

Parallel processing for the generation of saccades to simultaneously moving centrifugal targets

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Introduction

The simultaneous presentation of two static targets in the visual field leads to a saccade which lands on a location situated along a line that connects the two targets. The landing position depends upon the relative salience of the targets. The more salient the target, the stronger its influence on the landing position.

A similar process happens during saccades made in response to two sequentially presented targets. Saccades with the shortest latencies land on the location of the first target whereas saccades with longer latencies land closer to the second target location. Obviously, the visuomotor brain does not switch abruptly between two targets; the transition is gradual and made continuously.

The spatiotemporal properties of this averaging process were further explored by testing in the monkey the saccades made in response to two centrifugal targets moving rapidly and simultaneously in different directions.

Methods

Three rhesus monkeys (A, B, C) were used in this study. The movements of one eye were recorded with the scleral coil in magnetic field technique.

After fixating a central target for a variable interval, two conditions were possible.

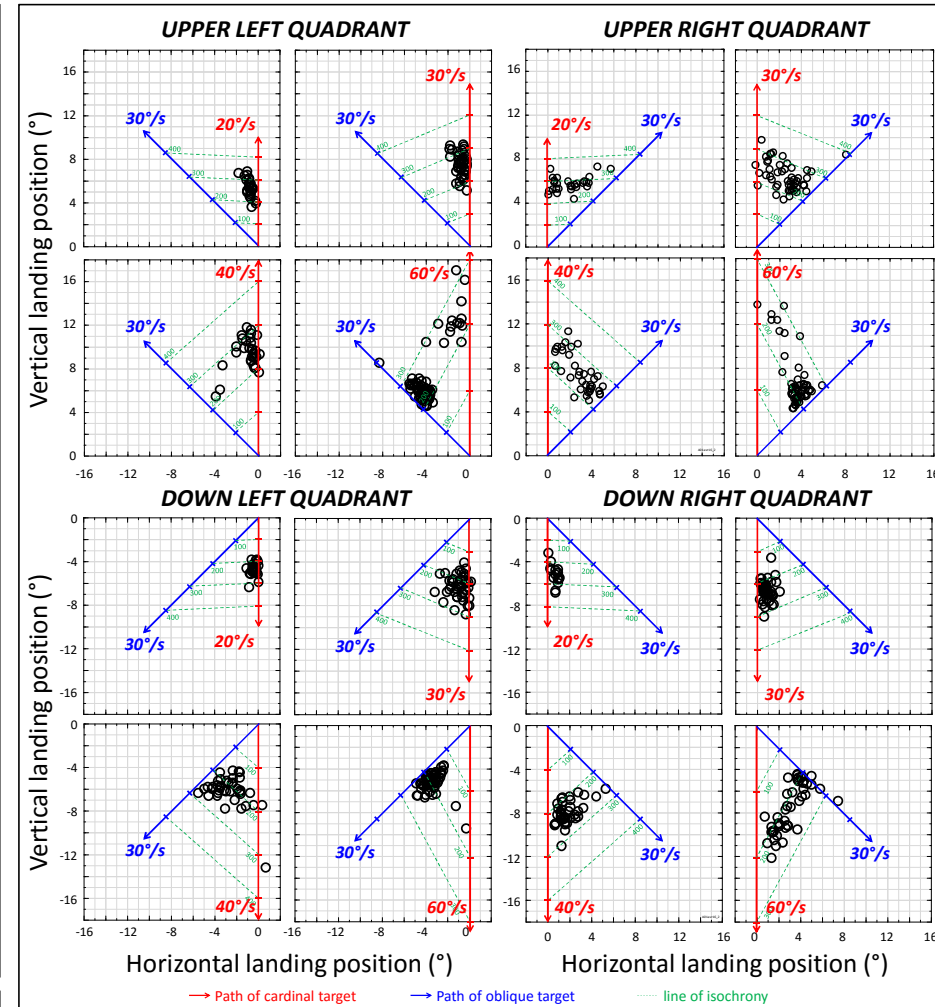
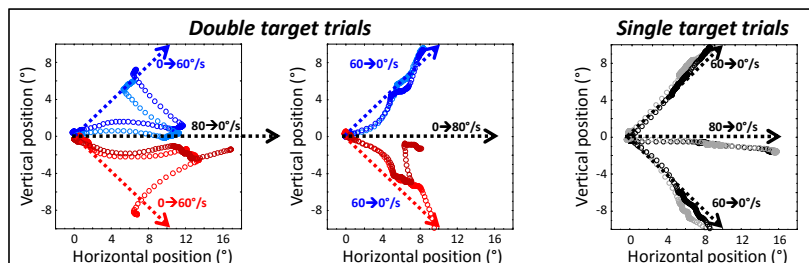
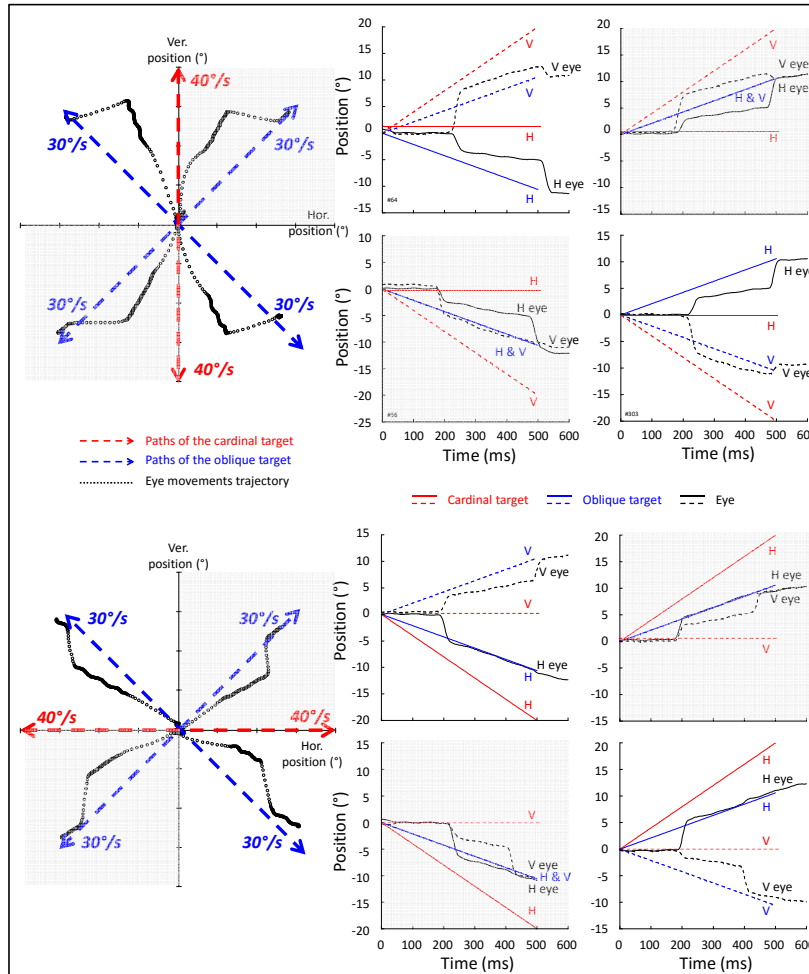
During the **single-target condition**, one target moved toward the periphery along the cardinal (horizontal or vertical) or oblique axes. During the **double-target condition**, the central target was replaced by two identical targets moving away from the center toward the periphery. One target moved along an oblique axis while the other target moved along one of the cardinal axes.

