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• E. Altenmüller, M. Wiesendanger and J. Kesselring (eds): *Music, motor control and the brain*, Oxford, New York: Oxford University Press, 2006, 327 pp., ISBN 0-19-853000-5 978-0-853000-5, price: € 53,99.

This book focuses on several fascinating technical issues of music performance: What are the cognitive underpinnings of instrument performance? How are rhythm and sound integrated? What kinds of movements characterize professional performance on an instrument? How do the brains of musicians differ from those of non-musicians? The two largest portions of the book deal with the neurobiology of musical performance, from plasticity in the brains of musicians (seven chapters) to focal dystonia in musicians (five chapters). Since the range of topics is extremely broad, this book cannot be summarized in a coherent overview. Instead, I will provide a short summary of each of the twenty chapters separately.

In the book's preface, the editors present the conflicting approaches of Salieri, a protagonist for the technical, analytical aspects of music performance and Mozart, the genius guided by his fascination with music. Technical dominance, as symbolized by Salieri, has become dominant in the field of classical music. Technical dominance constitutes a drastic challenge of the processing of musical performance. The chapters of this book illustrate important aspects of these processes, involving planning, execution, control and feedback differentiation, performed simultaneously.

PART 1: HISTORY

Andreas Lehmann provides an overview of the historical increase in expert musical performance skills. He offers precise descriptions of the optimization of instruments, playing techniques and training, which have resulted in a remarkable change in velocity of play and preciseness of performance. Musicians' rigorous specialization on one instrument, combined with intense worldwide performance competition, has precipitated this development. Furthermore, there is a trend among conductors to compose pieces of increasing complexity over the course of their careers. The piano sonatas of Joseph Haydn demonstrate this. The individual time spent with one instrument is increasing in modern musicians. Musicians begin specializing in one instrument earlier in life and spend greater amounts of time practicing than in the past.

PART 2: PSYCHOLOGY

Lutz Jänke describes the psychological processes associated with the cognitive control of musical performance. In this fascinating chapter, Jänke discusses perception of

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music, site reading and transformation in motor programs, memory processes, feedback perception and online control of movements. Multiple demands on perception result in remarkable improvements in several aspects of performance, such as discrimination of pitch, timbre, and the recognition of melody. Additionally, musicians are capable to read sites before playing them. Eye movement analysis has shown that musicians look ahead as they play. Experienced musicians cluster information, keeping it in short-term memory before transferring it into motor programs.

Jänke describes how the motor system is reorganized in musicians capable of incredible performance. Representations of complex movement patterns are tied together. Hebbian mechanisms of associated neuronal firing have built a specialized network of motor control.

Jänke also discusses the role of memory in musical performance. The perceptual storage of music enables high distraction of information and recognition of different aspects of music. For instance, melody is recognized independent of an instrument's timbre. This perceptive memory is represented in the primary auditory cortex, as well as in the inferior frontal and inferior temporal regions of the brain.

Caroline Palmer describes the nature of memory in skilled music performance in detail. She emphasizes the motor aspects of memory required by professional musicians, producing astonishingly high rates of 8-12 events per second with less than 3% error. Errors in performance often involve active memories for other events to be performed, such as tones intended for elsewhere in the same piece. Palmer describes the transfer of performance skills and how mental practice can improve performance. An important aspect of mental play is the absence of auditory or somatosensory feedback. This absence of auditory information during practice decreases the motor memory in future performances. Mental imagery is most effective when an auditory and motor engram for the piece has already been established by actual practicing.

Bruno Repp discusses musical synchronization. What enables a musician to synchronize his instrument with those of the ensemble? What are the factors that enable a dancer to detected sub unities of tempi, which enable a synchronous, but also artistic, dance? The author describes the limits of intervals between beats (200 ms) and its subdivisions (100 ms). On the other side of the time scale, a two-second interval is the longest for which a sensorimotor synchronization can be achieved. Interestingly, playing music in an ensemble is hampered by different systematic distractors, such as asynchronies between soloists and drummers in jazz musicians. Synchronization is better when the performer synchronizes his or her individual recorded performance with the performance of another person. Additional visual cues are important for sensorimotor synchronization between different performers.

PART 3: MOVEMENT ANALYSIS

Thomas E. Jerde and colleagues describe hand movements used in musical performance. The authors first describe the basic principles of the measurement of hand and finger movements. It is almost impossible to restrict motion to a single finger (enslavement). However, principal component analysis suggests that fine control of complex finger movements involves the superimposion of simple patterns of coactivations of different fingers during piano play. The authors describe the effort required for a musician to achieve a movement repertoire. After extensive practice, the musician is able to employ a fast interpretation of musical processes on the instrument without wasting cognitive load on the mastering of the individual finger sequences itself.

Hans-Christian Jabusch uses movement analysis of performing musicians to study the motion of the upper extremities. After describing historic approaches of the movement analysis of piano play, Jabusch delineates new methods such as the analysis of MIDI-files, which he uses to describe interindividual playing patterns, training-related changes in performance and characteristic features of different styles of performance. Further, the author described the use of modern movement analysis techniques for the detection of movement patterns important in medical issues related to performance. Different techniques have been used to help optimize hand ergonomics to avoid pain and overuse syndromes.

