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Sensorimotor transformation: lessons from the neurophysiological study of visually-guided eye movements

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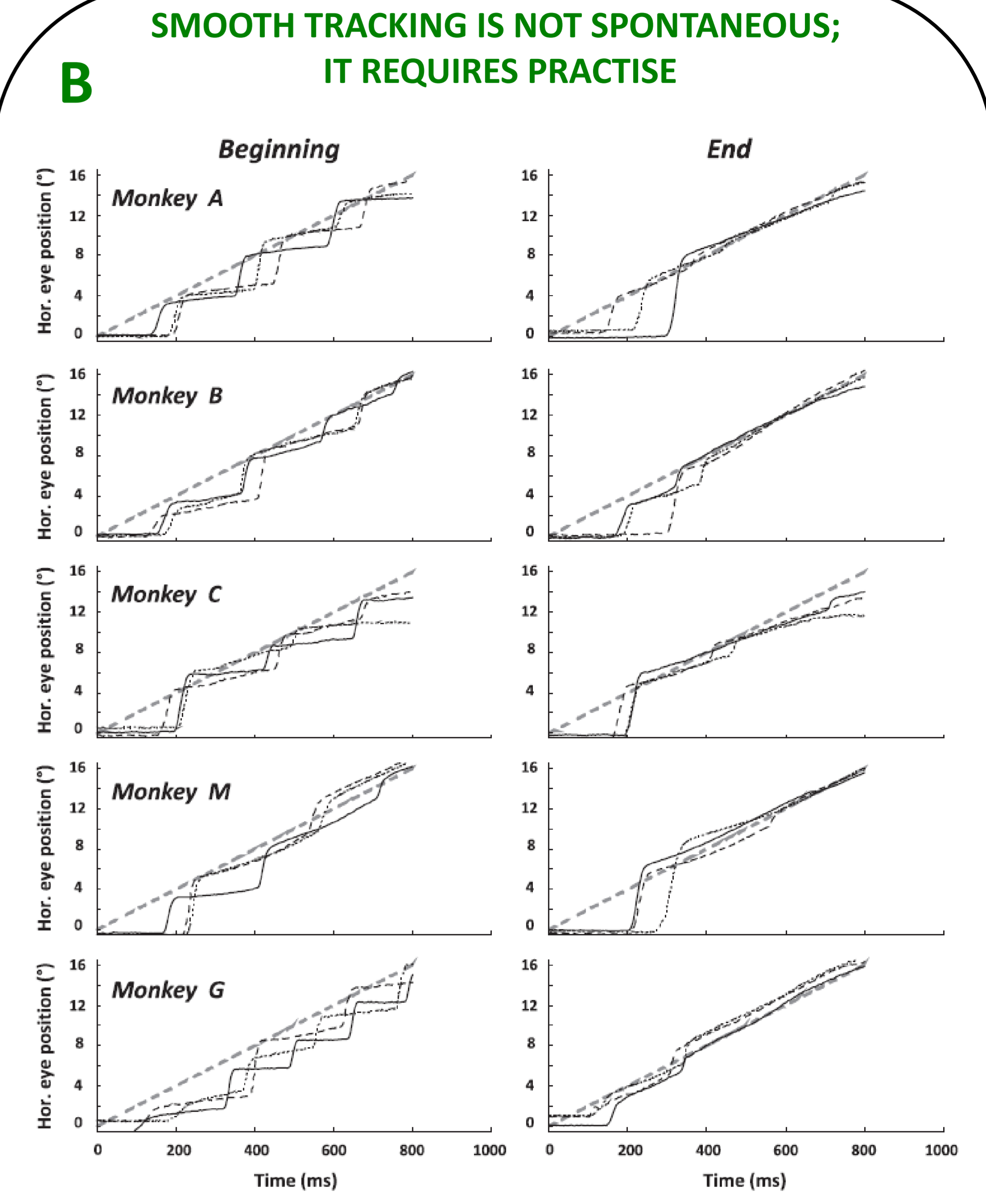
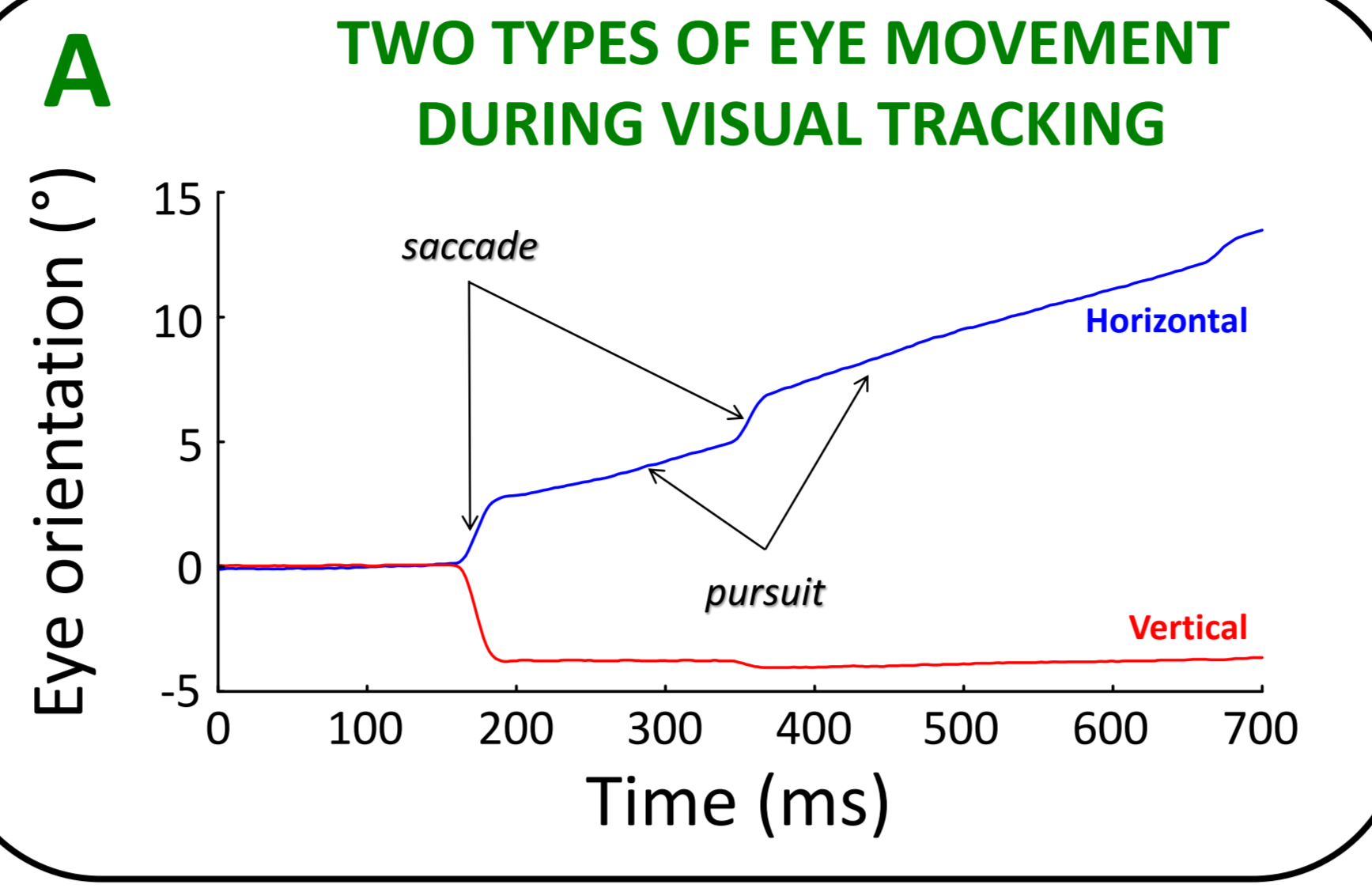
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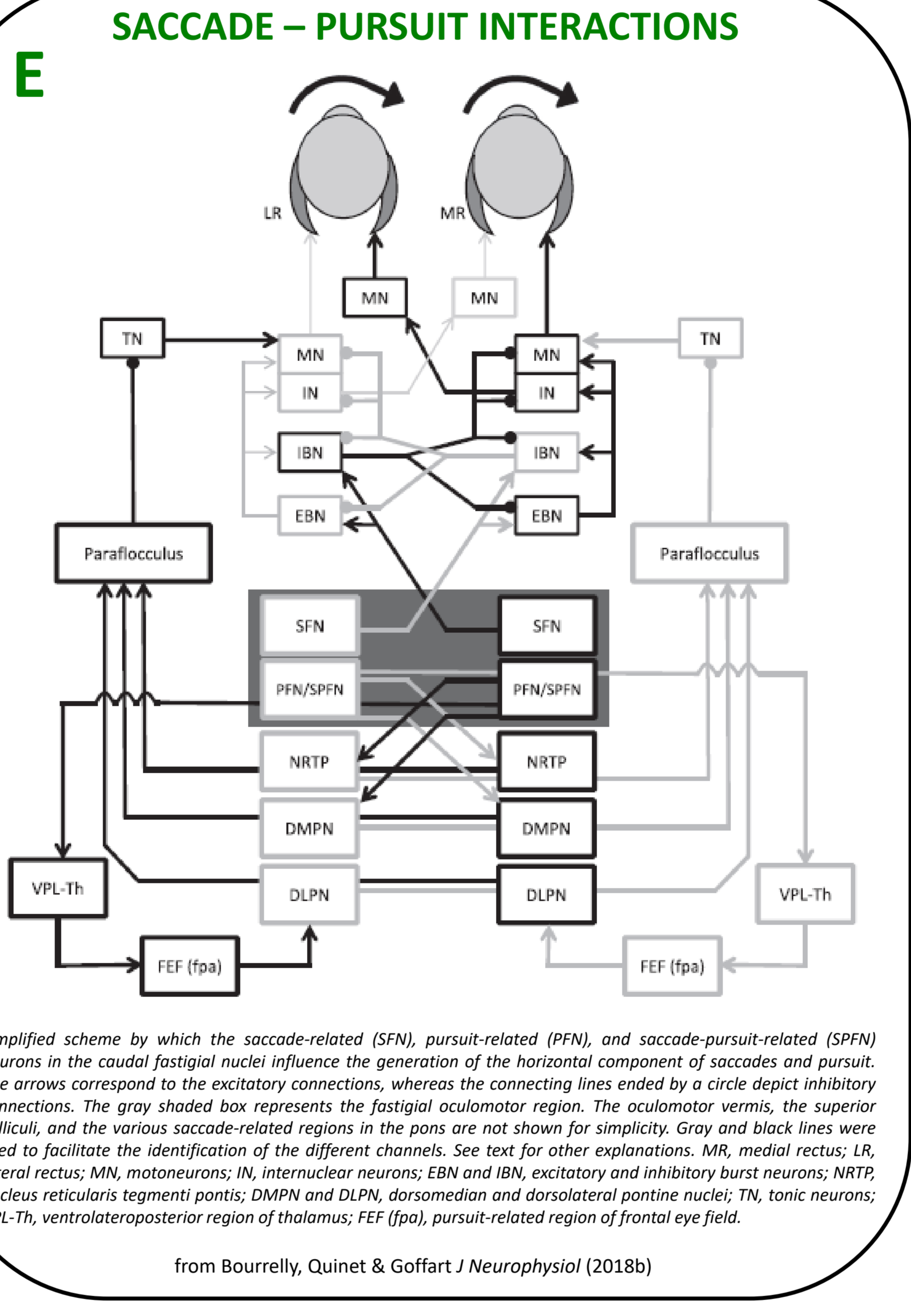
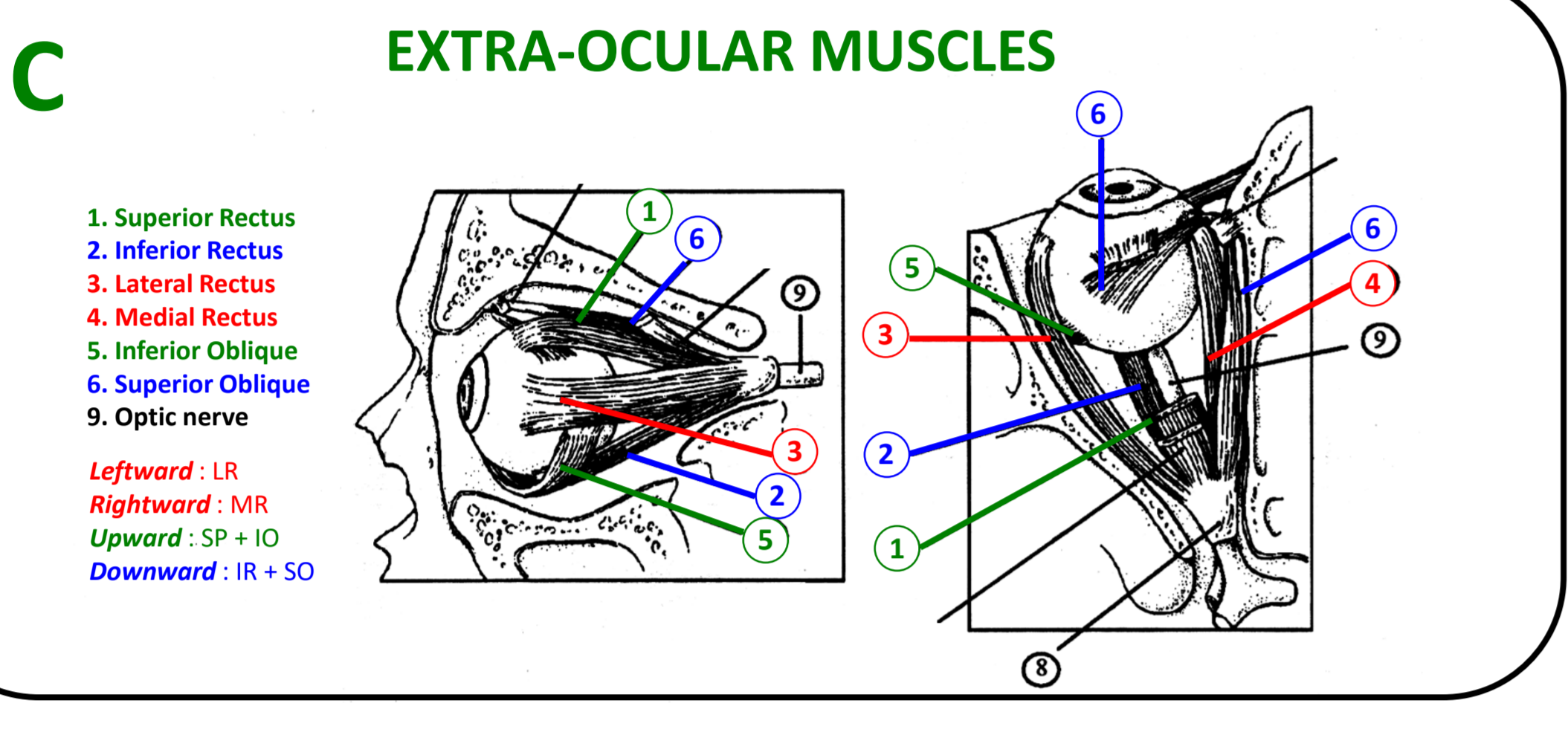
Tracking visually a target that moves in the physical world involves two types of eye movement which recruit parallel and largely distinct neuronal streams. The first movement is a very rapid movement (called saccade) which brings the target image within the central visual field, whereas the second movement, much slower, maintains the visual centering (A). Most of the time, the eyes do not rotate as fast as the moving visual target. The target image slips on the retina and the tracking