# 986.5 Post-saccadic Orientation Selectivity of Neurons in the Cat Visual Cortex


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## Introduction

Experimental studies suggest that visual perception undergoes a non-stationary state at the time of saccades; the same retinal inputs lead to differential perception depending on occurrence of a saccade. For example, when a visual motion is seen after a saccade, its perceived direction is biased in the direction opposite to the saccade (Park et al., 2001). This bias is independent of spatial mislocalization reported to occur before and after saccades (Cho & Lee, 2003). We previously suggested the possibility that orientation tuning of V1 cells may change around the time of saccades, underlying the bias in direction perception (Park et al., 2001). In the current study, we tested this possibility in awake cats trained to perform a visually-guided saccade task.

## Methods

**Animal preparation :** Two cats with scleral search coils implanted.

**Mapping of visual receptive field :** Visual receptive field of each cell was mapped with a 4°×4° white square stimulus at 4° intervals in a 11 x 7 rectilinear grid on a computer monitor. When the gaze remained stable for 300ms in free eye movement condition in the dark, the stimulus was presented, and neural activity was recorded for 300ms thereafter. On-line spike count and time course of neural activity were visually inspected and compared across the grid to determine the position and size of receptive field.

**Measure of orientation tuning curve :** Orientation tuning curves were derived by using a sinusoidal grating (Gabor) with a spatial frequency of 1cycle/deg confined within the receptive field. Gratings were drifted at a temporal frequency of 10Hz. We measured orientation tuning of each cell in two steps. First, we tested 6 orientations from 0° to 150° with a step of 60° to approximate the preferred orientation. Next, fine tuning was measured for 7 orientations from -15° to +15° with a step of 5° centered about the orientation associated with the strongest response. Orientation tuning curves were derived from the peak values of spike density functions within 0 - 200ms interval after stimulus onset.

**Saccade task and fixation task (Fig 1) :** In the saccade task, the cat was required to make a centripetal saccade after successfully fixating a peripheral target. Saccade offset was detected with a velocity criterion (<10deg/s), and immediately after saccade offset, the visual stimulus was presented for 100ms. A successful saccade followed by stable gaze was rewarded. In the fixation task, the animal was required to maintain stable fixation on the center target. Single-unit activities were recorded from the lateral gyrus (Areas 17 and 18).

