EDITORIAL

Special Issue: Spatiotemporal Music Cognition

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Human music processing comprises a wide range of activities including cognition, emotion, learning, interaction, and enculturation. In most cultures, music performance is a multimodal form of expression that is often associated with activities such as dance and theatre. Despite this fact, research on human music processing has traditionally concentrated solely on the auditory domain, thereby dissociating perception and action, and to a large extent ignoring multimodal interactions. Only recently have corporeality and multimodality of music processing become established topics of research.

The embodied view of human cognition (Maturana & Varela, 1980, 1987; Varela, Thompson, & Rosch, 1991) stresses the importance of the organism's sensorimotor capacities, body, and environment in cognitive processes. According to this view, the interaction between these elements allows particular cognitive capacities to develop, and determines the specific nature of those capacities. In opposition to traditional views of cognition that stress the importance of computation in cognitive processing, the embodied view emphasizes the importance of goal-directed actions unfolding in real time.

In musical activities, corporeality manifests in many aspects. First, dance is usually performed with music. Second, physical movement is often associated with the process of music listening. It is well known that periodic rhythmic structure tends to elicit accompanying movements. The elicited movements can be regarded as a means of facilitating the parsing of the rhythmic structure of music. Third, physical movement plays an important role in musical interaction and communication, helping musicians to maintain synchronization and convey expressive intentions. Finally, movement is an important ingredient in social interaction associated with music listening.

Recently, there has been growing interest in studies on various aspects of music and movement. The theoretical bases of embodied music cognition have been elaborated by Leman (2008). On the empirical side, sophisticated equipment, such as motion capture devices that allow recording movements of the body in three dimensions with high spatial and temporal accuracy are increasingly used in studies on musical activities. This was reflected already in last year's Special Issue on Musical Movement and Synchronization (*Music Perception, 26*, June 2009), edited by Peter E. Keller and Martina Rieger. The present issue provides a continuation of this theme, illustrating recent advances in the research on spatiotemporal music cognition, with a particular focus on its various kinematic aspects. Most of the seven articles in the issue are based on papers presented at the symposium Spatiotemporal Music Cognition, which was organized at the International Conference on Spatial Cognition at the University of Rome "La Sapienza" in September 2009.

In the first article of this issue, Phillips-Silver, Aktipis, and Bryant discuss coordinated rhythmic movement from a theoretical perspective. They present a typology of different forms of entrainment and propose that they all are results of various forms of adaptations that allow organisms to integrate perceived and produced rhythmic stimuli. Using this framework, they investigate various issues about entrainment in music and dance, in particular with regard to its social function and evolutionary history.

In the next article, Hove and Keller study the effects of spatiotemporal aspects of visual information on kinematic characteristics of rhythmic movements. They investigate whether apparent motion in visual sequences has an effect on movement characteristics and synchronization performance. Using a finger-tapping task, the authors discover that apparent motion improves synchronization accuracy. Furthermore, their analyses of motion capture data reveal correlations between spatiotemporal features of movement trajectories and local deviations of tap timing, which they interpret as manifestations of error correction mechanisms that facilitate stable synchronization.

For musicians to synchronize their sounds in an ensemble, it is necessary to coordinate their bodily movements. This is the topic of the next contribution by Keller and Appel. The authors study whether the capability for auditory imagery has an effect on the accuracy of temporal coordination. By comparing performers' body movements recorded with motion capture with MIDI recordings of their performances, the find a connection between body sway coordination and note timing.

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Furthermore, they find that the quality of inter-musician coordination is related to individual differences in auditory imagery, while the presence or absence of visual contact fails to have a significant effect. The authors conclude that auditory imagery improves coordination between musicians by enhancing the simulation of co-performers' actions through internal models.

In addition to helping maintain synchronization within an orchestra, the role of conductors' gestures is to convey emotional intentions. In their article, Luck, Toiviainen, and Thompson investigate visuomotor aspects of conductor-musician interaction. Using a continuous response paradigm with point-light displays, the authors study expressive movements by conductors, focusing on the dependence of perceived emotion on kinematic aspects of these movements. Their results suggest that certain dimensions of emotion, such as valence and activity, can be predicted with a relatively high accuracy from kinematic features of movement.

Whole-body movement is an important aspect of musical activities such as dance performances and music listening. The last three articles in this issue focus on kinematic aspects of these kinds of movements. Toiviainen, Luck, and Thompson study kinematics of music-induced movement in music listeners. More specifically, they investigate whether listeners moving to music embody the metrical structure of music. Analysis of motion capture recordings using signal processing and principal components analysis reveal that several metric levels are simultaneously present in the movements and that each metric level is associated with certain typical movement patterns.

The article by Leman and Naveda investigates repetitive gestures of professional samba and Charleston dancers. By applying periodicity transforms to motion capture data, they are able to identify spatiotemporal reference frames, or basic gestures, in the dancers' movements that are synchronized with musical cues. They suggest that the spatiotemporal reference frames control minimum effort points in action-perception couplings.

The last article of this issue, by Naveda and Leman, again focusing on movements of samba and Charleston dancers, proposes a new method, the Topological Gesture Analysis, to investigate gesture trajectories and their relationship with music. With this method, the authors study relationships between musical structure, dance style, and expertise, and show how relevant information about these issues can be obtained from simple topological relationships.

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