

Object Recognition during Eye Movements



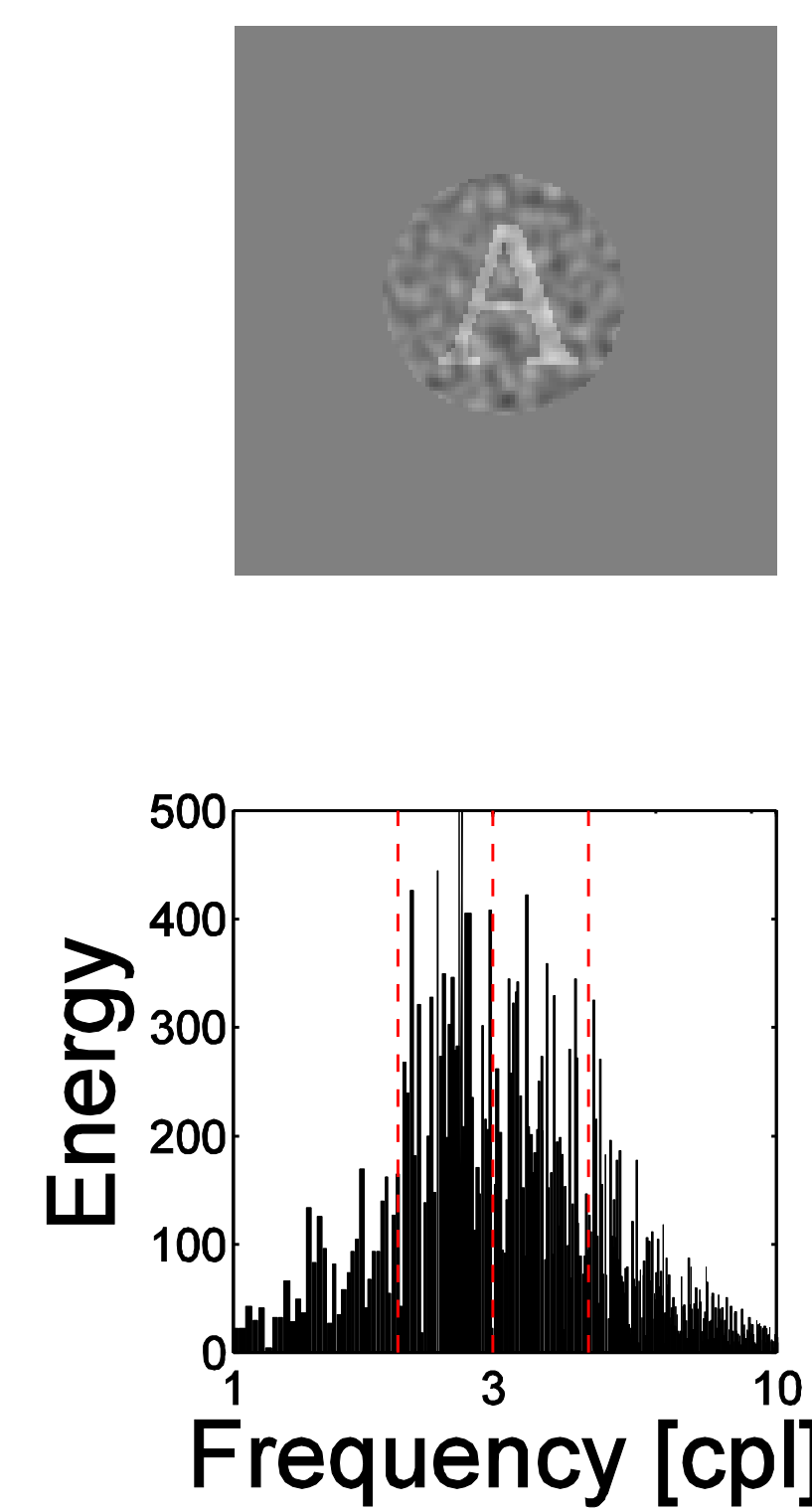
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Introduction & Methods

Primates use saccadic and smooth pursuit eye movements to bring and keep objects of interest in the fovea, the region of highest visual acuity. It is commonly assumed that this behavior aims at improving object recognition. However, these eye movements have also costs, which may hamper perceptual performance. For instance, the luminance sensitivity for low-spatial frequencies is strongly suppressed during saccades [1] and the perception of space [2] and time [3] is distorted. As object recognition occurs very fast [4], we were not only interested in the overall performance during eye movements, but also in the minimal presentation duration of the object.

