The human brain minimizes energy expenditure and integrates gravity in to the action plan

October 24 2008

When reaching for an object, the brain prepares neural commands sent to the target muscles to minimize energy expenditure, according to a study published in *PLoS Computational Biology* by neuroscientists and mathematicians from the INSERM and ENSTA.

How the human brain organizes and controls our actions is a crucial question in life sciences. In recent decades, an important theoretical advance has been the use of computational models and the assumption that the brain behaves like an optimal controller. In most studies, an optimality criterion is chosen a priori and assumed to produce smooth and harmonious movements, as those recorded experimentally. Most existing models, however, fail to explain how our interactions with the external environment are integrated into optimization processes.

In particular, gravity is one of the constraints that permanently act upon the movements of living organisms. The simple observation of vertical arm movements reveals that muscle activity when moving upwards differs from when moving downwards. This led the authors to surmise that the brain takes advantage of gravitational force during movement, trying to optimize energy consumption. The discovery of this biological rule has resulted from the use of a hypothetical-deductive mathematical method which predicted short periods of muscle inactivation and direction-dependent hand kinematics. These predictions have been verified experimentally using human volunteers. Moreover, they have demonstrated a necessary and sufficient condition of optimal control for arm movements which is a novelty in motor control studies.

The authors explain how the brain plans movements by integrating biological and environmental constraints and the method may be of potential value for understanding motor dysfunction and guiding subsequent rehabilitation programs. Moreover, it opens the prospect of studying brain functions by a cooperative interaction of mathematicians and neuroscientists. Interestingly, the paper is a clear demonstration that mathematical principles and theories, formerly used for understanding the non-living world, are now used for understanding how biological organisms integrate these laws.

Citation: Berret B, Darlot C, Jean F, Pozzo T, Papaxanthis C, et al. (2008) The Inactivation Principle: Mathematical Solutions Minimizing the Absolute Work and Biological Implications for the Planning of Arm Movements. PLoS Comput Biol 4(10): e1000194. doi:10.1371/journal.pcbi.1000194
dx.plos.org/10.1371/journal.pcbi.1000194

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