Entrainment Weekend I
Schedule
draft as at 11.10.04

Distribution list: Eric Berg , John Bispham, Nick Collins, Ian Cross, Satinder Gill, Jessica Grahn, Laura Leante, Archie Levey, Nikki Moran, Tommi Himberg, Joel Swaine, Udo Will, Luke Windsor, Matthew Woolhouse

Time	**Activity**	**Location**
Fri 15 Oct 10am-5pm	*Short presentations on current research by:* Eric Berg John Bispham Martin Clayton Nick Collins Ian Cross Satinder Gill Jessica Grahn Nikki Moran Tommi Himberg Joel Swaine Udo Will *(detailed programme and abstracts below)*	OU Library Research Seminar Room, Milton Keynes[1]
Sat 16 Oct 10am-1pm	Workshop reading session, based on Clayton, Sager and Will article *(distributed as pdf)*	CMS
2pm-5pm	Informal demonstrations and talks	CMS
6pm	Performance: Nick Collins and Nikki Moran	Recital Room, Music Faculty, Cambridge *(t.b.c)*
Sun 17 Oct 10am-1pm	Informal demonstrations and talks	CMS
2pm-5pm	Workshop on goals of entrainment research: what do we need to discover?	CMS
evening	Evening meal	t.b.c. (Cambridge)
Mon 18 Oct 10am-1pm	Planning: future meetings and collaborative projects	CMS

[1] For directions go to www.open.ac.uk/maps. Please note that the library, which opened earlier this year, is still described on the campus map as "New Library Project". If in doubt ask for directions from Reception in the Berrill Building, which is next to the Visitors Parking - the library is across the road from there. In the library, just follow the signs to the Research Seminar Room.

Entrainment Weekend: Presentations

Fri 15 Oct, 10am-5pm

OU Library Research Seminar Room, Milton Keynes[2]

09.30	**Arrival** *(coffee etc can be obtained from the Berrill cafe, across the road from the library!)*	
10.00	Ian Cross	Entrainment, evolution, language and music
	John Bispham	Preliminary thoughts on music, movement, rhythm, and entrainment in evolution
	Joel Swaine	Entrainment and the concept of 'Embodied Rhythm Cognition'
11.30	**Coffee**	
11.50	Nikki Moran and Martin Clayton	Observing entrainment in context: Introduction to a method
	Laura Leante and Martin Clayton	Visual evidence of entrainment phenomena in North Indian raga performance
12.50	**Lunch**[3]	
13.50	Satinder Gill	Pulse periodicity in para-linguistic coordination
	Jessica Grahn	Beat-based rhythm processing and the basal ganglia
	Nick Collins	Computational implementations of beat induction
15.20	**Tea**	
15.40	Tommi Himberg	Interactive tapping – a window to the cognitive foundations of musical interaction
	Eric Berg and Udo Will	Entrainment to non-periodic rhythms? Analyses of tapping responses to North Indian alap and jor
	Udo Will and Eric Berg	Does the brain get entrained to music: How are musical stimuli and brain responses related?
17.00	**Close**	

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[3] In the refectory across the road (some participants may prefer to bring their own!)

Entrainment Weekend: Presentations

Abstracts

Ian Cross, Entrainment, evolution, language and music

The issue of whether the same mechanism underlies the construction of a framework for the joint experience of time in human interactions in music and in language is one which remains to be explored. It seems most parsimonious to assume that a single mechanism underlies our capacities to entrain in both domains, and in this short paper I'll be presenting an outline of what appears to be a plausible scenario for the co-evolution of linguistic, cultural and musical capacities in the later hominid lineage.

John Bispham, Preliminary thoughts on music, movement, rhythm, and entrainment in evolution

My presentation will introduce my field of research, which is preliminarily (and possibly somewhat optimistically) framed as the Evolution of Musical Rhythmic Capabilities and Behaviours. I view rhythmic behaviours as having their evolutionary foundation in movement and suggest that the development of rhythmic abilities has evolved along mosaic lines. Within a putative model individual skills/mechanisms intrinsic to movement, perception of temporal events, and interpersonal interactions are gradually developed, conglomerated and abstracted into increasingly musical and/or terpsichorean contexts. I will discuss how the issue of Interpersonal Musical Entrainment fits into this structure and how recent evidence on entrainment to isochronous and rhythmic stimuli has thrown up some interesting questions with regard to the evolution of rhythmic abilities and entrainment.