The motor control of fingering and bowing in violinists is described by Mario Wiesendanger and colleagues. On average, changes in finger position require 20-30 ms. By measuring bow and fingering movements in violinists, the authors detected bimanual synchronization errors of 50-60 ms. Errors of this magnitude are tolerated in terms of auditory perception in string players. Interestingly, trajectories vary considerably between individual musicians. However, goal achievement is much less variable.

Sophia Dahl offers insights into movement analysis of drumming. In concordance with other instrumentalists, professional drummers show better movement control than amateurs. In professional drummers, the average standard deviation of movement inter-onset-interval is 2.8%; temporal accuracy is dependent on the level of professional expertise. These timing deviations are longer during softer play than louder play — accelerated strikes are performed with greater velocity. The movement strategies used in drumming can be described as whiplash-like and aim at achieving high velocities on impact. Most movement studies of drumming have focused on playing with a single stroke performed with one hand. More complicated interactions between the player's sticks and surface have not been examined.

PART 4: REPRESENTATION IN THE BRAIN

The forth part of the book begins with an overview by Gottfried Schlaug, who describes the morphological changes produced by intensive instrument training. However, it is not understood whether these changes are induced by training or are

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pre-existing differences that predispose a person to musical excellence. In an ongoing longitudinal study, the author and his team tracked a group of 5 to 7 year old children prior to and after some years of instrumental musical training.The authors are also interested in transfer effects between musical skill and other neuropsychological abilities, such as spatial orientation, memory concentration and phonetic skills. The inferior frontal regions, in particular, might be essential for superior integration of sound and movement.

Lutz Jänke summarizes functional results of motor representation studies in pianists and string players. He emphasizes the extreme amount of time a professional player spends with his instrument (more than 7000 hours accumulated practice time) in comparison to music teachers (3400 h) and amateur pianists (1600 h). Jänke lists the specific improvements of motor functions in pianists and string players and provides an overview on neuropsychological peculiarities of the sensorimotor system of skilled musicians. These studies can be differentiated in those employing motor tasks that could also be performed by non-musicians versus those comparing musicians with different levels of expertise during the performance of a musical piece. Both approaches point to an increased economization of motor activities in the higher trained group. Altered interhemispheric interactions — as detected with transcranial magnetic stimulation (TMS) — provide an electrophysiological explanation for a morphological increase in the size of the anterior corpus callosum in professional musicians.

Marc Bangert describes brain activation studies during piano play. After twenty minutes of playing a piano with auditory feedback, the auditory signal is associated even if the feedback is no longer provided. The author argues that this audio-motor coupling is processed in the right frontotemporal area, which was active during both listening to a trained musical piece without performing it and during performance without auditory feedback. If the piano-key tone is destroyed, this frontotemporal activation decreases. Therefore, it should be associated with the audio-motor coupling during piano play and might be the interface that translates music into movement. Bangert interprets findings concerning mirror neuron representations in the ventral premotor cortex as possible sources for this frontotemporal interface.

Arto Nirkko and Rumyana Kristeva predominantly describe results of their study on complex motor performance and executed and imagined violin playing using functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). Their considerations underscore the findings of Bangert and colleagues with respect to the importance of the opercular network in music production. Additionally, they describe two other possible functions of this area for audio-motor integration — motor sequencing and manipulation as well as the retrieval and rehearsal of internal non-linguistic auditory representations and time intervals.

Hermann Ackermann and colleagues provide a contribution about cerebral and cerebellar representations of vocal performance. They predominantly emphasize the differences and common factors of speaking and singing. They review reports on the dissociation of singing and speech in behavioral studies and imaging studies of brain lesions. Lesion studies and behavioral data suggest that singing is bilaterally represented in most subjects, while the representation of speech is lateralized. Haemodynamic mapping studies confirmed lateralization differences in singing versus speech, especially within the anterior insula. The authors conclude that, aside from the functional imaging data, clinical and experimental data indicate that singing capabilities are predominantly bound to the right hemisphere. These lateralization effects are less robust than the lateralization of speech production.

Reyna L. Gordon and colleagues provide a comparative approach on the sensorimotor networks used in singing and speaking. In contrast to the contribution of Ackermann *et al.*, these authors focus on perception. They summarize studies, pointing to an overlapping network for the perception of songs and speech. In fact, they argue that a song is language together with music. This provides the opportunity to manipulate either the linguistic or the musical dimension to study their relationships. Another interesting topic is the association of spoken or sung text with memory. The authors provide insights in recent own studies which separate sung and spoken recalls of songs. Aphasic patients did not show any difference between being able to recall sung versus spoken lyrics. The short-term rehabilitative effects of music on linguistic or cognitive abilities seem to be an artifact of mood, arousal or attention processes. It may nevertheless be helpful for longer periods of therapy and in selected patients — for instance, those who suffer from vocal/motor dysfunctions such as dysarthria.

