Andrea d'Avella

Department of Biomedical, Dental, Morphological and Functional Imaging Sciences, University of Messina, Messina, Italy
Laboratory of Neuromotor Physiology, IRCCS Fondazione Santa Lucia, Rome, Italy

Presentation Title:

Low-dimensional models of motor coordination at the kinematic and muscular levels

Abstract:

It has been 25 years since the first attempts to model motor coordination using data-driven synergies to capture low-dimensional structures, which may reflect the organization of neural control processes. I will review the different types of low-dimensional models that have been introduced at the kinematic and muscular levels, some of the insights that have been gained, and key open issues that must be addressed to move the field forward. Different types of models may reveal the functional organization of different neural structures at different scales of behavioral complexity. At the muscular level, while the most frequently used spatial models likely relate to spinal and corticospinal divergence, spatiotemporal models suggest a modular cortico-cerebellar organization. At the kinematic level, spatiotemporal models allow for the characterization of individual control strategies in complex real-life motor skills. One open issue is how to determine the dimensionality of the models. A toy model simulation demonstrates that the number of synergies estimated using standard criteria based on explained data variation depends on the amount of noise and may substantially differ from the ground truth. Moreover, low-dimensional models provide a statistical description of the

output of neural populations whose dynamics may have regularities that may be captured at multiple dimensionalities. A second open issue is the relationship between kinematic and muscular synergies. To investigate it, rather than relying on non-linear musculoskeletal models, one possibility is to assume an approximate linear relations and extract mixed kinematic-muscular synergies. Thus, new conceptual and methodological advancements are needed to exploit the full potential of low-dimensional models to characterize motor coordination and guide the investigation of its neural basis.

Short CV:

Andrea d'Avella obtained a Laurea (B.Sc.) in Physics at Milan University, and a Ph.D. in Neuroscience at Massachusetts Institute of Technology in 2000. In 2003 he joined the Laboratory of Neuromotor Physiology at Fondazione Santa Lucia, Rome, Italy. Since 2015 he is Professor of Physiology in the Department of Biomedical, Dental Sciences and Morphofunctional Imaging at the University of Messina, Italy. His research has focused on the modular organization of sensorimotor control and learning, in healthy subjects and after neurological lesions. Current interests include muscle synergies and motor skill learning, inter-individual differences in real-life motor skills such as catching and throwing, applications of myoelectric control and virtual reality to neurorehabilitation. He has coordinated and participated in national and international research projects funded by the Human Frontiers Science Program Organization, the European Union, the Italian Ministry of Health, and the Italian Ministry of University and Research. He has been a member of the Board of Directors of the Society for the Neural Control of Movement from 2006 to 2015 and has been elected again in 2020. He is a member of the Board of Directors of the Italian Physiological Society since 2020. He is a member of the Editorial Boards of the Journal of Motor Behavior, the Journal of Neurophysiology, Frontiers in Computational Neuroscience, Frontiers in Sports and Active Living,

Frontiers in Motor Neuroscience, Frontiers in Neurorobotics, Frontiers in Neuroprosthetics.