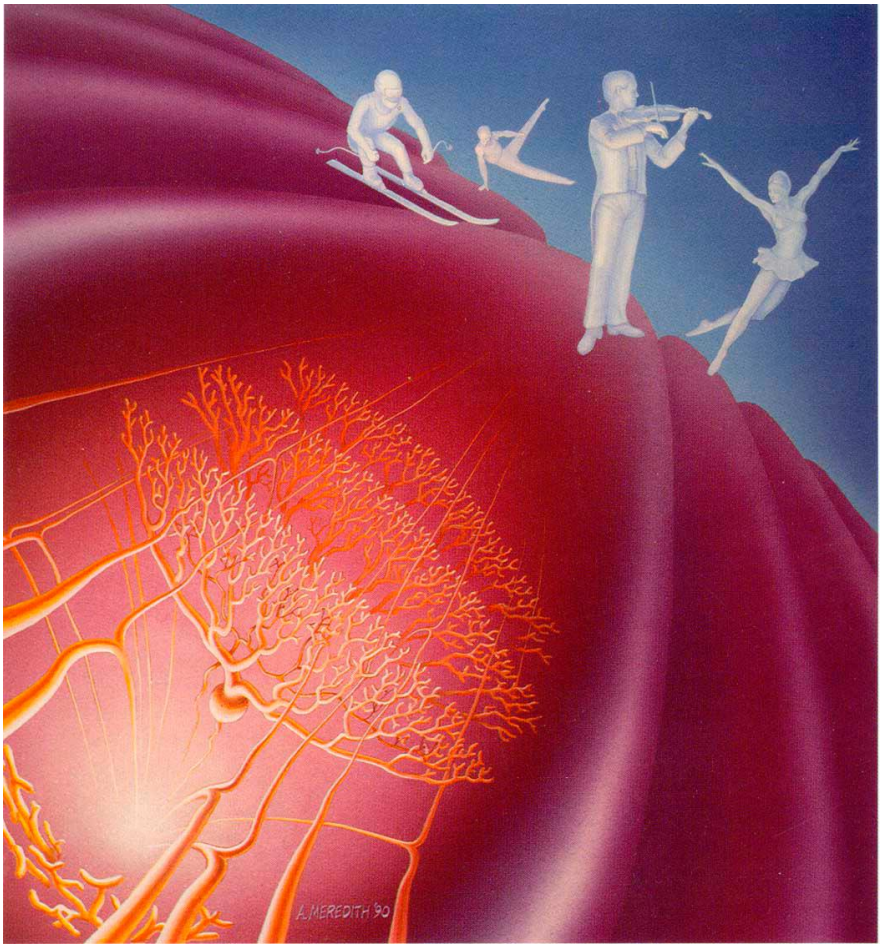
NCM Symposium--a set of related sessions

The Neuroscience of Extraordinary Motor Skill: Sensory-Motor, Cognitive, and Pathologic Attributes of Artistic Performance

Organized by Gary Paige and Eckart Altenmüller



Introduction

Hominid evolution has witnessed a remarkable expansion in sensory-motor integration, matched by facile adaptive capabilities and intelligence. In parallel, specialized skills across individuals have allowed us to form populations with complex capabilities, ultimately producing ever-sophisticated tribal units and societies. Somewhere early on, primordial humans developed the curious ability of 'symbolic expression'—the arts—and with them, the moorings of culture. This holds throughout humanity, as well as historically according to archeological record. The extraordinary skills and talents required at the highest levels of the performing arts are among the most exceptional examples of sensory-motor and adaptive behavior. These comprise the topic of several special sessions. Consider the following overarching considerations: 1) What constitutes artistic 'talent' and is it transferable across modalities (e.g. different instruments, or music to dance….), or even different endeavors (sports, surgical skill, etc.)? 2) What interactions between motor control and sensory feedback explain artistic talent and the ability to develop professional performance capabilities? 3) Are there distinct identifiable strategies in learning/teaching the performing arts as compared to the activities of daily life? 4) What selective advantage has propelled the arts—symbolic expression—into foundational elements of humanity?

