Entrainment Network Conference II
Entrainment in Music

April,1-3, 2005, OSU, School of Music, 177 Weigel Hall

Friday 1 April

Symposium

9:45

Opening address

10:00

Martin Clayton: (Intro): Overview of the work of the Entrainment Network

Ian Cross: "Music, entrainment and the evolution of sociality"

11:45

Lunch Break:

1:15

Devin McAuley: "Time of our lives I: Changes in preferred tempi and regions of entrainment across the lifespan" (theory and data on synchronization tapping)

Mari R. Jones : "Time of our lives II: Changes in preferred tempi and regions of entrainment across the lifespan" (theory and data on continuation tapping and its implications)

3:15

Coffee Break:

3:45

Edward Large: “Nonlinear oscillation: A musical universal?”

Udo Will: “Arnold tongues, period doubling and socio-cultural factors in Australian Aboriginal clap rhythms.”

18:00

Labtour: Cognitive Ethnomusicology and Music Cognition Labs (Mershon, 5th floor)

Sat 2 April

Network working sessions

10:00

(Entrainment to non periodic Music/ 'Alap-Group" session)
I.: instrumental alap
E. Berg, U.Will, M. Clayton, L. Leante: "Bi-cultural comparison of tapping responses to an instrumental alap performance."

L.Leante, M.Clayton, U. Will: "Entrainment to alap: listeners' responses studied via video analysis and interview "

II.: vocal alap
H. Utter, U. Will, M.Clayton, and L Leante: "Influence of auditory and visual information on the tapping responses to non-periodic music (vocal alap)."

11:45

Lunch Break

1:15

Nick Collins: "The problem of phase alignment in computational beat induction on musical audio signals."

Jessica Grahn: "Beat-based rhythm processing in the brain: behavioural, neuroimaging, and neuropsychological investigations."

Gabrielle Horstman & Udo Will: "Heart beat synchronization to musical rhythms? An ECG study on the influence of drum rhythms on human heart beats."

3:00

Coffee Break:

3:30

Tommi Himberg: "Cooperative tapping - insights to musical interaction"

Niki Moran: "Ethnographic contributions: on the experience of entrainment"

John Bispham: "Entrainment, Evolution, and Ethology: Together in Time, Sound and Action."

8:00

Conference dinner

Sun 3 April

<u>Open Workshop</u>

10:00

Discussion of important theoretical and methodological issues raised by the presentations. Topics: TBA

12:00

Lunch Break

1:30

Open Workshop (cont.)

Planning of future meetings and collaborative projects

Abstracts

Entrainment Network Conference II

Entrainment in Music

April,1-3, 2005, OSU, School of Music, 177 Weigel Hall

Martin Clayton: (Intro): Overview of the work of the Entrainment Network

This introduction give some background information on the Entrainment Network, its origins, its work since its inception, as well as future perspectives.

Ian Cross: "Music, entrainment and the evolution of sociality"

In a paper presented at the previous entrainment workshop (Cambridge, UK, October 2004), I suggested that entrainment processes might have played a significant role in the evolutionary emergence of human inter-personal flexibility; the entraining dimension of musicality could have constituted a temporal framework for gestural co-ordination that would have facilitate recognition of inter-personal intentional status. In the present paper I shall develop this idea further in the context of recent thinking on the ontogeny and evolution of human social behaviour and capacities, and on models of animal and human vocal communication.

Devin McAuley: "Time of our lives I: Changes in preferred tempi and regions of entrainment across the lifespan" (theory and data on synchronization tapping)

In this talk, lifespan changes in synchronization ability are examined for three-hundred five participants between the ages of 4 and 95 for simple auditory sequences that range in rate (tempo) from fast to slow. Overall, synchronization measures reveal an inverted U-shaped phase-coupling profile across the lifespan; both the youngest and oldest participants are more loosely coupled with the tested sequences than participants in the other age groups. To some extent, age-related changes in synchronization ability are tempo specific with the largest differences present at the fastest and slowest sequence rates. Assessments of preferred motor tempi and judgments about preferred sequence rate provide converging evidence that a preferred time-span of attending slows with age.

Mari R. Jones : "Time of our lives II: Changes in preferred tempi and regions of entrainment across the lifespan" (theory and data on continuation tapping and its implications)

Age-related slowing hypotheses about continuation tapping were evaluated with 305 participants, ranging in age from 4 to 95 years. Various perceptual and motor tasks, including paced and un-paced tapping were employed to assess models derived, respectively, from *interval*- and *entrainment* perspectives on event timing. Assessments of spontaneous motor tempo and judgments about preferred sequence rate provided converging evidence that a preferred time-span (period) of attending slows with age. Accuracy and variability of continuation tapping also varied systematically with age in a

manner consistent with the un-paced measures. These findings are in accord with the predictions of a *preferred period hypothesis* associated with an entrainment approach to event timing. This approach leads to a modification of Weber's Law, which we refer to as the *Restricted Weber Function*.

Edward Large: "Nonlinear oscillation: A musical universal?"

