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► **To cite this version:**

Laurent Goffart, Quinet Julie, Bourrelly Clara. Foveating a moving target here-and-now. Vision Sciences Society Annual Meeting 2014, May 2014, St. Pete Beach, United States. hal-04190320

HAL Id: hal-04190320

<https://hal.science/hal-04190320v1>

Submitted on 29 Aug 2023

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Foveating a moving target, here-and-now

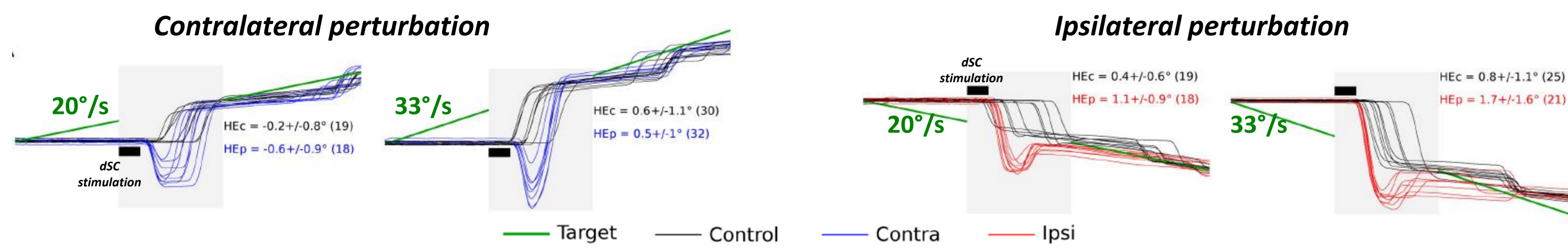
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Introduction

It is commonly believed that the visual motion signals are used by the oculomotor system to extrapolate the future position of a moving target and to generate a saccade that brings its image onto the fovea at the right time. But in most neurophysiological studies, the oculomotor behavior was recorded in over-trained animals who tracked a target whose motion velocity and path were therefore already known. Thus, the saccades were aimed at a location that was expected because of the training. Besides, some studies have shown that when the moving target is transiently occluded, the saccade landing positions fill-in the occlusion interval with relatively good accuracy, even if an unexpected perturbation had changed the eye position and delayed the target interception.



Based on these results, Fleuriot & Goffart (2012) conjectured that the signals which drive the oculomotor system are an estimate of the target position expected here-and-now rather than an estimate of some undefined future position. Therefore, we pursued our investigations by testing 1) the limits of the extrapolation made by the visuo-oculomotor system, 2) the influence of prior experience on the oculomotor tracking and 3) the nature of the internal model that is presumed to drive the tracking performance.

Methods

In three monkeys, eye positions were recorded with the search-coil-in-magnetic-field technique. Animals were required to shift their gaze from a central static target toward a peripheral moving one. The peripheral target appeared on the vertical meridian (16 deg above or below the central target) and moved horizontally to the left or to the right at 20°/s or 40°/s with a constant, accelerating or decelerating velocity, and for durations that gradually increased from 50 to 800 ms. The different durations and dynamics were tested on different days (shortest durations tested before). Control saccades toward static targets were recorded before all sessions to quantify the extrapolation.

