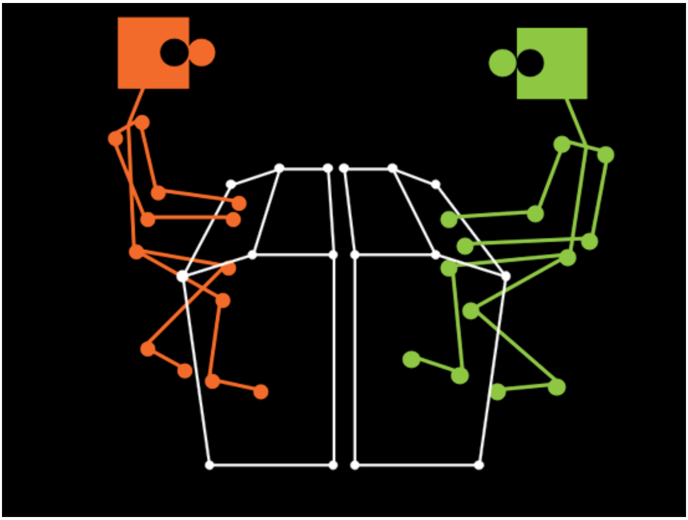
MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

Workshop "Musical Movement and Synchronization"

Leipzig, 3-4 May 2008



Symposium "Rhythmic Coordination in Dyads"

Leipzig, 5 May 2008

MUSIC COGNITION ACTION

Program

Workshop „Musical Movement and Synchronization“
3 - 4 May 2008

Organizers: Peter Keller [1], Martina Rieger [2], Caroline Palmer [3]
Assistants: Kerstin Träger, Gudrun Henze

and

Symposium “Rhythmic Coordination in Dyads”
5 May 2008

Organizers: Lena Nowicki [1], Peter Keller [1]
Assistants: Kerstin Träger, Gudrun Henze

[1] Independent Junior Research Group, Music Cognition & Action, Leipzig
[2] Department of Psychology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig
[3] Department of Psychology, McGill University, Montreal

Saturday, 3 May

8.45 – 9.00	Coffee and Welcome
9.00 – 9.45	**Caroline Palmer** Department of Psychology, McGill University, Montreal, Quebec, Canada
9.45 – 10.30	**Peter Pfordresher** Department of Psychology, University at Buffalo, Buffalo, NY, USA
10.30 – 10.45	Coffee break
10.45 – 11.30	**Bruno Repp** Haskins Laboratories, New Haven, CT, USA
11.30 – 12.15	**Janeen Loehr** Department of Psychology, McGill University, Montreal, Quebec, Canada
12.15 – 12.45	**Open Discussion**
12.45 – 13.45	Lunch (for all speakers and participants)
13.45 – 14.30	**Kate Stevens** MARCS Auditory Laboratories, University of Western Sydney, Sydney, Australia
14.30 – 15.15	**William F. Thompson** Department of Psychology, Macquarie University, Sydney, Australia
15.15 – 15.30	Coffee break
15.30 – 16.15	**Katie Overy** Institute for Music in Human and Social Development, University of Edinburgh, Edinburgh, UK
16.15 – 17.00	**Jane Davidson** University of Western Australia, Perth, Australia, and University of Sheffield, Sheffield, UK
17.00 – 17.15	Coffee break
17.15 – 18.00	**Open Discussion**
20.00	Closed dinner (only for invited speakers and guests): restaurant “Ratskeller” at Lotterstraße 1, Leipzig

Sunday, 4 May

8.45 – 9.00	Coffee and Welcome
9.00 – 9.45	**Marcelo M. Wanderley** Input Devices and Music Interaction Lab – CIRMMT, McGill University, Montreal, Quebec, Canada
9.45 – 10.30	**Geoff Luck** Department of Music, University of Jyväskylä, Jyväskylä, Finland
10.30 – 10.45	Coffee break
10.45 – 11.30	**Alan Wing** Behavioural Brain Sciences Centre, School of Psychology, University of Birmingham, Birmingham, UK
11.30 – 12.15	**Edward Large** Center for Complex Systems and Brain Sciences, Florida Atlantic University, Boca Raton, FL, USA
12.15 – 12.45	**Open Discussion**
12.45 – 13.45	Lunch (for all speakers and participants)
13.45 – 14.30	**Sofia Dahl** Institute of Music Physiology and Musician´s Medicine, Hanover University of Music and Drama, Hannover, Germany
14.30 – 15.15	**Simone Dalla Bella** Department of Cognitive Psychology, University of Finance and Management in Warsaw, Warsaw, Poland
15.15 – 15.30	Coffee break
15.30 – 16.15	**Werner Goebl** Department of Psychology, McGill University, Montreal, Quebec, Canada
16.15 – 17.00	**Peter Keller** Music Cognition and Action Group, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
17.00 – 17.15	Coffee break
17.15 – 18.00	**Open Discussion**
20.00	Closed dinner (only for invited speakers and guests): restaurant “Cavaliere” at Nürnberger Str. 11, Leipzig

