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The influence of retinal and head-centered motion on perceived duration

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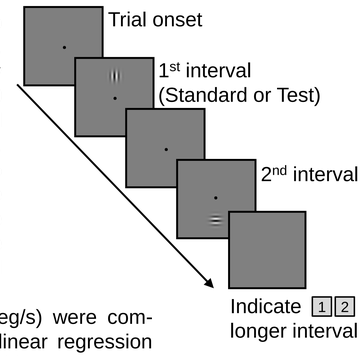
Introduction

The perceived duration of stimuli increases with their temporal frequency [1] or speed [2]. In the brain, motion is encoded in different reference frames: some neurons in areas MT & MST respond to retinal motion and some to head-centered motion [3,4,5]. Here we investigate if perceived duration depends on retinal motion or on head-centered motion, in order to shed light on the neural basis of time perception. Smooth pursuit eye movements were used to disentangle retinal and head-centered motion.

Methods

In a 2IFC-paradigm, observers (n=7) had to judge which one of two stimuli lasted longer. The standard stimulus was a horizontally oriented Gabor and had a fixed duration of 500 ms. The test stimulus was a vertically oriented Gabor and varied between 200 and 1580 ms. Both Gabors had a standard deviation of 0.75 deg, a spatial frequency of 1 c/deg and were randomly presented 4 deg above or below the fixation/pursuit target, which moved in the same way during the standard and test interval to avoid compression by pursuit [6].

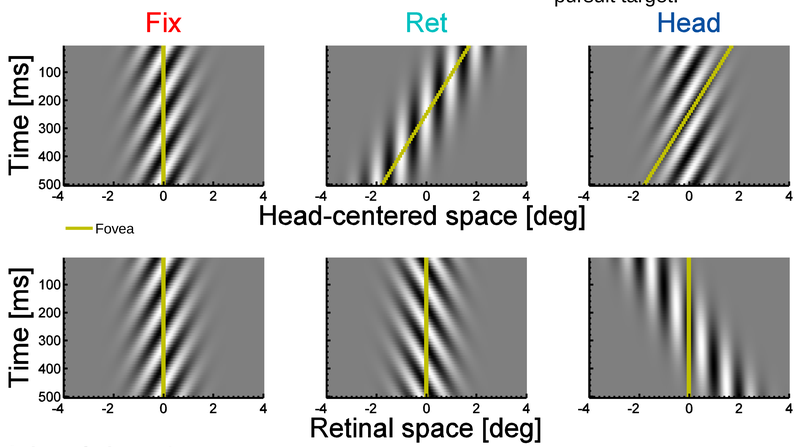


Four different speeds (3.5, 7.0, 10.5, 14.0 deg/s) were compared in three different motion conditions. A linear regression was used to estimate the increase of the PSE with speed.

Fixation: The sinusoid of the test drifted within the stationary Gaussian window. The standard was stationary.

Retinal: The Gaussian window of the test, standard and the pursuit target moved horizontally across the screen.

Head-centered: The Gaussian window was stationary and the sinusoid of the test drifted with the same speed as the pursuit target.

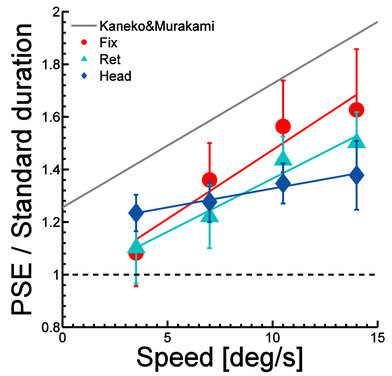


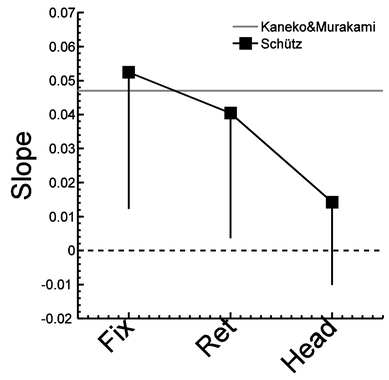
Acknowledgments:

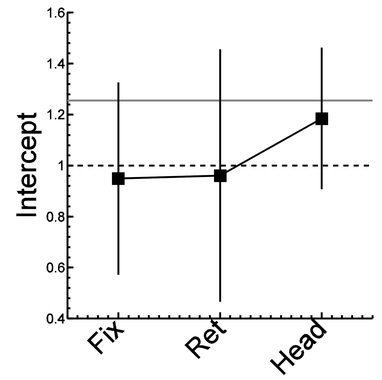
I thank Felix Lossin for discussion, Kurt Debono for participation as a subject and Sarah Jill Wagner and Janika Clös for help with data collection. This work was supported by the DFG Forscher-gruppe FOR 560 “Perception and Action”.