Joel Swaine, Entrainment and the concept of 'Embodied Rhythm Cognition'

The notion of entrainment remains fuzzy despite its significance for the psychological study of music. In this presentation I will be outlining, and discussing briefly, a framework of concepts that might be useful for clarifying and deepening our understanding of the psychology of musical entrainment. I will be unpacking the concept of 'embodied rhythm cognition', and I will be discussing a number of theoretical gaps in the psychology of musical rhythm, with particular reference to the study of emotion and attention. To provide a focus for the presentation, I will be relating these ideas to a discussion of the singing of a mantra.

Nikki Moran and Martin Clayton, Observing entrainment in context: Introduction to a method
Laura Leante and Martin Clayton, Visual evidence of entrainment phenomena in North Indian raga performance

These presentations concern the development of a methodology for studying entrainment in the context of ethnomusicological research, by extracting timing data from video recordings. We will introduce the basic principles of the analytical method we are developing, which employs The Observer (behavioural analysis software) as a tool for studying video recordings of music performances. We will then present the results of some early test analyses, which we believe do offer evidence of entrainment phenomena – evidence that that may not be available from audio recordings or from experiments carried out in a laboratory setting.

Satinder Gill, Pulse periodicity in para-linguistic coordination

Joint or collective action (Clark, 1996) involves grounding in understanding of the communicative situation. In this paper, the process of grounding is explored as the emergence and movement of para-linguistic pulse periodicities, during the building of a concept in a joint task. These emergent temporal patterns are explored as musical accents of change. The analysis develops upon earlier work on body movement coordination (Gil, Kawamori, Katagiri, Shimojima, 2000) that revealed sequential and

parallel rhythmic patterns but did not analyse their temporal structure, and considers these structures as possibly isochronous and polyphonic respectively. It is proposed that the structures of pulse periodicities facilitate tacit transformation in understanding and enable joint action to be maintained (Gill, 2004). The analysis is of video data of collaborative conceptual design sketching undertaken by dyads. This is work in progress and is part of a larger proposed project to investigate how aspects of rhythm and entrainment are manifested in linguistic (phonology) and paralinguistic interaction (gesture, movement) and comparing ways in which these are manifested in music (Cross, 2004).

Jessica Grahn, Beat-based rhythm processing and the basal ganglia

The research that will be presented examines the structural characteristics necessary for a temporal sequence to induce a beat, and the brain areas involved in processing that beat. I have been testing three types of sequences that vary in their ability to induce a beat, based on the C parameter in Povel and Essens' metric model. The first type of sequence, Metric Simple, uses intervals related by integer-ratios (1:2:3:4), and has regular, low-complexity accent structures. Metric Complex sequences contain the same intervals, but rearranged to give an irregular, complex accent structure. Nonmetric sequences were also tested; these sequences have noninteger interval ratios (1:1.4:3.5:4.5), and irregular accent structure. The results from testing performance of these sequences differentiate the role of integer-ratios and regular accents in beat-induction.
Metric simple rhythms are reproduced and discriminated more accurately than Metric Complex and Nonmetric rhythms, indicating that integer-ratios may be necessary, but are not sufficient to induce a beat. FMRI results show that listening to metric simple rhythms activates certain motor areas of the brain, including the basal ganglia and SMA, significantly more than the other two conditions.
As a follow-up, patients with Parkinson's disease, which involves degeneration of parts of the basal ganglia, were tested on a rhythm discrimination task. The goal was to determine if the integrity of the basal ganglia is required for beat perception, or if the basal ganglia are simply active when a beat is perceived. The results of these studies will be presented at this meeting. In addition, input will be solicited on how to assign accents in the metric complex sequences, which contain patterns not easily slotted into the Povel and Essens' model of accent perception.

Nick Collins, Computational implementations of beat induction

A discussion and demonstration shall be given of a number of engineering approaches to the problem of beat induction for tracking musical performance. Their relation to human auditory perception and possible cognitive mechanisms of entrainment will be explored.

Tommi Himberg, Interactive tapping – a window to the cognitive foundations of musical interaction

In my research on musical interaction, I focus on the temporal dimension: coordination and synchronization of beats, rhythms and timelines. Current research on these issues has looked into the abilities of individuals and there are various models on how sensorimotor synchronization works. However, all these models and the empirical work on them have focused on individuals only. I attempt to develop ways in which these cognitive mechanisms could be studied in a more natural environment – in musical interaction between people. I am currently developing an experimental setting where two people could be engaged simultaneously in various rhythmic tapping tasks.
[detailed abstract attached]

Eric Berg and Udo Will, Entrainment to non-periodic rhythms? Analyses of tapping responses to North Indian alap and jor

One of the fascinating questions in entrainment research is whether humans entrain to non-periodic rhythms. The study we report 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).

