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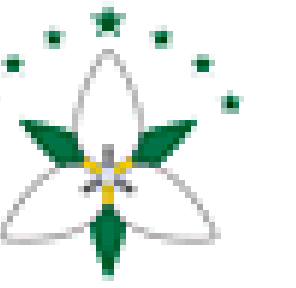


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Neural control of saccades to a moving target : contribution of the Fastigial Oculomotor Region

Laurent Goffart¹, Tepei Akao², Sergey Kurkin², Junko Fukushima² & Kikuro Fukushima²

1.CNRS, INCM Aix-Marseille Universités, Marseille, France
2.Dept of Physiology, Hokkaido University School of Medicine, Sapporo, Japan



INTRODUCTION

Saccades toward a moving target are astonishingly accurate. It has been proposed that their generation involves two parallel streams to the saccade generator (Keller et al. 1996).

One stream would carry a primary drive based on a snapshot of initial target eccentricity. Another stream would compute the complementary drive required to compensate for the subsequent target motion. These two commands would converge on saccade-related burst neurons in the contralateral reticular formation.

According to this "dual-drive" hypothesis, the primary drive would originate from the deep Superior Colliculus and the compensatory drive from the Cerebellum. Its projections to the saccade-related burst neurons in the pontomedullary reticular formation make the Fastigial Oculomotor Region (FOR) a possible candidate for relaying the cerebellar influence on the generation of saccades to moving targets.

Even though the notion of "snapshot" is hardly compatible with the anatomo-functional architecture of the visual system (Fleuret & Goffart *submitted*), we tested this hypothesis by studying in the monkey, the consequences of inactivating the FOR on the accuracy of saccades toward a moving target.

METHODS

Two monkeys (*Macaca Fuscata*) were trained with the head restrained to track the step and ramp displacements of a visual target (1° diam.) that appeared on a video monitor located 50 cm ahead. Eye movements were recorded with the search-coil-in-magnetic-field technique. Several experimental tests were performed.

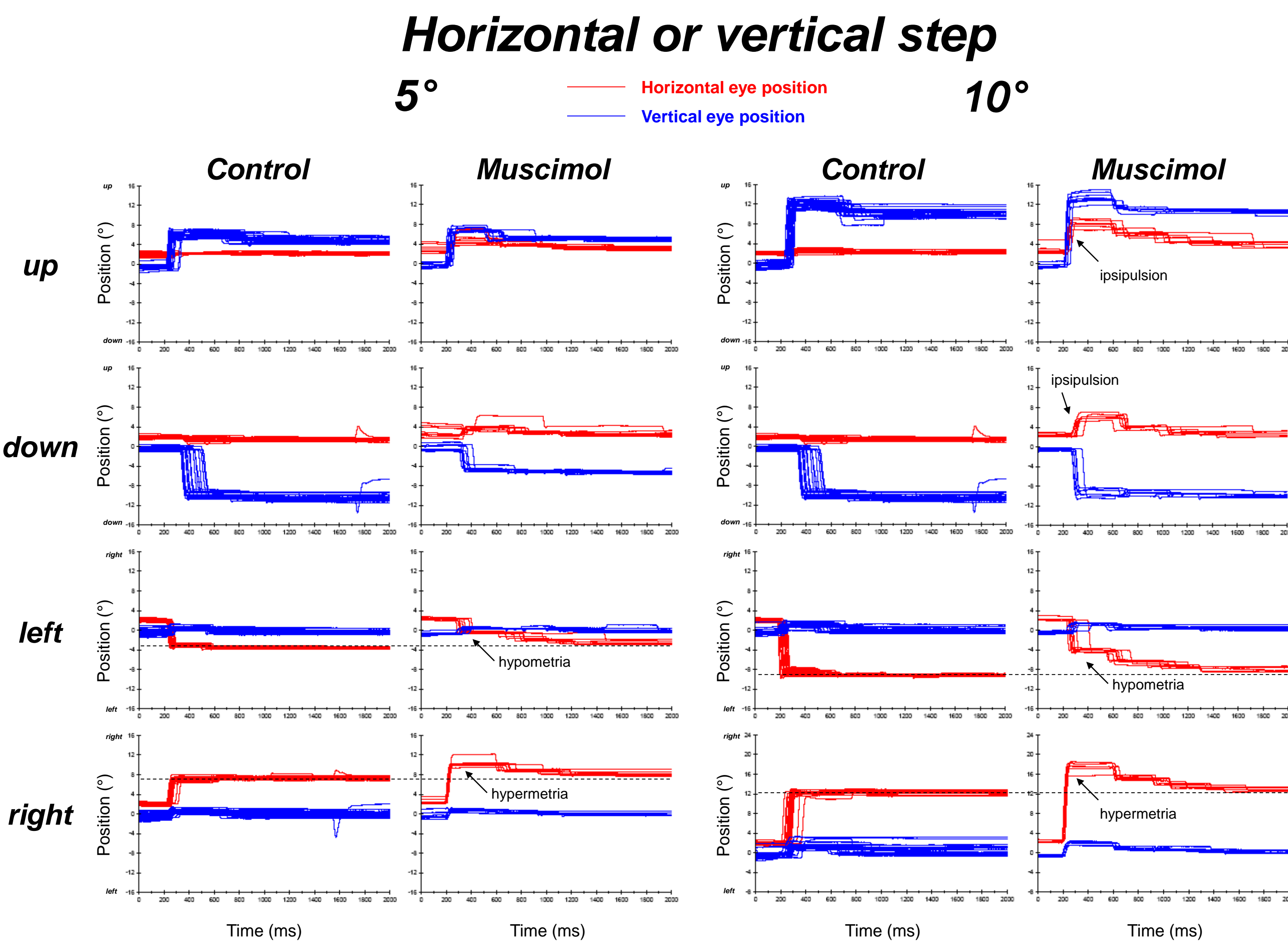
During each trial of the **step task**, the target stepped from the straight ahead position toward the periphery (5° or 10° horizontally or vertically) and the monkeys were rewarded after they looked at the peripheral visual target.

