Improved visual sensitivity during smooth pursuit eye movements

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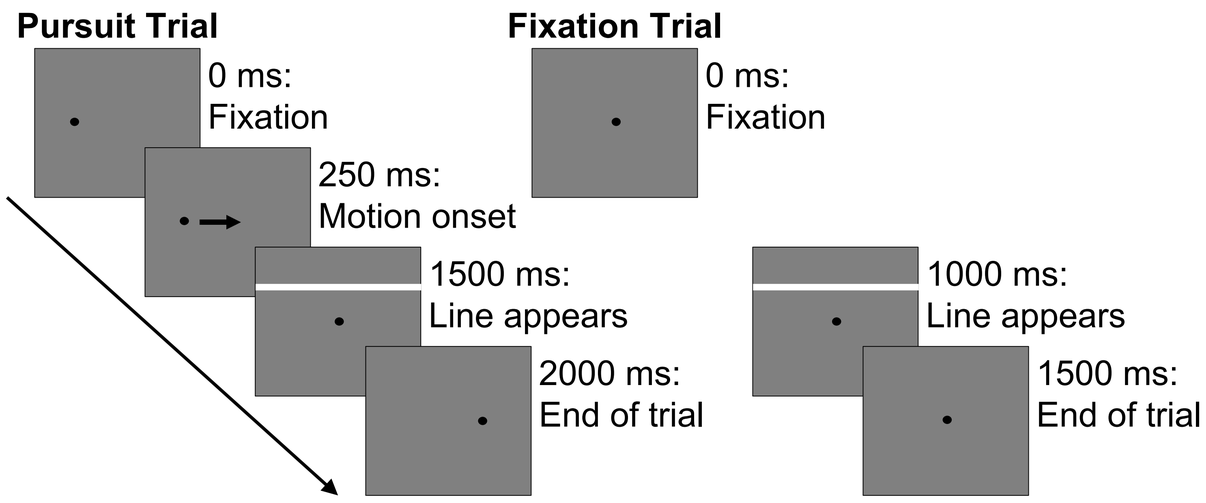
Introduction & Methods

Movements of the eyes do have negative effects on visual perception. During saccadic eye movements, for example, suppression has been reported for stimuli being processed in the magnocellular system[1], while at the same time the visual world is compressed towards the saccade target[2]. We explored the possibility that similar effects would surface during smooth pursuit eye movements. The sensitivity for peripheral luminance stimuli is suppressed during pursuit, probably due to the binding of spatial attention to the pursuit target[3]. Here we investigate the sensitivity for chromatic stimuli.

We measured the sensitivity for color and luminance stimuli during pursuit and fixation. Subjects had to track a spot target that was stationary (fixation) or moved horizontally (pursuit) with a velocity of 10.57 deg/s. Contrast sensitivity was measured by means of a blurred 0.3 deg wide horizontal line that appeared for 10 ms 2 deg above or below the pursuit trajectory. The line was defined by an increment or decrement in luminance or in isoluminant red-green color. A staircase procedure was used to find the contrast level at which the subjects could either just tell whether the line was presented above or below the pursuit target (detection), or at which they could just indicate whether the line appeared black, white, red or green (colour naming).



