Stronger premicrosaccadic sensitivity enhancement for dark contrasts in the primate superior colliculus

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Introduction

Microsaccades are small, rapid eye movements that occur during gaze fixation and are associated with strong motor bursts in the superior colliculus (SC), similar to those driving larger saccades. These movements result in significant perimovement alterations in visual sensitivity, perception, and neural response fields.

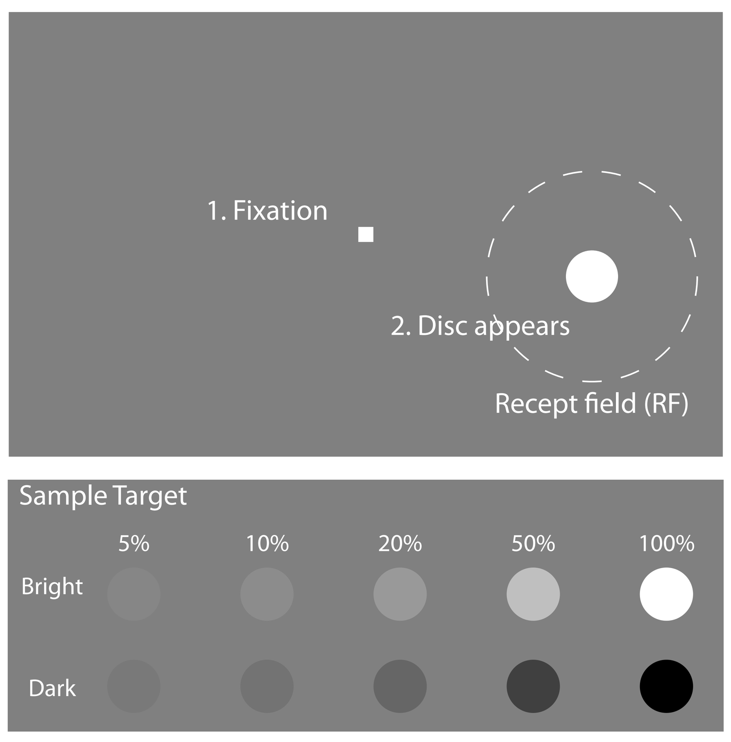
Perimicrosaccadic effects include premicrosaccadic enhancement and postmicrosaccadic suppression of visual sensitivity, as well as shifts in response field locations, consistent with changes in perception. Notably, these effects can influence sensory processing in experiments involving transient visual stimuli, such as attention cueing paradigms.

We investigated how luminance polarity affects SC visual responses during the microsaccades. Premicrosaccadic enhancement was stronger for dark stimuli at moderate contrasts, independent of neural preference, while postmicrosaccadic suppression was similar for both polarities. This asymmetry likely optimizes SC contrast sensitivity and enhances detection of dark contrasts prevalent in natural scenes, with implications for both microsaccades and larger saccades.

