COURSE SYLLABUS

Human Interaction Through Music

Instructor: Peter Keller, Professor
Department of Cognitive Science
Central European University
Fall, 2016
Course level: PhD
2 Credits
Course e-learning site: http://ceulearning.ceu.edu/course/view.php?id=????
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Course Description

Making music in groups is a widespread human activity and a powerful medium for nonverbal communication, social bonding, and cultural transmission. While essentially a vehicle for affective and aesthetic expression, group music making can also be viewed as a microcosm of social interaction to the extent that it draws on a broad spectrum of sensory, perceptual, cognitive, motor, and emotional processes that support collaborative behaviour more generally in everyday life. This course will address the mechanisms supporting human interaction through music from the perspectives of evolutionary biology, psychology, and cognitive neuroscience. The aim is to survey and critically evaluate state-of-the-art research on musical interaction, focusing on why do we do it, how it works (and what happens when it doesn't), and potential implications for pedagogy and applications in clinical settings.

Learning Outcomes

By the end of this course, students will be able to:

- ✓ Critically evaluate theories on the evolution of music
- ✓ Link psychological mechanisms underlying group music making to more general social interaction
- ✓ Understand methods used to study brain structures and functions supporting real-time interpersonal coordination
- ✓ Perform quantitative analysis and assessment of individual differences in interpersonal coordination skills
- ✓ Delineate pathways that lead from basic research on music to impact in applied domains

Course Requirements

(1) Oral presentations (80% of the final grade). This will be up to two presentations (20 minutes each) selected from the set 'Readings for presentation'. Grading criteria will be: Clear and concise communication of theory and/or findings, clear structure, time management, engaging delivery.

(2) Leading and participating in group discussions (20% of the final grade). Attendees will lead up to two group discussions on particular topics related to human interaction through music. Attendees are expected to be present during all sessions and to contribute with questions and comments to the discussions.

COURSE SCHEDULE

15 September 2016, 9:00-10:40. Introduction: What is musical interaction?

Basic concepts and definitions relevant to human interaction in musical contexts will be introduced in this session. Details about course requirements, learning outcomes, and assessments will be provided.

22 September 2016, 9:00-10:40. Why study musical interaction?

Music researchers have claimed that the study of human interaction through music can enrich the field of social cognition and cognitive science more broadly. It has been proposed that this is the case because the design features of music render it a domain well suited for balancing the trade-off between ecological validity and experimental control while parametrically modelling the complexity of human social interaction. Research adopting this approach has furthered our understanding of factors influencing the real-time dynamics of nonverbal communicative behaviour.

General background reading:

D'Ausilio, A., Novembre, G., Fadiga, L., & Keller, P.E. (2015). What can music tell us about social interaction? *Trends in Cognitive Sciences, 19,* 111–114.

Readings for presentation:

Badino, L., D'Ausilio, A., Glowinski, D., Camurri, A., & Fadiga, L. (2014). Sensorimotor communication in professional quartets. *Neuropsychologia, 55,* 98-104.

Goebl, W., & Palmer, C. (2009). Synchronization of timing and motion among performing musicians. *Music Perception, 26*, 427-438.

Loehr, J. D., & Palmer, C. (2011). Temporal coordination between performing musicians. *Quarterly Journal of Experimental Psychology, 64*, 2153-2167.

Moran, N., Hadley, L., Bader, M., & Keller, P.E. (2015). Perception of 'back-channeling' nonverbal feedback in musical duo improvisation. *PLoS ONE 10(6):* e0130070. doi:10.1371/journal.pone.0130070

Novembre, G., Varlet, M., Muawiyath, S., Stevens, C.J., & Keller, P.E. (2015). The E-Music Box: an empirical method for exploring the universal capacity for musical production and for social interaction through music. *Royal Society Open Science, 2*, 150286.

29 September 2016, 9:00-10:40. Evolutionary origins of music: Why do we do it?

Despite music being a universal and ancient form of human communicative behavior, its evolutionary roots are widely considered to be mysterious. Influential accounts hold that music serves cooperative functions related to social cohesion, ultimately buttressing human society and culture, versus competitive functions linked to sexual selection. While this issue has traditionally proven to be divisive in the evolutionary biology of music, recent comparative approaches—where analogous behavioral displays are examined across species—suggest that music may serve cooperative and competitive functions simultaneously. An even more radical view is that capacities for group music making evolved for their own sake in humans and coincidentally happen to be useful for more general forms of social interaction.

General background reading:

Brown, S. (2000). Evolutionary models of music: From sexual selection to group selection. In F. Tonneau & N. S. Thompson (Eds.), *Perspectives in ethology: Evolution, culture, and behavior* (pp. 231-281). Boston, MA: Springer.