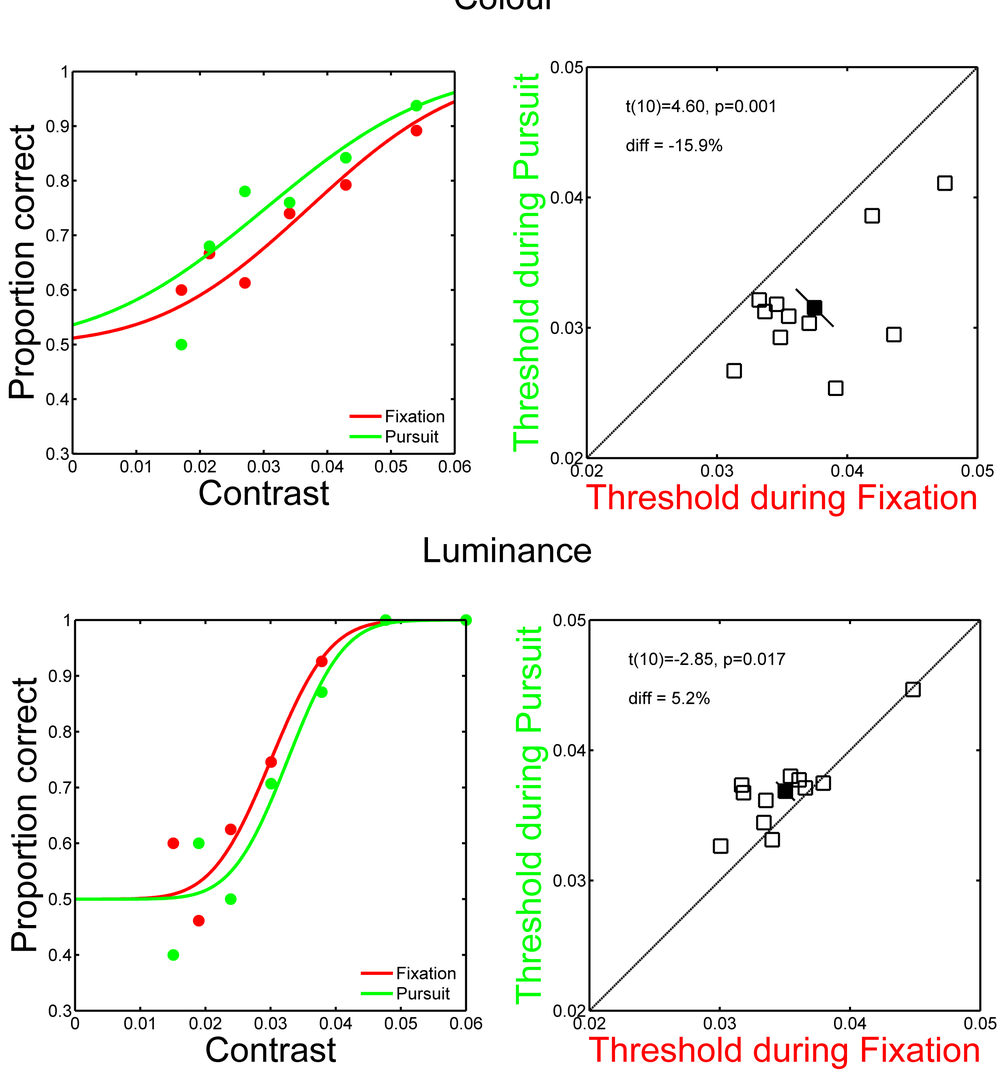
References:
[1] Burr, D.C., Morrone, M.C. & Ross, J. Selective suppression of the magnocellular pathway during saccadic eye movements. *Nature* 371, 511-513 (1994).
[2] Ross, J., Morrone, M.C., & Burr, D. C. Compression of visual space before saccades. *Nature* **386**, 598-601 (1997).
[3] Schütz, A.C., Delipetkos, E., Braun, D.I., Kerzel, D., & Gegenfurtner, K.R. Temporal contrast sensitivity during smooth pursuit eye movements. *Journal of Vision*, in press (2007).
[4] Schütz, A.C., Braun, D.I., & Gegenfurtner, K.R. Contrast sensitivity during the initiation of smooth pursuit eye movements. *Vision Research*, 47, 2767-2677 (2007).

Acknowledgments:
We thank Stefanie Bader, Maria Höfer and Elisabeth Baumgartner for help with data collection. This work was supported by the DFG Forschergruppe FOR 560 “Perception and Action” and the DFG Graduiertenkolleg GRK 885 “NeuroAct”.

Results & Conclusion

Peripheral Sensitivity

The detection thresholds for chromatic stimuli (top) were lowered during smooth pursuit on average by **16%** compared to fixation. For achromatic stimuli (bottom) in contrast the thresholds were on average **5%** higher during pursuit than during fixation. Colour naming thresholds followed the same pattern.