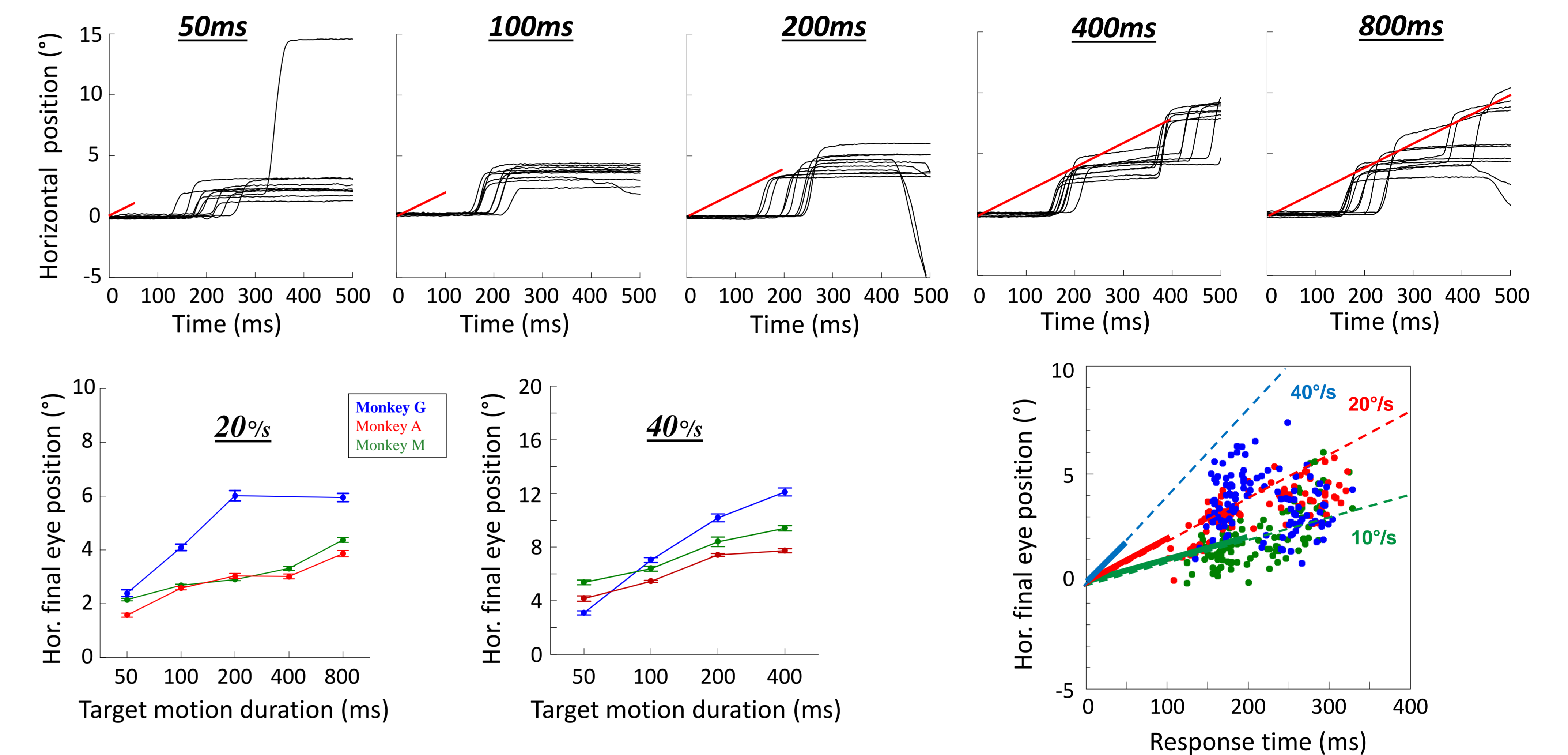
After the tracking became smooth (Burrelly et al. VSS 2014), we tested how this training affected the oculomotor responses to a transient moving target. A different procedure was also tested. After brief exposure, the moving target was occluded for a duration that gradually increased over consecutive days. When the tracking became smooth during the occlusion, responses to the transient target were again tested.