The speed of the target moving along the oblique axis was fixed (30 deg/s constant or accelerating from 0 to 60°/s or decelerating from 60 to 0°/s) whereas the target moving along the cardinal axis had a speed that was varied (from 15 to 60 deg/s, average speed, constant, accelerating or decelerating). Different pairs of speed were tested during separate block of trials.

The monkeys were free to track anyone of the targets and were rewarded on every trial.

Results

The examination of saccades made in response to targets moving in the same visual quadrant show different scatterings of landing positions between the testing conditions. During the double-target condition, the landing positions were scattered in the region of the visual field which is situated between the paths of the targets. Although their distributions were biased toward the slower target, the orientation of the scatters depended upon the speed of the two targets: the landing positions were scattered between lines of isochronous target locations.



Conclusion

In response to two centrifugal targets, the monkeys do not select one of the two targets prior to its saccadic foveation. A first saccade can indeed be made toward an intermediate location, a location which seems to correspond to a variable average of two commands weighted by their speed (or the duration of retinal exposure). The scattering of saccade endpoints between lines of target isochrony and the observation of some curved saccades indicate parallel and continuous visuomotor flows until the saccade is completed. Following the "averaging"-like saccade, the eye moves in the same direction with a slow velocity for duration which can last more than 200ms. Then, for "reasons" which would be interesting to further investigate, a "choice" is made between the two targets and a second saccade is made toward its changing location, with an accuracy which is relatively good.