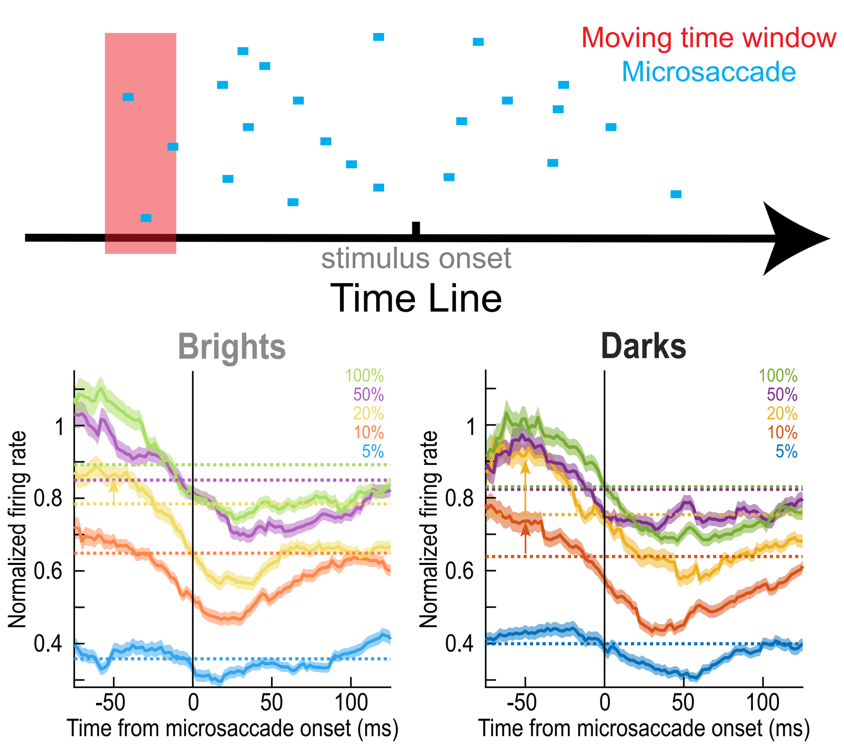
Methods

Two adult male rhesus macaque monkeys (***Macaca mulatta***) participated in the behavioral task. The task required the animals to maintain fixation on a small central point while a disc stimulus with varying luminance polarities was presented. Neural activity corresponding to the visual burst at disc onset was recorded, and a moving time window analysis was applied to compute the neural response modulation by the time of microsaccade onset relative to stimulus onset.

Behavioral task

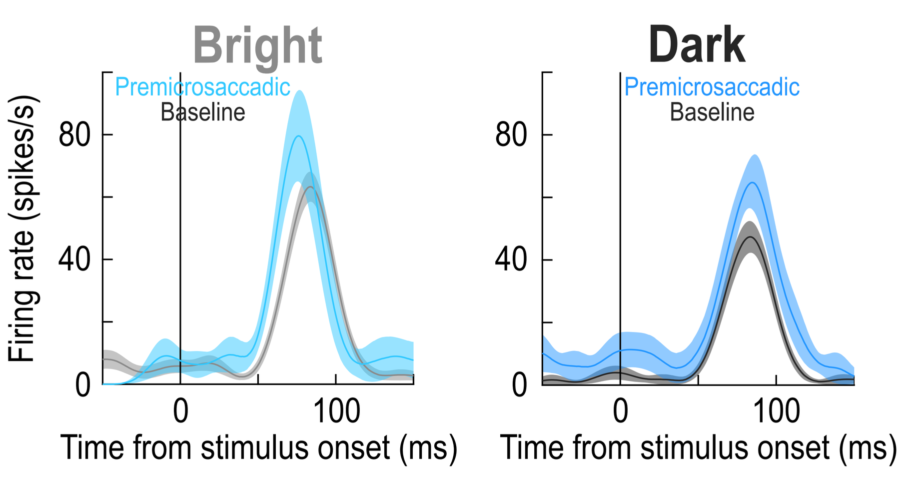


Measurement



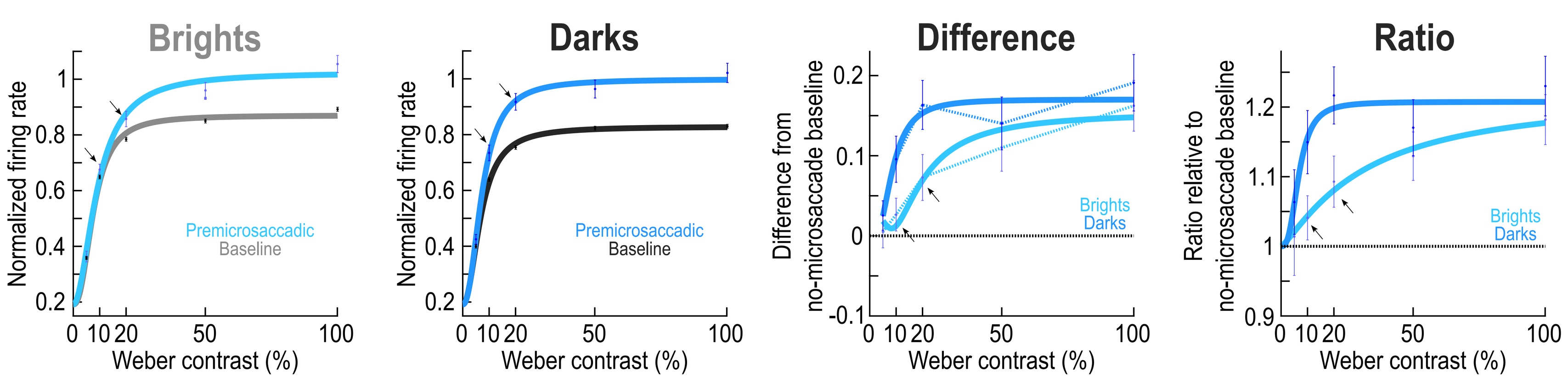
SC neurons have stronger premicrosaccadic enhancement for moderate dark contrasts

