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Fast versus slow: different saccadic behavior in cerebellar ataxias

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Spinocerebellar ataxia type 2 (SCA2) is a genetic neurodegenerative disorder primarily characterized by involvement of the brainstem and cerebellum, basal ganglia, spinal cord, cerebral cortex, but white matter is also involved. In late-onset cerebellar ataxia (LOCA), the cerebellum is mainly involved, as demonstrated by clinical and neuroradiological findings. These neurodegenerative diseases are often associated with progressive abnormalities in eye movement control, particularly saccadic changes. We recorded saccadic eye movements in eight SCA2 patients and 10 LOCA patients. Here, we suggest that abnormalities in saccadic parameters differ in the two groups of patients according to specific anatomical substrates. The different saccadic behavior observed in these two clinically distinct degenerative cerebellar diseases offers the opportunity to simplify some general mechanisms of saccadic motor control. Like his mentor Fred Plum, John Leigh strongly encouraged younger neuroscientists to tackle neurological problems by investigating "pathological physiology." With this teaching in mind, we studied patients with rare neurometabolic and neurodegenerative diseases.

Keywords: saccade accuracy; saccade velocity; spinocerebellar ataxia type 2; late-onset cerebellar ataxia

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Saccadic control

Saccades are rapid eye movements shifting foveation from point to point in visual space. The goal of a saccade is to be simultaneously fast and accurate, particularly when the stimulus is unexpected and potentially alerting.[1,2] Since the speed of saccades is usually faster than that of visual processing, any correction by visual feedback is denied; thus, saccade accuracy is ensured by an efferent copy of the ongoing motor command (forward model) that allows motor commands themselves to be controlled by predicting the sensory effects of the current movement and modifying movement trajectory if necessary.[3–5] In daily living, however, speed and accuracy need not necessarily be maximized for each saccade. In some conditions, saccades may last longer, making visual information available for directing the eye to its goal. Moreover, since the visual space normally explored by humans in daily living is progressively contracting, it is arguable that a visually driven saccade system could be favored by evolution. A useful method for understanding how the saccade system monitors dynamic parameters in various conditions is the application of optimal control theory frameworks to saccadic motor control.[6,7] This theory suggests that the saccade system is affected by intrinsic costs that tend to reduce its efficiency. The first cost is the poor vision for target eccentricity; the second is saccade endpoint variability due to signal-dependent noise. In this model, faster saccades are generated by higher motor commands, which are associated with greater noise that in turn produce higher endpoint variability; on the contrary, slow movements are more accurate at the expense of speed.[8] To minimize these costs, the saccade system modulates motor commands by controlling the trade-off between speed and accuracy.[9,10] Further implementation of this theory exploits neuroeconomic constructs based on the assumption that the relationship between saccade duration and velocity may be

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