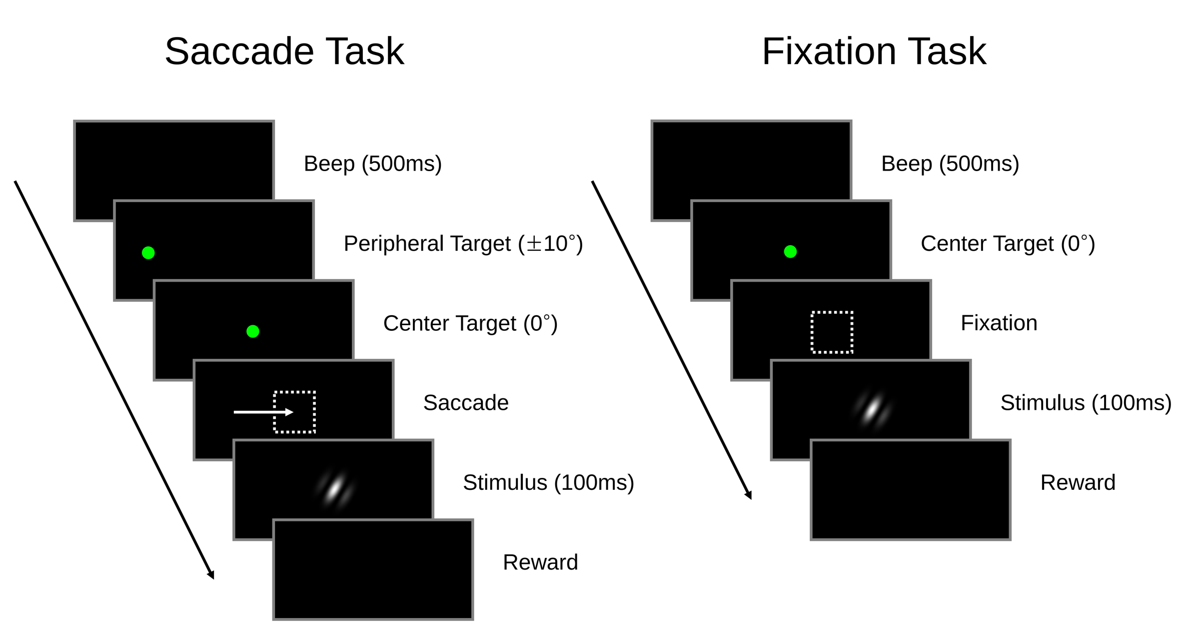


**Figure 1.** Sequence of stimuli presentation

## Results

### Preferred orientation in saccade condition is different from the control.

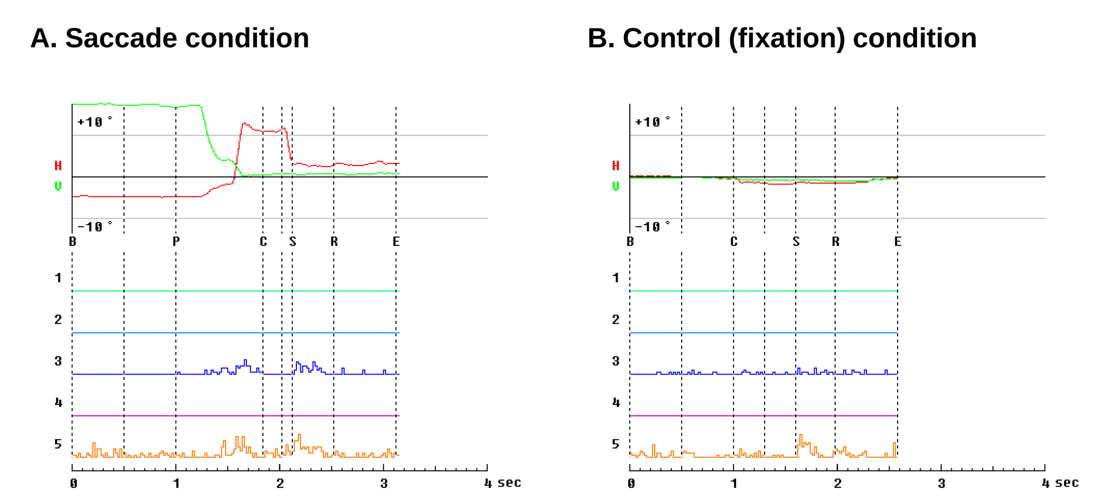


**Figure 2.** Examples of saccade (A) and control (B) trials. H: horizontal eye position, V: vertical eye position, 1-5: recording channel, Trace in each channel line: count of spikes (bin size: 20ms). Only Ch 3 and 5 were used for these trials. Trials starts with a beep (B to dotted line next to B). P: peripheral target ON, C: center target ON (dotted line next to C indicates center target OFF), S: Gabor patch onset time, R: reward, E: end of a trial.