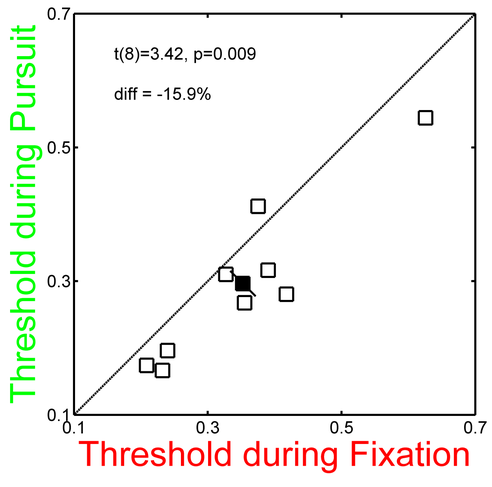


High Spatial Frequency

To investigate if the improvement is specific for the parvocellular pathway, we measured foveal sensitivity for an achromatic square wave pattern with a spatial frequency of 14 cpd.

For these stimuli we also obtained a **16%** improvement during pursuit compared to fixation.

As the sensitivity improvement occurs for colour and high spatial frequencies, we conclude that the parvocellular pathway is selectively enhanced.

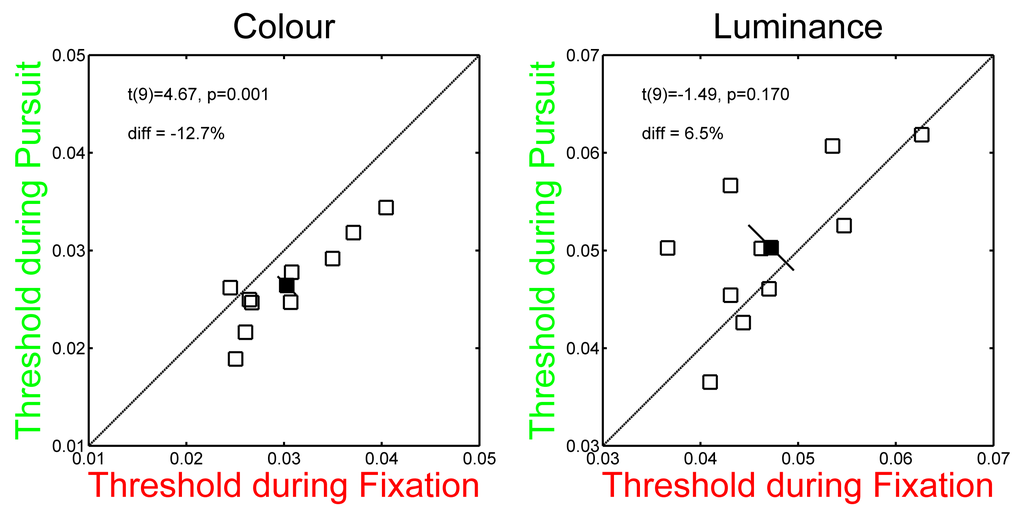


Foveal Sensitivity

To investigate, if the sensitivity enhancement depends on spatial location, we measured contrast sensitivity in the fovea. We presented the chromatic line (left) and the luminance line (right) vertically centered on the pursuit trajectory and asked the subjects to indicate the hue of the line.

Again the thresholds for chromatic stimuli were lowered during pursuit by **13%** compared to fixation. Therefore spatial location seems not to have any influence on the sensitivity enhancement during pursuit.

For foveal luminance stimuli, we did not find any significant threshold difference between pursuit and fixation. This indicates that the impairment for peripheral luminance stimuli during pursuit is caused by the binding of spatial attention to the pursuit target.



Pursuit Initiation

Here we flashed a horizontal red line with a fixed contrast at different points in time relative to the onset of a step-ramp target (left). By means of a sliding weighted histogram we calculated the detection rate over the time course of pursuit initiation[4].

The results (right) show an increase of the detection rate approximately **50ms** before the onset of smooth pursuit. This indicates an extra-retinal source of the sensitivity enhancement.