Cross, I., & Morley, I. (2009). The evolution of music: theories, definitions and the nature of the evidence. In S. Malloch & C. Trevarthen (Eds.), *Communicative musicality: Exploring the basis of human companionship* (pp. 61-81). Oxford, UK: Oxford University Press.

Readings for presentation:

Lomax, A., & Berkowitz, A. L. (1972). The evolutionary taxonomy of culture. *Science, 177*(4045), 228-239.

Merker, B. H., Morley, I., & Zuidema, W. (2015). Five fundamental constraints on theories of the origins of music. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 370*(1664), 20140095. doi:10.1098/rstb.2014.0095

Ravignani, A., Bowling, D. L., & Fitch, W. T. (2014). Chorusing, synchrony, and the evolutionary functions of rhythm. *Frontiers in Psychology, 5*, 1118. doi:10.3389/fpsyg.2014.01118

6 October 2016, 9:00-10:40. Psychological foundations: Musical entrainment & interpersonal coordination

The complex and varied patterns of interpersonal coordination that characterize group music making rely on the basic principle of entrainment. Entrainment—which generally entails the coupling of independently controlled rhythmic processes—is a widespread phenomenon in natural and built environments: Its effects can be observed in pendulum clocks that nudge each other into temporal alignment when mounted on a common support, in synchronously flashing fireflies and chorusing crickets, and during episodes of human interaction where interpersonal coordination emerges spontaneously or intentionally. Quantifying the strength and directionality of musical entrainment across timescales and modalities (sounds and body movements) provides a rich source of information about aspects of interpersonal coordination dynamics including leader-follower relations and mutual influence.

General background reading:

Clayton, M., Sager, R., & Will, U. (2005). In time with the music: The concept of entrainment and its significance for ethnomusicology. *European Meetings in Ethnomusicology, 11,* 1-45.

Phillips-Silver, J., Aktipis, C. A., & Bryant, G. A. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception, 28,* 3-14. doi:10.1525/mp.2010.28.1.3

Phillips-Silver, J., & Keller, P.E. (2012). Searching for roots of entrainment and joint action in early musical interactions. *Frontiers in Human Neuroscience,* 6:26.

Readings for presentation:

D'Ausilio, A., Badino, L., Li, Y., Tokay, S., Craighero, L., Canto, R., Aloimonos, Y., & Fadiga, L. (2012). Leadership in orchestra emerges from the causal relationships of movement kinematics. *PLoS ONE, 7,* e35757. doi:10.1371/journal.pone.0035757

Walton, A. E., Richardson, M. J., Langland-Hassan, P., & Chemero, A. (2015). Improvisation and the self-organization of multiple musical bodies. *Frontiers in Psychology, 6,* 313. doi:10.3389/fpsyg.2015.00313

Wing, A. M., Endo, S., Bradbury, A., & Vorberg, D. (2014). Optimal feedback correction in string quartet synchronization. *Journal of the Royal Society, Interface, 11*, 20131125.

13 October 2016, 9:00-10:40. Social foundations: Pro-social effects in adults

Psychological research on the social effects of interpersonal synchrony has shown that rhythmic coordination between individuals promotes feelings of affiliation, bonding, trust, and commitment, as well as overt cooperative behavior. Potential causes of these pro-social effects include blurring of the self-other distinction, positive enhancement of emotional state through activation of the brain's reward system, and modulation of levels of hormones that influence sociality. The spontaneous emergence of pro-social tendencies through interpersonal synchrony may provide a foundation upon which complex and rewarding patterns of intentional coordination are built in musical contexts.

General background reading:

Tarr, B., Launay, J., & Dunbar, R. I. (2014). Music and social bonding: "self-other" merging and neurohormonal mechanisms. *Frontiers in Psychology, 5,* 1096. doi:10.3389/fpsyg.2014.01096

Readings for presentation:

Hove, M. J. & Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition, 27(6),* 949-961.

Kokal, I., Engel, A., Kirschner, S., & Keysers, C. (2011). Synchronized drumming enhances activity in the caudate and facilitates prosocial commitment- If the rhythm comes easily. *PLoS ONE, 6,* e27272.