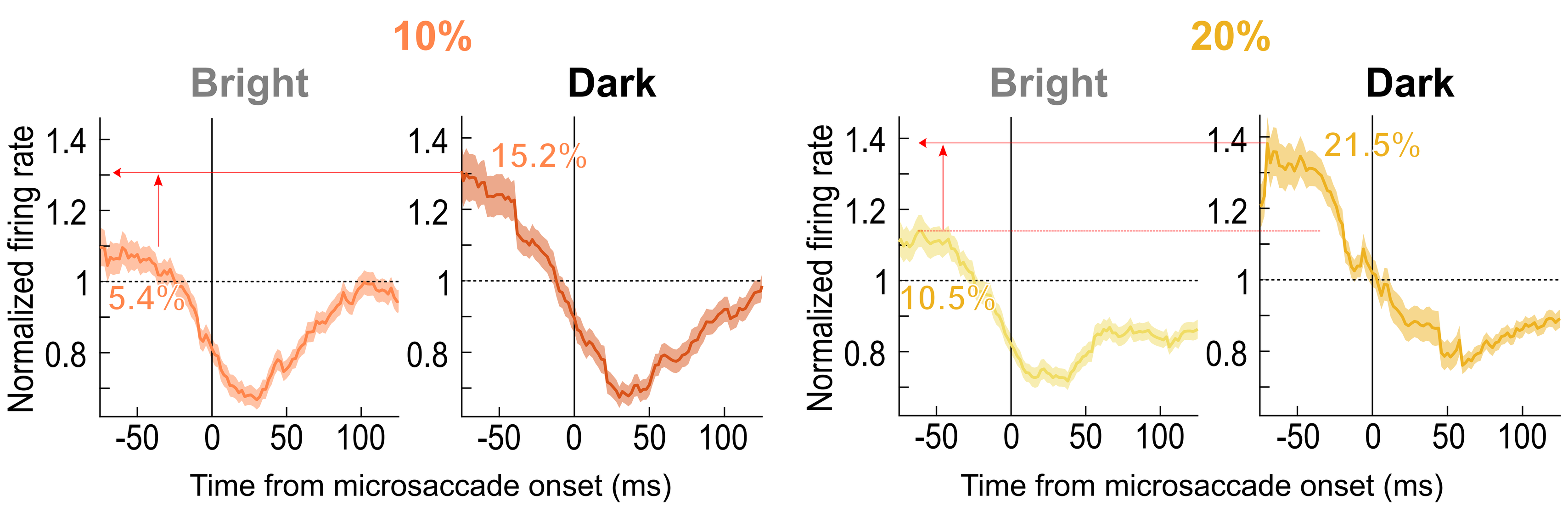
Sample neuron

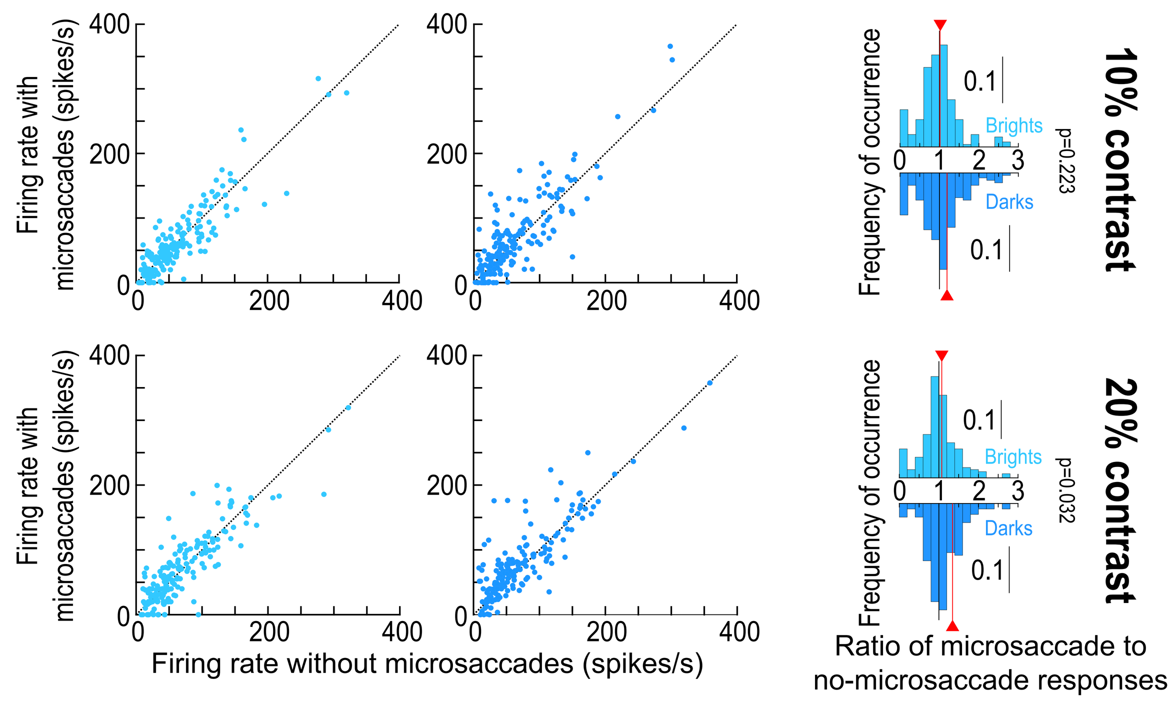


Premicrosaccadic: Target onset 25-75 ms before microsaccade onset

Baseline: No microsaccade occurs within 150 ms of target onset