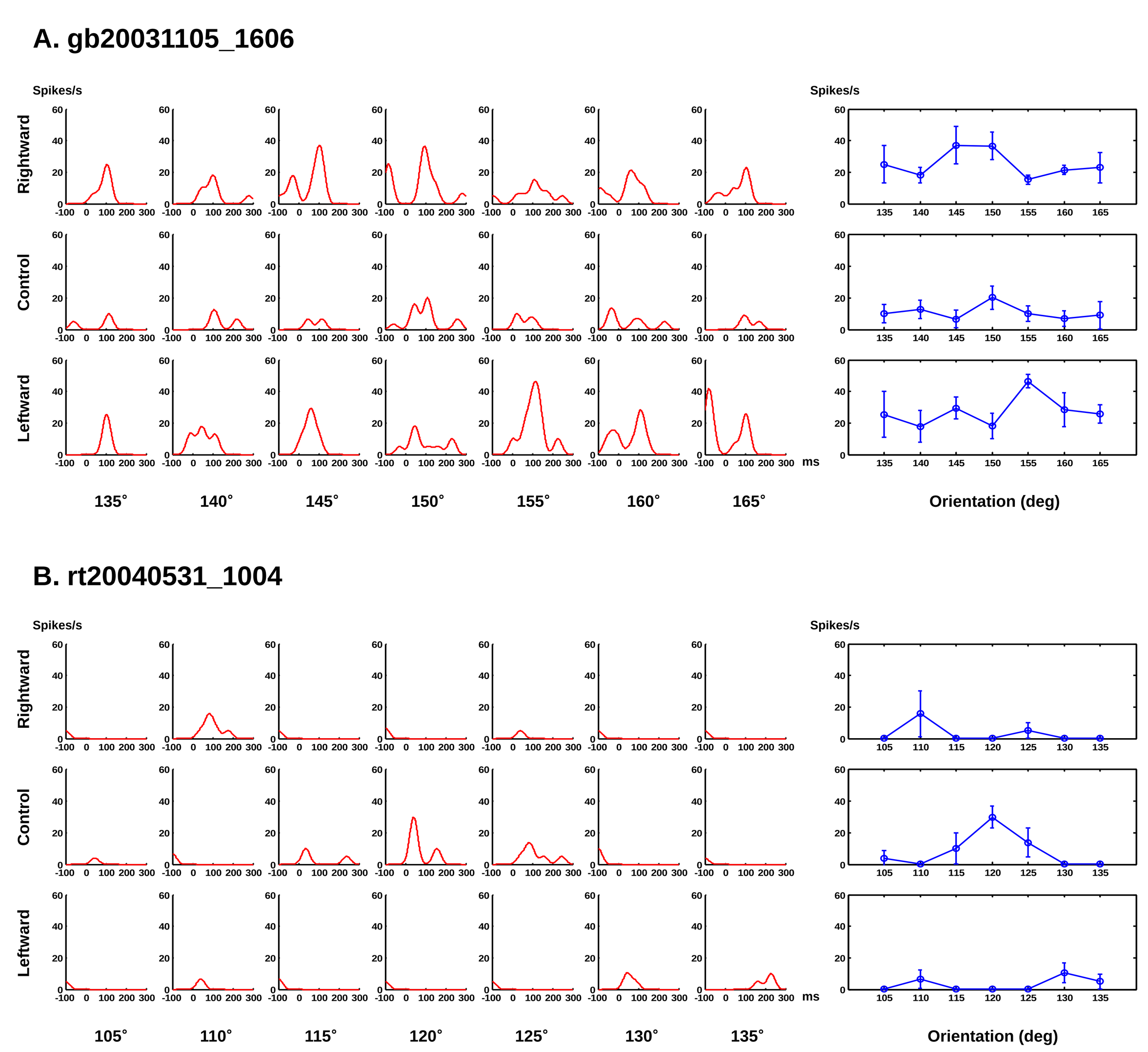


**Figure 3.** Visual responses to oriented stimuli presented after (rightward and leftward) saccade offset and during steady fixation (control). Spike density functions for each condition are shown on the left. '0ms' is the time of stimulus onset. In orientation tuning curves (right), each symbol represents the mean and standard error of the peak activity. Note that the orientation with the peak response changes across experimental conditions.