Thursday Evening: A Performance of Music and Dance

Kenneth Broadway and Peter Sparling

Program Notes:

Pianist Kenneth Broadway and dancer/choreographer/video artist Peter Sparling will "compare notes" regarding the development of motor skills and memory as essential components of their performance careers. A renowned interpreter of a broad range of piano repertoire, Ken looks at motor memory as being distinct from an intellectual analysis-based memorization. Performing short works from a lifetime of study, he shares his experiences from childhood and "playing from memory" to his gradual discovery of another more reliable method of memorization via visualization. Ken and Peter share an understanding of motor memory or muscle memory as a means towards the retention of either musical notation or danced sequences. Is there such a thing as muscle memory, or is it a myth that dancers cling to because of their identification with sensation and the physical act, characterized by weight (gravity), flow, and sensory awareness of time and space? Peter explores varying modes by which dancers learn movement and his own gradual shedding of all planned or pre-choreographed (i.e. memorized) movement for structured or free improvisation. How is memory activated (or seemingly obliterated) when nothing is pre-conceived and choices of what to do next are being made in a split second? Is there a feedback loop by which impulse, gesture or a particular movement provokes the next move? How does accumulation and momentum create flow and thus the ability to shape phrases and articulate expressive communication? How does the viewer receive images in motion (or music for that matter) both visually and viscerally? What is kinesthetic empathy, and is this related to the mirror neuron phenomenon?

How might these extremely specialized, "extraordinary skills"--honed in the cloistered world of the performing arts-- inform us about how we learn, make sense of our world, perform everyday tasks and forge new sensory-motor and cognitive pathways?

Ken will perform the following works:

Frédéric Chopin: Waltz in D-flat Major Op. 64, No. 1
Arnold Schoenberg: Klavierstück Op. 33a (excerpt)
Johann Sebastien Bach: Präludium from Partita No. 1 in B-flat Major, BWV 825
Franz Liszt: The Fountains at the Villa d'Este

Peter will screen excerpts from his videos.

Ken will perform four works from Six Encores for Piano (1990) by Luciano Berio, accompanied by a screening of dances entitled Fire/Earth/Air/Water, created especially for the event by Peter:

Feuerklavier, Erdenklavier, Luftklavier, Wasserklavier

Friday Sessions and Keynote Presentation

Special Session I:

Exploration of Extraordinary Skills: What can Neuroscientists Learn from Performers?

Dagmar Sternad and Terry Sanger, with Ken Broadway, Peter Sparling, and Gary Paige

Following upon the music and dance performances of Ken Broadway and Peter Sparling on Thursday evening, this session aims to connect insights gained from performance artists to motor neuroscience. Terence Sanger and Dagmar Sternad will set the stage by describing their perspectives on the opportunities for forming bridges between skill learning, skilled performance, and the neuroscience of motor performance and learning. A subsequent panel discussion including the session organizers, the two artists, and Gary Paige, will address the question of what new types of neuroscience research are needed in order to be able to understand and improve human motor learning for difficult tasks, and emulate it in artificial learning systems. This session will stir thoughts on new avenues for motor neuroscience. Active audience participation is encouraged.

Special Session II:

Multi-System, Complex, and Adaptive Attributes of Music Production
Guest presenters: Lutz Jäncke and Gottfried Schlaug

The production of music is a complicated sensorimotor and cognitive task. This session explores several key aspects of this process, including different forms of music: one derived from external instruments designed to generate artificial sound (e.g. piano), and another derived from the human voice. **Lutz Jäncke** will address the former while **Gottfried Schlaug** will present the latter.

