

## THE ROLE OF THE CEREBELLUM IN MODULATING VOLUNTARY LIMB MOVEMENT COMMANDS

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### INTRODUCTION

That the cerebellum plays a role in “fine-tuning” some aspect of limb movement commands has been appreciated for many years. By the middle of the 19<sup>th</sup> century, it had become clear that cerebellar lesions did not lead to the paralysis associated with the cerebral cortex, but rather a more complex set of motor signs. In human cerebellar patients, the consistent observations include limb movements that are relatively slow, hypermetric, and unusually curved, with poor coordination among joints. In a recent study, the primary cerebellar deficits were attributed specifically to the loss of the ability to compensate for interaction torques among limb segments, and more generally, to the inability to control a large number of muscles (2). Cerebellar dysfunction has also been implicated in a loss of the ability to time finger opening appropriately when throwing a ball (17). Alternatively, it has been proposed that the cerebellum is responsible for “setting the gain” of a variety of reflex loops (11). For example, eye movements controlled by the vestibuloocular reflex become hypermetric when the flocculus is lesioned (15).

Within the cerebellar cortex, the role of the Purkinje cell (PC) output has also been a topic of debate. Most of these cells *burst* during movement, despite their inhibitory influence on the cerebellar nuclei, an observation that is not adequately understood (7). The discharge of these cells has variously been described in terms of its relation to the *speed* of limb movement (12), the *direction* of limb movement (5) and the *combined* direction and speed of movement (4). The results we describe here show significant correlations between PC discharge and limb electromyographic signals (EMG).

In this paper we suggest that these disparate observations can be unified by assuming that the cerebellum produces a predictive signal that is combined with a relatively crude cerebral signal in order to produce an appropriately refined descending command. Consequently, as movements are produced in different environments (e.g. under uncertain loads, speed dependent loads, or spatial anisotropies), its compensatory discharge will take on the particular character of these environments.

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