Monday, 5 May

9.15 – 9.30	Coffee and Welcome
9.30 – 10.15	**Sebastian Kirschner** Department of Developmental and Comparative Psychology, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany
10.15 – 11.00	**Anna Kleinspehn** Center for Livespan Psychology, Max Planck Institute for Human Development, Berlin, Germany
11.00 – 11.30	Coffee break
11.30 – 12.15	**Viktor Müller & Shu-Chen Li** Center for Livespan Psychology, Max Planck Institute for Human Development, Berlin, Germany
12.15 – 13.45	Lunch (for all speakers and participants)
13.45 – 14.30	**Lena Nowicki** Music Cognition and Action Group, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
14.30 – 15.15	**Tommi Himberg** Department of Music, University of Jyväskylä, Jyväskylä, Finland
15.15 – 15.45	Coffee break
15.45 – 16.30	**Michael Hove**
16.30 – 17.15	**Juliane Honisch** Behavioural Brain Sciences Centre, School of Psychology, University of Birmingham, Birmingham, UK
19.00	Closed dinner (only for invited speakers and guests): China White at Peterssteinweg 17, Leipzig

Abstracts (In Alphabetical Order by Presenter)

Continuous Movements Generating Discrete Events:
Preparations and Limitations in Drumming Movements.

Sofia Dahl[1]

Music performance frequently displays fluent, continuous movement characteristics. Notes that at a first glance might be considered discrete events, separated in time, are in fact produced by coupled movements that form a larger motion pattern. Like speech and typing, the playing of an instrument belongs to the serial skills. Characteristic for a serial skill is that discrete movements are strung into new patterns where the sequential order is important. In contrast to typing or speaking, however, playing music also frequently requires synchronization with a musical pulse.

In order to play in synchrony anticipation is necessary. The earlier a player has an idea of when the next event is to occur, the more time there is to prepare for it. From a musical performance perspective, ample preparation time also gives a freedom of choice in how to play. For instance, an instrumentalist may strive to minimize the effort in playing, or choose to prioritize detailed control of attack or dynamic level instead. For intermediate tempo and dynamic level the player may be able to realize several such objectives, but more extreme tempi may reduce the possibilities for preparation and can decrease synchronization ability.

The degree of success in synchronization is particularly obvious for brief, percussive sounds. For players of piano or percussion instruments onsets that are too early or too late can be embarrassingly revealing. Pianists and percussionists also have little control over the note once initiated, implying that the preparatory movements are of special importance for these instruments.

In this talk I will discuss how percussionists prepare for separated strokes as compared to continuous rhythms. I will show examples of how preparatory movements change with playing conditions and discuss differences between healthy players of different expertise, and those suffering from movement disorders such as chronic pain or focal dystonia.

[1] Institute of Music Physiology and Musician's Medicine, Hanover University of Music and Drama, Hannover, Germany

Finger Anticipatory Movements and Markers of Personal Identity in Piano Performance.

Simone Dalla Bella[1]

Skilled piano performance is characterized by complex finger movements which are fluent and accurate. One hallmark of fluency is the performer’s ability to anticipate upcoming events (i.e., keypresses). The trajectories of these anticipatory movements are shaped by biomechanical and memory constraints and are aimed to achieve fine spatial and temporal control. Here I will show that kinematic properties of anticipatory movements can be described using Functional Data Analyses techniques. Moreover, I will demonstrate that this information can be used as a marker of personal identity. To this end, I will describe the results from a recent study in which the effects of tempo on pianists’ anticipatory finger movements, tone intensity, and timing were examined during performance. Finger movements were recorded with a passive-marker motion capture system while pianists performed melodies from memory at different tempi. It was found that pianists’ maximum finger heights above the keyboard before striking the keys increased as tempo increased. The time interval between the maximum finger height and the keypress increased as tempo decreased and on average corresponded to one tone duration. In addition, velocity/acceleration trajectories for finger movements in the vicinity of the keypress contained regions that were sufficiently unique to identify pianists. These properties were found across melodies and different tempi. Finger movement dynamics in the proximity of a goal (e.g., keypress in piano performance) in complex sequences carry information about personal identity.