Conclusion

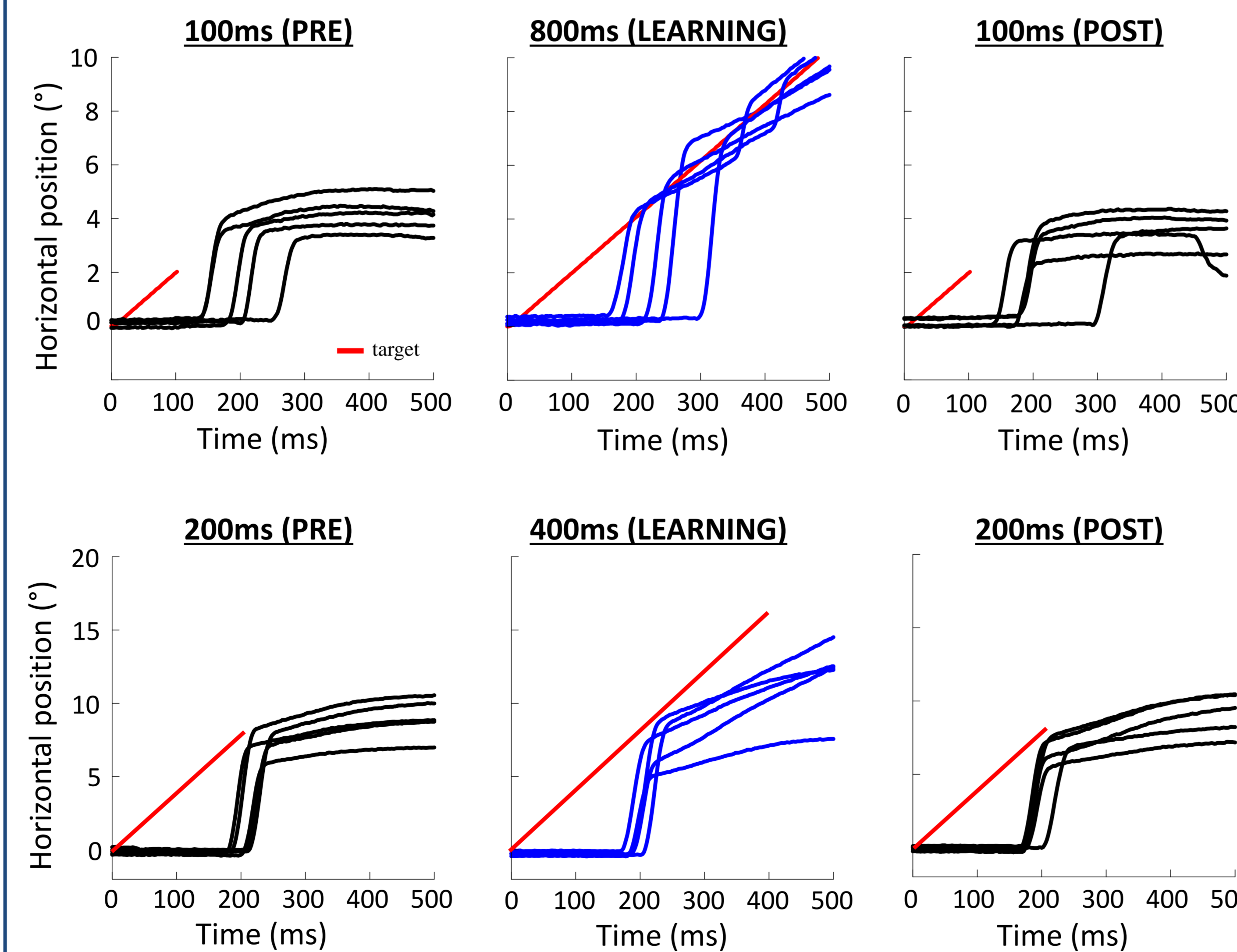
Our study documents the limits of the extrapolation abilities of the visuo-oculomotor system in response to a transient moving target. Second, it shows that experiencing the motion of a continuously moving target does not alter the oculomotor reaction to a transient moving target. Third, it suggests that the signals that encode the spatiotemporal trajectory and drive the on-going tracking behavior result from interpolation mechanisms and that they cannot be reduced to a memory of both the path and velocity of the target; it takes into account its moment-to-moment singularities (like the expectation of an occlusion). Our research should allow identifying the neural channels by which the mnemonic signals dynamically guide the on-going tracking response.

