Detection of speed differences of luminance & color stimuli during fixation & smooth pursuit eye movement

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Doris I. Braun, Alexander C. Schütz & Karl R. Gegenfurtner

Justus-Liebig-University Giessen

Contact: doris.braun@psychol.uni-giessen.de

Introduction

For the detection of speed changes of a single dynamic object during fixation changes of retinal image motion are the only source of information. If the object is surrounded by a structured background or if other dynamic objects are present also relative motion cues are available. Here we are tested whether smooth pursuit eye movements improve the detection of small speed changes of drifting peripheral context stimuli surrounding the pursuit target. Detection thresholds were also measured for fixation.

Pursuit eye movements, which are dependent on retinal image motion, cause a strong change of the retinal image velocities: By stabilizing the tracked object on the fovea, they nullify the retinal motion of this object and objects moving with the same speed in the same direction while for stationary objects retinal motion in the opposite direction is generated. In spite of these confounding effects introduced by pursuit, the perceptual system has to estimate the actual speed and direction of moving objects. Recently we found that pursuit has a positive effect on speed perception of isoluminant peripheral targets. This improvement of speed perception can be explained by additional information resulting from extraretinal signals and comparisons between eye and object velocity

Conditions

Eye Velocity	0	2	10	0	2	10
Pedestal Velocity	2	2	2	10	10	10
Retinal Velocity	2	0	- 8	10	8	0
Pursuit Gain	-	1.01	0.93	-	1.05	1.00

Methods

In a 2AFC design we investigated the sensitivity for speed changes during fixation and pursuit. 4 subjects tracked a central spot target moving horizontally at two speeds (2 & 10 deg/s) or they fixated a stationary central spot. Above and below the pursuit/fixation target, sine wave gratings moved at 2 or 10 deg/s speed. Both gratings were either modulated in luminance (10% contrast) or in red-green isoluminant color. One of the gratings increased or decreased its speed for 500 ms. Subjects had to indicate which grating had changed its speed. Eye movement were measured with an EyeLink II system

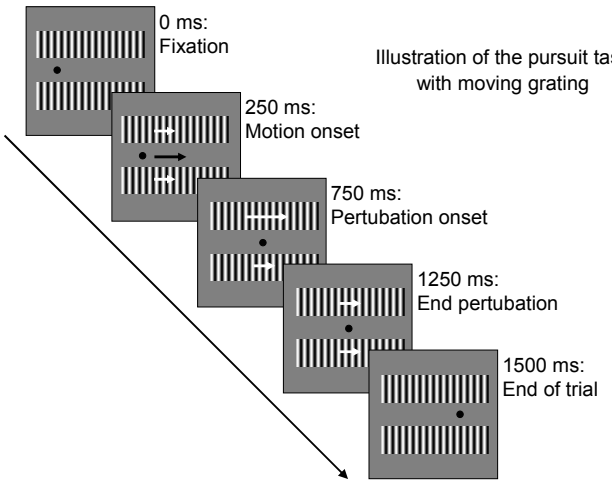

Illustration of the pursuit task with moving grating

Conclusions

Three major results arise from these experiments: (1) The sensitivity for the detection of speed changes is better, if the retinal motion is caused by eye movements compared to retinal motion by object motion. (2) Thresholds for isoluminant motion are only sligthly higher than for luminance motion. (3) Thresholds for velocity increments are higher than for velocity decrements.

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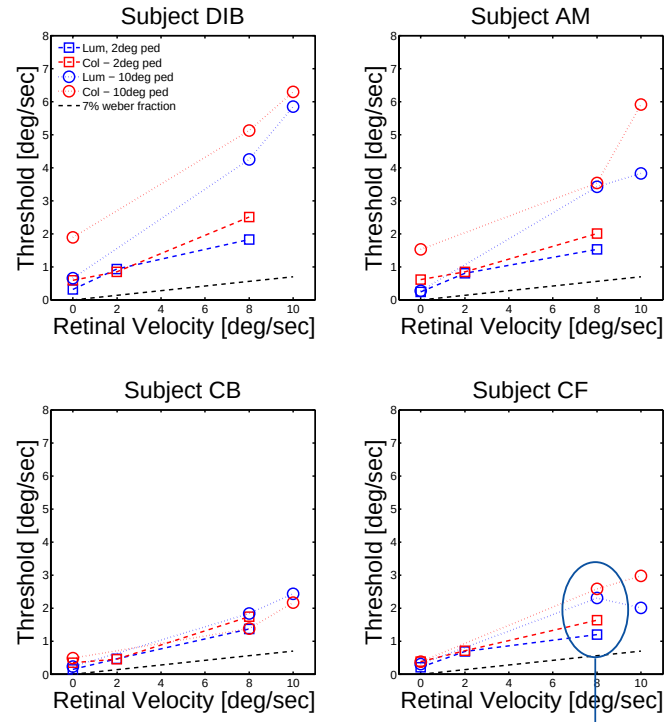
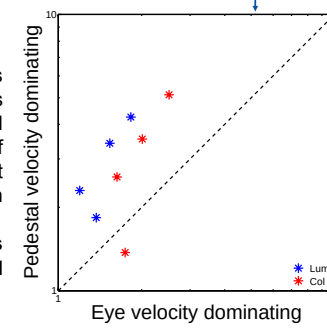
Results



Comparison of thresholds with equal retinal velocities:

At equal retinal velocities, thresholds for the detection of speed changes depend on the origin of the retinal image motion: Thresholds are higher, if the retinal motion is caused by object motion compared to retinal motion caused by pursuit eye movements.

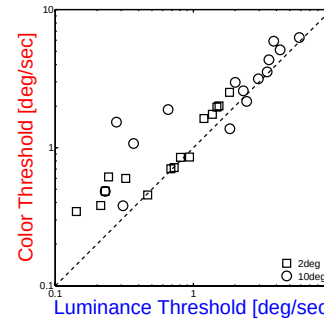
Origin of retinal image motion is important for the detection of speed changes.



Stimulus type:

The thresholds for speed changes depend also on the stimulus type: Thresholds for isoluminant stimuli are always higher than thresholds for luminance stimuli of equal cone contrast.

For isoluminant stimuli speed detection thresholds are slightly higher.



Direction of speed changes:

We find also a threshold difference for speed increments and decrements. One exception are the thresholds for luminance stimuli, with retinal motion opposite to the pursuit direction.

Increment thresholds are in most cases higher than decrement thresholds.