# Refining oculomotor control models: Generation of fixational saccades

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Our eyes are always in motion. Even when we attempt to maintain fixation on a stationary object, incessant drifts and microscopic saccades (microsaccades) continually modulate the spatiotemporal input to the retina. We have recently shown that these temporal modulations are critical for fine spatial vision[1] and appear to be matched to the characteristics of the natural world[2]. Furthermore, we have shown that microsaccades enable local exploration of the scene during execution of high acuity tasks, as they tend to relocate the gaze toward nearby regions of interest[3].

An important question that remains open is why microscopic saccades continue to occur even when observers maintain fixation on a single dot in the absence of other visual stimulation besides the fixation marker. These fixational saccades cannot serve an explorative function. Two main theories have long been proposed. Cornsweet[4] argued that fixational saccades serve to correct for fixation errors and are triggered by spatial displacement between the actual gaze position and the intended fixation point. In contrast, Nachmias[5] proposed that the generation of fixational saccades is primarily determined by temporal factors: the oculomotor system can suppress saccades of all sizes for a limited period of time only. This controversy has never been resolved, primarily because of technical limitations in precisely determining gaze position, i.e., where subjects look in the scene.

To investigate the spatial and temporal factors involved in the generation of fixational saccades, we have recently developed a new technique which greatly improves localization of the line of sight over standard approaches. Using this method, we examined the occurrence of fixational saccades in 6 observers while they maintained fixation on a small dot. Our results show that both spatial and temporal factors affect the generation of fixational saccades. Fixational saccades were most frequently generated when the gaze position was relatively close to the fixation marker. Since little spatial displacement occurs in this region, this result indicates that temporal factors play a role in eliciting fixational saccades. However, this was also the region where the center of gaze spent most of its time. When the probability of fixational saccades was normalized by time, the resulting rate increased drastically with the displacement between the gaze position and the fixation marker. Thus, spatial factors are also important. Furthermore, fixational saccades always tended to compensate for displacements, even at small distances. This compensation was extremely accurate on the horizontal axis. Our results suggest that both theories are correct: fixational saccades are more likely to occur in the presence of spatial displacements and will correct for them. But, given sufficient time, fixational saccades will also occur in the absence of any displacements, therefore generating an error.

## References

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