Results

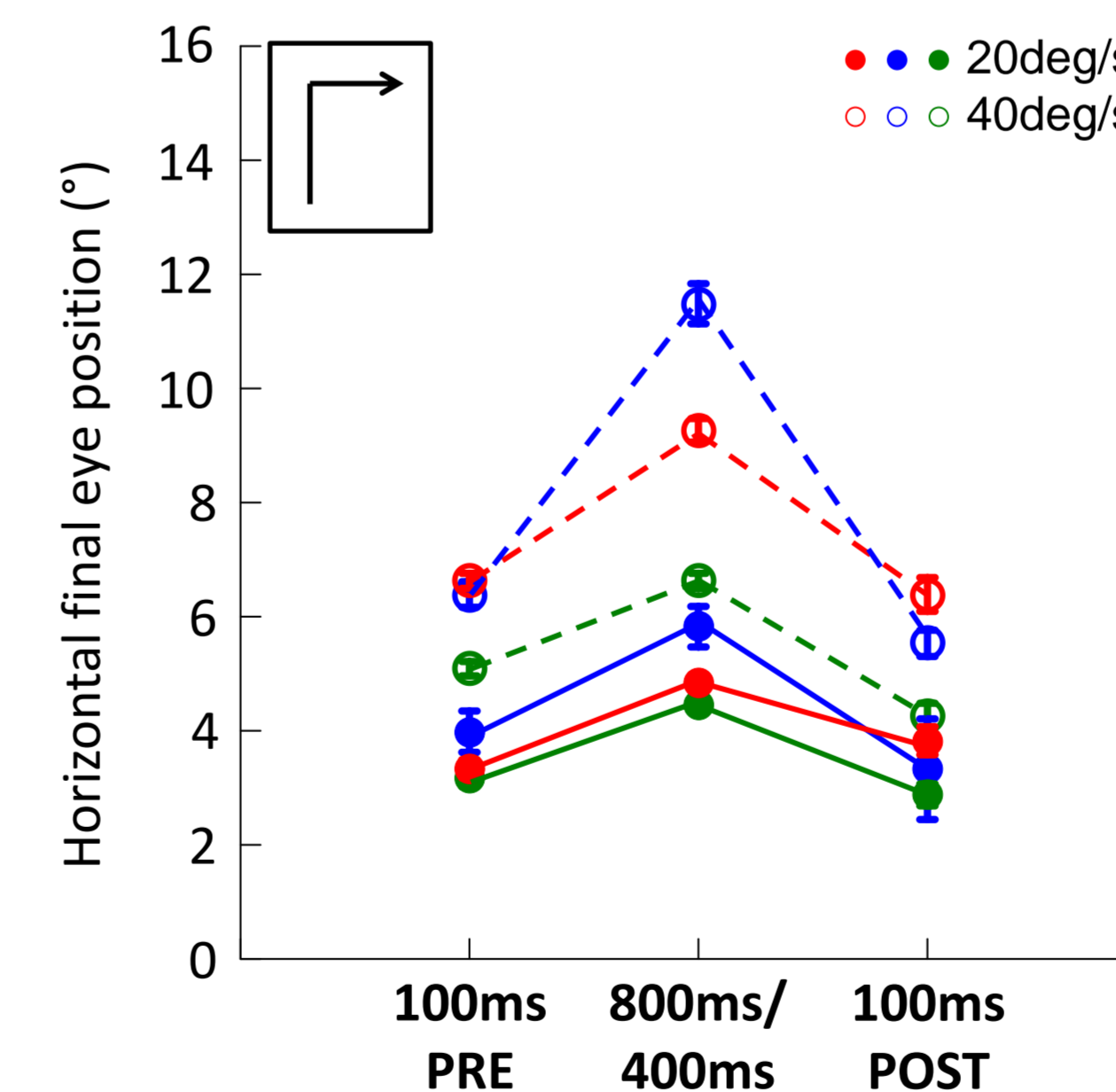
A- Intercepting a moving target



B- Learning to track a continuously moving target



Test of transfer



C- Learning to track a briefly occluded moving target