By varying the duration, contrast and presentation time of single target letters, we investigated how and when saccades and smooth pursuit influence higher level object recognition. Subjects were asked to identify a letter, which was flashed within a circular noise patch presented on a gray background. For each trial this letter was drawn from a sample of 21 upper case Latin letters in the font Bookman old. The letters B, I, O, Q, S & Z were not included. The letters were approximately 1.1 deg high. The patch covered an area of 2 deg diameter; it was defined by a one octave wide band pass filtered noise with a central frequency of 3 cycles per letter (cpl). Previous studies on letter identification showed that this frequency masks optimally letters [5]. The noise contrast amounted 50%. Eye movements were continuously measured with an Eye-Link II.



Summary & Conclusion

Letter recognition is only slightly reduced during the execution of smooth pursuit eye movements. To reach the same performance during pursuit as during fixation the contrast of letters has to be increased or the presentation time of letters has to be prolonged as shown in Experiment 1: For a letter contrast of 10% the duration has to be increased by 8 ms, for a letter presentation time of 20 ms the contrast has to be increased by 4%. This deficit is not due to an increased retinal position or velocity error during pursuit. These findings are replicated in Experiment 2: The temporal dynamics of letter recognition after the execution of the first foveating saccade followed by fixation or pursuit are similar and only slightly reduced for pursuit trials. In both tasks recognition performance increases for at least 150 ms after the saccade.

As the steepest boost occurs during the movement of the saccade, we conclude that this rise is mainly due to declining retinal velocity at the end of the saccade. Since attention is directed to the saccade target even before saccade onset [6], attention deficits can be ruled out. Saccadic suppression is also implausible, because it affects only low spatial frequencies [1], which are not essentially for letter recognition [5].

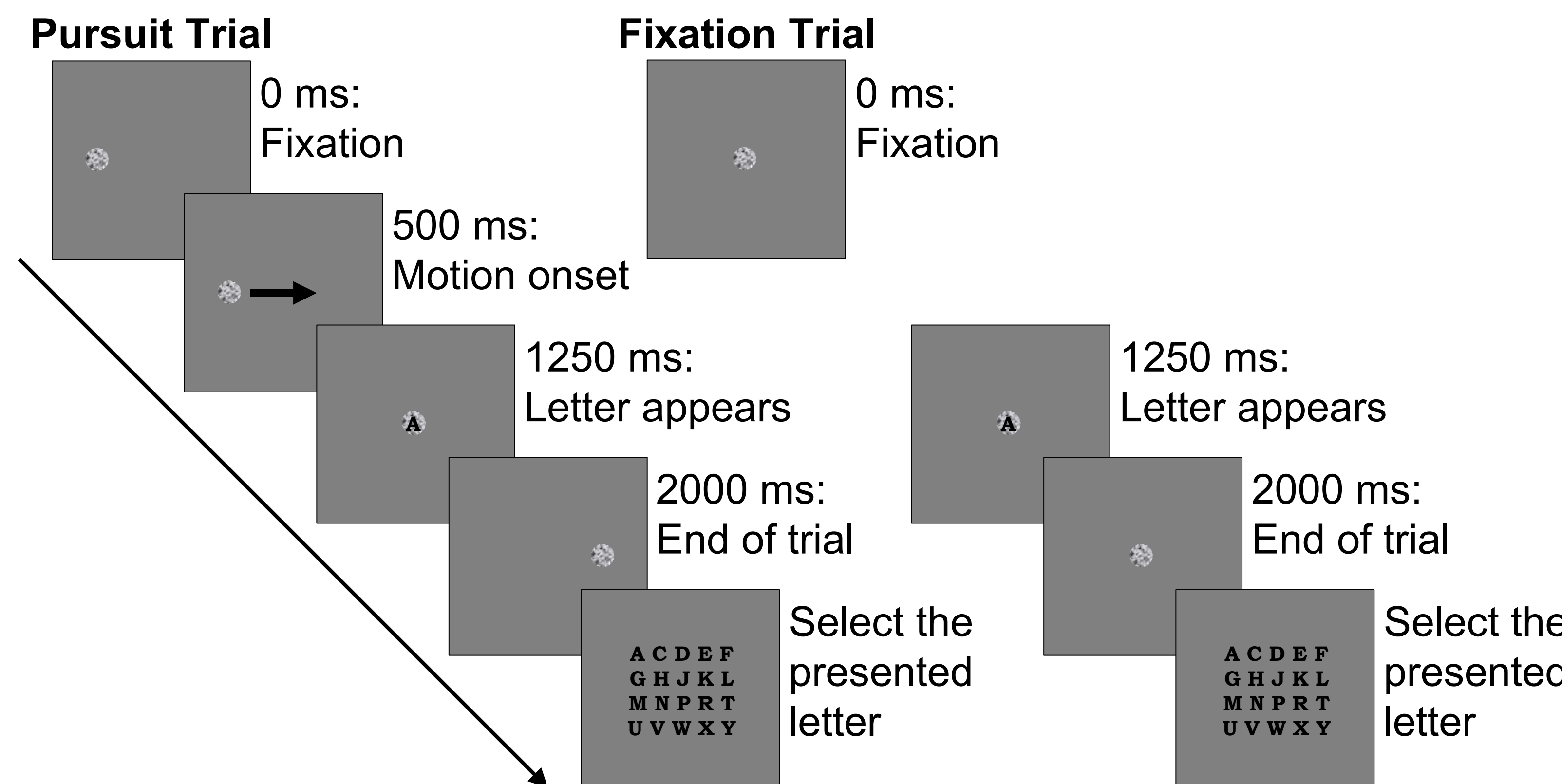
References:

- [1] Burr, D. C., Morrone, M. C., & Ross, J. (1994). Selective suppression of the magnocellular visual pathway during saccadic eye movements. *Nature*, 371(6497), 511-513.
- [2] Ross, J., Morrone, M. C., & Burr, D. C. (1997). Compression of visual space before saccades. *Nature*, 386(6625), 598-601.
- [3] Morrone, M. C., Ross, J., & Burr, D. C. (2005). Saccadic eye movements cause compression of time as well as space. *Nature Neuroscience*, 8(7), 950-954.
- [4] Thorpe, S., Fize, D., & Marlot, C. (1996). Speed of processing in the human visual system. *Nature*, 381(6582), 520-522.
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- [6] Deubel, H., & Schneider, W. X. (1996). Saccade target selection and object recognition: evidence for a common attentional mechanism. *Vision Research*, 36(12), 1827-1837.

Acknowledgments:

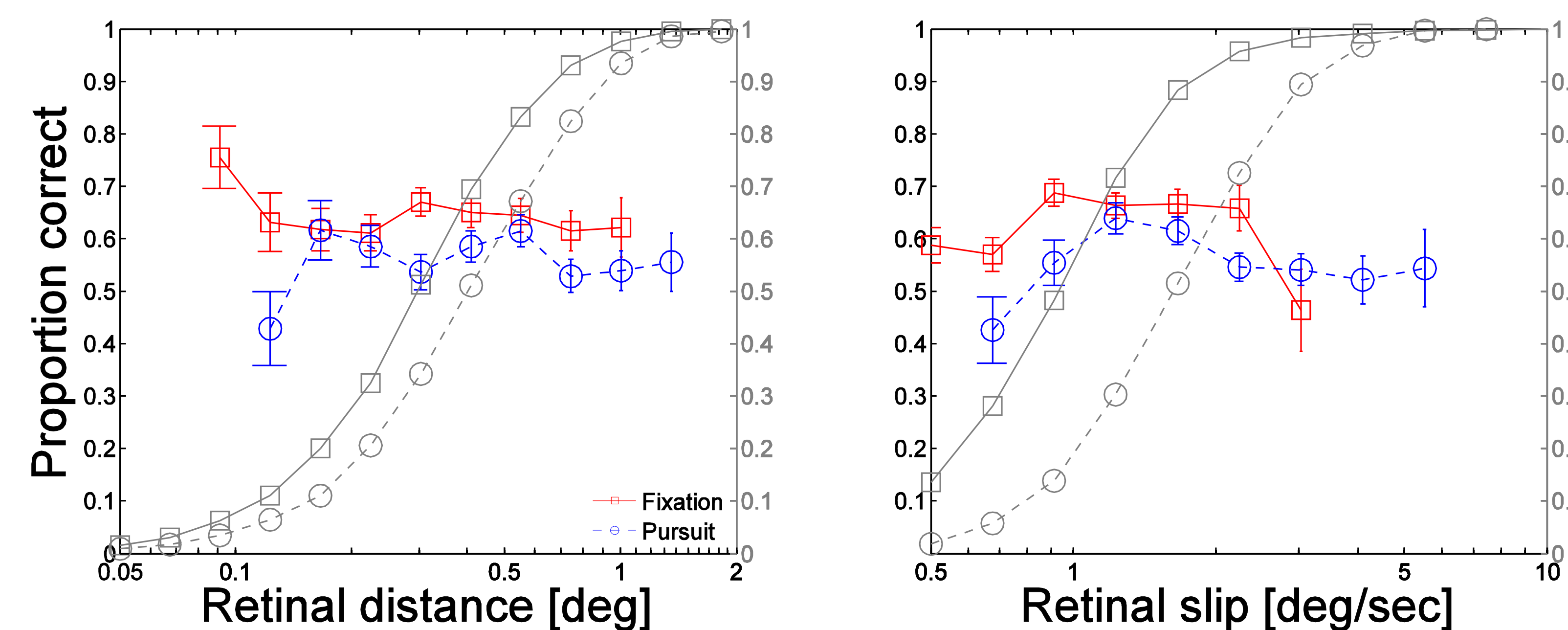
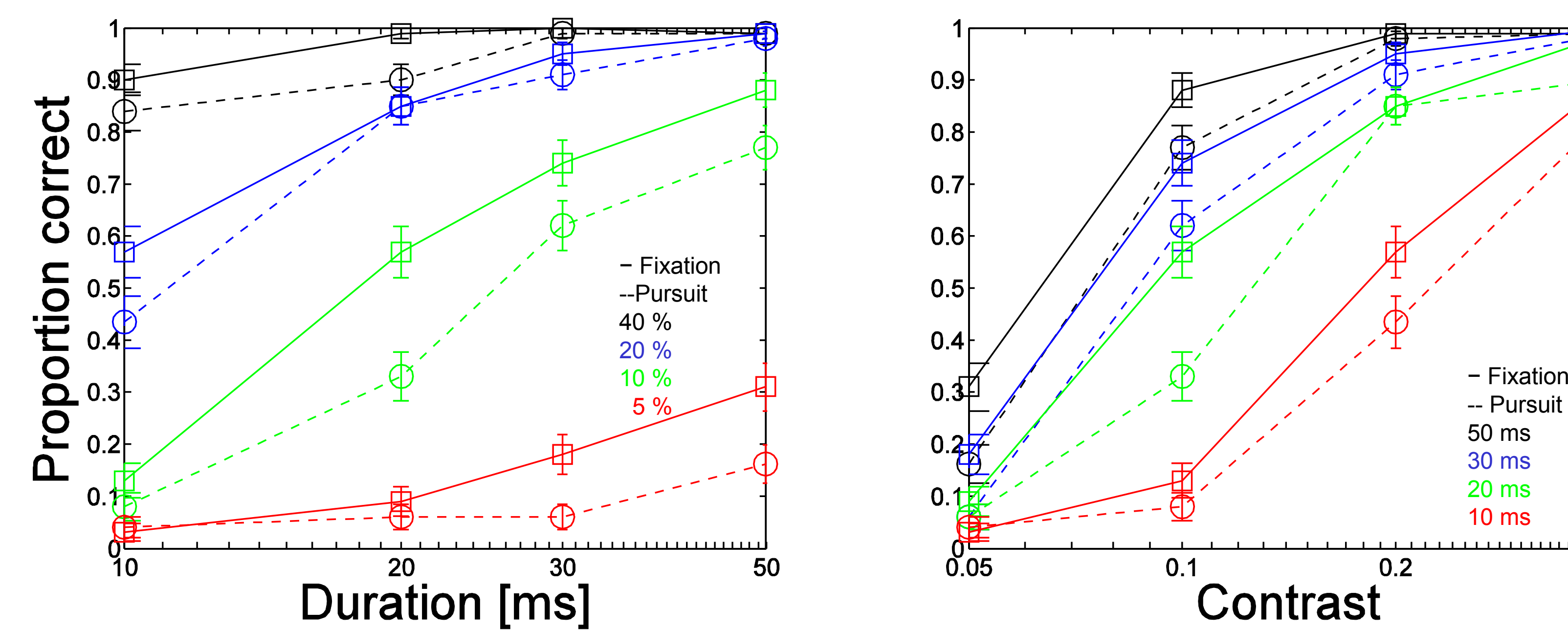
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Experiment 1