is punctuated by catch-up saccades. The performance during which gaze moves as if it were attached to the target is not a spontaneous oculomotor behavior; it is the outcome of a repeated training (B). This artifact is important to consider when eye movements are used as a probe for detecting neurological or even psychiatric disorders.

Saccadic and slow (pursuit) eye movements involve the same extraocular muscles (C) and the same motor nuclei (motor neurons MN and internuclei neurons in D) but different premotor circuits. The premotor neuronal network generating saccades involves complex symmetries between multiple pools of excitatory and inhibitory neurons (D). Its interactions with the premotor network generating slow eye movements is still under investigation (E).



Typical oculomotor behavior of a monkey tracking a visual target moving horizontally with a constant speed. The horizontal eye position is plotted as a function of time after target motion onset for 3 trials recorded during the first (Beginning, left) and last (End, right) training sessions. The time course of horizontal target position is illustrated by the dashed line. The selected trials were recorded in 5 monkeys (from top to bottom, monkeys A, B, C, M, and G) when the target moved in the upper right quadrant with a constant speed (20°/s). During the other randomly interleaved trials, the target moved similarly, horizontally and away from the vertical meridian, but in the lower right, the lower left, or the upper left quadrant.

from Goffart, Bourrelly & Quinton *J Neurophysiol* (2018)
see also Bourrelly, Quinet, Cavanagh & Goffart *J Neurophysiol* (2016)



Simplified scheme by which the saccade-related (SFN), pursuit-related (PN), and saccade-pursuit-related (SPFN) neurons in the caudal fastigial nuclei influence the generation of the horizontal component of saccades and pursuit. The arrows correspond to the excitatory connections, whereas the connecting lines ended by a circle depict inhibitory connections. The gray shaded box represents the fastigial oculomotor region. The oculomotor vermis, the superior colliculi, and the various saccade-related regions in the pons are not shown for simplicity. Gray and black lines were used to facilitate the identification of the different channels. See text for other explanations. MR, medial rectus; LR, lateral rectus; MN, motoneurons; IN, internuclei neurons; EBN and IBN, excitatory and inhibitory burst neurons; NRT, nucleus reticularis tegmenti pontis; DMPN and DLPN, dorsomedian and dorsolateral pontine nuclei; TN, tonic neurons; VPL-Th, ventrolateral posterior region of thalamus; FEF (tpa), pursuit-related region of frontal eye field.

from Bourrelly, Quinet & Goffart *J Neurophysiol* (2018b)