The term universal grammar, borrowed from linguistics, is shorthand for the idea that there exists a set of general principles underlying all human languages. These principles provide a set of innate constraints that define the set of possible human languages, thus enabling children to acquire linguistic competence from impoverished learning data. Is it possible that nonlinear resonance provides a set of constraints that would constitute a universal grammar for music? I review evidence that nonlinear resonance provides constraints on musical structure, applying to percepts as diverse as pitch, tonality and rhythm. I discuss how learning may further shape musical percepts.

Udo Will: "Arnold tongues, period doubling and socio-cultural factors in Australian Aboriginal clap rhythms."

The theory of coupled, non-linear oscillators can serve as a framework for theories of rhythm perception as well as rhythm production. A hypothesis emerging from such a framework is that rhythms are produced along Arnold tongues – the synchronization regions between coupled oscillators. From this would follow that rhythm production is guided by the principle of small integer ratios. In this presentation I shall examine this hypothesis with analyses of clap stick rhythms from a corpus of ca. 400 songs from various regions of Aboriginal Australia. The analyses indicate that the majority of data are not compatible with the hypothesis and I discuss alternative interpretations.

E. Berg, U.Will, M. Clayton, L. Leante: "Bi-cultural comparison of tapping responses to an instrumental alap performance."

The study we report here investigates whether entrainment effects can be detected in tapping responses of participants listening to N. Indian alap (from Rag Marwa by Ali Akbar Khan, 1994). A section of this performance was electronically manipulated (speeded up and slowed down, each by 15%, the two resulting versions were replayed and subjects were asked to tap to the music; the tap responses were recorded and analyzed off line. The experiment was performed with two groups of subjects, one from Columbus and one from Kolkata.
Mean response rates varied from subject to subject with a slight tendencies of Indian subjects to respond at higher as well as lower rates than the Columbus group. Except for one subject the changes in tapping rate did not correspond to the speed change between the sound files. However, all subjects except the one mentioned, showed significant intermittent phase synchronization with the music, confirming previously reported results by E. Berg (2004), that listeners, although having mean response rates not determined by the music, clearly interact and respond to the music they are listening to. As for the one

exception to the general pattern, we suggest that in this case a different response strategy, based on or leading to frequency synchronization, was applied.

L.Leante, M.Clayton, U. Will: "Entrainment to alap: listeners' responses studied via video analysis and interview "

In December 2004 we carried out part of the preceding study (tapping to a recording of Ali Akbar Khan), and supplemented it with clips from a vocal performance by Veena Sahasrabuddhe. All subjects were experienced listeners of Indian raga music, most were professional or semi-professional performers and at least two were internationally-recognised concert artists. In addition to the tapping data extracted from the audio file (see above), we also made video recordings of the experiments, and interviewed each subject about their understanding of the task and their own performance. This presentation describes the role of these additional elements in both enriching the data collected and helping in its interpretation.
First, the video recordings reveal significantly more evidence of periodic behaviour than the audio files (e.g. silent finger taps between the audible claps), which can be coded using observational analysis software. Second, listeners were able in several cases both to verbalise their own theories of rhythmic organisation in alap, and to explain the strategies they had used during the experiment. Although it is clear that there is no standard "expert" way of perceiving and entraining to pulse in alap, it may be possible to generalise to some extent about the strategies employed by experienced listeners, and that this is only possible through a combination of experimental and ethnographic methods.

H. Utter, U. Will, M.Clayton, and L Leante: "Influence of auditory and visual information on the tapping responses to non-periodic music (vocal alap)."

The importance of the visual system for transmitting entraining forces in humans has been known since long (for review: Clayton et al., 2004). There is considerable research in social psychology (e.g. influence of gestures and movements on interpersonal synchronization) but it has received little attention in music research, probably due to the preoccupation with the 'auditory channel'. In this study we investigate the question of how visual information influences the evocation of pulse in listeners of a musical performance. Listeners (11) were first presented with a random sequence of the audio clips from a vocal alap performance, then a random sequence of video clips (with sound) from the same sections of the performance, and were asked to tap along. Tapping time and tap durations were extracted from the recordings of subjects responses. Here, we are going to present the analysis of the responses to that sequence for which we already have data from a movement analysis of the video: There are highly significant differences in the response to the audio and video clip. However, the most striking result being that individual responses, varying in terms of response rate for the audio presentation, are reorganized and focused on at least two 'attractor' zones in case of the video presentation. Data from the movement analysis of the video permit us to argue that the main factor for these changes stems from the visual information supplied by the movement of the main soloist on stage/video.

Nick Collins: "The problem of phase alignment in computational beat induction on musical audio signals."

Are efficient causal FFT-based approaches sufficient for robust beat tracking of musical audio signals? Methods based on energy correlational features alone, using autocorrelation [1,2], impulse signal cross-correlation [3] or comb filters [4] were found successful at tempo tracking but could lead to phase alignment errors, particularly the pi-phase error of tapping on off-beats. This could happen even in the case of supposedly simple-to-track 4/4 Western popular music. The incorporation of higher level signal processing for the detection of chord changes and drum patterns, following the lead of Masataka Goto [2], helped to reduce such phase alignment errors. A consistency requirement that modeled confidence in tracking hypotheses was introduced to avoid gratuitous changes of alignment. Applications in real-time computer music are discussed including a recent concert performance where an acoustic drummer was tracked by a computerised improvisation system.