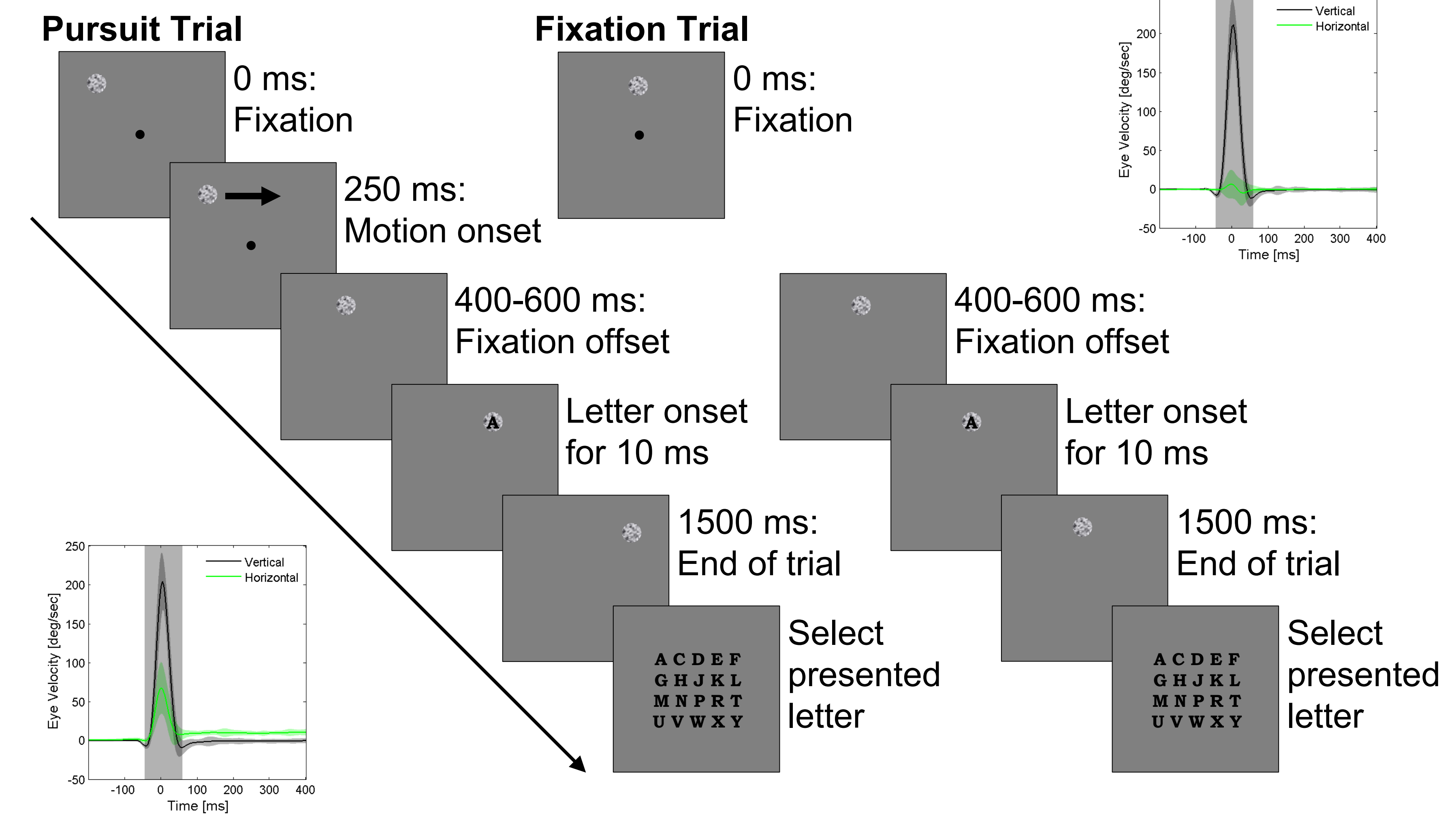


In the first experiment, we compared perceptual performance of letter identification during steady-state pursuit with fixation. In the pursuit task subjects tracked the noise patch moving horizontally with 10.5 deg/sec, in the fixation task they kept their eyes on the central stationary noise patch. We varied the presentation duration (10, 20, 30 & 50 ms) and contrast (5, 10, 20 & 40%) of the letter. All conditions were presented interleaved.

The results show a small disadvantage for letter identification during pursuit compared to fixation. Sensitivity was slightly lower during pursuit in low contrast and short duration conditions. Although retinal position errors and velocity errors were larger during pursuit than during fixation, this was not the reason for the deficit during pursuit.



Experiment 2



In Experiment 2, we were interested in the temporal dynamics of letter recognition after foveating saccades. After the offset of the central fixation spot, subjects had to perform a foveating saccade to the 7.5 deg peripheral noise patch and to pursue it, when it moved horizontally with 10.5 deg/sec (pursuit task) or to keep it fixated, when it was stationary (fixation task). We varied the time of the letter onset relative to the saccade onset from 0 to 350 ms after saccade onset.

Again letter recognition is slightly reduced during pursuit. More interestingly, letter identification performance raised until 150 ms after saccade onset for both tasks. The strongest ascent occurs during the movement time of the saccade. After the saccade, there is only little further increase in performance.