Small-field Gabors

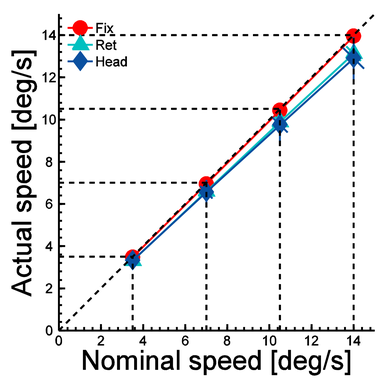
In the fixation condition, perceived duration increased with speed. The slope was similar to the one estimated by Kaneko & Murakami [2]. In the retinal motion condition, perceived duration increased with a similar slope. However in the head-centered condition, perceived duration depended less on speed. Here the slope was not significantly different from zero. All intercepts were not significantly different from unity, but there was a trend for a higher intercept in the head-centered condition.

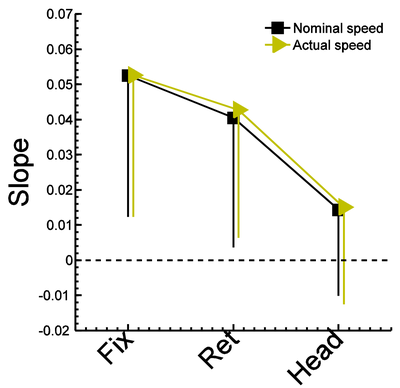






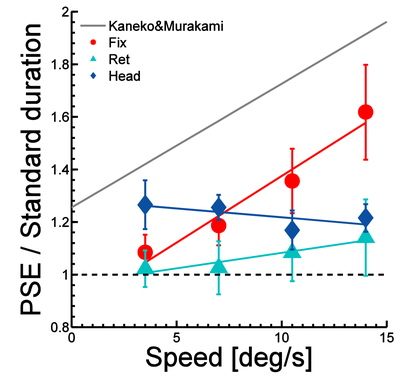
In the retinal and head-centered condition, the speed of the stimuli depended on the speed of the pursuit eye movements. Pursuit was slightly slower than the target speed, but this could not explain the differences in PSE between the experimental conditions.

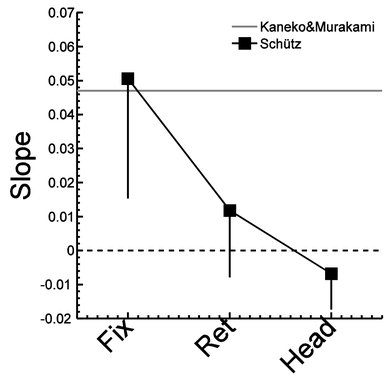


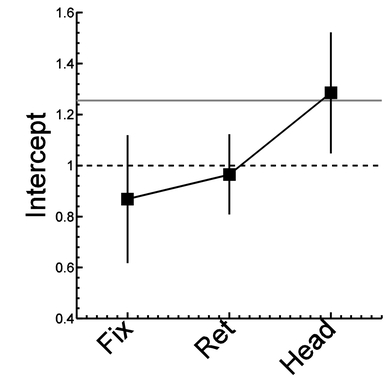


Large-field gratings

In this experiment, motion stimuli were gratings, which covered 45x16 deg, instead of Gabors. Results during fixation were very similar as with Gabors, showing a significant slope of 0.05. However for the retinal and the head-centered conditions, the slopes were lower and not significantly different from zero. In the head-centered condition the intercept was 1.29 and significantly larger than unity. Hence the perceived duration of the large-field gratings did not depend on speed in the pursuit conditions.







Discussion

The present results show that perceived duration depends more on retinal speed than on physical speed for small-field Gabors. This suggests that perceived duration is influenced by neurons which do not compensate for smooth pursuit eye movements. For large-field gratings, perceived duration depended on speed only during fixation, but not in the two pursuit conditions. It might be that the retinal or head-centered motion of the grating is interpreted as background motion during pursuit and thus does not affect perceived duration. Neurons in MST, which respond differentially to small and large targets [7] might contribute to that distinction.

References:

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