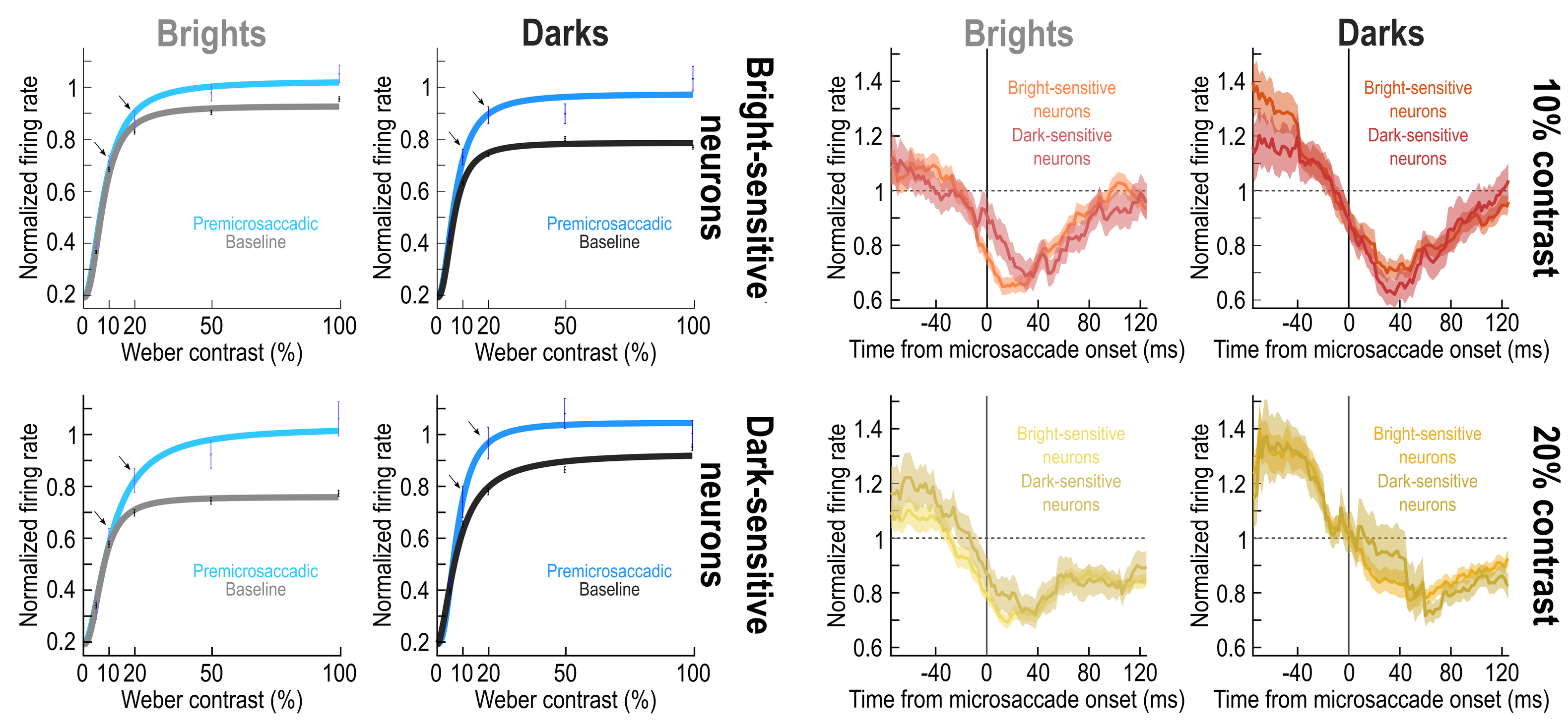






We observed consistent premicrosaccadic enhancement across the SC neuron population, with the enhancement being particularly stronger for dark (negative luminance polarity) stimuli, especially at moderate contrast levels.