Christian Gerloff and Friedhelm Hummel summarize the role of inhibition in the motor control of finger function. They focus on a "nogo-situation" which can be present in a concert situation, for instance when the violinist has to pause presentation while the cellist is acting. The authors call this process "active inhibition," which can be measured in the hemisphere ipsilateral to the executing hand. The coactivation of the non-executing hand must be inhibited immediately before the executing signal is sent from the primary motor cortex to the effector muscles in the executing hand. Decreased activation in fMRI is associated with decreased TMS excitability and a power decrease in the alpha range in EEG. In contrast, patients suffering from musicians' dystonia or writers' cramp did not show this active inhibition, illustrating that increased facilitation results in a coactivation of different fingers during the critical performance.

Part 5: Loss of motor control in musicians

This portion of the book is introduced by a vivid presentation of the most prominent historic case of music dystonia of Robert Schumann, reviewed by Eckart Altenmüller. The author summarizes the case of Schumann's focal dystonia in such a stringent way that, after enjoying the example, the reader knows which factors characterize this disease — high expectations from the environment and from the artist himself, specific personality traits, high technically oriented and extremely long

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training times, training on technically demanding pieces and high self-criticism. The time course of the disease is developed and therapeutic interventions are reported. Schumann tried changes in hand position and built a device to influence the cramp ("cigar mechanics"). He also avoided use of the finger and even wrote the Toccata / Opus7, which does not include movements of the affected right middle finger. Finally, Schumann changed to improvisation — a return to the roots of music with less perfection and greater inner freedom.

Hans Christian Jabusch and Eckart Altenmüller summarize the epidemiology, phenomenology and therapy of musician's cramp. Approximately 1% of musicians are affected, most of them being keyboard musicians (with their right hand) and string players (with their left hand). Dystonia preferentially affects the dominant hand, due to the fact that it is associated with overlapping enlarged representations, which are larger for the dominant hand. In one third of patients, the dystonia is also present during performance of other movements and is not restricted to the movements on the instrument. Interestingly, 74% of patients never experience pain in the affected region. The overwhelming majority of patients are specialists in classical music. This summary is particularly valuable, because the authors provide an excellent overview of the prevalence, diagnosis and treatment of dystonia.

One of the most outstanding studies in the field of musical dystonia in recent years was conducted by Karin Rosenkranz in the lab of J.C. Rothwell. She describes the neurophysiology of focal hand dystonia in musicians. The dystonic syndrome is context-sensitive in most cases. Therefore, there is a dynamic map, which changes in different contexts. Rosenkranz summarizes her latest findings, illustrating the context-dependence of somatosensory representations. Further, she explains how sensory inputs and motor outputs interact by gating. This preparatory gaiting is impaired in patients with writers' cramp. Additionally, prolonged practice in musicians leads to permanent brain reorganization, which can be advantageous because it would favor cooperation between finger movements in rapid sequences of movements. In contrast, in patients with musicians' dystonia, the inputs of functionally unrelated hand muscles facilitate each other. In susceptible individuals, an initially beneficial adaptation of sensorimotor organization progresses too far and leads to problems in targeting motor commands.

Nancy N. Byl and Alberto Priori report implications for intervention in the development of focal dystonia in musicians as a consequence of maladaptive plasticity. They provide an extensive overview on the etiology, pathophysiology and management of focal hand dystonia. They also offer essentials on neuroplastic changes and the basic mechanisms of training conditions that result in large-scale cortical plasticity in the sensorimotor system (repetitive, progressive, effortful). Furthermore, they have developed therapeutic strategies predominantly based on intensive, goal oriented, progressive learning based training. The authors describe in detail the learning-based sensorimotor training, concentrating on the improvement in somatosensory differentiation, and relearning, starting with simple movements, by providing detailed feedback. In practice, patients start training (30-60 minutes per day) under supervision (1-2 weeks) and continue for a period of 6 to 12 weeks at home. This therapeutic approach improves motor control in these patients to an average of 70-94% of normal.

The last chapter of the book, written by Jörg Kesselring, is devoted to music performance anxiety. Arousal behaves in an U-shape form in relation to the increase in performance. Up to a certain point, increasing arousal increases performance, but above this point performance drastically decreases. High anxiety is associated with disrupted concentration, blocked memory retrieval and loss of steadiness in the hands and voice. Stage fright is a form of social phobia. The inner censor is most frequently critically, doubtful and cowardly. Approximately half of professional orchestral players considered musical performance anxiety to be disturbing often. Treatment strategies include cognitive-behavioral, feedback and relaxation techniques. Medications (beta blockers) and sport are also effective therapies. Interestingly, in the US, 27% of musicians in major symphonic orchestras take beta blockers.

CONCLUSION

This book can be recommended without restrictions. The book is highly enjoyable and would be valuable for researchers and students interested in the neurobiology of musical performance. It provides a fascinating overview written by the most important researchers in the field. The overlap of the different chapters is astonishingly small, but is present in discussions of the functional representation of musical performance. A separation between the chapter on brain activation during piano and violin play is not useful, since many studies are not designed to test performance on a specific instrument. The use of color plates for all articles does not seem useful. I doubt that many readers will search for figures as they read the article, especially since the page numbers of figures are not provided in the text.

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