During the **ramp task**, the central visual target moved from the center toward the periphery with 3-4 different constant speeds (7, 14, 21 or 28°/s). The reward was given just after the target was brought outside the monitor.

During the **sinusoidal pursuit task**, the target stepped toward a 15° eccentric position and moved toward the opposite side with a speed that varied sinusoidally with a maximum when the target crossed the centre of the visual display. The monkeys were manually rewarded by the experimenter in a pseudo-random manner while they tracked and foveated the moving target.

The performance was recorded before and after injecting a small amount of muscimol (5µg/µl) in the oculomotor region of the caudal fastigial nucleus, as identified with recording (pursuit-related and saccade-related activity) and microstimulation techniques.

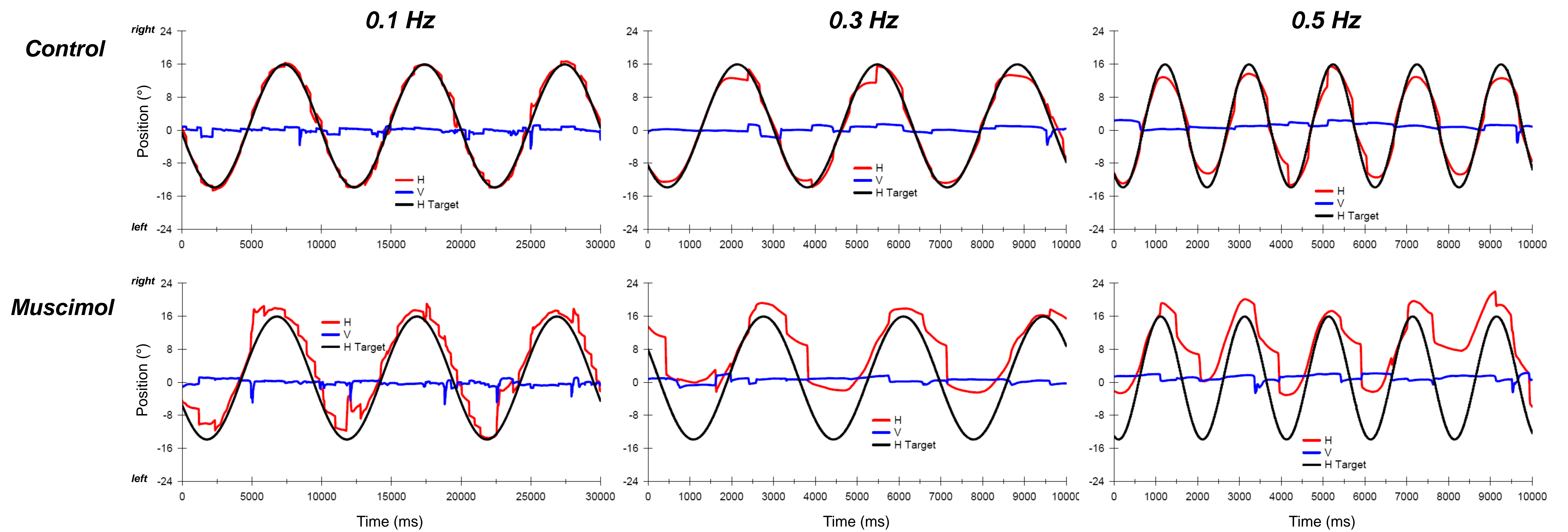
We present here data collected in one monkey before and after injecting 0.2 µl muscimol in the right FOR.