Weinstein, D., Launay, J., Pearce, E., Dunbar, R. I., & Stewart, L. (2016). Group music performance causes elevated pain thresholds and social bonding in small and large groups of singers. *Evolution and Human Behavior, 37(2),* 152-158

20 October 2016, 9:00-10:40. Social foundations: Pro-social effects in children

It has been proposed that the roots of group music making can be found in the vocal and gestural exchanges that characterize mother-infant interaction. Basic social interaction abilities thus acquired early in life are gradually transformed through development into skills that allow individuals to achieve the fine temporal precision and flexibility required for interpersonal coordination in musical contexts. Recent work with young children points to the inherently social origins of these abilities by demonstrating that interpersonal synchrony leads to overt altruistic cooperative in toddlers and even infants.

General background reading:

Trainor, L. J., & Cirelli, L. (2015). Rhythm and interpersonal synchrony in early social development. *Annals of the New York Academy of Sciences, 1337,* 45-52.

Readings for presentation:

Cirelli, L. K., Einarson, K. M., & Trainor, L. J. (2014). Interpersonal synchrony increases prosocial behavior in infants. *Developmental Science, 17(6),* 1003-1011.

Kirschner, S., & Tomasello, M. (2010). Joint music making promotes prosocial behavior in 4-year-old children. *Evolution and Human Behavior, 31,* 354-364.

Rabinowitch, T., Cross, I., & Burnard, P. (2013). Long-term musical group interaction has a positive influence on empathy in children. *Psychology of Music, 41(4),* 484-498.

Rabinowitch, T. C., & Knafo-Noam, A. (2015). Synchronous rhythmic interaction enhances children's perceived similarity and closeness towards each other. *PLoS ONE, 10*(4), e0120878.

27 October 2016, 9:00-10:40. Psychological foundations: Knowledge

In many cultural traditions, individuals invest considerable time and effort in preparing for group musical performance through a combination of individual private practice and collaborative rehearsal. Group rehearsal allows performers to gain familiarity with the structure of each other's parts and the expressive style in which these parts will be played. It has been proposed that such knowledge is represented in memory as shared performance goals, and that the degree of similarity between these shared representations across co-performers is an important determinant of ensemble cohesion.

General background reading:

Keller, P.E., Novembre, G., & Loehr, J. (2016). Musical ensemble performance: Representing self, other, and joint action outcomes. In E.S. Cross & S.S. Obhi (Eds.), *Shared representations: Sensorimotor foundations of social life* (pp. 280-310). Cambridge: Cambridge University Press.

Readings for presentation:

Ginsborg, J., Chaffin, R., & Nicholson, G. (2006). Shared performance cues in singing and conducting: A content analysis of talk during practice. *Psychology of Music, 34,* 167-194.

Ragert, M., Schroeder, T., & Keller, P.E. (2013). Knowing too little or too much: The effects of familiarity with a co-performer's part on interpersonal coordination in musical ensembles. *Frontiers in Auditory Cognitive Neuroscience,* 4:368.

3 November 2016, 9:00-10:40. Psychological foundations: Online 'ensemble skills'

Precise yet flexible interpersonal coordination during group music making is presumably facilitated by online sensorimotor and cognitive processes that allow co-performers to anticipate, attend, and adapt to each other's actions in real time. On this view, an individual's abilities related to these core 'ensemble skills' determine his or her ability to coordinate with others. Individual differences ensemble skills may thus constrain group cohesion.

General background reading:

Keller, P.E. (2014). Ensemble performance: Interpersonal alignment of musical expression. In D. Fabian, R. Timmers, & E. Schubert (Eds.), *Expressiveness in music performance: Empirical approaches across styles and cultures* (pp. 260-282). Oxford: Oxford University Press.

Keller, P.E., Novembre, G., & Hove, M.J. (2014). Rhythm in joint action: Psychological and neurophysiological mechanisms for real-time interpersonal coordination. *Philosophical Transactions of the Royal Society B, 369,* 20130394.

Readings for presentation:

Keller, P.E., & Appel, M. (2010). Individual differences, auditory imagery, and the coordination of body movements and sounds in musical ensembles. *Music Perception, 28,* 27-46.

Konvalinka, I., Vuust, P., Roepstorff, A., & Frith, C. D. (2010). Follow you, follow me: continuous mutual prediction and adaptation in joint tapping. *Quarterly Journal of Experimental Psychology, 63*, 2220-2230.

Nowicki, L., Prinz, W., Grosjean, M., Repp, B.H., & Keller, P.E. (2013). Mutual adaptive timing in interpersonal action coordination. *Psychomusicology: Music, Mind, and Brain, 23,* 6-20.

Pecenka, N., & Keller, P. E. (2011). The role of temporal prediction abilities in interpersonal sensorimotor synchronization. *Experimental Brain Research, 211(3-4),* 505-515.