### Preferred orientation changes systematically depending on saccade direction.

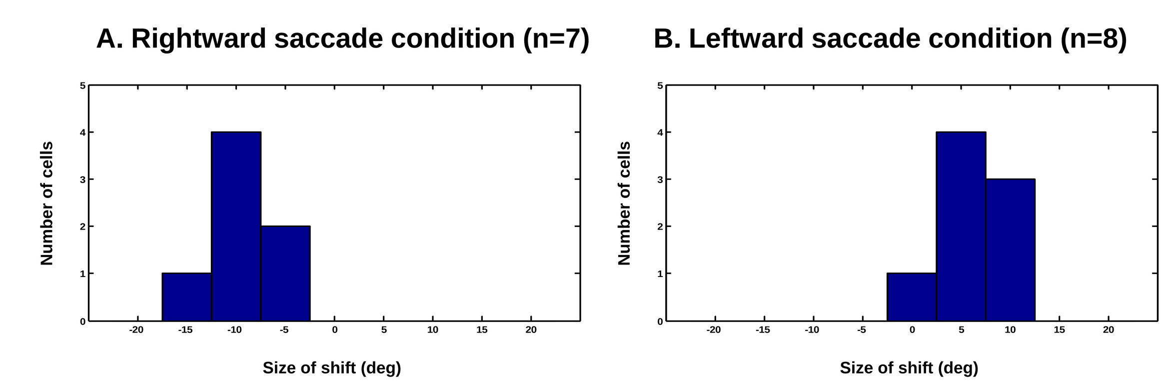


**Figure 4.** Shift of orientation tuning from the control. The peak orientation of tuning curve in the rightward saccade condition shifted in clockwise direction. In contrast, in leftward saccade condition, it shifted in counter-clockwise direction.

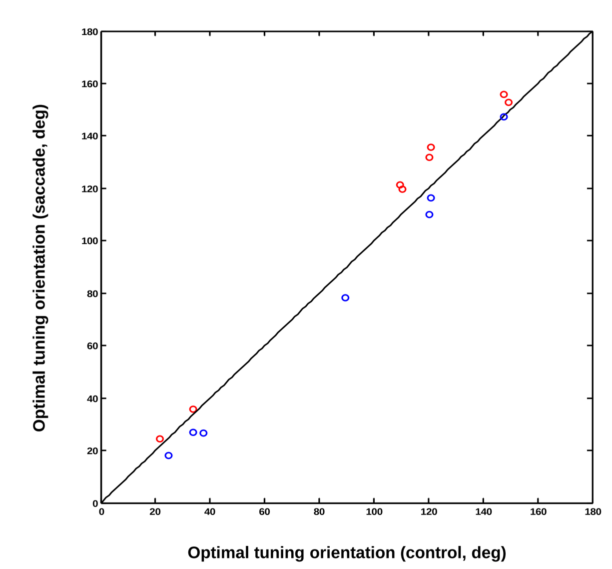


**Figure 5.** Magnitude of tuning shift. Each circle represents optimal orientation of each cell derived by Gaussian fitting. Blue circle: rightward saccades, Red circle: leftward saccades.

| Cell no. | Receptive field | | Optimal tuning orientation | | |
|---|---|---|---|---|---|
| | Center | Diameter | Rightward | Control | Leftward |
| gb20031105_1606 | ( -2°, -6°) | 8° | 147.4° | 147.7° | 155.9° |
| rt20040510_1703 | ( 6°, -2°) | 8° | 116.3° | 120.8° | 135.6° |
| rt20040529_0906 | (-10°, -2°) | 12° | 26.9° | 33.7° | 35.7° |
| rt20040531_1004 | (-10°, -6°) | 8° | 110.0° | 120.4° | 131.8° |
| rt20040514_1505 | ( 2°, -2°) | 8° | 78.4° | 89.5° | |
| rt20040525_1902 | ( 2°, 2°) | 12° | 26.6° | 37.6° | |
| rt20040529_1206 | (-10°, -2°) | 12° | 18.1° | 24.9° | |
| gb20031031_3304 | ( -2°, -2°) | 8° | | 149.4° | 152.7° |
| gb20031109_1602 | ( -2°, -6°) | 8° | | 110.5° | 119.7° |
| rt20040529_1005 | (-10°, -2°) | 12° | | 21.7° | 24.48° |
| rt20040531_1401 | (-10°, -6°) | 8° | | 109.6° | 121.3° |

**Table 1.** Summary of orientation tuning shift. Centers of receptive fields are presented in Cartesian angles with respect to the line of gaze.

## Perceptual modulation by a saccade

In a typical population-decoding scheme, the perceived stimulus property is determined by the profile of active neuronal population. We show one such scheme in which a clockwise shift in the orientation tuning at the time of a rightward saccade cause a counter-clockwise shift in perceived orientation (Fig 6), and vice versa.

