Striking the right balance with muscle control

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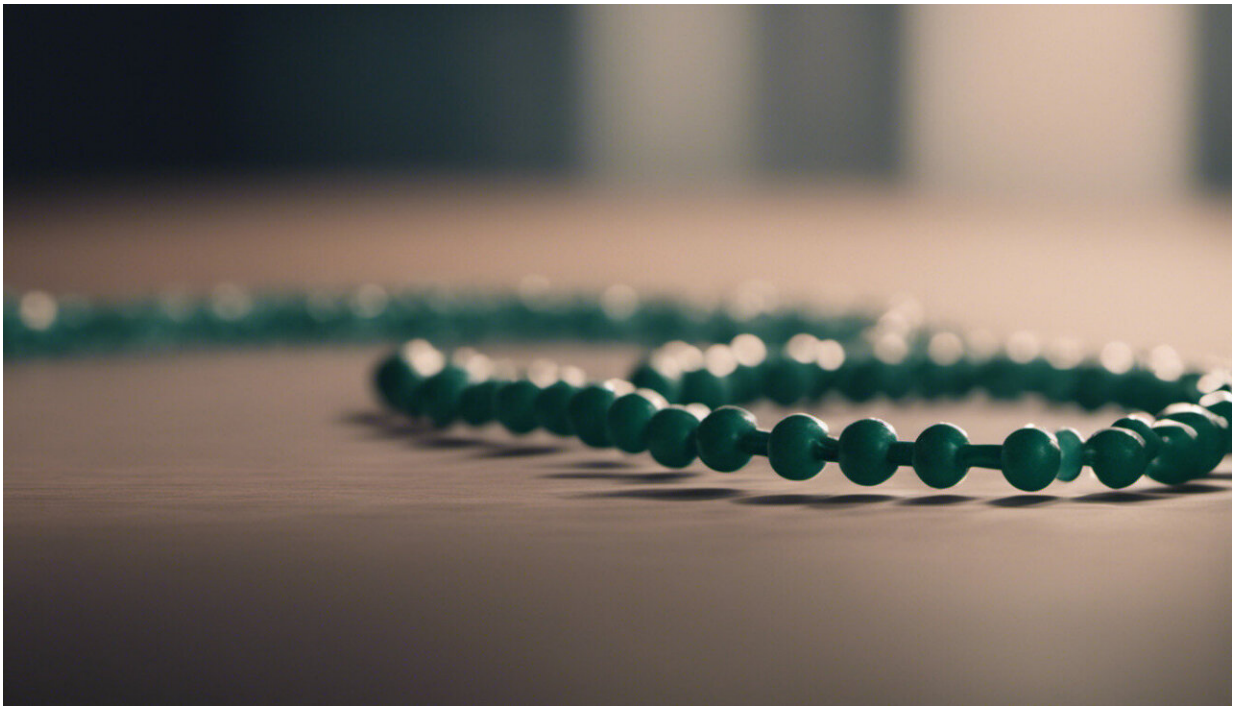

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The central nervous system (CNS) comprises the brain and spinal cord, and coordinates all our bodily activities. One of the functions of the CNS is to choose the most efficient muscle movements in order to conserve energy and allow the body to move smoothly, and it is believed that the CNS trains itself through experience to narrow down the number of

options. Fady Alnajjar and colleagues from the Intelligent Behavior Control Unit of the RIKEN Brain Science Institute have now modeled the behavior of muscles during balance tests to illustrate how the human CNS trains itself to maintain balance1.

"Modeling of the computational mechanisms between the CNS and muscle control, which we call muscle synergy, is challenging," explains Alnajjar. "Our study concerns the muscle synergy behind basic motor skills, such as maintaining balance, in healthy humans."

Alnajjar's team developed a model of 'muscle synergy' by devising two novel parameters: the synergy stability index (SSI), which measures the similarities between muscle usage in repeated behaviors and therefore the stability of the neural command, and the synergy coordination index, which measures the overall size of the synergy space required to carry out a movement and therefore the level of coordination between muscles.

The researchers used these two parameters to measure the interactions between the human CNS and muscles during balance tests. Eight participants were asked to stand on a randomly moving platform, using only their hips and ankles to maintain balance, with electrodes attached to their major leg and back muscles.

Both indices were found to successfully characterize the muscle synergy associated with balance skill. "Participants with strong balancing ability showed high SSI levels," notes Alnajjar, "implying that their CNSs were aware of the best muscle synergy for responding to balance disturbances. Participants with low balancing ability had low SSI levels. Also, good balancers used tightly coordinated muscles, resulting in smoother movements."

In each case, the CNS appeared to search for a narrow muscle-synergy

space of stable neural commands and coordinated muscle reactions. In a second set of experiments using the lowest scorers from round one, each person completed five more sessions on the balance platform. The participants showed significant improvement on completion, suggesting that with training, the CNS can narrow its muscle-synergy space and thus improve coordination.

Alnajjar hopes that an advanced version of these indices could be used to develop therapies for post-stroke motor function recovery as a means of creating targeted, effective neuro-rehabilitation systems.

More information: Alnajjar, F., Wojtara, T., Kimura, H. & Shimoda, S. "Muscle synergy space: Learning model to create an optimal muscle synergy." *Frontiers in Computational Neuroscience* 7, 136 (2013). DOI: 10.3389/fncom.2013.00136

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