[1] Department of Cognitive Psychology, University of Finance and Management in Warsaw, Warsaw, Poland

**Body Movement Studies from 1991 to 2008:
The Highs, Lows and Many Unanswered Questions.**

Jane Davidson[1]

This paper aims to contribute to the understanding of expressive body movement in musical performance. It is based upon a long-standing interest in the field. My research over the past 20 years has reflected a personal fascination in how a performer uses his/her body to assemble and execute a musical performance. My enquiries have taken me from production to perceptual study and from objective measurement to work on social reflection and interpersonal dynamics. The intention of this paper is to provide an overview of my research, drawing out findings that have lead to further and more productive areas of enquiry, and also findings that have left me frustrated and without a way forward. In addition to this exposé, I shall highlight matters of central importance to me by presenting recent data on an instrumental duo which highlight the many questions for which I continue to seek answers. The study focuses on how a flautist and clarinettist come together in a rehearsal process to produce an agreed and coordinated timing and interpretation of an unfamiliar work. Data to be explored includes musical sound information, movement information, and spoken commentary.

[1] University of Western Australia, Perth, Australia, and University of Sheffield, Sheffield, UK

Synchronization of Sound and Motion in Piano Duet Performances.

Werner Goebl[1], Caroline Palmer[1]

Music ensemble playing poses considerable demands on the performing musicians.
They have to align their actions with one another in order to adhere to a common musical goal. In this study, we investigate the influence of auditory feedback, relative note density, and musical role on the synchronization of two pianists playing together.

Sixteen skilled pianists forming 8 piano duos performed two-voice melodies with their right hands on a digital piano while wearing closed headphones. Their finger motion was recorded with a three-dimensional motion capture system. The pianists were provided either full auditory feedback (natural), one-way feedback (the accompanying pianist heard everything, but the leading pianist heard only his/her own play) or self (each pianist heard own playing, but not the other). The three melodies had either more notes in the upper voice (eighth notes versus quarter notes), fewer notes (quarter versus eighth notes), or equal amounts of notes. The pianist playing the upper voice was instructed to lead and the other had to accompany.

Timing analyses showed that asynchrony increased when auditory feedback was limited.
This effect was modulated by note density; the person playing more notes tended to precede the other voice in the limited auditory feedback conditions. Best synchrony was observed in the absence of beat subdivision. We compare those patterns with the motion of fingers prior to the asynchronies, to investigate cross-pianist influences.

[1] Department of Psychology, McGill University, Montreal, Quebec, Canada

Studying Personality and Musical Interaction Using Co-operative Tapping.

Tommi Himberg[1]

This study investigates the links between personality and rhythmic motor performance and co-ordination, individually and in interacting pairs.
Music as a communicative medium is said to lack unambiguous referential and propositional meaning. On the other hand, e.g. metrical structure provides a clear framework for interactions, and it thus is a "safe" domain for those (e.g. autistics) who generally have problems in interpersonal interactions.
Personality traits reflect the ways in which individuals engage in social interactions – will they also predict their behaviour in musical interaction?
Personality traits were measured using standardised tests (Big Five Inventory BFI for extroversion, Agreeableness, Conscientiousness, Neuroticism and Openness) and Scale for Interpersonal Behaviour SIB for Assertiveness). Tapping performance (solo and duet) was measured with synchronisation, continuation and turn-taking tapping tasks. For the duet tasks, people were paired based on their BFI and SIB scores, creating pairs with either matching or contrasting profiles.

[1] Finnish Centre of Excellence in Interdisciplinary Music Research, Department of Music, University of Jyväskylä, Finland

Interpersonal Synchronization: A Paradigm for Analysing Synchrony in Dancers.

Juliane Honisch[1]

Dance consists of controlled rhythmic movements in space. In dance ensembles, synchronizing such spatial movements requires agreement on timing and dynamics (Maduell and Wing, 2007). However, this is a highly demanding task, as dancers' visual and auditory dynamics may vary from one another. For example, dancers have to modify the dynamic requirements of choreography (which may be different for all members of the ensemble) in order to synchronize their performance with that of the others and the music.

My current research is focused on tempo control, analysing how pairs synchronize oscillatory arm movements. In each pair, one is designated Lead (synchronizing movements to an auditory metronome) and the other as Follower (synchronizing movements to those of the Lead). This paradigm is allowing me to investigate questions including: How does visual information exchange help to decrease variance in interresponse intervals and improve asynchrony? How variable is performance when synchronizing with or without a metronome? In future, I will apply the paradigm, to include more dance-like movements.

[1] Behavioural Brain Sciences Centre, School of Psychology, University of Birmingham, Birmingham, UK

Interpersonal Synchrony, Affiliation, and the Self/Other Distinction.

Michael J. Hove[1]

The tendency to mimic and synchronize with others is well established. Although mimicry has been shown to lead to affiliation between co-actors, the effect of interpersonal synchrony on affiliation remains an open question, despite widespread anecdotal evidence for affiliative effects of playing music and dancing with others. We investigated the effect of interpersonal synchrony on affiliation by having participants match finger movements with a visual moving metronome. In Experiment 1, affiliation ratings were compared for an experimenter who either a) tapped to a metronome that was synchronous to the participant's metronome, b) tapped to a metronome that was asynchronous, or c) did not tap. As hypothesized, the degree of synchrony between participant and experimenter predicted subsequent affiliation ratings. Experiment 2 limited the amount of tapping to explore the minimal conditions necessary for creating affiliation and Experiment 3 found that the affiliative effects were unique to interpersonal synchrony. We interpret these results in terms of perception/action links and blurring of the self/other distinction during interpersonal synchrony.