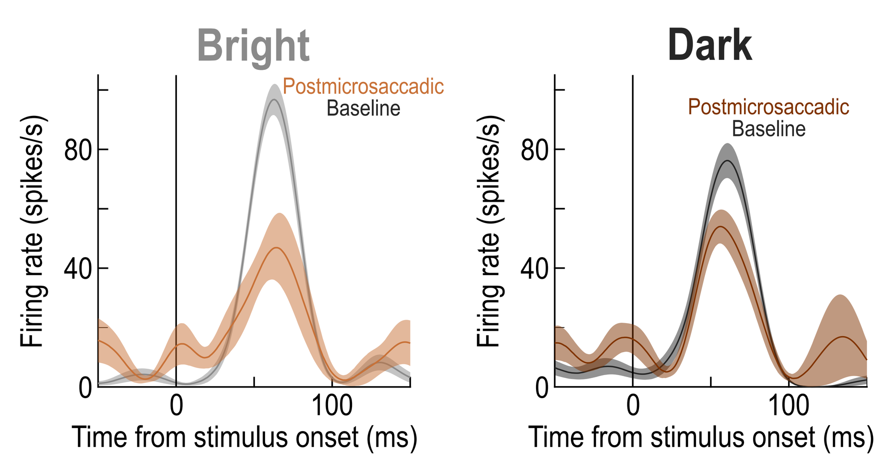
Independence from individual neuron preferences for darks or brights



At moderate contrast levels, stronger premicrosaccadic enhancement for dark contrast responses in the SC was a general property, and it was not explained by the intrinsic preferences of individual neurons.

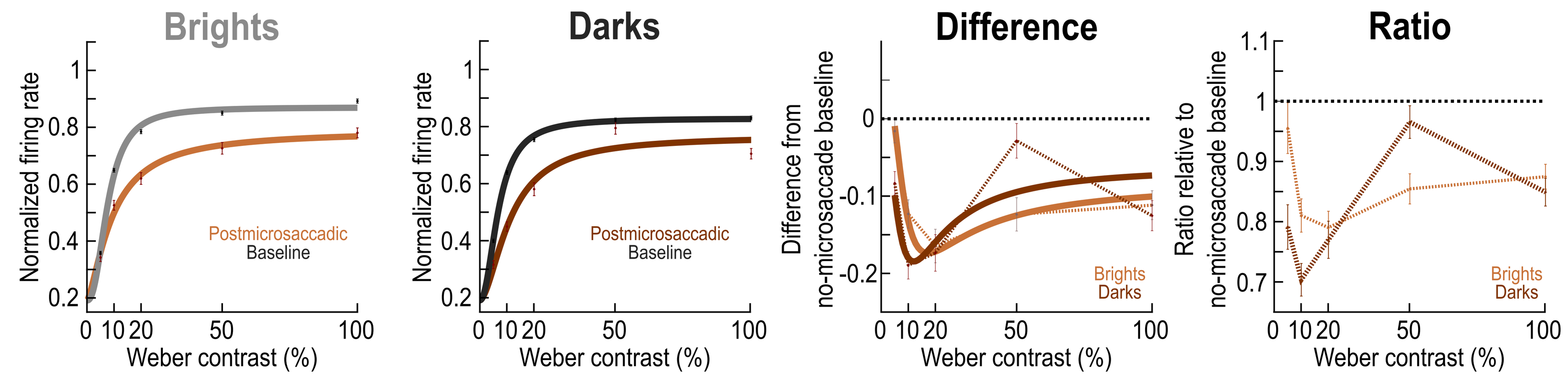
Similar postmicrosaccadic suppression for darks and brights

Sample neuron



Postmicrosaccadic: Target onset 25-75 ms after microsaccade onset

Baseline: No microsaccade occurs within 150 ms of target onset



There was generally similar postsaccadic suppression for the bright and dark stimuli.

Conclusions

This study found that premicrosaccadic enhancement in the SC exhibits a dependence on luminance polarity, with stronger enhancement observed for dark stimuli, particularly at moderate contrast levels. This enhancement effect is independent of the luminance preferences of SC neurons, indicating a general property of premicrosaccadic processing. This mechanism may have ecological significance, such as optimizing the detection of stimuli under shadows or low-light conditions. Our findings add to evidence that ON- and OFF-channel visual processing can differ across brain regions, with SC exhibiting a distinct reformatting of visual inputs compared to V1.