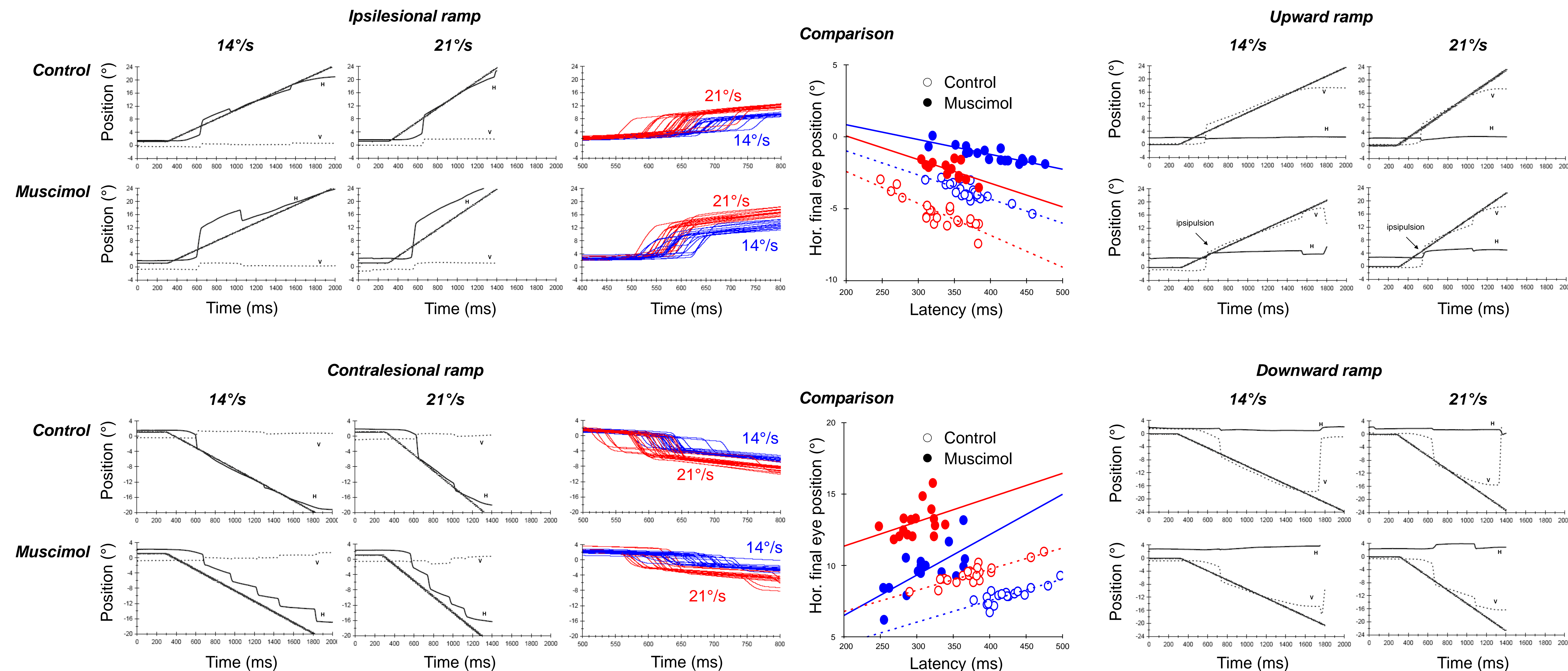
As shown in other studies (Goffart et al. *JNP*2004; Robinson et al. *JNP* 1993), inactivation of the FOR affects the accuracy of saccades toward a static visual target. Ipsilesional saccades are hypermetric, contralesional ones hypometric and vertical saccades are deviated toward the injected side (ipsipulsion). Note that FOR inactivation does not lead to a tremendous increase in the variability of saccade amplitudes and that the dysmetric saccades are followed by correction saccades after relatively long latencies.

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Horizontal sinusoidal motion



FOR inactivation also affects eye movements generated during tracking of a moving target. Because of 1) the contralesional hypometria, 2) the reduced gain pursuit and 3) the latency for generating correction saccade (see effects during the step task), the monkey is unable to pursue the target when it moves toward the contralesional side unless its velocity is reduced (e.g., 0.1Hz).



Tracking a target that moved with a constant velocity was an easier task for the monkey. During ipsilesional target motions, because of the saccade hypermetria and increased pursuit gain, gaze position often led the target. During contralesional target motions, the amplitude of catch-up saccades was diminished. The reduced pursuit gain, the hypometria and the long latency for generating correction saccades (see effects during the step task) altogether prevented the animal to foveate the target : gaze position always lagged behind the target. Ipsipulsion was observed but its magnitude was smaller than during saccades to static targets. Interestingly, regardless the target motion direction (ipsi- or contralesional), the amplitude of the first generated saccades increased with target velocity and saccade latency.

Altogether, these results indicate that the target motion-related signals can reach the saccade generator even when one FOR is inactivated, regardless the injection side. The FOR does not seem to be critical for providing the saccade generator with the target motion-related signals required to generate a saccade toward a moving target.

The "dual-drive" hypothesis has recently been questioned in an other study (Fleuret & Goffart, *submitted*). A hypothesis alternative has also been proposed (Fleuret et al. *J. Neurophysiol.* 2011).