These experiments indicate that the alap constitutes a weak and 'noisy' interacting force for the tapping responses that leads to intermittent phase synchronization. An interesting question, what determines the response level (mean duration) of the tapping, did not yet find a conclusive answer. *[detailed abstract attached]*

Udo Will and Eric Berg, Does the brain get entrained to music: How are musical stimuli and brain responses related?

"In the early days of EEG research it was also discovered that some of the alpha and beta waves could be synchronized - entrained - to the frequency of an external, bright strobe light stimulus. The English neurosurgeon Gray Walter was the first to report that at certain 'entrainment' frequencies of the external stimulus, his subjects would enter trance-like states where they began to experience deep peacefulness, dream-like visions, and other unexpected sensations (Walter 1953). Later it was discovered that not only strobe lights but also rhythmic noises could produce such effects". (Clayton et al, 2004 ESEM CounterPoint,1). The study reporting these effects was by A. Neher (Electroenceph.clin.Neurophysiol, 1961, 13: 449-451), who, in a later publication claimed that his results could serve to explain certain trance state behavior observed in ceremonies involving drums. Neher's study, which is not unproblematic, has never been replicated and we undertook the present EEG study to see whether we could obtain comparable results.
As stimuli we used recordings of North American Indian shaman drum song (section without voice), which we manipulated to obtain drum rates from 0.5 to 8 beats/sec. Sounds were presented with amplitudes of about 70dB, for some extra runs we used 100 dB. Our results are different from those reported by Neher in terms of amplitude and location of the evoked potentials. Only in a few subjects we obtained results similar to those of Neher, however, these potentials were identified as 1:1 responses of the temporal muscles and not of central origin. The cortical responses we recorded showed clear signs of 'attunement' to the drum stimuli: Responses continue to be present for missing drum beats, and it takes time to 'rebuild' responses when a beat sequence is followed by off-beat sequence. It will be discussed whether and how the observed brain responses can be related to 'attending oscillations', one of the cornerstones in M. R. Jones' entrainment model.

Tommi Himberg
Interactive tapping – a window to the cognitive foundations of musical interaction

Background

In my research on musical interaction, I focus on the temporal dimension: coordination and synchronization of beats, rhythms and timelines. Current research on these issues has looked into the abilities of individuals and there are various models on how sensorimotor synchronization works. However, all these models and the empirical work on them have focused on individuals only. I attempt to develop ways in which these cognitive mechanisms could be studied in a more natural environment – in musical interaction between people.

Experiments

I am currently developing an experimental setting where two people could be engaged simultaneously in various rhythmic tapping tasks.

The tappers, each having a MIDI drum pad, have two types of tasks: in synchronization task they tap along a beat provided by the computer, as accurately as possible. In continuation task, the computer metronome is turned off after a brief synchronization period, and the tappers are asked to continue tapping in the original tempo. In this basic setting, several variables can be studied. In the first experiments, I have focused on interactive channels and task conditions. With interactive channels I mean simply whether the two tappers can hear and/or see each other while doing the tasks. Task condition means that the two tappers might be performing the same task (i.e. either both are 'synchronising' or 'continuing') or different tasks (i.e. the other tapper is 'synchronising' while the other hears no metronome and is thus 'continuing'). Other factors might include tempo, grouping or accenting of the metronome, deviations in tempo or inter-onset interval etc.

Preliminary results

In the pilot study, 5 pairs of tappers (of varying musical background, none of the pairs had been training or performing together before) were tested in three interactive conditions (visual, auditory, auditory + visual) using three task types (synchronisation, continuation, mixed) in two tempi (120 and 70 bpm).

Due to technical problems related to the metronome, only synchronisation between the tappers is analysed, not synchronisation of either of the tappers to the metronome. I will term the synchronization between the tappers as 'coordination', so that it can be easily distinguished from the 'synchronization' that I will use when referring to the accuracy of synchronizing to the referent beat. In addition, various measures of periodicity were analysed.

