Nonlinear Dynamics, Psychology, and Life Sciences, Vol. 13, No. 1, pp. 1-2.

Introduction to the Special Issue on Psychomotor Coordination and Control

Mark Shelhamer[1], *The Johns Hopkins School of Medicine, Baltimore, MD*

The area of motor control in humans and animals is advancing rapidly on many fronts. Improved knowledge of limb control has immediate implications for programs of rehabilitation for patients with movement disorders. The study of motor control has also proved to be an especially rich platform for the development and investigation of theoretical constructs such as forward and inverse models, multiple learning rates, and performance optimization. More specifically from the point of view of nonlinear dynamics, the field of motor control and coordination provides a rich venue for the exploration of high-order models, dynamical-systems measures, and concepts such as fitness landscapes and fractal time series.

Unfortunately, at this point in time, it is largely the case that there are two segregated groups of motor-control researchers. One group stems from a neuroscience and bioengineering background while the other is more closely associated with dynamics, cognitive science, psychology, and kinesiology. While there is some overlap, there is great potential for more extensive interactions between these groups. The articles in this issue are very much from the second group. Perhaps distribution of this special issue to receptive investigators from the first group can be an initial step in establishing dialogue between the groups.

The contributions in this special issue on Psychomotor Coordination and Control span a range, from broad overviews of work on motor learning, to studies on the generation of 1/f noise in motor control, to experimental studies of specific motor-control tasks. All have as a common element the interpretation of empirical results in terms of the concepts underlying nonlinear dynamical systems.

Mayer-Kress, Newell, and Liu present a rather general overview of motor learning in terms of attractors (fitness landscapes), placing the authors' own works in a broader perspective and providing a framework that can guide

[1] Correspondence address: Mark Shelhamer, 210 Pathology, The Johns Hopkins School of Medicine 600 N. Wolfe St. Baltimore, MD 21287. E-mail: mjs@dizzy.med.jhu.edu

future studies. This approach enables a unified line of attack for different sources of variability such as learning and adaptation, fatigue, and skill and difficulty levels, with possibly different time courses.

Chow and colleagues likewise summarize a great deal of information from previous studies, again with particular emphasis on the authors' own work. Their article provides a wonderful set of examples as to how multi-articular motor-control results might be interpreted in the context of metastability and self-organization, with emphasis on skill learning and practice.

Kello and Van Orden present a survey and review of principles of metastability and relative coordination in sensorimotor functions that involve the coordinated interaction of several component parts. They show that such principles lead to 1/*f* scaling in the dynamics of these systems, reflecting a balance between independence and interdependence.

Wijnants and co-authors examine sequences of times taken by subjects in moving between two targets. As subjects learn the task, their performance becomes less random and a more coherent pattern emerges, as demonstrated by a larger magnitude of the 1/*f* spectral slope. This is verified by RQA and other methods, and is interpreted as a reduction in the number of degrees of freedom as independent subsystems act more cooperatively.

Guastello, Nathan, and Johnson propose a nonlinear model for reaching and grasping movements. The model can reproduce the occurrence of a grasping motion during arm reaching, which previous models cannot do adequately. Movement trajectories are interpreted in terms of attractors (goal points along the motion), and the model describes them in terms of positional coordinates rather than in terms of time. A structural equation based on attractor stability as assessed by Lyapunov exponents is developed. The work has implications for programming of robots used in neurological rehabilitation (teaching patients to make natural movements after a stroke).

Harbourne and colleagues analyze postural control in infants, and show that nonlinear dynamical measures (approximate entropy and Lyapunov exponents) explain more of the variability in center-of-pressure recordings than do standard linear measures.

One of the true pleasures of serving as guest editor for this issue was working with the many authors and reviewers who have contributed, as well as with the founding editor Stephen Guastello. Needless to say, this issue ultimately reflects their dedication to the field. Another noteworthy aspect was the opportunity to see the breadth of work being pursued under the general banner of nonlinear dynamical systems, which gives great hope for its continued growth.