[1] Department of Psychology, Cornell University, Ithaca, NY, USA

Thinking Ahead in Solo and Ensemble Music Performance.

Peter E. Keller[1]

Music performance involves the anticipation of one’s own sounds and the sounds produced by others. I will report the results of two studies that addressed the role of these forms of anticipatory auditory imagery in controlling the timing of musical actions. The first study investigated the effects of auditory imagery on finger movement timing and kinematics in an auditory sequence production task that was designed to approximate the demands of solo performance. The second study examined the relationship between individual performers’ auditory imagery abilities and the coordination of their movements (anterior-posterior body sway) and sounds with co-performers in piano duos. Based on the results of these studies, it is proposed that musical action control is stabilized via cross-modal anchoring by auditory images in the context of both solo and ensemble performance. Thus, anticipatory auditory imagery may facilitate exceptional motor timing by serving as a scaffold that shapes individual and group movement dynamics.

[1] Music Cognition and Action Group, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

The Age of Joint Drumming: About the Social Origins of Rhythmic Coordination.

Sebastian Kirschner[1]

The scientific discussion about the evolutionary origin of human musicality goes back to Darwin (1871), who believed that music constitutes an ancient and important form of human communication, intertwined with, but independent from, language (Fitch, 2006). Recently, most evolutionary scenarios have focused on music's ability to align emotional states and to foster social bonding among performers through harmonious vocal blending and rhythmic coordination of movements.

During my talk I will first summarize the arguments and predictions from the social bonding hypothesis with special focus on the evolutionary history of rhythmic coordination in humans.

Second I will present an empirical study, testing a prediction derived from the social bonding hypothesis: Preschool children would perform better at a beat perception and synchronization task if the stimulus is presented in a social context (human drum partner) compared to an audiovisual but nonsocial stimulus (drum machine) or a metronome (drum sounds coming from a speaker).

[1] Department of Developmental and Comparative Psychology, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

Drumming Together: Interpersonal Action Synchronization Across the Lifespan.

Anna Kleinspehn[1], Michaela Riediger[1], Florian Schmiedek[1,2], Timo von Oertzen[1], Shu-Chen Li[1], & Ulman Lindenberger[1]

The ability to coordinate one's goal-directed behavior with that of others at high temporal precision (interpersonal action synchronization; IAS) is a fundamental characteristic of successful social interactions. However, little is known about the ontogeny of IAS. Using a dyadic drumming paradigm, we examined age differences in IAS. Girls or women from four age groups (5, 12, 20-30, and 70-80 years) were asked to synchronize their constant-rate drumming beats at self-chosen frequencies with one participant from each age group. Individuals' sensorimotor skills were positively related to IAS accuracy, and measures of social competencies were partly associated to interpersonal outcomes. Dyads among adults showed higher synchronization accuracy than dyads including children. Individuals experienced the drumming partner and the interaction more positively when reaching higher IAS accuracy. The study contributes new insights about lifespan age differences in the ability to synchronize with others, and points to possible mechanisms and consequences.

[1] Center for Lifespan Psychology, Max Planck Institute for Human Development, Berlin, Germany
[2] Department of Psychology, Humboldt University Berlin, Berlin, Germany

Fractal Tempo Scaling and Predictive Pulse Synchrony.

Edward W. Large[1]

Our goal is to understand the ability of musicians and non-musicians to follow the beat in musical performances with naturally fluctuating tempo.
In Experiment 1, we examined tempo fluctuations in piano performance. We collected performances of four pieces from different musical periods, baroque, classical, romantic, and jazz, by a piano student who was instructed to play the pieces with natural expression. We extrapolated beat times by comparing the performances with the scores, and the inter-beat intervals were subjected to a spectral analysis and Hurst's rescaled range analysis. Results indicated fractal scaling of performance tempo in each case.
Next, we conducted a synchronization experiment using two of the performances as stimuli, the Aria from J.S. Bach's Goldberg Variations, and Frederick Chopin's Etude in E major, Op. 10, No. 3. Additionally, mechanical versions were sequenced on a computer with precise note durations and a steady tempo. Participants were asked to synchronize at a slower metrical level, and at a faster metrical level on different trials for both versions of both pieces. Both musicians and non-musicians synchronized successfully and were able to accommodate large tempo fluctuations. Subjects were less variable for the mechanical versions, and synchronization was superior at the slower metrical level.
Moreover, subjects appeared to predict tempo changes, suggesting covert monitoring of multiple metrical levels, and coupling between structural levels, consistent with the model of Large & Palmer (2002). A possible relationship between fractal tempo scaling, predictive pulse synchronization, and coupled oscillation is proposed.