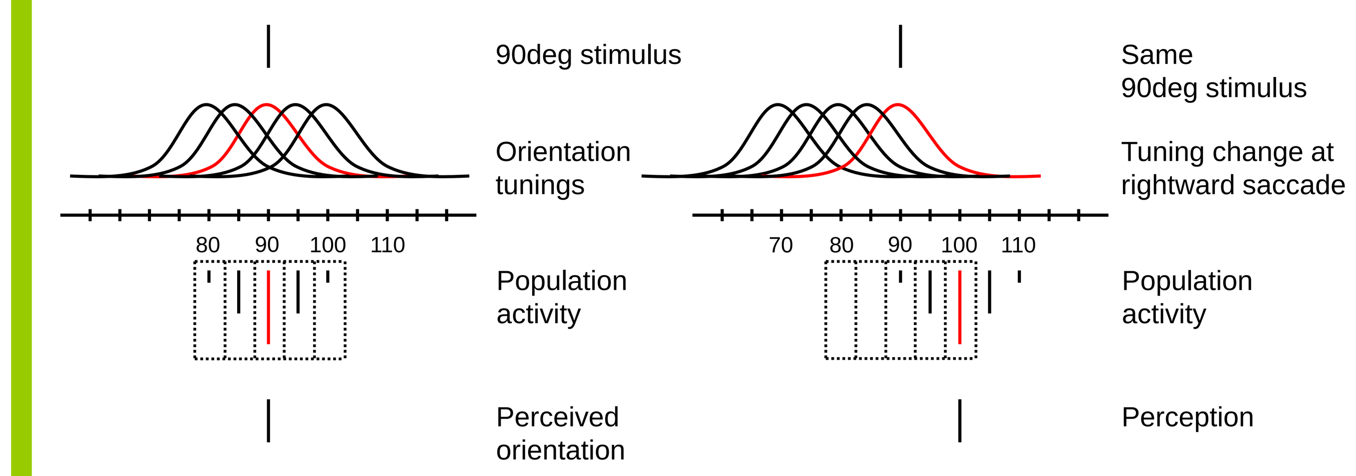


**Figure 6.** Scheme in which a saccade affects perceived orientation

The above scheme is consistent with human psychophysical data (Park et al., 2001), where subjects reported the perceived angle of a moving stimulus after saccades. The perceived angle of a moving stimulus shifts in positive (counter-clockwise) after rightward saccades and in negative (clockwise) after leftward saccades (Fig 7).

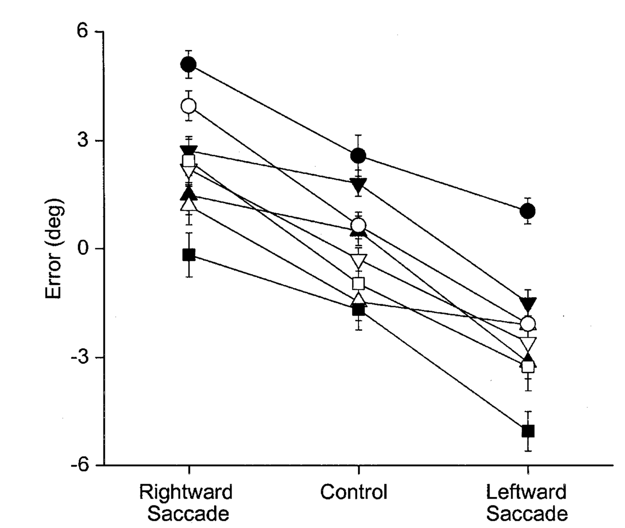


**Fig 7.** Perceptual errors of 8 human subjects for moving stimuli (Park, Lee & Lee, 2001).

## Conclusions

1. Preferred orientation shifts around the time of saccades, in clockwise (counter-clockwise) direction after rightward (leftward) saccades.
2. This shift of orientation tuning is consistent with perceptual bias reported to occur after saccades.
3. Saccade-related activities in the visual cortex (Park & Lee, 2000) is related to the shift of orientation tuning, and hence perceptual bias.

## References


Cho S, Lee C (2003) Expansion of visual space after saccadic eye movements. *Journal of Vision* 3: 906-918.

Park J, Lee J, Lee C (2001) Non-veridical visual motion perception immediately after saccades. *Vision Research* 41: 3751-3761.

Park J, Lee C (2000) Neural discharge coupled to saccade offset in the cat visual cortex. *Neuroreport* 11: 1661-1664.


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