10 November 2016, 9:00-10:40. Practical session: Assessing coordination skills

Although interpersonal coordination in musical contexts is a universal human capacity, it is subject to large individual differences. Recent research has sought to identify the underlying causes of these individual differences by combining behavioral experimentation on sensorimotor synchronization with computational modeling. The behavioral experiments typically employ laboratory tasks that require repetitive movements (e.g., finger taps or drum strokes) to be produced in time with sequences of auditory or visual events generated by a computer, sometimes while completing a concurrent secondary task. This approach yields objective measures of an individual's anticipation, attention, and adaptation abilities. The functional processes behind these behavioral measures can be interrogated through computational modeling and computer simulations, allowing individual differences in the operation of mechanisms underlying the observed behavior to be estimated. This session will provide a practical introduction to these assessment methods. Outcomes of such assessment further our understanding of how sensorimotor and cognitive processes interact to determine the quality of interpersonal coordination, paving the way to developing techniques for enhancing the operation of these processes in pedagogical and clinical contexts.

General background reading:

Mills, P.F., van der Steen, M.C., Schultz, B.G., & Keller, P.E. (2015). Individual differences in temporal anticipation and adaptation during sensorimotor synchronization. *Timing & Time Perception, 3,* 13-31.

Nozaradan, S., Peretz, I., & Keller, P.E. (2016). Individual differences in rhythmic cortical entrainment correlate with predictive behavior in sensorimotor synchronization. *Scientific Reports, 6,* 20612.

van der Steen, M.C., Schwartze, M., Kotz, S.A., & Keller, P.E. (2015). Modeling effects of cerebellar and basal ganglia lesions on adaptation and anticipation during sensorimotor synchronization. *Annals of the New York Academy of Sciences, 1337,* 101–110

17 November 2016, 9:00-10:40. Neurophysiological underpinnings: Brain networks for real-time coordination

The brain networks supporting temporal anticipation and adaptation during real-time coordination with external rhythms have been investigated in neuroimaging studies employing adaptive virtual partners and tempo-changing sequences resembling those found in music. This work has revealed neural networks comprising cortical and sub-cortical brain regions forming a sensorimotor timing hub with connections to other brain systems. These systems include—depending on task demands—cortical regions implicated in executive functions (working memory, attentional monitoring, and decision-making) and the so-called default mode network, as well as subcortical regions that regulate basic functions related to motivation, emotion, and the internal modelling of environmental events. The overlap in brain networks for temporal anticipation/adaptation and those implicated in social-cognitive processes (e.g., empathic response) is especially noteworthy.

Readings for presentation:

Fairhurst, M.T., Janata, P., & Keller, P.E. (2013). Being and feeling in sync with an adaptive virtual partner: Brain mechanisms underlying dynamic cooperativity. *Cerebral Cortex, 23,* 2592-2600.

Fairhurst, M.T., Janata, P., & Keller, P.E. (2014). Leading the follower: an fMRI investigation of dynamic cooperativity and leader-follower strategies in synchronization with an adaptive virtual partner. *NeuroImage, 84,* 688–697.

Jantzen, K. J., Steinberg, F. L., & Scott Kelso, J. A. (2009). Coordination dynamics of large-scale neural circuitry underlying rhythmic sensorimotor behavior. *Journal of Cognitive Neuroscience, 21(12),* 2420-2433.

Pecenka, N., Engel, A., & Keller, P.E. (2013). Neural correlates of auditory temporal predictions during sensorimotor synchronization. *Frontiers in Human Neuroscience,* 7:380.

24 November 2016, 9:00-10:40. Neurophysiological underpinnings: Representing 'self' & 'other' in the brain

Group music making is a balancing act that requires simultaneous self-other merging and self-other distinction. The integration of information related to one's own part and others' parts is necessary to represent shared goals and to monitor and evaluate joint action outcomes, while segregation between parts produced by self and others is necessary for agency attribution and autonomous movement control. Neurophysiological markers of simultaneous self-other integration and segregation have been identified in dual-EEG studies of musical duo performance and related brain stimulation studies that provide evidence for agent-specific representations at the level of the motor system.

Reading for presentation:

Loehr, J. D. , Kourtis , D. , Vesper , C. , Sebanz , N. , & Knoblich , G. (2013). Monitoring individual and joint action outcomes in duet music performance. *Journal of Cognitive Neuroscience , 25(7),* 1049 – 1061 .

Novembre, G., Sammler, D., & Keller, P.E. (2016). Neural alpha oscillations index the balance between self-other integration and segregation in real-time joint action. *Neuropsychologia, 89,* 414-425.