[1] Center for Complex Systems and Brain Sciences, Florida Atlantic University, Boca Raton, FL, USA

Subdividing The Beat: Auditory and Motor Contributions to Synchronization.

Janeen Loehr[1], Caroline Palmer[1]

Music ensemble performance often requires synchrony among performers at the beat level while individuals perform notes that subdivide the beat. In tapping tasks, adding auditory subdivisions between sequence tones reduces asynchronies between taps and tones, as does adding non-contact movement between taps (Wohlschlager & Koch, 2000). We addressed whether asynchronies are reduced when pianists synchronize music that contains both auditory feedback and movements between beats with an isochronous metronome, and whether those effects are due to the presence of auditory feedback or movement production.

Seventeen pianists performed melodies in which subdivisions occurred between none, half, or all of the beats in a synchronization task with a metronome sounded at 500-ms inter-beat intervals. Auditory feedback was manipulated such that participants either did or did not hear the subdivisions occurring between beats. We compared participants' synchronization accuracy under conditions in which beats were subdivided by movement only, auditory feedback only, neither, or both. Participants' movements were recorded with an active motion capture system, and we examined temporal asynchronies on the metronomic beat as well as finger motion trajectories.

When auditory feedback matched motor performance, adding subdivisions between beats increased asynchrony on the beats (contrary to previous literature); the more subdivisions in the melodies, the earlier participants performed beats relative to the metronome. When participants heard auditory subdivisions while performing melodies without subdivisions, they played beats early relative to the metronome; asynchronies were less affected when participants did not hear the subdivisions they performed. Motion analyses indicated that performing subdivisions increased variability of the finger acceleration trajectories leading up to the beats. These findings document that subdividing the beat increases asynchrony when performing music with a metronome. Furthermore, auditory subdivision has a greater impact on synchronization than does movement subdivision.

[1] Department of Psychology, McGill University, Montreal, Quebec, Canada

Quantifying Musical Movement and Synchronization Using a Computational Feature Extraction Approach.

Geoff Luck[1]

A growing body of research is utilizing computational feature- extraction methods to quantify both music and music-related movement. The use of signal processing and visualization techniques, for example, is widespread in the music information retrieval (MIR) community. At the same time, similar techniques are being applied to the analysis of movement data acquired using motion capture systems, and are being increasingly used to quantify both temporal and expressive movements of musicians and others engaged in music-related activity. In the first part of this talk, music and movement feature-extraction techniques will be discussed, and some of the methodological challenges associated with the collection of musical-movement data, primarily with regards to the use of motion-capture systems, will be highlighted. Such issues will include how to deal with the enormous amount of data generated by such systems, and how to turn this data into knowledge. In the second part of the talk, recent and ongoing music- and movement-related work being carried out at the Department of Music of the University of Jyväskylä will be presented. The work to be presented will address two main themes: musicians' temporal and expressive gestures during performance, and sensory-motor synchronization abilities in different age groups. A common thread running through this research is the use of computational feature-extraction techniques and statistical analyses to quantify music-related movement, and, where applicable, identify relationships between the musical and movement features.

[1] Department of Music, University of Jyväskylä, Jyväskylä, Finland

Inter- and Intrabrain Synchronization While Playing Guitar.

Viktor Müller[1], Shu-Chen Li1, and Ulman Lindenberger[1]

Considerable research indicates that synchronized neuronal activity during perception and action and oscillatory couplings between cortical and muscle activities during voluntary movement are among the neural mechanisms subserving brain-body-world interaction. Using EEG recordings, we investigated synchronous brain activity during playing guitar in duet. EEG was simultaneously recorded from the brains of pairs of guitarists playing a short melody together. Applying phase synchronization algorithms to interbrain analyses, we found that phase synchronization both within and between brains increased significantly during the periods of (i) preparatory metronome tempo setting and (ii) play onset. Phase alignment extracted from within-brain dynamics was related to behavioral play onset asynchrony between guitarists. We propose that oscillatory coupling between brains provides a neurophysiological mechanism for interpersonally coordinated voluntary actions in the musical domain, and may also play an important role in other forms of social interaction.

[1] Center for Lifespan Psychology, Max Planck Institute for Human Development, Berlin, Germany

Investigating Interpersonal Sensorimotor Synchronization and Empathy.