To summarise the results:

- the interactive conditions had an effect to the coordination accuracy: having the visual channel open improved the coordination
- tempo had an effect: in slower tempo, coordination was better
- task congruence had an effect: coordination was better when both tappers were engaged in the same task than when the task was 'mixed'
- there were statistically significant interactions between these variables

All the factors selected for this experiment thus seem to contribute to musical interaction. That is not so surprising, but the direction of some of these effects is. It is noteworthy, however, that these effects are for coordination accuracy, not synchronisation. In general, although there is limited data available, it seems that in many cases synchronisation accuracy and coordination accuracy are in competition. Synchronisation has been found to be better in a tempo close to the preferred tapping rate, and when

there is no confusing feedback (Mates, Radil & Pöppel 1992). These seem to hold true also in my research, and this view is then complemented by the notion that in less than ideal synchronisation conditions, the interaction with the other tapper draws our attention and coordination overtakes synchronisation in importance.

In addition to these statistically apparent effects, the preliminary data seems to contain a lot of interesting phenomena that can be seen by looking into each pair and each run as a single case. The interpersonal dynamics can be seen "in action" for example when the 'continuing' tapper manages to draw the 'synchronising' tapper out of synchrony by slowing down her tempo. Another interesting phenomenon is the 'recovery of a lost synchrony' that sometimes happens. Without verbal coordination, after having drifted out of sync, the two tappers manage to find the correct phase again by "resetting" their tapping almost simultaneously. The 'musical' cues used in this process and the dynamics of it are currently under analysis.

Future directions

It is clear that there are a number of other factors involved in interactive tapping. More of these needs to be analysed before a tentative model can be constructed. Also the exact way in which the current variables interact needs to be analysed. In addition, there is a wealth of factors in the level of nonverbal communication, gestures and cues that should be taken into account. This can be done by using videoanalysis. This will be, in some way, included in the future experiments. The immediate goal will be to reproduce the experiment in the pilot study, after correcting some of the faults in the current setting. After that, one goal is to start using rhythm patterns instead of isochronous beats, to make the setting more authentic.

Any comments and suggestions regarding the setting, the methods of analysis or their future use will be greatly appreciated.

Eric Berg and Udo Will

Entrainment to non-periodic rhythms? Analyses of tapping responses to North Indian alap and jor

One of the fascinating questions in entrainment research is whether humans entrain to non-periodic rhythms. The study we report 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).
In the 1st experiment subjects were instructed to listen to the musical excerpt and tap the pulse they perceive. Music and tapping responses were recorded and subsequently analysed. The main results were:
a) In alap as well as jor: several distinct response modes. For the alap the mean durations for the three response modes are 0.89, 1.5, and 1.84 sec. For the jor the responses seem to be related to mean event (note) duration: Some subjects tap at half the event rate, some at one third and one subject at a fourth of the event rate.
b) These mean response durations could not be related to any average (statistical) measure of sound events. It is possible that the mean tap responses are related to certain periodicities in the music (mean duration of fast responses (0.89 sec) appears as a major spectral component in the several sections of the alap).
c) There is significant intermittent phase synchronization in alap (intermittent) and jor (continuous): ChiSquare test (comparing the distribution of measured phases against a random walk distribution) for Alap phases was significant for some , but not all participants. ChiSquare tests for jor phases from all subjects were significant (p=0.05 and better).
2nd Experiment. To better understand the relation between the music and the tapping rate we changed the duration (speed) of the sound files and subjects listend to two modified version, one 15% slower and one 15% faster than the original. Subjects were also asked to tap spontaneously before listening to any music. In addition the instruction was modified. Subjects were simply asked 'to tap to the music', which led to a higher number of tap responses. The main results for this experiment:

a) Again we found distinct response modes with mean durations corresponding to 1:2, 2:3, and 3:2.
b) Mean tap duration did not seem to be related to the spontaneous tapping rate.
c) Differences in the mean tapping rate for the slow and fast version did not correspond to the speed shift!
d) There is significant phase synchronization in alap and jor. ChiSquare test for the alap phases were significant for all subjects.
e) Analysis of the time course of relative phase and the change rate of the phase for both the slow and fast version shows that phase sync is indeed related to the music: phase stabilization occurs at the same points in the music, but at different points on the time scale (for the two versions)!

These experiments indicate that the alap constitutes a weak and 'noisy' interacting force for the tapping responses that leads to intermittent phase synchronization. An interesting question, what determines the response level (mean duration) of the tapping, did not yet find a conclusive answer.