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Multisensory Integration for Motor Control and Adaptation

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This special issue was inspired by the 2011 meeting of the Society for the Neural Control of Movement (NCM) in San Juan, Puerto Rico. NCM is an international community of scientists, clinician-investigators, educators, and students whose common goal is to understand how the brain controls movement. The society's mission is to provide a forum for advancing knowledge on the structure and function of neural systems underlying the control of movement and their associated disorders (<http://ncm-society.org/>). The April 2011 meeting in Puerto Rico exemplified these goals. In this special issue of *Journal of Motor Behavior*, we emphasize and expand on selected research on multisensory integration and motor adaptation presented at this meeting.

For many decades now, sensorimotor research has revealed remarkable intricacies in the bidirectional relationships between input from individual sensory systems and motor output. At the same time, research on multisensory integration has expanded our appreciation of additional computational problems that have to be solved, and our understanding of the anatomical and functional organization of the neural systems that underlie solutions to those problems (Ernst & Bühlhoff, 2004; Sarlegna & Sainburg, 2009; Sober & Sabes, 2005). Our increased understanding of that complexity is reflected by rapid developments in applied neural sciences such as rehabilitation and neural engineering. For example, research on sensory integration and motor adaptation has contributed to the development of brain machine interfaces for the restoration of movement, adaptive environmental control and communication in disabled individuals (Lebedev & Nicolelis, 2006; Mussa-Ivaldi & Miller, 2003; Schwartz, Cui, Weber, & Moran, 2006), as well as to the development of rehabilitation devices, such as robotic interfaces for training stroke patients and patients with spinal cord injuries (Díaz, Gil, & Sánchez, 2011; Hidler & Sainburg, 2011). This area of research is currently inspiring the development of training protocols that alter sensory feedback for enhancing motor learning in virtual environments (Patton & Huang, 2012).

This special issue presents seven articles that address sensorimotor integration for the adaptive control of voluntary movements. The topics range from the fundamentals of finger coordination to details of engineering human-machine interfaces. Rincon-Gonzalez, Naufel, Santos, and Helms Tillery present evidence that the coding of tactile features is embedded in a proprioceptive frame of reference that provides the structure for haptic perception. Weber, Friesen, and Miller address how the nervous system transforms sensory information arising in the periphery into central representations in the cortex, with the goal of developing

principles for the design of neural prosthetics. Casadio, Ranganathan, and Mussa-Ivaldi directly apply principles of sensorimotor integration to the design and implementation of human-machine interfaces for facilitating adaptive motor control in rehabilitation. The importance of multisensory integration in adaptive control is further emphasized by Henriques and Cressman, who review the effects of visual and proprioceptive integration on motor adaptation, including how discrepancies between these modalities alters adaptation. Seidler, Bo, and Anguera describe an overlap between cognitive learning processes and motor learning processes, focusing on the importance of spatial working memory on motor adaptation. Mutha, Haaland, and Sainburg describe evidence that voluntary movements are subserved by specialized mechanisms in each cerebral hemisphere, which results in hemisphere-specific motor control and adaptation deficits in patients with unilateral stroke. Finally, Wu, Pazin, Zatsiorsky, and Latash demonstrate that training of a multieffector task results in a larger variety of redundant solutions when training multiple effectors simultaneously than when training each effector separately.

Taken together, these articles reflect our expanding knowledge of how the brain integrates and uses sensory information to solve problems in motor control and adaptation, and describe the application of this information to neural technologies. We hope that the readers find the articles as engaging and stimulating as we have in preparing this special issue of *Journal of Motor Behavior*.

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