Lena Nowicki[1], Peter Keller[1]

How is musical interaction affected by one's ability to put themselves 'in another's shoes'? The present study addresses this question by investigating sensorimotor synchronization between co-actors in dyads. Across a series of experiments, pairs of musically trained participants were asked to tap with the beat of a tonal metronome either on their own (solo) or in alternation or synchrony with their partner (joint). Asynchronies between taps and tones were analyzed as a measure of synchronization accuracy. Results show significant differences in the mean asynchronies in the joint conditions depending on whether taps were made at strong or weak metric locations. Further, the variability of asynchronies was significantly higher in the joint than in the solo condition. These results indicate the mutual interaction between co-actors during interpersonal sensorimotor synchronization. To find out more about the nature of this interaction, we are currently estimating the correlation between tapping performance and empathy across participants.

[1] Music Cognition and Action Group, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Being Together in Time:
Musical Movement and the Mirror Neuron System.

Katie Overy [1]

One of the most exciting developments in neuroscience in the last few years has been the discovery of individual neurons (often referred to as “mirror neurons”) that fire not only when an action is executed, but also when that same action is observed. This discovery is leading to an extraordinary conceptual shift in our understanding of perception-action mechanisms, human communication and human empathy.

In a recent model of the role of mirror neurons in musical communication, Molnar-Szakacs and Overy (2006) proposed that musical sound is perceived not only in terms of the auditory signal, but also in terms of the temporally synchronous, intentional, hierarchically organised sequences of expressive motor acts behind the signal. According to this model, the recruitment of the mirror neuron system in both sender and perceiver of a musical signal allows for co-representation and sharing of a musical experience. This has powerful implications for communication, learning and therapy.

Drawing on this model, my presentation will focus on the role of rhythmic synchronization in language support activities, and will propose that imitation and shared experience are the key elements of successful work in this area.

[1] Institute for Music in Human and Social Development, University of Edinburgh, Edinburgh, UK

The Ups and Downs of Clarinet Performance:
Finger Motion and Temporal Accuracy.

Caroline Palmer[1], Erik Koopmans[1], Janeen Loehr[1], and Christine Carter[1]

Most studies of synchronization examine finger movements whose temporal goals involve surface contact (tapping, drumming, piano performance) or no surface contact (finger wiggling). Some studies propose that finger-surface contact generates proprioceptive information that may guide future performance (Aschersleben, Gehrke & Prinz, 2004; Goebl & Palmer, 2008). We examine the case of clarinet performance, in which finger movements have to be synchronized both with and without surface contact (key arrivals). We compare the temporal accuracy of sounded tones with the finger movements that generate them, to examine whether proprioceptive feedback from key contact improves performance.

Clarinetists' finger movements were measured during performance of simple melodies in which they synchronized with a metronome. Eight clarinetists performed melodies that required the successive depression or release of clarinet keys; the clarinetists were instructed to use continuous blowing (no tonguing), and thus the finger movements determined the time of pitch change. Each clarinetist performed the melodies at three successively faster tempi. An active motion capture system recorded the clarinetists' finger movements, which were normalized with respect to the clarinet plane. The sounded performance was recorded and synchronized with the movement data.

Analyses of the sound recordings indicated that clarinetists' interonset intervals that were bounded by key depressions were more accurate across the range of tempi than those intervals bounded by key releases. Analyses of the finger movement accelerations indicated a positive acceleration peak prior to key bottom (at key arrival) in the interval preceding a key depression, similar to finger-key contacts in piano performance. Finger movements that generated finger-key contacts were succeeded by more accurate IOIs than were other finger movements, consistent with the notion that proprioceptive feedback from key contact improves performance.

[1] Department of Psychology, McGill University, Montreal, Quebec, Canada

Surface Composition and Synchronization.

Peter Q. Pfordresher[1], Caroline Palmer[2]

In studies of synchronization participants typically either tap on a hard, stiff surface (e.g., a table) or move limbs through the air, not making contact with any surface. Musical synchronization, in practice, usually does not match either extreme. Contact points that provide kinesthetic feedback about beat matching are often associated with movable surface (the piano) that may be composed of flexible material (a guitar string). Performers thus must learn to synchronize by adapting their timing to the physical materials used in performance. Theoretically, the Paillard-Fraisse hypothesis accounts for synchronization accuracy entirely based on the length of afferent connections, irrespective of the kind of tactile/kinesthetic feedback provided by the surface. By contrast, the sensory accumulation hypothesis suggests that more accurate synchronization should be found for hard, stiff surfaces than for soft, flexible surfaces (which may yield larger negative asynchronies).
We tested the influence of surface composition on synchronization among a group of trained pianists who synchronized with the beat by either tapping on a table or on a sponge secured to the table with tape. Pianists synchronized using different fingers of the right hand, to address possible roles of finger independence. We measured finger movements during synchronization through motion capture.
Results indicated greater mean asynchronies (anticipation of the beat) on average when people tapped on the sponge than when they tapped on the table. In addition, analyses of finger position, velocity, and acceleration all indicated a tendency to use more extreme movement patterns when tapping on the sponge than the table. These results are in line with the sensory accumulation hypothesis, and suggest a strategy of enhancing tactile feedback through movement amplitude when synchronizing with a flexible surface. This strategy is apparently not fully successful, however, given significant differences in asynchrony.

