Music Cognition: Learning and Processing

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Goals and Scope

In recent years, the study of music perception and cognition has witnessed an enormous growth of interest. Music cognition is an intrinsically interdisciplinary subject which combines insights and research methods from many of the cognitive sciences. This trend is clearly reflected, for example, in the contributions in special issues on music, published by journals such as *Cognition*, *Nature Neuroscience*, and *Connection Science*.

This symposium focuses on music learning and processing and will feature perspectives from cognitive neuroscience, experimental psychology, computational modeling, linguistics, and musicology. The objective is to bring together researchers from different research fields and traditions in order to discuss the progress made, and future directions to take, in the interdisciplinary study of music cognition. The symposium also aims to illustrate how closely the area of music cognition is linked to topics and debates in the cognitive sciences.

Henkjan Honing
Beat induction: uniquely human and music specific?

Beat induction, the process in which a regular isochronous pattern (the beat or tactus) is activated while listening to music, is considered a fundamental human trait that, arguably, played a decisive role in the origin of music. Theorists are divided on the issue whether this ability is innate or learned. In a recent study we were able to show newborn infants develop expectation for the onset of rhythmic cycles (the downbeat), even when it is not marked by stress or other distinguishing spectral features. Omitting the downbeat elicits brain activity associated with violating sensory expectations. Thus our results strongly support the view that beat perception is innate. And, as such, are further support for the hypothesis that beat induction is a fundamental human trait that is specific to music.

Martin Rohrmeier and Patrick Rebuschat
Implicit learning of music and language

Interaction with music, in the form of listening, performing or dancing, involves numerous cognitive processes that rely on knowledge of complex musical structures. Musical knowledge, like linguistic knowledge, is largely implicit, i.e. it is the result of a learning process that occurs largely incidentally and without awareness of the knowledge that was acquired (Perruchet, 2008). For example, nonmusicians possess musical knowledge to a high extent even though they are unable to express this knowledge. Similarly, in the case of language, all native speakers have developed a complex syntactic system, despite the fact that they are unable to provide accurate accounts of the rules that govern their native language. It is generally accepted that implicit learning constitutes a key process in musical enculturation or language acquisition. However, the implicit learning paradigm has not been applied extensively to the study of these acquisition processes. This paper compares functions of implicit knowledge in the perception of music and language and presents the results of Artificial Grammar learning experiments that directly compared the implicit learning of music and language for grammars of different structural complexity. These studies exemplify how the methodology provided by implicit learning research can be applied to the investigation of the acquisition of musical and linguistic knowledge.

Psyche Loui
Neural correlates of new music learning

One of the major questions in cognitive science concerns how learning occurs in the human brain. In the musical domain, learning includes the formation and refinement of expectations for musical structures, which include melody, harmony, and rhythmic processes. Artificial musical systems are useful for studying learning because they offer a controlled environment free of pre-existing associations, in which one can systematically observe the brain as it reacts to auditory exposure. Here we present a neurophysiological study on the rapid probabilistic learning of a novel musical system (Loui et al., 2009). Participants listened to different combinations of tones from a previously unheard system of pitches based on the Bohlen-Pierce scale, with chord progressions that form 3:1 ratios in frequency, notably different from 2:1 frequency ratios in existing musical systems (Krumhansl, 1987). Event-related brain potentials elicited by improbable sounds in the new music system showed emergence over a 1 h period of physiological signatures known to index sound expectation in standard Western music (Koelsch et al., 2000). These indices of expectation learning were eliminated when sound patterns were played equiprobably, and covaried with individual behavioral differences in learning. Results suggest that humans use a generalized probability-based auditory perceptual learning mechanism to process novel sound patterns in music.

Geraint A. Wiggins, Marcus T. Pearce, Daniel Müllensiefen
Computer Modelling of Music Cognition

We present a computer model of music cognition based on machine learning and information-theoretic analysis of the outputs of a predictive model, which we have extended into a preliminary partial model of a musical creative system (Wiggins et al., 2009). The model works at the level of note percepts and their sequence, deriving transition probabilities for a complex Markov Model, based both on a melody being "heard" and a long-term memory of previously "heard" pieces, represented in a multiple viewpoint framework (Pearce, 2005). The model is capable of predicting human pitch expectations with up to 91% correlation; it also predicts human pitch judgements of expectedness with up to 90% correlation (Pearce et al, in review). We have extended it, using information theory to predict segmentation in melody, which it does to a level comparable with programmed, rule-based systems, with an F1 of .61 or better (Pearce et al., 2008), and to make predictions which coincide with the independent analysis of an expert musicologist. Recent work has shown statistically significant neural correlates of the expectedness values, suggesting that melody processing involves motor cortex.

We believe that this is the first computational model of musical melody to work on the basis of learning (rather than being programmed), to predict an important aspect of the human experience of pitch, to then predict a different phenomenon (segmentation) merely by further analysis of its output, and to show correlation with brain activity. Thus, we propose that the model is a good candidate, at a certain level of abstraction, for a mathematical understanding of the processing of perceived event sequences by the brain.

Moderators:
Martin Rohrmeier and Patrick Rebuschat

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