For a non-musician it is always astonishing to notice the speed and accuracy with which pianists find the correct keys (mostly) without any substantial error. How do they achieve this extraordinary performance in which brain networks are involved in the control of this performance? Jäncke will present anatomical and neurophysiological data from professional and non-professional musicians at least partly uncovering the extraordinary neural underpinnings of piano playing. These data will underscore that the brain of pianists has been shaped most likely by experience. It will also show that some musicians are equipped with a specific neural "prerequisite", which might support the acquisition of their extraordinary ability. In addition, he will demonstrate how the functional neural network operates during different variants of piano playing. All in all, pianists provide an excellent "natural" opportunity to study how the human brain implements specific sensorimotor proficiencies.

Singing, or making music with one's own vocal apparatus, is a multimodal activity that involves the integration and adaptive training of auditory and sensorimotor feedback and feedforward processes. The human ability to sing is evident from infancy, and does not depend on formal vocal training but can be greatly enhanced by training. Schlaug will present several studies examining the neural correlates of (1) singing and its similarities and differences with speaking in expert and occasional singers, (2) a congenital disorder of singing exemplified by a group of individuals with an auditory-motor disorder who can't sing in tune, (3) an induced dysfunction of singing by altering sensory feedback or by causing temporary cortical dysfunctions using non-invasive brain-stimulation to examining the role of nodal points in the sensorimotor network of

singing, and (4) therapeutic effects of singing in individuals with acquired lesions and congenital disorders.

Keynote Presentation:

Functional and dysfunctional plasticity in motor systems of musicians

Eckart Altenmüller [includes performance: Altenmüller (flute) and Broadway (piano)]

Motor systems of musicians are an excellent paradigm to study functional and dysfunctional brain plasticity, visuo-auditory-sensory-motor integration, and metaplasticity, as well as the impact of neuro-hormones and limbic functions of the nervous tissue. Further, sensory-motor skills of musicians have interesting specific qualities: learning begins at an early age in a playful atmosphere. Routines for stereotyped movements are rehearsed for extended periods of time with gradually increasing degrees of complexity. Via auditory feedback, the motor performance is extremely controllable by both performer and audience. All movements are strongly linked to emotions – pleasure or anxiety – processed by the limbic system. These specific circumstances seem to play an important role in plastic adaptation at several levels of the central nervous system. With modern neuroimaging methods, diverse anatomical changes of cortical and subcortical executive sensory-motor, auditory, and limbic regions can be observed in musicians. Plastic adaptations are not only reflected in morphological but also in functional changes. The temporal dynamics of these changes are fascinating: When commencing to learn to play an instrument, auditory-sensorimotor integration is accompanied by rapid modulations of neuronal connectivity in the time range of 20 minutes.

In recent years, the concept of metaplasticity in motor systems has been strongly supported by empirical findings. For example, in a recently published study, we showed that early training before the age of seven years leads to functional optimization of neural networks in the putamen and the sensory-motor systems rather than enlargement of grey or white matter. Early training thus provides a scaffold for later mastery, i.e. for extraordinary sensory motor skills acquired during pre-adolescence and adolescence.

Early training not only provides a scaffold for later expertise, it furthermore renders motor skills more stable than does intensive training later in life. This is one of the reasons why degradation of control of skilled movements is five times more frequent in musicians who start to play their instrument later in live. This condition, termed **musicians' dystonia** (MD), leads to involuntary dysfunctional movements of motor programs involved in playing a musical instrument. Neuroimaging studies point to dysfunctional (or maladaptive) neuroplasticity as its cause. Compared to healthy musicians, musicians with dystonia showed, for example, a fusion of the digital representations in the somatosensory cortex. Such a fusion and blurring of receptive fields of the digits may well result in a loss of control, since skilled motor actions are necessarily bound to intact somatosensory feedback input.

Interestingly, psychopathology of musicians suffering from focal dystonia emphasizes the existence of two different populations based on diverse psycho-behavioural features. Here, we speculate that dystonia in musicians could be a maladaptive procedure developed via different circuits of the cortico-basal ganglia-thalamic structures between dystonia patients of the first and second subgroups. The resulting classification will enrich the diagnostic procedure of MD and will be crucial for the selection of suitable treatment methods.