Abstract

Natural variation plays an important but subtle and often ignored role in neuromechanical systems. Natural variation can be defined as the genetic, hormonal, and morphological diversity found among in situ populations\(^1\). This is especially important for understanding the function of neuromechanical systems, which can be defined as the biologically-salient study of how neuromuscular, environmental, and movement variables are interrelated.

This can be accomplished by taking a population phenomics approach to modeling and analyzing such systems. This involves taking into consideration standing variation, expression of variation across the lifespan, and the by-products of evolutionary and demographic processes. One aspect of this variation involves biological differences which are amplified or repressed in particular environments. Differences between two groups of people can be mitigated or even erased in a deleterious environment. On the other hand, switching between two environments in a rapid and patterned manner can encourage the expression of previously hidden variation.

The potential of natural variation can be classified as either robustness or brittleness. When provided with an environmental challenge, biological mechanisms can rise to this challenge and adapt immediately, adapt with some training, or fail to adapt altogether. Of particular interest is how the regulation of gene expression plays a role in regulating this response. We can characterize this variation in a theoretical manner, using known information about the structure of the genome and how environmental pressures produce an adaptive response.

This variation can be put to good use in human-machine system design. One way is by contributing to the nonlinear control mechanisms needed to control complex interacting systems. Another way is by better understanding how individuals adapt to a particular interface or wearable device. The variation found in a single individual or group of individuals can be the basis of nonlinear control strategies\(^2\). Finally, it allows us to better understand how short-term decrements in performance can lead to more substantial long-term gains.

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\(^1\) In situ populations are defined in contrast to statistical populations. In situ populations represent groups belonged to by the individual (e.g. familial or ethnic) being sampled.

\(^2\) Examples might include the rate-limiting effects of pharmaceutical agents, the dampening effects of muscle and connective tissues, and the feedback effects of physical training on the regulation of gene expression.