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Muscle synergies and how they contribute to the movement of the tail during the nociceptive withdrawal response in the rat's tail

Hasti Izadpanah
James Madison University

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the Faculty of the Undergraduate

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by Hasti Izadpanah

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Accepted by the faculty of the Biology, James Madison University, in partial fulfillment of the requirements for the Honors College.

FACULTY COMMITTEE:

Project Advisor: Corey L. Cleland, Ph.D.,
Associate Professor, Biology

Reader: Katrina Gobetz, Ph.D.,
Associate Professor, Biology

Reader: Marquis Walker, Ph.D.
Assistant Professor, Biology

HONORS COLLEGE APPROVAL:

Bradley R. Newcomer, Ph.D.,
Dean, Honors College

PUBLIC PRESENTATION

This work is accepted for presentation, in part or in full, at Biosymposium in April 2018, at the Society for Neuroscience Annual Meeting in November 2017, and at the TriBeta National Conference in May 2018.

Abstract

Noxious stimuli can evoke the nociceptive withdrawal response (NWR), which protects the affected part of the body from injury. The rat's tail, because of the large number of joint (n=84) and muscle (n=300) degrees of freedom, may present a computational challenge to the central nervous system. Previous studies have revealed that synergies act to reduce the number of degrees of freedom across diverse movements in a variety of animals; however, there is little information in mammals on synergistic control of the tail.

The long-term specific aim of this project is to test the hypothesis that during the NWR muscle synergies controlling rat's tail reduces the muscular degrees of freedom by recording the electromyograms (EMGs) from intrinsic tail muscles during heat evoked NWRs.

Adult, male Sprague Dawley rats were briefly anesthetized with isoflurane. The tail was marked in thirteen equally spaced locations on the dorsal surface of the tail for stimulation and tracking. To record the EMG, 14 fine wires were inserted at seven locations along the length of the tail. Heat stimuli were delivered at 11 locations along the tail to evoke a NWR that was captured by high speed video.

Robust single and multi-unit EMG recordings were obtained. The EMG had two components, an early component right after stimulation and a late component. The early component coincided with initial movement of the tail away from the heat stimulus; however, it consistently lagged movement onset by 93 ms. The location of peak EMG closely matched the site of heat stimulation. In order to find possible synergies, principle component analysis revealed that 93% of the movement could be explained by three synergies constructed from

seven possible muscle degrees-of-freedom, thus reducing computational complexity from 7 to 3 degrees of freedom.

These results demonstrate that intrinsic tail muscles contribute to tail movement, but because of the lag relative to movement they are not sufficient to fully explain the initial movement of the NWR. Further, the results support the use by the central nervous systems of synergies to reduce the substantial computational complexity of tail movement.