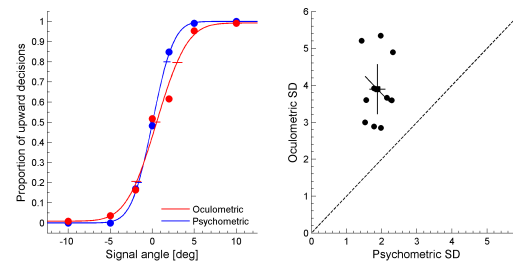
**Results:** The right fig. show power functions fit to the combined decisions congruent with perturbation direction for perturbations towards and away from gaze position, in order to estimate the weight given to each perturbation eccentricity. The perturbation effect increased with increasing size of the perturbation width and with closer proximity to the gaze position.



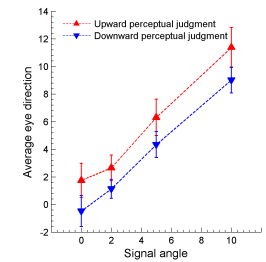
## 3 Pursuit vs perception

**Methods:** We varied the signal angle in order to obtain oculometric and psychometric functions (see left fig. for a representative observer).

**Results:** The PSE for oculometric and psychometric data was similar for all observers. Middle fig. shows that the psychometric functions were steeper overall (n=10).



The fig. on the right shows that the average eye direction across all observers for upward perceptual decisions was consistently above that for downward perceptual decisions for all signal angles. This suggests that perceptual and ocular decisions were not completely independent.



### References:

[1] Watamaniuk SN & Heinen SJ. (1999). Human smooth pursuit direction discrimination. Vision Research 39(1), 59-70.

### Acknowledgments:

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