[1] Department of Psychology, University at Buffalo, Buffalo, NY, USA
[2] Department of Psychology, McGill University, Montreal, Quebec, Canada

Sensorimotor Synchronization with Adaptively Timed Sequences.

Bruno H. Repp[1], Peter E. Keller[2]

Most studies of human sensorimotor synchronization require participants to coordinate actions with computer-controlled event sequences that are unresponsive to their behavior. In the present research, the computer was programmed to carry out phase and/or period correction in response to asynchronies between taps and tones, and thereby to modulate adaptively the timing of the auditory sequence that human participants were synchronizing with, as a human partner might do. In five experiments the computer's error correction parameters were varied over a wide range, including "uncooperative" settings that a human synchronization partner could not (or would not normally) adopt. Musically trained participants were able to maintain synchrony in all these situations, but their behavior varied systematically as a function of the computer's parameter settings. Computer simulations were conducted to infer the human participants' error correction parameters from statistical properties of their behavior (means, standard deviations, auto- and cross-correlations). The results suggest that participants maintained a fixed gain of phase correction as long as the computer was cooperative, but changed their error correction strategies adaptively when faced with an uncooperative computer.

[1] Haskins Laboratories, New Haven, CT, USA
[2] Music Cognition and Action Group, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Dance as a Dynamical System: Analysis of Contemporary Dance Movement in the Presence and Absence of a Musical Soundscape.

Catherine Stevens[1], Christian Kroos[1], Shaun Halovic[1], Johnson Chen[1], Emery Schubert[2], Mark Gordon[1], Julien Tardieu[1], and Garth Paine[1]

Perception of dance, like live music, is multimodal. Participants and/or beholders, at the very least, respond to visual, temporal, and auditory cues. An experiment was conducted during a live performance and under controlled conditions to investigate the effect of the presence and absence of a musical soundscape on the kinematics and dynamics of a male contemporary dancer. It was hypothesized that attractors would be evident in both visual only and auditory + visual conditions, with some heightened definition when music accompanied the movement. The motion of the dancer performing in a trio was tracked using 10 Vicon cameras. Phase portraits will be presented. A single point on the dancer's body will be analysed and a principal components analysis of all 24 points conducted. One prediction is that the first component captures the translatory movement of the whole dancer in space.

In addition to capturing the dancer's motion, continuous data from 20 audience members was recorded as the audience watched the live dance performance under visual only, auditory only, and auditory + visual conditions. Audience members used the portable Audience Response Facility (pARF) – a hand-held computer with a stylus – to rate the emotion that they felt was being expressed during each 5-minute performance/condition. The pARF sampled emotional response on arousal and valence dimensions, twice per second. Accelerations and velocities of the dancer recorded while audience members rated their emotional response will be used to aid interpretation of audience reactions to dance under auditory + visual and visual-only conditions. For example, approach movements cueing reports of relatively positive valence compared with avoidance movements cueing reports of more negative valence.

[1] MARCS Auditory Laboratories, University of Western Sydney, Sydney, Australia
[2] School of English, Media and Performing Arts, The University of New South Wales, Sydney, Australia

The Emotional-Production Synchronisation Paradigm: Analysis of Time-Varying Facial Signals of Emotion.

William Forde Thompson [1], Steven Livingstone[1], and Caroline Palmer[2]

Research suggests that perceivers are highly attuned to facial expressions and gestures of musicians, and such information affects their interpretation of attributes such as interval size, emotional connotation, timbre, and tonal tension. Performance movements also reflect motor planning for the communication of structural and emotional qualities of music. In this workshop, we describe how motion capture of facial expressions in performance can be used to elucidate motor plans for production. We summarize the emotional-production synchronisation (EPS) paradigm, which was developed to elucidate the perception and production of musical emotions. In this paradigm, short verbal phrases are sung multiple times with contrasting emotional intentions (sad, joyful, neutral) and video-recorded. Experimental participants then attempt to imitate these target performances as closely as possible, focusing their attention on the emotional qualities of the performances. Analyses of preparatory movements are then conducted to elucidate the time course of motor planning and to test the hypothesis that preparatory movements are evident prior to an emotional utterance, reflecting advanced motor planning. Such analyses can also identify the types of movements associated with each emotion, corroborating previous evidence that changes in expressive intent yield reliable differences in time-varying patterns of facial expression (e.g., eyebrow movement, head movement). We argue that motion capture is a powerful tool for elucidating the psychological mechanisms underlying emotional singing.

