# Refining oculomotor control models: Accuracy and precision of microsaccades

Martina Poletti[1] and Michele Rucci[1,2]

martinap@bu.edu, mrucci@bu.edu

Departments of Psychology[1] and Graduate Program in Neuroscience[2], Boston University, Boston, Massachusetts 02215

Microsaccades are microscopic gaze shifts that occur during periods of fixation. We have recently shown that these eye movements, are not random but tend to relocate the preferred locus of fixation toward nearby regions of interest (Ko et al., 2010, Nature Neuroscience). This finding raises an important question: how precisely can the oculomotor system control microsaccades? Even though microsaccades have long been the focus of intense research, two main technical limitations have so far prevented rigorous examination of the accuracy and precision of microsaccades. The first problem has been the difficulty in accurately localizing the line of sight on the display—and, thus, in measuring microsaccadic errors—, because of the inherent uncertainty resulting from the presence offixational eye movements during preliminary calibration procedures. The second limitation has been the occurrence of retinal image motion in the retinal projection of the saccade target, and thus the consequent need for the visual system to tune the microsaccade while it is being programmed. To overcome these problems, we *(a)* developed a gaze-contingent calibration, which effectively reduces uncertainty in localization of the line of sight by one order of magnitude; and *(b)* eliminated retinal image motion by positioning saccade targets at the desired distance directly on the retina. We show that microsaccades between 7' and 20' produce larger angular errors, but smaller amplitude deviations than larger saccades. Although less efficient than larger saccades, they reduce the distance between the center of gaze and the saccade target by more than 50%, particularly for microsaccades larger than 14’. These factors are taken into account by the motor system: the probability of eliciting a microsaccade decreases with targets located at eccentricities for which the microsaccade is likely to reduce the visual error. These results have important implications for building neural models of oculomotor control: they demonstrate that microsaccades can be generated voluntarily, and that the oculomotor system controls microsaccades almost at the same level as larger saccades. This data provide further evidence that microsaccades are controlled by the same neural structures and processes underlying the planning and execution of larger saccades.

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