[1] Matthew E. P. Davies and Mark D. Plumbley. Beat tracking with a two state model. In Proceedings of IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, 2005.

[2] Masataka Goto. An audio-based real-time beat tracking system for music with or without drum-sounds. Journal of New Music Research, 30(2):159?71, 2001.

[3] Jean Laroche. Efficient tempo and beat tracking in audio recordings. J. Audio. Eng. Soc., 51(4):226?233, April 2003.

[4] Eric D. Scheirer. Tempo and beat analysis of acoustic musical signals. J. Acoust. Soc. Am., 103(1):588?601, January 1998.

Jessica Grahn: "Beat-based rhythm processing in the brain: behavioural, neuroimaging, and neuropsychological investigations."

When we listen to rhythm, we often move in time to the beat. This movement may result from automatic processing of the beat by certain motor areas. To determine what rhythm structures induce a beat, we asked subjects to listen to and reproduce different types of short rhythmic sequences. One type of sequence was designed to induce a beat; the other two types of sequences were designed to not induce a beat. Improved reproduction was observed for the beat-based rhythm type. A subsequent fMRI study of musicians and nonmusicians revealed that listening to the rhythms that induced a beat elicited higher neural activity in the basal ganglia and SMA in both musicians and nonmusicians. Musicians showed additional activation for all rhythm types in premotor, inferior frontal, and cerebellar areas. Follow-up studies were conducted with patients that had damage to the basal ganglia from infarction, and patients with Parkinson's disease. The former group showed no impairment on rhythm tasks, whereas the Parkinson's group showed rhythm discrimination deficits, which were greater for beat-based rhythms.

Gabrielle Horstman & Udo Will: "Heart beat synchronization to musical rhythms? An ECG study on the influence of drum rhythms on human heart beats."

Various physiological functions of the human body have been reported to be influenced by and, under certain conditions, even synchronize with periodic external stimuli. Recently, Anischenko et al.(1999) reported a synchronization effect of weak (low volume) periodic click pulses on the human heart beat. As regular periodic pulses are found in various types of music, we wanted to know whether regular sequences of drum beats also have synchronizing effects on the human heart beat. In this presentation we report on a first experiment in which 10 subjects listened to several periodic series of drum sounds while heartbeat, finger pulse and breathing movement were recorded. The stimulus intensity was 65-70 dB and the repetition rate of the drum sounds were –50, -30, -10, 0, +10, +30, and +50 % of the respective pre-stimulus heartbeat rate. We did not find any phase synchronization for any subject under any of the stimulus conditions. However, more than half the subjects showed a clear interaction effect of stimulus frequency and heartbeat, though no frequency synchronization. Interestingly, the stimuli effects on finger pulse transmission time indicate two response types: one group of subjects respond with an increase in the transmission time (i.e. reduced activity of the peripheral (sympathetic) autonomous nervous system), and the other groups responded with a reduced transmission time (augmented activity of the peripheral sympathicus). It is this latter group that showed the strongest interaction effects between stimulus rate and heart beat rate.

Niki Moran: "Ethnographic contributions: on the experience of entrainment"

What do musicians say about their experience of interaction in musical activity? The notion of musical "groove" is often used to define a particular quality of togetherness with regard to African-American music, but other ethnographic accounts of musical interaction may also allude to the phenomenon. This presentation examines how "groove" might pertain to a practice-based understanding of musical entrainment, giving examples from recent interviews with North Indian classical musicians.

John Bispham: “Entrainment, Evolution, and Ethology: Together in Time, Sound and Action.”

Questions crucial to an evolutionary perspective on entrainment are presented for consideration: is IPE present in other species?; has it evolved independently in our lineage?; under what conditions is IPE (interpersonal entrainment) an evolutionarily adaptive trait and why?; and how does the concept of IPE fit into the evolution of human cognition?. The presentation will concentrate on the first of these questions, exploring existing evidence and putting forward suggestions as to how a comparative approach on IPE can be further investigated. I will argue that the key to identifying IPE is to locate evidence of error correction mechanisms within an interaction or series of produced events. In other words what must be demonstrated is not simply behaviour that appears synchronous but evidence of a consistent relationship between temporal changes within a sequence of temporally structured stimuli and the temporal structure of events produced by the executor. The search for error correction mechanisms has, as yet, been largely ignored in analyses of animal auditory signals (e.g. Arcadi et al., 2004) despite being a

focus of psychological entrainment research here in Cambridge (e.g. Himberg & Cross, 2004) and elsewhere (e.g. Thaut et al., 1998, 2003). Methodological considerations for future projects will be put forward to demonstrate the focus of my proposed further research and to stimulate discussion on the direction of future work in this area.