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Motion Capture of Performer Movements: Expressive and Effective Movements and Technical Issues.

Marcelo M. Wanderley [1]

In this talk I will review various projects carried out at the Input Devices and Music Interaction Laboratory at McGill University on the measurement of musicians' movements using motion capture (mocap) devices. This will be done in three parts. I will initially focus on expressive movements (also called ancillary gestures) of clarinetists, i.e. movements that do not aim at sound generation, but that are nevertheless omnipresent in music performances. This part of the talk will discuss the analysis of the different movements produced, their variability (within and across subjects), as well as alternative ways to study them including for instance the sonification of mocap data or the use of movement description techniques such as Laban-Bartenieff Movement Fundamentals. Secondly, I will discuss the mocap of percussionists' effective movements (also called instrumental gestures) with the goals of a) comparing performances using different percussion devices (acoustic and electronic) and b) generating (synthesizing) movements of virtual characters[i]. Finally, I will briefly present preliminary results on the development of applications for motion capture using various trackers as well as other types of data in real-time (digital video/audio, Open Sound Control/MIDI messages) and the issues of data manipulation and synchronization associated with the choice of devices[ii].

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Forms of Phase Shift Compensation in Synchronization Stepping by Dancers and Nondancers.

Alan Wing[1], Huiya Chen[1], Kevin Lucas[1], and Marie Bonser[1]

When synchronising with a periodic metronome, even if the response period matches that of the metronome, the variability of motor timing means that response phase will inevitably become random unless phase correction is applied. A simple model for maintaining phase is that the current interval is modified in proportion to the preceding metronome-response asynchrony (Vorberg and Wing 1996). This linear phase correction model of synchronization may be studied by introducing a phase change in the metronome through shortening (phase advance) or lengthening (phase retard) one interval in the series. Group average data reveal a phase compensation function in which the asynchrony introduced by the phase shift damps down in geometric manner to restore the asynchrony to pre-perturbation levels (for review see Repp 2005). Such compensation is consistent with the linear phase correction model. However, it has been noted that individual subjects' average compensation functions do not always conform to the model (Repp 2002). I will describe a study in which 10 trained dancers and 10 non-dancers synchronized stepping responses with a 500 ms beat. The metronome was subject to 125 or 250 ms phase shift at unpredictable times. In separate blocks participants were required either to correct for the change of phase (C) or to maintain their old phase (M). Compensation functions obtained on individual trials (5 replications per subject per condition) were classified by two observers in terms of whether or not they accorded with the linear phase correction model. If they were not, they were further classified on various aspects including: whether there was delayed compensation, whether old phase was maintained, whether period changed, whether there was over-compensation. In my talk I will summarize the relative frequency of these other forms of compensation function for dancer and non dancer groups and discuss implications for the phase correction model and the development of timing skill.

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2 „Ratskeller"

3 „Cavaliere"

4 „White China"

Musical Movement and Synchronization Workshop

	Saturday May 3	Sunday May 4
08.45 – 09.00	*Coffee and Welcome*	*Coffee and Welcome*
09.00 – 09.45	**Caroline Palmer**	**Marcelo Wanderley**
09.45 – 10.30	**Peter Pfordresher**	**Geoff Luck**
10.30 – 10.45	*Coffee break*	*Coffee break*
10.45 – 11.30	**Bruno Repp**	**Alan Wing**
11.30 – 12.15	**Janeen Loehr**	**Edward Large**
12.15 – 12.45	Open Discussion	Open Discussion
12.45 – 13.45	*Lunch*	*Lunch*
13.45 – 14.30	**Kate Stevens**	**Sofia Dahl**
14.30 – 15.15	**Bill Thompson**	**Simone Dalla Bella**
15.15 – 15.30	*Coffee break*	*Coffee break*
15.30 – 16.15	**Katie Overy**	**Werner Goebl**
16.15 – 17.00	**Jane Davidson**	**Peter Keller**
17.00 – 17.15	*Coffee break*	*Coffee break*
17.15 – 18.00	Open Discussion	Open Discussion
20.00	*Dinner (Ratskeller)*	*Dinner (Cavaliere)*

Symposium „Rhythmic Coordination in Dyads"

	Monday May 5
09.15 – 09.30	*Coffee and Welcome*
09.30 – 10.15	**Sebastian Kirschner**
10.15 – 11.00	**Anna Kleinspehn**
11.00 – 11.30	*Coffee break*
11.30 – 12.15	**Viktor Müller & Shu-Chen Li**
12.15 – 13.45	*Lunch*
13.45 – 14.30	**Lena Nowicki**
14.30 – 15.15	**Tommi Himberg**
15.15 – 15.45	*Coffee break*
15.45 – 16.30	**Michael Hove**
16.30 – 17.15	**Juliane Honisch**
19.00	*Dinner (China White)*