Pre-movement enhancement of sensitivity ahead of saccade endpoints

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Introduction

(Hafed and Clark, 2002; Engbert and Kliegl, 2003) → Strong **correlation** between microsaccades and covert attention shifts

(Hafed, 2013; Chen et al., 2015; Hafed et al., 2015; Tian et al., 2016) → Almost-deterministic **link** between microsaccade generation and neural/behavioral performance changes even with **no** attentional tasks

(Zhang et al., VSS, 2020) → Triggering microsaccades (foveal action) is sufficient to cause neural and perceptual changes typical of peripheral covert attentional effects

Here we show that saccades in general (not only microsaccades) can be associated with improved visual sensitivity well ahead of their endpoints

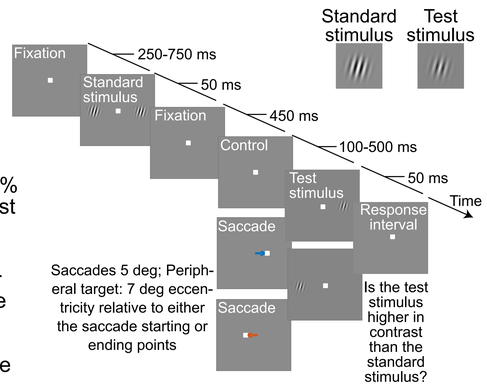
Methods (human psychophysics)

Visually-guided saccade task in 5 deg

Eight subjects compared the contrast of a test stimulus to that of an earlier standard stimulus (Rolfs & Carrasco, 2012)

Standard stimulus contrast: 25%
Test stimulus differed in contrast (33%,29%,25%,21%,17%)

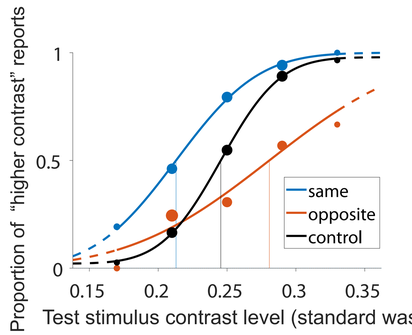
The test stimulus could appear before or after a saccade in the same or opposite direction, on either side of fixation at 7 deg eccentricity relative to either the saccade starting or ending points



Sample psychometric curve for stimulus presented peri-saccadiccally

Here is an example showing one subject result for psychometric curve

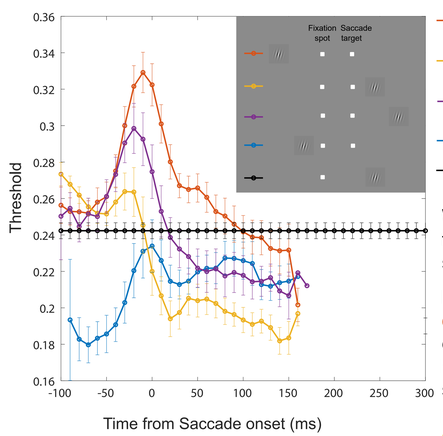
Threshold was defined as the contrast level allowing 50% "higher" reports



Compared with psychometric curve in control condition (black curve), when the curve shifted to left in same condition (blue curve), it means the subject was easier to percieve test stimulus as a higher contrast, which indicated an enhanced effect

In opposite, when the curve shifted to right (red curve), it represented a decreased effect

Result



Test sitmulus happened in oppsite direction as saccade, 7 deg relative to saccade **starting** point

Test sitmulus happened in same direction as saccade, 7 deg relative to saccade **starting** point

Test sitmulus happened in same direction as saccade, 7 deg relative to saccade **ending** point

Test sitmulus happened in oppsite direction as saccade, 7 deg relative to saccade **ending** point

Control condition, **no** saccade happening

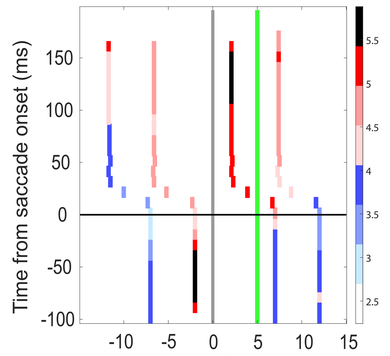
We plotted time course of performance threshold with time window of 40ms in step size of 10ms

Pre-saccadically, performance in red curve (opposite condition, test stimulus 7 deg from saccade starting point) was the hardest; for the same distance of test stimulus from saccade, when they happened in the same direction (yellow curve), performance was enhanced

Although in purple curve, test stimulus was 12 deg away from saccade starting point, subjects performed better than red curve, because in purple, test stimulus and saccade were in same direction

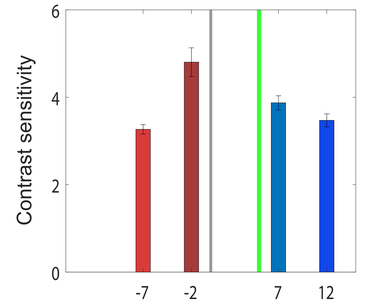
In blue curve, the task the was the easierst for subjects, because if test stimulus was 7 deg relative to saccade ending point, it means the distance between them was only 2 deg pre-saccadically.

Contrast sensitivity as a function of the time of test stimulus relative to saccade onset



The horizontal black line at time 0 marks the saccade onset

Test stimulus appearing 50ms before saccade onset



The fluorescent green vertical line marks the 5 deg saccade landing postion

Black vertcal line: Saccade starting postion (fixaton spot locaton at screen center)

Pre-saccadically, performance at 2 deg was the best, performance at 7 and 12 deg eccentricities in the same direction as the saccade was higher than performance at 7 deg eccentricity in the opposite direction, even though both 7 and 12 deg were ahead of the saccade target

Summary

In recent study, we controlled microsaccades directions and found that microsaccades have higher senstivity in periphery which means farther away from saccade end point. So we asked why this might be and we tested for higher sensitivity farther away from larger saccades as well. We found similar phenomenon.

These results, not unlike observations in (Shurygina et al., 2021), suggest that saccades in general can be associated with improved visual sensitivity well ahead of their endpoints.