Novembre, G., Ticini, L.F., Schütz-Bosbach, S., & Keller, P.E. (2012). Distinguishing self and other in joint action. Evidence from a musical paradigm. *Cerebral Cortex*, *22*, 2894-2903.

1 December 2016, 9:00-10:40. Neurophysiological underpinnings: Intra- and inter-brain neural entrainment

The capacity for entrainment between neural oscillatory activity in the brain and rhythms the external environment is the glue that holds together musical interaction, as it facilitates the coupling of motor processes in one individual with incoming perceptual information about the actions of others. Studies employing electroencephalography (EEG) have addressed neural entrainment using intra-brain and inter-brain approaches. The intra-brain approach examines the coherence and power of oscillatory activity within a single individual's brain as an indirect measure of information flow and the entrainment of internal to external rhythms. The inter-brain approach attempts to shed light on interpersonal entrainment in rhythmic coordination tasks by directly examining the coherence of oscillations in neural activity recorded from the brains of co-acting individuals simultaneously with dual-EEG setups.

General background reading:

Hasson, U., & Frith, C. D. (2016). Mirroring and beyond: coupled dynamics as a generalized framework for modelling social interactions. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences,* 371(1693). doi:10.1098/rstb.2015.0366

Hasson, U., Ghazanfar, A. A., Galantucci, B., Garrod, S., & Keysers, C. (2012). Brain-to-brain coupling: a mechanism for creating and sharing a social world. *Trends in Cognitive Sciences, 16*, 114-121.

Konvalinka, I., & Roepstorff, A. (2012). The two-brain approach: how can mutually interacting brains teach us something about social interaction? *Frontiers in Human Neuroscience, 6,* 215.

Tognoli, E., & Kelso, J. A. S. (2015). The coordination dynamics of social neuromarkers. *Frontiers in Human Neuroscience, 9,* 563. doi:10.3389/fnhum.2015.00563

Readings for presentation:

Sänger, J., Müller, V., & Lindenberger, U. (2012). Intra- and interbrain synchronization and network properties when playing guitar in duets. *Frontiers in Human Neuroscience, 6,* 312.

Sänger, J., Müller, V., & Lindenberger, U. (2013). Directionality in hyperbrain networks discriminates between leaders and followers in guitar duets. *Frontiers in Human Neuroscience, 7,* 234.

Konvalinka, I., Bauer, M., Stahlhut, C., Hansen, L. K., Roepstorff, A., & Frith, C. D. (2014). Frontal alpha oscillations distinguish leaders from followers: multivariate decoding of mutually interacting brains. *Neuroimage*, *94,* 79-88.

Naeem, M., Prasad, G., Watson, D. R., & Kelso, J. A. (2012). Electrophysiological signatures of intentional social coordination in the 10-12 Hz range. *Neuroimage*, *59*, 1795-1803.

Yun, K., Watanabe, K., & Shimojo, S. (2012). Interpersonal body and neural synchronization as a marker of implicit social interaction. *Scientific Reports, 2*, 959. doi:10.1038/srep00959

8 December 2016, 9:00-10:40. Applications in assessing and treating clinical disorders

Techniques based on musical interaction have proven to be effective in the rehabilitation of physical and social-emotional clinical disorders. Areas where these advances can be observed include the assessment and treatment of clinical conditions characterised by cognitive disturbances (dementia and aphasia), motor deficits (stroke and Parkinson’s disease), and social-communicative dysfunction (autism spectrum disorder).

General background reading:

Hove, M.J., & Keller, P.E. (2015). Impaired movement timing in neurological disorders: Rehabilitation and treatment strategies. *Annals of the New York Academy of Sciences, 1337,* 111-117.

Thaut, M., McIntosh, G. C., & Hoemberg, V. (2015). Neurobiological foundations of neurologic music therapy: Rhythmic entrainment and the motor system. *Frontiers in Psychology, 5.* doi:10.3389/fpsyg.2014.01185

Readings for presentation:

Hove, M. J., Suzuki, K., Uchitomi, H., Orimo, S., & Miyake, Y. (2012). Interactive rhythmic auditory stimulation reinstates natural 1/f timing in gait of Parkinson's patients. *PLoS ONE, 7,* e32600. doi:10.1371/journal.pone.0032600

Samson, S., Clement, S., Narme, P., Schiaratura, L., & Ehrle, N. (2015). Efficacy of musical interventions in dementia: methodological requirements of nonpharmacological trials. *Annals of the New York Academy of Sciences, 1337*, 249-255.

Spiro, N., & Himberg, T. (2016). Analysing change in music therapy interactions of children with communication difficulties. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 371(1693).* doi:10.1098/rstb.2015.0374